Title: Extent, Impacts, and Dynamics of Red Pine Defoliation by Jack Pine Budworm

Location: Wisconsin, Minnesota

Duration: 2 yrs.

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Cooperators:
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Project Objectives:

1. Evaluate the extent and impacts of defoliation of red pine by jack pine budworm
2. Determine underlying physiology and behavior that causes host switching by jack pine budworm
3. Assess risk to the red pine resource based on statewide jack pine budworm survey data and red pine resource data.

Justification: Insect damage levels that deviate from historical conditions

Jack pine budworm (JPBW) has historically undergone intermittent outbreaks throughout the Great Lakes region. These outbreaks have caused serious impacts on jack pine productivity, aesthetic value, and fire risk. Outbreaks have been especially problematic in areas where endangered species such as Karner Blue butterfly limit control options, as opposing management objectives cause significant conflict.

JPBW has traditionally been limited to a single host species, and so is a classic "monophagous" insect. State and federal survey records throughout WI, MN, and MI provide reliable data on this restricted relationship (with an exception in the 1950's of a couple of stands adjacent to jack pine (Kulman & Hodson 1961). This specialization is illustrated in the accompanying Appendix. The upper three photographs document the historical pattern. A strict boundary between JPBW feeding on jack vs. red pine can be seen at several levels of scale. The upper left photo shows widespread defoliation of self-regenerating jack pine. Several red pine plantations appear as "green islands", illustrating that despite ample access to red pine, JPBW remained solely on jack pine. The upper right photo shows a similar pattern, where jack and red pine plantations were established in adjoining strips. The photo beneath it shows a single jack pine nearly 100% defoliated, despite no feeding on intermingled red pines.

During the last few years, JPBW has begun causing significant defoliation of red pine. We currently have no explanation for this change, its extent, the impact it will have, or an appropriate management response. This has occurred in sections of WI and MN, as documented by DNR surveys. The lower three pictures on page three show substantial defoliation of sapling and mature red pines by JPBW in the central sands region of WI, during 2005, a marked deviation from normal trends.

The implications of the jack pine budworm transitioning to red pine are significant for WI and MN. Both states have extensive areas of red pine that support the paper and wood industry and provide thousands of acres of forested lands for recreation. Mortality of red pine from defoliation could cause a severe fire hazard. The fragmented nature of ownerships also provides a challenge for mitigating an outbreak of jack pine budworm that crosses multiple ownerships.

Description

Background

JPBW is the most important defoliator of jack pine. Populations remain at low, non-damaging levels for many years, constrained by a combination of natural enemies, climate, and host susceptibility (Kouki et al. 1997, Wallin & Raffa 1998). At intermittent intervals they undergo landscape-level eruptions (Volney & McCullough 1994) that cause significant economic losses (Conway et al. 1999). In addition to direct injury, defoliation can increase susceptibility to tree-killing bark beetles (Wallin & Raffa 2001).

Until recently, JPBW has been restricted to jack pine. However it has recently begun causing significant defoliation on red pine, including stands distant from jack pine. These include at least 600 acres in MN alone. The extent, impact, and underlying causes of this transition are unknown.

Methods: We propose a three-tier study: Field monitoring / assessment, bioassay, tree chemistry.

Field-monitoring and assessment will have two components, extensive sampling, and detailed analyses of within-stand defoliation. The former will be conducted state-wide by the MN and WI DNR's, and be incorporated into their annual surveys. Survey data along with inventory data related to the red pine resource will be used to assess the risk of jack pine budworm transitioning to red pine. Additional observations will include understory composition and proximity between jack and red pines. Plots will be established for evaluation of long-term impacts such as growth reduction, mortality, infestation by secondary agents, and cone production. The second component will be conducted on approx. 10 jack pine and 10 red pine stands each in MN and WI, under the direction of K. Raffa. Defoliation estimates will be made on a per-tree basis, with particular emphasis on the relative amount of defoliation accompanying a given population level, and the distribution of feeding. Preliminary observations suggest most defoliation on mature red pine is concentrated on a few particularly susceptible trees. This information will provide guidance to the insect bioassay and tree chemistry approaches of our study. Background populations will be monitored using pheromone traps.

Insect bioassays will be conducted to determine the relative preference of JPBW for each species during oviposition and feeding, the potential for population growth on each tree, and whether incipient budworm subspecies may be arising. This portion will be conducted by J. Hubbard. We will collect egg masses from red and jack pine, rear larvae from each on each tree, and evaluate performance, test larvae from each tree for relative feeding preference, and test ovipositional preferences of brood adults.

E. Singsaas will measure chemical differences that underlie susceptibility of trees to JPBW. Particular emphasis will be placed on volatile terpenes, which vary considerably among trees, and in response to defoliation by JPBW (Wallin & Raffa 1999). We will collect foliage in the field, and compare terpene profiles among susceptible and nonsusceptible red and jack pines. Chemoassays will be done throughout the growing season from trees at field monitoring plots as above. The number and relative abundance of terpenes will be related to insect feeding as determined by the bioassays.

Conway, B. E., L. A. Leefers, & D. G. McCullough. 1999. Yield and financial losses associated with a jack pine budworm outbreak in Michigan and the implications for management. Can J For Res 29:382-392.

Kouki, J., D. G. McCullough, & L. D. Marshall. 1997. Effect of forest stand and edge characteristics on the vulnerability of jack pine stands to jack pine budworm (Choristoneura pinus pinus) damage. Can J For Res 27:1765-1772.

Kulman, M., & A. C. Hodson. 1961. The jack-pine budworm as a pest of other conifers, with special reference to red pine. J Econ Entomol 54: 1221-1224.

McCullough D G, Marshall L D, Buss L J, & Kouki J. 1996. Relating jack pine budworm damage to stand inventory variables in northern Michigan. Can J For Res 26:2180-2190.

Raffa, K.F., Krause, S.C., & P. Reich. 1998. Long-term influence of defoliation on *Pinus resinosa* suitability to insect herbivores feeding on diverse plant parts. Ecology. 79: 352-364.

Volney, W. J. A., and D. G. McCullough. 1994. Jack pine budworm population behaviour in northwestern Wisconsin. Can J For Res 24:502-510.

Wallin, K.F., & K.F. Raffa 1998. Association of within-tree and within-needle variation of water, nutrient and monoterpene concentrations with canopy level and jack pine budworm feeding patterns. Can J For Res 28: 228-233.

Wallin, K.F., and K.F. Raffa 1999. Altered constitutive and inducible phloem monoterpenes following natural defoliation of jack pine: Implications to host mediated inter-guild interactions and plant defense theories. J Chem Ecol 25: 861-880

Wallin, K.F., & K.F. Raffa. 2001. Effects of folivory on subcortical plant defenses: Can defense theories predict interguild processes? Ecology 82: 1387-1400.

Products

Results will be published in scientific journals, and be presented at meetings attended by forest protection specialists. We will ultimately provide guidelines for managing JPBW in red pine. The information from this project will facilitate the development of management options, which ultimately must be developed in order to avoid a significant forest health problem.

Schedule of Activities

Plot selection will be conducted during late 2006. Field sampling will be conducted during 2007 - 2008. Bioassays will be conducted during peak insect abundance, and chemoassays will be conducted throughout the winter. Data analysis will be conducted at the end of each year.

Costs and Justification for each of two years

	Forest Service Share			Total	Cost Share (UW)	
	Field Monitoring (To UW-M)	Bioassay (To UW-SP)	Chemoassay (To UW-SP)	(FS)	UW-M	UW-SP
Salary & Fringe	5,000	12,000	0	17000	10,000	12,000
Travel to Field Sites	2,500	0	0	2500	0	0
Supplies	2,500	3000	5000	10,500	0	8000
Total	10,000	15,000	5000	**30,000**	10,000	20,000

Salary and Fringe are for an hourly tech for the monitoring work (UW-M) and a grad. student for the bioassays (UW-SP). Travel for field monitoring is for vehicle rental and lodging (UW-M). Supplies are for field monitoring and pheromones (UW-M), lab bioassay dishware (UW-SP), and chemoassay reagents, columns & standards (UW-SP).

NC-EM-07-04

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Jim Doyle, Governor
Scott Hassett, Secretary

August 14, 2006

Manfred Mielke
USDA Forest Service
1992 Folwell Ave.
St. Paul, MN 55108

Subject: Evaluation Monitoring Grant Application

Dear Manfred:

Please find attached an application for funds from the USDA Forest Service Evaluation Monitoring Grant program. We are extremely concerned about a developing forest health issue that could cause a serious level of mortality to red pine and impact both the forest industry and all of the stakeholders who enjoy Wisconsin and Minnesota's forest lands. The jack pine budworm has been observed feeding on red pine for the past three years in Minnesota and Wisconsin. During the 60 years Wisconsin and Minnesota have been monitoring jack pine budworm, we have never observed it causing this level of defoliation on red pine. Approximately 6,000 acres of red pine were defoliated in MN in 2005. The full extent of the population on red pine in Wisconsin is unknown, yet it has been observed in west-central, central and north central Wisconsin. The Minnesota and Wisconsin populations are not adjacent but approximately 200 miles apart. Observations in both states show that after 3 years of defoliation, top mortality, and in some cases, total tree mortality has occurred. There are several questions that need to be answered before we can develop a management strategy; this issue is one of our top priorities to address.

Wisconsin DNR, Minnesota DNR and the University of Wisconsin – Madison and Stevens Point are teaming up to evaluate and investigate this critical issue. Thank you for considering our integrated proposal.

Dr. Ken Raffa	*Jane Cummings Carlson*	*Jana Albers*
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University of Wisconsin	WI DNR	MN DNR