United States
Department of
Agriculture

Forest Service

Forest Pest
Management

Davis, CA

SEVENTH REPORT

NATIONAL STEERING COMMITTEE FOR MANAGEMENT OF WESTERN DEFOLIATORS

FPM 95-2
December 1994

Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

FPM 95-2
December 1994

Seventh Report

National Steering Committee
for Management of Western
Defoliators

Compiled by:

John W. Barry
Chairperson

USDA Forest Service
Forest Pest Management
2121C Second Street
Davis, CA 95616
(916)758-4600
FAX (916)757-8383

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I. INTRODUCTION

A. Place and Purpose of Meeting

The Committee met at Spokane, WA, on April 12-13, 1994, hosted by Ladd Livingston, to identify and prioritize needs for the FY 95 FPM Technology Development Program, and to revise the draft of the Strategic/Tactical Plan for the Management of Western Defoliators. We were successful in realizing meeting objectives. The committee enthusiastically pursued discussions of the draft plan and actively participated in reviewing and finalizing the draft. Meeting call letter with agenda is enclosed as Appendix A.

B. Attendees

Dayle Bennett	FPM (Albuquerque, NM)
Bob Campbell	USFS (Ret.)
Nancy Campbell	FPM (Missoula, MT)
Dave Grimble	PNW Res. Sta. (Corvallis, OR)
Bruce Hostetler	FPM (Portland, OR)
Ladd Livingston	Idaho Department of Lands (Coeur d'Alene, ID)
Amy Onken	FHP (Morgantown, WV)
Dave Rising	MTDC (Missoula, MT)
Julie Weatherby	FPM (Boise, ID)
John Wenz	FPM (Sonora, CA)
Jack Barry, Chair	WO/FPM (Davis, CA)

C. Appendices to Report

Appendices A-G are enclosed for information and future reference. A special thanks to each participant who contributed a report.

II. COMMITTEE REPORTS

A. Sub-Committee Reports

Dick Reardon, Chair of the Non-Target Effects Sub-Committee did not attend the meeting thus no report. The Committee decided to cancel the sub-committee as the work falls within the charter of the National Center for Forest Health (see letter Appendix B). The Committee supports non-target work and looks forward to cooperating with the NCFH.

John Wenz, Chair of the Strategic/Tactical Plan for Management of Western Defoliators, presented an updated draft of the plan. The draft was reviewed by the committee (see part III, C). A copy of the plan is enclosed as Appendix E.

B. Committee Member Reports

Committee member reports are enclosed in Appendix C. These reports contain important information and readers are encouraged to review the enclosures.

III. DISCUSSION

A. Discussion Notes

Managing western defoliators within context of forest health and ecosystem management and other discussion topics. (See Chief's memorandum on implementing ecosystem management, Appendix F.)

1. Julie Weatherby. Field needs capability to predict trees that are at high risk from Douglas-fir tussock moth. Concerning the Idaho outbreak, Ladd Livingston was frustrated that last outbreak wasn't treated earlier. Julie believes the Forest Service might be more interested in treating next outbreak with the TM-Biocontrol virus. John Wenz mentioned if outbreak were in California the approach would be to question the outbreak's effects on the ecosystem. British Columbia has been successful in using the virus in the Kamloops area, but its use in the US Northwest failed - possibly because virus was too weak, but we don't know. Research has no plans to pursue this question. What are the impacts of DFTM outbreaks on ecosystem elements and functions? FPM and FIDR roles need to be defined before we can address management of western defoliators.

2. Bruce Hostetler. R-6 would like to improve the approach in the future for making decisions about suppression of defoliators. In some areas, dead trees are looked upon favorably as habitat for some cavity-nesting birds or mammals or as future down woody material. Others may look upon the dead trees as an opportunity for additional harvest. It is more important than ever now to involve all resource specialists in discussions about the effects of insects and diseases on forest structure and function. It is important to evaluate the effects of letting nature, through insects and diseases, take its course (resulting in an increased probability of fire) versus the effects of salvage of trees killed by insects and diseases to reduce the risk of fire. There may be some conflict between FPM's traditional approaches and roles, and new ones. FPM needs to sell its talents to other disciplines and staffs. Our name, Forest Pest Management, is a real deterrent to communications with some resource specialists. Not much more to report since our September 1994 meeting. Forecast for DFTM populations and other defoliators is for low levels in most areas of the Region. There are several areas with outbreak levels of WSB on the eastern slope of the Oregon Cascades and in northern Washington. A western hemlock looper outbreak is continuing in parts of northwestern Washington. There is little interest in suppression at this time. WSB larval data are still being collected from the Meacham Project area (treated with Bt in 1988) by Torolf Torgersen, PNW.

3. Amy Onken. Need more environmentally sensitive control methods. National Center for Forest Health's (NCFH) program of work is in draft form and your input is invited. NCFH wants to become involved in biocontrol of exotic weeds. Amy mentioned work on the growth regulator Mimic for Lepidoptera insects. Several NCFH program items are those identified by the National Steering Committee for Managing Western Defoliators. Question - how does NCFH, FPM's TD Program, National Steering Committees, MAG, and Davis relate and fit into the national agenda? Editor's note -- this needs to be addressed by Director, FPM and the field FPM directors.

4. Bob Campbell. In understanding defoliators we need to look at past data sets and at larger land areas. Low temperatures in May and heavy rainfall can reduce survival of western spruce budworm. See Bob's paper (Appendix C) on understanding budworm population dynamics.

5. Nancy Campbell. We need commitments to permanent plots and we need to make assignments.

6. Dayle Bennett. Western spruce budworm levels have been low in R-3 but came back in 1993. About 8,000-9,000 acres were planned

for aerial treatment but project cancelled. The Carson NF treated 14 campgrounds in June 1994 with Dipel 4L to control western spruce budworm. R-3 is managing 25 permanent plots. Need to document no treatment alternatives. Red River report is being printed.

7. Dave Grimble. Insects are not being considered in forest diversity studies conducted by PNW. Holsten, Werner, and Mask are requesting 5K for a permanent plot project. (Dave and the committee support this request.)

8. John Wenz. Budworm showing up on 50,000 to 200,000 acres on the Modoc NF.

B. Issues and Needs

1. The committee strongly supports the permanent plot program. There is a perception that management is not committed to sustaining the permanent plot program. The need for the permanent plot program is obvious and critical to understanding the role of insects and diseases in forest health and how they relate to forest ecosystems. With retirement of researchers the program is folding.

2. The committee identified need for base-line studies starting with developing a bibliography.

C. Strategic/Tactical Plan for Management of Western Defoliators

1. The committee reviewed the draft plan in detail and made some additions and rearrangement. It was decided that we would distribute the plan as a draft as soon as the revisions were incorporated.

2. The Strategic/Tactical Plan for Management of Western Defoliators, was distributed in draft form in September 1994. The reference is: USDA Forest Service.1994. Strategic/Tactical Plan for Management of Western Defoliators (Draft), FPM 94-7. USDA Forest Service, Davis, CA (Appendix E). The report covers west-wide management of western defoliators, not just that supported by the FPM technology development program. The plan should be useful to those doing research, detection and survey, technology development, and technology transfer. The committee believes this is a significant plan and should be used to coordinate western defoliator activities.

3. Within the background discussion of the plan, the sub-committee identified the need for further committee work to explore approaches to gather, sort, analyze, and apply existing information and data on western defoliator insect biology, dynamics, impact, management, and data gaps. To initiate action on this need the sub-committee will evaluate this need, identify the lead insect (Douglas-fir tussock moth or western spruce budworm), and develop a detailed contract scope of work for a contractual effort. The final product of the contract is envisioned to be an expert system database or comparable system which will serve as a resource in pursuing resources management and technology development activities.

   The committee believes that this is an appropriate activity for considered sponsorship by the NCFH, (see letter, Appendix G).

D. Priorities for Fiscal Year 1995

The committee identified as listed below ten needs/issues for action in FY 95. Each is high priority and the list was forwarded to Director, FPM on August 2, 1994 (Appendix D). The number code following each need is the applicable paragraph to the committee's draft strategic/tactical plan (Appendix E).

- Evaluate the need to continue monitoring of existing population plots established by PNW Wickman and Mason. (2-C-1)

- Determine the effects of western spruce budworm and Douglas-fir tussock moth effects on resources and ecosystem structure and function. (1-B-1)

- Analyze and summarize existing permanent plot data to evaluate effects of a current western spruce budworm outbreak. (1-A-1)

- Evaluate the efficacy of silvicultural treatments designed to prevent/reduce unacceptable effects of defoliation on vegetation, resources, and ecosystems. (3-A-1)

- Evaluate the potential for using natural enemies for population management of Douglas-fir tussock moth and western spruce budworm. (3-B-5)

- Determine the potency of TM Biocontrol-1 with Entotech carrier on wild populations of the Douglas-fir tussock moth from different geographical areas including a) laboratory bioassays, and b) field tests. (3-B-1)

- Validate and calibrate the western spruce budworm damage model. (1-C-1)

- Compare, evaluate, and improve risk and hazard rating systems for western spruce budworm and Douglas-fir tussock moth over different geographical areas. (1-D-1)

- Identify potentially important western hardwood defoliators and evaluate their roles and effects in western hardwood ecosystems. (1-A-5)

- Pursue and obtain registration of the Douglas-fir tussock moth pheromone for mating disruption. (3-B-2)

In addition, the committee recommends special funding for R-10 in the amount of $5,000.00 to evaluate data collected from the first outbreak of spruce budworm ever reported to occur in white spruce stands of Alaska. Data have been collected annually during the outbreak (1990 - 1993). These data include budworm infestation levels; effects on tree growth and survival, cone and seed productivity, and foliage nutrient content; and the incidence of bark beetle attack of defoliated trees. The information from this evaluation would be used to provide guidelines for the development of management activities. This is a cooperative effort between FHM in Region 10 and PNW.

IV. SUMMARY

The National Steering Committee for Management of Western Defoliators met at Spokane, WA, April 12-13, 1994. The primary purpose of the meeting was to prioritize FPM Technology Development Program needs and to revise draft of the Strategic/Tactical Plan for Management of Western Defoliators. The meeting was highly productive with the members reaching consensus on all elements and actions of the plan. The Committee expresses its appreciation to Ladd Livingston for hosting the meeting. The 1995 meeting of the committee will be held at Portland, OR hosted by Bruce Hostetler, R-6.

APPENDICES

A. Meeting call letter with Agenda

B. Non-Target Sub-Committee - Letter

C. Committee Member Reports

D. Technology Development Needs - Letter to Director, FPM

E. Strategic/Tactical Plan for Management of Western Defoliators - Draft

F. Implementing Ecosystem Management - Memorandum

G. Western Defoliator Committee Action Item - Letter to Director, FPM

Appendix A

Meeting call letter with Agenda

United States Department of Agriculture
Forest Service
Washington Office
2121 C Second Street
Davis, CA 95616
PH (916) 551-1715
FAX (916) 757-8383

Reply To: 3400   Date: January 14, 1994

Subject: Meeting - National Steering Committee for Management of Western Defoliators

To: Members

The 1994 meeting of our Western Defoliator Steering committee will be held at Spokane, Washington on April 12-13, 1994, hosted by Ladd Livingston. The purpose of the meeting is to update the 1993 technology development program recommendations and priorities for the Director, Forest Pest Management (WO/FPM), and to advance the draft of the "Strategic/Tactical Plan for Management of Western Defoliators." I suggest we spend one day on the former and another on the latter as shown on the draft agenda.

The strategic/tactical plan draft is awaiting the rationale statements for each of the action items. It's important that these be completed before the meeting otherwise we could get "bogged down" with this effort. Assignments are indicated on the September 8, 1993 draft: John and I appreciate the contributions that have been submitted by three of our members. The next step will be to develop strategies under each of the Actions, contingent upon receipt of your rationale statements.

A block of 15 rooms has been reserved at the Sheraton Spokane Hotel, 322 North Spokane Falls Court, Spokane, WA 99201-0165, (800) 325-3535, fax (509) 455-6285, for 3 nights, 11 April - 13 April. The government rate is $55.00 single occupancy and $70.00 double occupancy, including taxes. Please use the enclosed card to make your reservations by March 21. Public transportation is available from the airport to the Sheraton, and complimentary parking is provided for guests registered at the hotel.

Please give me a call if you have any questions or suggestions. I look forward to meeting with you in Spokane.

JOHN W. BARRY
Chairperson

Enclosures
  Reservation Card
  Draft Agenda

cc: Mel Weiss, WO/FPM
    Jesus Cota, WO/FPM
    Nancy Lorimer, WO/FPM
    Max Ollieu, R-6/FPM
    George Shoemaker, Sheraton

DRAFT AGENDA
(31 January 1994)

National Steering Committee for Management of Western Defoliators

Spokane, WA

12-13 April 1994

April 12		Discussant Leader
0800	Introduction	
	Welcome	Ladd Livingston
	Announcements and Schedule	Jack Barry
	Meeting Objectives	Jack Barry
	FPM Technology Development Program	WO/Representative
0830	Review 1993 Recommendations to Director, FPM	Jack Barry
	Open Discussion - Managing Western Defoliators in Forest Health and Ecosystem Management	Julie Weatherby
	Sub-Committee Reports	Chairs
	Committee Member Reports	Members
	Retrospective on the Western Spruce Budworm and other Related Matters	Bob Campbell (State U.of NY)
1630	ADJOURN	

April 13

0800	Strategic/Tactical Planning	
	Review and Update Draft	John Wenz
	Action Items and Rationale Statements	Contact Scientists
	Develop Strategies under Actions	Contact Scientists
	Update Strategic/Tactical Plan	Members
	Technology Development Recommendations	Jack Barry
	Place, Dates, and Host Next Meeting	Members
1630	ADJOURN	

Appendix B

Non-Target Sub-Committee -
Letter

United States Department of Agriculture
Forest Service
Washington Office
2121 C Second Street
Davis, CA 95616
PH (916) 551-1715
FAX (916) 757-8383

Reply To: 3400

Date: April 15, 1994

Subject: Non-Target Effects

To: Dick Reardon

At the Spokane meeting of the National Steering Committee for Managing Western Defoliators it was decided to cancel the non-target effects sub-committee. It was felt that this committee was a duplication of a goal announced on the National Center for Forest Health Management (NCFHM). The committee is supportive of work that furthers our understanding impact of control agents on non-target organisms. The committee members look forward to working with the NCFHM on this important issue.

John W. Barry

JOHN W. BARRY
Committee Chair

cc: Steering committee members

Appendix C

Committee Member Reports

Dayle Bennett, R-3

Bob Campbell, USFS (Ret.)

Dave Grimble, PNW

Bruce Hostetler, R-6

Roy Mask, R-10

Amy Onken, NCFH

Dick Reardon, NCFH

Lonne Sower, PNW

Julie Weatherby, R-4

John Wenz, R-5

Richard Werner, PNW

Ed Holsten, R-10

R-3 REPORT TO THE WESTERN DEFOLIATOR STEERING COMMITTEE
APRIL 12, 1994
DAYLE BENNETT

The status of defoliators in the Southwestern Region is unchanged from our previous report of August, 1993. Western spruce budworm (WSB) populations increased throughout northern New Mexico in 1993, causing light defoliation on the Carson, Cibola, and Santa Fe National Forests (NF) and on the Navajo Indian Reservation. High WSB egg mass counts have prompted a proposal to conduct a ground application of Bt in 1994 to protect foliage within 14 campgrounds on the Camino Real Ranger District, Carson NF. FPM specialists will be assisting Carson NF personnel in conducting this project.

A Technology Development Project has been funded for FY94-95 to develop, calibrate and validat a usuable hazard rating system for WSB in northern New Mexico. Ann Lynch, Rocky Mountain Station, and myself will be conducting this project.

Bob Campbell, USFS (Ret.)

UNDERSTANDING BUDWORM POPULATION DYNAMICS THROUGH HISTORICAL RECORDS

Abstract -- A study on the population dynamics of the western spruce budworm was based on historical records from nine population-scale projects (Campbell 1993). The study yielded a description of the equilibrium structure of the population system (including systematic spatial and temporal variants in that structure), as well as budworm responses to insecticides, forest conditions, interstand relations, and weather. The results of the study provide a solid empirical basis for modifying several hypotheses about the population dynamics of the pest, and yield information that supplements and modifies guidelines to managers who must deal with budworm-susceptible forests.

The total mass of historical records that have accumulated on the North American needle-eating budworms dwarfs the records I was able to assemble for the above study. In fact, existing data could provide a useable data base on the major budworm species that would include information from states and provinces from the Atlantic coast to the Pacific, and from Alaska to New Mexico. Using budgetary data presented in Stipe and others (1983) and Dohrmann (1988) to estimate the costs of budworm-related data acquisition in Montana and Oregon as a guide, I estimate that about $200,000,000 (in 1988 dollars), as well as at least 50 years of sampling work, would be required to acquire an equivalent data base. To my knowledge, a population-scale data base this massive would be completely unprecedented.

INTRODUCTION

Many authors (for example, Carolin and Coulter 1975, Harris 1977, Morris 1955, Schmid and Farrar 1982) have noted that budworm densities differ among parts of their forest universe. Multicrown sampling (Morris 1955) provides an effective, albeit expensive way to deal with such differences. As an alternative, a largely retrospective study on numerical behavior of the western spruce budworm, *Choristoneura occidentalis* Freeman, hereafter called "western budworm," began when we realized that larvae, pupae, emerging moths, and egg masses of this species all exhibit distinct and rather precise intratree patterns of occurrence (Campbell and others 1984). These results imply that samples drawn from a single crown stratum can provide reliable estimates of density on the whole tree. Consequently, the study described in Campbell (1993) was accomplished by assembling, analyzing, and comparing historical records that were collected primarily from midcrown branch tips. The data were collected between 1959 and 1988, during nine unrelated projects in six western states (Washington, Oregon, Idaho, Montana, Colorado, and New Mexico).

More specifically, a variety of graphic, tabular, univariate, and multivariate techniques was used to produce projection capabilities for both defoliation and each of four budworm densities (eggs per mass, nominal fourth instars, emerging moths, and egg masses). Within limits set by the data, each projection capability summarized relations found between one of these variables and influences in each of the following seven categories: prior budworm density, temporal shifts in survival, spatial differences, insecticide treatment, site and stand conditions, interstand relations, and weather.

In Campbell (1993), I also compared relations between density and age-interval survival in the three major North American needle-eating budworms (the western budworm, the spruce budworm, *C. fumiferana* (Clem.), hereafter called "eastern budworm," and the jack pine budworm, *C. pinus* Freeman). Descriptions of numerical behavior of the eastern and jack pine budworms were extracted largely from publications that document patterns found in small plots; primarily using results in Crawford and Jennings (1989), Foltz (1969), Mott (1963), Royama (1984), and Watt (1963). Many similarities were found among the three species in density-survival relations; just as equivalent similarities are evident between eastern budworm data derived from the midcrown samples of MacDonald (1963) and the multicrown-based sample data of investigators such as Mott (1963) and Watt (1963). These many similarities provide strong support for the idea that samples drawn from midcrown branch tips can yield an acceptably precise sequence of density estimates for many studies on the population dynamics of these three species.

INDICES OF ENVIRONMENTAL INFLUENCES

With rare exceptions, historical records will <u>not</u> provide an adequate basis for developing explicit, empirically based models of the processes that are important in budworm dynamics. Rather, the strength of such records lies primarily in two areas: the uniquely broad bases they provide to evaluate existing population-related hypotheses, and the clues they provide about population-related processes.

Prior Budworm Density

In all the needle-eating budworms, stage-specific rates of numerical change are often related to density at the start of the stage. More precisely, prior density entered first or second in every one of the 22 stage-specific multivariate models tested against the western budworm by Campbell (1993). For example, Figure 1 shows mean apparent survival rates for three stage-specific intervals (eggs to fourth instar, fourth instar to emerging moths, and egg masses per emerging moth) in three projects (IDAHO, MONTANA, and NEW MEXICO A). In the figure, the data were stratified into low, medium, and high density categories, and survival rates were calculated for each project and category. In all three projects, both mean survival from eggs to fourth instar and the number of egg masses found per emerging moth decreased as density increased. Conversely, density and mean survival from fourth instar to adults increased together.

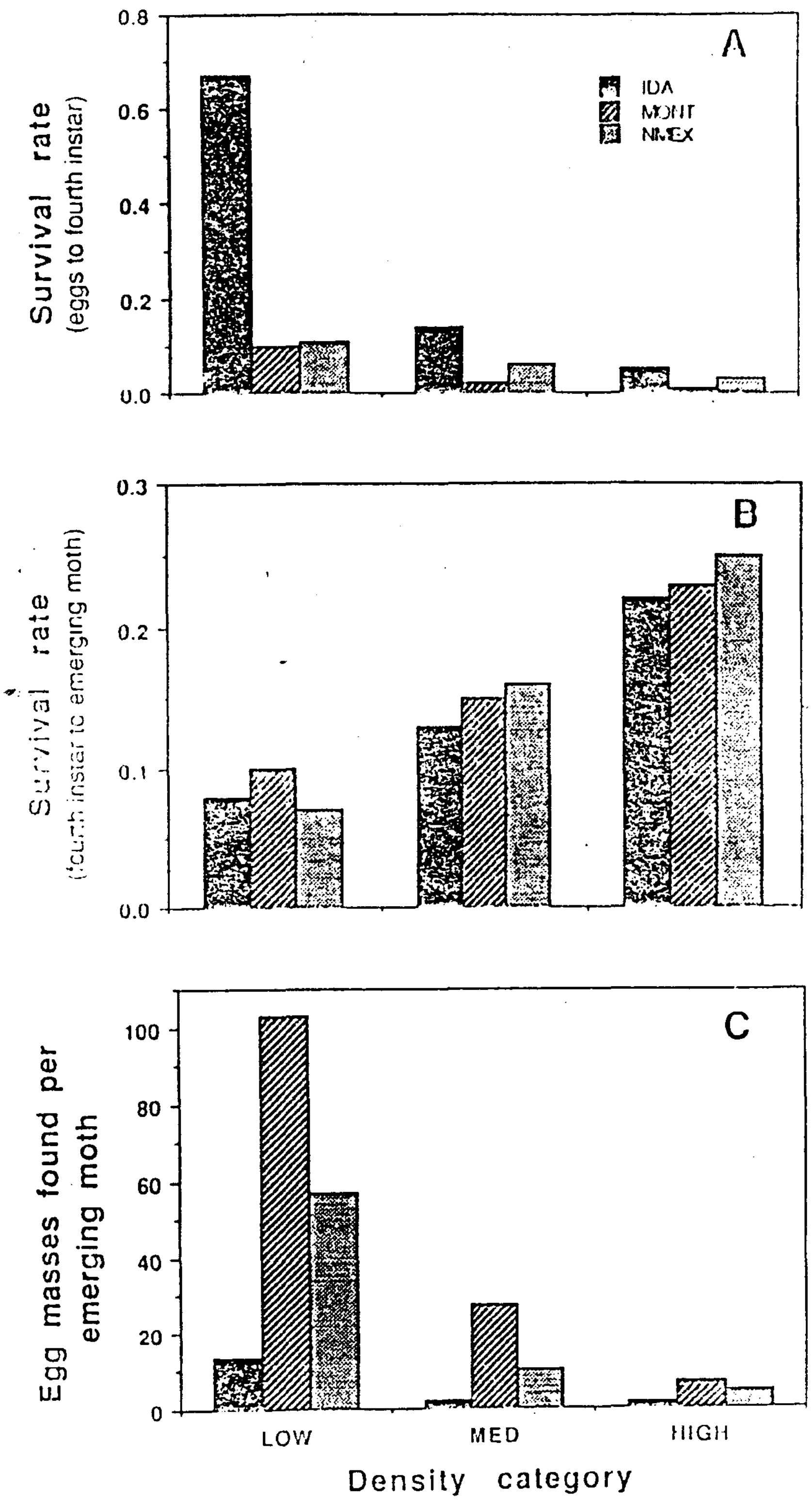

Figure 1 - Mean survival rates in plots where densities were categorized as low, intermediate, and high in IDAHO, MONTANA, and NEW MEXICO A.

Temporal Shifts

Many investigators agree that systematic temporal shifts in the survival rate of large larvae are important in budworm dynamics (Blais 1985, Campbell 1993, Morris 1963, Royama 1984). In the western budworm, for example, density-related phenomena in any given area often differed systematically from one year to the next. In fact, after prior density, an index representing systematic year-to-year differences was usually the second variable to enter the multivariate western budworm models (Campbell 1993). In populations of this pest, three of these differences -- defoliation, survival from eggs to half-grown larvae (fig. 2), and survival from half-grown larvae to emerging moths (fig. 3) -- systematically declined across the course of extended outbreaks. Interestingly, survival from half-grown larvae to emerging moths was remarkably similar in eastern and western budworm populations, at least from about 1 to 20 half-grown larvae per m^2, and during the late phase of this particular western budworm outbreak (fig. 3).

Spatial Differences

Under apparently identical conditions, trends in budworm numbers may still differ systematically among areas. For example, comparison among the western budworm data sets suggests a systematic west-to-east decline in early instar survival during prolonged outbreaks (Campbell 1993). Here are some projected values for both westerly populations (OREGON and IDAHO) and those further east (MONTANA, NEW MEXICO A, and NEW MEXICO B).

Survival rate from eggs to fourth instar projected from:

Area	100 eggs per m^2	400 eggs per m^2
OREGON (1985-88)	0.222	0.070
IDAHO (1980-81)	0.228	0.088
MONTANA (1981-83)	0.041	0.019
NEW MEXICO A (1977-79)	0.079	0.047
NEW MEXICO B (1979-84)	0.082	0.035

These results, which are compatible with a mortality-causing process described by Perry and Pitman (1983), are postulated to reflect a west-to-east increase in the inherent ability of interior Douglas-fir to respond to budworm outbreaks.

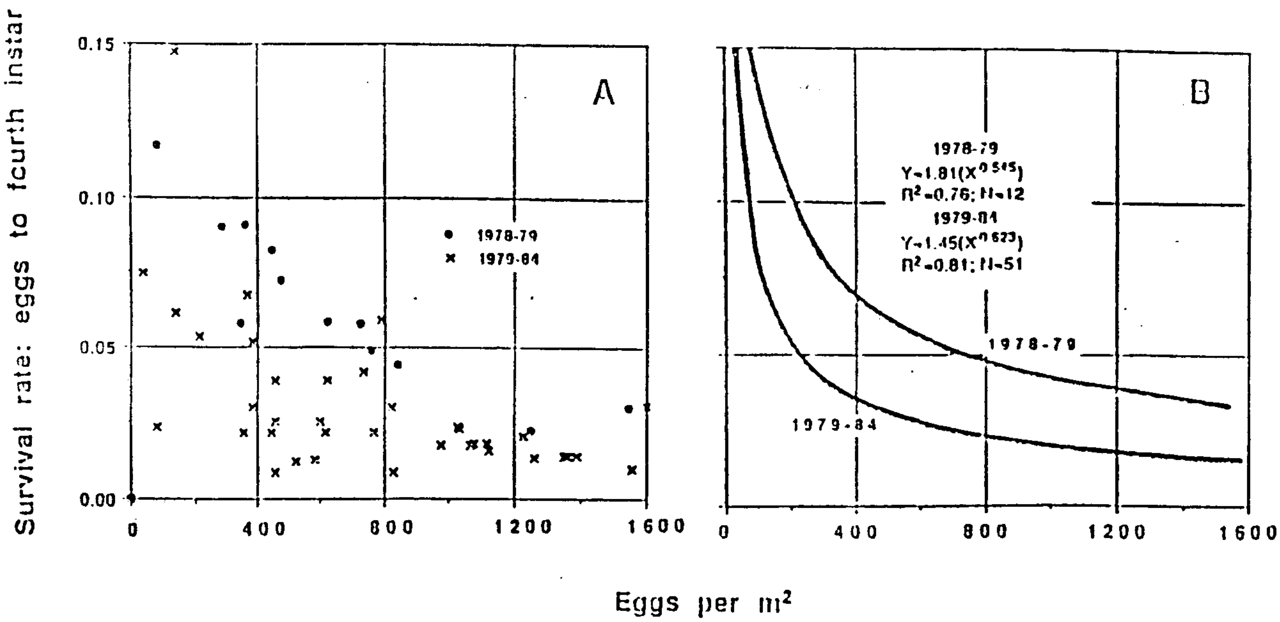

Figure 2 - Egg density and survival rate from eggs to fourth instar in the New Mexico Damage Assessment: A, scatter diagram, 1978-79 and other years; B, comparison, 1978-79 and other years (from Campbell 1993).

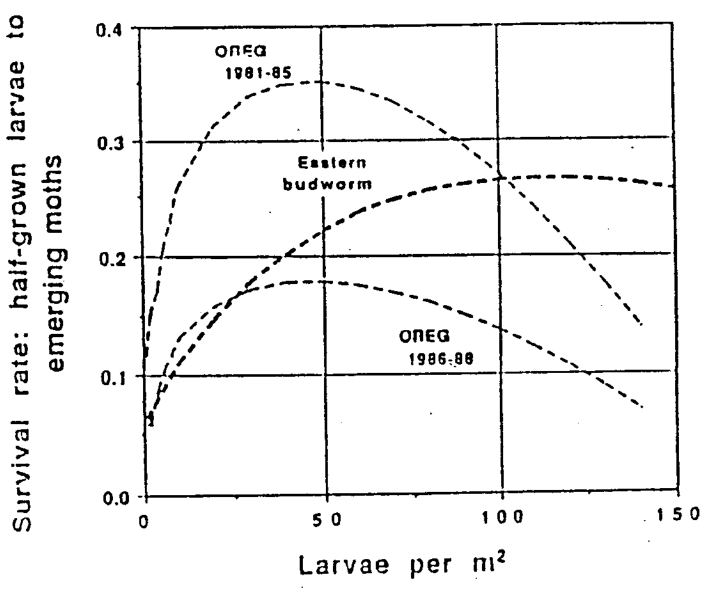

Figure 3 - Density of fourth instars (if western budworm) or third instars (if eastern budworm) and survival rates to emerging moths. Western budworm relation is from an outbreak in Oregon; eastern budworm relation adapted from Watt (1963). The figure is from Campbell (1993).

Insecticides

In projects involving insecticide treatment, the third variable to enter most of the multivariate western budworm models tested by Campbell (1993) was an index representing differences between treated and untreated plots. Surprisingly, perhaps, western budworm survival rates and defoliation both tended to be higher in control plots than in treated ones during posttreatment years (fig. 4). These results, together with information in papers such as Dimond and Morris (1984) and Fleming and others (1984), suggest that the timing (year) of a pesticide application during a multi-year outbreak can influence subsequent budworm survival rates and defoliation intensity.

Site and Stand

In recent years, interest in managing forest pests has often shifted from controlling outbreaks to preventing future ones through judicious forest management (Blum and MacLean 1984, Carlson and Wulf 1989, Mason and others 1989). For this reason, a central purpose of Campbell (1993) was to examine relations between budworm numbers and attributes of sites and stands. Unfortunately, only weak correlations were usually found between the western budworm and such attributes. Further, these correlations were often both inconsistent among areas and unstable within any given area. In contrast, the positive relations between the proportion of Douglas-fir in the overstory and the number of egg masses found per emerging moth (fig. 5) leave little doubt that gravid western budworm adults gravitate to stands with a high proportion of this host.

Interstand Relations

Relations between the density of emerging western budworm moths and the subsequent density of egg masses are shown for each of two years or an area in northern New Mexico (fig. 6). Enormous variability occurs in this relation in the western budworm, both from year to year in an area (fig. 6) and among areas (fig. 7). For comparison with the western budworm, Figure 7 also shows the projected relation between emerging moths and subsequent eggs found per moth in some eastern budworm populations in New Brunswick. In both species, egg production per emerging moth clearly varied inversely with the density of emerging moths.

Greenbank and others (1980) used radar to conclusively demonstrate that mass flights of gravid eastern budworm females are rather commonplace, and a summary of results (fig. 7 and Campbell 1993) suggests that this phenomenon is common in all three budworms. These and similar results led me to suggest that planners for forest-wide budworm-related management should make coping with such interstand flights a linchpin in developing their strategies (Campbell 1993).

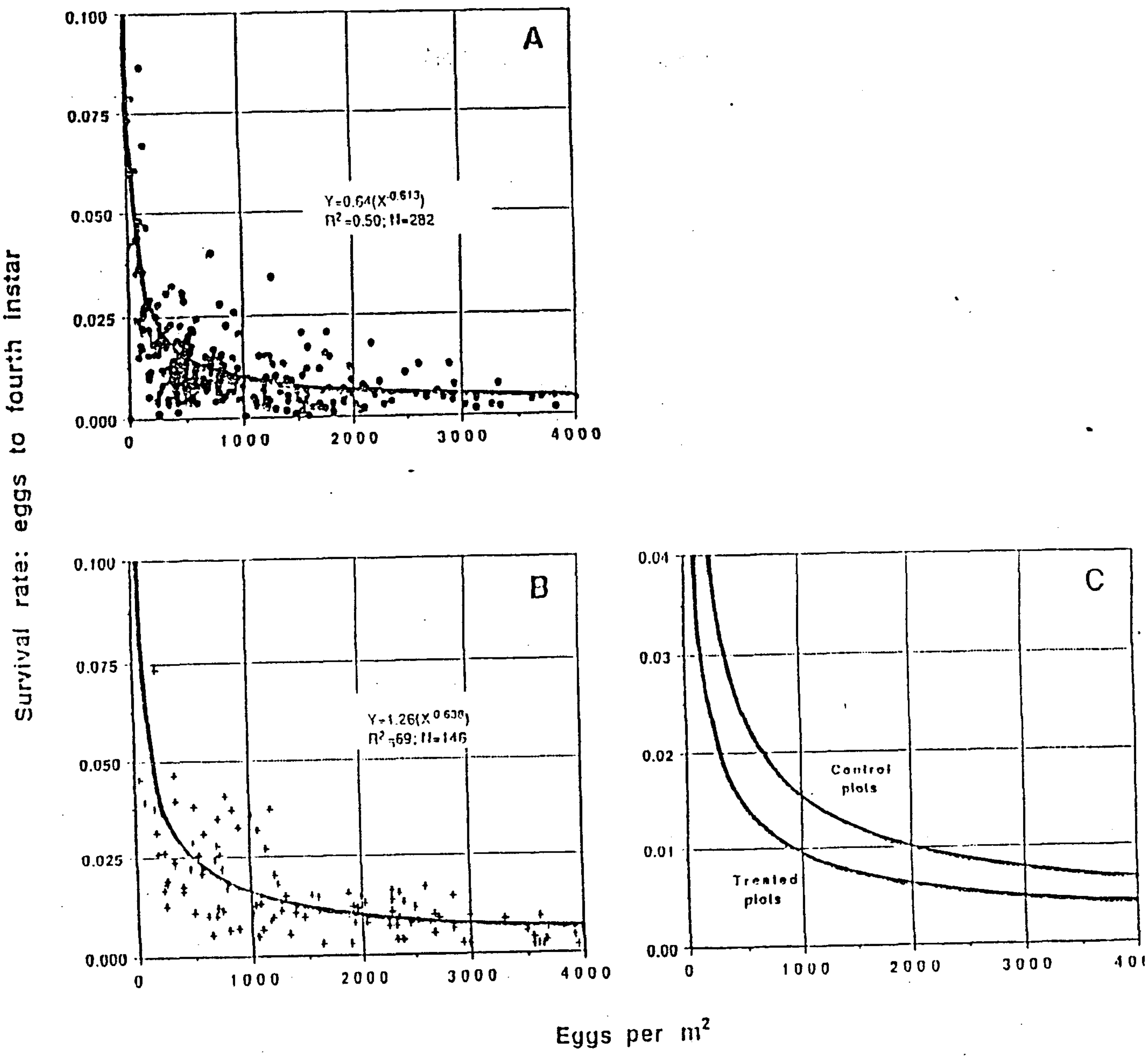

Figure 4 - Egg density and survival rate to fourth instar after insecticide treatment in the Montana B.T. Project: A, treated plots; B, control plots; C, comparison, treated and control plots (from Campbell 1993).

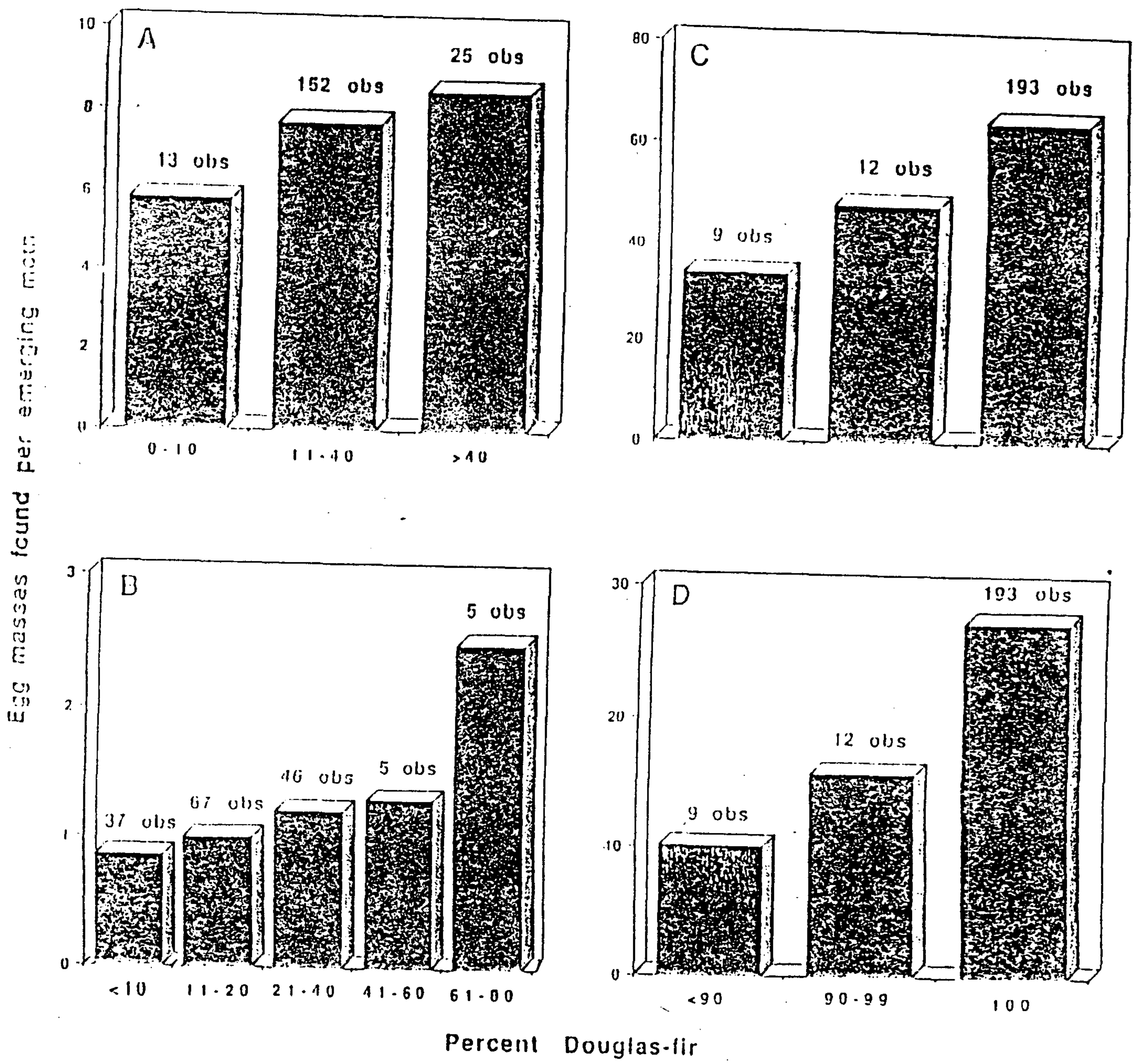

Figure 5 - Proportion of Douglas-fir in the overstory and the number of egg masses found per emerging moth: A, New Mexico Suppression Project; B, Idaho Control Project; C, Montana B.T. Project in 1982; D, Montana B.T. Project in 1983 (from Campbell 1993).

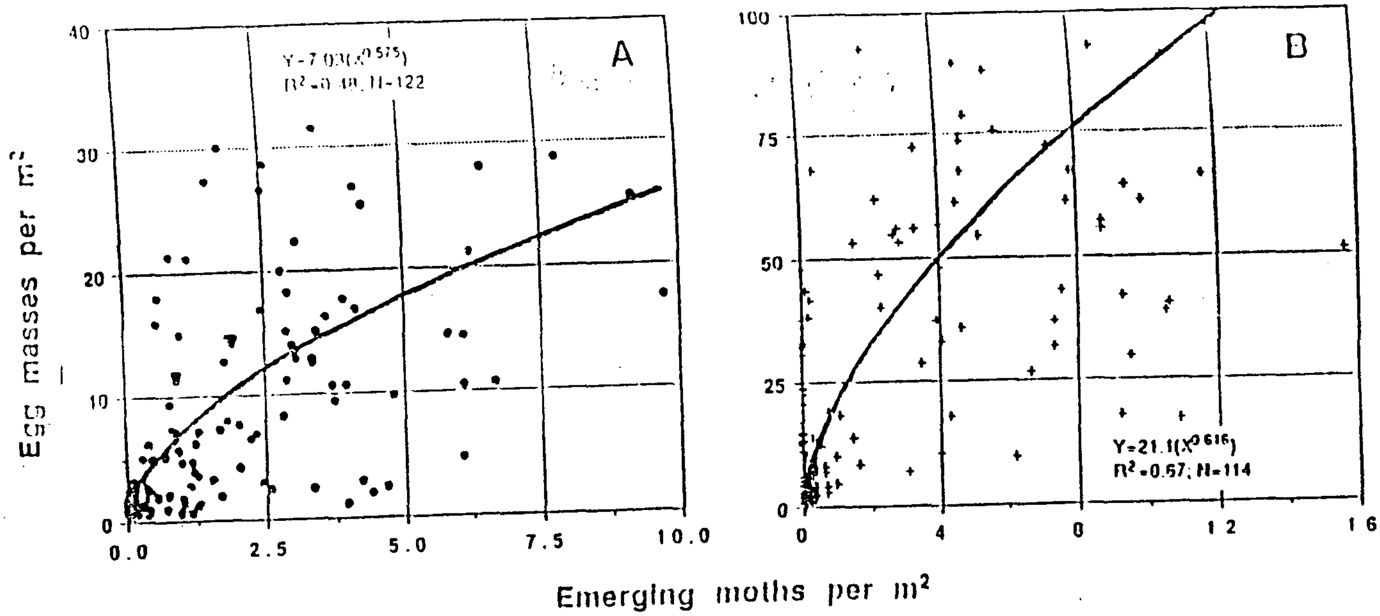

Figure 6 - Emerging moths and subsequent egg mass density in the New Mexico Suppression Project: A, 1978; B, 1980 (from Campbell 1993).

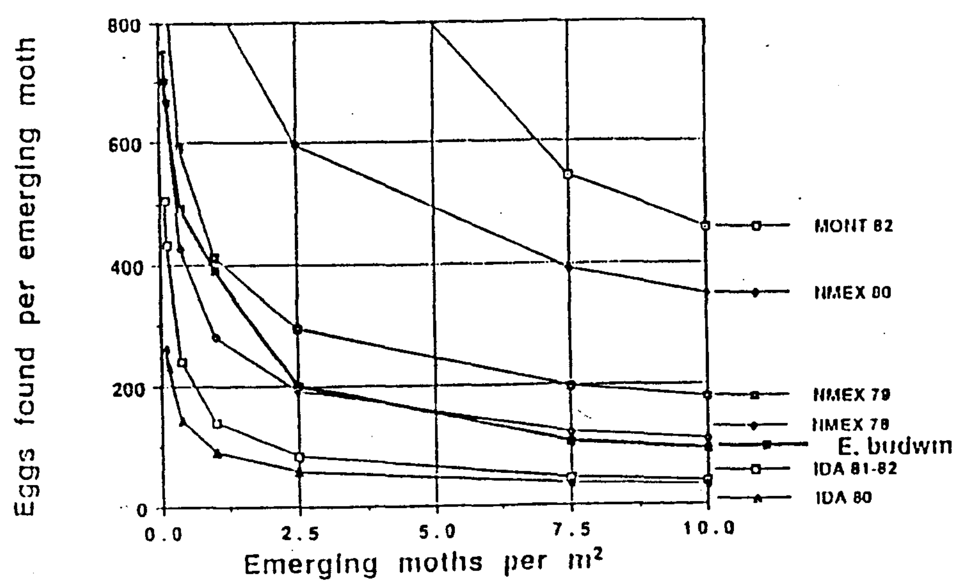

Figure 7 - Emerging moths and projected eggs found per moth (western budworm relations are from Campbell 1993; eastern budworm relations adapted from Royama 1984). The figure is from Campbell (1993).

Unfortunately, although several authors have touched on the need to develop a regional management strategy for budworm-susceptible forests (for example Blum and MacLean 1984, Campbell 1993, Clark and others 1978, Mattson and others 1988, Sippell 1984), only a few rather preliminary tools related to budworm dynamics have been developed to meet this need. For example, two indices of interstand influences in western budworm population dynamics are shown in Figures 8 and 9. In the first (fig. 8), fourth instar density in year (n) is shown as a function of the distance to visible defoliation in year (n-1). In the second (fig. 9), egg mass density is shown as a function of an index of outbreak size. These indices and other methods, such as a variety of geostatistical techniques (Isaaks and Srivastava 1989) should be used in evaluating similar historical data sets.

Weather

Some of the reported correlations between weather phenomena and budworm survival reflect relations that operate directly on the budworm (for example, Fellin and Schmidt 1973, Lucuik 1984). Other correlations reflect cause-and-effect relations that operate primarily through their influence on the host (for example, I. Campbell 1989, Clancy 1991, Mattson and Haack 1987). Whatever the causal pathways, in each of the budworm life systems biologically significant and, occasionally, drastic changes in budworm numbers have been correlated with particular temperature or moisture conditions (Campbell 1993, Greenbank 1956, Hard and others 1980, Kemp 1985, Pilon and Blais 1961, Volney 1988). In any case, there is a need for a data base that will allow an analyst to examine differences in age-interval survival among many places and budworm generations as a function of relevant weather phenomena. For example, a close correlation was found in Montana between mean May temperature and subsequent budworm egg-mass density (fig. 10). Further evaluation would reveal whether such correlations could provide reliable indices of budworm trends.

USEFULNESS OF HISTORICAL RECORDS

Recently, Volney (1989) labeled the eastern budworm "the most destructive pest of living trees on the continent." Thus, it is not surprising that this insect is one of the world's most studied organisms (Knight 1981). Nevertheless, information on the population dynamics of the pest "... is far from complete, and some of it is controversial" (Blais 1985). In particular, Blais noted that conclusions derived from one region and during one outbreak "...do not necessarily apply at large. It is dangerous to generalize on studies limited in time and place." Recent results (Campbell 1993) extend this advice to the western budworm. For many species, in fact, it may not be enough to describe system behavior either through time at any one place, or in many places during a single gradation. Rather, meaningful insights into relations between a species and its environment may only come when its population dynamics "... is known

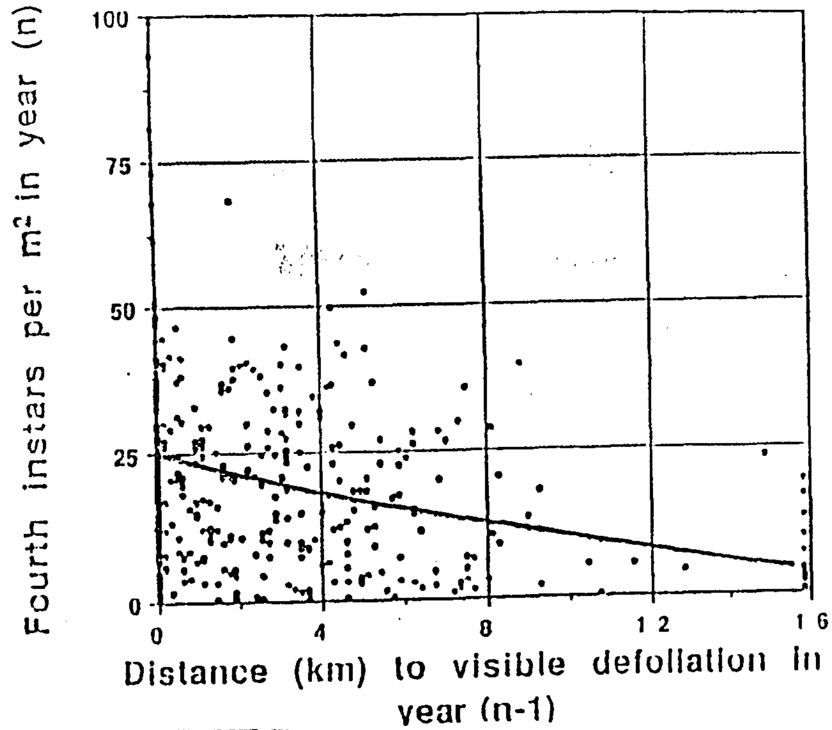

Figure 8 - Distance to visible defoliation in year (n-1) and fourth instar density in the Idaho Control Project; starting density ≤ 100 eggs per m^2. (By definition, distances ≥ 16 km = 16 km) (from Campbell 1993).

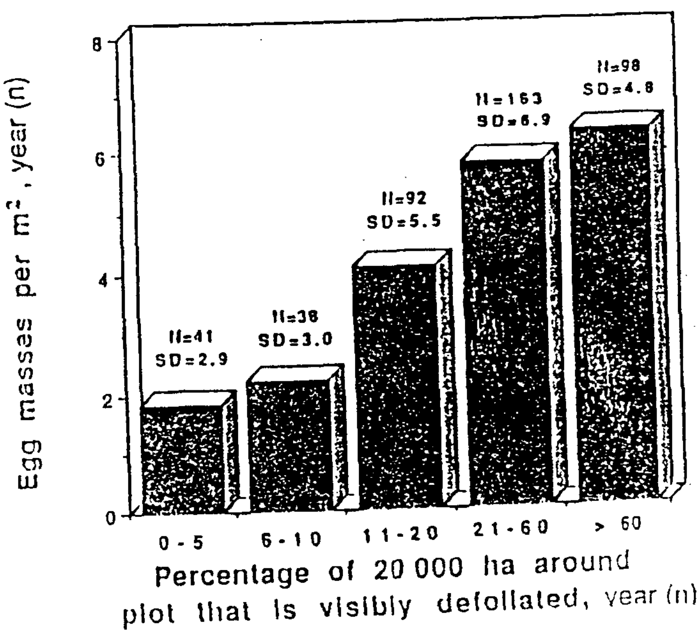

Figure 9 - Outbreak size and egg-mass density in the Idaho Control Project (from Campbell 1993).

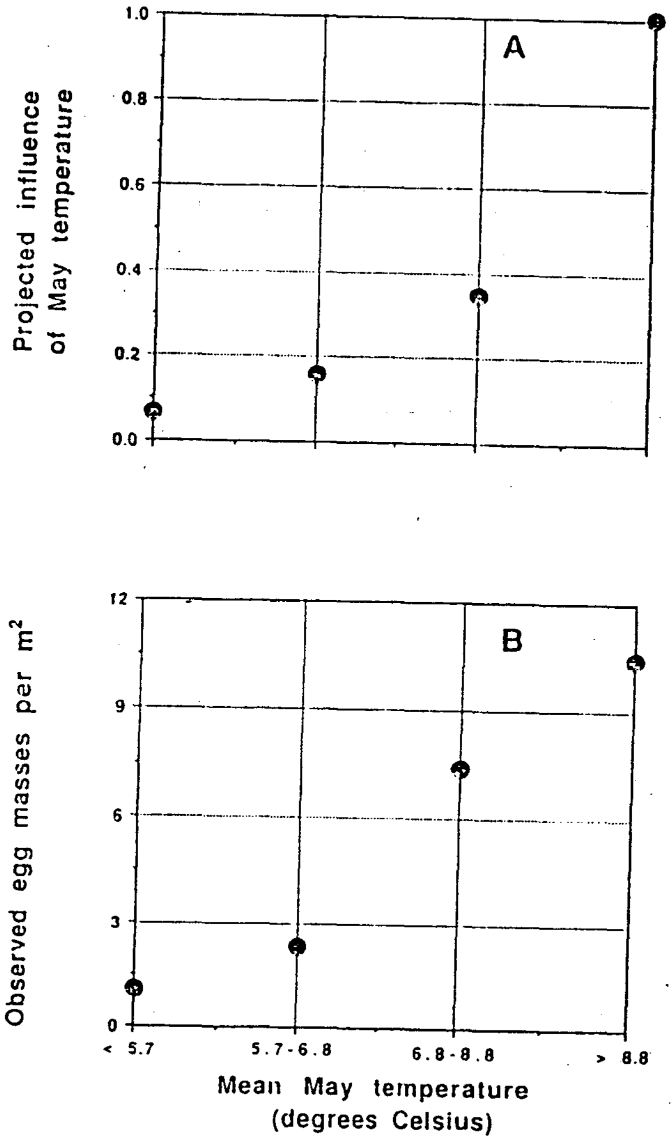

Figure 10 - Correlation between mean May temperature and density in the Montana Baseline Project; A, influence projected b coefficients; B, mean egg-mass densities at the end of the generation (from Campbell 1993).

for different competitive situations under different ecological conditions throughout its geographic range" (Organ 1961).

In a critique of several research and development programs on major forest pests, Allen and others (1982) noted that "fiscal constraints and public demands for accountability indicate that researchers can no longer either pursue 'hobbies' or devote many years to every detail of a pest's ecology." Also, as Gilbert (1976) pointed out, ascertaining that an outbreak may occur is not enough. Projections are also required on both likely outbreak-related effects and the efficacy of possible controls. Despite all these concerns, managers must have several packages of budworm-related information to fully implement integrated pest management in budworm-susceptible stands. First, to make intelligent budworm-related decisions, managers need a working knowledge of the processes that dominate year-to-year changes in budworm numbers. Second, to derive optimal results from management activities, managers need to be able to project the likely consequences of these activities on the numerical behavior of subsequent budworm generations. Third, managers need a device that will allow them to put budworm-related activities in a larger planning context. More generally, a clear understanding of how naturally-occurring population control processes work is of fundamental importance in our efforts to solve problems ranging from controlling insect pests and setting harvest limits to conserving endangered species. Information obtained by assembling and analyzing the magnificent data base that appears to be available on the North American needle-eating budworms could provide important guidelines for many of our efforts to understand and use the natural processes that control animal numbers.

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Bob Campbell's recommendations from

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6 Recommendations

If the only alternative to an overly simple model is an elaborate framework of guesses, nothing much has been gained.

—From "Mathematical Ecology" by E.C. Pielou (1977)

IPM implies a compatible blending of three elements: management practices, the natural processes of pest control, and uncertainty. Unfortunately, in attempting to develop IPM, the element of uncertainty has often been managed badly. What starts out as a plausible hypothesis may soon be perceived as established truth, a mistake that can block the very paths that would lead to better management. In short, an investigator must be willing to say "I don't know."

6.1 Historical Records

A major body of untapped information is undoubtedly contained in the records that continue to accumulate about our forest pests. Currently, investigators who propose to use such records in retrospective studies may be frustrated by the following problems: (1) identifying studies that contain relevant information; (2) finding stored and ignored records; (3) coping with the lack of a subset of variables common to several data sets, preventing full use of otherwise valuable records; and (4) specifying realistic objectives, which may be impossible until after the available records have been identified, acquired, assembled, and evaluated. A few suggestions follow.

- Many studies that contain potentially valuable information are not identified in the published record. To alleviate this problem, I think that an annotated catalog should be assembled for each of our major North American forest pests that identifies and describes the records that document all population studies, pilot control projects, damage assessments, and related work.

- The loss of most of the gypsy moth-related Melrose Highlands records during a disastrous fire at the Forest Insect and Disease Laboratory in New Haven, Connecticut, is a reminder (Campbell 1967) that records can be lost even when they are known to be worth saving. Both to minimize such losses in the future and to make the information broadly available, I think that forest management organizations should publish more of their data and not just summarize results. Model publications include the sequence of annual reports on the New Mexico Control Project, which begins with Parker and others (1978), and the report by Stein and McDonnell (1982) on the New Mexico Damage Assessment Project.

- A lot of money is spent to obtain reliable estimates of pest population density. Frequently, however, a sampling technique developed in one area may be modified to accommodate conditions, objectives, or constraints in another area (Allen and others 1984). To ensure that these estimates will be fully usable, I think that North American forest research and management organizations should agree on a common minimal subset of variables for each major pest and include estimates of these common variables in all subsequent population studies and projects.

- Several time-consuming steps may have to be completed before realistic objectives can even be specified for a retrospective study. First, the study may have to begin with a search for relevant records. Second, once identified, the records have to be acquired and assembled. Third, the assembled data have to be evaluated to get a preliminary idea about their strengths and their shortcomings. Sadly, research managers do not smile on projects that require such a long gestation before the investigators can even specify what they hope to achieve. To alleviate this problem, I think that major retrospective studies could be authorized in a sequence of two or more parts. For example, authorization to identify, acquire, and assemble relevant historical records should provide a basis for subsequent decisions about the assembled data.

6.2 Budworm Population Dynamics

In a critique of several research and development programs on major forest pests, Allen and others (1982) noted that "...fiscal constraints and public demands for accountability indicate that researchers can no longer either pursue 'hobbies' or devote many years to every detail of a pest's ecology." Also, as Gilbert (1976) pointed out, ascertaining that an outbreak may occur is not enough. Projections are also required on both likely outbreak-related effects and the efficacy of possible controls.

Despite all of these problems, managers must have several packages of budworm-related population information to fully implement the pest management philosophy of the USDA Forest Service in budworm-susceptible stands. First, to make intelligent budworm-related decisions, managers need a working knowledge of the processes that dominate year-to-year changes in budworm numbers. Second, to derive optimal results from management activities, managers need to be able to project the likely consequences of these activities on the numerical behavior of subsequent budworm generations. Third, managers need a device that will allow them to put budworm-related activities in a larger planning context.

The results in this paper suggest several studies that will be required to fully implement pest management in budworm-susceptible forests. These recommended studies support and extend Mitchell's (1987) recommendations for further work on the population ecology of the western budworm. In addition, the decision-support system projected earlier for this pest (McFadden 1979, Twardus and Brookes 1983, Wickman 1976) has now incorporated many untested hypotheses about various aspects of budworm population dynamics, including several hypotheses that are not supported by the results of this study— for example, elements in Carlson and others (1985a), Sheehan and others (1989), Stark and Wright (1987), and Wulf and Cates (1987). The recommended studies provide a basis for testing and modifying many of these elements, and for developing and testing components for an improved IPM system.

In addition, the results of this study strongly suggest that the principal differences among the dynamics of the genetically similar populations of the western, eastern, and jack pine budworms arise from differences among their host sites, stands, and communities of natural enemies, together with systematic differences in weather among the three pest distributions. Thus, the interspecies patterns and comparisons displayed in figures 43, 46, 48, 51, and 54 suggest many opportunities to optimize the value of individual study results through a deliberate series of comparable studies on the population dynamics of all three pests. In particular, continent-wide trends in components of the budworm life systems, across a wide range in densities, could provide an effective way to monitor northern and alpine terrestrial environments for possible changes in ecosystem resilience. Realistically, some of these studies will require a coordinated interregional effort. Here are some suggested objectives for such an effort and a procedural framework for reaching them.

6.2.1 Population Processes and Environmental Influences

The dynamics of the budworm populations reported here exhibited several major attributes that refute commonly accepted notions. To ensure that appropriate budworm-related management decisions will be made in budworm-susceptible forests, further information is needed on certain population attributes and processes known to be important and on more precise ways to project the consequences of these attributes.

Objective 1: Evaluate the roles of predation, macro-parasitism, and disease in the dynamics of sparse populations.

Background—Some process or processes commonly maintain populations of both the eastern and western budworms at sparse densities. In the Northwest, exclosure trials show that predation by birds and ants provides a low stable equilibrium density. In eastern forests, stomach analyses of feeding birds also suggest that birds play a major role in sparse populations, but exclosure trials have yielded equivocal results. In the Southwest, only fragmentary studies have been conducted on these processes.

Recommendation—Conduct standardized exclosure trials and acquire standardized estimates of density and mortality-by-cause on about 12 sites in each of five regions (Pacific Northwest, northern Rockies, southern Rockies, Lake States, and Maine). In Canada, equivalent regions might be British Columbia, the Prairie Provinces, Ontario, Quebec, and the Maritime Provinces.

Objective 2: Assemble a basis for projecting within-generation survival in sparse populations as a function of both resident budworm density and characteristics of sites and stands.

Background—In both eastern and western forests, susceptibility to budworm outbreaks and vulnerability to subsequent damage are determined by some processes that are identical and some that are very different. Thus, attempts to deduce causes of susceptibility from observations of outbreak phenomena (such as defoliation) can be misleading. Unfortunately, such attempts currently provide most of the basis for recommended silvicultural treatments of budworm-susceptible forests.

Recommendation—Acquire standardized estimates of both density and site and stand characteristics on about 30 sites in each of the five specified regions. **Note:** In each region, 12 of these sites could also be used to achieve objective 1.

Objective 3: Evaluate the roles of interstand migration by gravid moths in the release of sparse populations to outbreaks, the year-to-year maintenance of outbreaks, and declines from outbreaks to sparse populations.

Background—In both eastern and western forests, immigration of gravid moths commonly exceeds the combined effects of emigration and on-site moth mortality. In western forests, several documented outbreaks would almost certainly have declined without occasional massive migration. In both eastern and western forests, however, the role of moth migration in budworm dynamics continues to be in dispute.

Recommendation—Acquire standardized estimates of density, including moth catches in pheromone-baited traps, from about 25 sample points in each of 12 sites (6 sparse and 6 outbreak) in each of the five specified regions. **Note:** In each region, the six sparse sites used here could also be among those used to achieve objectives 1 and 2.

Objective 4: Assemble a basis for projecting sources and sinks for gravid moths as a function of both site and stand characteristics and interstand attributes.

Background—Site and stand attributes have a major influence on where female moths deposit their eggs. In the West, at least, some areas appear to be chronic "sinks" for gravid moths. Conversely, some evidence suggests that even a chronic sink may occasionally be the source of a massive outflight.

Recommendation—Acquire standardized data on defoliation, site and stand characteristics, and interstand influences from each of the specific sampling points, sites, and regions used to reach objective 3.

Objective 5: Evaluate the role of host responses induced by defoliation in budworm population dynamics.

Background—In the West, the survival rate of small larvae changes from a relatively high and constant rate at the start of an outbreak to a relatively low, density-dependent one as the outbreak progresses. This pattern is consistent with findings that some host foliage becomes toxic to the pest as an outbreak progresses. Declining values of both defoliation and large larval survival also occur during outbreaks and appear to be functions of declining foliage quality. Apparently, defoliation activates some sort of defensive responses by the host trees. Some of these patterns also appear to occur in the life systems of both the jack pine with jack pine budworm and the balsam fir with eastern budworm.

Recommendation—Acquire and freeze foliage samples from each site used to reach objectives (3) and (4). Depending on population trends, bioassay these samples for insights into underlying processes.

6.2.2 Evaluating Treatment Efficacy

To select appropriate management tactics and develop optimal total strategies, managers need a quantitative basis from which to project the budworm-related consequences of various possible management actions. Much of this quantitative basis still remains to be developed.

Objective 6: Evaluate the efficacy of various silvicultural options in maintaining budworm populations at sparse densities.

Background—Unlike the standardized protocols used to evaluate insecticides, no equivalent protocols exist for evaluating the efficacy of silvicultural treatments in modifying budworm dynamics. Further, in both eastern and western forests, the vast majority of current silvicultural guidelines for keeping populations sparse have been extrapolated from studies based on outbreaks.

Recommendation—Acquire standardized estimates of both density and within-generation survival in sparse populations on at least three replicates of each silvicultural treatment widely used in budworm-susceptible forests in each of the five specified regions. **Note**: In each region, data accumulated to reach objective 2 could provide baseline survival rates for untreated stands.

Objective 7: Evaluate the role of host responses to defoliation in determining insecticide efficacy during posttreatment years.

Background—In Montana, New Mexico, and Idaho, western budworm survival during posttreatment years was consistently lower in blocks that had been treated with an insecticide. This difference in budworm survival between treated and untreated blocks is thought to arise from defensive responses to defoliation by the host trees. Similar but weaker posttreatment responses after insecticide treatment have also been noted in the life system of the eastern budworm. To my knowledge, insecticide applications have never been deliberately timed to complement such host responses.

Recommendation—Conduct standardized insecticide trials in a new outbreak (3 treatment blocks and 12 check blocks) in each of the specified regions. Assuming that the outbreak persists, treat three of the check blocks each year for each of three subsequent years. Maintain density and defoliation records on all blocks for six years. In addition, accumulate and freeze foliage samples from each block. Depending on results, bioassay these samples for insights into underlying processes.

6.2.3 Modeling Budworm Dynamics

Decision-support systems that provide managers with the ability to test a variety of management alternatives in a model of the ecosystem have become "the heart" of IPM (Berryman 1986). Because of their central position, the models imbedded in these decision-support systems must yield reasonably accurate projections.

Objective 8: Validate and improve current models for DEF, EG, N_L, N_A, and N_M, and calibrate them for each of the specified regions.

Background—In this work, I have described projection capabilities for both defoliation and four successive western budworm densities (eggs per mass, fourth instars, emerging moths, and egg masses). Within limits set by the data, each projection capability summarizes relations found between one of the above dependent variables and influences in the following categories: attributes of sites and stands, density dependence, interstand influences, weather, systematic year-to-year differences, and influences of insecticide treatment.

Recommendation—Ensure that objectives 1 through 7 are met. Together, they provide the information needed to reach this objective.

Objective 9: Develop and field-test a regionally calibrated and management-oriented model of budworm population dynamics.

Background—At present, western managers can either use a model that "...simulates the processes that affect budworm population dynamics in great detail" (Sheehan and others 1987), or they can virtually ignore budworm dynamics, assume a particular outbreak duration, and use their best guess about expected defoliation.

Recommendation—As Holling (1978) noted, "A simple but well-understood model is the best interface between a complex system and a complex range of policies." The analyses in this paper were intended to provide much of the basis for just such a model. First, this model should be developed. Second, it should be field-tested and calibrated against the information assembled to reach objectives 1 through 8.

Dave Grimble, PNW

IMPACTS OF BACILLUS THURINGIENSIS ON NONTARGET LEPIDOPTERA IN WESTERN CONIFEROUS FORESTS

by

David G. Grimble

Pacific Northwest Research Station
3200 SW Jefferson Way
Forestry Sciences Laboratory
Corvallis, OR 97330

NAPIAP Study No. : PNW-43

(PROGRESS REPORT FY 1993)

Approval:

____________________ Date: ____________________

Gary Daterman, Program Manager
Protection of Forest Health and Productivity RD&A Program
PNW Forest and Range Experiment Station
Portland, OR 97208

USFS Contact: D.G.Grimble, (503-750-7366)

INTRODUCTION

Microbial insecticides are preferred for suppression of forest defoliators because of their insect selectivity, high degree of environmental safety, and general public acceptance. Since 1980, Bacillus thuringiensis Berliner subsp. kurstaki, known as Bt, has been the microbial of choice for most forest spraying in the United States and Canada. Although Bt is a lepidopterous disease agent and its relative safety has been determined for most organisms in the environment, such as birds, fish, mammals, some non-lepidopterous insects and other arthropods (e.g. Eidt 1985; Niwa et al. 1987; Kreig and Langenbruch 1981). Questions, however, frequently arise about whether or not other desirable moths and butterflies in the spray area may be decimated along with the target species. In a study related to the gypsy moth suppression program in oak stands in Oregon in 1986, Miller (1990) found that 35 species in 10 lepidopterous families were reduced in abundance, at least temporarily, by Bt sprays. In that instance, however, Bt was sprayed three times in one season over the same acreage, whereas for western spruce budworm or Douglas-fir tussock moth suppression, the norm is only one spray per year and many years interval before that control is again necessary. No investigation of the effects on nontarget lepidoptera in western mixed coniferous forests has yet been done, although it is known that many species of nontarget lepidoptera exist in areas sometimes sprayed for western spruce budworm and/or Douglas-fir tussock moth suppression (Forsberg et al.1986).

With the prospect of increased use of Bt for forest protection in the future, it is essential that we learn more about which nontarget species may be unintentionally affected and what the long-term impacts of Bt-use might be. We know that, within the lepidoptera, degrees of vulnerability exist. Some species are in the wrong life stage to be affected when sprays are applied, some are protected by their secluded life styles (stem borers,leaf tiers), and some lack the necessary acidic gut pH and enzymes which would make them susceptible to infection (Flexner et al.1986). This study was begun to establish baseline data necessary for evaluation of Bt impacts on nontarget lepidoptera present on potential spray sites. Specific objectives were: 1. to determine species diversity and relative abundance of nontarget lepidoptera present in typical eastern Oregon mixed coniferous forests, with particular emphasis on those species in larval form at the time when spraying might occur; and 2. to evaluate the relative vulnerability of those species to Bt sprays, considering their life styles and biological characteristics.

METHODS

In April 1992, paired plots were established in the Umatilla N.F. and the Wallowa-Whitman N.F.(Table 1). In each forest, two 16 Ha (40A.) plots were located about 1 km apart in areas with riparian vegetation, either along Meadow Creek or in spring-fed wet areas. Plots were rectangular in shape with the long axis along the watercourse, to maximize inclusion of riparian vegetation. Plots 1 and 2 were located on Starkey Experimental Forest, about 10 km east of plots 3 and 4 in the Pearson Creek drainage. All four plots had similar woody vegetation present (Table 2), as well as a wide variety of grasses and forbs. All plots were subject to at least light grazing, but Plot 1 did contain some fenced areas to exclude cattle. In June 1993, we were informed that the Endangered Species Act was being enforced to protect the Salmon River fishery and we would , therefore, not be allowed to spray BT on Plot 1 as planned. Thus,a substitute plot (Plot 5) was established on Battle Creek about 3 miles south of Meadow Creek, still within the Starkey Experimental Forest (Table 1). Plant species on this drainage were essentially the same as on Meadow Creek; the primary difference at this site was that the creek normally dried up in mid-summer, whereas Meadow Creek has year-round running water.

Two ULV black light insect traps were placed in each plot during the first week of May 1993, as in 1992. The traps were operated for 3 consecutive nights per week until October 1. Moths were collected daily in separate cups for each trap and transported to the lab for later identification by a specialist. Thus, the traps sampled populations of all moth species present on the plots, except possibly those which did not respond to ULV light. Day-flying species, primarily butterflies, were sampled by frequent net collections after ULV traps were serviced. Net collected specimens and a representative portion of trapped moths were pinned for a reference collection.

A transect series of 100 or more woody plants on each plot (Table 2) were marked and sampled twice each year for lepidopterous larvae (last week of May and the second week of June). The more common woody species were represented by at least 10 individuals on the sample plant transect, especially those which seemed to have a large complement of lepidopterous larvae (e.g. Ribes cereum, R.lacustre, Mallow ninebark, willows). Some species, like the pines and larch, were quickly dropped from further consideration after the first sampling because they seemed to harbor only sawflies. Designated sample trees and shrubs were sampled by the "branch beating" method (Mason et al. 1989), with three 45 cm branch tips beaten per tree. All larvae found were retained in separate cups for laboratory rearing and photography. While branch sampling , any additional lepidopteran larvae or adults seen on plots were also collected for identification. In the lab, collected larvae were reared on fresh foliage of their original food plant, because survival was poor for those individuals placed on a standard artificial media.

On June 29, 1993, Plots 5 and 3 were sprayed with a Bell Ranger 206 helicopter, equipped with Beecomist nozzles. An aqueous formulation of Thuricide with sticker was applied at the rate of 16 BIU/A in 96 oz. volume per acre. Spraying was timed to be the period when spruce budworm larvae were in the 3rd-4th instars.

RESULTS

Again, as in 1992, identifications from light trap collections showed that a large number of species of lepidoptera is resident on the plots. Although these plots are located in what might be considered a relatively harsh environment, compared to the more mesic forests of western Oregon, we identified 440 species of lepidoptera in 1992 (Table 3), and an additional 36 more species in 1993 (total: 476 species). Total species recorded for 1993, however, was only 387 because many species, from apparently sparce populations, tallied in 1992, were not again recorded in 1993. As expected, most of these insects were Noctuids or Geometrids. One Noctuid genus alone (Euxoa) has 40 species represented on our plots. Many of these species, of course, are not in larval form at the time when spraying might occur. Also, most of the moth species recorded are ones that feed on woody vegetation, not grasses or forbs. In fact, our searches for lepidopterous larvae on ground plants in May and early June was not particularly fruitful--perhaps because the plants and their lepidopterous fauna were not yet well developed at that time. Later in the summer, a larger variety of larvae can be found on these plants.

Most of the larvae collected at "spray time" and reared for identification were taken from woody plants (Table 4). Each species listed here represents several individuals, but all these species are present as "open and free feeding larvae at "spray time", and presumably susceptible to Bt poisoning. It is also true that many species overwinter as pupae or eggs, and the effects of Bt sprays (if any) will not be evident until the following spring, when adults are not present to be attracted to the ULV traps. We will investigate next year the extent to which individual species are or are not killed by Bt. However, one well established principle has been demonstrated once again in our collections. That is, that normal population variations and variation caused by weather are likely to be greater than differences caused by spray-no spray treatments. For example, spring 1992 was extremely "early", very dry and with temperatures in the high 90's each day. In contrast, spring 1993 was cool, rainy, and daytime highs rarely exceeded 50 degrees F. until mid-July. Partly as a result of these temperature differences (We believe!), trap collections showed that 92 moth species recorded from 1992 were not again trapped in 1993 (as noted above). All of these were species considered "rare", based upon the frequency of specimens caught, and may well show up again in 1994 traps, but for this season at least were not detected.

To date, 3 papers have been written and submitted for publication from this work:

1. Grimble, David G.; Roy C. Beckwith; Paul C. Hammond. 1993. New Lepidoptera records for the Blue Mountains of eastern Oregon. PNW-RP-469, U.S.Dept. Agric., Forest Service, Pacific Northwest Research Station, Portland, OR 6 p.

2. Grimble, David G.; Roy C. Beckwith. 1993. Temporal presence of late instar Mitoura spinetorum (Lycaenidae) in eastern Oregon. J. Lepidopterist's Soc. 47 (4):(p.?). (Expected December 1993)

3. Grimble, David G.; Roy C. Beckwith; Paul C. Hammond. 199_. A survey of the Lepidoptera fauna from the Blue Mountains of eastern Oregon. J. Research on Lepidoptera. (Publication expected early in 1994).

PLANS FOR 1994 SEASON

In 1994, we will again begin ULV light trap operations in April, as soon as weather permits, to sample those early-flying moth populations which may have eluded our traps this year. Again, trapping will continue till cool fall temperatures stop insect activity. We believe we have most of the lepidopteran species on our plots already recorded, but will no doubt add more by starting earlier.

Also, we will expand the woody plant sampling transects on plots as much as possible, stressing those species which we now know harbor many lepidopterous larvae. Since larval populations on most woody plants are low and erratic (not concentrated), maximum sampling effort will be needed to collect sufficient larvae for rearing to adult stage. Net collecting will also be expanded because we believe there are some butterflies on site not yet represented in our collections. Again, larval rearing efforts will be concentrated on those species which we find as free feeding larvae at "spray time".

A Final Report on this project will be prepared by January 1995, after all collected insects have been identified and field data examined.

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Niwa, C.G., M.J. Stelzer, and R.C. Beckwith. 1987. Effects of Bacillus thuringiensis on parasites of western spruce budworm (Lepidoptera:Tortricidae). J. Econ. Entomol. 80: 750-753.

Table 1. Plot locations for Bt/nontarget lepidopteran impact study; 1992 and 1993.

Plot	National Forest	Location
	Established 1992:	
1.	Wallow-Whitman N.F.	Sec.35; T.3 S.;R.34 E.; - Meadow Creek bottomlands
2.	Wallow-Whitman N.F.	Sec.27; T.3 S.;R.34 E.; - Meadow Creek bottomlands
3.	Umatilla N.F.	Sec.25; T.3 S.;R.32 E.; - springs area,Pearson creek
4.	Umatilla N.F.	Sec.35; T.3 S.;R.32 E.; - springs, Granite Meadows
	Established 1993:	
5.	Wallowa-Whitman N.F.	Sec.14; T.4 S.;R.34 E.; - Battle Creek drainage

Table 2. Woody plant species present on field plots in eastern Oregon, 1992.

Species	Plots 1	2	3	4
Douglas-fir; Pseudotsuga menziesii (Mirb.) Franco	XX	XX	XX	XX
Grand fir; Abies grandis (Dougl.) Lindl.	-	X	X	XX
Lodgepole pine; Pinus contorta Dougl.	-	X	XX	XX
Ponderosa pine; Pinus ponderosa Dougl. ex. Laws	XX	XX	XX	XX
Engleman spruce; Picea englemanni Parry	X	X	X	X
Western larch; Larix occidentalis Nutt.	X	X	XX	XX
Thinleaf alder; Alnus incana (L.) Moensch.	XX	XX	X	X
Black hawthorn; Crataegus douglasii var. douglasii Lindl.	XX	XX	X	X
Rocky Mountain maple; Acer glabrum Torr.	XX	XX	X	X
Serviceberry; Amelanchier alnifolia Nutt.	X	X	X	X
Redstem ceanothus; Ceanothus sanguineus Pursh.	-	-	-	XX
Utah honeysuckle; Lonicera involucrata ??	-	-	X	X
Mallow ninebark; Physocarpus malvaceus (Greene) Kuntze	XX	XX	X	X
Wax current; Ribes cereum ??	XX	XX	X	X
Swamp gooseberry; Ribes lacustre (Pursh) Foir.	X	X	-	-
Sticky current; Ribes viscosissimum Pursh	X	X	X	X
Nootka rose; Rosa nutkana Presl.	XX	XX	X	X
Baldhip rose; Rosa gymnocarpa Nutt.	XX	XX	X	X
Scouler willow; Salix scouleriana Barratt	X	X	X	X
Sandbar willow; Salix ??	XX	XX	X	X
Buffaloberry; Shepherdia canadensis (L.) Nutt.	-	-	X	XX
Elderberry; Sambucus racemosa L.	X	X	X	X
Common snowberry; Symphoricarpos albus ??	-	-	X	X
Quaking aspen; Populus tremuloides Michx.	-	-	-	X
Common chokecherry; Prunus virginiana L. (A.Nels.)Sarg.	XX	XX	X	X
Red-osier dogwood; Cornus stolonifera var. stolonifera Michx.	XX	X	-	-
Raspberries; Rubus sp.	XX	XX	X	X

XX = common, abundant   X = present, rare   - = not found on site

Table 3. Species abundance recorded from field collections; 1992 and 1993.

Family	Species 1992	Species 1993	Family	Species 1992	Species 1993
Alucitidae	1	0	Oecophoridae	2	2
Arctiidae	7	6	Papilionidae	2	0
Geometridae	93	87	Pericopidae	1	0
Hepialidae	2	0	Pieridae	6	9
Hesperiidae	7	6	Plutellidae	1	1
Incurvariidae	0	1	Pterophoridae	1	1
Lasiocampidae	4	4	Pyralidae	33	28
Lycaenidae	16	16	Saturniidae	2	2
Lymantriidae	1	0	Satyridae	4	4
Noctuidae	212	174	Sphingidae	6	4
Notodontidae	3	2	Thyatiridae	3	2
Nymphalidae	19	21	Tortricidae	14	17

TOTAL 1992: 440 species
TOTAL 1993: 387 species

(Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pericopidae, Pieridae, and Satyridae are diurnal groups, caught with aerial nets, and were not systematically sampled.)

Table 4. Spring-collected lepidopteran species and their host plants.

Species	Host plant(s)
PERICOPIDAE	
Gonophaela vermiculata (Grt)	Tall bluebells
NYMPHALIDAE	
Vanessa cardui (L.)	Thistle
LYCAENIDAE	
Satyrium sylvinus (Bdv)	Scouler willow
LASIOCAMPIDAE	
Malacosoma disstria Hubner	Thinleaf alder
LYMANTRIIDAE	
Orgyia pseudotsugata (McD.)	Douglas-fir
NOCTUIDAE	
Aseptis binotata (Walker)	Ribes cereum
Zotheca tranquilla Grt.	Elderberry
Xylena thoracica (Putnam-Cramer)	Ceanothus sp.
GEOMETRIDAE	
Dysstroma brunneata (Pack.)	R.cereum; mallow ninebark
Dysstroma formosa (Hulst)	R.cereum
Dysstroma hersiliata (Guenee)	R.cereum
Elpiste lorquinaria (Guenee)	Scouler willow; thinleaf alder
Eulithis xylina (Hulst)	Black hawthorn;mallow ninebark nootka rose; scouler willow choke cherry
Hesperumia sulphuraria Pack.	R.cereum; Nootka rose
Itame bitactata (Walker)	R.cereum
Nematocampa limbata (Haworth)	Rose
Sicya crocearia Pack.	Mallow ninebark;scouler willow; rose
Semiothisa neptaria (Guenee)	Scouler willow
TORTRICIDAE	
Choristoneura occidentalis Free.	Douglas-fir, grand fir
Choristoneura rosaceana (Har.)	R.cereum; thinleaf alder
Clepsis persicana (Fitch)	Buffaloberry

Region 6 Report to National Steering Committee for Management of Western Defoliators

April 12, 1994

Western Spruce Budworm

Budworm defoliation was detected on 331,000 acres during the 1993 aerial detection survey, down from 3.3 million acres in 1992. Over 70 percent of the defoliation was detected in Washington with 95 percent of that being classified in the light effects category, with about 30 percent detected along the eastern slope of the Cascade Mountains. No defoliation was detected in the Blue Mountains of northeastern Oregon.

One suppression project covering 64,000 acres was conducted in 1993 on the Warm Spring Indian Reservation. Insecticide application began on June 19 and was completed on July 19. Budworm development was slower than normal due to a cool, wet spring and early summer. Pre-treatment budworm populations for the three analysis units ranged from 3.3 to 7.1 larvae per 45-cm branch midcrown branch tip, and post-treatment populations ranged from 0.5 to 0.8 larvae per branch. Population reductions, as determined by pre- and post-treatment larval sampling, were 86, 93, and 94 percent (uncorrected for natural mortality) for the three analysis units. The project objective was to reduce the budworm populations by at least 90 percent.

Budworm larval population levels were estimated for several potential analysis units on the Mt. Hood, Willamette, Colville and Wenatchee National Forests. Only two areas had high enough populations to warrant sampling of adult males using pheromone traps. Larval data will be collected on these two analysis units, which occur on the Mt. Hood National Forest, in Summer 1994.

Measuring of defoliation, topkill, and mortality of trees in the 33 stands with permanent plots was completed for the ninth consecutive year. These stands are located on the Malheur and Wallowa-Whitman National Forests in northeastern Oregon. We plan to format the data to be compatible with the new PTIPS software being developed by MAG. We hope that some preliminary analysis of these data can be accomplished in 1995. We plan to collect tree growth data from these plots in 1996, which will be four or five years (depending upon the stand) after budworm populations decreased to low levels.

Ecologists from the Mt. Hood and Willamette National Forests collected increment cores from old trees in several stands along the Cascade Crest. These cores were examined using established dendrochronology techniques to try and determine the patterns of previous budworm outbreaks. A draft report indicates that the data show promise for characterizing past budworm activity. More stands may be sampled in the future.

All budworm defoliation and insecticide treatment data for Region 6 since the start of the current outbreak (1980) have been entered into our geographic information system. Spatial analyses of these data are being conducted and will be documented in a report.

Douglas-fir Tussock Moth

Defoliation was detected on 46,000 acres on the Malheur National Forest in 1993, up from approximately 7,600 acres in 1992. Predictions are that this population will collapse in 1994 due to natural mortality factors.

Regionally, pheromone trap catches have shown a decreasing trend since 1991. Trap catches in 1994 are expected to remain low.

Modoc Budworm

Defoliation was detected on 30,000 acres in southern Oregon in 1992. No defoliation was detected in 1993.

Western Hemlock Looper

Western hemlock looper was detected on a little over 2,000 acres on the Mt. Baker-Snoqualmie National Forest in 1992. In 1993 it was detected on approximately 48,000 acres scattered across the Mt. Baker and Darrington Ranger Districts, and on 1,400 acres on North Cascades National Park. Some understory hemlocks have been killed, and a few larger hemlocks appear to be dead in some of the more severely defoliated pockets. Much of the defoliation is located within northern spotted owl Habitat Conservation Areas.

Pandora Moth

The current pandora moth infestation in central Oregon is in its tenth year or fifth generation. Over 77,000 acres showed defoliation in 1992 and, due to high levels of egg hatch and larval survival, defoliation in 1994 is expected to occur over the same acreage with the possibility of expanding to additional areas.

For Western Steering Committee Report 1994

MESSAGE SCAN FOR JACK BARRY

To J.Barry:R05H
CC J.Wenz:R05F16A

From: Roy Mask:R10A
Postmark: Mar 31,94 11:29 AM Delivered: Mar 31,94 12:31 PM
Status: Certified
Subject: Forwarded: SBW Activity in Alaska

Comments:
From: Roy Mask:R10A
Date: Mar 31,94 11:29 AM
Attached is a brief summary regarding SBW impact work that Skeeter Werner will be submitting as a '95 Tech. Devel. Proposal. It speaks directly to item 1-A of the steering committee's strategic plan. Just wanted to give the defoliator steering committee some advance notice on this one. We are sorely lacking in regard to certain defoliator impact information for Alaska. I will likewise be refining my '94 proposal (unfunded as '94 Tech. Devel. Project) regarding black-headed budworm impacts for submittal as a '95 project.

THANKS! -Roy

Previous comments:
From: Richard Werner:S26L02A
Date: Mar 24,94 11:28 AM
Here is a revised draft of the progress report I sent earlier.

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March 24, 1994

1993 SPRUCE BUDWORM ACTIVITY IN ALASKA

Richard A. Werner, Supervisory Research Entomologist, Institute of Northern Forestry, Pacific Northwest Research Station, Fairbanks, AK,
and
Edward H. Holsten, Entomologist, Forest Health Management, State and Private Forestry, Region 10, Anchorage, AK

Areas of white spruce (Picea glauca) in interior Alaska defoliated by eastern spruce budworm (Choristoneura fumiferana) increased from 160,000 acres in 1992 to 190,000 acres im 1993. Populations of C. orae were low in 1993 because of their 2-year life cycle. The stands infested contain the most productive white spruce stands in Alaska and also include one of the National LTER sites (Bonanza Creek Experiment Forest).

High population levels of C. fumiferana and C. orae were first observed in the Bonanza Creek Experimental Forest near Fairbanks in July 1989. Samples of foliage shot from the tops of white spruce contained large numbers of budworm pupae; however, only light defoliation was observed on this foliage and no defoliation was visible on the lower crowns. Populations of C. fumiferana increased dramatically from 1989 through 1991, then decreased in 1992, and again increased in 1993 as indicated by the number of adults caught in pheromone-baited traps. From 1990 through 1993, high numbers of larvae were detected on all sizes of spruce from 2-year-old seedlings to mature trees.

C. fumiferana has one generation a year and overwinters as second-instar larvae in silken shelters (hibernaculum) under loose bark scales and in the notches of twigs. These larvae emerge in late May and bore into expanding spruce buds and eventually feed on new needles and stems. Larvae develop through five instars and consume most of the foliage during the last two instars. Larvae transform into pupae in mid-June and new adults emerge from late June to early July. Eggs are laid and first instar larvae emerge in mid-July. C. orae has a 2-year cycle with one generation every two years but otherwise develops the same as C. fumiferana.

Budworm population levels have been monitored from 1990 to 1993 using pheromone baited traps and the population is predicted to decline in 1994 as mature spruce trees were entirely covered with silk webbing in June 1993, pupae were found in old-growth needles, and pupal weights were smaller in 1993; all indicators of a declining population.

Spruce budworm trap catches and parasitism by year

	Number of adults per trap per week		
Year	Choristoneura fumiferana	Choristeneura orae	Percent pupal parasitism
1990	36	29	80
1991	32	2	75
1992	19	16	11
1993	51	2	28

Impact plots were established in stands of white spruce in 1990 and have been remeasured annually. Ten 1/5-acre circular plots contained an average of 74 trees per plot of which 83% were white spruce. Preliminary results four years after the first heavy defoliation (100% of new growth) indicate that 68% of the spruce were live and no mortality was directly caused by defoliation alone. Snow breakage and windthrow were evident in 11% of the spruce following the winter of 1991 and 15% of the trees died.

Successive heavy defoliation from 1991 to 1992 caused top-kill in trees and mortality in seedlings and saplings. Mature spruce which were previously defoliated did not produce new growth in the upper third of the crown in 1992 and 1993; therefore, all budworm defoliation occurred on new growth of the lower part of the crown. No tree mortality from bark beetles was recorded prior to 1993; however, 40% of the impact plots had an average of 2.3% mortality from Ips perturbatus and 0.70% from Dendroctnous rufipennis in 1993.

An examination of increment cores from impact plots showed a gradual decrease in radial growth from 1986 to 1991. This was probably caused by successive years of budworm defoliation. Reduced radial growth was also evident from 1974 to 1981 and is assumed to have been the effect of budworm defoliation.

Populations will be monitored again in 1994 and impact plots remeasured to determine the percentage of tree mortality caused by bark beetles and budworm defoliation.

Funds are needed in FY95 to evaluate data collected from the first outbreak of spruce budworm ever reported to occur in white spruce stands of Alaska. This data has been collected annually during the outbreak from 1990 through 1993 and includes data on budworm infestation levels; effects on tree growth and survival, cone and seed productivity, and foliage nutrient content; and the incidence of bark beetle attack of defoliated trees. The information from this evaluation would be used to provide guidelines for the development of suppression activities. This is a cooperative effort between FHM, Region 10 and PNW. The amount needed in FY95 is $5,000.

Amy Onken, NCFH

MESSAGE SCAN FOR JACK BARRY

To J.Barry:R05H
CC R.Reardon

From: AMY H. ONKEN:S24L08A
Postmark: Apr 15,94 10:26 AM   Delivered: Apr 15,94 7:26 AM

Subject: 1994 West. Def. Steering Comm. Report

Comments:
Jack, enclosed is a copy of the report I gave at the meeting. I thoroughly enjoyed the session and I am thankful that I was given the opportunity to attend. Amy

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1994 Report Submitted to the National Steering Committee for Management of Western Defoliators, Spokane Meeting, April 12 - 13, 1994

Amy Onken, National Center of Forest Health Management, Morgantown, WV

Background of the National Center

The National Center of Forest Health Management was established in Morgantown, WV in April 1993. It is involved in technology development with three broad areas of work. These include:

1. biorational methods for forest health managment;
2. biological control methods for forest health management;
3. nontarget effects of forest health activities.

The concept of the National Center grew from the need to advance understanding of forest health and the recognition that ecologically-based forest health technologies are urgently needed. The National Center will take a leading and proactive role in the development and implementation of management tools that speak to this need. Also, the National Center will evaluate the consequences of selecting and implementing the "no action" alternative to management.

Projects Funded for Fiscal Year 1994

BIORATIONAL PROJECTS

1. **Douglas-Fir Tussock Moth Management Using the Nucleopolyhedrosis Virus Product TM-Biocontrol-1**

   Duration: First of three-year effort
   Objective: 1. Year 1 -- Determine an efficacious dose of the current Douglas-fir tussock moth nucleopolyhedrosis virus product TM-Biocontrol-1 against both laboratory (Goose Lake) and and wild strains of Douglas-fir tussock moth.
   2. Year 2 -- Evaluate several ready-to-use carriers using various application rates, and application technology (e.g. nozzles) to determine spray characteristics.
   3. Year 3 -- Pilot test the most efficacious dose, rate and ready-to-use formulation of TM-Biocontrol-1.

   Accomplishments: Initiated efforts to conduct laboratory bioassays of TM-Biocontrol-1

2. **Initiate Registration Process for Douglas-Fir Tussock Moth Pheromone for Mating Disruption**

   Duration: First of three-year effort
   Objective: To Obtain registration of the Douglas-fir tussock moth pheromone for use as a management technique.
   Accomplishments: Begin to accumulate and acquire efficacy, residue, and and nontarget data required by US-EPA for registration of the DFTM pheromone.

3. **Coordinate the Development of the Insect Growth Regulator MIMIC for Managing Forest Defoliators**

<u>Duration</u>: First of two year effort
<u>Objective</u>: Aerial application of MIMIC to a broadleaved forest: efficacy, residue levels and impacts to canopy and aquatic arthropods.
<u>Accomplishments</u>: Replicated plots established in Ohio, APHIS to supply pilots and aircraft, and Rohm and Haas Co., to supply MIMIC and assist in deposit assessment.

BIOLOGICAL CONTROL PROJECTS

1. **Conduct National Survey to Identify Opportunities for the Use of Natural Enemies to Control Forest and Shade Tree Pests in North America**

<u>Duration</u>: First of one-year effort
<u>Objective</u>: To review the scientific literature on the major forest and shade tree insect pests in North America in such a way that their potential to be controlled by biological controls can be estimated.
<u>Accomplishments</u>: Cooperative agreement initiated with University of Massachusetts and regional sub-contracts completed.

NONTARGET PROJECTS

1. **Coordinate with Forestry Canada in Developing Techniques and a Database Concerning Impacts of Insecticides to Nontargets in Forest Ecosystems**

<u>Duration</u>: Ongoing
<u>Objective</u>: 1. To maintain an electronically accessible database on the documented nontarget impacts of insecticides when applied to forest ecosystems.
2. To develop recommendation concerning procedures/techniques for monitoring nontargets to determine acute and chronic impacts.
<u>Accomplishments</u>: Two coordination meetings scheduled in 1994. Lists of of potential cooperators and their current nontarget activities developed for each country.

The Goals and Objectives of the National Center

Goal 1. Promote and facilitate the development and application of technologies to sustain or enhance forest health.

Objectives

1.A. Facilitate the development and use of semiochemical products/methods for forest health management.
1.B. Facilitate the development and use of microbial products/methods for forest health management.
1.C. Facilitate the development and use of other (e.g. growth regulators) environmentally benign methods for forest health management.
1.D. Serve as a focal point for gathering, managing and disseminating information on biological control as relates to forest ecosystem management.
1.E. Facilitate the development and use of biological controls for forest health management.
1.F. Coordinate the transfer of biological control technology for forest health management internationally.

Goal 2. Advance the understanding of the roles of forest health and the impact of forest health technologies on ecosystem functions.

Objectives

2.A. Coordinate efforts to determine the impacts of forest health activities on components of forest ecosystems.
2.B. Coordinate efforts to determine the impacts of components of forests ecosystems on forest health.

Dick Reardon, NCFH

DG message information
on NOVO produced
Carrier for TM-Biocontrol

MESSAGE DISPLAY FOR JACK BARRY

To   R.Reardon:s24108a
CC   J.Hadfield:r06c
BC   Jack Barry

From: Jack Barry
Postmark: Apr 29,94   5:40 PM   Delivered: Apr 29,94   5:40 PM

Subject: Novo carrier

Message:
There are several questions I feel need to be answered re the Nov carrier - probably the same ones that you and Jim have listed. Atomization likely isn't a concern assuming it has or will be tested in the field using operational equipment and atomizers. Also assume field mixing and handling have been demonstrated not to be a problem. Efficacy is my main question. How does the new mixture compare with the old fromulation? As we know lab data is one thing and so often field data is something else. These are some basic thoughts - concluding that we need field testing. Jack

-------=========X=========-------

MESSAGE DISPLAY FOR JACK BARRY

To Jack Barry:R05H

From: RICHARD REARDON:S24L08A
Postmark: Apr 25,94 1:14 PM Delivered: Apr 25,94 10:13 AM

Subject: Reply to a reply: NOVO carrier

Reply text:
From: RICHARD REARDON:S24L08A
Date: Apr 25,94 1:14 PM
to the best of my knowledge there is no reason to suspect that 244 will perform any different whether with tm-bio-control or gypchek or any other virus.therefore,why have "duplicte" efforts on-going.our plan with tm-bio-control was to i.d. a field efficacious dose and determine the viability of the previously produced product--both of which have nothing to do with the carrier 244.would appreciate your suggestion as to priorities from your perspective.thanks.

Preceding message:
From: Jack Barry:R05H
Date: Apr 25,94 9:20 AM
Is anything happening with the carrier and TM Biocontrol?

From: RICHARD REARDON:S24L08A
Date: Apr 23,94 11:29 AM
PLEASE READ MY PREVIOUS REPLY--DO NOT CALL THE CARRIER FORAY--PLEASE THIS IS A GROSS ERROR AND IS CAUSING MUCH GRIEF!I HAVE BEEN COORDINATING WITH HADFIELD CONCERNING THIS EFFORT AND AMY SHOULD HAVE REPORTED CONCERNING OUR EFFORTS AT YOUR MEETING.THE CANADIANS ARE ALSO COOPERATING WITH US IN THE USE OF THIS CARRIER FOR DISPARVIRUS.ALSO,WE PURCHASED APPROX 24,000 GAL FOR ITS OPERATIONAL USE WITH GYPCHEK IN 1994.PODGWAITE IS CONDUCTING SPRAY TOWER EVAL OF IT'S STICKABILITY AND EFFICACY.THANKS.

From: Jack Barry:R05H
Date: Apr 20,94 1:01 PM
At the western def meeting last week question was asked about status of FORAY carrier for TM BioControl. Do you know ststus and who has responsibility of testing?

-------========X========-------

MESSAGE DISPLAY FOR JACK BARRY

To Jack Barry:R05H
CC J.HADFIELD:R6/PNW

From: RICHARD REARDON:S24L08A
Postmark: Apr 30,94 6:25 PM Delivered: Apr 30,94 3:25 PM

Subject: Reply to: Novo carrier

Reply text:
From: RICHARD REARDON:S24L08A
Date: Apr 30,94 6:25 PM
WE HAVE FIELD TESTED THE CARRIER FOR GYPSY MOTH OVER THE PAST 3 YEARS AND CUNNINGHAM WILL FIELD TEST IT THIS YEAR.IT WORKS AS WELL AS THE STANDARD BUT MORE IMPORTANTLY IT IS COMMERCIALLY AVAILABLE AND COMES AS A USABLE PRODUCT--NOT LIKE THE STANDARD FORMULATION WHICH IS 3 OR 4 INGREDIENTS WHICH BY THE WAY ARE DIFFICULT TO OBTAIN.IN MY OPINION,AS STATED BEFORE,SINCE THE VIRUS IS SEPARATE FROM THE CARRIER I REALLY DOUBT THAT IT WOULD BE "GOOD" FOR GYPCHEK AND NOT FOR TM-BIOCONTROL.I WOULD PREFER THAT WE USE THE 12,000 GAL OPERATIONALLY THIS YEAR AND SEE HOW IT PERFORMS BEFORE USED WITH TM-BIOCONTROL.BESIDES WHAT FIELD DOSE WOULD YOU USE--IT IS MY UNDERSTANDING FROM GRIMBLE AND WETHERBY THAT THIS HAS NOT BEEN ANSWERED?ALSO,HOW VIABLE IS THE PRODUCT AFTER YEARS OF STORAGE--ALL ?? THAT NEED TO BE ANSWERED BEFORE FIELD TRIALS.JACK,WHAT IS THE SOURCE OF YOUR URGENCY TO FIELD TEST THE PRODUCT?

Preceding message:
From: Jack Barry:R05H
Date: Apr 29,94 5:40 PM
There are several questions I feel need to be answered re the Nov carrier - probably the same ones that you and Jim have listed. Atomization likely isn't a concern assuming it has or will be tested in the field using operational equipment and atomizers. Also assume field mixing and handling have been demonstrated not to be a problem. Efficacy is my main question. How does the new mixture compare with the old fromulation? As we know lab data is one thing and so often field data is something else. These are some basic thoughts - concluding that we need field testing. Jack

-------=======X=======-------

MESSAGE DISPLAY FOR JACK BARRY

To RICHARD REARDON:S24L08A
BC Jack Barry

From: Jack Barry
Postmark: Apr 25,94 9:21 AM Delivered: Apr 25,94 9:21 AM

Subject: Reply to a reply: Forwarded: Reply to: Forwarded: NOVO carrier

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Reply text:
From: Jack Barry:R05H
Date: Apr 25,94 9:21 AM
To avoid confusion I suggest you pass out the word - first I have heard this designation..

Preceding message:
From: RICHARD REARDON:S24L08A
Date: Apr 23,94 11:15 AM
THE CARRIER IS PRODUCED BY NOVO AND IS DESIGNATED 244--IT IS NOT FORAY AND PLEASE DO NOT REFER TO IT AS SUCH!!!WE ARE DOING FIELD AND LABORATORY EVALUATIONS--FIELD IN VIRGINIA STARTING ON 5/2-6 AND LAB EVAL OF STICKABILITY AND EFFICACY.STUDY PLANS ARE AVAILABLE FOR BOTH.

From: Jack Barry:R05H
Date: Apr 21,94 10:34 AM
Re TM Biocontrol-1.

Previous comments:
From: James S. Hadfield:R6/PNW
Date: Apr 21,94 10:18 AM
WE ARE PIGGY BACKING ONTO THE GYPCHEK EFFORT AND OBSERVING THE PROGRESS THEY ARE MAKING WITH THAT PRODUCT BEFORE MOVING OUT WITH TM BIOCONTROL. WORK WITH GPYCHEK APPEARS TO BE GOING VERY WELL.

From: Jack Barry:R05H
Date: Apr 20,94 4:04 PM
Jim, do you know status?

From: Jack Barry
Date: Apr 20,94 1:01 PM
At the western def meeting last week question was asked about status of FORAY carrier for TM BioControl. Do you know ststus and who has responsibility of testing?

-------=======X=======-------

MESSAGE DISPLAY FOR JACK BARRY

To Jack Barry:R05H
CC J.COTA:W01C

From: RICHARD REARDON:S24L08A
Postmark: Apr 23,94 11:29 AM Delivered: Apr 23,94 8:28 AM

Subject: Reply to: NOVO carrier

Reply text:
From: RICHARD REARDON:S24L08A
Date: Apr 23,94 11:29 AM
PLEASE READ MY PREVIOUS REPLY--DO NOT CALL THE CARRIER FORAY--PLEASE THIS IS A GROSS ERROR AND IS CAUSING MUCH GRIEF!I HAVE BEEN COORDINATING WITH HADFIELD CONCERNING THIS EFFORT AND AMY SHOULD HAVE REPORTED CONCERNING OUR EFFORTS AT YOUR MEETING.THE CANADIANS ARE ALSO COOPERATING WITH US IN THE USE OF THIS CARRIER FOR DISPARVIRUS.ALSO,WE PURCHASED APPROX 24,000 GAL FOR ITS OPERATIONAL USE WITH GYPCHEK IN 1994.PODGWAITE IS CONDUCTING SPRAY TOWER EVAL OF IT'S STICKABILITY AND EFFICACY.THANKS.

Preceding message:
From: Jack Barry:R05H
Date: Apr 20,94 1:01 PM
At the western def meeting last week question was asked about status of FORAY carrier for TM BioControl. Do you know ststus and who has responsibility of testing?

-------=======X=======-------

Lonne Sower, PNW

Information for Defoliator Steering Committee, April 1994

From L. Sower, PNW Corvallis

New DFTM survey trap baits:

Here are a few comments on the new trap baits purchased from Pherotech by MAG. Previous lots of Pherotech baits were tested against the old PVC baits in 1991 and had equivalent results. The new baits obtained from Pherotech in 1993 also appeared to catch about as many DFTM (0.5 male / trap) as PVC baits (0.01 male / trap). With both baits, catches were the lowest seen in years and numbers were too small to make any kind of statistical statement.

Although the overall indication is that Pherotech baits gave about the same results as the old PVC baits through most of the DFTM range there is an exception: From about the Oregon border and south into California the pherotech baits appear to catch increasing numbers of males relative to the PVC baits. This pattern was seen in 1991 (previously reported) and, even with the low catches, appeared to be present in 1993. My assumption still is that Pherotech pheromone is probably purer, on account of recent improved synthesis, and that purity mattered more to California DFTM than to more northern DFTM. I have no other explanation for the apparent difference but California users should expect to catch more males than in the past, populations being equal, with the new baits.

We again tested the USDA gypsy moth trap (orange) as a suitable trap for DFTM. This type of trap catches about the same number of males as the Forest Service trap we use until over 40 males per trap are caught. Since the gypsy moth trap has less sticker coated area, and thinner sticker, its capacity is reached sooner. For most practical purposes the standard gypsy moth trap could be substituted for our tussock moth trap as captures much above 40 males indicate that alternative survey methods are more appropriate anyway. My opinion is that the gypsy moth trap is OK for DFTM. Make sure the trap's ends are not folded-in as they would be for gypsy moth. DFTM won't enter the smaller orifice created by folding the trap's ends in.

Other DFTM survey information

Two years ago traps we placed a transect of survey plots down a ridge and more or less across the host type for a DFTM population. Survey methods included traps in standard clusters of 5, lower crown beating, cryptic shelters, and single traps at 1/4 mile intervals completely through the host area. The line of single traps extended a mile or so beyond where the other methods were used until reaching the bounds of fir type. The deployment and methods were instigated by John Wenz who did something similar in CA. Data are shown on the attached sheet.

Standard survey traps, cryptic shelters, and single traps all had fairly high numbers of insects in 1992, predicting the population was approaching outbreak in 1993. Larvae surveys, and visually searching for cocoons did not. We deemed the 1992 larvae survey inadequate on account it was taken too late in the season and done on too few trees. Interestingly, fifteen single pheromone traps at 1/4 mile intervals yielded the same information as 10 conventional 5 trap clusters (50 traps) suggesting the same information can be got with fewer traps.

All this tends to confirm my own bias that any of the above survey methods are likely to tell you about the same thing if done properly and interpreted with reasonable perspective. The method that "DID NOT WORK" this time was the old reliable larval beating, in 1992, but that was because we screwed up not because the method was inherently inadequate.

In 1993 the larval survey was done properly, and on-time, and indicated a pre-outbreak population with some areas over 20 /1000. Cryptic shelter data taken later in 1993 showed the pupae population doubled from the previous year, but the number of egg masses found declined markedly. This indicates sick insects and a collapsing population. Pheromone trap data were not taken in 1993 on account of the population was already advanced beyond the stage where trap data are considered useful.

DFTM population study- 1992/1993
Malhuer NF, Burns RD, Beaverdam Creek, Rd. 2680, R 32 E, T 19 S, Section 1
Cryptic shelters were picked up 10/21-92 and 10/12/93
Plots were arranged as a transect through a DFTM population center

Plot # at 1/4 mi + interval	Cacoons per 20 shelters (10 tree) in 1992	Egg mass per 20 shelters (10 tree) 1n 1992	Cacoons per 20 shelters (10 tree) in 1993	Egg mass per 20 shelters (10 tree) in 1993	Average Male per Trap (5tp) in 1992	92 Ave. larvae per 1000 (3-4 inst)	93 Ave. sm larvae per 1000 (1-3 inst)	Single traps thru plots 1/4 mi int. in 1992	Single traps extended 2 mi in 1992	Estimated defoliation in 1993 %
									5	
									5	
									12	
									17	
									23	
									30	
									37	
									24	
									37	
									93	
									63	
								44	44	
								35	35	
1	5	2	7	1	50.4	0	1.3	74	74	10
2	7	1	2	0	54.8	0.4	1.4	72	72	0
3	5	0	1	0	31.8	0.2	1.5	75	75	0
4	13	4	0	0	75.2	0	0.8	47	47	0
5	43	12	22	2	71.6	1	6.2	62	62	15
6	81	19	60	9	56.4	0.02	13.2	83	83	30
7	52	14	68	6	69.6	1.6	14.5	81	81	10
8	80	35	229	23	83.8	1.4	24.7	90	90	35
9	94	26	198	12	75.8	1	11.4	82	82	20
10	64	21	198	18	46.4	0.06	19.5	85	85	40
								72	72	
	44.4	13.4	78.5	7.1	61.58	0.568	9.45	10	10	
								43	43	
									67	
								63.66667	80	
									78	
									70	

Julie Weatherby, R-4

1994 Report Submitted to the National Steering Committee for Management of Western Defoliators, Spokane Meeting, April 12 - 13, 1994.

Julie Weatherby, R4, Boise

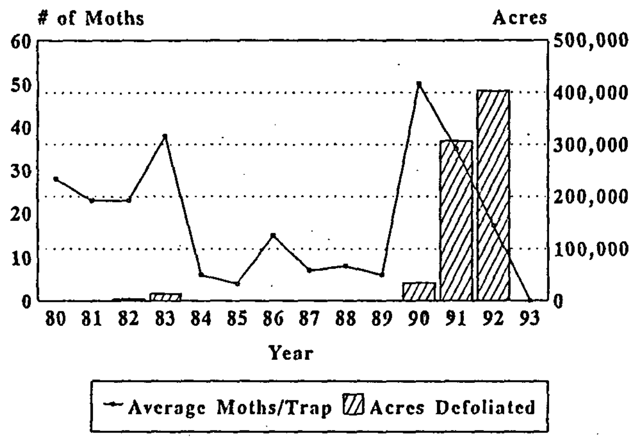
Pest: Douglas-fir tussock moth

Recent Outbreak History:

Date	Idaho		Utah	
	Ac. Defol.	Pred. Sp.	Ac. Defol.	Pred. Sp.
1990	51,200	DF, GF	2,900	SAF
1991	312,000	DF, GF	4,900	SAF
1992	418,000	DF, GF	3,200	SAF
1993	0		0	

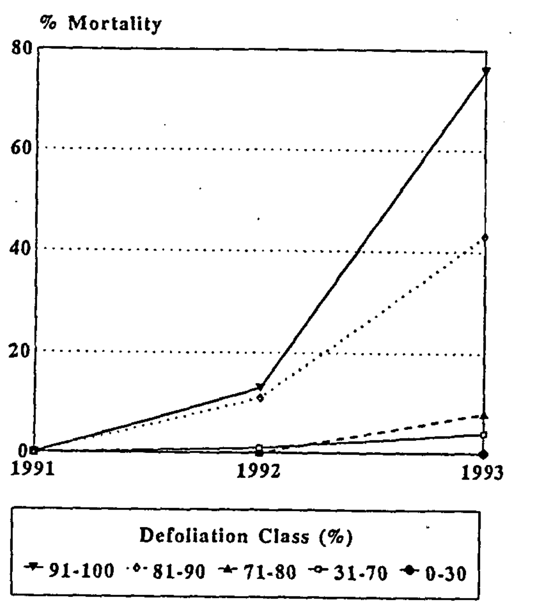
Early Warning System:

Average Douglas-fir Tussock Moths/Trap
& Acres of Defoliation Across Southern Idaho
1980 - 1993

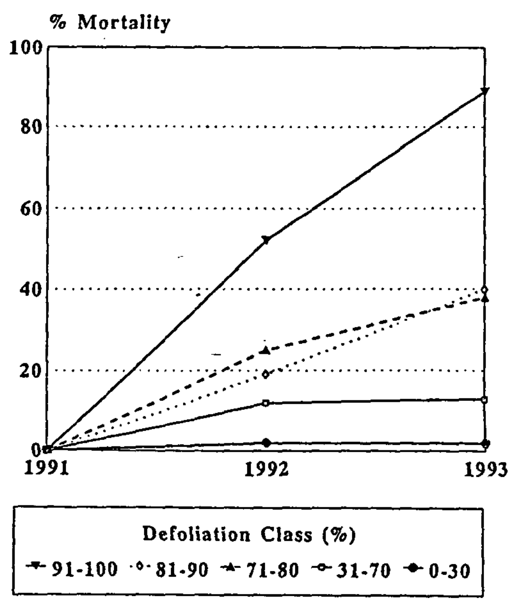


Impacts:

Percent Mortality of Grand Fir Trees
Caused by Douglas-fir Tussock Moth
1991 - 1993



Percent Mortality of Douglas-fir Trees
Caused by Douglas-fir Tussock Moth
1991 - 1993



Infestations	Defol. Intensity	Stocking Levels (T/A) Pre-Out. (1990)	Post-Out. (1993)
Boise River	V. Heavy	64	21
	Heavy	146	75
	Moderate	148	122
Deer Cr./Elk Cr.	V. Heavy	264	67
	Heavy	154	81
	Moderate	-	-
Sagehen	V. Heavy	113	52
	Heavy	136	92
	Moderate	134	125
Mann Cr.	V. Heavy	-	-
	Heavy	113	100
	Moderate	60	56

Hazard Rating: A 2 phase hazard rating system was developed for use by the land manager. In order to hazard rate a stand, the probability of an outbreak must be estimated by locating the stand within an area with a known outbreak frequency. If the stand is located in an area where outbreaks are highly likely or likely then the expected impacts caused by a tussock moth outbreak could be predicted using the vulnerability model. In order to determine the vulnerability of a stand, the position on the slope, the aspect class, and the percent basal area in host must be known. Appropriate numerical values associated with these characteristics are summed to obtain a composite rating ranging between 3 and 8. Composite ratings of 7 and 8, 5 and 6, and 3 and 4 indicate high vulnerability, moderate vulnerability, and low vulnerability, respectively. Stands which are classified as highly likely to have an outbreak and which have a high vulnerability rating are of greatest concern. These stands could be prioritized as needing prompt treatment. Stands where outbreaks are possible but infrequent and vulnerability ratings are high would have a lower overall hazard rating because the probability of an outbreak is low. However these stands could suffer tree mortality if an outbreak were to occur. Stands where outbreaks are possible but infrequent and vulnerability ratings are low would have a very low priority for treatment.

Figure 1. Areas in southern Idaho with a history of defoliation caused by DFTM.

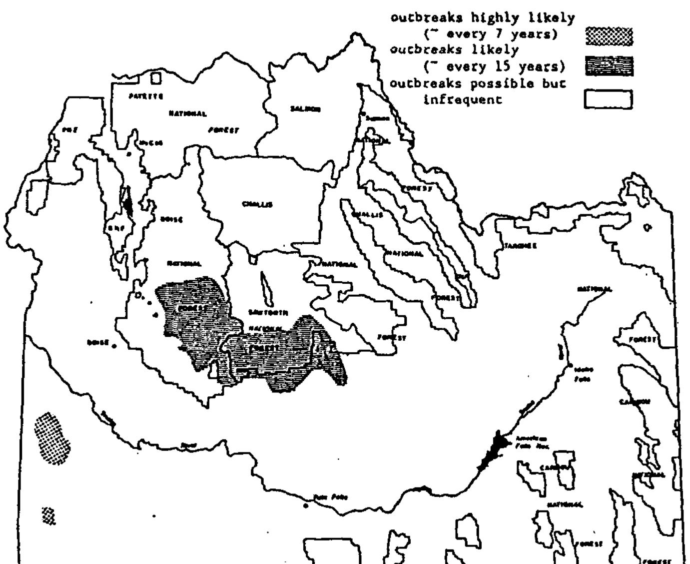


Table 5. Vulnerability model used to predict damage in infested DFTM stands.

Aspect	Position on slope[a]	% Basal Area in host
E, SE, NE (3)	.86 - 1.00 (3)	.86 - 1.00 (2)
S, SW (2)	.76 - .85 (2)	.00 - .85 (1)
N, W, NW (1)	.00 - .75 (1)	

[a] Position on the slope is defined as the elevation of the stand divided by the elevation of the highest forested ridgeline in the area. If the highest forested ridgeline exceeds 7,400 ft, the ridgeline elevation defaults to 7,400 ft.

NATIONAL STEERING COMMITTEE
FOR
MANAGEMENT OF WESTERN DEFOLIATORS

R5- Pacific Southwest Region Report
12-13 April 1994

John M. Wenz

Current Status

Defoliator activity in Region 5 (California) continued at low levels in 1994. No defoliator suppression or eradication projects were conducted.

Modoc budworm , Choristoneura viridis, defoliation on the Modoc NF in northeastern California declined to generally low levels in 1994, affecting about 50,000 to 100,000 acres of true fir. White fir sawfly, Neodiprion sp., feeding similarly declined to very low levels.

Highly variable, low to heavy, defoliation of oaks, primarily black oak, associated with feeding by the fruittree leafroller, Archips argyrospilus, was again reported from northern California. Approximately 25,000 acres were affected in Shasta and Trinity Counties. Western oak looper, Lambdina fiscellaria somniaria, was also observed feeding on white oak in many of the same areas.

Ecosystem Management/ Forest Health

Each Region was asked to briefly discuss defoliator and other insect/pathogen, management-related, issues associated with the increasing emphasis on ecosystem management and forest health. Following are some issues/ questions that have surfaced in R5:

1) Identifying historical defoliator activity/effects in the context of defining the "range of natural variability".

2) Emphasis on "landscape or watershed level" analyses- implications for providing insect/pathogen information/input (see #3) as participants in NEPA analyses.

3) Defining and quantitatively measuring the ecological roles/effects of defoliators and other forest invertebrates in forest ecosystems. Includes defining effects of traditional "pests" on non-traditional, ecosystem attributes and processes, defining the ecological roles of other invertebrates (e.g., canopy and forest floor organisms) and identifying and assessing the diverse effects of implementing various land/ vegetation management" alternatives" on these organisms and their activities/ ecosystem functions.

4) Continued concern over the effects of suppression strategies on non-target organisms.

5) Increasing questions/interest in more "ecologically sound" biological control methods of pest management.

6) What are the roles/interactions of FPM and Research (FS, university, private) under ecosystem management and how should the above changing information needs be addressed?

7) How, to what extent, can FPM funding be used for "non-traditional" ecosystem management-related insect/pathogen "management/ evaluation/ monitoring" activities?

Richard Werner, PNW and
Ed Holsten, R-10

PNW REPORT TO NATIONAL STEERING COMMITTEE FOR MANAGEMENT OF WESTERN DEFOLIATORS

1. Alaska:

1993 Spruce Budworm Activity In Alaska

Richard A. Werner, Supervisory Research Entomologist, Institute of Northern Forestry, Pacific Northwest Research Station, Fairbanks, AK,
and
Edward H. Holsten, Entomologist, Forest Health Management, State and Private Forestry, Region 10, Anchorage, AK

Areas of white spruce (*Picea glauca*) in interior Alaska defoliated by eastern spruce budworm (*Choristoneura fumiferana*) increased from 160,000 acres in 1992 to 190,000 acres im 1993. Populations of *C. orae* were low in 1993 because of their 2-year life cycle. The stands infested contain the most productive white spruce stands in Alaska and also include one of the National LTER sites (Bonanza Creek Experiment Forest).

High population levels of *C. fumiferana* and *C. orae* were first observed in the Bonanza Creek Experimental Forest near Fairbanks in July 1989. Samples of foliage shot from the tops of white spruce contained large numbers of budworm pupae; however, only light defoliation was observed on this foliage and no defoliation was visible on the lower crowns. Populations of *C. fumiferana* increased dramatically from 1989 through 1991, then decreased in 1992, and again increased in 1993 as indicated by the number of adults caught in pheromone-baited traps. From 1990 through 1993, high numbers of larvae were detected on all sizes of spruce from 2-year-old seedlings to mature trees.

C. fumiferana has one generation a year and overwinters as second-instar larvae in silken shelters (hibernaculum) under loose bark scales and in the notches of twigs. These larvae emerge in late May and bore into expanding spruce buds and eventually feed on new needles and stems. Larvae develop through five instars and consume most of the foliage during the last two instars. Larvae transform into pupae in mid-June and new adults emerge from late June to early July. Eggs are laid and first instar larvae emerge in mid-July. *C. orae* has a 2-year cycle with one generation every two years but otherwise develops the same as *C. fumiferana*.

Budworm population levels have been monitored from 1990 to 1993 using pheromone baited traps and the population is predicted to decline in 1994 as mature spruce trees were entirely covered with silk webbing in June 1993, pupae were found in old-growth needles, and pupal weights were smaller in 1993; all indicators of a declining population.

Spruce budworm trap catches and parasitism by year

Year	Number of adults per trap per week: Choristoneura fumiferana	Choristeneura orae	Percent pupal parasitism
1990	36	29	80
1991	32	2	75
1992	19	16	11
1993	51	2	28

Impact plots were established in stands of white spruce in 1990 and have been remeasured annually. Ten 1/5-acre circular plots contained an average of 74 trees per plot of which 83% were white spruce. Preliminary results four years after the first heavy defoliation (100% of new growth) indicate that 68% of the spruce were live and no mortality was directly caused by defoliation alone. Snow breakage and windthrow were evident in 11% of the spruce following the winter of 1991 and 15% of the trees died.

Successive heavy defoliation from 1991 to 1992 caused top-kill in trees and mortality in seedlings and saplings. Mature spruce which were previously defoliated did not produce new growth in the upper third of the crown in 1992 and 1993; therefore, all budworm defoliation occurred on new growth of the lower part of the crown. No tree mortality from bark beetles was recorded prior to 1993; however, 40% of the impact plots had an average of 2.3% mortality from Ips perturbatus and 0.70% from Dendroctnous rufipennis in 1993.

An examination of increment cores from impact plots showed a gradual decrease in radial growth from 1986 to 1991. This was probably caused by successive years of budworm defoliation. Reduced radial growth was also evident from 1974 to 1981 and is assumed to have been the effect of budworm defoliation.

Populations will be monitored again in 1994 and impact plots remeasured to determine the percentage of tree mortality caused by bark beetles and budworm defoliation.

Funds are needed in FY95 to evaluate data collected from the first outbreak of spruce budworm ever reported to occur in white spruce stands of Alaska. This data has been collected annually during the outbreak from 1990 through 1993 and includes data on budworm infestation levels; effects on tree growth and survival, cone and seed productivity, and foliage nutrient content; and the incidence of bark beetle attack of defoliated trees. The information from this evaluation would be used to provide guidelines for the development of suppression activities. This is a cooperative effort between FHM, Region 10 and PNW. The amount needed in FY95 is $5,000.

2. LaGrande:

R. Mason -- Update and conclusion of long-term studies described in 1993 Committee Report: Analyses are underway on long-term work on tussock moth, budworms, and lodgepole needle miner; Manuscripts in preparation or review on spider predator diversity, tussock moth population dynamics and prediction, and fertilization effects on pines in a pandora moth outbreak. Also, paper due out soon on long-term monitoring techniques for tussock moth and budworms.

T.Torgersen -- Reporting on studies described in 1993 Committee Report:

Torgersen, T.R. 1993. Maintenance and restoration of ecological processes regulating forest-defoliating insects. pp. 27-30. IN: R.Everett (Ed.), Eastside Forest Health Assessment, Vol.IV, Restoration of Stressed Sites and Processes.

Torgersen, T.R., et.al. 1993. Patterns of occurrence and new sampling implications for instar IV western spruce budworms (Lepidoptera: Tortricidae). For.Sci. 39(3):573-593.

Torgersen, T.R.,et.al. Population behavior of western spruce budworm and growth response of host trees after treatment with Carbaryl: a 7-year analysis. (Subm. to For. Sci.).

orgersen, T.R., et.al. Relationship between lower crown sampling and mid-crown sampling for Choristoneura occidentalis Freeman after treatment with Bacillus thuringiensis Berliner. J. Econ. Entomol. (In press).

Schmidt, F.H. 1993. A western spruce budworm sampling program for Husky Hunter field data recorders. USDA Forest Service, Res. Note PNW-RN-511. 19 p.

ALSO: Several other manuscripts in preparation or review related to current studies of budworms and population dynamics.

3. Corvallis:

L.Sower -- offered some comments on recent pheromone trap efficiency tests (see additional handout sheet). Briefly, they tested the new Pherotech baits against the "old" PVC baits and found them quite acceptable and comparable, except for a perceived tendency to catch more male moths in southern Oregon and California from apparently equal population levels. Also tested the new USDA gypsy moth trap as a substitute DFTM trap; - conclusion was that the GM trap would be adequate for DFTM, if care is taken in folding. DFTM apparently do not enter small orifices as readily as GM.

D.Grimble -- plan to continue (and conclude) the ULV blacklighting fieldwork described in minutes of last meeting.

1. At Starkey Exp. For./Umatilla N.F., this will be 3rd year of operating light traps to evaluate possible impacts of BTK sprays on nontarget Lepidoptera. Two 40-acre plots were treated last July with 16 BIU in 96 oz./A from Beecomist nozzles on a Bell Ranger helicopter. Operation of blacklight traps for 2 years has allowed identification of 432 species of nocturnal Lepidoptera resident on these plots (and nearby unsprayed plots), mostly Noctuidae and Geometridae. A large proportion of these were represented in traps by few specimens--either naturally low population levels or poor response to ULV light. Until we have completed this year's trapping, it will not be possible to speculate on unintended impacts of the spray, simply because many species are univoltine, and data on their abundance (or absence) this year is critical.

To date, 3 papers have been written on this work:

Grimble,D.G.; R.C.Beckwith; P.C.Hammond. 1993. New Lepidoptera records for the Blue Mountains of eastern Oregon. PNW-RP-469, U.S.D.A. Forest Service, Pacific Northwest Forest Experiment Station, Portland. 6 p.

Grimble,D.G., R.C.Beckwith 1993. Temporal presence of late instar Mitoura spinetorum (Lycaenidae) in eastern Oregon. J. Lepidopterist's Soc. 47(4): 329-330.

Grimble,D.G.; R.C.Beckwith; P.C.Hammond. 199-. A survey of the Lepidoptera fauna from the Blue Mountains of eastern Oregon. J. Res. Lepidoptera (Publ. expected early 1994).

2. At Warm Springs Indian Reservation (WSIR) and in the Santiam Pass we will be ULV trapping for the second season. At WSIR,the purpose is to evaluate the possible unintended impacts of an operational BTK spray in 1993 on nontarget Lepidoptera, and in the Santiam Pass, the aim is a survey of the available food sources for the sensitive species,Townsend's big-eared bats. Again, since many moths are univoltine, we need this summer's catch record to evaluate impacts of BTK at WSIR. So far, we have identified 442 moth species on the WSIR, and 401 species in Santiam Pass. As always, Noctuidae and Geometridae are the largest Families represented.

Appendix D

Technology Development Needs -
Letter to Director, FPM

United States Department of Agriculture | Forest Service | Washington Office | 2121 C Second Street
Davis, CA 95616
PH (916) 551-1715
FAX (916) 757-8383

Reply To: 3400

Date: August 2, 1994

Subject: Priorities - 1995 Technology Development Program

To: Acting Director, FPM

The National Steering Committee for Managing Western Defoliators conducted its annual meeting in Spokane, Washington on April 12-13, 1994. The purpose of the meeting was to identify high priority FY 1995 technology development program needs and to advance the draft of the "Strategic/Tactical Plan for Management of Western Defoliators." The committee identified as listed below ten needs/issues for action in 1995. Each is high priority. The number code following each need is the applicable paragraph to the committee's draft strategic/tactical plan.

Evaluate the need to continue monitoring of existing population plots established by PNW Wickman and Mason (2-C-1)

Determine the effects of western spruce budworm and Douglas-fir tussock moth effects on resources and ecosystem structure and function. (1-B-1)

Analyze and summarize existing permanent plot data to evaluate effects of a current western spruce budworm outbreak. (1-A-1)

Evaluate the efficacy of silvicultural treatments designed to prevent/reduce unacceptable effects of defoliation on vegetation, resources, and ecosystems. (3-A-1)

Evaluate the potential for using natural enemies for population management of Douglas-fir tussock moth and western spruce budworm. (3-B-5)

Determine the potency of TM Biocontrol-1 with Entotech carrier on wild populations of the Douglas-fir tussock moth from different geographical areas including a) laboratory bioassays, and b) field tests. (3-B-1)

Validate and calibrate the western spruce budworm damage model. (1-C-1)

Compare, evaluate, and improve risk and hazard rating systems for western spruce budworm and Douglas-fir tussock moth over different geographical areas. (1-D-1)

Identify potentially important western hardwood defoliators and evaluate their roles and effects in western hardwood ecosystems. (1-A-5)

Pursue and obtain registration of the Douglas-fir tussock moth pheromone for mating disruption. (3-B-2)

In addition, the committee recommends special funding for R-10 in the amount of $5,000.00 to evaluate data collected from the first outbreak of spruce budworm ever reported to occur in white spruce stands of Alaska. Data have been collected annually during the outbreak (1990 - 1993). These data include budworm infestation levels; effects on tree growth and survival, cone and seed productivity, and foliage nutrient content; and the incidence of bark beetle attack of defoliated trees. The information from this evaluation would be used to provide guidelines for the development of management activities. This is a cooperative effort between FHM in Region 10 and PNW.

A report of the committee meeting and the Tactical/Strategic Plan for this committee will be submitted separately.

/s/John W. Barry
JOHN W. BARRY
Chair

cc: Members, Steering Committee
B. Eav
J. Cota

Appendix E

Strategic/Tactical Plan for Management of Western Defoliators - Draft

United States
Department of
Agriculture

Forest Service

Forest Pest
Management

Davis, CA

STRATEGIC/TACTICAL PLAN FOR MANAGEMENT OF WESTERN DEFOLIATORS - DRAFT

FPM 94-7
September 1994

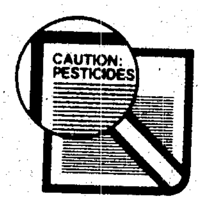
Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.



FPM 94-7
September 1994

Strategic/Tactical Plan for Management of Western Defoliators

DRAFT
September 7, 1994

Prepared by:

Members
National Steering Committee
for Management of Western
Defoliators

USDA Forest Service
Forest Pest Management
2121C Second Street
Davis, CA 95616
(916)551-1715
FAX (916)757-8383

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List, Committee Members

Introduction

Emphasis on Ecosystem Management and Forest Health has surfaced the need to re-evaluate traditional approaches and strategies for managing defoliators. Management emphasis is changing from attaining predetermined resource targets to restoring and maintaining sustainable forest ecosystems. Increasingly, entomologists and plant pathologists are being asked for information on the roles, functions and interrelationships of insects, including defoliators, and pathogens in, and their effects on, western forest ecosystems ("disturbance ecology"). Such questions and issues are part of our attempts to define forest health, the "range of natural variability", and "desired conditions" for given ecosystems and how they are affected by defoliator activity. The following plan is intended to help focus and connect Forest Pest Management (FPM) with these activities.

This Strategic/Tactical Plan was developed with the following assumptions:

(1) The primary objective of the Plan is to identify and prioritize needs for understanding and managing defoliators of western forest ecosystems. The Plan is intended to provide a framework for: (1) identifying critical issues and information needs relative to understanding the functions and interactions of western defoliators in forest ecosystems; (2) integrating traditional defoliator management strategies and methodologies with current emphases on forest health and ecosystem management; and (3) developing a tactical plan that prioritizes short-term (5 year) defoliator management technology development needs.

(2) The basic objective of western defoliator management is to determine, evaluate and maintain the effects of defoliators on ecosystems/resources at acceptable levels within the context of defined management goals and objectives, the "range of natural variability", and sustainable ecosystems ("desired condition").

(3) The following are needed for effective defoliator management:

(a) The ability to identify, understand, and predict defoliator effects on diverse resource management goals and objectives, forest health, and sustainable ecosystem structures, processes and functions.

(b) The ability to predict when and where unacceptable defoliator ecosystem/resource effects are going to occur.

(c) The availability of strategies, technologies and methodologies to implement effective management of forest ecosystems affected by western defoliators.

The following elements, sub-elements, rationale statements, and action items are intended to focus on these basic issues and help facilitate identification of information and technology development needs.

Element 1. <u>Functions/Interactions of Defoliators in Western Forest Ecosystem Dynamics.</u>

<u>1-A:</u> <u>Identification and Measurement of Effects</u>: There is a need to quantitatively measure defoliator effects (e.g., host mortality, top-kill, loss of foliage, growth-loss) on forest vegetation.

<u>1-A-1</u>: Identify, analyze and summarize existing data to evaluate effects of WSB outbreaks.

<u>Rationale</u>: Analyses of existing data will provide important information on the relationship of defoliation intensity and duration to tree mortality and top-kill. These relationships will be useful in validating and calibrating the current mortality and top-kill equations used in the Budworm Damage Model. The defoliation records will also be useful for validating, calibrating, and streamlining the Budworm Dynamics Model. A Technology Development Project for this purpose was funded in FY94.

Current data from many plots include root disease and dwarf mistletoe information in addition to defoliation data. These data will be useful in the development of a multiple insect and disease model. A project to develop such a model is being planned.

Some existing permanent plots have been treated silviculturally or with insecticides. Data analyses will provide an opportunity to (1) compare effects of WSB between treated and untreated stands, and (2) if appropriate, continue sampling for longer-term comparisons.

<u>Actions</u>:

1) Develop computerized procedures to check Region 6 data sets for errors, correct errors, summarize data, and produce appropriate output tables.

2) Write report on interim results of data collected annually since 1986 from (1) 33 stands in the Blue Mountains of eastern Oregon, and (2) 21 stands established during the early 1990's in the Northern Region.

3) Summarize data from 918 plots previously established in R4.

4) Identify and assess unpublished, unused, information contained in files/records located in various locations (e.g., Forest Pest Management (FPM), Research, and Districts).

5) Standardize permanent plot data in PTIPS.

6) Continue to establish plots, as needed, to validate models.

1-A-2: Continue monitoring/re-measuring permanent plots for effects of defoliation on mortality, top-kill, and growth.

Rationale: Radial and height growth information has not been collected from trees on most existing plots. There is a need to collect growth information from plot trees several years after the collapse of the outbreak. In addition, there is a need to follow top-kill and mortality after collapse of the outbreak to determine if mortality caused by other organisms, such as root disease and bark beetles, is greater than would be expected in non-outbreak areas.

If these plots can be followed for several decades, the long-term effects on stand growth, composition, and structure can be measured and compared to those estimates generated by models for use in environmental and economic analyses. There are very few empirical data sets available on these long-term effects. This information should also be useful in estimating the effects on resources such as vertebrate wildlife, fisheries, recreation, visual resources, and fuels.

Actions:

1) Develop sampling plan for collection of statistically reliable radial and height growth data from permanent plots in the 33 WSB stands in the Blue Mountains of eastern Oregon.

2) Collect radial and height growth data in 1995 and/or 1996 from the 33 WSB stands in the Blue Mountains of eastern Oregon.

3) Continue collecting data from established WSB/Douglas-fir tussock moth (DFTM) plots in Regions 1, 3, 4, and 6.

4) Re-measure the 105 WSB plots in Region 2 established in 1977 and 1978.

5) Prepare report, evaluate conclusions,and develop recommendations from Actions 2-4.

1-A-3: Evaluate the effects of western budworm larval feeding and defoliation on Douglas-fir cone crops.

Rationale: Budworm feeding on cones of host trees can result in significant losses. Even at moderate population levels, a significant portion of cone crops can be destroyed; at high levels, 100% of the cone crop can be destroyed. In addition to direct damage to seeds and cones, loss of foliage can negatively impact cone production. Both the effects of defoliation on cone/seed production and direct effects of budworm feeding should be evaluated and quantified.

Actions:

1) Summarize and analyze published and non-published data/information and make recommendations.

1-A-4: Collect and evaluate data on the effects of the first recorded outbreak of spruce budworms complex in Alaskan white spruce stands.

Rationale: High population levels of *Choristineura fumiferana* and *C. orae* were first observed in the Bonanza Creek Experimental Forest near Fairbanks, AK, in July, 1989. Subsequently, population levels, defoliation, and top-kill have generally increased, with approximately 190,000 acres defoliated by *C. fumiferana* in 1993. The infested stands contain the most productive white spruce stands in Alaska and also include one of the National Long Term Ecosystem Productivity Sites (Bonanza Creek Experimental Forest). Impact plots were established in 1990 and have been measured annually. Information collected from these plots includes; budworm infestation levels, effects on tree growth and mortality, cone and seed productivity, foliage nutrient content, and incidence of bark beetle attack on defoliated trees.

Actions:

1) Analyze data collected from 1990-1993 from the impact plots, develop conclusions and make recommendations.

1-A-5: Identify potentially important western hardwood defoliators and evaluate their roles and effects in western hardwood and riparian ecosystems.

Rationale: Although about 90% of the hardwood volume in the United States occurs in the East, hardwoods are increasingly being recognized as a critical component of western forest and riparian ecosystems. For example, aspen accounts for about 31% of the commercial forest land in Utah and 25% in Colorado. In addition to being a major constituent of the vegetation in riparian areas and woodlands (eg., southwestern Oregon and northern California), hardwoods are also an important component of forest cover types like the Interior Alaska White Spruce-Hardwoods Type and various "mixed conifer" types throughout the west. Important hardwood species include oak, alder, willow, aspen, cottonwood, birch, madrone and maple. In addition to being utilized for wood products, hardwoods are recognized as important to wildlife, forage production, riparian habitats, recreation, aesthetics and represent a key component of biodiversity. These perceived roles are receiving increased importance under the changing emphasis to forest health and ecosystem management.

With the exception of a few defoliators like the forest tent caterpillar, the large aspen tortrix, the fruittree leafroller, and the potential for establishment of gypsy moth, defoliators have generally not been considered major problems for western hardwoods. However, with the emphasis on forest health and ecosystem management, it is prudent to begin to consider the roles and effects defoliators play in western hardwood forest dynamics.

Actions:

1) Participate on teams working with hardwoods to determine and evaluate the roles and effects of defoliators in western hardwood ecosystems.

2) Develop recommendations from team findings.

1-B: Assessment of Effects (Resource Impact Analysis). There is a need to assess the impact, meaning, or significance of the defoliator effects (as defined in 1-A, above) on resource management goals and objectives, ecosystem structure and function, ecosystem sustainability, and the health (desired condition) of the ecosystem. This includes determining how ecological conditions and management activities affect defoliator population dynamics and the consequent effects of defoliators on ecosystems.

1-B-1: Determine the effects of WSB and DFTM on resources and ecosystem structure and function.

Rationale: Considerable information has been compiled concerning the effects of WSB and DFTM defoliation on vegetation and more specifically on the timber resource. However, serious data gaps exist concerning the impacts of WSB and DFTM defoliation on other resources/ecosystem elements (e.g., soils, hydrology, wildlife habitat, fuels).

Actions:

1) Develop a Technology Development Proposal to assess the effects of the 1989-1992 DFTM outbreak in central Idaho and the 1992 WSB outbreak in R1 on specific ecosystem attributes, including big game habitat (thermal cover) and fish habitat (stream temperature). Cooperative TDP project involving FPM (R4, R5, R1) and NFS (R4, R1).

1-B-2: Determine the history of defoliator outbreaks to help define the "range of natural variability".

Rationale: Little is known about the long-term dynamics of the forest-budworm system, especially with regard to the possible influence of climatic variation or human activities such as fire suppression and timber harvesting. However, we do know that forest conditions today are very different than they were 150 years ago. Selective harvesting of pines in the past, the large fires of the late 1800's and fire suppression after 1900 led to higher proportions and densities of budworm host trees than existed in pre-settlement forests. Modern forests provide a favorable food base for budworm which promotes extensive outbreaks. The effects of defoliators on resources may have also changed in response to changing forest conditions.

Actions:

1) Determine the history of WSB/DFTM outbreaks in specific locations throughout the West. The analysis would address how changes in vegetation have affected insect populations and how this translates into effects on forest ecosystems by comparing historic vegetation with current conditions. Changes in defoliator population parameters such as outbreak occurrence, intensity, and duration would also be examined by using historic data and tree-ring analyses.

1-C: Prediction of Effects: There is a need to predict ecosystem effects of defoliators with and without management/treatment.

1-C-1: Validate and calibrate the Budworm Damage Model.

Rationale: Millions of dollars have been spent over the last decade for insecticide treatment of WSB. Estimates of tree effects (mortality, top-kill, radial growth) are based upon estimates generated from processing stand data through the Forest Vegetation Simulator (formerly called the Stand Prognosis Model) linked with the Budworm Damage Model. There is concern that these effects are not adequately portrayed for some stands. This can result in under or over estimating the effects on resources such as wood fiber, vertebrate wildlife habitat, fish habitat, old growth habitat, recreation, visual quality and fuels. There is a need to validate and calibrate (if necessary) the Budworm Damage Model to increase the confidence in the model outputs upon which these high-priced decisions are based.

Actions:

1) After tree data (defoliation, top-kill, growth, and mortality) are summarized from plots in the West, the data should be used to validate/calibrate the Budworm Damage Model.

2) Establish additional permanent WSB plots to gather more information on the influences of silvicultural activities on WSB effects and use such information to validate/calibrate the Budworm Damage Model. Establishment of plots is planned for the following situations: various silvicultural strategies in pure Douglas-fir and in mixed conifer stands (Region 1); uneven-aged vs. even-aged management in mixed conifer and spruce/fir types (Region 2); and several silvicultural strategies vs. no silvicultural action (Region 3).

1-C-2: Evaluate the capabilities and limitations of the WSB/DFTM population dynamics models.

Rationale: The Budworm Population Dynamics Model was developed through funding of the Canada/United States Spruce Budworms Program (CANUSA-West) in the 1980's. This population dynamics model was intended to be a research tool. The CANUSA program planned to evaluate the research model, identify key features that influenced model behavior, and then produce a management-oriented model for forest managers which would provide information regarding the effects of WSB on their forests and, thus, would provide important information for consideration in decision-making processes.

The research model has not been thoroughly evaluated, and the management-oriented version has not been produced. At present the only model that is used is the Budworm Damage Model. A major weakness of using this model is that all outbreak and defoliation parameters (timing and length of outbreak; intensity of defoliation by year of outbreak, tree species, crown third, and foliage age) must be defined by the user, and most times the same scenario is used to predict WSB effects on all stand types within an analysis area. There is a pressing need to have a streamlined, useable population dynamics model which incorporates stochastic processes for timing outbreaks, and which will vary defoliation levels in response to stand characteristics. Until a model with these capabilities is available, there is no useful tool to incorporate WSB effects into forest planning processes. In addition, a model such as this would greatly enhance the reliability of predicted effects used in analyses that affect the allocation of money for large suppression projects using insecticides.

In the 1970's development of a DFTM Outbreak Model was sponsored by the Expanded Douglas-fir Tussock Moth Research and Development Program. This model was linked to the Stand Prognosis Model (now modified and called the Forest Vegetation Simulator or "FVS"). The DFTM Outbreak Model predicts population dynamics on midcrown branches of medium-sized trees. Unfortunately, the link between midcrown branch defoliation and whole tree defoliation is inherently weak, and the model will require major changes to address this problem. To date, the model has not been changed. The model was used for an environmental analysis in 1990 to predict effects on tree growth within a DFTM outbreak area in northeastern Oregon. The analysis resulted in a recommendation of insecticide treatment in 1991. There is concern that the effects on the trees and stands were significantly overstated. Before this can become a reliable tool in which we can be confident, an evaluation of the capabilities and limitations is required, and an effort to incorporate new information is needed.

Actions:

1) A Technology Development Project has been funded to "streamline" the existing WSB Population Dynamics Model which links to the FVS. An intensive analysis of the behavior and sensitivity of the existing population dynamics model will be conducted. Key factors will be extracted from the existing model to create a new streamlined version.

2) A recent evaluation of the mortality and top-kill predictive capabilities of the DFTM outbreak model indicates the need for development of a DFTM damage model which can more accurately incorporate the effects of DFTM on FVS predictions.

1-C-3: Develop procedures for using the WSB/DFTM models in the forest planning process that is changing to reflect ecosystem management needs .

Rationale: Currently, the effects of WSB and DFTM on forest ecosystems are taken into account in a cursory way in forest planning efforts. There is a need to develop procedures for using the models to generate outbreaks in these long-term planning processes to insure that effects on forest ecosystem structure and function are accounted for. This will help reduce the risk of making decisions now that will result in unattainable objectives in the future. With the current efforts to incorporate ecosystem management concepts in forest planning efforts, it is imperative that we be able to model the effects of disturbance agents such as defoliators.

Actions:

1) A Technology Development Project has been funded in FY94 to "streamline" the existing WSB Population Dynamics Model. This should make it useful as a management tool and allow it to be incorporated into the current (and changing) forest planning process.

2) Conduct an evaluation of the use of the "streamlined" version of the WSB Population Dynamics Model with the current forest planning model(s).

1-D: Hazard/Risk Rating: There is a need to develop and evaluate hazard/risk rating systems for use in predictive ecosystem effects modeling and focusing detection and prevention efforts.

1-D-1: Compare, evaluate, and improve existing, and/or develop new, risk and hazard rating systems for WSB/DFTM over different geographical areas.

Rationale: Efficient management of forest insects is best accomplished by setting priorities to work in those areas where the effort will have the greatest effect. Risk and hazard rating systems that evaluate stand and insect population conditions can be used to help set these priorities.

While there are existing systems for both the WSB and the DFTM, there have been times and locations where they have not provided reliable results. Also, forest insect/host interactions tend to differ by geographic region, thus the risk and hazard rating systems need to be calibrated for each region to make them more dependable. Continuing efforts are needed to improve these, and/or develop new, systems.

Actions:

1) Develop/evaluate WSB hazard rating system for the southern Rockies (R3).

2) Validate and modify as needed the Wulf hazard rating system for WSB for Region 1.

3) Develop/evaluate DFTM hazard rating systems for dry Douglas-fir sites in southern Idaho.

Element 2. Population Evaluation

2-A: Survey/Detection: There is a need to develop and use effective survey and detection systems to predict when and where populations will reach levels that might cause unacceptable ecosystem effects.

2-A-1: Evaluate the DFTM early warning pheromone system to improve predictability and efficiency of the system.

Rationale: Since the operational use of the DFTM early warning system was initiated in 1980, there have been three outbreaks of DFTM in the western United States (eastern Oregon, Idaho, and northern California). In at least two of the outbreaks, the early warning system was not considered effective in predicting when and where the outbreaks occurred.

Actions:

1) PNW and R5-FPM initiated a cooperative effort in 1992 to a) assess reasons why the system did not adequately and consistently predict the recent outbreaks and b) evaluate alternative trapping deployment strategies to improve predictability. PNW (Sower) and R5-FPM (Wenz) should report the results of this effort and propose modifications to the system, as appropriate, in 1994-95.

2) Develop/implement changes to system as identified in Action #1.

2-A-2: Examine capabilities for long range forecasting of DFTM populations using historical pheromone trapping data (MAG data base and other sources).

Rationale: Analysis of historical data sets often reveal patterns or relationships associated with cyclic populations. An opportunity exists to evaluate one such data set, the west-wide DFTM pheromone data set residing at MAG. This information has been used locally with limited success to predict population trends. A thorough evaluation of the west-wide data set may reveal patterns which could greatly improve forecasting capabilities.

Actions: No actions proposed at this time.

2-B: Population Dynamics. There is a need for an adequate understanding of defoliator population dynamics, including the relationship between population levels and resource/ecosystem effects.

2-B-1: Evaluate the role of natural enemies in the population dynamics of WSB/DFTM.

Rationale: Many factors, including insects and diseases, are known to play an important role in maintaining defoliator populations at low densities. Generalized predators such as birds and ants play an important role in the population dynamics of the WSB. As we move toward ecosystem management, the need to explore natural processes and controls will be highlighted. An alternative to treating "high" or outbreak populations of defoliators, is to try and keep defoliator populations at low levels for longer periods of time. We need to further explore the relationship of selected natural enemy arthropod populations and defoliators during both low level and epidemic population levels. Multi-year data are needed on how these populations interact over time.

Actions:

1) Establish plot systems to examine the relationship between arthropod natural enemies and defoliators over time. Several management scenarios, which include the effects of fire, should be represented by the plot network.

2) Standardize variables and coordinate data collection across regions.

3) Develop and/or refine monitoring/sampling techniques for assessing natural enemy populations across regions.

2-B-2: Continue to evaluate the potential of using WSB pheromone trap catches to predict subsequent defoliation.

Rationale: In WSB analyses, a prediction of the following year's population/defoliation levels is helpful in providing lead time for making management decisions. In the past, such predictions were made using results from late summer/early fall egg mass sampling. This was expensive and predictions were not very reliable. Currently, pheromone trapping is generally used to predict next year's population/defoliation levels. The predictive capabilities of pheromone trapping, with the trapping methods currently employed, are not much better than those of egg mass sampling: but the sampling process is cheaper and can be done with fewer people. There is a need to improve the ability to predict future WSB population/ defoliation levels through refinement of pheromone data trapping methods and analyses. This will help improve decision-making.

Actions:

1) Conduct analyses of pheromone trap data collected by PNW over the last several years. Such analyses would use GIS to incorporate variables (e.g., defoliation history and intensity, host type, soils, weather) into predictive equations to more accurately predict defoliation levels the year following flight.

2) Explore feasibility of commercial production of the WSB pheromone.

3) Explore opportunities to combine/add pheromone trapping plots with other WSB population and/or foliage quality plots.

2-C: Population Assessment and Monitoring: There is a need to develop methodologies for spatial and temporal assessment/monitoring of defoliator populations, and for summarizing and analyzing the data obtained through use of these methodologies.

2-C-1: Evaluate the need to continue the monitoring of existing WSB/DFTM population plots established by PNW (Wickman, Mason).

Rationale: Plots exist in Oregon and Washington from which about 15 years of population density information for both WSB and DFTM have been collected. Data from such long-term plots should prove to be extremely valuable with the move toward using concepts which will allow sustainable forest ecosystems. There are few opportunities currently to gather sets of long-term data and, in fact, research organizations appear to be providing little support for future projects which involve collecting insect population data over multiple years. This opportunity to continue adding information to the 15-year sets of data should not be missed.

Actions:

1) Examine plot site information, tree data, and WSB/DFTM population information and evaluate to determine worth/need for continued sampling.

2) If continuation of data collection is warranted, investigate ways to obtain resources/funding to continue.

2-C-2: Develop a sampling system for western hemlock looper.

Rationale: For the last two or three years, areas with defoliation caused by western hemlock looper (WHL) have been detected in British Columbia and Washington. This defoliation is occurring primarily in interior forests, whereas most of the early research data were collected in coastal forests. Adequate sampling systems are not available for estimating insect population densities that can be related to effects on trees.

A cooperative study by the Canadian Forest Service and Simon Fraser University to develop a pheromone trapping and forecasting system was initiated in 1992 and continued in 1993. Estimates of larval, pupal, and overwintering egg population densities, and defoliation severity, were made at 27 sites. Preliminary results show promise for predicting succeeding generation population levels. However, there is no information that relates WHL population levels to effects on trees and stands.

There is a need to develop population sampling systems that relate population densities to effects on trees and stands. This would help improve decision-making and provide an opportunity to adapt one of the defoliator models to simulate the effects of WHL on trees and stands.

Actions:

1) No action needed at this time. Projections are that populations will decline in 1994 in Washington and WHL is not currently a high priority with forest managers.

Element 3. Management and Assessment of Treatment Effects.

3-A: Habitat Management: There is a need to develop and assess silvicultural techniques and approaches designed to prevent and/or reduce unacceptable defoliator effects. Defoliator effects should be considered in the development and implementation of silvicultural prescriptions.

3-A-1: Evaluate the efficacy of silvicultural treatments designed to prevent/reduce unacceptable effects of defoliation on vegetation, resources, and ecosystems.

Rationale: Silvicultural treatments are frequently recommended as ways to prevent unacceptable losses. Unfortunately there is not much documented evidence that supports the premise that these treatments can prevent or even reduce future losses. Many of the recommended treatments are counter to the prescriptions being recommended under adaptive forestry for extracting resources and for maintaining ecosystem health. Therefore an evaluation of the efficacy of silvicultural treatments is needed if we propose to continue to recommend these treatments for prevention or reduction of impacts caused by WSB and DFTM.

Actions:

1) Establish additional permanent WSB population/effects plots in areas where sustainable ecosystem concepts are being incorporated using non-traditional silvicultural techniques (See section 1-C-1, Action 2).

2) Continue to monitor plots established across various silvicultural treatments in R1 and R4.

3-B: Population Management: There is a need to develop and assess strategies, techniques, and methodologies, including semiochemicals, microbials, growth regulators, biological controls and chemical insecticides, maintain defoliator populations at, or reduce to, acceptable levels relative to resource/ecosystem effects.

3-B-1: Determine the potency of TM BioControl-1 with Entotech carrier on wild populations of the DFTM from different geographical areas using a) lab bioassays and b) field tests.

Rationale: TM BioControl-1 is a registered biological pesticide containing polyhedral inclusion bodies of a naturally occurring Douglas-fir tussock moth nucleopolyhedrosis virus as its active ingredient. This virus is very selective to species of tussock moth. Aerial and ground applications of TM BioControl-1 have suppressed DFTM populations. However, the most recent use of TM BioControl-1 was not successful. The recommended application rate had been established from tests on long-standing laboratory colonies that had apparently been weakened through inbreeding. In the field, this dosage rate was not adequate. To avoid future failures, the dosage rate needs to be established by testing on colonies from wild populations, including those from different geographical areas so as to account for any genetic resistance that may exist.

In addition, a virus carrier, developed by Entotech, has been shown to be an effective carrier for Gypcheck, a viral insecticide used in gypsy moth management. Studies have shown that this carrier is easier to use (handle, mix, and store) than carriers currently being used with TM BioControl-1.

Actions:

1) Conduct lab bioassays and field tests of TM BioControl-1 plus Entotech's carrier to determine rain fastness, persistence, viability, and efficacy.

3-B-2: Pursue and obtain registration of the DFTM pheromone for mating disruption.

Rationale: Aerial application of the DFTM pheromone can effectively reduce mating success and can be considered for use alone or in conjunction with other prevention/suppression methodologies.

Actions:

1) PNW and FPM (WO and appropriate Regional personnel) continue to pursue registration in 1994.

3-B-3: Improve DFTM pheromone application and delivery technology and formulation for mating disruption.

Rationale: It is important to control the DFTM moth at low population levels to avoid defoliation and damage to the trees that results when high numbers of larvae are present. Mating disruption accomplished by the application of synthesized sex attractant pheromones has been found to fulfill this need. The procedures and equipment for formulation, application, and delivery need to be evaluated, improved, and standardized so as to be available for operational use during the next outbreak.

Actions:

1) The Missoula Technology Development Center should complete and report on the survey of pheromone application equipment and technology and develop recommendations.

2) Devise plans to obtain or develop equipment/technologies.

3-B-4: Conduct field tests of DFTM pheromone for mating disruption to determine optimal time of treatment within an outbreak cycle.

Rationale: It is important to control the DFTM at low population levels in order to avoid the defoliation and damage to the trees that result when high numbers of larvae are present. Work is needed to determine the optimal timing for disrupting DFTM mating during its outbreak cycles.

Actions:

1) Develop plans to utilize outbreak opportunities to assess timing of DFTM mating disruption strategy

3-B-5: Evaluate the potential for using natural enemies for population management of DFTM/WSB.

Rationale: Thirty-two species of insectivorous birds are known to feed on DFTM and WSB and 20 of these are neotropical migrants. In addition, there are at least 120 species of parasites of WSB and DFTM. Many species of ants, birds and spiders are very effective predators of defoliators. Ants are dominant in the ecological hierarchy because of the position they occupy and their abundance in almost every ecosystem. There has been considerable interest and work over the last few decades in trying to manipulate predaceous ants to benefit forest health. Research efforts have been aimed at protecting, encouraging, and transplanting ants.

Western forests that are known to be susceptible to WSB and DFTM where timber yields are not the main or only consideration, provide an excellent opportunity to evaluate and utilize the management potential of natural enemies. Predatory ants and many insectivorous birds are influenced by the availability of standing or down dead wood, or stumps. Stand structure also strongly influences the presence and abundance of many predaceous ant and bird species.

Actions:

1) Examine the habitat requirements, such as stand conditions, for previously identified key natural enemies of WSB and DFTM.

2) Develop effective monitoring methods for key natural enemies of WSB and DFTM.

3) Evaluate the effects of harvesting practices and prescribed fires on natural enemy populations.

4) Determine potential standards for log retentions to protect and enhance natural enemy populations.

3-B-6: Evaluate the impacts of microbial insecticides on non-target Lepidoptera and other organisms.

Rationale: Microbial insecticide treatments have proven to be effective, economical, and in general, socially acceptable for use against many forest defoliators. However, the direct, indirect and cumulative effects of these microbials on non-target organisms in the West are largely unknown. This lack of information has resulted in a number of questions and concerns from resource managers, resource specialists, and interested publics that should be addressed so that proposed treatments can be adequately evaluated. Studies are needed to determine baseline population information, develop effective and efficient sampling procedures, and to monitor post treatment effects under a wide range of conditions in the West.

Actions:

1) Initiate baseline surveys for organisms, especially Lepidoptera, potentially subject to impacts by use of microbial insecticide treatments.

2) Complete R3 report on baseline survey for Lepidoptera.

3) Identify and develop annotated list of taxonomists available to identify non-target organisms to species level.

4) Identify alternative users of taxonomic expertise in the non-target area and sources of cooperative funding for taxonomic support.

5) Develop/evaluate field methods to predict/monitor microbial insecticide effects on non-targets.

3-B-7: Evaluate the effects of population suppression methodologies on threatened, endangered, and sensitive species.

Rationale: Western defoliator population suppression methodologies have the potential to affect threatened, endangered, and sensitive (TES) species. The potential effects of population suppression, both direct and indirect, continue to pose unanswered questions and concerns among forest managers, resource specialists, and interested publics. However, very little information is available regarding these potential effects in the West. While a few studies have been initiated to determine some of these effects, additional studies are needed and should be supported to determine if and how various treatments do affect TES species. Specific needs include baseline information on potentially affected TES species, development of population sampling methodologies and analysis techniques, and post treatment population monitoring of TES species to determine effects of various treatments westwide.

Actions: No actions proposed at this time.

3-B-8: Develop and evaluate methods/systems capable of treating individual trees with various insecticides that are safe, efficient, economical, and environmentally acceptable.

Rationale: Current methods of treating single trees with pesticides is hazardous, inefficient, costly and often unacceptable to segments of the public. Practices include hydraulic spraying with high volumes of diluted pesticides, high pressure airblast spraying that causes excessive off-target movement, and backpack spraying from elevated platforms. There is a need for single tree protection to protect white pine blister rust candidate and proven resistant trees, selected trees in seed orchards, seeds/cones on selected trees, trees of historic and aesthetic value, urban street and landscape trees, trees in developed campgrounds and administrative sites, and trees bordering urban/wildlife interfaces.

Actions:

1) Continue research and development of a system, currently in progress at the Pacific Southwest Station, that involves installation of a semi-permanent hose and nozzle system in selected trees.

2) Request the Missoula Technology and Development Center to establish an FPM project to address "Single Tree Application Systems".

Element 4. Technology Transfer.

4-A: Information Transfer: There is a need for timely transfer of information to, and coordination with, cooperators (NFS, Research, States, community interest groups).

4-A-1: Develop procedures to assist in the decision-making, planning, and implementation and reporting of suppression projects.

Rationale: The documentation of standardized procedures for preparing and conducting suppression projects would be very useful. Reports of previous projects are often not available or do not include enough detail to be a useful guide in the preparation of environmental statements, work plans, or field procedures. A procedures manual would greatly facilitate this process, while helping to assure that important details are not overlooked.

Actions:

1) Review draft manual being prepared by R8/R9 and make recommendations.

2) Implement recommendations as appropriate.

Appendix

List, Committee Members

Members

<u>National Steering Committee for Management of Western Defoliators</u>

John W. Barry
USDA Forest Service
Forest Pest Management
2121-C 2nd Street
Davis, CA 95616
DG J.Barry:R05H
PH (916) 758-4600
FAX (916) 757-8383

Dayle Bennett
USDA Forest Service
Forest Pest Management
517 Gold Avenue, SW
Albuquerque, NM 87102
DG D.Bennett:R03A
PH (505) 842-3190
FAX (505) 842-3800

Leo Cadogen
Forest Pest Management Institute
P.O. Box 490
Sault Ste. Marie, Ontario
Canada P6A 5M7
PH (705) 949-9461
FAX (705) 759-5700

Nancy Campbell
USDA Forest Service
Forest Pest Management
P.O. Box 7669
Missoula, MT 59807
DG N.Campbell:R01A
PH (406) 329-3281
FAX (406) 329-3347

Jesus Cota
USDA Forest Service
Forest Pest Management, AB-2S
P.O. Box 96090
Washington, DC 20090-6090
DG J.Cota:W01C
PH (202) 205-1600
FAX (202) 205-1174

John Cunningham
Forest Pest Management Institute
P.O. Box 490
Sault Ste. Marie, Ontario
Canada P6A 5M7
PH (705) 949-9461
FAX (705) 759-5700

Dave Grimble
Forestry Sciences Laboratory
3200 SW Jefferson Way
Corvallis, OR 97331
DG D.Grimble:S26L05A
PH (503) 750-7366
FAX (503) 750-7329

Tom Hofacker
USDA Forest Service
Forest Pest Management
P.O. Box 96090
Washington, DC 20090-6090
DG T.Hofacker:W01C
PH (202) 205-1600
FAX (202) 205-1174

Bruce Hostetler
USDA Forest Service
Forest Pest Management
P.O. Box 3623
Portland, OR 97208
DG B.Hostetler:R06C
PH (503) 326-3765
FAX (503) 326-5569

Ladd Livingston
State of Idaho
Department of Public Lands
P.O. Box 670
Coeur D'Alene, ID 83814
PH (208) 769-1525
FAX (208) 769-1524

Roy Mask
USDA Forest Service
Forest Pest Management
201 E. 9th Avenue
Anchorage, AK 99501
DG R.Mask:R10A
PH (907) 586-8769
FAX (907) 586-7848

Sheri Smith
USDA Forest Service
Forest Pest Management
Stanislaus National Forest
19777 Greenley Road
Sonora, CA 95370
DG S.Smith:R05F16A
PH (209) 532-3671
FAX (209) 533-1890

Dick Reardon
USDA Forest Service
Forest Pest Management
180 Canfield Street
Morgantown, WV 26505
DG R.Reardon:S24L08A
PH (304) 285-1563
FAX (304) 559-7041

Dave Rising
USDA Forest Service
Equipment Development Center
Fort Missoula - Building #1
Missoula, MT 59801
DG D.Rising:R01A
PH (406) 329-3900
FAX (406) 329-3719

Julie Weatherby
USDA Forest Service
Forest Pest Management
1750 Front Street, Rm. 202
Boise, ID 83702
DG J.Weatherby:R04F02A
PH (208) 364-4220
FAX (208) 364-4111

John Wenz
USDA Forest Service
Forest Pest Management
Stanislaus National Forest
19777 Greenley Road
Sonora, CA 95370
DG J.Wenz:R05F16A
PH (209) 532-3671
FAX (209) 533-1890

Appendix F

Implementing Ecosystem Management - Memorandum

United States Department of Agriculture
Forest Service
Washington Office
14th & Independence SW
P.O. Box 96090
Washington, DC 20090-6090

Reply to: 1330-1 Date: February 24, 1994

Subject: Implementing Ecosystem Management

To: Regional Foresters, Stations Directors, IITF Director, Area Director, and WO Staff Directors

REPLY DUE APRIL 15

Putting ecosystem management principles into practice throughout the Forest Service is one of my highest priorities. We have had very helpful learning and testing experiences during the last several years and we need to accelerate applying what we have learned. It is time to consolidate what we know and make sure we are basing our management activities on that knowledge. We also need to address high priority activities that continue to both broaden our understanding of ecosystem management and facilitate rapid application by every Forest Service unit.

We have developed the enclosed national Action Plan for Implementing Ecosystem Management based upon the following strategic goals:

- Institutionalize an ecosystem-based management approach throughout the Forest Service as rapidly as possible;
- Integrate ecosystem management into all our activities and recognize that responsibility and accountability for ecosystem management is shared by all our employees;
- Strengthen collaboration, flexibility, innovation and creativity; and
- Ensure our management actions are ecologically responsible, economically viable, and socially acceptable.

The action plan identifies a number of efforts necessary at the corporate level to move toward these goals. Many of them are underway and involve a number of your staff. We need to further refine our efforts through a conscious choice of both "bottom up" and "top down" activities. We will use the action plan as a starting point and identify additional activities, infrastructure, and information management needed at the national level to move us forward. At the same time, you need to continue leading those efforts best done at the field level to aid in our understanding and application of ecosystem management.

In a separate letter, I will be requesting the assistance of some of your personnel to aid us in refining our national action priorities. In the meantime, I ask you to review the strategic plans you jointly developed more than a year ago. Your review should be done in a partnership approach in the same way as the original plan was developed. It should consider the activities you identified in light of those we are undertaking on a national level and to assure they are focused in a way to deal with ecosystem management issues best addressed at a regional or local level.

Any questions or comments you may have concerning the national action plan should be submitted to the Acting Director, Ecosystem Management Staff (EM:W01C). Please also provide a brief summary (no more than 2 pages) by April 15 of any strategic realignment of your activities that you will make based on your review and experiences thus far in ecosystem management.

/s/ Sterling J. Wilcox
for

JACK WARD THOMAS
Chief

Enclosure

From Concepts to Clarity: The Next Steps
An Action Plan for Implementing Ecosystem Management
USDA Forest Service

Developing an ecosystem-based management approach is necessary to implement the Forest Service Mission, and Guiding Principles. It will be an evolutionary path, with each phase building on the understanding gained during the previous. The action plan summarizes the major national activities needed to complete development and speed implementation of an agency wide approach. It is based upon the testing, demonstrations and learning that have taken place over the last several years across the agency and in interactions with many other organizations and groups. While the actions will be coordinated nationally, they will be accomplished in collaboration with field units and partners.

This action plan represents the commitment of the Forest Service to shift from the testing and demonstration phase of the last several years into a major agency effort focused on full implementation of ecosystem management. The strategic plans developed by the Regions and Stations supplement these agencywide activities.

Underlying Strategy for Action Plan

The following strategic objectives drive the action plan:

- **institutionalizing an ecosystem-based management approach** throughout the Forest Service as the way of doing business through evolutionary phases or steps. This will be done consistent with our Mission, Vision, and Guiding Principles and within the constraints of existing laws and regulations. As opportunities or impediments are identified, we will make administrative changes or seek legislative relief.

- **integrating ecosystem management into all our activities** in a way that responsibility and accountability for success are shared by all employees, as opposed to ecosystem management becoming an additional, separate program or responsibility.

- **encouraging collaboration, flexibility, innovation, and creativity** throughout the Forest Service as we proceed along the evolutionary path of understanding and implementing ecosystem management.

- **ensuring Forest Service actions are ecologically responsible, economically viable, and socially acceptable**. This will be done by following the key principles of ecosystem management, including taking an ecological approach, using the best science, and through collaboration and grass roots participation.

We are delineating the leadership role for the Washington Office staffs in achieving the above objectives through actions to be undertaken in four major categories. These actions will be accomplished by the Staff Directors working as an integrated leadership team, involving interdisciplinary staff teams, and in collaboration with field offices and external partners. The four categories are:

- scientific underpinnings, tools and technology;
- communications, coordination, and cooperation;
- policies and procedures; and,
- organization and operational effectiveness.

Each action item will be completed within an identified timeframe as follows:

- Nearterm (within 18 months)
- Midterm (within 36 months)
- Longterm (within 60 months)

SCIENTIFIC UNDERPINNINGS, TOOLS AND TECHNOLOGIES

NEAR TERM ACTIONS

IMPLEMENT USE OF ECOLOGICAL CLASSIFICATION SYSTEM as a framework for organizing ecosystem management related information across a variety of scales. Reach national agreement on classification systems for both terrestrial and aquatic ecosystems that will be used in support of resource information, integrated inventories and ecological mapping, planning, research and project implementation. Address the relationship and linkages of classification across geographic scales. **Lead Staff: EM/WSA**

ESTABLISH A PROCESS AND PROTOCOLS AND SET PRIORITIES FOR CONDUCTING ECOLOGICAL ASSESSMENTS for various ecoregions of the United States. Develop a funding strategy. Develop partnerships and cooperators to help develop the process and provide information needed at the very broad geographic scales. **Lead Staff: EM**

DEVELOP AN ECOSYSTEM MANAGEMENT GUIDELINE SERIES that provides dynamic documentation of specific practices and procedures for the components of ecosystem management that represent the "state of knowledge." Continuously update and amend this series to provide information to all Forest Service units. **Lead Staff: EM**

DEVELOP AN AGENCY-WIDE MONITORING AND EVALUATION FRAMEWORK for Forest Service activities at all scales. **Lead Staff: LMP/EM/FER**

MIDTERM ACTIONS

DEVELOP HABITAT CONSERVATION ASSESSMENTS AND STRATEGIES to help maintain viability of species at risk. Involve scientists and stakeholders in the development of these assessments and strategies. **Lead Staff: WL&F/FER**

ESTABLISH AN AGENCY-WIDE APPROACH FOR INCORPORATING THE HUMAN DIMENSION into ecosystem management activities. Include the role of past and current human activities in ecosystems. Conduct adaptive social science research on how humans perceive and value their environment, and on human use, and consumption patterns. **Lead Staff: RN/S&PF/FIERR**

LONGTERM ACTIONS

DEVELOP AN ANALYSIS OF MAJOR ENVIRONMENTAL DISTURBANCE FACTORS at appropriate scales in conjunction with field offices and provide information on the historic range of variation. Develop a parallel review of the understanding of the major cycles and flows of energy and materials. **Lead Staff: FFASR**

INCREASE FUNDAMENTAL RESEARCH on understanding ecosystems, human-ecosystem interactions and assessing sustainable management options. Identify research-management needs and priorities, develop a funding strategy. **Lead Staff: RES**

EXPAND THE NETWORKS OF LONG TERM ECOLOGICAL RESEARCH SITES to represent the ecoregions of the United States including Research Natural Areas, experimental forests, etc. Develop partnerships and cooperators to develop information and knowledge useful to many interests. **Lead Staff: FER/FMR**

PARTICIPATE FULLY IN THE INTERNATIONAL GEOSPHERE BIOSPHERE PROGRAM. **Lead Staff: FFASR**

DEVELOP A FULLY INTEGRATED INVENTORY APPROACH, increase emphasis, and set priorities and protocols for all Forest Service inventories and surveys both within and across the spatial and temporal scales. **Lead Staff: EM/FIERR**

COMMUNICATIONS, COORDINATION AND COOPERATION

NEAR TERM ACTIONS

PARTICIPATE IN DEVELOPING AN INTERAGENCY COMPREHENSIVE GLOSSARY FOR ECOSYSTEM MANAGEMENT. **Lead Staff: EM**

MAINTAIN A COORDINATED APPROACH WITH THE SOIL CONSERVATION SERVICE for ecosystem management activities. **Lead Staff: EM/WSA/CF**

MAINTAIN CLOSE WORKING RELATIONSHIPS WITH USDA AGENCIES for ecosystem management activities. **Lead Staff: EM/S&PF**

MAINTAIN AN INTERAGENCY ECOSYSTEM MANAGEMENT COORDINATING GROUP as a means for sharing information, developing common efforts and supporting communications related to ecosystem management at the operational level. Develop an MOU on ecosystem management with other interested Federal agencies. **Lead Staff: EM**

MAINTAIN COMMUNICATIONS WITH NON-GOVERNMENT ORGANIZATIONS; ACADEMIA; INDUSTRY; TRIBAL, STATE, AND LOCAL GOVERNMENT REPRESENTATIVES on ecosystem management activities. **LEAD STAFF: EM**

EXPAND ECONOMIC ACTION PROGRAMS TO HELP LOCAL COMMUNITIES promote sustainable development that is consistent with ecosystem management using existing programs like the Stewardship Program and Rural Development Program. **Lead Staff: CF**

DEVELOP A COMMUNICATIONS PLAN for the Forest Service ecosystem management approach as it evolves. Provide timely information to both internal and external audiences. **Lead Staff: EM**

DEVELOP A CUSTOMER SERVICE ACTION PLAN to provide high quality, consistent, information and services for all contact points for Forest Service. **Lead Staff: RHWR/PAO**

LONGTERM ACTIONS

USE THE NATURAL RESOURCE CONSERVATION EDUCATION PROGRAM to help the public understand the complexities of ecological issues and to develop the critical skills needed to help address them. **Lead Staff: S&PF**

POLICIES AND PROCEDURES

NEAR TERM ACTIONS

REVISE NATIONAL FOREST MANAGEMENT ACT REGULATIONS to fully integrate the principles and actions necessary to implement ecosystem management through forest plans. **Lead Staff: LMP**

ASSIST FIELD TO ADJUST THE APPROXIMATELY 80 FOREST PLANS to fully incorporate ecosystem management principles and procedures. Develop a Forest Plan Prototype to reflect ecologically-based planning. Synchronize the timing of Forest Plan revisions so forests within the same ecoregions are generally within similar timeframes. **Lead Staff: LMP**

ISSUE INTERIM DIRECTIVES Delete or modify existing direction which is an obstacle to improved efficiency or ecosystem management while remaining within constraints of the existing rule. **Lead Staff: NFS Staffs**

FRAME THE 1995 RPA PROGRAM AND POLICY STATEMENT to assist Forest Service positioning to address and respond to national resource conditions and trends. **Lead Staff:RPA**

UPDATE REGION-STATION STRATEGIC PLANS for implementing ecosystem management. **Lead Staff: EM Staff**

EVALUATE THE CURRENT SET OF STATUTES, REGULATIONS AND POLICIES directing the Forest Service and propose administrative or legislation changes for those that cause problems for implementing ecosystem management approaches. **Lead Staff: LA**

MIDTERM ACTIONS

CLARIFY HOW SHARED LEADERSHIP AND HIGHLY PARTICIPATORY MEANS WILL BE EMPLOYED in Forest Service planning activities. **Lead Staff: PAO/LMP**

REVISE APPEAL REGULATIONS governing forest plan decisions. **Lead Staff:LMP**

ORGANIZATION AND OPERATIONAL EFFECTIVENESS AND EFFICIENCY

NEAR TERM ACTIONS

PARTICIPATE IN FOREST SERVICE REINVENTION EFFORT. Design adjustments or different structures that will support ecosystem management. Evaluate and define workforce skills needed for the future. During the transition period, facilitate and coordinate agency ecosystem management efforts to support and enhance field efforts. **Lead Staff: EM**

ESTABLISH A MEANS TO ENSURE QUALITY CONTROL AND FEEDBACK during the development, application and evolution of ecosystem management within the Forest Service. Provide sufficient review opportunities so field units can get an objective assessment of their ecosystem management efforts and that the Forest Service can get an assessment of the development of the agency's approach from external interests and partners. **Lead Staff: EM**

DEVELOP A FRAMEWORK FOR DECISION SUPPORT SYSTEMS, ecological process models and analytical methods in support of ecosystem management. Models and methods will address relationships, conditions, and trends at varying time and at varying spatial scales. Ensure that equal treatment is given to social, economic and environmental interests. **Lead Staff: LMP/EM**

EVALUATE THE CURRENT FOREST SERVICE BUDGET STRUCTURE and continue development of budget information needs to support ecosystem management implementation. **Lead Staff: PD&B**

MIDTERM ACTIONS

DEVELOP AN EDUCATION AND TRAINING PROGRAM for internal use that will provide the broad understanding of the Forest Service ecosystem management approach and the skills to implement it on the ground. Provide information and experience with the latest tools, concepts and knowledge. Build partnerships with other agencies, universities and interested parties to establish a national program. **Lead Staff: EM/TM/SO**

DEVELOP AND STRENGTHEN MECHANISMS FOR INCORPORATING ADAPTIVE MANAGEMENT APPROACHES IN LAND MANAGEMENT and provide for a highly collaborative process of communication and technology transfer between scientists and resource managers. **Lead Staff: FER/EM**

DEVELOP APPROACHES TO MAXIMIZE USE OF GEOGRAPHIC INFORMATION SYSTEMS FOR ECOSYSTEM MANAGEMENT. Evaluate and summarize the knowledge available from the large scale GIS tests conducted to date or currently underway. Develop guidelines based on that information for the implementation of GIS for ecosystem management support. **Lead Staff: LMP/EM/RES**

ESTABLISH MEASURES OF ACCOUNTABILITY to better display the results of our stewardship actions to demonstrate to partners, the public, and Congress, what the implementation of ecosystem management means in terms of ecosystem sustainability while providing goods and services for people. Use this approach to develop a long term process for area based outcomes as a product of ecosystem management. **Lead Staff: EM/PD&B**

Appendix G

Western Defoliator Committee Action Item -
Letter to Director, FPM

United States Department of Agriculture
Forest Service
Washington Office
2121 C Second Street
Davis, CA 95616
PH (916) 551-1715
FAX (916) 757-8383

Reply To: 3400

Date: August 27, 1993

Subject: Western Defoliator Action Item

To: Director, FPM

This memorandum is in follow-up to the 1993 meeting of the National Steering Committee for Managing Western Defoliators. Within the background discussion of the Strategic Plan for the Management of Western Defoliators the sub-committee identified the need for further committee work to explore approaches to gather, sort, analyze, and apply existing information and data on western defoliatory insect biology, dynamics, impact, management, and data gaps. To initiate action on this need the sub-committee, under the chair of John Wenz, will evaluate this need, identify the lead insect (Douglas-fir tusseck moth or western spruce budworm), and develop a detailed contract scope of work for a contractual effort. The final product of the contract is invisioned to be an expert system database or comparable system which will serve as a resource in pursuing resources management and technology development activities.

The committee believes that this is an appropriate activity for considered sponsorship by the National Center for Forest Health.

John W. Barry

JOHN W. BARRY
Chairperson

cc: Committee Members
Jesus Cota