FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL

PROJECT STATUS: New, not previously funded.

PROJECT NUMBER: R3-1999-01

PROJECT TITLE: Spruce aphid impact assessment and hazard rating in the Southwest

SUBJECT: Spruce aphid on Engelmann spruce

PROJECT OBJECTIVE(S): Develop a hazard-rating system for spruce aphid in the Southwest.

BRIEF DESCRIPTION OF PROJECT: Existing color-infrared stereo pair photography will be interpreted for defoliation and site and stand factors. The photo-interpretation (PI) data will be verified using ground plots. Data will be analyzed for associations to form the basis of a hazard-rating system.

FHP PERSON WHO WILL LEAD THE PROJECT: Jill Wilson, R-3 Arizona Zone Entomology & Pathology

JUSTIFICATION: This is a new (possibly exotic) pest on a widely-distributed and important host species in the Southwest and Rocky Mountain States. The insect (figure 1) was first reported in the Southwest in 1988 from Santa Fe, NM and the White Mountains in AZ. Identification of the insect was confirmed by the National Systematic lab in 1997. Prior to 1988, we have not found any written reference to this organism or any unknown organism causing defoliation in spruce going back to the turn of the century. Since the findings in the White Mountains and Santa Fe, the insect has also been reported from the Sacramento mountains in SE New Mexico and in the Mogollon Mountains in SW New Mexico. If the insect is introduced, the mode of introduction is unknown although likely possibilities include both ornamental and forestry nursery stock coming from the northwest. Furniss and Carolin (1977) suggest that the the insect may have been introduced to the Northwest from Europe. In the future, we hope to send specimens to a geneticist in Canada who will compare insects from different sources. This may shed more light on this important question.

The most significant outbreak of this insect was the most recent one, which occurred between 1995 and 1997 in the White Mountains of Arizona when 28,000 acres of defoliation was detected from the air. This is probably a conservative estimate of the total affected area. Heavy defoliation was reported in many areas (figure 2). In 1998 substantial mortality was observed in the more heavily defoliated areas. We estimate that mortality rates approach 50 percent of the host type in some of these locations. They are lower in other areas. A better estimate of mortality will be obtained next year when impact plots will be re-surveyed (cooperatively funded by the Region and Rocky Mountain Research).

In North America, spruce aphid epidemics have historically been limited to maritime climates on Sitka spruce and white spruce. Similarly in Europe, outbreaks have also been limited to areas with a maritime influence. Even then the outbreaks are limited to "mild winters". These outbreaks in the southwest are first time that this insect has been reported so far inland. In 1998, significant defoliation was observed for the first time as high as 10,000 feet, which in the White Mountains is in pure spruce-fir type. Our temperature studies suggest that the insect is surviving and even thriving at temperatures far below what it has previously been reported to survive (Lynch et al 1998). This raises new concerns for spruce-fir forests in other inland parts of the west. In the White Mountains, management concerns have risen regarding effects to recreation values and to fire hazard. In addition, because a good portion of the current outbreak area is in Tribal ownership, significant concerns about effects on timber values have been raised. The White Mountain Apache Tribe maintains an active timber program.

This proposal is one component of the work that is ongoing concerning this insect in the southwest and involves cooperation beween the Southwestern Region, Rocky Mountain Research Station and the Fort Apache Agency (BIA). Additional work that has been initiated, external to this proposal, includes using CFI plot data to evaluate tree characteristics associated with tree damage, installing temperature monitoring data loggers in host stands to determine actual temperature regimes, analyzing historic climate records to identify unique characterics of the epidemic events, and re-visiting the CFI plots in 1999 to evaluate tree mortality. We also plan to evaluate foliage characteristics for differences between Engelmann spruce, Sitka spruce and white spruce, specifically to determine if Engelmann spruce foliage has a very low winter moisture content or if it freezes (ice crystal formation) at a lower temperature (which might explain why the aphids seem to be surviving at temperatures lower than previously recorded). In addition we have been actively monitoring other areas, not known to be currently infested to see if we can find evidence of the insect there. We also hope, once we can collect new live specimens, to send them to a systematist in Canada who will conduct some comparative genetic analyses to see how these southwestern aphids compare to those in other infested areas in the northwest and in Europe.

While the current proposal is but one segment of these studies it is nonetheless very important. Through this proposal, we hope to gain a better understanding of which areas have been impacted the greatest. Casual observation has suggested some patterns on the landscape that we hope will show up better through this methodology. Understanding these infestation patterns may help provide clues to how to better manage this insect.

URGENCY: This insect is a new pest (possibly exotic) to the Southwest, is extensively damaging a widely-distributed and important host species, is maintaining epidemics outside conditions previously reported to limit it's population dynamics, and is perceived to be a potential threat throughout the Interior West on Engelmann spruce, and perhaps to other Picea in Mexico. The ecology of this insect in the Southwest is completely unknown. Although epidemics appear to be associated with mild winters, this is based on two observations and may be coincidental. If the association is real, the timing of the

next mild climate cycle is unpredictable. There is some concern that mild winters are increasing in frequency due to climate change. It is paramount that we gain as much understanding of the insect's ecology as rapidly as possible in order to evaluate the potential threat, and to develop some management guidelines. Additionally, the Fort Apache Indian Reservation Forest Management Plan is being revised for release in 2000, and the Apache/Sitgreaves N.F. revision is scheduled for release in 2002. The BIA and the A/S need to incorporate spruce aphid information in the planning process, particularly regarding the likelihood of recurrence and risk-rating guidelines.

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES: This proposal has links to several of the stated high priority objectives. Information on relationships between site and stand variables and spruce aphid impact will help in developing guidelines for integration of silvicultural procedures, prescribed burning, or other tools and techniques that may reduce adverse impacts of this insect (Priority #2). If indeed the insect is exotic, which we think it is, then this proposal will help to develop or improve detection, analysis, and management of an exotic pest (Priority #4).

SCOPE OF APPLICATION: The most narrow interpretation of application scope would be to forests containing Engelmann spruce in the Southwest and Southern Rockies (Arizona, New Mexico, Colorado, Utah). Depending upon factors which limit population dynamics on Engelmann spruce (which are unknown at this time), the potential application scope includes the interior west of North America, and perhaps to additional spruce species in Mexico.

RESEARCH BASIS: Little is known about the biology, effects, or management of this insect in the Southwest, since the insect has only been reported in recent years. Nor is it known if the insect is native or exotic to the region. However, because the first written report of the insect was made in 1988, and because the impacts seem so severe (for an aphid), we are suspicious that the insect may indeed be exotic. Hanson (1952) advocated that Norway Spruce might be the original host of Elatobium. The studies described in this proposal are the first studies that have been conducted on this insect in the interior west. Outbreaks seem to develop rapidly and with little warning and seem to subside equally rapidly, yet with significant impact.

Spruce aphid, Elatobium abietinum (Walker), feeds on foliage of Picea, with known infestations previously restricted to coastal areas (Koot 1991). Economically important damage is known only from areas with mild maritime winter climate on Picea sitchensis (Bong.) Carr. and P. glauca (Moench) Voss: the northwestern North America coast, Britain, Iceland, Norway, Denmark, southern Sweden, northwestern Germany, Holland, and New Zealand (Bejer-Petersen 1962). E. abietinum was first reported in North America in 1916 in British Columbia (Koot 1991) and is presumed to be introduced from Europe (Bejer-Petersen 1962, Furniss and Carolin 1977), although it's status as exotic or indigenous in the Pacific Northwest is uncertain (Hennon and Mask 1994, Koot 1991). Northern North American forest epidemics are sporadic and short, but can cause extensive spruce mortality. Previously, it's North American distribution was limited to

the Northwestern and Pacific regions of the continent, and to North Carolina (Johnson and Lyon 1991).

The biology of this insect in maritime climates on Sitka spruce and white spruce is fairly well known, mostly from European work (Bejer-Peterson 1962, Carter 1972, Eglitis 1994, Hussey 1952, Koot 1992). Most research has focused on temperature relations, influence of nitrogen levels and host impacts (largely growth loss). Damage-causing epidemics have been restricted to areas with mild maritime climates, which moderates winter weather (Bejer-Petersen 1962, Ohnesorge 1961). Outbreaks are associated with mild winters, parameterized either as winters with all monthly mean temperatures above 32F (Bejer-Petersen 1962) or as winters where ambient temperatures do not fall to 7 to 18F (Carter 1972, Ohnesorge 1961, Powell and Parry 1976). The coldest temperature recorded for aphid survival is -9F (Carter 1972, Powell 1974). These limits are clearly exceeded in the spruce zones of the Southwestern mountains. Winter temperatures at Alpine AZ, located at 8,050 ft in the ponderosa pine belt of the White Mountains, fall below -20F almost every winter, and often to -30F (NOAA 1994).

While research on temperature effects on the insect have dominated the literature and are clearly important, there are references to site and stand effects. Bevan (1966) notes that serious defoliation often occurs on exposed edges, in shelter belts, and crops near the coast. Areas of windblow, and young crops up to the thicket stage seem prone to attack. Likewise, Hennon and Mask (1994) report that heavy defoliation in southeast Alaska often occurs on trees in exposed settings. Thus it seems that while temperature regimes seem to affect overall distribution of the insect and initiation of outbreaks, site and stand factors may influence the level of defoliation within the generally infested zones.

The work proposed here will provide baseline information on associations between spruce aphid damage and site and stand factors. It will also demonstrate whether or not color-infrared photography can be used as an effective tool for development of a coarse hazard rating system. No hazard rating systems have been published previously for this insect though its strong association with certain temperature regimes as well as with certain site locations suggests that it may well be possible to develop a coarse system using such factors as elevation, aspect, percent host etc.

METHODS: Color-infrared stereo-pair aerial photographs at scale 1:10,000 were taken of approximately 280 square miles of the outbreak area in May 1997. We propose to interpret these photographs to characterize forest and topographic conditions associated with defoliation from spruce aphid. A systematic grid sample will be evaluated from the photos for factors such as tree density or stocking, tree height distribution, species composition, host dominance, ponderosa pine and Douglas-fir dominance (because defoliation severity appears to be more severe on sites where these species are present), site elevation, site slope, site aspect, distances and slope direction to nearest large opening and water body (because of the insect's historic association with maritime climate effects), and host tree defoliation by none-moderate-severe categories. The PI data will be verified using CFI plots in approximately half the flight area, which were last measured in 1994 and visited in spring 1997 for defoliation assessments. Additional

ground data may need to be collected for verifying the interpretation data, and is allowed for in the budget. The PI data will be analyzed for associations between defoliation and site and stand factors to develop a basic risk-rating system.

Ground-based sampling is usually a better approach to developing risk- and hazard-rating systems, as the quantity and precision of PI data is limited. In this case, a photo-based approach was selected because a) of the uncertainty about outbreak duration, b) accurate defoliation estimates are much more difficult after bud flush, and c) field crew resources were limited. We needed to capture information on the existing outbreak in a short period of time, with limited resources, and with little lead time. The flight mission was funded jointly by Arizona Zone Entomology & Pathology and the Rocky Mountain Research Station and conducted by the Forest Health Technology Enterprise Team.

MEASURE OF SUCCESS: This project will be successful if site and/or stand factors associated with spruce aphid defoliation are identified. Additional success will be achieved if those factors can be quantified and a basic risk-rating system developed.

Figure 1. Spruce aphid on Engelmann Spruce

Figure 2. Defoliation on Engelmann Spruce

LITERATURE CITED:

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COOPERATORS: Ann Lynch, Rocky Mountain Research Station; Jill Wilson, Arizona Zone Entomology & Pathology; Fort Apache Agency, Bureau of Indian Affairs.

PRODUCTS: A delineation of defoliated and non-defoliated host areas will be completed in FY'99. Photo-interpretation of a systematic sample of the photographed

area should be completed in FY'99 as well, but may require work in FY 2000, depending on various strategies for completing the PI (contract, in-house, etc.). Field work for additional PI data verification will be conducted in FY 2000. Analysis and development of a risk-rating system will be completed in FY 2000.

PUBLICATION: The results will be published in appropriate refereed and Region outlets.

TECHNOLOGY TRANSFER: Information on site and/or stand factors associated with spruce aphid defoliation will be incorporated into a risk-rating system, published in appropriate outlets, presented at appropriate training sessions and work shops. Information will be provided to the BIA and National Forest such that it can be used in Forest Plan revision.

PROJECT DURATION: Two years, FY 1999 & FY 2000.

LONG TERM BUDGET:

Item	FY1999	FY2000	TOTAL
1. Salaries or contract for photo-interpretation	$28,000	0	28,000
2. Salaries Two GS-5.5 for 2 months for field validation of PI	6,568	6,568	
3. Travel			
Travel to UT and CO for consultation with RSAC & FHTET	1,500	1,200	2,700
Field work, 2 people, 45 days, $70/day	6,300	6,300	
4. Equipment, supplies, ortho maps	1,000	1,000	
5. Illustration services	500	500	1,000
6. Overhead (RMRS Program Administration)	3,445	1,620	5,065
TOTAL	$34,445	$16,188	$50,633

Additionally, in FY'97 the Rocky Mountain Research Station and Arizona Zone Entomology & Pathology contributed $6,500 and $12,000 respectively, to fund the flight mission and collection CFI data.

FY 1999 BUDGET REQUEST: See above

BENEFIT AND COST: See enclosure 1.
(ENCLOSURE 1, new proposal, continued)

STDP PRODUCTION FUNCTION

PROJECT NUMBER:R3 99 01

PROJECT COST: STDP Cost	$50,633
Other Costs (costs incurred by R3 and RMRS FY 97)	$18,500

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

Project objective is to develop a risk rating system for spruce aphid in the in the Southwest. This system will result in greater understanding of the factors associated with varying levels of defoliation caused by this insect and lead to improved management practices that will reduce losses. Using the system, the Fort Apache Agency, in particular, could concentrate treatments in those areas where there would be the most benefit. The benefit of this project used in the economic analysis is to shift/accelerate harvest to capture green value.

We would like to mention that the system would have other benefits to other resources including recreation, scenic beauty, wildlife, and fire. Defoliation has already affected scenic beauty at a popular ski resort on the reservation. The system also will hopefully have application in areas outside the reservation where the aphid is currently found or may spread. This analysis however was limited to spruce within the commercial timber type on the reservation.

ASSUMPTIONS:

-The risk rating system will lead to better planning, silvicultural prescriptions and cultural practices, resulting in forests with healthier and larger components of Engelmann and blue spruce than without the system.

-In the next 20 years, 174,000 acres will be harvested with the mixed conifer type on the Fort Apache Indian Reservation.

-The average time to harvest is 10 years

-Timber sale administrative and treatment costs are the same with or without the project

-Continued spruce aphid outbreaks and associated defoliation will lead to low levels of mortality. We are already seeing some mortality but the amounts have not been quantified at this time as it is still too soon to measure following the last outbreak.

-With the project, the amount of green spruce harvested per acre will be 1.98 MBF and the amount of dead spruce will be 0.02 MBF

-Without the project, the amount of green spruce harvested per acre will be 1.96 MBF and the amount of dead spruce will be 0.04 MBF.

BACKGROUND DATA:

-Value of Green Spruce is $180/MBF

-Value of Dead Spruce is $40/MBF

CALCULATIONS

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

EOV W/O Proj.= (174,000 Ac) * (1.96 MBF/Ac) * $180.00/MBF * .6756 (discount)
+ (174,000 Ac) * (0.04 MBF/Ac) * $40.00/MBF * .6756 (discount)

= $41,661,279

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

EOV w/ Proj.= (174,000 Ac) * (1.98 MBF/Ac) * $180.00/MBF * .6756 (discount)
+ (174,000 Ac) * (0.02 MBF/Ac) * $40.00/MBF * .6756 (discount)

= $41,990,432

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:

B = $(with) - $(without)

= $41,990,432 - $41,661,279
= $329,153

BENEFIT/COST RATIO:

B/C = $(with) - $(w/o)
$(STDP cost) + $(treatment cost, where applicable)

= $329,153/$50,633
= 6.5

BENEFIT ATTRIBUTABLE TO STDP:

Benefit attributable to STDP funds = $(STDP cost) x (B/C)
$50,633 * 6.5 = 329.153

PNV OF PROJECT:

PNV of project = $(Benefit) - $(cost)
= $329,153 - $50,633
= $278,520

PNV OF STDP:

PNV of project = $(Benefit attributable to STDP) - $(STDP cost)
= Same as above