Ecological Effects of Leaf Mining
Plant Performance and Trophic Dynamics

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Local leaf miner and chewers densities on deciduous trees

Year
Number insects m$^{-2}$
0 50 100 150 200 250
Leaf miners
External chewers

BC LTER: Defoliating Insect Population Levels – Werner & Kruse
Major leaf miner outbreaks across Alaska

Area infested (ha)

Aspen leaf miner
Willow leaf blotch miner

Aerial Insect Detection Survey – USFS
Outline

• Why did ALM outbreak last so long?
• What caused the end of the ALM outbreak?
• How does aspen leaf miner (ALM) affect aspen performance?
• New experiment: Long term ecosystem consequences of insect herbivory, mammalian browsing, and their interaction
Aspen leaf miner moth
*(Phyllocnistis populiella)*

- North American native
- One generation per year
- Larvae consume epidermal cell layer
- Restricted to one side of a single leaf until adulthood
- Adults emerge in June, overwinter under spruce
Why did the ALM outbreak last so long?

• High plant tolerance of herbivory
  – Nutrient stores

• Insect behavior
  – Larvae unable to attack foliage produced late in growing season (one generation, larvae immobile)
  – Aggression towards conspecifics prevents decimation of food supply
Competition

Eggs per leaf

Leaf area mined (%)

Pupal mass of survivors (mg)

Initial larvae per leaf

Doak & Wagner in review
Competition

Eggs per leaf

Leaf area mined (%)

Pupal mass of survivors (mg)

Intense interference competition:
• Prevents food limitation
• Allows some larvae to survive leaf overpopulation
• Preserves leaf function

Doak & Wagner in review
What ended the outbreak?

- Phenological mis-match
- Adult overwintering survival
- Egg mortality
- Larval parasitism
- Larval and pupal predation (ants, birds)
- Larval and pupal mortality unassigned (other predators, pathogens, plant quality)
What ended the outbreak?

- Phenological mis-match
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What ended the outbreak?

Survivors per leaf

Percent of individuals

Indirect effect of WLBM increase?

Doak & Wagner in review
How does leaf mining affect aspen performance?

Methodology

• Experimental suppression of leaf miner density on aspen < 2m
• 2 sites: Bonanza Creek and Ester Dome; mixed stands
• 7 years
How does leaf mining affect aspen performance?

• Mortality
  – No effect of leaf miner suppression

• Growth and size
  – Strong effects
Effects of leaf mining across 7 years

Implications for browsing, competition

Wagner & Doak 2013
Mechanisms of ALM-caused aspen decline

• Early leaf abscission (Wagner et al. 2008)
• Leaf mining reduces photosynthesis by disrupting stomatal function (Wagner et al. 2008)
• Mining disrupts water balance (unpubl.)
• Mining induces ineffectual defenses
  – Phenolic glycosides (Young et al. 2007)
  – Extrafloral nectar (Newman & Wagner 2013)
  – Both increase costs
Willow leaf blotch miner
(Micrurapteryx salicifoliella)
Willow leaf blotch miner
(*Micrurapteryx salicifoliella*)

- One generation
- Multiple *Salix* hosts
- Larvae consume mesophyll
- Mobile – will move to new leaves within plant
Wide variation in susceptibility among willow species

% Leaf mining

2010

2011

Willow species

MYRT  ALAX  GLAU  BEBB  NIPH  PSMY  ARBU  INTE  PULC  LASI  PSMO

0  20  40  60  80  100

2010

2011
Questions

• What are the individual and combined effects of invertebrate and vertebrate herbivores on the early successional plant community & ecosystem?

• Do invertebrate and vertebrate herbivore interact indirectly through effects on plant:
  – Production
  – Plant chemistry / palatability

• E.g. Summer insect leaf herbivory may affect availability or palatability of species preferred by mammals in winter
Experiment: Impact of, and interactions between, invertebrate & vertebrate herbivores

- Started spring 2012; ~10 year duration
- Invertebrate suppression (insecticide) x exclusion of moose/hares (fencing)
- Dependent variables:
  - Willow herbivory, browse, litter production, chemistry
  - Community composition
  - Soil nutrients, decomposition
Impact of, and interactions between, insect & vertebrate herbivores

• Preliminary results
  – Suppressing insect herbivory increased woody browse production (~ 50% in 2012)
  – No effect of insect suppression on browse C/N, tannin PPC
  – No effect of insect suppression on browsing removal
  – No notable changes in community composition to date
Summary

• Why did ALM outbreak last so long?
  Strong interference competition reduced food limitation and plant damage

• What caused the end of the ALM outbreak?
  Juvenile mortality by biotic agent

• How does aspen leaf miner (ALM) affect plant performance?
  Weak effects on outright mortality; strong negative effects on plant size

• New experiment: Long term consequences of invertebrate herbivory, vertebrate browsing, and their interaction
  Underway, more to come