United States Department of Agriculture | Forest Service | R-6

Reply to: 3400 Date: May 4, 1994

Subject: Report and Strategic Plan of National Bark Beetle Steering Committee

To: Mel Weiss, Acting Director, WO-FPM

Enclosed is the "National Bark Beetle 5 Year Strategy". This document is the strategic plan for bark beetle research and technology development prepared by the National Bark Beetle Steering Committee. The Strategic Plan was prepared to help guide, focus, and prioritize project needs for 14 bark beetle species; it identifies short term and long term emphasis areas for both basic research and applied technologies, and information transfer. It will also be used to monitor overall progress and effectiveness of projects. This is a dynamic document, and was developed on a five year time frame to help identify the sequence for projects; however, when projects will actually be done is dependant on funding, available insect populations, and results or questions identified in ongoing projects.

Also included is the "Report of the 1993 National Bark Beetle Steering Committee Meeting". The Report of the 1993 Meeting contains summaries of 47 projects (excluding Tomicus) that were conducted in 1993; 12 projects (27%) were funded all or in part by Technology Development Project funds.

IRAL RAGENOVICH, Chair
National Bark Beetle Steering Committee

Enclosures

cc:
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NATIONAL BARK BEETLE
5 YEAR STRATEGY
1993

Prepared by
National Bark Beetle Steering Committee

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NATIONAL BARK BEETLE ACTION PLAN

prepared by the
National Bark Beetle Steering Committee

INTRODUCTION

Bark beetles play an important role in the coniferous forest types in the United States. Major outbreaks can devastate large areas of mature or stressed forests. This increases risk of fire, impacts recreation values, and destroys millions of board feet of timber. These epidemics are often symptomatic of stressed tree conditions. In many areas, effective long-term fire suppression and past harvesting practices have contributed to the creation of large acreages of overstocked stands. Trees in these stands suffer from severe competition for the limited amount of available sunlight, water, and nutrients. Often, trees are further stressed by drought, disease and other factors.

Effective management options that would prevent and greatly reduce bark-beetle caused tree mortality, and improve overall forest health were, and are, needed for both the short- and long-term. Some of the most promising tools for reducing bark beetle losses in the short-term involve the use of the behavioral semiochemicals, and silviculture management is a major player in both short-and long-term management.

For many years entomologists in each Region and Research Station were conducting bark beetle projects independently in an effort to meet the particular needs and issues facing their respective areas. Entomologists from the Western Regions and Stations formed a Bark Beetle Task Force in an effort to coordinate development and use of semiochemicals for managing bark beetles. Other bark beetle coordination groups that existed included the Canada/US Mountain Pine Beetle Task Force and a group designated to develop a west wide Bark Beetle Research, Development, and Application Program (BBRDA). The Bark Beetle Task Force has evolved into the National Bark Beetle Steering Committee, and has expanded to include bark beetles nationwide. Aspects, such as silvicultural methods, population dynamics, and information transfer, were incorporated, many of which were originally developed for the BBRDA. The Committee also serves as the technical advisory committee for the WO FPM Technology Development Projects.

General Objectives for the National Bark Beetle Steering Committee are:

1. Develop and demonstrate the use of semiochemical technology to minimize bark-beetle impacts on forest resources.

2. Promote long term forest health by developing and demonstrating silvicultural prescriptions for preventing and reducing bark beetle outbreaks.

3. Increase public awareness/understanding of bark beetles and forest ecology.

In an effort to operate efficiently and effectively the Committee has developed Terms of Reference that identify the objectives of the Committee and its role as a Technology Development Steering Committee.

A 5-Year Strategic Plan, which consists of individual strategic plans for 14 different bark beetles, has been prepared to help focus the efforts for these bark beetles, as well as meet the needs of the FPM Technology Development Program.

The Strategic Plan incorporates the basic and applied research needs for western bark beetles that were identified under the west wide Bark Beetle Research, Development, and Application Program (BBRDA).

In addition, the proposed activities help realize several of the strategic goals identified in "Healthy Forests for America's Future: A Strategic Plan". These include:

Planning - The ecological significance of pests and wildfire is considered in all forest resource management planing processes.

-Develop pest modeling and decisions support systems to assist land managers making ecosystem management decisions.

Prevention - Susceptibility to pests is decreased by applying available forest management options.

-Encourage use of resource management practices that prevent pest losses.

Suppression - Pest suppression and fire control options and funding are available to meet resource management objectives.

-Increase research and development of pest suppression options.

Pesticides - Environmentally acceptable pesticides are available to protect forest values and achieve resource management objectives.

-Ensure necessary data are available to assess environmental impacts of key pesticides (including pheromones).

-Obtain registration of pheromones and other behavioral chemicals.

-Increase the availability and effectiveness of microbial pesticides and pheromones.

Forest Protection Technology - Effective, economical, and environmentally acceptable forest protection technologies are available to meet forest resource management objectives.

-Ensure that the latest integrated pest management technology is made available to forest managers.

-Accelerate the development and application of new integrated pest management technologies for major pests.

-Make increased use of environmentally benign pest management technologies including classic biological control, conservation, and augmentation of native natural controls, ...

-Increase knowledge of the role of forest insect pests, other arthropods, and microorganisms in ecosystems in relation to forest health.

-Evaluate alternative silvicultural methods for harvesting systems for ecosystem management that reduce the impacts of drought, pests, and wildfire and promote forest health.

Management of Introduced Forest Pests - Plans and capabilities exist to limit spread or eradicate new introductions of exotic forest pests and to minimize ecosystem disruption from pests that have already been introduced or may be introduced in the future.

-Cooperate with APHIS on survey and impact evaluation of the recently discovered common European pine shoot beetle.

-Continue to support pilot tests and impact assessments for introduced pests.

International Cooperation in Forest Health Protection - Forest health is recognized as a problem requiring international cooperation, common interests are identified with other countries, and long-term relationships are developed to maintain and protect forest health worldwide.

-strengthen international cooperation and scientific exchanges to enhance research capabilities for protecting forest health.

This document includes the Terms of Refernce for the National Bark Beetle Steering Committee and the 5-Year Strategic Plans for 14 bark beetles. They are: Douglas-fir beetle, mountain pine beetle, western pine beetle, southern pine beetle, spruce beetle, Ips pini, Ips perturbatus, California five-spined Ips, Arizona five-spined Ips, Jeffrey pine beetle, roundheaded pine beetle, fir engraver, western balsam bark beetle, and European pine shoot beetle.

National Bark Beetle Steering Committee

Chair: Iral Ragenovich

WO Tom Hofacker
WO Dave Thomas
R1 Ken Gibson*
R2 Bernie Raimo*
R3 Dayle Bennett*
R3 Jill Wilson
R3 Mark Schultz
R4 Steve Munson
R4 Ralph Thier*
R5 John Wenz*
R6 David Bridgwater *
R8 Wes Nettleton*
NA Dan Kucera
R10 Ed Holsten*

WO Bob Bridges
PSW Pat Shea*
PNW Lonnie Sower*
PNW Skeeter Werner
PNW Gary Daterman
RM Jose Negron*
INT Jesse Logan*
SO Jane Hayes*
NC Bob Haack
IDL Ladd Livingston
OSU Darrell Ross

*voting member for Technology Development Program

NATIONAL BARK BEETLE STEERING COMMITTEE

TERMS OF REFERENCE

Insects, diseases, vertebrates, and vegetation are natural components of the forest ecosystem. Bark beetles, and how they interact and affect this system, are the specific interest of the National Bark Beetle Steering Committee.

There are a number of bark beetles that interact in a variety of forest types, such as Douglas-fir beetle, spruce beetle, western pine beetle, southern pine beetle, mountain pine beetle and engraver beetles. Management problems are comparable for the various forest types and Regions. These bark beetles are often of intraregional, interregional and international interest. The information available regarding the development and use of bark beetle semiochemicals for population manipulation, and vegetation and stand management varies with each bark beetle.

It is necessary that there be close coordination and information transfer among those involved in bark beetle related research and studies, forest management, and policy and support. Accordingly, the objectives of this Committee include:

1. To provide a forum for sharing the most recent and current information regarding research, technology development, and vegetation management as it relates to the various bark beetles or forest types.

2. To provide a current action plan to outline a logical sequence of short and long term research and technology development, and application.

3. To recommend to the WO FPM on an annual basis, those technology development projects that we deem of highest priority for the coming year.

4. To facilitate coordination of research and transfer of information Internationally between entomologists and forest managers.

5. To facilitate and encourage development and registration of bark beetle management techniques.

6. To facilitate and provide information regarding development of strategies on forest health and ecosystem management as related to bark beetles to the WO FPM, other Steering Committees, and Regions.

OPERATING GUIDELINES

The Committee is comprised of entomologists and professionals with a common interest in these goals and is open to participation by university, State, and international cooperators, as well as Forest Service representatives from Forest Pest Management and Research.

The Committee will meet as often as deemed necessary to address the objectives outlined above.

In an official capacity, the Committee functions as an advisory committee for the WO-FPM Technology Development Project process. In serving this function, the voting membership will consist of two (2) representatives from each Region, at least one of whom will be an FPM representative.

The Committee will meet annually to develop prioritized lists (East and West) of continuing and new Technology Development Projects, which are in keeping with the established Bark Beetle Action Plan, or for a more immediate need (e.g. such as *Tomicus piniperda*).

A chair and co-chair, who need not be voting memebers, will provide coordination for the Committee as a whole and organize subcommittee meetings, as needed, to develop priority lists from the East and West. Although developed separately, these lists will be discussed by the Committee as a whole and sent forward to WO-FPM in a letter of recommendation from the Chair.

MOUNTAIN PINE BEETLE 5-YEAR STRATEGIC PLAN

Gene Amman, Ken Gibson and Bernie Raimo
1993

A. Basic Mountain Pine Beetle (MPB) Biological and Ecological Studies:

1. Population dynamics--particularly of endemic populations, epidemic triggers, attack behavior, and ability of MPB to colonize hosts of varying physiological condition. Specifically, determine endemic population dynamics of MPB throughout its range and its association with its several host species: lodgepole, ponderosa, sugar, western white, limber, and whitebark pines.

2. MPB dispersal:
    a. Distances beetles can fly within host stands and in open areas.
    b. Effective distance of aggregation and anti-aggregation pheromones to MPB.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1. Obtain mortality and impact information with respect to MPB on non-timber resources, to include:
    a. Recreation, aesthetic quality
    b. Wildlife habitat of major indicator species such as grizzly bear or other T & E species
    c. Successional changes in overstory and ground vegetation
        1) Effect of MPB of growth and yield of its host(s)--validation of proposed "Western Pine Bark Beetle Model" and its incorporation as a variant of PROGNOSIS.

2. Determine fuel loading and risk of wildfire over time in stands infested by MPB.

3. Validate existing hazard and risk models, or develop others (depending on host) to predict amount of host basal area killed in a 5- to 10-year outbreak, and the probability of outbreaks within 2-3 years.

4. Monitor insect diversity of sites affected by MPB.
    a. Establish plots using standard methods in riparian, forest, and alpine sites with both endemic and epidemic populations of MPB.
    b. Incoporate as part of Forest Health Monitoring permanent plot system, when established.

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Semiochemicals:
    a. Anti-aggregation pheromones:
        1) Efficacy of aerial and ground applications of verbenone (or other pheromone mixture), in most efficacious dispersal medium, for protection of uninfested stands managed for timber values.
            a) Determine optimal release rates and temperatures
            b) Determine area affect of verbenone beads and bubble caps.
        2) Efficacy of verbenone beads and/or bubble caps for individual tree protection in high-value areas such as campgrounds, administrative sites, etc.
            a) Determine optimal density and placement of verbenone beads or bubble caps for individual tree protection.
    b. Effect of competitor species pheromones (Ips, Pityogenes, and Pityophthorus) on MPB attraction with and without addition of verbenone.
    c. Aggregation pheromones:
        1) Determine area affect of aggregation pheromones.
        2) Determine:
            a) Number of trees and trap placement for MPB population monitoring, trapout, diversion, and spot-trapping strategies.
            b) Release rates for monitoring, trapout, diversion, and spot-trapping strategies.
    d. Pheromone characteristics; determine:
        1) Area affect of pheromones.
        2) Effect of semio-chemicals on non-target insects such as parasites, predators, and competitor species.
        3) Effect of semio-chemicals on species diversity.
        4) Geographic variations in pheromone complexes and effects.

2. Stand modification techniques--effect(s) of different silvicultural strategies for protecting host stands from MPB attack, to include:

a. Thinning.

b. Fertilization.

c. Uneven-aged management.

d. Mixed-species management (favoring non-host species).

1) Establish demonstration areas to demonstrate effects of "new perspectives" and ecosystem management.

2) Develop and validate models which could simulate effects and lead to better alternative selection.

3. Technology transfer to include:

a. Produce "Best Management Practices" guidelines for MPB in stands of its various hosts.

b. Produce publications on the role of bark beetles in forest ecosystems.

c. Produce "How To" publications describing individual tree protection alternatives and techniques.

d. Produce educational information in a variety of media formats and for a variety of audiences.

e. Development of an operational "decision support system."

MOUNTAIN PINE BEETLE
5-Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Aggregation pheromone components						
a. Define, make improvements	X	X	X			
b. Define geographic differences	X	X	X	X	X	
2. Anti-aggregation pheromones components						
a. Verbenone enantiomers	X	X	X			
b. Combinations of other pheromones		X	X	X		
3. Pheromone effects on assoc. species						
a. Competitive displacement		X	X	X		
b. Flight periodicities		X	X	X		
c. Effect on species diversity			X	X	X	
4. Dynamics of endemic populations						
a. Managed stands	X	X	X	X	X	
b. Unmanaged stands	X	X	X	X	X	
c. Epidemic "triggers"			X	X	X	X
5. Beetle dispersal						
a. How far do they fly?	X	X				
b. Distance of pheromone response		X	X	X		
6. Pheromone effects on natural enemies		X	X	X		
7. Attraction to fire-weakened trees			X	X	X	
B. Long Term Basic Research:						
1. Semio-chemical based population monitoring			X	X	X	X
2. Fate of semio-chemicals in environment			X	X	X	X
a. Effect of stand microclimate			X	X	X	
b. Effect of host condition			X	X	X	
3. Fate of semio-chemical adjuvants		X	X	X		
4. Effect of semio-chemicals on non-target organisms		X	X	X		

	1	2	3	4	5	5+
5. Primary host attraction behavior	X	X	X			
6. Population "fitness" (genetics)		X	X	X		
7. Host/beetle interaction relative to semio-chemical response		X	X	X		
8. Biological control				X	X	X
C. Short Term Applied Research:						
1. Hazard rating systems for all hosts						
a. Managed stands	X	X	X	X	X	
b. Unmanaged stands	X	X	X	X	X	
c. Mature/second-growth stands	X	X	X	X	X	
2. Short-term modeling (expert system)			X	X	X	
3. Verbenone evaluations						
a. Aerial--Dose, formulation	X	X	X	X		
b. Bubble caps--Dose, formulation	X	X	X	X		
c. Individual tree protection		X	X	X	X	
d. Where do "dispersed" beetles go?			X	X	X	X
D. Long Term Applied Research:						
1. Trap-out strategy--is it viable?			X	X	X	X
2. Semiochemical-based population monitoring			X	X	X	X
3. Stand management based on stand micro-climate/beetle biology interactions				X	X	X
4. Silvicultural treatments						
a. Unevenaged management		X	X	X	X	
b. Ecosystem management		X	X	X	X	X
5. Model development and validation						
a. Western Pine Bark Beetle Model (ESSA)			X	X	X	X
b. PROGNOSIS variant			X	X	X	X
6. Operational "decision support system"				X	X	X

	1	2	3	4	5	5+
E. Operational Activities:						
1. "How To" publications		X	X	X		
2. Sanitation/Salvage effectiveness	X	X	X			
3. Individual tree protection alternatives		X	X	X	X	
4. Silvicultural treatment effectiveness						
a. Demonstration areas		X	X	X	X	
b. Effects in various hosts	X	X	X	X		
5. Bait and cut effectiveness	X	X	X			
6. Spray and bait effectiveness		X	X	X		
7. Evaluate hazard-rating systems	X	X	X	X		
8. Evaluate/refine loss prediction model(s) for all hosts	X	X	X	X		

WESTERN PINE BEETLE 5-YEAR STRATEGIC PLAN

Ralph Thier and Pat Shea
1993

A. Basic Western Pine Beetle Biological and Ecological Studies:

1. Beetle Dispersal
    a. How far do they fly
    b. How far is pheromone response effective

2. Aggregation and Antiaggregation Pheromones:
    a. Define pheromone spectra.
    b. Determine dose response to verbenone, ipsenol and ipsdienol.

3. Biology
    a. Determine host selection behavior
    b. Explore host/prey interactions
    c. Natural controls- importation, augmentation, conservation
    d. Behavior- primary attraction

B. Planning -- Incorporate Forest Pest Management Considerations Into Forest Resource Management Planning Processes:

1. Determine the Impact of WPB Caused Tree Mortality on Threatened and Endangered Species.

2. Silviculture or Stand Conditions:
    a. hazard rating,
    b. determine the effects of past thinning on current WPB caused tree mortality.

3. Impacts:
    a. loss and impact predictions,
    b. growth and yield models,

4. Role of WPB Caused Mortality on Creating and Maintaining Critical Wildlife Habitat.

5. Develop Data-Visualization Sequence

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Aggregation and Antiaggregation Pheromones:
    a. Efficiency of verbenone treatments:
        1) field bioassay of different anantiomers.
        2) field bioassay of verbenone plus aggregation pheromones of competitive species.
        3) different release rates.
        4). individual tree protection.
            a) efficacy.
            b) develop operational release device.
        5) effects on nontarget organisms, particularly natural enemies.
        6) area protection.
            a) efficacy.
            b) develop operational release devices.
    b. Efficacy of combination of protective sprays and baits
        1) determine optimum density of treatment centers
        2) effects on non-target organisms particularly natural enemies
    c. Efficacy of combination of baits and infested tree removal
        1) use baits to prevent spring dispersal of overwintering populations
        2) determine optimum density of treatment centers
        3) effects on nontarget organisms particularly natural enemies
        4) quantify "spillover" around baited centers
    d. Beetle monitoring systems
        1) optimum trapping density and pattern
    e. Trap out strategy for low level populations
        1) optimum trap density pattern
        2) effects on nontarget organisms particularly natural enemies

2. Silviculture and Stand Conditions
    a. Treatments
        1) trap trees
    b. efficacy of thinning
    c. high-risk tree removal.
    d. efficacy of stand fertilization
    e. influence of pruning
    f. sanitation/salvage-efficacy

3. Protective Sprays for Individual Trees- identify new materials

WESTERN PINE BEETLE

5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Beetle Dispersal						
a. How far do they fly	X	X				
b. How far is pheromone response effective	X	X				
2. Aggregation and Antiaggregation Pheromones						
a. Define pheromone spectra	X	X				
b. Determine dose responses to verbenone, ipsenol& ipsdienol		X	X	X		
c. Determine optimal release rates and temperatures			X	X	X	X
d. Determine nontarget effects particularly natural enemies	X	X	X	X	X	X
e. Determine geographical variation in response to pheromones		X	X	X		
3. Biology						
a. Determine host selection behavior		X	X	X		
b. Explore host/prey interactions			X	X	X	X
B. Long Term Basic Research:						
1. Aggregation and Antiaggregation Pheromones						
a. Host/insect interactions relative to semiochemical responses	X	X	X	X	X	X
2. Biology						
a. Natural controls						
1. importation, augmentation, conservation	X	X	X	X	X	X
b. Behavior						
1. primary attraction			X	X	X	X
3. Determine the impact of WPB caused tree mortality on threatened and endangered species	X	X	X	X	X	X

	1	2	3	4	5	5+
C. Short Term Applied Research						
1. Aggregation and Antiaggregation Pheromones						
a. Efficacy of verbenone treatments						
1. field bioassay of different enantiomers	X	X	X			
2. Field bioassay of verbenone plus aggregation pheromone of competative species		X	X	X		
3. Different release rates			X	X	X	
4. Individual tree protection						
a. efficacy		X	X	X		
b. develop operational release device			X	X	X	
5. Effects on nontargets such as natural enemies		X	X	X	X	
6. Area protection						
a. efficacy			X	X	X	X
b. develop operational release devices			X	X	X	X
b. Efficacy of combination of protective sprays and baits						
1. determine optimum density of treatment centers		X	X	X		
2. effects on nontargets such as natural enemies		X	X	X	X	X
c. Efficacy of combination of baits and infested tree removal						
1. use of baits to prevent dispersal of overwintering populations			X	X	X	X
2. determine optimum density of treatment centers				X	X	X
3. effects on nontargets such as natural enemies				X	X	X
4. quantify "spillover" around baited centers			X	X	X	X
2. Silviculture or Stand Conditions						
a. Treatments						
1. trap trees	X	X	X	X	X	
b. hazard rating	X	X	X	X	X	

	1	2	3	4	5	5+
D. Long Term Applied Research:						
1. Aggregation Pheromones						
a. Beetle monitoring systems						
1. optimum trapping density and pattern	X	X	X	X	X	X
b. Trap out strategy for low level populations						
1. optimum trap/density pattern	X	X	X	X	X	X
2. effects on nontarget organisms such as natural enemies	X	X	X	X	X	X
2. Silviculture or Stand Conditions						
a. Efficacy of thinning	X	X	X	X	X	X
b. High risk tree removal	X	X	X	X	X	X
c. Efficacy of stand fertilization	X	X	X	X	X	X
d. Influence of pruning	X	X	X	X	X	X
3. Impacts						
a. Loss and impact predictions	X	X	X	X	X	X
b. Growth and yield models	X	X	X	X	X	X
4. Role of WPB caused mortality on creating and maintaining critical wildlife habitat	X	X	X	X	X	X
E. Operational Activities:						
1. "How to" series of publications		X	X	X	X	
2. Sanitation/Salvage efficacy	X	X	X	X	X	X
3. Protective sprays for individual trees - identify new materials			X	X	X	X
4. Use of Antiaggregants	X	X	X	X	X	X
5. Develop data visualization sequence	X	X	X	X	X	X

ROUNDHEADED PINE BEETLE STRATEGIC PLAN

Dayle Bennett, Bernie Raimo, and Patrick Shea
1993

A. Basic Beetle Biological and Ecological Studies:

1. Determine flight periodicity

2. Determine flight distance

3. Determine outbreak triggers

4. Determine relationship to other insect and disease occurrences, ie. root diseases, dwarf mistletoe, needlecast, and bark beetles.

5. Determine effects of outbreak on:
    a. vegetation structure and composition
    b. wildlife habitat, ie. Mexican Spotted Owl and northern goshawk
    c. biodiversity
    d. visual quality

6. Determine outbreak phenology, ie. how do outbreaks develop once they start, both within stand and across landscapes.

B. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Determine and develop aggregation pheromone
    a. optimum blend
    b. optimum release rates
    c. geographic differences in response
        1) Sacramento Mountains, NM
        2) Mt. Graham, AZ
        3) Southern Colorado

2. Determine and develop antiaggregant pheromone(s)
    a. optimum blend
    b. optimum release rates
    c. geographic differences in response
    d. test application of antiaggregant for stand and areawide protection.

3. Develop hazard and risk models

4. Model Integration

a. loss and impact prediction

b. growth and yield model, including vegetation effects necessary to predict effects on other resources, or ecosystem effects.

ROUNDHEADED PINE BEETLE

5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Applied Research:						
1. Aggregation Pheromone						
a. optimum blend	X	X				
b. optimum release rate		X				
c. geographic difference in response	X	X				
2. Antiaggregants						
a. optimum blend	X	X	X			
b. optimum release rates		X	X			
c. geographic difference in response	X	X	X			
3. Dispersal						
a. flight periodicity	X	X				
b. flight distance		X	X			
c. pheromone effective distance			X	X		
4. Develop Hazard and Risk Models			X	X	X	
5. Determine Outbreak Triggers		X	X			
6. Model Integration						
a. loss and impact prediction				X	X	X
b. growth and yield model				X	X	X
7. Association with other insects and pathogens	X	X				
8. Effects of outbreak on:						
a. stand structure and composition	X	X				
b. MSO habitat	X	X				
c. biodiversity	X	X				
d. visual quality			X	X		

	1	2	3	4	5	5+
B. Long Term Applied Research:						
1. Aggregation Pheromones						
a. population monitoring						
1) effective number of traps			X	X	X	X
2) trap placement			X	X	X	X
b. trap-out						
1) release rates			X	X	X	X
2) trap placement			X	X	X	X
c. bait and cut						
1) spot treatment			X	X	X	X
2) area-wide effects			X	X	X	X
2. Antiaggregants						
a. stand/area-wide protection				X	X	X
C. Operational Activities						
1. Silvicultural Treatments To Reduce Risk/Hazard						
a. unevenaged regeneration			X	X	X	X
b. evenaged regeneration			X	X	X	X
c. thinning			X	X	X	X

JEFFREY PINE BEETLE 5-YEAR STRATEGIC PLAN

Patrick J. Shea, Steve Munson, and Ralph Thier
1993

A. Basic Jeffrey Pine Beetle Biological and Ecological Studies:

1. Beetle Flight Behavior
    a. Determine flight periodicity
    b. Distance of beetle flight?
    c. Effective distance of pheromone response.

2. Determine the pheromone complex.
    a. Identify the aggregation pheromone
    b. Identify the antiaggregation pheromone
    c. Synthesize the pheromones for field bioassay
    d. Field bioassay (dose/response) the pheromones
    e. Determine response of associates and natural enemies

3. Biology
    a. Determine host selection behavior (incl. role of host volatiles)
    b. Explore host/prey interactions.
    c. Behavior
    d. Behavior (ie primary attraction, etc.).

B. Planning -- Incorporate Forest Pest Management Considerations Into Forest Resource Management Planning Processes:

1. Determine the impact of JPB caused tree mortality on creating and maintaining critical wildlife habitat

2. Silviculture and Stand Conditions a. hazard rating

3. Impacts
    a. loss and impact predictions (ie economic, wildlife etc)
    b. growth and yield models
    c. Fire (fuel loading)

4. Management differences for east-side vs west-side Jeffrey pine
    a. Role of JPB depending on habitat
    b. Impact plots to monitor vegetative diversity (pre to post JPB events).

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Aggregation and Antiaggregation Pheromones
    a. Efficacy of antiaggregation strategies
    b. Individual tree protection
        1) efficacy of insecticides
        2) efficacy of pheromone treatments
        3) development of release devices and optimal release rates
    c. Efficacy of 'spray and bait' strategy
        1) Area effect
    d. Efficacy of 'bait and cut' strategy
        1) Area effect
    e. Efficacy of sanitation salvage
        1) Area effect (ie campground,etc.).
    f. Development of pheromone based monitoring system
    g. Efficacy of trap out strategy for low level populations
    h. Optimum trap density/pattern
    i. Efficacy of push/pull technique

2. Silviculture and Stand Conditions
    a. Treatments with trap trees
    b. Efficacy of thinning
    c. High-risk tree removal
    d. Efficacy of stand fertilization
    e. Influence of pruning
    f. Efficacy of sanitation/salvage efficacy
    g. Mixed stand management- uneven age strategies

3. Effects of management strategies on non-target organisms esp. insect predators.

D. Technology Transfer

1. Develop how-to's on pheromone strategies, best silvicultural management strategies, individual tree protection techniques, etc.

2. Update Forest Insect Disease Leaflet (FIDL)

3. Station Publications, Journal articles

JEFFREY PINE BEETLE
5 Year Strategy

	YEAR SCHEDULED					
	1	**2**	**3**	**4**	**5**	**5+**
A. Short Term Basic Research:						
1. Determine flight periodicty		X	X	X		
2. Identify, isolate, and sythesize aggregation and antiaggregation phermones	X	X				
3. Field bioassay phermones		X	X	X		
4. Determine insect/pathogen interactions	X	X	X	X		
5. Determine geographical variation in response to pheromones		X	X	X		
6. Determine natural enemies	X	X	X			
B. Long Term Basic Research:						
1. Dispersal-- How far to beetles fly?	X	X	X	X	X	X
2. Host/insect/pathogen interaction	X	X	X	X	X	X
3. Role of associated species relative to semiochemical complex	X	X	X	X	X	X
4. Role of primary attraction in beetle behavior and host selection	X	X	X	X	X	X
5. Effects of JPB caused mortality on decreasing critical wildlife hab.	X	X	X	X	X	X
C. Short Term Applied Research:						
1. Develope hazard rating system	X	X	X			
2. Test efficacy of 'bait and cut'		X	X	X		
3. Pilot test thinning and pruning (ie Toiyabe NF 1988)	X	X	X			
4. Test individual tree protection treatments (phermones/insecticides)	X	X	X			
5. Pilot test Sanitation/Salvage Treatments (ie LTBM campgrounds)	X	X	X			
6. Effects of hazard tree removal on area mortality	X	X	X	X		
7. Develope antiaggregation strategies for mortality reduction		X	X	X		
8. Effects of combining antiaggregation strategies with pheromones of competitors			X	X	X	
9. Test efficacy of fertilization	X	X	X			
10. Test efficacy of trapout strategy		X	X	X		

	1	2	3	4	5	5+
D. Long Term Applied Research:						
1. Develop silvicultural strategies	X	X	X	X	X	X
2. Develop long term pheromone based monitoring system	X	X	X	X	X	X
3. Role of pathogens in beetle attack/ host selection behavior	X	X	X	X	X	X
4. Role of natural enemies in the population dynamics of JPB	X	X	X	X	X	X
5. Develop population dynamics model coupled to growth and yield	X	X	X	X	X	X
6. Role of JPB in creating and maintaining unique wildlife hab. (snags, down woody material etc)	X	X	X	X	X	X
7. Establish demostration sites for documenting changes in vegetative structure, pre to post JPB events	X	X	X	X	X	X
E. Operational Activities:						
1. How to's			X	X	X	X
2. Sanitation salvage	X	X	X	X	X	
3. Demonstrate hazard rating system			X	X	X	
4. Demonstrate area effects of hazard reduction		X	X	X	X	
5. Develop data visualization series			X	X	X	

SOUTHERN PINE BEETLE 5-YEAR STRATEGIC PLAN

Jane Hayes and Wes Nettleton

1993

A. Identify Abiotic and Biotic Factors that Contribute to SPB Population Fluctuation

1. Host-tree/insect interactions
    a. Determine responses important to resistance to SPB attack and brood development in plantation-grown loblolly pine across a range of stand and site conditions.
    b. Environmental conditions.
    c. Mechanisms of tree response to attack and fungal inoculation.

2. Determine the role of natural enemies in SPB population dynamics
    a. Determine which natural enemy species cause substantial SPB mortality.
        1) Numerical and functional response from clerids
        2) Clerid SPB/IPS switching.
        3) Survey of natural enemy occurrence
    b. Identify and isolate parasitoid host-detection cues
    c. Determine seasonal dynamics of natural enemies.
    d. Determine if natural enemies are responsible for the initiation or termination of SPB outbreaks (long-term, basic research).

3. Identify beetle characteristics (environmental or gentically-based) that indicate SPB population fluctuations.
    a. Develop a continuous (artificial) rearing technique basic
    b. Identify & determine heritability of characteristic attributes of endemic and epidemic populations
    c. Determine the potential critical relationship of these attributes relative to SPB population dynamics.

4. Investigate the role of symbiotic associates of SPB/beetle quality in SPB population dynamics.

a. Lipid-fungal associates.
b. Effect of nematodes on beetle.
c. Explore bacterial/viral control.
d. Validate annosum root rot/SPB association.

B. Develop and Improve technology to Predict Changes in Insect Populations in Space and Time

1. Winter biology-seasonal dynamics and modification of Arkansas SPB spot growth model .

2. Refine clerid/SPB trap prediction scheme .

3. Movement:

a. Describe SPB dispersal pattern .
b. SPB movement model.
c. Definition of SPB population concentration around mass-attacked pine trees .
d. Influence of tree spacing and composition on movement.
e. General bark beetle movement model.

4. Landscape level models.

5. Validations:

a. Control tactics .
b. Prediction models.
c. SPB Demonstration Area Project.

6. Management tools:

a. ISPBEX II.
b. INFORMS .
c. CLEMBEETLE .
d. Pine plantation hazard rating.

C. Investigate New Prevention and Suppression Strategies Using Natural Enemies, Selective Chemicals and Pheromones

1. Use of host-based compounds for individual tree protection .

2. Use of semiochemical-based tactics in remedial control .
    a. Antiaggregation chemicals for SPB .
    b. SPB and behavioral chemicals.
    c. Push-pull spot strategy.
    d. Impact of semiochemicals on SPB natural enemies.

3. Use of selective chemicals for remedial control.
    a. Evaluation of systemic chemicals for SPB control .

4. Identify and evaluate possible SPB biological control agents, including microbial agents and insect natural enemies.

5. Influence of RCW habitat management strategies on SPB populations.

SOUTHERN PINE BEETLE
5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Host-tree/insect interactions						
a. determine responses important to resistance to SPB attack and brood development in plantation-grown loblolly pine across a range of stand and site conditions	X	X	X			
b. mechanisms of tree response to attack and fungal inoculation	X	X				
2. Determine the role of natural enemies in the population dynamics of SPB						
a. determine which natural enemies cause substantial mortality of SPB						
1. numerical and functional response from clerids	X	X	X			
2. clerid SPB/IPS switching	X	X				
b. identify and isolate parasitoid host-detection cues	X	X				
c. determine seasonal dynamics of natural enemies	X	X				
3. Identify beetle characteristics (environmental or gentically-based) that indicate SPB population fluctuations.						
a. develop a continuous (artificial) rearing technique	X	X	X	X		
4. Investigate the role of symbiotic associates of SPB/beetle quality in SPB population dynamics.						
a. lipid-fungal associates	X	X				
b. effect on beetle of nematodes	X	X	X			
c. valid annosum/SPB associate	X					

	1	2	3	4	5	5+
5. Develop and improve technology to predict changes in insect populations in space and time.						
a. Winter biology-seasonal dynamics	X					
b. Movement model						
1. dispersal pattern	X					
2. SPB movement model	X	X	X			
3. definition of SPB population concentration around mass-attacked pine trees	X	X				
4. influence of tree spacing and composition on movement	X	X	X	X		
6. Investigate new prevention & suppression strategies using natural enemies, selective chemicals, and pheromones.						
a. impact of semiochemicals on SPB natural enemies	X					
B. Long Term Basic Research:						
1. Host-tree/insect interactions						
a. environmental conditions	X	X	X	X	X	X
2. Determine the role of natural enemies in the population dynamics of SPB						
a. determine which natural enemies cause substantial mortality of SPB - survey of natural enemy occurrence	X	X	X	X	X	
b. determine if natural enemies are responsible for the initiation or termination of SPB outbreaks	X	X	X	X	X	X
3. Identify beetle characteristics (environmental or gentically-based) that indicate SPB population fluctuations.						
a. identify & determine heritability of characteristic attributes of endemic and epidemic populations	X	X	X	X	X	
b. determine the potential critical relationship of these attributes relative to SPB population dynamics	X	X	X	X	X	
4. Investigate the role of symbiotic associates of SPB/beetle quality in SPB population dynamics.						
a. explore bacterial/viral control	X	X	X	X	X	

	1	2	3	4	5	5+
5. Develop and improve technology to predict changes in insect populations in space and time.						
a. general bark beetle movement model	X	X	X	X	X	X
b. landscape level models	X	X	X	X	X	X
6. Investigate new prevention & suppression strategies using natural enemies, selective chemicals, and pheromones.						
a. identify and evaluate possible SPB biological control agents, include microbial agents and insect natural enemies	X	X	X	X	X	X
C. Short Term Applied Research:						
1. Develop and improve technology to predict changes in insect populations in space and time.						
a. modification of spot growth model	X	X				
b. clerid/SPB trap prediction scheme	X					
2. Validations						
a. control tactics	X	X	X			
b. prediction models	X	X	X			
3. Management tool						
a. ISPBEX II	X	X				
b. INFORMS	X	X				
c. CLEMBEETLE	X	X				
d. Pine Plantation Hazard Rating	X	X				
4. Investigate new prevention & suppression strategies using natural enemies, selective chemicals, and pheromones.						
a. use of host-based compounds for individual tree protection	X	X				
b. use of semiochemical-based tactics in remedial control						
1. antiaggregation chemicals for SPB	X					
2. SPB and behavioral chemicals	X					
3. push-pull spot strategy	X					

	1	2	3	4	5	5+
5. Use of selective chemicals for remedial control.						
a. evaluation of systemic chemicals for SPB control	X					
6. Influence of RCW habitat management strategies on SPB populations	X	X	X			
D. Long Term Applied Research:						
1. Validation						
a. SPB Demonstration Area Project	X	X	X	X	X	X

SPRUCE BEETLE 5-YEAR STRATEGIC PLAN

Edward Holsten and Richard Werner

1993

A. Basic Spruce Beetle Biological and Ecological Studies:

1. Population dynamics, attack behavior, and "fitness" of spruce beetle "populations". Specifically, determine basic biology and population dynamics of spruce beetles in maritime Sitka spruce forests.

2. Spruce beetle dispersal:
   - a. Distances beetles can fly within stands of spruce and in open areas.
   - b. Effective distance of aggregation and antiaggregation pheromones to spruce beetles.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1. Obtain loss and impact information with respect to spruce beetles on non-timber resources; to include:
   - a. recreation, aesthetic quality
   - b. wildlife habitat of major indicator species such as moose and brown bear.
   - c. successional changes in overstory and ground vegetation
     - 1) effect of spruce beetle on growth and yield of white and Lutz spruce stands -- development of a variant of PROGNOSIS

2. Determine fuel loading and risk to wildfire overtime in stands infested by spruce beetles.

3. Develop Hazard (amount of spruce basal area killed in 5-10 years; a reflection of stand susceptibility) and Risk (probability of a spruce beetle outbreak within 2-3 years) Models for maritime Sitka spruce stands.

4. Monitor insect diversity on sites impacted by spruce beetles.
   - a. Establish plots using standardized methods in riparian, forest, and alpine sites with endemic and epidemic populations of spruce beetles.

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Semiochemicals:
    a. Antiaggregation pheromones:
        1) Efficacy of aerial and ground applications of MCH beads for protection of live stands adjacent to blowdown, rights-of-way construction, logging operations, and burned areas.
            a) Determine optimal release rates and temperatures
            b) Determine area affect of MCH beads and bubble-caps.
        2) Efficacy of MCH beads and/or bubble caps for individual tree protection in high-value areas such as campgrounds, administrative sites, etc.
            a) Determine optimum density and placement of MCH bubblecaps for individual tree protection
    b. Effect of competitor species pheromones (Ips, Polygraph's, and Dryocoetes) on spruce beetle attraction with and without the addition of MCH.
    c. Aggregation pheromones:
        1) Determine area affect of aggregation pheromones
        2) Determine:
            a) Number of trees and trap placement for spruce beetle population monitoring, trapout, diversion, and spot trapping.
            b) Release rates for monitoring, trapout, diversion, and spot trapping strategies
    d. Pheromone characteristics; determine:
        1) Area effect of pheromones
        2) Effect of semio-chemicals on non-target insects such as parasites, predators, and competitor species
        3) Effect of semiochemicals on species diversity
        4) Geographic differences

2. Stand modification techniques -- effect(s) of different silvicultural strategies for protecting spruce stands from beetle attack; to include:
    a Pruning
    b Thinning
    c Fertilization
    d Mixed stand management using non-host species, uneven aged stand management
    e Establishment of demonstration areas using New Perspectives strategies

3. Technology transfer to include:

a. Produce "Best Management Practices" guidelines for spruce bark beetles

b. Produce publications on the role of bark beetles in forest ecosystems

c. Produce "How to" publications describing individual tree protection techniques

d. Produce videos for secondary education, general public information, and home-owner training

SPRUCE BEETLE

5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Spruce Beetle Dispersal:						
a. How far do they fly?	X	X				
b. How far is pheromone response effective?		X	X			
2. Anti & Aggregation Pheromones:						
a. Determine optimal release rates and temps.		X	X			
b. Geographic differences among spruce beetles		X	X	X		
B. Long Term Basic Research:						
1. Population dynamics & attack behavior of spruce beetle in Sitka spruce.		X	X	X	X	X
2. Effect of semiochemicals on non-target organisms		X	X	X		
3. Effect of semiochemicals on species diversity			X	X	X	X
C. Short Term Applied Research:						
1. Develop Hazard & Risk Models for Sitka spruce	X	X				
2. MCH Evaluations:						
a. Aerial--dose, formulation	X	X	X			
b. Bubble caps--dose, formulation		X	X			
c. Individual tree protection		X	X	X		
3. Competitor species pheromone	X	X	X	X		
a. Use with & without MCH	X	X				
b. Aerial/ground--dose, form.			X	X	X	

	1	2	3	4	5	5+
D. Long Term Applied Research:						
1. Aggregation pheromones:						
a. Population monitoring--# of traps, trap placement		X	X	X		
b. Trapout--release rates, trap placement		X	X	X		
2. Silvicultural treatments:						
a. Uneven-aged management			X	X	X	X
b. Thinning, pruning, and fertilization	X	X	X	X	X	X
3. Modeling integration:						
a. Loss & Impact Predictions	X	X	X	X	X	X
b. Growth & Yield Models	X	X	X	X	X	X
E. Operational Activities:						
1. Demonstration areas:						
a. Thinning	X	X	X	X	X	X
b. Bait & Cut		X	X	X		
2. "How to" series of pubs.		X	X	X		
3. "Best Management Practices" Guidelines		X	X	X	X	X

DOUGLAS-FIR BEETLE 5-YEAR STRATEGIC PLAN

David Bridgwater, Lonne Sower

1993

A. Short Term Basic Douglas-fir Beetle Biological and Ecological Studies:

1. Dispersal of MCH and related material
    a. What happens to MCH released from dispensers such as polyvinyl beads or bubblecaps.
    b. How does the material disperse vertically.
    c. What is the release and longevity characteristics of the various dispensers in the field.
2. Dispersal patterns of the DFB.

B. Long Term Basic Biological and Ecological Studies:

1. Population dynamics and basic ecology.
    a. Develop a better understanding of the factors that predispose trees to attack and the factors that determine the suitability of a tree for brood production.
    b. Improve understanding of the role that beetle associated fungi (i.e., "blue stain" type fungi), root pathogens, predators, and parasites play in the population dynamics of the Douglas-fir beetle.
    c. Determine the effect that various ecosystem management. practices such as creating snags and leaving large cull logs will have on beetle populations.

C. Short Term Applied Research:

1. Test MCH to manage DFB.
    a. Test MCH beads for protection of standing green trees.
    b. Test MCH bubble caps for protection of standing green trees.
    c. Additional formulations should be examined, particularly if standing tree treatment results are inconsistent with previous down-tree treatments.
    d. Effects of MCH on non-target organisms.
2. Test mitigating materials in Coastal Douglas-fir forests.
3. Determine usefulness of new attractants.
4. Develop hazard/risk rating models.
5. Test methods for individual tree protection.
6. Develop methods for population monitoring.

D. Long Term applied Research

1. Silvicultural treatment for management of unevenaged stands.

E. Operational Activity

1. Literature search.

2. Popular article.

3. Update FIDL when needed.

4. Updated "How To" on DFB management at end of program.

5. Register MCH with EPA.

DOUGLAS-FIR BEETLE

5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Dispersal of MCH and related material						
a. Dispersal and fate in air	X	X				
b. Release characteristics of dispensors	X	X				
2. Dispersal Patterns of DF beetle	X	X	X			
B. Long Term Basic Research						
1. Population dynamics						
a. Factors predisposing trees to attack		X	X	X	X	
b. Fungi associated with beetle damage		X	X	X	X	
c. Natural enemies of DFB	X	X	X			
C. Short Term Applied Research						
1. Test MCH						
a. Test beads for green tree protection	X	X				
b. Test MCH bubble caps for standing green trees	X	X	X			
c. Develop improved formulation			X	X	X	
d. Effects of MCH on non-target animals		X	X	X		
2. Test mitigants such as MCH in coastal area			X	X	X	
3. Determine usefulness of new attractants	X	X				
4. Develop hazard/risk rating models.		X	X	X		
5. Test methods for individual tree protection						
6. Develop methods for population monitoring	X	X	X			

	1	2	3	4	5	5+
D. Long Term Applied Research						
1. Silvicultureal Treatment for management of uneven aged stands		X	X	X	X	
E. Operational Activity						
1. Literature search		X				
2. Popular article		X				
3. Forest Insect Pest Leaflet up-date				X	X	
4. Up-date on DFB management "How To"						
5. Register MCH with EPA	X	X	X			

FIR ENGRAVER BEETLE 5- YEAR STRATEGIC PLAN

Patrick J. Shea, Ken Gibson, and Ladd Livingston
1993

A. Basic Fir Engraver Beetle Biological and Ecological Studies:

1. Determine flight distance.

2. Determine effective response distance for Pheromone.

3. Define the semiochemical complex.

4. Determine geographical variation in response to pheromones.

5. Host selection behavior.

6. Host/insect/pathogen interaction.
    a. Root diseases.
    b. Localized defect (patch killing) due to beetle attack.
    c. Interaction of beetle attacks on triggering latent infections of Indian paint fungus.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1. Determine the effect of fir-engraver caused tree mortality on threatened and endangered species.

2. Silviculture and Stand Conditions.
    a. Hazard and risk-rating systems for Inland Empire.

3. Impact.
    a. Loss and impact predictions.
    b. Growth and yield models.

4. Role of the fir engraver in creating and maintaining critical and unique wildlife habitat

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Develop management strategies that utilize semiochemicals.

2. Determine effects of treatment strategies on non-target organisms.

3. Develop semiochemical based monitoring systems.

4. Develop Silvicultural treatments.
    a. timing of thinning.
    b. effects of evenaged and unevenaged systems.

5. Develop 'how-to's' and management guides.

6. Development of decision support systems.

FIR ENGRAVER
5 Year Strategy

	YEAR SCHEDULED					
	1	**2**	**3**	**4**	**5**	**5+**
A. Short Term Basic Research:						
1. Isolate, identify, synthesize pheromone complex	X	X	X			
2. Field bioassay candidate compounds		X	X	X		
3. Determine geographic variation to pheromones		X	X	X		
B. Long Term Basic Research:						
1. Dispersal- How far do beetles fly?		X	X	X	X	X
2. Primary attraction behavior		X	X	X	X	X
3. Host/insect/pathogen interaction						
a. root diseases	X	X	X	X	X	X
b. localized defect due to beetle attack			X	X	X	X
4. Interaction of beetle attacks on triggering latent infections of Indian paint fungus	X	X	X	X	X	
5. Effects of semiochemicals on natural enemies			X	X	X	X
6. Effect of fir engraver caused tree mortality on threatened and endangered species habitat	X	X	X	X	X	X
7. Effect of fir engraver caused tree mortality on creating and maintaining critical and unique wildlife habitat	X	X	X	X	X	X
8. Use of synomones to prevent attack				X	X	X
C. Short Term Applied Research:						
1. Develop hazard rating system for grand fir/Inland Empire	X	X	X			
D. Long Term Applied Research:						
1. Develop various semiochemical based management strategies for population manipulation	X	X	X	X	X	X
2. Area management of fir engraver		X	X	X	X	
3. Test trap-out strategy			X	X	X	
4. Develop silvicultural treatments						
a. effect of timing of thinning		X	X	X	X	X
5. Develop pheromone based monitoring system	X	X	X	X	X	X

	1	2	3	4	5	5+
E. Operational Activities:						
1. Develop How to's						
a. Hazard rating systems for California, white & red fir		X	X			
b. Hazard and risk rating systems for Inland Empire.			X	X	X	
2. Silvicultural Treatments						
a. Hazard reduction	X	X	X	X	X	X
b. Sanitation/Salvage	X	X	X	X	X	X
c. Use of trap trees			X	X	X	X

ARIZONA FIVE-SPINED PINE ENGRAVER BEETLE
5-YEAR STRATEGIC PLAN

Dayle Bennett, Bernie Raimo, Patrick Shea, and Jill Wilson
1993

A. Basic Beetle Biological and Ecological Studies:

1. Determine flight periodicity.

2. Determine flight distance.

3. Determine outbreak triggers (besides pine slash),and relationships between factors such as seasonal moisture and I. lecontei in the southwest.

4. Determine relationships with other insects and diseases, ie. other bark beetles, dwarf mistletoe, and root disease.

5. Determine relationships between stand conditions (structure, density, etc.) and Ips-caused tree mortality.

B. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Determine and develop aggregration pheromone.
    a. Optimum blend.
    b. Optimum release rate.

2. Determine and develop antiaggregant pheromone(s).
    a. Optimum blend.
    b. Optimum release rates.

3. Evaluate Trap-out strategy in slash.

4. Evaluate effectiveness of antiaggragant.
    a. Slash piles--bubble caps.
    b. Slash piles--broadcast beads.

5. Validate and modify slash disposal recommendations.

ARIZONA FIVE SPINED IPS

5 Year Strategy

	YEAR SCHEDULED					
	1	**2**	**3**	**4**	**5**	**5+**
A. Short Term Basic Research:						
1. Identify bait	X					
2. Identify antiaggregant		X	X			
B. Short Term Applied Research:						
1. Determine optimum bait blend		X				
2. Determine optimum bait release rate			X			
3. Determine flight periodicity		X				
4. Determine optimum antiaggregant blend			X	X		
5. Determine optimum antiaggregant release rate			X	X		
C. Long Term Applied Research:						
1. Determine outbreak triggers		X	X	X	X	X
2. Determine relationships with stand factors		X	X	X	X	X
3. Develop hazard rating system			X	X		
D. Operational Activities:						
1. Evaluate effectiveness of baited slash in trap-out strategy				X	X	X
2. Evaluate effectiveness of anti-aggregrant in protecting slash piles					X	X
3. Validate and modify slash disposal recommendations	X	X	X			

CALIFORNIA FIVESPINED IPS BEETLE 5-YEAR STRATEGIC PLAN

Patrick J. Shea, John Wenz, and Sheri Smith
1993

A. Basic California Fivespined IPS Beetle Biological and Ecological Studies:

1. Beetle Dispersal.
    a. Determine flight distance.
    b. Determine effective response distance to pheromone.

2. Aggregation and Antiaggregation Pheromones.
    a. Determine dose/response to verbenone.
    b. Field bioassay to array of enantiomers of ipsdienol, ipsenol.
    c. Determine response of nontarget organisms to various semiochemicals of CFIB
    d. Determine the geographic variation in response to pheromones

3. Biology
    a. Natural controls
        1) Importation, augmentation, conservation of natural enemies.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes.

1. Determine impacts of beetle build-up in untreated slash to adjacent standing trees.

2. Silviculture and Stand Conditions.
    a. Hazard rating systems.

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Aggregation and Antiaggregation Strategies.
    a. Efficacy of combination of pheromones for protecting disperse and piled slash from build up of CFIB populations.
    b. Field test the efficacy of antiaggregation strategies for keeping CFIB from leaving infested slash and entering uninfested standing timber.
    c. Test the efficacy of the trap-out strategy for reducing tree mortality in isolated stands infested with CFIB.

CALIFORNIA FIVESPINED IPS

5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Determine geographic variation in response to established aggregation and antiaggregation pheromones		X	X	X		
2. Determine response of natural enemies to various pheromones of the CFIB	X	X	X			
B. Long Term Basic Research:						
1. Determine the effects of semiochemical based management strategies on the natural enemy complex		X	X	X	X	X
2. Dispersal- How far do beetles fly?	X	X	X	X	X	X
3. Interaction between CFIB and pine engraver via semiochemicals		X	X	X	X	X
C. Short Term Applied Research:						
1. Test efficacy of semiochemical based management strategies on prevent CFIB build-up in slash	X	X	X			
2. Test efficacy of a combination of semiochemical based management strategies to prevent build-up of CFIB and pine engraver simultaneiously		X	X	X		
D. Long Term Applied Research:						
1. Develop pheromone based monitoring system		X	X	X	X	X
E. Operational Activities:						
1. Operation test of antiaggregation efficacy for preventing build-up of ips beetles in slash.				X	X	X

IPS PINI 5-YEAR STRATEGIC PLAN

R.Ladd Livingston, Ken Gibson & Patrick J. Shea
1993

A. Basic I. Pini Biological and Ecological Studies:

1. Determine basic biology and population dynamics of I. pini for different geographical regions.

2. Dispersal patterns.
   a. Determine flight periodicity patterns for different geographical regions.
   b. Determine flight distance.

3. Continue investigation of the semiochemical complex of I. pini and associated scolytids.

4. Continue investigations of geographic variation of pheromones.

5. Determine live host selection behavior.

6. Determine the purpose of fall feeding activity and its impact on resources.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1 Obtain impact information with respect to I. pini activity on forest and non-forest resources; to include:
   a. Timber, especially second-growth stands and plantations.
   b. Recreation, aesthetic quality.
   c. Wildlife.
   d. Subdivisions and other developments.

2. Develop hazard and risk models for I. pini in ponderosa and lodgepole pine stands.

C Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1 Develop management strategies that utilize semiochemicals.

a. Continue investigations of pheromones of competing species for use against I. pini. Prepare a list of the principle competing species by geographic region.

b. Determine suitable semiochemicals or blends there of, for limiting I. pini population buildup by preventing attack of slash. Prevention of population buildup in slash will protect live stands adjacent to or within activity areas.

1) Determine optimal pheromone release rates for beads, bubble caps, and other release devices.

2) Determine optimal and maximum distance of beetle response to baits.

3) Develop aerial and ground application techniques.

c. Test trap-out strategies including area-wide and spot trapping of slash piles.

d. Develop techniques to protect individual trees.

1)Develop and test new pheromone deployment techniques.

2)Determine optimal density and placement of bubble caps.

2 Develop a semiochemical based population monitoring system.

3 Develop/document silvicultural strategies.

a. Timing of creation of slash.

b. Use of trap trees.

c. Use of prescribed fire on overwintering adult population found in the duff of the forest floor.

4. Side effects of pheromone use.

a. Determine effect on non-target insects such as parasites, predators, and competitor species.

b. Determine effect on species diversity.

c. Develop techniques to exclude non-target species from survey or masstrapping traps.

5. Technology transfer to include.

a. Produce "Best Management Practices" guidelines for Ips pini.

b. Produce "How to" publications describing slash management, pheromone use and individual tree protection techniques.

c. Produce videos for forest managers, the general public, and home owners.

IPS PINI

5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. *I. pini* dispersal:						
a. How far do they fly?		X	X			
b. How far is the pheromone response effective?		X	X			
c. Determine flight periodicity be used as a management tool?	X	X	X	X	X	
B. Long Term Basic Research:						
1. Aggregation pheromone blends:						
a. pheromone components	X	X	X	X	X	
b. geographic variation	X	X	X	X	X	
2. Antiaggregation pheromone blends of associated species:						
a. pheromones of different species	X	X	X	X	X	
b. enantiomers		X	X	X	X	X
c. geographic variation		X	X	X	X	X
3. Fate of applied semiochemicals in the environment.				X	X	X
4. Determine impact of feeding attacks.			X	X	X	X
5. Determine live host selection behavior			X	X	X	X
C. Short Term Applied Research:						
1. Continue development of antiaggregants to prevent attack of slash by *I. pini*.						
a. Improve bead formulations	X	X	X			
b. Evaluate bubble caps	X	X				

	1	2	3	4	5	5+
D. Long Term Applied Research						
1. Development /document silvicultural strategies.						
a. Timing of creation of slash			X	X	X	
b. Use of trap trees				X	X	
c. Use of prescribed fire on overwintering adult populations in the duff			X	X	X	
2. Models:						
a. Loss and impact predictions				X	X	X
b. Insect phenology/population dynamics				X	X	X
3. Beneficial role of Ips populations in reducing stand basal area					X	X
E. Operational Activities:						
1. "How to" series publications			X	X	X	
2. "Best Management Practices" Guidelines, update			X	X	X	

IPS PERTURBATUS 5-YEAR STRATEGIC PLAN

Richard Werner & Edward Holsten
1993

A. Basic Ips perturbatus Biological and Ecological Studies:

1. Ips dispersal.
    a. Distances beetles can fly within stands and in open areas.
    b. Effective distance of aggregation and antiaggregation pheromones to Ips beetles.

2. Determine characteristics of overwintering sites.

3. Interrelationship between spruce and Ips beetles in interior Alaska white spruce forests.

4. Effect of budworm defoliation, spruce susceptibility, and Ips attack.

5. Effect of ice and snow breakage on Ips population build-up.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1. Obtain loss and impact information with respect to Ips beetles of forest resources; to include:
    a. Timber.
    b. Recreation, aesthetic quality.
    c. Wildlife habitat.
    d. Successional changes in overstory and ground vegetation.

2. Develop hazard and risk models for Ips beetle in interior white spruce stands.

3. Role of Ips populations in reducing stand basal area and role(s) of Ips activity on white spruce ecosystem stability.

4. Monitor insect diversity on sites impacted by spruce beetles.

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Semiochemicals:
    a. Antiaggregation pheromones.
        1) Efficacy of antiaggregants on Ips populations.
        2) Determine optimal release rates and temperatures.
        3) Determine area effect of different formulations.
    b. Effect of competitor species pheromones.
    c. Pheromone characteristics; determine.
        1) Effect on non-target insects such as parasites, predators, and competitor species.
        2) Effect on species diversity.

2. Stand modification techniques--effect(s) of different silvicultural strategies for protecting white spruce stands from Ips attack; to include.
    a. Thinning.
    b. Fertilization.
    c. Mixed stand management using non-host species, uneven aged stand management.
    d. Establishment of demonstration areas.
    e. Effects of prescribed fire on overwintering populations in leaf litter of cut-over areas.

3. Technology transfer to include.
    a. Produce "Best Management Practices" guidelines for Ips perturbatus.
    b. Produce publications on the role of Ips and other bark beetles in interior Alaska white spruce ecosystems.
    c. Produce "How to" publications describing individual tree protection techniques.
    d. Produce videos for secondary education's, general public information, and home-owner training.

IPS PERTURBATUS
5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Ips beetle dispersal:						
a. How far do they fly?	X	X				
b. Do they fly across openings?		X	X			
2. Antiaggregation pheromones:						
a. Release rates of ipsenol and methyl butenol (beads & caps)	X	X				
3. Determine characteristics of overwintering sites	X	X				
B. Long Term Basic Research:						
1. Effects of semiochemicals on non-target organisms			X	X	X	
2. Effect of semiochemicals on species diversity			X	X	X	X
3. Interrelationship between spruce beetle and Ips			X	X	X	
4. Effect of budworm defoliation and Ips attack	X	X	X	X	X	
5. Effect of ice/snow breakage on Ips population buildup		X	X	X		
C. Short Term Applied Research:						
1. Effect of ipsdienol on parasites & predators	X	X				
2. Evaluate efficacy of anitaggregants on Ips populations	X	X				
3. Develop hazard and risk models for white spruce			X	X		
4. Effects of prescribed fire on over-wintering populations in leaf litter of cutover areas				X	X	

	1	2	3	4	5	5+
D. Long Term Applied Research:						
1. Silvicultural treatments:						
a. Even-aged/unevenaged management				X	X	X
b. Thinning	X	X	X	X	X	X
c. Fertilization			X	X	X	X
2. Models:						
a. Loss and impact predictions				X	X	X
b. Growth and yield models				X	X	X
3. Role of Ips beetle activity on white spruce ecosystem stability			X	X	X	X
4. Beneficial role of Ips populations in reducing stand basal area			X	X	X	X
E. Operational Activities:						
1. Demonstration areas:						
a. Thinning		X	X	X	X	X
b. Fertilization		X	X	X	X	X
2. "How to" series publications		X	X	X	X	
3. "Best Management Practices" Guidelines		X	X	X	X	

WESTERN BALSAM BARK BEETLE 5-YEAR STRATEGIC PLAN

Steve Munson and Ralph Their
1993

A. Basic Beetle Biological and Ecological Studies:

1. Population dynamics, attack behavior, and "fitness" of western balsam bark beetle populations. Specifically, determine basic biology and population dynamics of western balsam bark beetle in Subalpine fir forests.

2. Western balsam bark beetle dispersal:
    a. Distances beetles can fly within stands of fir and in open areas.
    b. Effective distance of aggregation and antiaggregation pheromones to western balsam bark beetle.

3. Determine host, root disease and western balsam bark beetle relationships.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1. Obtain loss and impact information with respect to western balsam bark beetles on timber and non-timber resources; to include:
    a. Economic Effects.
    b. Recreation, aesthetic quality.
    c. Wildlife habitat of major indicator species such as Northern Goshawk.
    d. Successional changes in overstory and ground vegetation
        1) Effect of western balsam bark beetle on growth and yield of subalpine fir, grand fir, white fir and Englemann spruce.

2. Determine fuel loading and risk to wildlife over-time in stands infested by western balsam bark beetle.

3. Develop hazard (amount of subalpine fir basal area killed in 5-10 years; a reflection of stand susceptibility) and risk (probability of western balsam bark beetle outbreak within 2-3 years) schemes for subalpine fir.

4. Monitor vegetative diversity and impact on sites infested by western balsam bark beetle.

a. Establish plots using standardized methods in riparian, forest and alpine sites with endemic and epidemic populations of western balsam bark beetle.

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Semiochemicals

a. Antiaggregation pheromones:

1) Determine antiaggregation compound.

a) Determine optimal release rates and temperatures.

b) Determine area effect of bubble caps.

2) Efficacy of bubble caps for individual tree protection in high-value areas such as campgrounds, administrative sites, etc.

a) Determine optimum density and placement of bubble caps for individual tree protection.

b. Aggregation pheromones:

1) Determine area effect of aggregation pheromones.

2) Also determine:

a. Number of trees and trap placement for western balsam bark beetle monitoring, trapout, diversion, and spot trapping.

b. Release rates for monitoring, trapout, diversion, and spot trapping strategies.

c. Pheromone characteristics - determine:

1) Area effect of pheromones.

2) Effect of semiochemicals on non-target insects such as parasites, predators and competitor species.

3) Effect of semiochemicals on species diversity.

4) Geographic differences.

2. Stand modification techniques -- effect(s) of different silvicultural strategies for protecting subalpine fir stands from beetle attack to include:

a. Pruning.

b. Thinning (decreasing basal area and removing high risk trees).

c. Fertilization.

d. Mixed stand management using non-host species, uneven aged stand management.

e. Establishment of demonstration areas.

3. Technology transfer to include:

a. Produce Forest Insect Disease Leaflet "FIDL" for western balsam bark beetle.

b. Produce "Best Management Practices" guidelines for western balsam bark beetle.

c. Produce publication on the role of western balsam bark beetle in the forest ecosystem.

d. Produce "How To" publications on methods describing individual tree protection techniques.

e. Produce videos for secondary education, general public information and home-owner training.

WESTERN BALSAM BARK BEETLE
5 Year Strategy

	YEAR SCHEDULED					
	1	2	3	4	5	5+
A. Short Term Basic Research:						
1. Biology						
a. Life history	X	X	X	X		
- Life cycles						
- Geographic & elevational influences on development						
- Attack densities & pattern						
- Brood sizes						
- Symbiotic fungal associations						
- # of generations						
- Re-emergence patterns						
- Hosts						
- Insect associations						
b. Adult flight	X	X	X	X		
- Periodicity						
- Distances						
- Dispersal						
- Orientation						
2. Pheromones						
a. Aggregants						
- How far is response effective	X	X	X	X	X	
b. Antiaggregants						
- Define	X	X	X			
B. Long Term Basic Research:						
1. Biology						
a. Predators & Parasites	X	X	X	X	X	X
- Define						
- Effect						

	1	2	3	4	5	5+
2. Host/WBBB Interactions						
a. Root disease associations	X	X	X	X	X	X
b. Habitat type associations	X	X	X	X	X	X
c. Climate/weather associations			X	X	X	X
d. Host response to attack	X	X	X	X	X	X
e. Susceptibility to attack	X	X	X	X	X	X
- tree size						
- tree age						
- stand density						
- stand damage						
C. Short Term Applied Research:						
1. Treatments						
a. Increase stand vigor & susceptibility to attack through fertilization.	X	X	X	X		
b. Thinning	X	X	X	X	X	
c Pruning	X	X	X	X	X	
d. Insecticides		X	X	X	X	
- Identify						
- Develop application techniques						
2. Pheromones						
a. Mode of application -						
- Aggregants	X	X	X	X		
- Antiaggregants			X	X	X	
b. Strategies for population management.						
- Trap out			X	X	X	
- Lethal traps			X	X	X	
- Bait & cut			X	X	X	
c. Population monitoring			X	X	X	
3. Impacts						
a. Economic				X	X	
b. Changes in stand density			X	X	X	
c. Changes in species comp.			X	X	X	
d. Changes in snow retention				X	X	X
D. Long Term Applied Research:						
1. Develop hazard rating scheme			X	X	X	X
2. Develop silvicultural techniques to reduce stand hazard				X	X	X
3. Model development					X	X
4. Expert system					X	X

	1	2	3	4	5	5+
E. Operational Activities:						
1. "How to" series of publications			X	X	X	X
2. Sanitation/Salvage methodology			X	X	X	X
3. Trap trees		X	X	X	X	
4. Hazard tree removal			X	X	X	X
5. Insecticide treatment individual tree protection				X	X	X
6. Silvicultural treatments				X	X	X
7. Bait & cut strategies				X	X	X
8. Data Visualization Series			X	X	X	X

TOMICUS PINIPERDA 5-YEAR STRATEGIC PLAN

Robert Haack and Robert Lawrence
1993

A. Basic Tomicus Piniperda Biological and Ecological Studies:

1 Life History of Tomicus piniperda in the United States.

a. Describe overwintering behavior.
b. Describe flight activity/periodicity.
c. Describe reproduction, brood development, and re-emergence.
d. Identify common fungal associates.
e. Determine what internal pathogens are present.
f. Determine which native predators and parasites attack Tomicus.
g. Determine host-selection behavior during shoot feeding.
h. Determine within-tree colonization pattern.
i. Determine interactions with native pine bark beetles.
j. Determine degree of genetic similarity among major Tomicus populations in the United States and compare with Eurasian populations.
k. Determine fate of Tomicus adults in cut Christmas trees, both for trees that were used indoors and for those that were never sold.

2. Develop survey/trapping methodologies.

a. Determine attraction to alpha-pinene.
b. Determine radius of attraction of alpha-pinene lures.
c. Develop trap trees as survey tools.
d. Develop methods to estimate population levels using shoot-feeding damage.

3. Evaluate ability to shoot-feed and reproduce in native conifers.

a. Describe shoot-feeding behavior in Scotch pine and native conifers.
b. Determine whether Tomicus can reproduce and shoot-feed in native eastern, western, and southern conifers.
c. Determine whether Tomicus can attack and kill live native conifers.

B. Planning -- Incorporate Forest Pest Management Considerations into Forest Resource Management Planning Processes:

1. Obtain impact information with respect to Tomicus activity on forests, Christmas trees, and nurseries.

C. Pest Control Technology -- Development of Effective and Economical Integrated Pest Management Technology:

1. Develop pest management tactics.
    a. Develop methods to prevent/limit spread of Tomicus within and between infested forest stands and Christmas tree plantations.
    b. Determine effectiveness of insecticides for control of Tomicus in shoots, logs, stumps, and at overwintering sites at base of tree.
    c. Determine the effectiveness of chipping infested trees, logs, and slabs in killing Tomicus adults and brood.
    d. Determine the effectiveness of trapping infested logs and slabs in preventing the spread of Tomicus life stages.
    e. Determine the window of opportunity for shipping uninfested pine logs from regulated to unregulated areas.
    f. Determine when currently infested logs can be declared "uninfested" and shipped without fumigation and/or bark removal (i.e., by what date have practically all brood adults left logs?).
    g. Determine the "anti-aggregation" activity of verbenone.

2. Technology transfer.
    a. Develop "Best Management Practices" for Tomicus in forests, Christmas tree plantations, and nurseries.
    b. Produce "How to" publications describing logging guidelines, slash management, and monitoring procedures.
    c. Produce slide/tape sets on Tomicus biology, identification, and management.

TOMICUS PINIPERDA
5 Year Strategy

	YEAR SCHEDULED					
	1	**2**	**3**	**4**	**5**	**5+**
A. Short Term Basic Research:						
1. Life History of T. piniperda in the United States						
a. Overwintering behavior	X	X	X			
b. Flight activity/periodicity	X	X	X			
c. Reproduction, brood development, and re-emergence	X	X	X			
d. Identify fungal associates	X	X				
e. Determine internal pathogens	X	X	X			
f. Determine predators & parasites	X	X	X			
g. Determine within-tree attack pattern.	X	X				
h. Determine survival in cut Christmas trees			X	X		
B. Long Term Basic Research:						
1. Life History of T. piniperda						
a. Determine host-selection behavior	X			X	X	X
b. Determine interactions with native bark beetles	X	X	X	X	X	X
c. Determine dispersal potential				X	X	X
d. Determine genetic similarity among different US sub-populations		X	X	X	X	
2. Evaluate Ability to Shoot-feed and Reproduce in Native Conifers						
a. Describe shoot-feeding behavior in Scotch pine and native conifers	X	X	X	X		
b. Describe reproduction in Scotch pine and native conifers	X	X	X	X		
c. Describe ability to attack and kill live North American conifers			X	X	X	

	1	2	3	4	5	5+
C. Short Term Applied Research:						
1. Develop Survey/Trapping Methodologies						
a. Determine attraction to alpha-pinene	X	X				
b. Determine radius of attraction of alpha-pinene lures		X	X			
c Develop use of trap trees as a survey tool		X	X	X		
d. Develop methods to estimate population levels using shoot-feeding damage		X	X	X		
2. Develop Control Tactics						
a. Develop methods to prevent within and between-stand spread		X	X	X		
b. Determine effectiveness of insecticides for control	X	X	X			
c. Determine effectiveness chipping and tarping for control	X	X	X			
d. Determine effectiveness of verbenone		X	X	X		
D. Long Term Applied Research:						
1. Develop Impact Studies		X	X	X	X	X
2. Develop Silvicultural Strategies						
a. Timing of logging operation		X	X	X	X	
b. Slash treatment		X	X	X	X	
c. Use of trap trees		X	X	X	X	
d. Handling methods for infested logs			X	X	X	X
E. Operational Activities:						
1. Develop Best Management Practices			X	X	X	
2. Develop "How To" publications			X	X	X	
3. Produce slide/tape series			X	X	X	