Special Technology Development Program
Progress Report

PROJECT NUMBER: R4-2001-02

PROJECT TITLE: Development of a Monitoring and Management Tool for the Central Rocky Mountain Populations of Mountain Pine Beetle, *Dendroctonus ponderosae*

PROJECT STATUS: Continuing (funds are being requested for the next fiscal year to continue the project)

EXPECTED PROJECT DURATION: 3 years

ORIGINAL EXPECTED COMPLETION DATE OF THE PROJECT: 2003

EXPECTED COMPLETION DATE OF THE PROJECT: 2003

SUBJECT: (mark all that apply using 1 for primary category and 2 for secondary categories)
Biological control___, Invasive Species___, Methyl Bromide Alternatives___, Models___, Monitoring_1_, Organism Biology___, Pesticides: Microbial___, Pesticides: Synthetic___, PTIPS___, Population___, Risk and Hazard___, Remote Sensing___, Semiochemicals_1_, Silvicultural Technology_2_, Social Values___, Spray Technology___, Other – Landscape Mgt. _2_

STATUS OF SUBJECT SPECIES: Native

PROJECT OBJECTIVES: Development, publication and technology transfer of geographically specific pheromone blends for use in the management of ponderosa and lodgepole stands in the Rocky Mountain region. Our goal is to utilize these compounds to monitor and manage mountain pine beetle populations. Developing a successful attractant will contribute to reducing impacts that negatively effect management objectives in Rocky Mountain forests such as recreation, wildlife, aesthetics, and timber production.

BRIEF DESCRIPTION OF THE PROJECT: Through laboratory and field studies we propose to substantially improve our ability to detect and manage populations of the mountain pine beetle in stands of ponderosa and lodgepole pine in the Rocky Mountains. Through an already established collaborative network at three locations with previously constructed rearing facilities (Ogden, UT; Gunnison CO; & Rapid City, SD), mountain pine beetles will be reared, population-specific blends of semiochemicals will be determined, and field responses will be assayed. Trap catch data will be matched with succeeding aerial mapping data to establish an early warning tool to forecast population trends in this region of the US. An improved mountain pine beetle attractant will also be used to bait trap trees for suppression treatments. Management guidelines utilizing the geographically specific monitoring and tree-baiting tool will be developed and published for widespread use by land managers throughout the central Rocky Mountain area.

Primary Activities---Year 2001:

- In FY2001, field evaluations of the commercially available bait for MPB were conducted simultaneously at four locations in the Rocky Mountains (two lodgepole pine and two ponderosa pine stands).
- In FY2001, seven monoterpenes were tested as potential geographically specific additives to the commerically available bait. Terpinolene appears to be the optimal additive.In FY2001, Research Associate, Elizabeth Vaughan, was hired at the University of Minnesota to sort, count, and curate the trap catches from the four field evaluations.
- In FY2001, nearly 40 semiochemical extracts of variously treated MPB were prepared at the University of Minnesota for chemical analysis.

- In FY2001, quantitative analyses of semiochemical extracts from MPB collected in lodgepole pine near Stanley, ID revealed that *exo*-brevicomin (males), *trans*-verbenol (females), and cis-verbenol (both sexes) were frequently occurring semiochemicals. Frontalin was also present in the males. In FY2002 and FY2003, additional chemical analyses need to be conducted—particularly stereochemical analyses. Other analyses include more extracts from populations in CO and SD and more extracts involving feeding on pine phloem and juvenile hormone treatment from all three locations.

CHANGES TO ORIGINAL PROJECT SCOPE OR OBJECTIVES: The scope and objectives of our project have not changed.

ADDITIONS TO ORIGINAL PROJECT SCOPE OR OBJECTIVES: There are no additions to the scope or objectives of our project.

FHP LEAD CONTACT:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Steve Munson	FHP - Ogden, UT	P: (801) 476-9728 F: (801) 479-1477 smunson@fs.fed.us

FHP LEAD INVOLVEMENT:

Role	Time Commitment
Coordinates project activities among FHP and academic cooperators. Conducts field evaluations in Idaho.	5 weeks

PRINCIPAL INVESTIGATORS:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Steven J. Seybold Assistant Professor	University of Minnesota Entomology & Forest Resources St. Paul, MN	P: (612) 624-3715 F: (612) 625-5299 sseybold@tc.umn.edu
Darrell W. Ross Professor	Oregon State University Department of Forest Resources Corvallis, OR	P: (541) 737-6566 F: (541) 737-1393 Darrell.ross@orst.edu

PRINCIPAL INVESTIGATORS INVOLVEMENT:

Name	Role	Time Commitment
Seybold	Serves as lead investigator, conducts semiochemical analyses on various MPB populations, proposes field evaluations of semiochemicals, provides semiochemicals for field evaluations, participates in field evaluations, and assembles and reports trap-catch data.	5 weeks
Ross	Provides expertise on design and treatments for field evaluations, participates in field evaluations, and provides expertise on data analysis from field evaluations.	3 weeks

COOPERATORS:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Tom Eager	Region 2, Gunnison, CO	P: (970) 641-0471 F: (970) 641-1928 teager@fs.fed.us
Kurt Allen	Region 2, Rapid City, SD	P: (605) 343-1567 F: (605) 343-7134 kallen@fs.fed.us
Joel McMillin	Region 2, Rapid City, SD	P: (605) 343-1567 F: (605) 343-7134 jmcmillin@fs.fed.us

COOPERATOR INVOLVEMENT:

Name	Role	Time Commitment
Tom Eager	Trapping, Collecting, Rearing MPB and Field Analysis	6 weeks
Kurt Allen	Trapping, Collecting, Rearing MPB and Field Analysis	3 weeks
Joel McMillin	Trapping, Collecting, Rearing MPB and Field Analysis	3 weeks

PRODUCTS AND DUE DATES: Initial evaluations have been directed toward the development of regionally specific aggregant formulations that significantly increase mountain pine beetle trap catch (2001-2002). This project would help to establish monitoring and treatment guidelines using the new aggregants (2002). Examples of management guidelines include: "Monitoring of mountain pine beetle populations using pheromone baited traps" and "Use of pheromone baited traps for managing mountain pine beetle populations." The monitoring and treatment protocols will be disseminated through resource manager's workshops, FHP training sessions and "How To" guides in hard copy and posted on the Internet (2003).

STATUS OF PRODUCTS/PRESENTATIONS: Initial evaluations of semiochemical production and response have been proceeding as planned (see below). Development of guidelines and training sessions will follow in succeeding years.

ACCOMPLISHMENTS TO DATE:

Products:

FY2001--Semiochemical Production: Populations of MPB were collected during the summers of 2000 and 2001 from three Rocky Mountain locations (Stanley, ID, Salida, CO, and Rapid City, SD). The ID populations were collected in lodgepole pine, *Pinus contorta*, while the CO and SD populations were collected in ponderosa pine, *Pinus ponderosa*. To induce pheromone production, adults from each population were treated by exposure to pine monoterpenes (e.g. alpha-pinene and myrcene) or through topical application of juvenile hormone (Table 1). These insects were dissected and abdominal tissue extracts were made in pentane:ether. With the ID population, adults of each sex were also fed on lodgepole and ponderosa pines and then semiochemical-laden volatiles were trapped from the adults over a ten-day period. The samples were collected on Porapak Q and extracted with pentane.

Table 1: Semiochemical Samples Prepared from Three Rocky Mountain Populations of Male and Female Mountain Pine Beetle

population	treatment	sex	# beetles	extracted	quantitative analysis	stereochemical analysis
Idaho	*R*-(+)-α-pinene	m	131	✓	✓	✓
		f	199	✓	✓	✓
	S-(−)-α-pinene	m	120	✓	✓	✓
		f	100			
	(±)-α-pinene	m	100	✓	✓	✓
		f	113	✓	✓	
	β-myrcene	m	117	✓	✓	
		f	121	✓	✓	
	heptane	m	132	✓	✓	
		f	133	✓	✓	
	2.2 μg JHIII	m	116	✓	✓	
		f	128	✓	✓	✓
	fed on ponderosa pine (CO)	m	~150			
		f	~200	✓		
	fed on lodgepole pine (ID)	m				
		f				
Colorado	*R*-(+)-α-pinene	m				
		f	60	✓		
	S-(−)-α-pinene	m				
		f	111			
	(±)-α-pinene	m				
		f	117	✓		
	β-myrcene	m				
		f	97			
	heptane	m				
		f	118			
South Dakota	β-myrcene	m	15			
		f	16			
	25 μg JHIII (pre-emerged)	m	~50 (4 reps)			
		f	~50 (4 reps)			
	acetone (pre-emerged)	m	~50 (4 reps)			
		f	~50 (4 reps)			

A check mark denotes that the sample has been extracted, analyzed quantitatively, or analyzed stereochemically.

Using these techniques, nearly 40 samples were prepared for chemical analysis. Nearly all of the samples from the ID population have been analyzed quantitatively for semiochemical production (Table 2). These samples are presently being analyzed for the stereochemistry of the semiochemicals. Analysis of the abdominal extracts of males and females revealed that *exo*-brevicomin was present in male samples regardless of treatment. When males were treated with juvenile hormone, they were stimulated to produce high levels of frontalin, which may be a minor attractive or interruptive pheromone component. Females extracts did not contain frontalin and are currently being re-esamined to determine if *exo*-brevicomin is present. All female MPB contained *trans*-verbenol in their abdominal tissue regardless of treatment and the amount was elevated in females that had been exposed to alpha-pinene. Only males exposed to alpha-pinene produced *trans*-verbenol, and these males also produced *cis*-verbenol, which was more abundantly produced than in comparably treated females. Both sexes produced similar amounts of verbenone when exposed to alpha-pinene and females produced verbenone following other treatments as well. Finally, males converted myrcene to ipsdienol and both sexes converted heptane to 1- and 2-heptanol.

Table 2: Semiochemical Production by Male and Female Mountain Pine Beetles (Stanley, Idaho)

			Mass of Pheromone Component (ng/beetle)								
Treatment	Sex	number beetles	frontalin	*exo*-brevicomin	*cis*-verbenol	*trans*-verbenol	verbenone	1-heptanol	2-heptanol	ipsdienol	*E*-myrcenol
R-(+)-α-pinene	m	131	--	204	423	566	31	--	--	--	--
	F	199	--		148	1790	51	--	--	--	--
S-(-)-α-pinene	m	120	--	117	25	632	--	--	--	--	--
	F	100	--								
(±)-α-pinene	m	100	--	152	144	370	15	--	--	--	--
	F	113	--		51	1525	20	--	--	--	--
β-myrcene	m	117	--	196	--	--	--	--	--	5	0.29
	F	121	--		9	169	21	--	--	--	--
heptane	m	132	--	72	--	--	--	11	25	--	--
	F	133	--		--	102	17	31	31	--	--
2.2 μg JHIII	m	116	71	17	--	--	--	--	--	--	--
	F	128	--		--	366	20	--	--	--	--

Summary of pheromone production results: *exo*-Brevicomin, *trans*-verbenol, and *cis*-verbenol have all been reported as attractive pheromone components in other populations of MPB, and the sex specificity of production of these compounds in our analyses agrees with previous work. Both *exo*-brevicomin and *trans*-verbenol are key beetle-produced compounds in the commercial attractant of MPB. *cis*-Verbenol is also generally present in that attractant as a contaminant of *trans*-verbenol. The stereochemistry of these compounds in our extracts may be the key to the differences in behavioral responses to the commercial bait by Rocky Mountain populations and other populations. The results of the stereochemical analyses should be completed in FY2002. The results of these monoterpene metabolism studies will be compared to the results of analyses of samples of volatiles trapped from phloem-fed beetles and this should place the metabolism studies in a more natural context. In FY2002 we plan to also make abdominal extracts from phloem-fed beetles from ID.

FY2001--Semiochemical Response: From June and July, through September and October, 2001, field evaluations of MPB semiochemicals were conducted in four Rocky Mountain locations (Stanley, ID, Salida and Vail, CO, and Rapid City, SD). The goal of these evaluations was to determine if any commercially available monoterpenes were more attractive to MPB than myrcene (which is part of the commercially available bait—myrcene, *exo*-brevicomin [50%-(-)], and *trans*-verbenol [86%-(-)], Phero Tech, Inc.).

In each of the four areas, the following eight treatments were tested on12-unit Lindgren funnel traps: 1) Standard Phero Tech commercial MPB bait (eB+tV+myrcene), 2) eB+tV+(+)-alpha-pinene, 3) eB+tV+(-)-alpha-pinene 4) eB+tV+(-)-beta-pinene, 5) eB+tV+3-carene, 6) eB+tV+Dipenten LPX (beta-phellandrene and limonene), 7) eB+tV+terpinolene, and 8) eB + tV. Two areas (Stanley and Vail) were lodgepole pine standsand two areas were ponderosa pine stands (Salida and Rapid City). The major monoterpene component of lodgepole pine is beta-phellandrene; the major monoterpene components of ponderosa pine are alpha- and beta-pinene, 3-carene, and myrcene.

In each of these field evaluations, the treatments were replicated 4 times in a randomized block design. The traps were spaced at least 30 to 50 m apart and the blocks were 300 to 500 m apart. Traps were placed at least 10 m away from infested trees or green pines and were hung on non-hosts, rebar, aluminum piping, or ropes. The trap/lure combinations were re-randomized within the blocks each time that the traps are emptied. Baits were replaced if it appeared that monoterpenes had completely eluted through the release devices.

Traps from all sites were emptied and the insects from each catch were placed into labeled Ziploc bags, frozen, and shipped to Seybold's lab in Minnesota for counting, sex determination, etc. An M.S.-level research associate, Ms. Elizabeth Vaughan, has been hired at the University of Minnesota to process these samples and will work from September 2001 until April 2002 on this project.

FY2002--Semiochemical Response: From preliminary observations of the trap catches, it appears that one monoterpene, terpinolene, was the most potent of the components tested in 2001. If this result is supported by analysis of the trap catches, then terpinolene will replace myrcene in the "Rocky Mountain formulation" of the MPB attractant. Further, we were not able to test a pure formulation of beta-phellandrene as it is not commercially available. However, there is the potential to have a company called Millenium Specialty Products distill beta-phellandrene from lodgepole pine resin for use in future field evaluations. We will explore working with this company to procure beta-phellandrene for field testing. Whichever of terpinolene or beta-phellandrene ultimately becomes the best monoterpene component in the bait, we will explore the following field evaluations in FY2002 and FY2003:

1) Test the relative release rates of the most active monoterpenes relative to eB and to tV.
2) Test the relative release rate of eB to tV holding the monoterpene release rate constant
3) Test the effect of (+)- vs. (-)-tV or the effect of (+)- vs. (-)-eB

Publications: There have been no publications associated with the project in FY2001.

Technology Transfer: There have been no technology transfer activities associated with the project in FY2001.

FIRST FISCAL YEAR FUNDED: FY2001

FUNDS OBLIGATED FROM BEGINNING OF PROJECT THROUGH CURRENT FISCAL YEAR: (include both monetary and in-kind, excluding FHP base funding and salaries) (extend table as needed)**:**

	Item	**Requested Funding**	**Received Funding**	**Expended Funding**
PREVIOUS YEAR FY 20001				
Administration	Salary	35,000	35,000	35,000
	Overhead			
	Travel	5,000	5,000	5,000
Procurements	Contracting	0	0	0
	Equipment	1,200	1,200	1,200
	Supplies	1,800	1,800	1,800
YEAR TOTALS		43,000	43,000	43,000

CURRENT YEAR FY 2002				
Administration	Salary	36,000		
	Overhead			
	Travel	5,000		
Procurements	Contracting	0		
	Equipment	1,200		
	Supplies	1,800		
YEAR TOTALS		44,000		

FY 2003		**Requested FHP STDP Funding**	**Other Source Funding**	**Source**
Administration	Salary	37,000		
	Overhead			
	Travel	5,000		
Procurements	Contracting			
	Equipment	1,200		
	Supplies	1,800		
YEAR TOTALS				
PROJECT TOTALS				

FUNDS NOT USED FROM PREVIOUS FISCAL YEAR (If there are unused funds, what is the reason for not using them? How will the project continue without these funds?)

Fiscal Year	**STDP Funding Allocated**	**Funds Obligated**	**Funds Unused**
2001	**43,000**	**43,000**	**0**

EXPECTED BUDGET FOR NEXT FISCAL YEAR: (include both monetary and in-kind, excluding FHP base funding and salaries) (extend table as needed)**:**

	Item	**Requested FHP STDP Funding**	**Other-Source Funding**	**Source**
Administration	Salary	36,000		
	Overhead		8,400	UMN
	Travel	5,000		
Procurements	Contracting			
	Equipment	1,200		
	Supplies	1,800		
Totals				

DIFFERENCE BETWEEN ORIGINAL AND AMENDED REQUESTS AND JUSTIFICATION:
No difference.

STDP FUNDING NEEDED:

Total estimated additional future funding needed beyond the current fiscal year: FY2002-$44,000; FY2003-$45,000

Estimated STDP funding needed in remaining year(s) of the project by fiscal year. Show separately the funding to be requested/provided from other sources (extend the table as necessary).

Fiscal Year	**STDP Funding**	**Other-Source Funding**	**Source**
FY2002	44,000		
FY2003	45,000		