



# Environment and Natural Resources Trust Fund

## 2021 Request for Proposal

### General Information

**Proposal ID:** 2021-277

**Proposal Title:** Biocontrol Breakdown in Minnesota's Spruce Budworm-Affected Forests

### Project Manager Information

**Name:** Brian Aukema

**Organization:** U of MN, College of Food, Agricultural and Natural Resource Sciences

**Office Telephone:** (612) 624-1847

**Email:** BrianAukema@umn.edu

### Project Basic Information

**Project Summary:** Spruce budworm is native to Minnesota and the most significant tree-killing defoliator in spruce-balsam fir forests. We examine whether a breakdown in biological control is associated with sustained outbreaking populations.

**Funds Requested:** \$200,000

**Proposed Project Completion:** 2024-06-30

**LCCMR Funding Category:** Small Projects (H)

**Secondary Category:** Foundational Natural Resource Data and Information (A)

### Project Location

**What is the best scale for describing where your work will take place?**

Region(s): NE, Central,

**What is the best scale to describe the area impacted by your work?**

Region(s): Central, NE,

**When will the work impact occur?**

During the Project and In the Future

## Narrative

### **Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

Spruce budworm is the most significant defoliating pest of spruce and balsam fir forests in North America. It is a native moth, and thus ineligible for project consideration by the Minnesota Invasive Terrestrial Plant and Pests Center. Caterpillars mine buds and devour needles. Sustained feeding causes extensive mortality, especially to balsam firs.

Records of budworm outbreaks in eastern North America date back to the 1700s, with approximately three outbreaks per century. Eruptions from Ontario to Maine occur roughly every 35 years with peaks lasting 5-6 years. In contrast, Minnesota has noted defoliated areas for 67 consecutive years (!). Tree-killing budworm hotspots are a constant feature in the northeastern part of our state, affecting forest structure, wildlife, fire risk, and timber production.

Multiple competing theories abound to describe causes of budworm population cycles: natural enemies, warm weather, tree condition, insect dispersal, and more. We do not know why Minnesota experiences sustained outbreaks instead of typical cycling behavior, or how spruce budworm impacts cascade through spruce-fir forests. Insights from other regions provide useful starting points however, and indicate that changes in the natural enemy (i.e., biological control) complex are likely responsible at least in part for altered disturbance dynamics.

### **What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.**

To understand why Minnesota's populations do not cycle stereotypically, we will:

1. Survey then compare natural enemies in outbreak vs. endemic populations within the state. It is hypothesized that buildup of generalist natural enemies in outbreaking populations, in concert with a decline in foliage abundance and quality, contribute to outbreak collapse. Surprisingly, the natural biological control agents in the spruce budworm system have never been studied in Minnesota.
2. Quantify spring climatic signatures associated with increased defoliation. Warm and dry spring weather is hypothesized to increase survival of overwintering budworms, such that they escape biological control by specialist natural enemies. We will analyze historic defoliation data curated by the US Forest Service and the DNR Forest Health Team to uncover key climatic predictors associated with high budworm populations. We have a demonstrated track record of success in this area (e.g., eastern larch beetle and tamarack forests).
3. LEVERAGED FUNDING OPPORTUNITY (FYI; not LCCMR). We aim to combine this work with a new National Park Service project on Isle Royale (with introduced Minnesota wolves!) examining predator-prey dynamics in forest gaps created by budworm outbreaks. Do wolves enhance regeneration of young trees after budworm outbreaks by restricting excessive moose browse?

### **What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?**

Deciphering how the diversity of specialist vs. generalist natural enemies in the biological control complex changes between endemic vs. outbreaking populations of budworms, and the climatic signatures associated with high outbreak years, moves us toward population forecasting tools (beyond current understandings of how many budworms it takes to kill a balsam fir). Forecasting yields short- and long-term benefits. For example, St. Louis County, the DNR, and the USDA Forest Service currently incorporate aerial survey data of spruce budworm defoliation and mortality into Community Wildfire Protection Plans (dead standing conifers with needles generally increase risks of quickly spreading wildfire).

## Activities and Milestones

### Activity 1: Characterize the natural enemy complex in different population types

**Activity Budget:** \$107,618

**Activity Description:**

We will examine historic aerial survey data and work with DNR Forest Health Team partners to select sites in northern Minnesota with low vs. high populations of budworms (exact number to be determined based on access and statistical power). We will use published methods from other states and provinces to collect budworms, rear them on diet within the laboratory, and collect emerging parasitoids. Parasitoids will be identified to species and we will compare 1) number, 2) diversity, and 3) feeding breadth between population types. We hypothesize that endemic populations of spruce budworm are dominated by specialist parasitoids, while outbreaking populations are associated with a different guild of generalist parasitoids. We will also analyze hyperparasitoids (i.e., parasites of parasitoids), which are hypothesized to interfere with primary control in budworm forests and may be associated with sustained outbreak behavior.

The activity will be conducted by PhD student Grace Haynes as a component of her dissertation. Data will be analyzed by standard statistical techniques such as analysis of variance, and results will be shared in oral and written form at appropriate venues (workshops, scientific journals, etc.).

**Activity Milestones:**

Description	Completion Date
Collect and rear out parasitoids from high vs. low budworm sites (two years)	2023-06-30
Identify and analyze diversity, numbers, and feeding guild differences	2024-06-30

### Activity 2: Analyze climatic predictors of enhanced budworm activity

**Activity Budget:** \$92,382

**Activity Description:**

We will rasterize historic defoliation data of spruce budworm curated by the US Forest Service and the DNR Forest Health Team. Climatic data will be obtained from the PRISM climate group at Oregon State University, who have developed sophisticated methods to interpolate temperatures across the continental United States. (We have used PRISM products with great success for biogeoclimatic studies of other forest insects in Minnesota, such as the invasive larch casebearer). Based on literature surveys and discussions with other experts, we will define several climatic variables biologically relevant to spruce budworms and parasitoids noted in Activity 1 (e.g., accumulated degree days in the spring before a certain date may reflect spring warming that activates L2 budworm larvae from their overwintering hibernaculæ structures among the conifer needles). We will use spatiotemporal regression techniques to examine which variables are most closely associated with budworm populations levels.

The activity will be conducted by PhD student Grace Haynes as a component of her dissertation. Data will be analyzed by standard statistical techniques such as analysis of variance and results will be shared in oral and written form at appropriate venues (workshops, scientific journals, etc.).

**Activity Milestones:**

Description	Completion Date
Integrate historic aerial survey data with PRISM climate data	2023-06-30
Determine climatic signatures associated with high vs. low budworm populations	2024-06-30



## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Forest Health Team	MN Department of Natural Resources	Collaborators who will help with site selection and field sampling.	No

## Long-Term Implementation and Funding

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?**

Despite being Minnesota's top native tree-killer of balsam fir and white spruce, LCCMR has not invested in a study of spruce budworm to date. We are requesting a three-year appropriation in the small project category (\$200K). The investment will be used to leverage two other opportunities: 1) a National Park Service grant on Isle Royale (with direct relevance to Minnesota spruce-fir forests and moose-wolf ecology) and 2) a US Forest Service federal monitoring grant targeted at understanding unusual insect or pathogen behavior in the nation's forests.

## Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Mountain Pine Beetle Invasive Threat to Minnesota's Pines	M.L. 2014, Chp. 226, Sec. 2, Subd. 04e1	\$175,000
Biosurveillance and Biocontrol of Emerald Ash Borer - Phase 2	M.L. 2014, Chp. 226, Sec. 2, Subd. 04d	\$447,000
MITPPC #2: Mountain Pine Beetle, Phase II: Protecting Minnesota	M.L. 2015, Chp. 76, Sec. 2, Subd. 06a	-
MITPPC #5: Optimizing Tree Injections Against Emerald Ash Borer	M.L. 2015, Chp. 76, Sec. 2, Subd. 06a	-
MITPPC #9: Dispersal Characteristics of Gypsy Moth Larvae to Improve the Effectiveness of Quarantines	M.L. 2015, Chp. 76, Sec. 2, Subd. 06a	-
Emerald Ash Borer Biocontrol - Phase III	M.L. 2017, Chp. 96, Sec. 2, Subd. 06b	\$729,000

## Project Manager and Organization Qualifications

**Project Manager Name:** Brian Aukema

**Job Title:** Professor of Forest Insect Ecology

**Provide description of the project manager's qualifications to manage the proposed project.**

Dr. Brian Aukema directs the Forest Insect Laboratory in the Department of Entomology at the University of Minnesota. Prof. Aukema and his students work on both native and invasive species threatening the state of Minnesota and region (e.g., mountain pine beetle on pines, emerald ash borer on ash, gypsy moth on oak and aspen, eastern larch beetle and larch casebearer on tamarack, and more). Students he has taught can be found in a wide variety of resource professional positions, from city arborists to industry, NGOs, and state and federal government positions.

Prof. Aukema joined the Department of Entomology as their Forest Insect specialist in the fall of 2010. Prior to this, he was a research scientist for five years with the government of Canada and was responsible for a program managing large-area insect outbreaks. Prof. Aukema has successfully administered more than \$2 million in research project

funding from a wide variety of state, federal and industrial sources in his career. He has received early career awards for Creativity and Innovation (Government of Canada) and a McKnight Land-Grant award from the University of Minnesota.

**Organization:** U of MN - Twin Cities

**Organization Description:**

The University of Minnesota-Twin Cities, founded in 1851, is the largest campus within the University of Minnesota system with an enrolment of just over 50,000 students. As a historic land-grant university, the University of Minnesota's mission is to engage students and faculty to address Minnesota's most pressing issues.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Graduate student		Conduct the parasitoid surveys and climatic analyses (3 yrs). Amount includes tuition (3 yr total \$58,425).			19.9%	1.5		\$131,965
Faculty member		Oversee project experiments and analyses (partial time in summer)			36.5%	0.3		\$45,000
Undergraduate student helper		Help in rearing biological control agents from field samples			0%	0.75		\$7,800
							<b>Sub Total</b>	<b>\$184,765</b>
<b>Contracts and Services</b>								
							<b>Sub Total</b>	-
<b>Equipment, Tools, and Supplies</b>								
	Tools and Supplies	Vials, insect rearing media (i.e., lab diet), identification guides, misc. field supplies	Executing the biological control agent sampling and identification					\$3,000
							<b>Sub Total</b>	<b>\$3,000</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	-
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	Field sampling; est. 4 trips to NE part of state each of 3 years @ \$800/trip (320 miles, UMN vehicle rental, lodging)	Sampling budworms and their biological control agents for Activity 1					\$9,600

							<b>Sub Total</b>	<b>\$9,600</b>
<b>Travel Outside Minnesota</b>								
	Conference Registration Miles/ Meals/ Lodging	Conference or workshop (inside or outside of state; est. 1/year)	To share project results and seek advice from other budworm experts	X				\$2,400
							<b>Sub Total</b>	<b>\$2,400</b>
<b>Printing and Publication</b>								
	Printing	Printing outreach materials	Dissemination of results on research poster at workshop/conference					\$150
							<b>Sub Total</b>	<b>\$150</b>
<b>Other Expenses</b>								
		Shipping	Shipping certain biological control agents to specialists for identification help					\$85
							<b>Sub Total</b>	<b>\$85</b>
							<b>Grand Total</b>	<b>\$200,000</b>



## Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
<b>Travel Outside Minnesota</b>	Conference Registration Miles/Meals/Lodging	Conference or workshop (inside or outside of state; est. 1/year)	Request permission to share results at workshops or conferences and gain valuable feedback from other colleagues in forest health.

## Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
<b>State</b>				
			<b>State Sub Total</b>	-
<b>Non-State</b>				
In-Kind	Federal funds from National Park Service	We have been invited by National Park Service staff to partner with them on budworm ecology at Isle Royale National Park. We have attended a joint research/planning workshop in January and are submitting an NPS proposal in their summer grant session.	Potential	\$100,000
			<b>Non State Sub Total</b>	<b>\$100,000</b>
			<b>Funds Total</b>	<b>\$100,000</b>

## Attachments

### Required Attachments

#### *Visual Component*

File: [7bd2ab87-ed2.pdf](#)

#### *Alternate Text for Visual Component*

Photo of spruce budworm and spruce-fir forests, overlaid by smaller photos of aspects of proposal leveraged with other funding agencies (e.g., moose and wolves at Isle Royale National Park with National Park Service)

### Optional Attachments

#### *Support Letter or Other*

Title	File
Letter of support from Sustainable Forests Education Cooperative	<a href="#">94dfb2d7-53b.pdf</a>
Letter of support from National Park Service (Isle Royale)	<a href="#">35ef9d5b-26c.pdf</a>
Authorization to submit proposal from UMN grant administration	<a href="#">77432042-9ad.pdf</a>

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Does your project have patent, royalties, or revenue potential?**

No

**Does your project include research?**

Yes

**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

2021 Project Proposal

# Spruce Budworm



## Biocontrol breakdown in Minnesota's spruce budworm-affected forests

Spruce budworm is native to Minnesota and the most significant tree-killing defoliator in spruce-balsam fir forests, affecting Minnesota's forest structure, wildlife, fire risk, and timber production

**Project Lead: Dr. Brian Aukema**

(Forest Insect Lab, University of Minnesota)

Activity 1: Characterize the natural enemy complex in different population types

Activity 2: Analyze climatic predictors of enhanced budworm activity

Three Years, \$200 K