FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL

PROJECT STATUS: New, not previously funded.

PROJECT NUMBER: NA-2000-02

PROJECT TITLE: Application of Density Management Diagrams to Forest Health: An Integrated Approach to Reducing Adverse Impacts of Forest Insects

SUBJECT: Insect management, silviculture, density management, spruce budworm, *Choristoneura fumiferana*

PROJECT OBJECTIVE(S): Development, publication and technology transfer of Density Management Diagrams (DMDs) for use in the management of white spruce plantations in the Great Lakes region. Our goal is to utilize these diagrams to manage white spruce plantations in a manner that reduces the impact of spruce budworm feeding on the white spruce resource.

BRIEF DESCRIPTION OF PROJECT: Using spruce budworm and white spruce as a model system, we propose to integrate entomological and silvicultural expertise to apply a relatively new silvicultural tool, Density Management Diagrams (DMDs), to forest insect management. DMDs have rarely been applied to management of non-forest tree resources (Smith and Long, 1987), and our proposed project would be the first application of DMDs to forest insect management with implications for widespread application in forest health management on a national level.

FHP LEAD CONTACT:

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PRINCIPAL INVESTIGATOR(S):

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Klaus Puettmann, Associate Professor, Department of Forest Resources, University of Minnesota, St. Paul

Mike Saunders, Research Fellow, Department of Forest Resources, University of Minnesota, St. Paul

COOPERATOR(S):

Mike Albers, Forest Health Specialist, Minnesota DNR, Grand Rapids
Alan Jones, Forest Health Program Coordinator, Minnesota DNR, Grand Rapids
Robert Pajala, Forest Development Program Coordinator, Minnesota DNR, St. Paul

John Zasada, Research Silviculturist, USFS-North Central Research Station, Grand Rapids

Robert Brittain, Forest Silviculturist, Chippewa/Superior National Forests

Chris Peterson, Forester, Blandin Paper Corporation, Grand Rapids

JUSTIFICATION: White spruce plantations have been widely established in the Lake States region with the belief that cultivated white spruce would suffer less severe impacts from spruce budworm than naturally occurring balsam fir. However, an ongoing budworm outbreak in Minnesota has led to prolonged defoliation in many spruce plantations causing unexpected growth loss, top-kill and tree mortality in the last decade. The long-term prognosis for these plantations is unclear and management

recommendations, in the face of budworm depredation, are not yet defined. Previously developed spruce budworm guidelines were generated for balsam fir stands (Bean and Batzer, 1956; Batzer, 1969) and, as we are finding, are not relevant to white spruce monocultures. To further compound the problem, general management recommendations targeted at stands ten to fifty years of age are non-existent for the Lake States. In Minnesota alone, there are over 100,000 acres of white spruce plantations. Therefore, many plantations exist that are in need of thinning or other silvicultural practices. Forest managers have expressed concerns for the sustainability and productivity of these plantations without management tools to guide them in making decisions. This project, which integrates entomological and silvicultural expertise, would produce both a tool (DMD) and white spruce management guidelines to fill the void.

URGENCY: Spruce budworm defoliation in Minnesota white spruce stands has been ongoing problem in the 1990's. Defoliation in white spruce plantations has also been observed in the past 3-5 years in Wisconsin and Michigan, where extensive plantings exist. White spruce is quite tolerant of defoliation but delaying thinning activity in these stands could lead to extensive top-kill, tree mortality and significant growth loss.

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES: This project relates directly to the high priority objective: Develop guidelines for the integration of silvicultural procedures, prescribed burning, and other tools and techniques to reduce the adverse impacts of insects and diseases.

SCOPE OF APPLICATION: This project should be directly relevant to white spruce plantations in Minnesota, Michigan and Wisconsin. However, the use of DMDs may be applicable over a much wider area and for a number of other forest pests.

RESEARCH BASIS: Minnesota and other Northeastern Area states have had a long history of defoliation by the spruce budworm, *Choristoneura fumiferana*. Generally, the host most impacted by this insect has been balsam fir. However, in the early 1990's spruce budworm began causing growth loss, top-kill and mortality in increasing numbers of white spruce plantations in northern Minnesota and Michigan. The intensity and persistence of defoliation in white spruce plantations has been surprising and perplexing, particularly because it has even occurred in areas where little or no balsam fir exists. There is very little published information regarding the impact and management of budworm in pure white spruce stands, and land managers in the Lakes States region are searching for a way to assess, predict, and ameliorate the impact of this forest insect on widely established plantations.

Over the past 20 years, DMDs have become increasingly important silvicultural tools for the management of many tree species. DMDs are based on the self-thinning rule of plant growth, which states that plant density and plant size are inversely related to one another because of mortality resulting from intraspecific competition (Dean and Jokela 1992, Puettmann et al. 1992a,b, 1993, Wilson et al. 1999). These diagrams replace stocking charts and provide for a more flexible analysis of forest resources in that they can allow the land manager to model the forest over time for resources that can be directly related to tree size and density (e.g., thermal cover for deer, shelter for grouse, etc.) (Smith and Long 1987). A DMD for white spruce in the Lake States would provide a valuable technological tool for describing tree size-density combinations that correlate with increased risk of defoliation, top-killing, or mortality by spruce budworm (Activity 1) and for developing general white spruce management guidelines (Activity 2).

METHODS: Over the past year, we have developed a draft DMD for white spruce with data obtained from the North Central Research Station (USFS), from Minnesota, Wisconsin, and Michigan FIA surveys, and UPM-Blandin Forestry permanent plots. Although some of this data tracked diameter growth under a variety of thinning regimes, most data represented single assessments of characteristics of unthinned stands. Stand characteristics such as average stand height, site index, or incidence of budworm activity were not often included in this preliminary survey. This limits the use of the data to development of a basic DMD that only relates tree diameter with tree density and, most importantly, cannot assess how budworm affects the tree size-density relationships. Therefore, to enhance the data set that relates thinning regimes to budworm impact, we have established six thinning trials in state, federal and industrial plantations in Minnesota that have had a history of budworm defoliation over the past six years.

<u>Proposed Technology Development Activities:</u>

Activity 1—Assess Impact of Thinning White Spruce on Growth and Level of Budworm Infestation: Enhancing the basic DMD for assessment of budworm infestation risk requires that we know how the growth of white spruce is affected under various levels of budworm infestation and intraspecific competition. To that end, we propose a study to assess the population levels and impact of budworm on white spruce growth both in thinned and unthinned conditions. Budworm populations will be monitored by branch sampling, water trapping, and sticky trapping (Prϑvost et al., 1999) and budworm impact will be assessed by established forest health monitoring protocols. The 6 plantations that are slated for thinning this year would be included in the study. These sites vary in age and level of budworm infestation. On each of the 6 sites, a 3 to 5 acre area was left as an unthinned control. Growing conditions before thinning were measured within 6 plots on each site during this past summer; post-thinning measurements will be taken in October 1999. White spruce growth, budworm population levels, and budworm impact will be monitored annually for the next 5-10 years (pending availability of MN DNR and MN Agricultural Experiment Station funding). We hope to utilize support from this proposal to add and monitor at least 9 sites, with at least 2 sites being younger, pre-commercial plantations. Depending on funding from local sources, this study may be expanded to a total of 30 plantations that range from 25-50 years old and have light to heavy budworm infestation levels. Results from this study would allow us to integrate and overlay a budworm tree size-density risk "zone" into our working version of the white spruce DMD, thereby identifying tree size-density combinations that have higher risks of significant growth loss and/or tree mortality during budworm outbreaks.

Activity 2—Developing White Spruce Management Guidelines: Little is known about the long-term impacts of budworm on white spruce management. Most recommendations are "borrowed" from studies on budworm in balsam fir. In this regard, it has been difficult to formulate solid recommendations from established studies; most recommendations have to be observational in nature (i.e., "this worked and this did not"). Therefore, formal guidelines for white spruce may be a number of years off, as more research is done on its interaction with spruce budworm. This project would help to establish preliminary guidelines that will disseminated in workshops and "How To" guides. Eventually, the guidelines would be published on the Internet along with the DMD program. To expand the utility of a DMD for white spruce in the Lake States, we have contacted Dr. David J. Smith of the Ontario Forestry Research Institute. He is currently developing a computerized DMD for white spruce in Ontario that would include such basic stand characteristics as tree height, tree volume, and stand volume. This should lead to a software program that summarizes stand development in the absence of budworm throughout the Lake States region. Our goal is to develop a computer-based package that integrates budworm defoliation into this program. The program should allow managers to model how thinning and other stand activities interact with budworm populations and impact. Funding this project should allow a shareware dissemination of the software to resource managers.

MEASURE OF SUCCESS: Implementation of the guidelines by public, industrial and private resource managers. We would judge this by the number of acres thinned using this procedure by FY2005, a goal of 10,000 to 20,000 acres would be realistic.

COOPERATORS:

Mike Albers, Forest Health Specialist, Minnesota DNR, Grand Rapids
Alan Jones, Forest Health Program Coordinator, Minnesota DNR, Grand Rapids
Robert Pajala, Forest Development Program Coordinator, Minnesota DNR, St. Paul

John Zasada, Research Silviculturist, USFS-North Central Research Station, Grand Rapids

Robert Brittain, Forest Silviculturist, Chippewa/Superior National Forests

Chris Peterson, Forester, Blandin Paper Corporation, Grand Rapids

Plantations sampled in this study would be located on Minnesota DNR, Chippewa National Forest, and Blandin Papers managed lands.

PRODUCTS: This project would help to establish guidelines that will be disseminated in workshops and "How To" guides. Eventually, the guidelines would be published on the Internet along with the DMD program. To expand the utility of a DMD for white spruce in the Lake States, we have contacted Dr. David J. Smith of the Ontario Forestry Research Institute. He is currently developing a computerized DMD for white spruce in Ontario that would include such basic stand characteristics as tree height, tree volume, and stand volume. This should lead to a software program that summarizes stand development in the absence of budworm throughout the Lake States region. Our goal is to develop a computer-based package that integrates budworm defoliation into this program. The program should allow managers to model how thinning and other stand activities interact with budworm populations and impact. Funding this project should allow a shareware dissemination of the software to resource managers.

PUBLICATION: The DMDs would be published in the appropriate peer reviewed journals. How To guides and other management guidelines would be published either as a Forest Service or University of Minnesota publication.

TECHNOLOGY TRANSFER: The DMDs would be made available at workshops designed and targeted at white spruce plantation management. These workshops would be held in northern Minnesota in either FY 2001 or 2002. They would be co-sponsored by the US Forest Service, Northeastern Area and the University of Minnesota. In addition, all DMDs and associated text and background material would be available over the internet. Finally, publications targeted at woodlot owners and forest managers would be developed that would explain the DMD principles and encourage certain management practices that should reduce spruce budworm impact in white spruce plantations.

PROJECT DURATION: Completion expected in fiscal year 2002.

LONG TERM BUDGET: See below.
FY 1999 BUDGET REQUEST:

Item	**FY2000**		**FY2001**		**FY2002**	
	STDP Request	**In Kind Contribution**	**STDP Request**	**In Kind Contribution**	**STDP Request**	**In Kind Contribution**
Personnel	25,000	24,500	25,500	25,000	21,025	25,525
Supplies & Equipment	500	---------	500	--------	500	--------
Travel	5,000	---------	5,000	--------	5,000	--------
Indirect Costs	--------	2,170	--------	2,240	---------	2,314
TOTAL	30,500	26,670	31,000	27,240	26,525	27,839

Total STDP Request: $88,025; Total In Kind Contributions: $81,749. Funds are requested to support a graduate student, Mr. Darren Blackford, who is presently completing his B.S. in Forestry at the University of Wisconsin-Stevens Point. As a part of his M.S. work at the University of Minnesota, Mr. Blackford would evaluate the effect of various thinning regimes on the population levels and impact of spruce budworm. Mr. Blackford would be co-supervised by Seybold and Puettman and work cooperatively with silviculturalists Puettman and Saunders to link this information to the white spruce DMD. Salary and tuition for Mr. Blackford would be matched by funds from a Minnesota Agricultural Experiment Station project (under Seybold). Additional in kind contributions would include $2,500 from the Minnesota DNR to be used for monitoring all field plots and one-month each of contributed salary from Seybold and Puettman (U of M) . Indirect costs are calculated at 14% of direct costs as allowed by the University of Minnesota Sponsored Projects Administration.

LITERATURE, CITATIONS, ATTACHMENTS, etc:

Batzer, H.O. 1969. Forest character and vulnerability of balsam fir to spruce budworm in Minnesota. For. Sci. 15:17-25.

Bean, J.L., and Batzer, H.O. 1956. A spruce budworm risk-rating for the spruce-fir types in the Lake States. USDA For. Serv. Lake States For. Exp. Stn. Tech. Note No. 453, 2 pp.

Dean, T.J. and E.J. Jokela. 1992. A density-management diagram for slash pine plantations in the lower Coastal Plain. South. J. Appl. For. 16: 178-185.

Prϑvost, Y.H., Dang, Z., and Sanders, C. 1999. The effect of harvest treatments on spruce budworm, Choristoneura fumiferana (Clem.) (Lepidoptera: Tortricidae), dispersal within forest stands. Can. J. For. Res. (In Prep).

Puettmann, K.J., D.W. Hann, and D.E. Hibbs. 1992a. Evaluation of the size-density relationships for pure red alder and Douglas-fir stands. For. Science 39: 7-27.

Puettmann, K.J., D.E. Hibbs, and D.W. Hann. 1992b. The dynamics of mixed species stands of *Alnus rubra* and *Pseudotsuga menziesii*: extension of the size-density analysis to species mixtures. J. Ecol. (Oxford) 80: 449-458.

Puettmann, K.J., D.S. DeBell, and D.E. Hibbs. 1993. Density management guide for red alder. Forest Research Laboratory. Oregon State University, Corvallis. Research Contribution 2, 6 p.

Smith, F.W. and J.N. Long. 1987. Elk hiding and thermal cover guidelines in the context of lodgepole pine stand density. West. J. Appl. For. 2: 6-10.

Wilson, D.S., R.S. Seymour, and D.A. Maguire. 1999. Density management diagram for northeastern red spruce and balsam fir forests. North J. Appl. For. 16: 48-56.

STDP PRODUCTION FUNCTION

PROJECT NUMBER: NA-XX-2000

PROJECT COST:

Item	FY2000		FY2001		FY2002	
	STDP Request	**In Kind Contribution**	**STDP Request**	**In Kind Contribution**	**STDP Request**	**In Kind Contribution**
Personnel	25,000	24,500	25,500	25,000	21,025	25,525
Supplies & Equipment	500	---------	500	--------	500	--------
Travel	5,000	---------	5,000	--------	5,000	--------
Indirect Costs	--------	2,170	--------	2,240	---------	2,314
TOTAL	30,500	26,670	31,000	27,240	26,525	27,839

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PROJECT OBJECTIVE: Using spruce budworm and white spruce as a model system, we propose to integrate entomological and silvicultural expertise to apply a relatively new silvicultural tool, Density Management Diagrams (DMD's), to forest insect management. DMD's have rarely been applied to management of non-forest tree resources (Smith and Long, 1987), and our proposed project would be the first application of DMD's to forest insect management with implications for widespread application in forest health management on a national level.

The benefit of this project (shift/accelerate harvest to capture green value) will be in capturing volume that would be lost to budworm mortality and to increase future growth and yield in the thinned plantations.

ASSUMPTIONS:

Beginning in FY 2002, guidelines will impact management activities on 20,000 acres of white spruce plantations in Minnesota

Budworm populations will continue to cause noticeable defoliation and tree mortality for the next 10 years

If untreated, budworm defoliation will kill or top-kill the majority of trees on the 20,000 acres resulting in clearcut salvage sales on 5,000 acres per year for the next 4 years

If treated (thinned), green clear cut sales will occur in 40 years on the thinned stands. At that time much of the volume will be in valuable sawlog products.

There are no treatment costs without the project, however, there is a large loss in value because pulp buyers do not want dead or top-killed spruce resulting in very low salvage values.

BACKGROUND DATA:

Approximately 100,000 acres of white spruce plantation has been established in Minnesota

A cord of white spruce pulp (green timber, no budworm damage) is approximately $20

A cord or white spruce pulp that is from dead or top-killed material (Salvage) is $5

Thinnings would remove 20 cords per acre

Net present Value along with growth and yield on these plantations was determined by running thinned plantations on the TWIGS growth and yield model for 40 years from 1999. At that point stands were clearcut. Thinning costs in 1999 (sale administration) were estimated at $50/acre, thinning income (1999) was $393/acre, sale cost in the year 2039 was estimated at $168 per acre, sale income in 2039 was estimated at $27,910 per acre.

CALCULATIONS

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

EOV Without Project = 5,000 acres per year for the next 4 years x 30 cords per acre x $5 per cord (salvage price) = $750,000 per year for 4 years , total =’s $ 2,722,421 discounted

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

Net present value on 20,000 acres affected by the project is $1514/acre x 20,000 acres = $ 30,280,000

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:
B = $(30,280,000) - $2,722,421 = $27,557,579

BENEFIT/COST RATIO:
$27,557,579 / 169,774 = 162 / 1

BENEFIT ATTRIBUTABLE TO STDP:
$88,025 x 162 = $14,260,050

PNV OF PROJECT:
$27,557,579 – $169,774 = $27,387,805

PNV OF STDP:
$14,260,050 – 88,025 = $14,172,025

**This benefit is obviously inflated. Some thinning activity will occur without the project. However, the project will refine density targets and the amount of thinning encouraged by technology transfer will be much greater with the project. At this time, most landowners will not thin stands during outbreaks, this project should inform them if that is a viable option that can capture mortality and maintain a healthy stand into the future.