

TITLE: Assessment of aspen leaf miner distribution in Alaska using satellite imagery.

LOCATION: Anchorage and Fairbanks, Alaska

PROJECT LEADER/S: John E. Lundquist and James Kruse, Forest Health Protection, State and Private Forestry, USDA Forest Service, Anchorage and Fairbanks, resp.

COOPERATORS: Robin M. Reich, Colorado State University, Fort Collins, Colorado; and Dustin Wittwer, Region 10 Forest Health Protection, Juneau, Alaska.

PROJECT OBJECTIVES: The work proposed below attempts to develop a technique to predict insect pest presence and severity in areas not covered by aerial pest surveys.

JUSTIFICATION: Insect pest outbreaks are common in Alaska forests. Some infestations have been reported to reach hundreds of thousands of acres. In the 1950s, for example, the black headed budworm and the hemlock sawfly, together, reportedly infested the entire range of hemlock – over millions of acres. During the last decade, spruce beetles killed most of the spruce trees on the Kenai Peninsula – over a million acres. Last year, the aspen leaf miner was found on over 600,000 acres of forest. Because these outbreaks commonly occur in locations of low or no human populations, sometimes even huge infestations can go unnoticed.

Alaska presents a unique challenge because of its vast acreage. Aerial surveys conducted by State and Private Forestry annually cover no more than a small percentage of the total vegetation, thus values used for total infested acres used in summary statistics represent only a portion of those actually infested. These statistics are nonetheless used in statewide, regional, and national summaries for reporting pest conditions. A way of estimating pest conditions between flight lines would certainly be useful. This study aims at developing such methods.

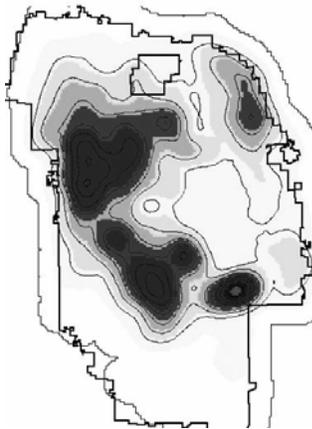
DESCRIPTION:

Background: Aspen leaf miner *Phyllocnistis populiella* Chambers is a native moth in the family Gracillariidae that feeds on trembling aspen and balsam poplar. Before 1999, this insect in Alaska was at endemic population levels and hardly noticeable. Subsequently, however, populations began steadily increasing near Delta Junction and Tok through the late-1990's, and increased in the Fairbanks area by 2001. In 2002, acreage affected by leaf miner and detected during aerial surveys rose dramatically to 299,468 acres. The infestation continued to balloon in ensuing years, to 351,000 acres in 2003, 584,400 acres in 2004, and 659,500 acres in 2005. Areas most severely affected included the Alaska Highway between Delta Junction and Tok, Fairbanks area, Yukon Flats, Yukon River Valley, and the Tanana River Valley. Aspen was also affected by severe drought in 2004 and 2005, and many aspen already in dry or marginal sites succumbed to the combined effects of leaf miner and drought.



The aspen leaf miner causes a distinct grayish-silver tone to the canopies of affected trees (see above figure). This symptom is easily seen from the ground or air and probably also shows up in satellite images. Since aerial survey coverage is very limited in Alaska, much of the forest area infested by this leaf miner probably goes unsurveyed. Consequently, distribution maps are incomplete, and impact figures underestimated. A cost effective method of complete coverage is in great need.

Some promising work has been done recently on spatial modeling of insect pests and diseases using satellite images and spatial modeling (Reich et al. 2004). These procedures were able to generate distribution maps for mountain pine beetle that were very similar to those developed from complete coverage aerial surveys (Lundquist and Reich in review; figure below). More over, accuracy values could be calculated from the former. Maps represented by spatial models can offer useful tools to decision makers managing insect pests.

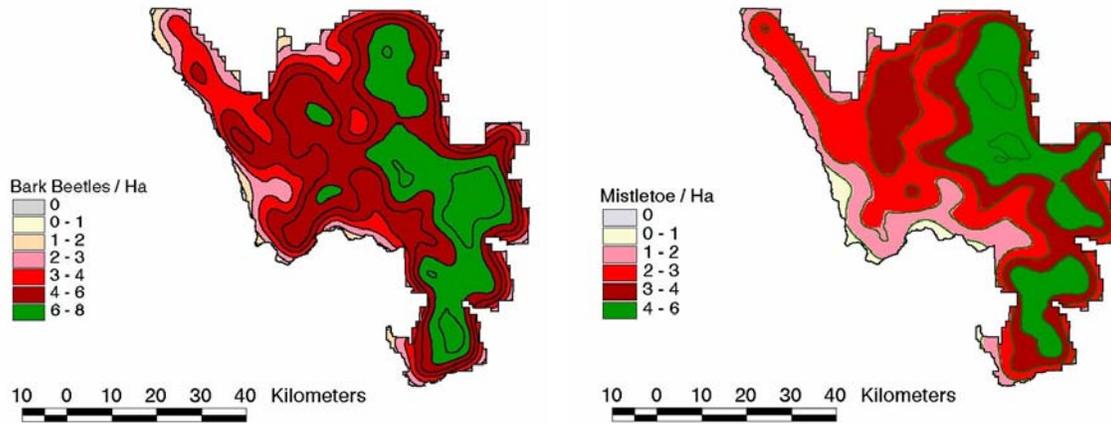


Mountain pine beetle probability distribution based on satellite coverage imagery 2003



Distribution of Mountain pine as determined by complete aerial survey 2003.

As a test case, these procedures were applied to forests in the Front Range of Colorado to predict the spatial distributions of bark beetles, root diseases, dwarf mistletoe, canker diseases, wind damage, and a variety of other biotic and abiotic agents (Lundquist et al. in preparation; see figure below).



In this study, we propose to evaluate and adapt a technique that will facilitate and possibly improve existing pest survey methods conducted in Alaska by applying spatial modeling techniques. We will evaluate the ability to 1) detect the spatial distribution of aspen leaf miner, 2) estimate severity of the damage caused by the leaf miner, and 3) assess the accuracy of these assessments.

Methods:

Study areas will be selected based on ease of access and the presence of forest stands showing a range of infestation intensities. Ideally, several study areas would be used. However, the cost of the high resolution satellite (Quickbird) imagery prohibits the size of this study, at least initially. Initially, one study area (40,000 to 100,000 acres) will be selected.

Methods published previously by Reich and his collaborators will be tested and adapted, and integrated with high resolution satellite imagery. A sample of 1000 30 m x 30 m plots will be randomly located on Quickbird imagery in the study area. Sample plots will be interpreted to determine the presence and intensity of leaf miner infestations. Between 50 and 100 of these plots (or as many plots as possible) will be visited in the field and ground truthed; a special aerial survey flight may be needed if these plots are difficult to access. Using presence/absence data with various other existing spatially referenced auxiliary data (e.g., GIS, vegetation types maps, imagery data layers, etc.) binary classification trees will be developed to predict presence/absence of the leaf miner, and to enable estimations of prediction error using methods developed by Reich et al. (2004). Presence/absence predictions will then be made in un-sampled areas (each pixel on a Quickbird image) using the classification trees. The resulting surfaces will be subjected to kernel density estimator using methods developed by Lundquist and Reich (2006) to determine intensity or number of pixels per hectare that one would expect to observe a particular causal agent. This procedure will result in maps of the probability of distribution and severity of aspen leaf miner over the extent of area covered by the Quickbird image.

The methods adapted and developed above will subsequently be used to generate larger scale statistical models describing the spatial distribution and extent of leaf miner occurrence by coupling the Quickbird satellite image (=2.5 m resolution) with Landsat ETM (30 m), and Landsat with MODIS (250 m). A nested design will be used to select the sample plots on the satellite imagery. The size and shape of the sample plots will correspond to the spatial resolution of the satellite imagery. To facilitate comparisons among the various satellite imagery sample plots, the Quickbird image will be nested within selected Landsat ETM pixels, which will be nested within select MODIS pixels. In addition, information from the aerial surveys will be converted to a raster format with a 250 m spatial resolution corresponding to the resolution of the MODIS imagery of the state of Alaska. All infestations will be identified on the Quickbird imagery corresponding to aerial survey lines that intersect the sample areas. Ratio type estimators will be developed to adjust estimates obtained from the MODIS imagery using estimates obtained from the Landsat ETM imagery and the Quickbird imagery. Double sampling will be used to assess the accuracy of the Landsat TM imagery and MODIS, relative to Quickbird in modeling the spatial distribution of insect outbreaks in the state of Alaska. Using procedures developed by Reich et al. (2004) models will be developed to predict the spatial distribution of infestations for the state of Alaska using information from the aerial surveys and the MODIS imagery. Cross-validation procedures will be used to assess the predictive performance of the models.

Products: The product of this study will be a method that can be used to predict the presence and severity of aspen leaf miner at a regional and/or statewide spatial scale associated with estimates of prediction accuracy. A statewide model will be generated, but since the number of study areas will be limited, the accuracy due to extrapolating beyond the actual study area will probably be low. Accuracy within the study area might be high. Nonetheless, we see this as a first step in developing a digital map of the statewide distribution of any insect pest at a cost probably much less than currently spent on aerial surveys. This map would be compatible with GIS systems used routinely on National Forests, and thus able to be incorporated into long and short term planning. The derived methodology will have a parallel benefit in that it will augment future “riskmap” efforts

Schedule of Activities:

FY 2007: To be completed in FY 2007.

- 1) Locate and acquire auxiliary data: GIS layers, veg maps, soil maps, etc. (early spring) for each study area.
- 2) Identify and select study area (April).
- 3) Acquire/analyze satellite imagery and field data (July to Aug).
- 4) Develop non-spatial predictive forest pest models for aspen leaf miner, and generate spatial-referenced local pest distribution models; estimate accuracy (Winter months).
- 5) Generate large-scale spatial-referenced leaf miner distribution models; estimate accuracy (Winter months).

FY 2008: To be completed in FY 2008.

Manuscript preparation and submission.

Progress/Accomplishments:

COSTS:

	Item	Requested FHP EM Funding	Other- Source Funding	Source
<i>FY 2007</i>				
<i>Administration</i>				
	Salary (Reich)	\$4,247.20		
	Salary (Grad Assistant)	\$3,984.00		
	Salary (Principal investigators)		\$16,451.20	R10 FHP
	Salary(2 X GS-9)		\$4,344.00	R10 FHP
	Overhead	0		CSU
	Travel (Reich and Grad Studt)	\$4,230.00		
	Travel (Principal investigators and Crew)	\$6,075.00		
	Supplies (1 Quickbird; 1 Landsat images)	\$3,800.00		
	Supplies		\$2000	R10 FHP
	Aerial Detection Survey – Aircraft Costs		\$70,000	R10 FHP
Year Totals		\$22,336.20	\$92,795.20	

<i>YEAR—2008</i>				
<i>Administration</i>	Publication	\$2500.00	\$	
Year Totals		\$2500.00		
Grand Total		\$24,836.20		

BUDGET REQUEST EXPLANATION:

FY 2007 – Salary: 1/2 month for Full Professor (80 hrs at 53.09 / hr) and 1 month for 1 graduate student (160 hrs at 24.90 / hr); Overhead: none, if cooperative agreement or joint venture agreement is the funding vehicle; 1 plane trip for 2 people Fort Collins to Anchorage and back at \$800 / trip (Reich and student); Lodging and per diem for 2

people for 5 days each at \$263 / day (Reich and student); Lodging and per diem for 3 people (crew and one PI) for 15 days at \$135 / day; Tech Transfer (meetings, training, workshops, etc): 3 people for 5 days at \$263 / day; Plane fares: \$3000. Supplies: 1 Quickbird image at \$3700 /image; 1 Landsat images at \$200 / image; 1 MODIS image at \$0 / image; misc field and office equipment at \$2000.

FY 2008 – Publication - \$2500.

LITERATURE CITED:

Lundquist, J.E. and R.M. Reich. 2006. Tree diseases, canopy structure and bird distributions in ponderosa pine forests. *Journal of Sustainable Forestry* 23 (2): 17- 45.

Lundquist, J.E. and R.M. Reich. Predicting the landscape spatial distribution of fuel-generating-diseases, insects, and other types of disturbances. *Forest Ecology and Management* (in review).

Reich, R.M., J.E. Lundquist, and V.A. Bravo. 2004. Spatial models for estimating fuel loads in the Black Hills, South Dakota. *International Journal of Wildland Fire* 13:119-129.

Reich, R.M. and J.E. Lundquist. 2005. Use of spatial statistics in assessing forest diseases. pp. 127-143. In: J.E. Lundquist and R.C. Hamelin, eds. *Forest Pathology -- From Genes to Landscapes*. APS Press, St. Paul. 175 p.