TITLE: Evaluation of eastern larch beetle activity in the Northern Great Lakes Region
LOCATION: Lake States
DATE: September 30, 2013
DURATION: Year 3 of 3 year project
FUNDING SOURCE: Base
PROJECT LEADER: Brian Aukema, U Minnesota, (612) 624-1847
BrianAukema@umn.edu

COOPERATORS: Mike Albers, Forest Health Specialist, MN DNR
Jana Albers, Forest Health Specialist, MN-DNR
Val Cervenka, Forest Health Specialist, MN-DNR
Rob Venette, USDA FS Research Biologist, St. Paul, MN
Fraser McKee, PhD Candidate, University of Minnesota

FHP SPONSOR/CONTACT: Steve Katovich, S&PF-FHP St. Paul, MN
(651) 649-5264, skatovich@fs.fed.us

PROJECT OBJECTIVES:
1. Evaluate the extent of eastern larch beetle activity in the Great Lakes region
2. Characterize the seasonal phenology of this insect in actively-infested areas
3. Determine the association of climatic and/or forest inventory variables with occurrence of tree-killing activity

JUSTIFICATION:

a. Linkage: This project studies the severity and cause of unprecedented ongoing mortality of *Larix laricina* from eastern larch beetle. This native insect is present in tamarack across the Northcentral/Northeast states (MN, WI, IL, IN, MI, OH, PA, NY, VT, NJ, MA, NH, CT, RI, ME) stretching through the boreal forest of Canada into Alaska. High mortality of tamarack due to eastern larch beetle has been noted along the southwestern portions of the insect’s host range sweeping through MN (now >150,000 acres over the past decade). Mortality has been detected in both FIA plot data and more than a decade of off-plot aerial survey data.

b. Significance Outbreaks of eastern larch beetle typically commence on trees stressed by drought, flooding, defoliation (casebearer, budworm, sawfly), fire, or advanced age. However, predisposing biotic stresses (e.g., defoliation) to this outbreak have been unapparent. MN, WI, (and, directly north, MB), have seen mortality for 12 years, more than 3X as long as “typical” outbreaks. In MN, approximately 20% of the ca. 1M acres of tamarack covertype have been affected, excluding another large increase this month.

c. Scientific Basis/Feasibility We continue to work across scales to gain insight on mechanisms underlying the cause of this unusual mortality. Prolonged outbreak activity - especially at distributional range margins – suggests a region-wide stress, likely climatic, acting at a landscape-level scale. Excellent FIA and DNR data continue to aid the landscape-level climate analyses. Field and laboratory studies with this insect in collaboration with our cooperators are shedding insights into mechanisms behind the climatic signals detected (see Progress/Accomplishments section). Methods are being ported from other field and landscape-level analyses linking tree mortality to climatic causes in other bark beetle systems (e.g., Aukema et al. 2006, 2008, 2010; Sambaraju et
al. 2011). Project leader is proficient in environmental statistics (e.g., Zhu et al. 2008; Zheng and Aukema 2010; Reyes et al. 2011).

d. **Cost/economic efficiency** Budget request is unchanged from Years I & II. Partnership with DNR for field camp lodging at distant sites continues to aid project.

e. **Priority Issues:** This project examines the effect of abiotic stress such as **drought/flooding** (deviations from normal precipitation) on the abundance of eastern larch beetle and associated **tree mortality**. Our data are showing strong departures in seasonal phenology from the scientific literature, possibly an indication of **climate change**. Statistical techniques/platforms developed in this and previous studies (see above) may be easily ported to future **insect and disease risk models**.

**DESCRIPTION:**

a. **Background:** Continued progression of outbreaks of eastern larch beetle in the absence of obvious predisposing agents (e.g., defoliators, localized spring flooding, etc.) over a prolonged duration (>5 years) suggest manifestations of climatic stress in the southern portions of the insect’s range. We are working on a landscape-level analysis to detect climatic signals associated with continuing mortality to tamarack from eastern larch beetle. At the same time, we are monitoring infestation progress on field plots to determine timing of attack, reproduction, emergence, and overwintering life stages. Laboratory studies are examining reproductive potential at various temperature regimes.

b. **Methods:** **Landscape-level:** We are working on 10x10km grids with FIA & DNR staff to detect climatic signals associated with mortality. Likelihood of mortality is being estimated using logistic regression incorporating appropriate spatial and temporal dependence structures to reduce bias in estimates of climatic covariates. Climatic covariates include spring and summer temperatures, Julian date of frost free status, growing degree day terms for maximum emergence, and several more. Estimates are being obtained using maximum pseudolikelihood methods. **Stand-level:** We are using weekly censuses to detect attacked trees in stands. To determine seasonal phenology, new attacks and life stages are monitored by sampling 10x10cm bark squares over the course of the growing season. Emergence cages on infested trees are being used to monitor progeny and parental reemergence for sister brood production. Select brood are being transported to the lab for reproductive and physiological assays to distinguish F1 from sister brood reproduction.

c. **Products:** Research updates on this work were presented at the International Union of Forestry Research Organizations Section 7.03.05 (population dynamics), Sept 15-19, 2013 in Banff, Alberta and the North Central Forest Pest Workshop in Frontenac, MN Sept 23-26, 2013. An outreach presentation was provided at the Minnesota Native Plant Society (Dec 2012). MPR “All Things Considered” featured this work on July 8 (“Climate change might be enabling beetles’ rise against trees”) as well as CBC (Canada) July 10, 2013. As this work concludes, peer-reviewed publications will be prepared. This project is providing (1) new information on the biology of *D. simplex* (2) understanding of climatic factors (temperature, precipitation) that affect its success (3) peer reviewed publication(s) as part of the dissertation work of Fraser McKee (4) presentations.
d. Schedule of Activities:

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer 2012</td>
<td>Collect field data</td>
<td>Completed</td>
</tr>
<tr>
<td>Fall 2012 / Winter 2013</td>
<td>Analyze field data, gather climate data</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Summer 2013-2015</td>
<td>Collect field data</td>
<td></td>
</tr>
<tr>
<td>Fall/Winter 2012-14</td>
<td>Analyze field and climate data</td>
<td></td>
</tr>
<tr>
<td>Fall 2014 / Spring 2015</td>
<td>Write and disseminate results</td>
<td></td>
</tr>
</tbody>
</table>

e. Progress/Accomplishments:

Landscape-level: We have detected several temperature signals associated with increased mortality of tamarack to eastern larch beetle. These variables include warm summers, late springs, and warm springs. It seems counterintuitive that a late spring is associated with climate change and/or increased tamarack mortality. We find in laboratory studies, however, that insects with a prolonged cold period emerge more synchronously in the spring. This would aid in host procurement through pheromone-mediated mass attacks. Late frost-free dates also seem to be associated with increased snow melt around the base of the trees due to gradual solar gain. This allows the beetles to emerge from their overwintering refugia in the duff before the tree roots thaw away from the bole below the snow. Attack before the tree is fully able to defend itself aids in beetle colonization. To date all larval broods have occurred in timber that is standing and apparently healthy. We are now exploring whether there is a precipitation deficit also associated with insect activity.

Stand-level & laboratory studies: In 2012, we saw a third set of trees become attacked in late summer. The literature suggest that this is a second or third sister brood because eastern larch beetle requires an obligate reproductive diapause (Langor and Raske 1987ab). Our laboratory assays however indicate that adults do not require an overwintering diapause. We have been examining several lines of evidence that suggest this third peak is an F1 generation rather than a sister brood, including: (1) attacks occur at the same time that first brood progeny of the summer are emerging and flying (2) color morphs of the attacking adults. The insects that are attacking new trees are lighter in color indicating younger age. This past summer, extensive sampling was conducted to show these lighter color insects decrease through time and thus are not a genetic color morph as seen in spruce beetle. Insects in the third set of trees developed to maturity before the winter and were able to successfully overwinter. In this final year we are examining emergence patterns of the sister broods and putative F1 generation and testing their reproductive viability.

By the end of this project, we will be able to decipher whether the increase in tamarack mortality due to eastern larch beetle in the absence of traditional predisposing factors is due to a recent warming trend that is permitting viable bivoltine (rather than univoltine) reproduction along the southern margin of this insect’s range. This would be a new finding for this insect.

f. Citations


**COSTS:** (Similar to Years I & II; this is Final Year III of proposed three year project)

<table>
<thead>
<tr>
<th>YEAR 3 of 3</th>
<th>Item</th>
<th>Requested FHM EM</th>
<th>Other-Source(^a)</th>
<th>Source</th>
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<tbody>
<tr>
<td>Administration</td>
<td>Salary(^b)</td>
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<td>38,212</td>
<td>UMN McKnight to PI</td>
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<td></td>
<td>Overhead (22%)</td>
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<tr>
<td></td>
<td>Travel</td>
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<td>5,000</td>
<td>DNR lodging, survey, time</td>
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<tr>
<td>Procurements</td>
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<tr>
<td></td>
<td>Equipment</td>
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<td>Computer, growth chamber, software licenses UMN</td>
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<tr>
<td></td>
<td>Supplies</td>
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<tr>
<td><strong>Total (Year 3 of 3)</strong></td>
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<td>$59,920</td>
<td>$59,920</td>
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</tbody>
</table>

Indexed 2.5%/year for increasing fringe (Y1: $57,568; Y2: $58,832; Y3: $59,920)

\(^a\) Cost share includes graduate student tuition paid by College, start-up funds, & McKnight professorship to BHA in years I-III, academic year salary of PI

\(^b\) Salary includes graduate student F. McKee, summer student, partial faculty summer support

NOTE: Funds received in Years I & II totaled $82,500 + $58,800 so only $35,000 is needed this year to complete project.