



Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Global change and plant resistance against pests

Christer Björkman

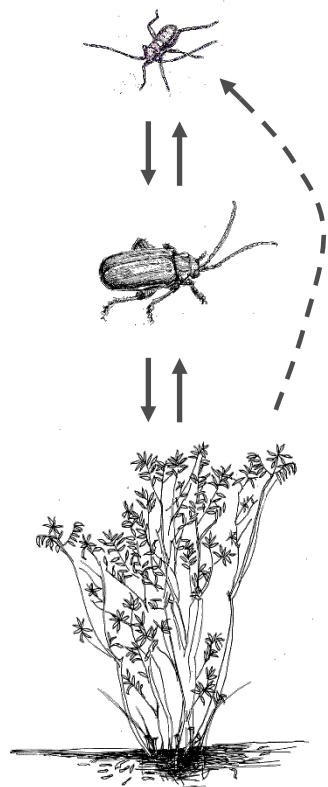
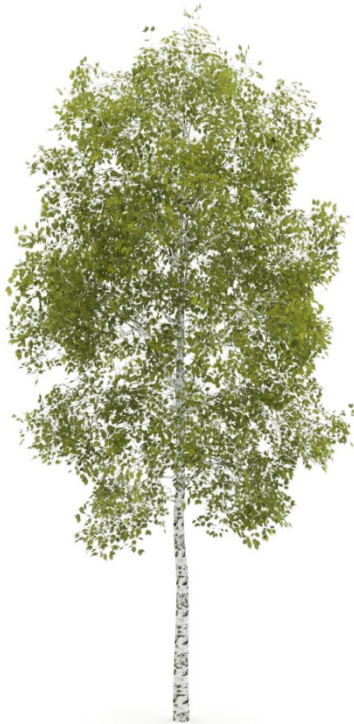
Department of Ecology, Uppsala, Sweden

June 7-9, 2016

HealGenCAR conference, Punkaharju, Finland

Plant resistance

- Direct – affecting pests negatively
- Indirect – affecting natural enemies positively
- Tolerance – coping with the damage; grow

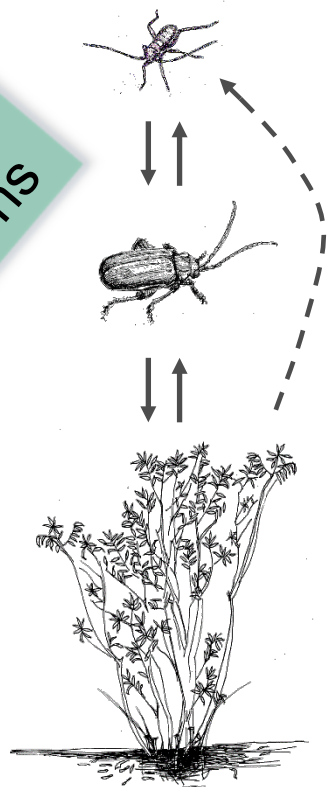


Plant resistance

- Direct – affecting pests negatively
- Indirect – affecting natural enemies positively
- Tolerance – coping with the damage; grow



Tri-trophic interactions



Direct resistance

- Defences

- Chemical
- Mechanical

- Constitutive
- Inducible

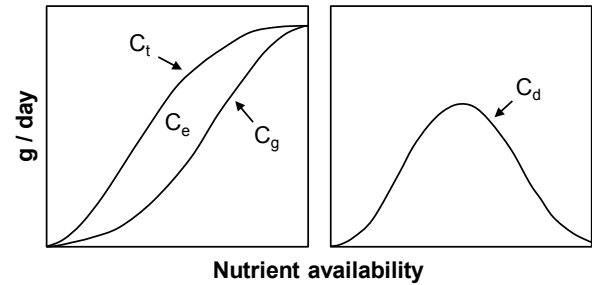
Chemical defences

- Carbon-based
 - Phenolic compounds
 - Terpenoids
- Nitrogen-based
 - Alkaloids

Plant defence theories

- Carbon-Nutrient Balance (CNB) hypothesis

Bryant et al. (1983), Tuomi et al. (1988)

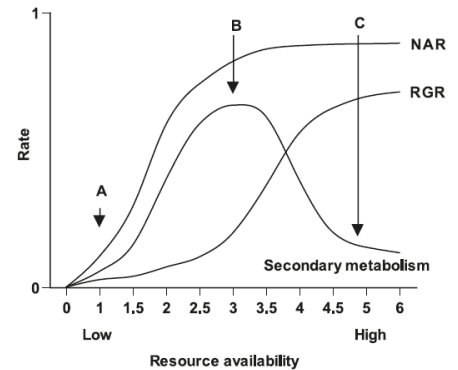


C_t = C total
 C_g = C growth
 C_e = C excess

C_d = C defence

- Growth-Differentiation Balance (GDB) hypothesis

Loomis (1953), Herms and Mattson (1992)



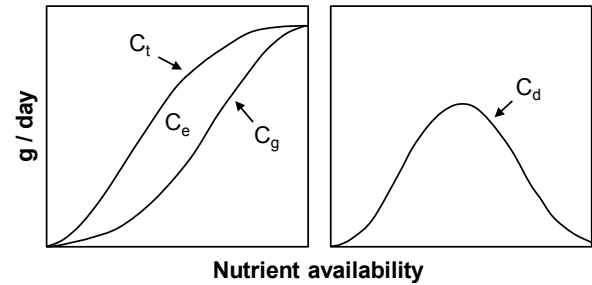
Link between growth and defence

Global change affect plant growth

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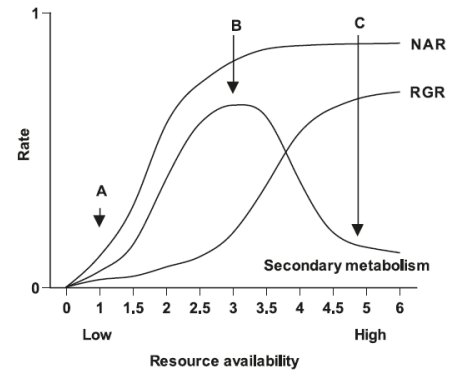


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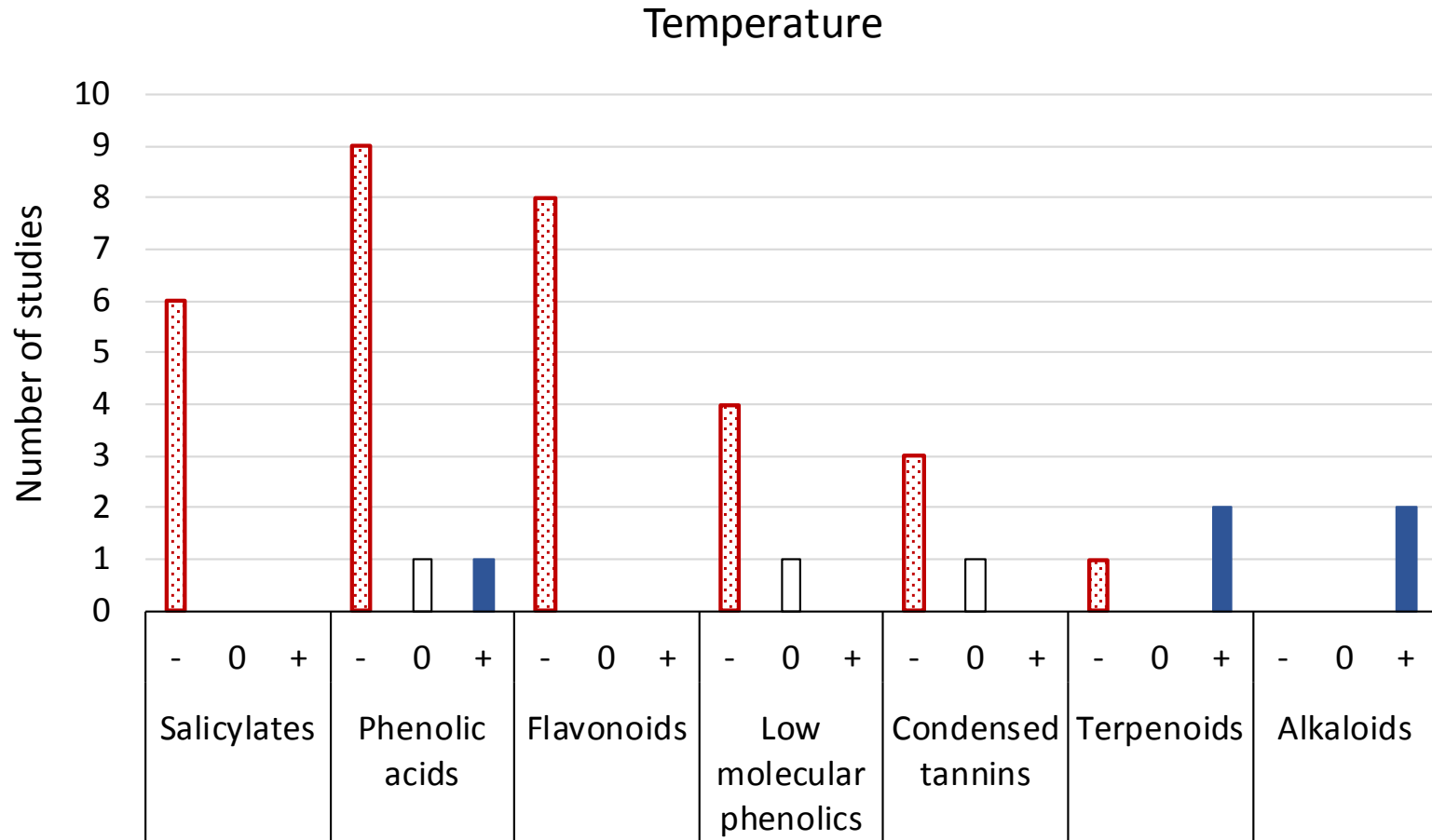
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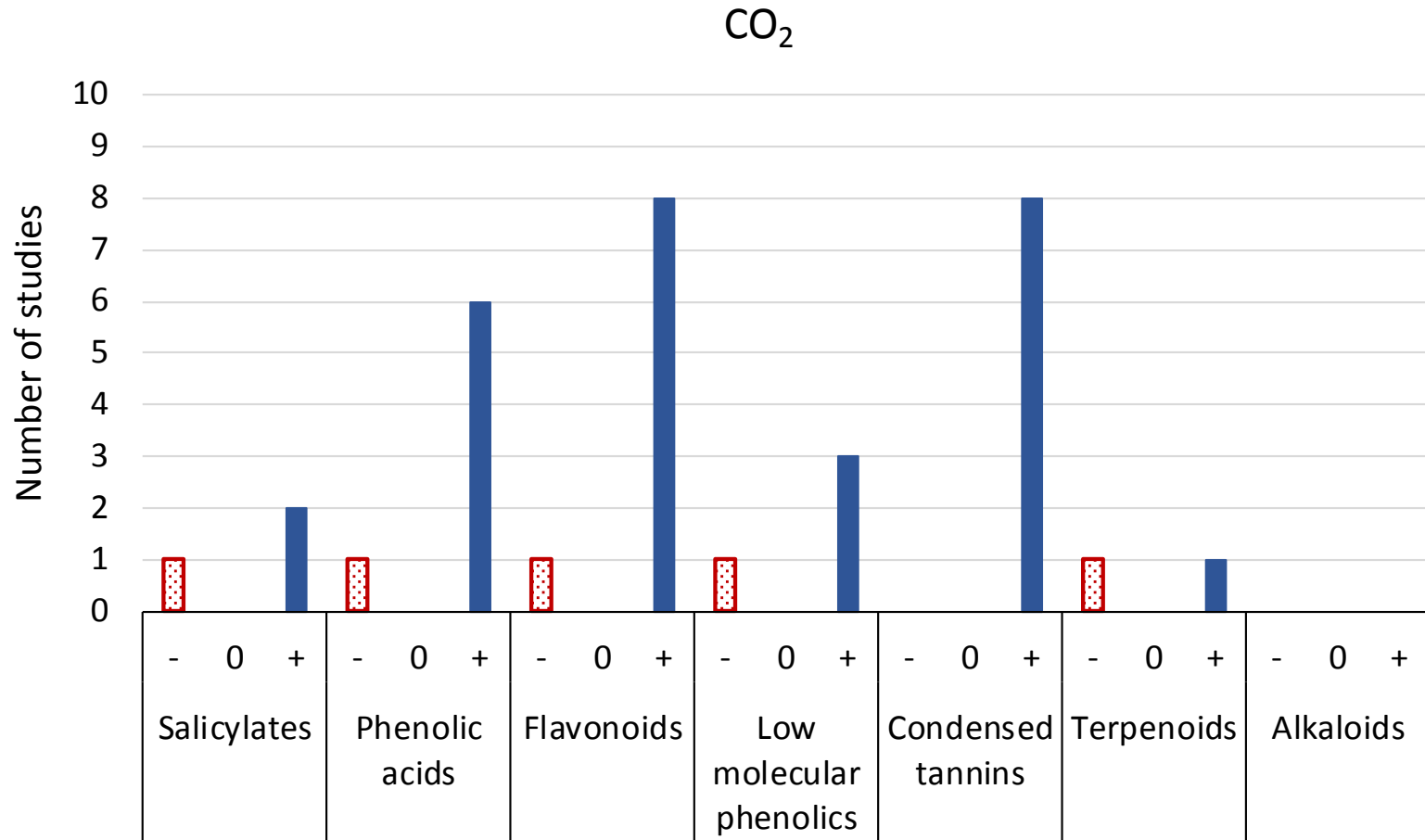
Link between growth and defence

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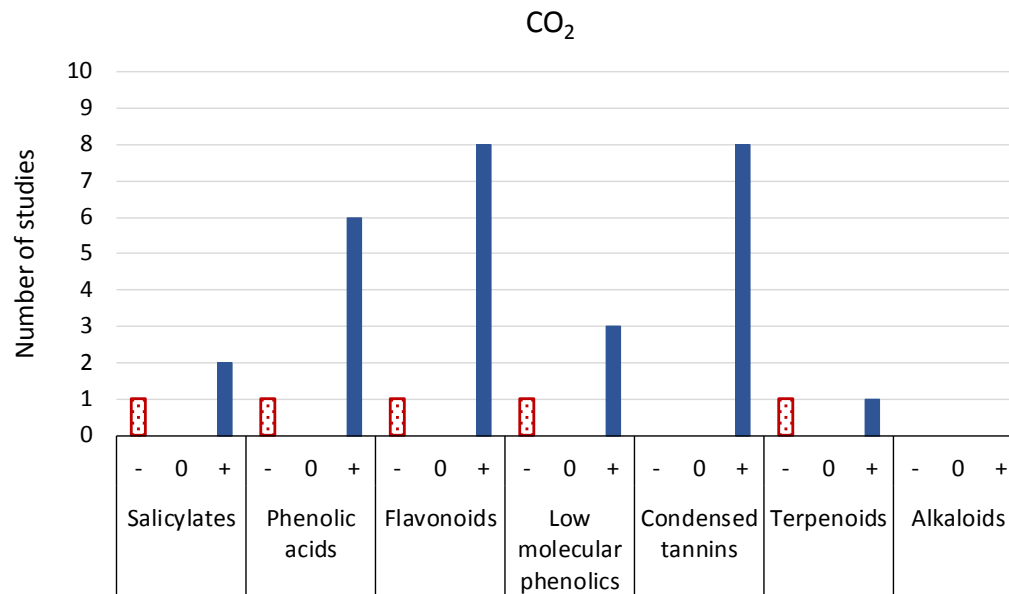
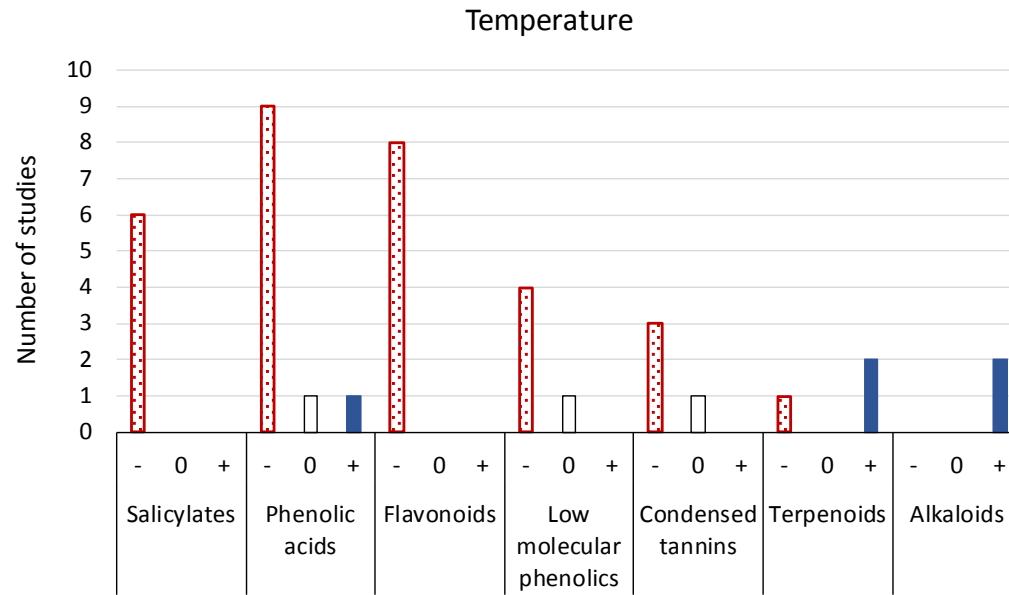
Plant defence compounds and climate change







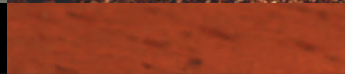
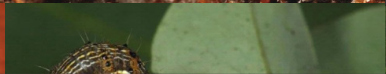

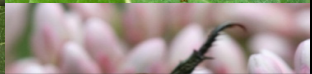










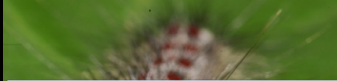

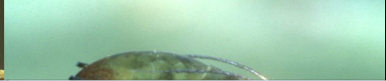



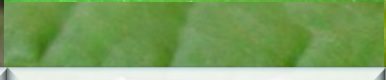




Plant defence compounds and climate change

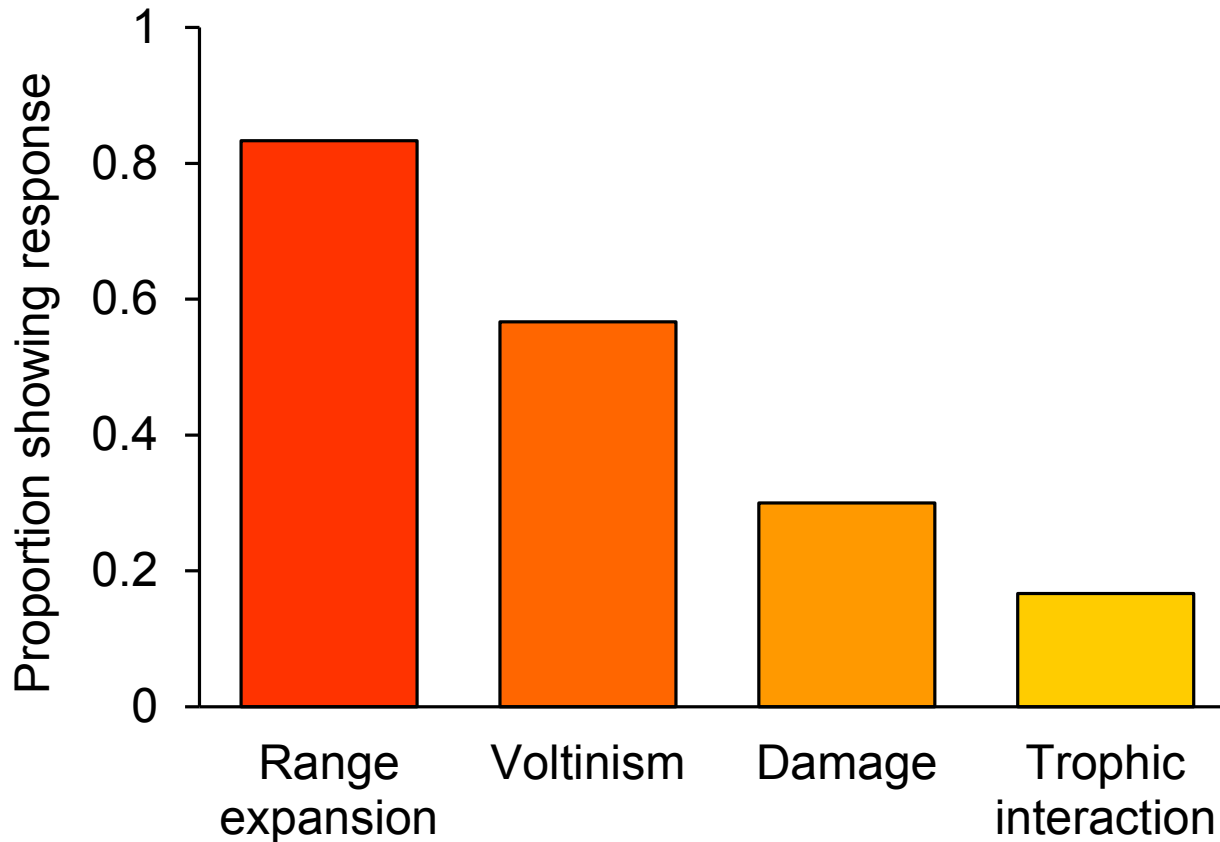


Plant defence compounds and climate change



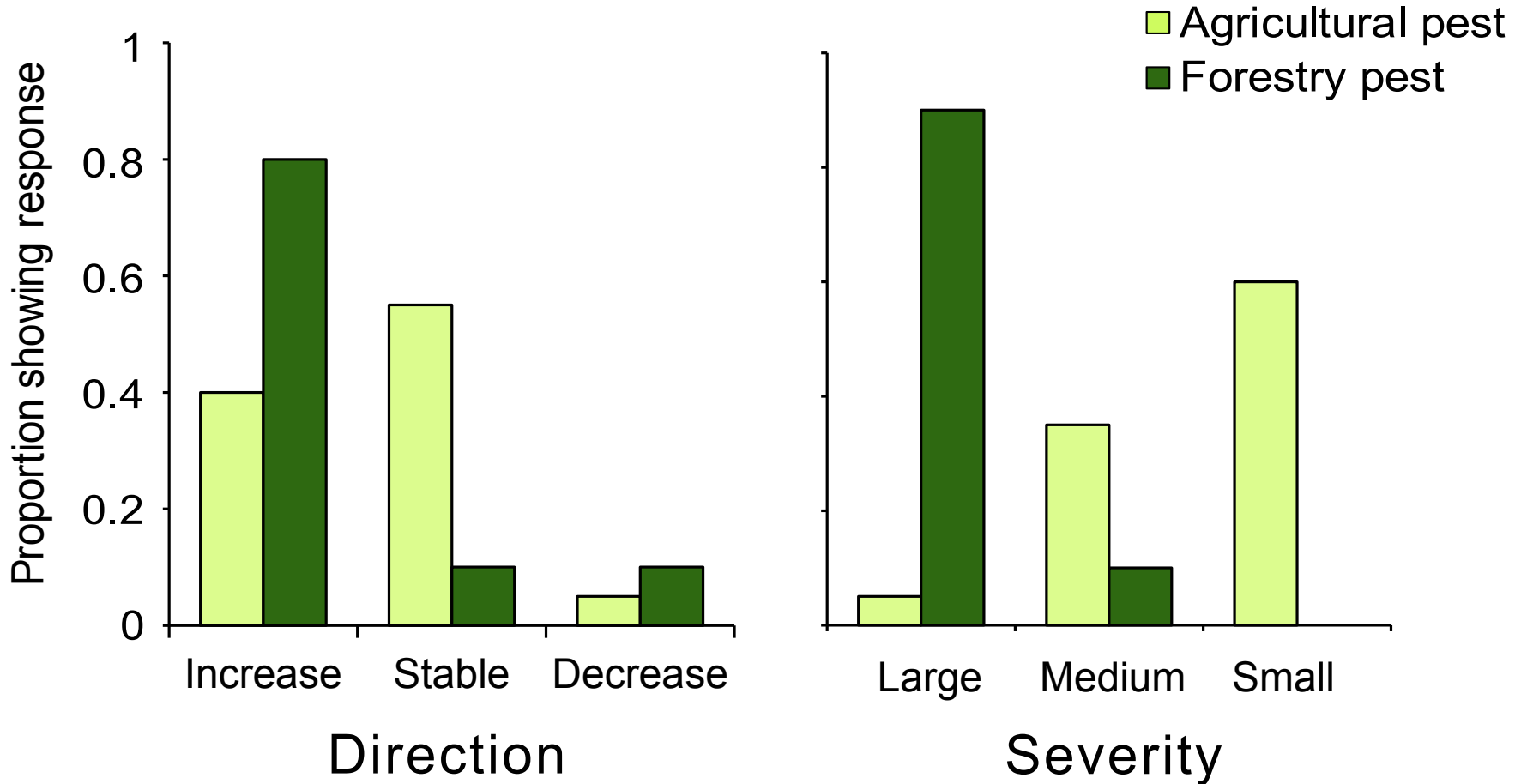
 Mountain pine beetle <i>Dendroctonus ponderosae</i>	 Southern pine beetle <i>Dendroctonus frontalis</i>	 European spruce bark beetle <i>Ips typographus</i>	 Hemlock woolly adelgid <i>Adelges tsugae</i>	 Green stink bug <i>Chinavia hilaris</i>
 Olive fly <i>Bactrocera oleae</i>	 Asiatic rice borer <i>Chilo suppressalis</i>	 Cotton bollworm <i>Helicoverpa armigera</i>	 European corn borer <i>Ostrinia nubilalis</i>	 Japanese beetle <i>Popillia japonica</i>
 Western corn rootworm <i>Diabrotica virgifera</i>	 Winter moth <i>Operophtera brumata</i>	 Autumnal moth <i>Epirrita autumnata</i>	 Pine processionary moth <i>Thaumetopoea pityocampa</i>	 African sugarcane borer <i>Eldana saccharina</i>
 Coffee berry borer <i>Hypothenemus hampei</i>	 Codling moth <i>Cydia pomonella</i>	 Colorado potato beetle <i>Leptinotarsa decemlineata</i>	 Migratory locust <i>Locusta migratoria</i>	 Pollen beetle <i>Meligethes aeneus</i>
 Gypsy moth <i>Lymantria dispar</i>	 Bruce Spudworm <i>Christoneura fumiferana</i>	 Bird cherry oat aphid <i>Rhopalosiphum padi</i>	 Russian wheat aphid <i>Diuraphis noxia</i>	 Silverleaf whitefly <i>Bemisia tabaci</i>
 Maize stem borer <i>Chilo partellus</i>	 Diamondback moth <i>Plutella xylostella</i>	 Coffee leaf miner <i>Leucoptera coffeella</i>	 Citrus leaf miner <i>Phyllocnistis citrella</i>	 Citrus peelminer <i>Marmara gulosa</i>

Responses of pest insects to climate change



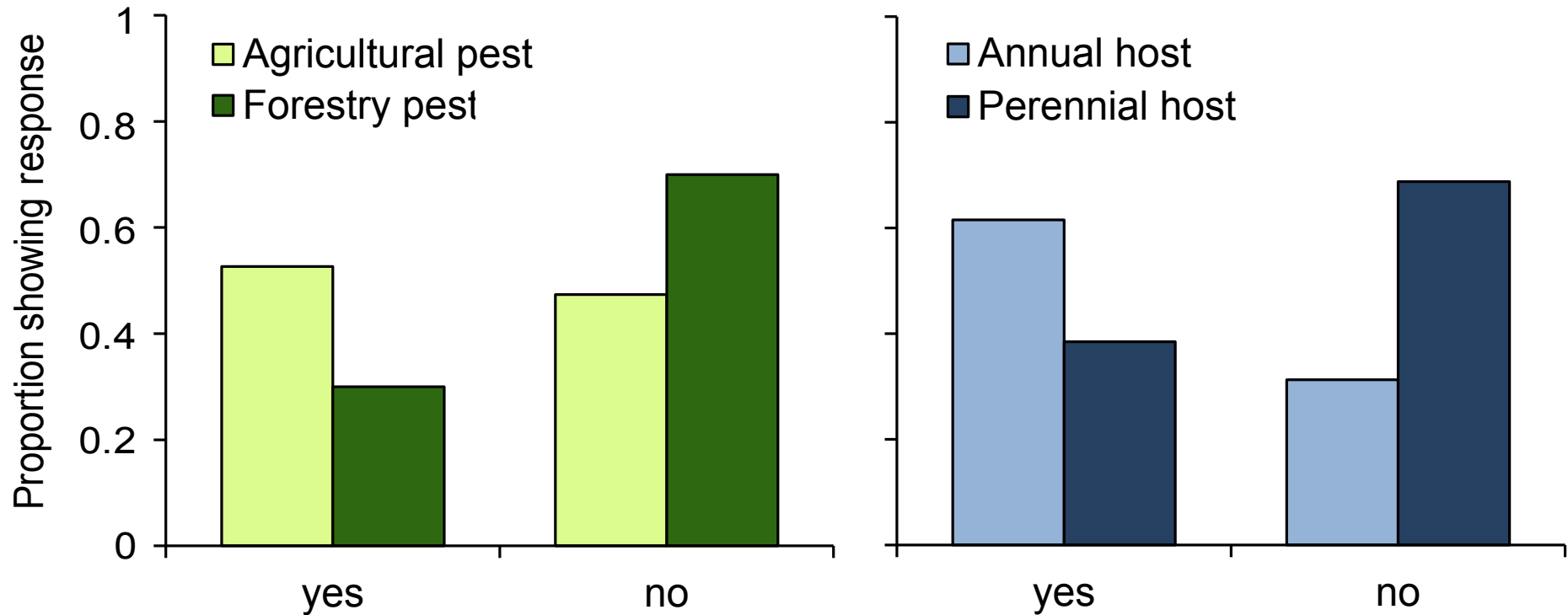
Note: Single species can show more than one response.

Ecological impact

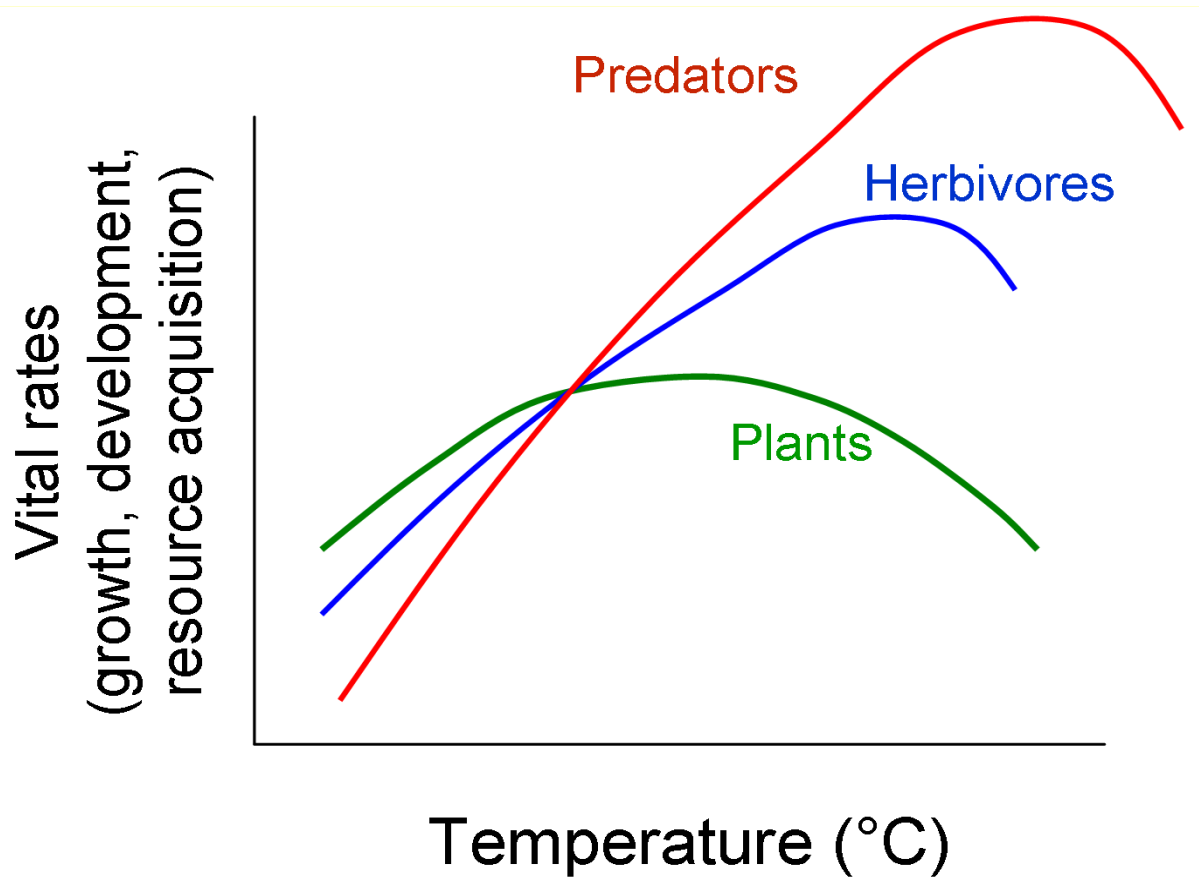


Ecological impact – effects on other organisms than their normal host plants.

Also 'negative' response to climate change

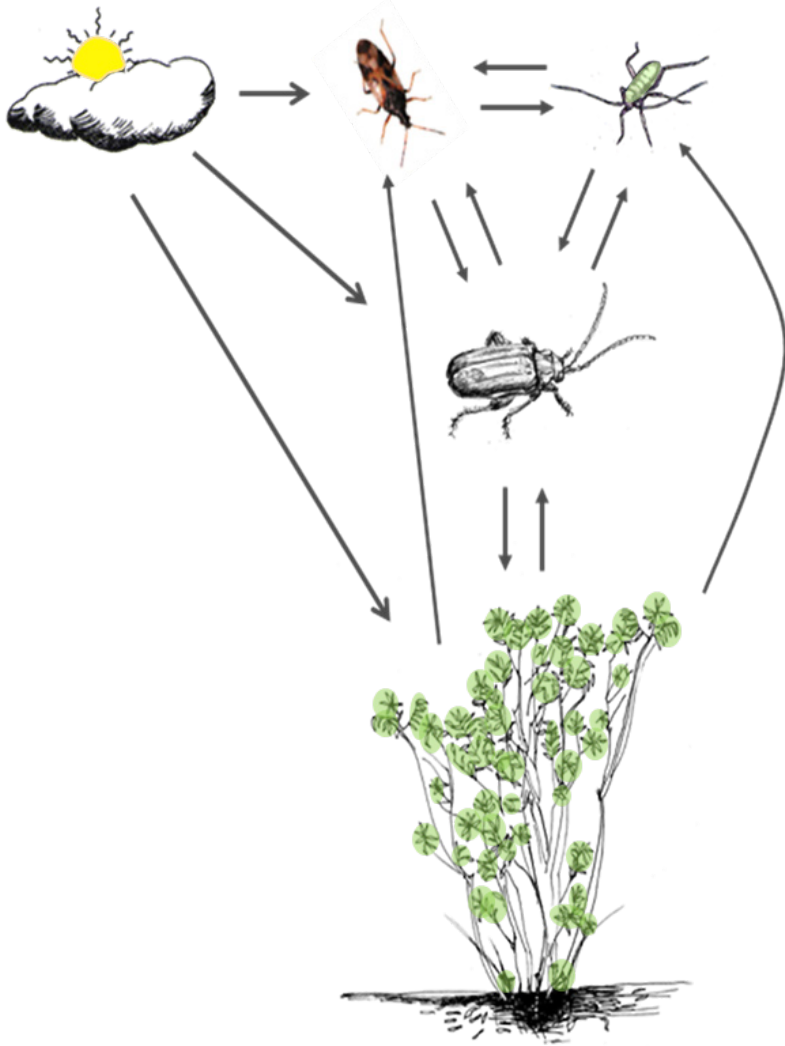


'Negative' response to climate change; e.g. range retraction or decreased damage.

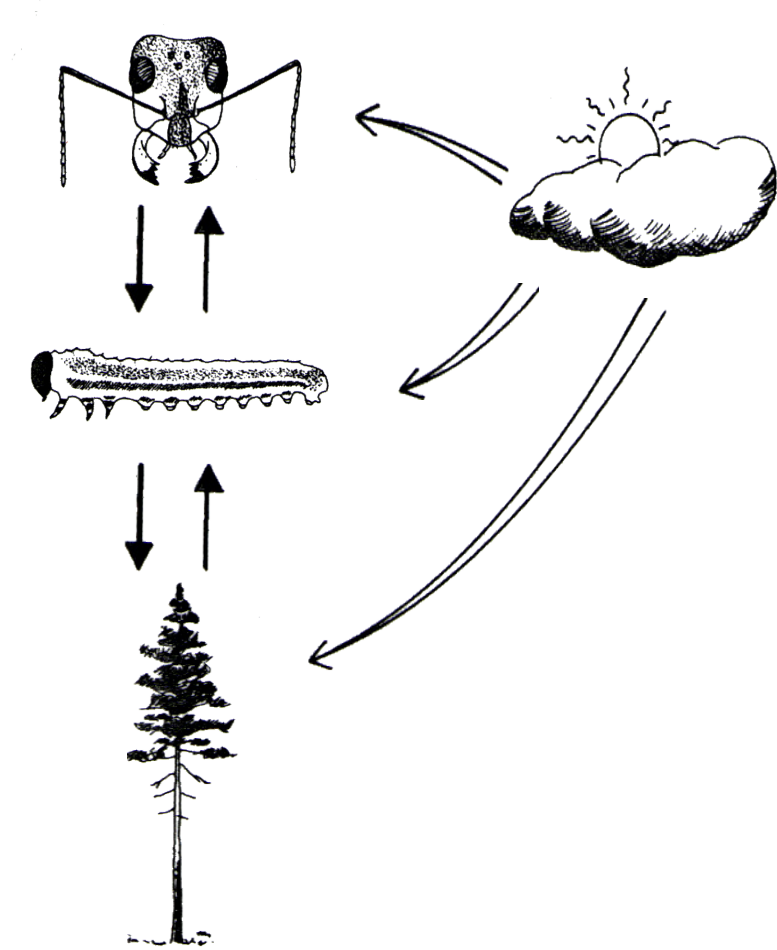


Berggren et al. (2009) Oikos

Two systems



Willow leaf beetles

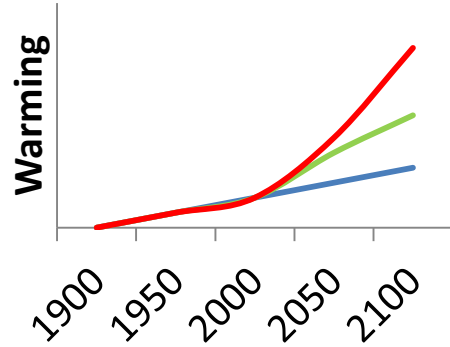


Pine sawflies

Three environmental drivers

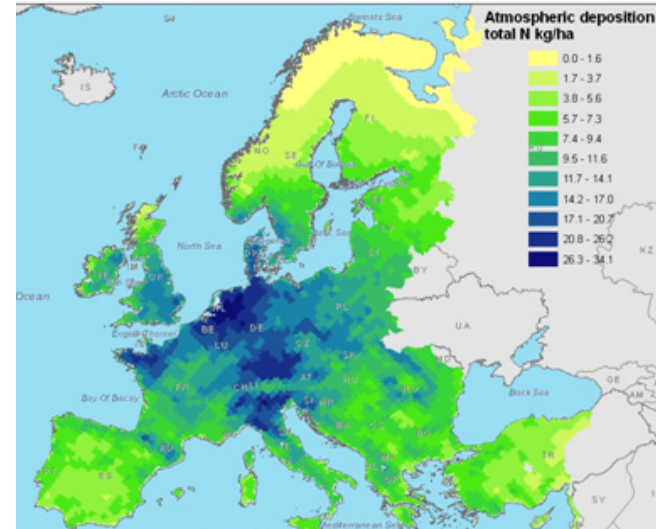
Climate

Climate change



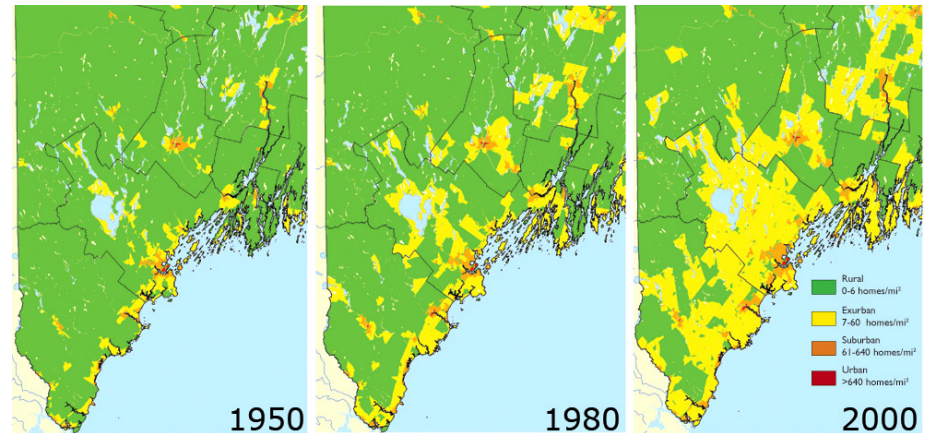
Nitrogen

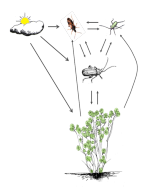
Nitrogen deposition



Land use

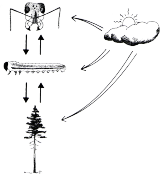
Land use change





Willow leaf beetles

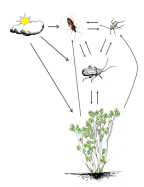
Pine sawflies



Climate

Nitrogen

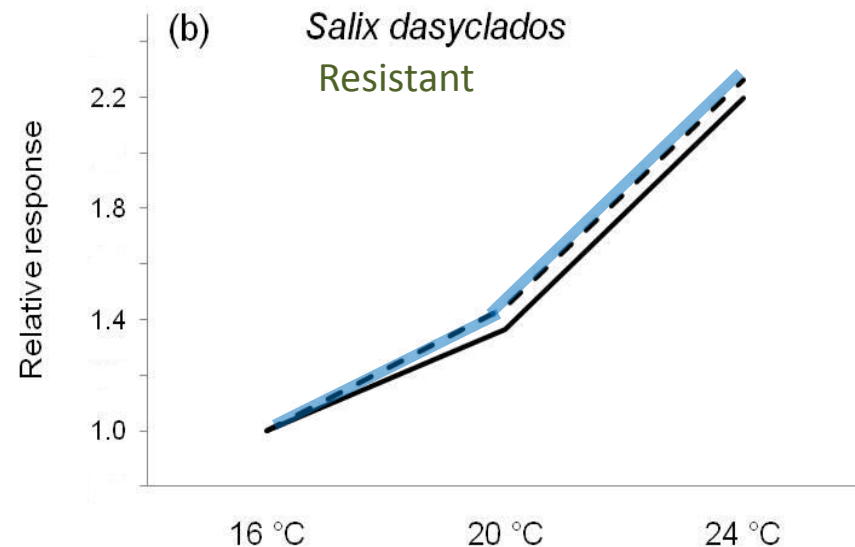
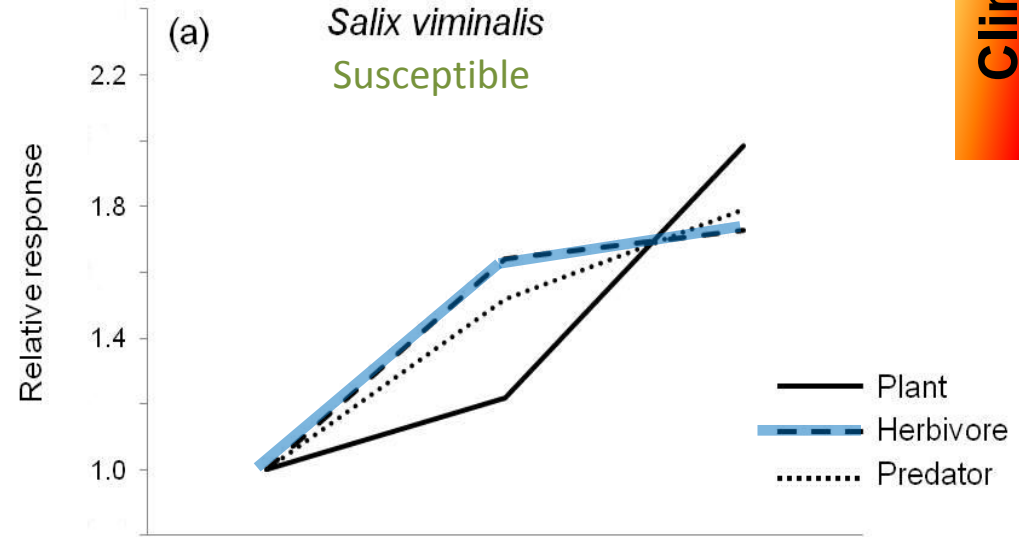
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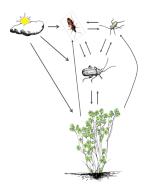


Willow leaf beetles

Maximum oviposition rate reached at moderate temperatures on susceptible plant genotypes

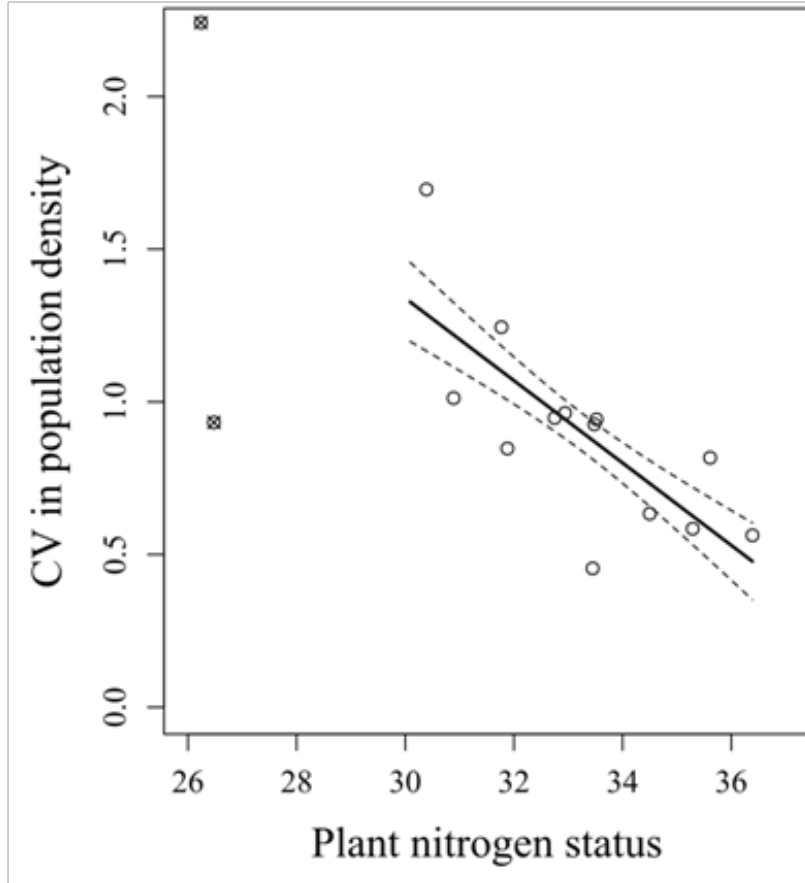
Increasing temperature



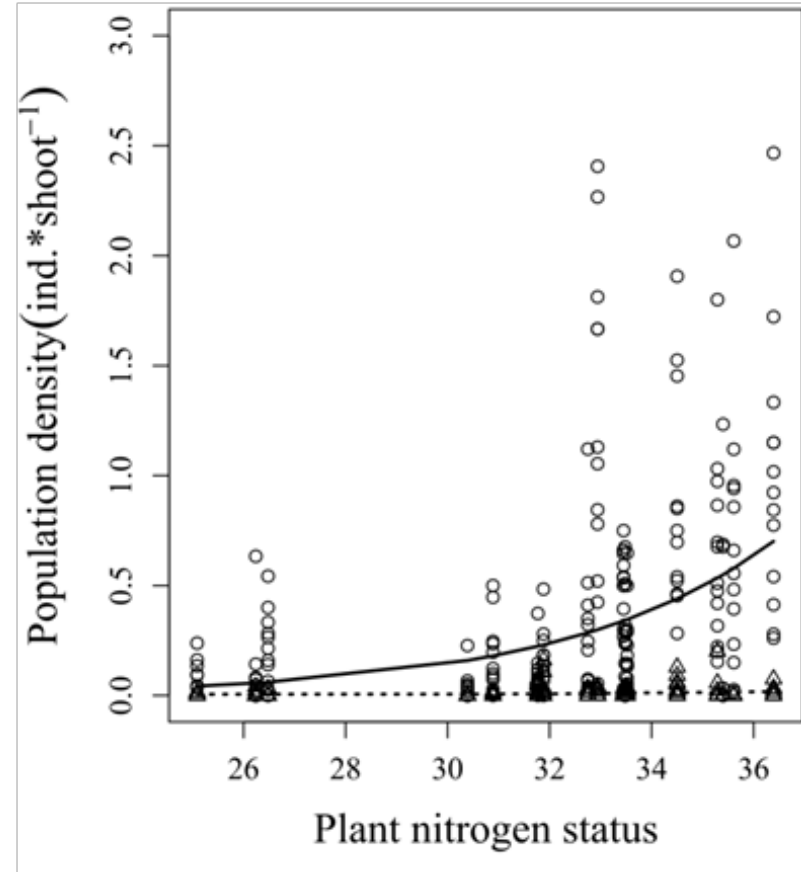


Willow leaf beetles

Higher and more stable population densities of omnivorous predators

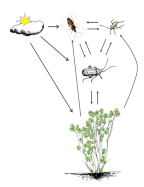


Increasing N



Nitrogen



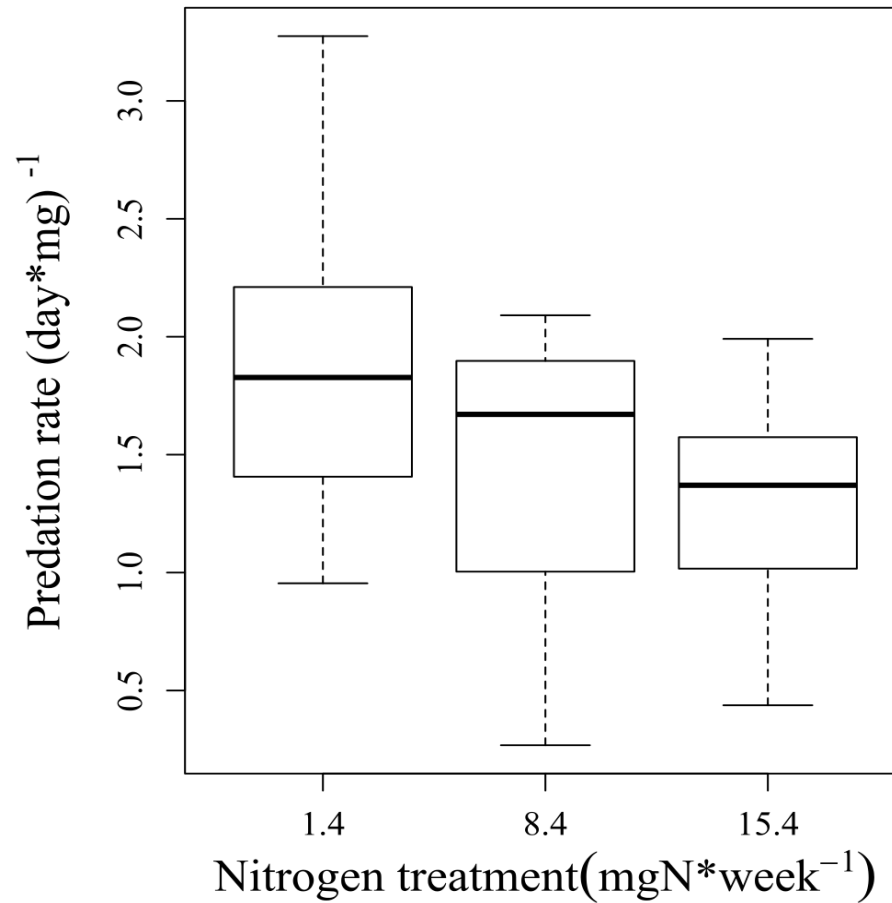


Willow leaf beetles

Increasing N

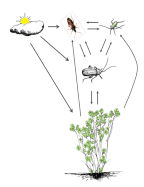
Nitrogen

Omnivorous predators become less predatory

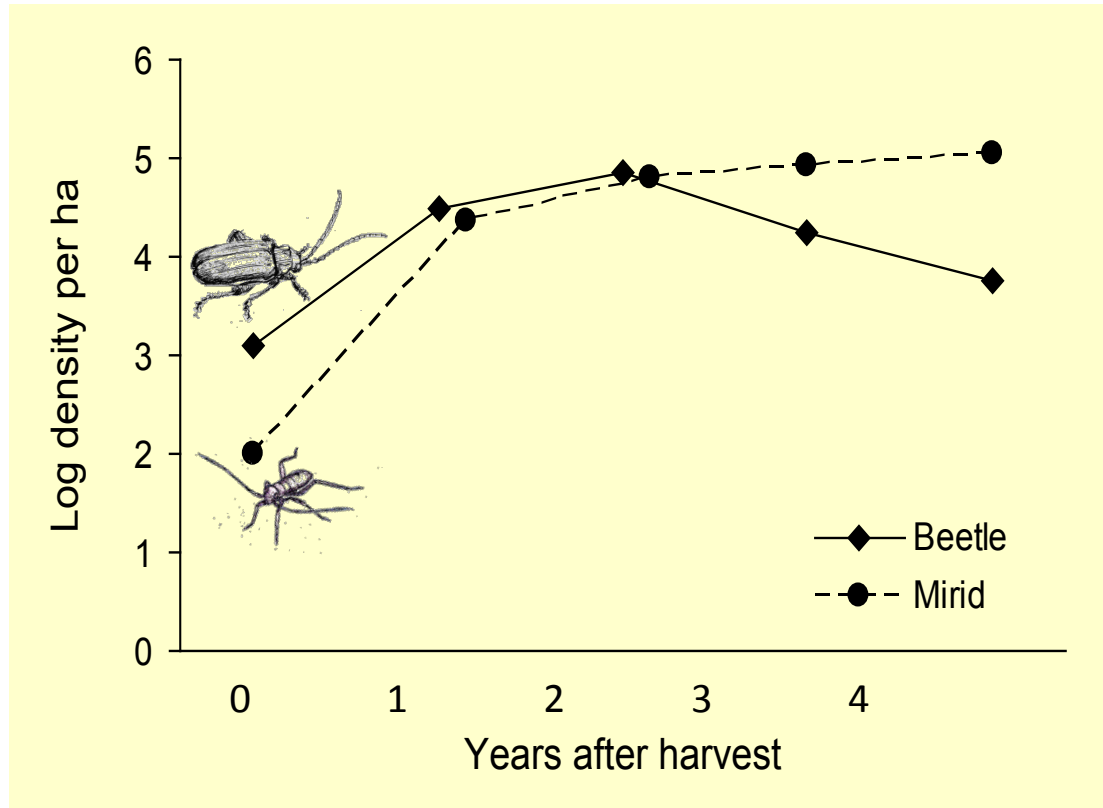


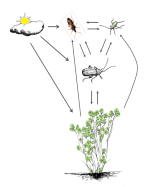
Liman et al. (2016) *Oecologia* (in press)





Harvesting disrupts natural biological control



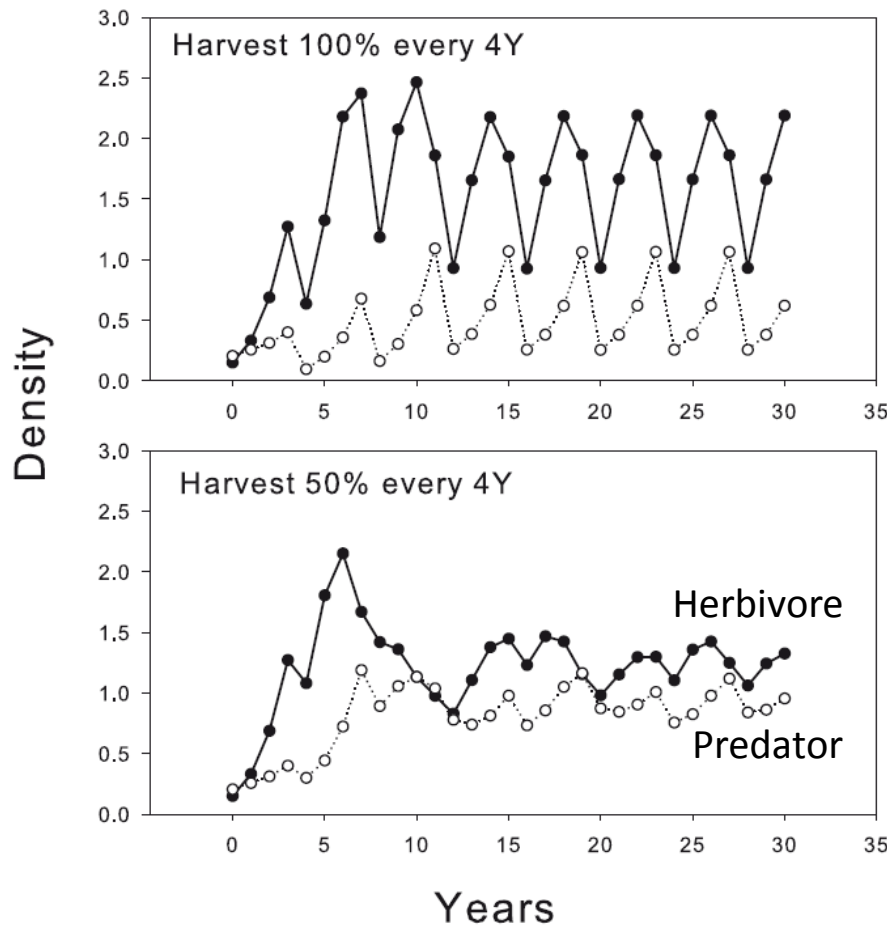


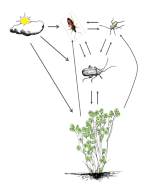
Willow leaf beetles

Effects of harvesting

In theory, leaving unharvested refugia, containing enemy eggs, should promote biological control

Land use



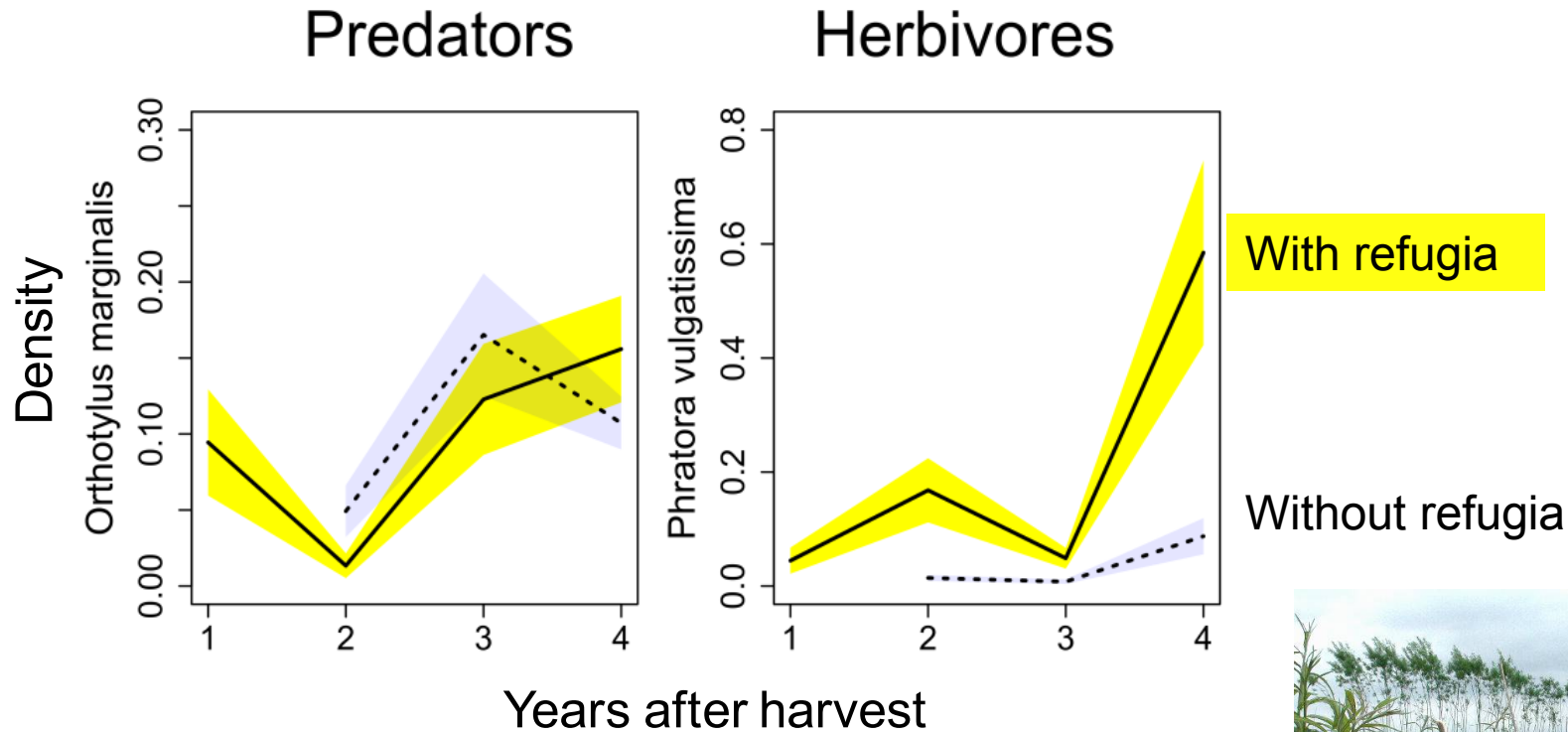


Willow leaf beetles

Effects of harvesting

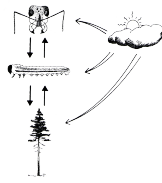
Land use

In practice, leaving refugia promotes herbivores more than their predatory natural enemies



Increasing temperature

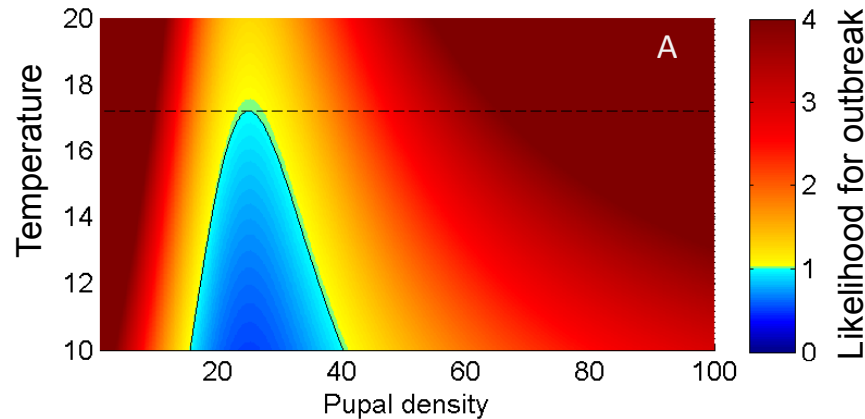
Pine sawflies



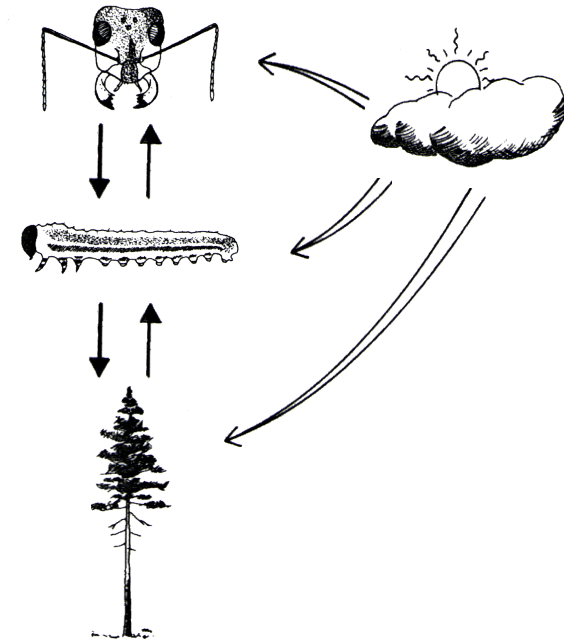
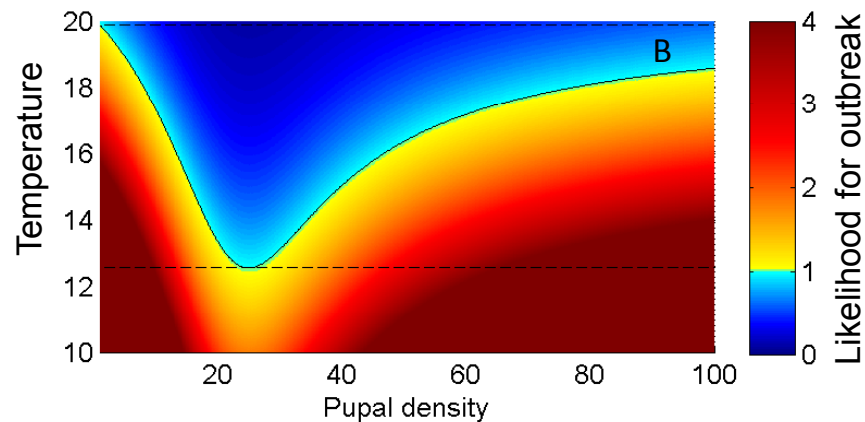
Likelihood for outbreaks

- increases with temperature on low resin pines
- decreases with temperature on high resin pines

Low resin

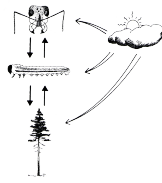


High resin



Increasing temperature

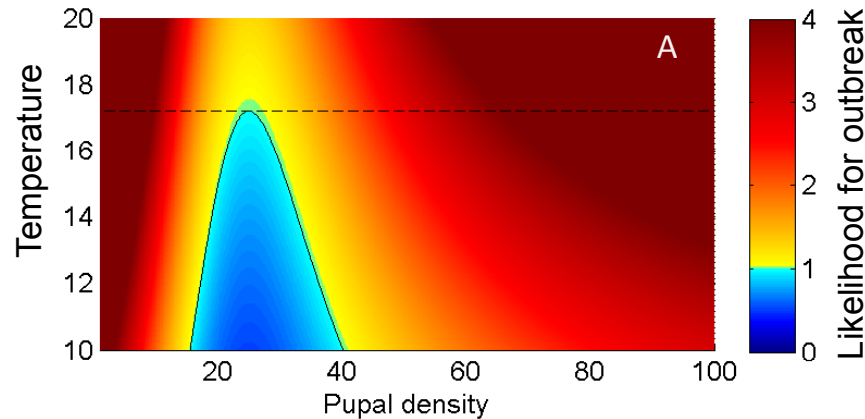
Pine sawflies



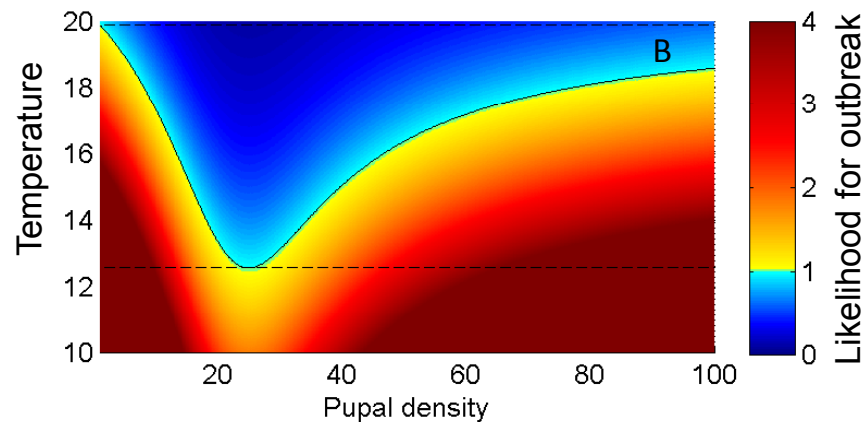
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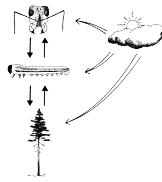


High resin

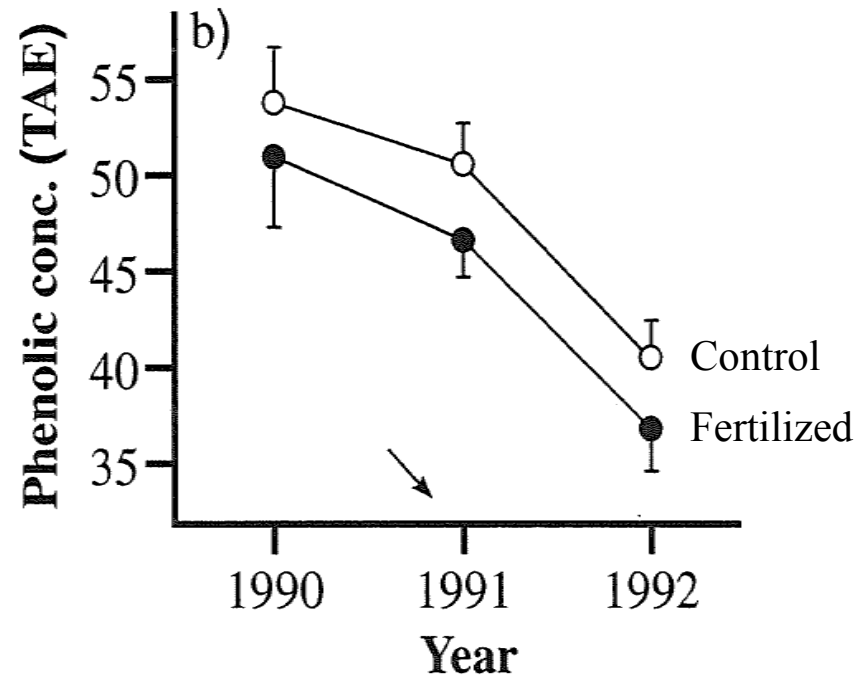
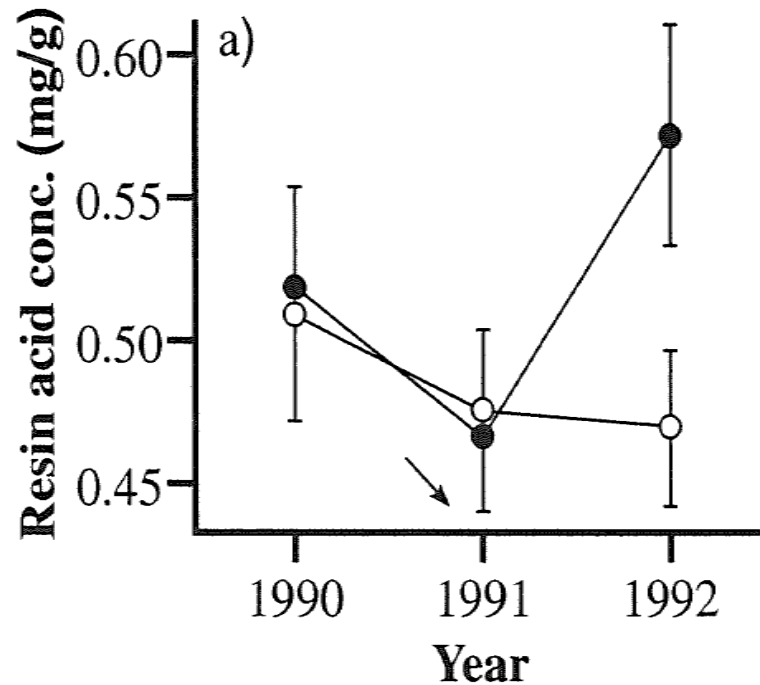


Increasing N

Pine sawflies

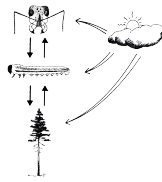


Diterpenoid resin acids increase after fertilization

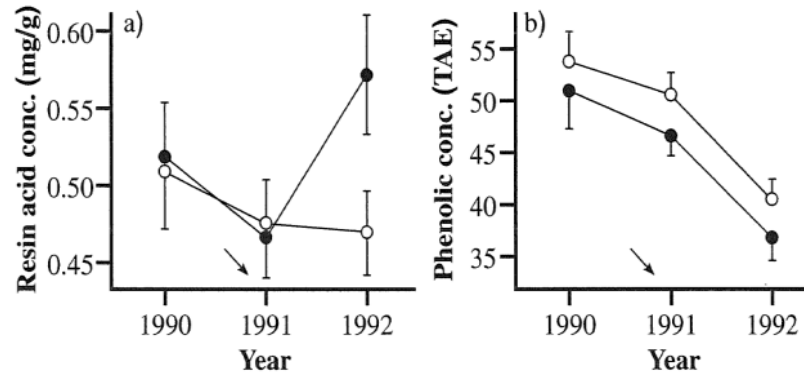
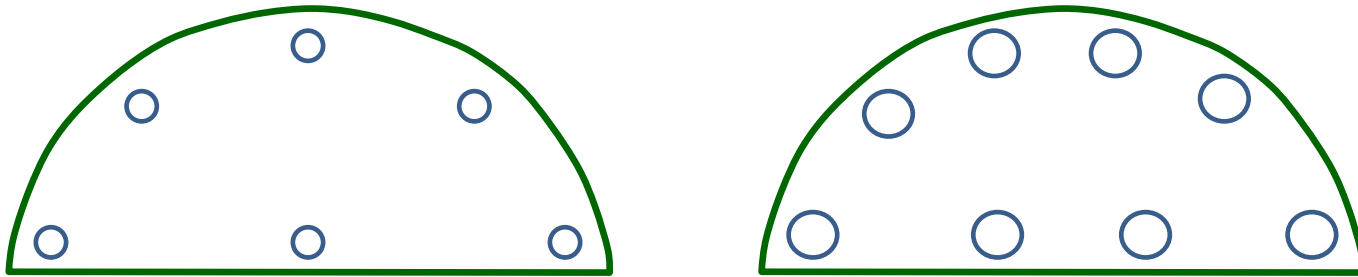


Increasing N

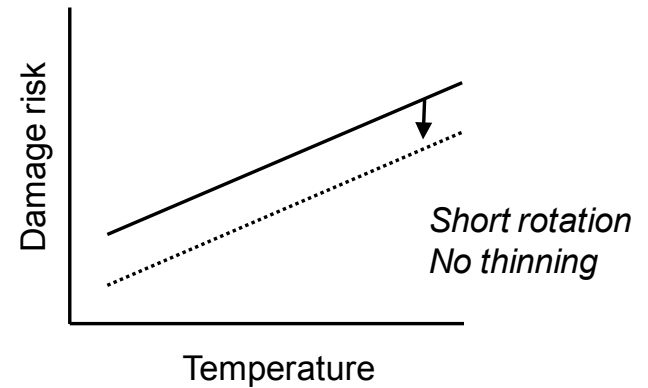
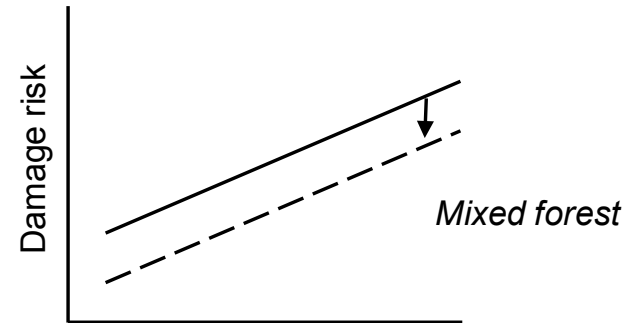
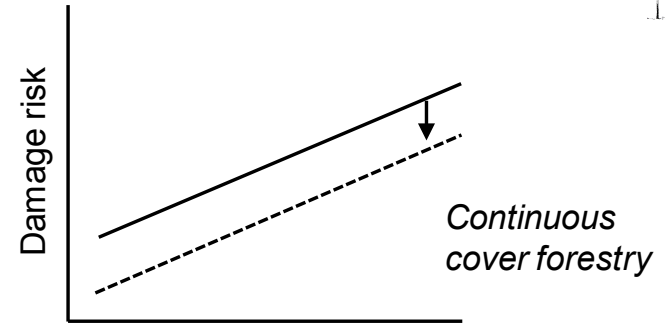
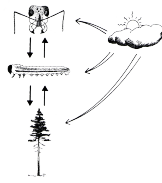
Pine sawflies

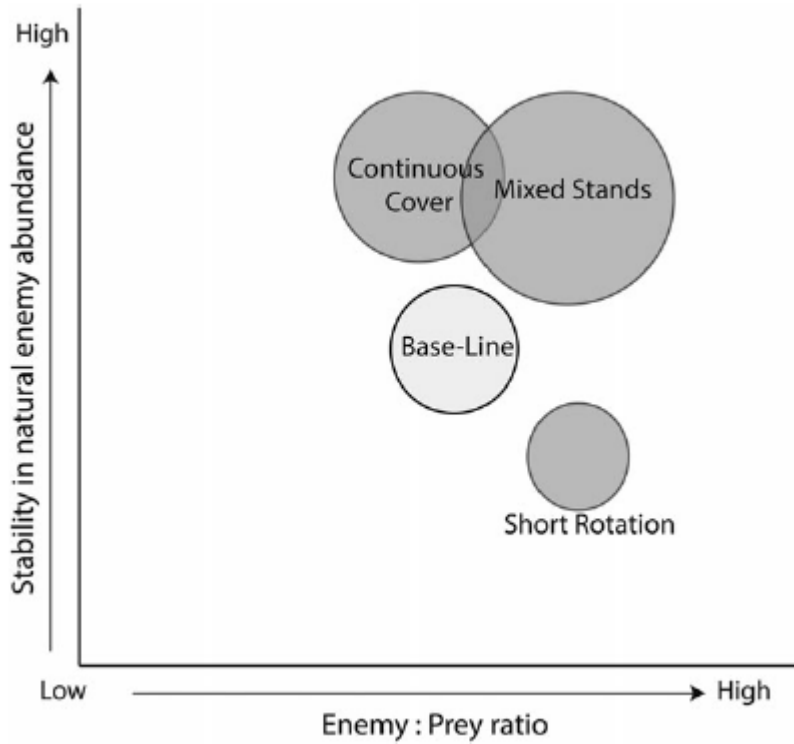


Diterpenoid resin acids increase after fertilization as a consequence of more and larger resin canals



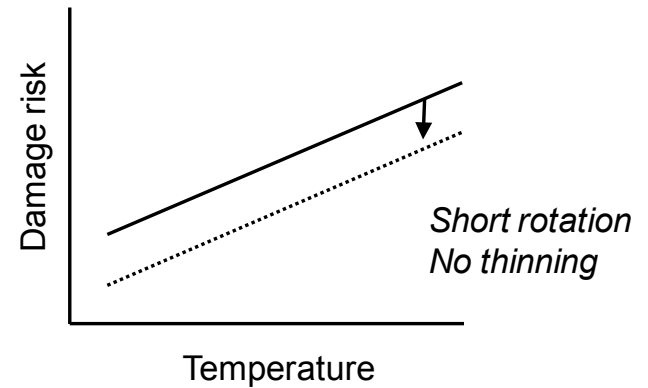
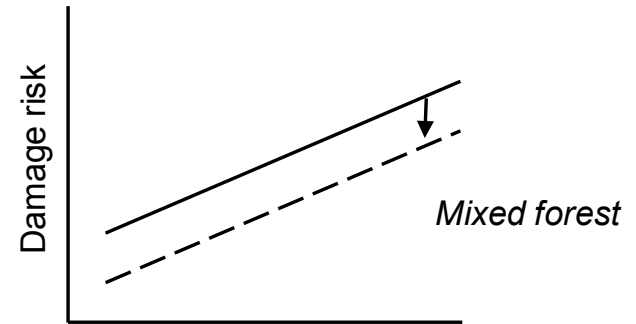
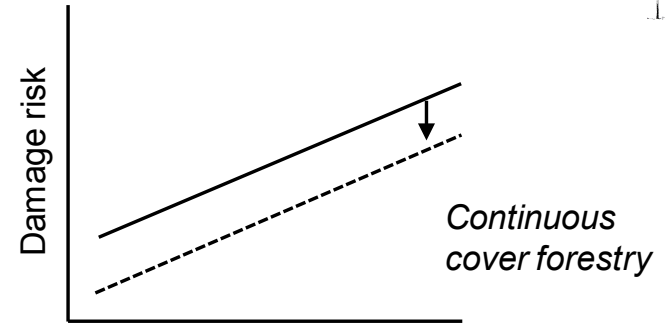
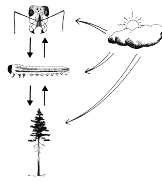
Pine sawflies





Klapwijk et al. (2016) Forestry

Pine sawflies



Björkman et al. (2015) In *Climate Change and Insect Pests*

Emerging patterns

- Increase in temperature alters outbreak risk but depend on plant resistance level
- Increase in nitrogen result in altered tri-trophic interactions
- More intense land use result in both increased and decreased outbreak risks, depending on system

Climate

Nitrogen

Land use

Remaining key question

- What happens when two or more drivers change simultaneously?
- More or less stability?
- Modeling

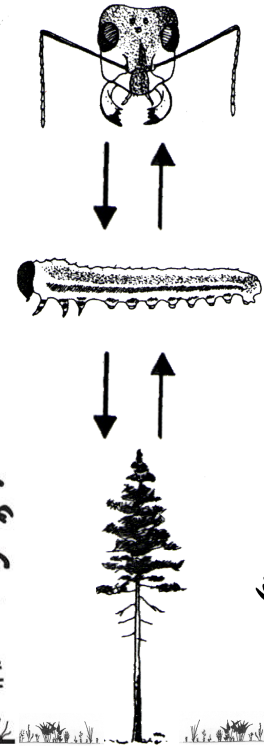
Climate

Nitrogen

Land use

Steps forward

- Professional phenotyping
- Multiple stressors
+ sequence



- Collaborations

Thank you for listening

Acknowledgements

Maartje J. Klapwijk	Helena Bylund
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Seppo Neuvonen	Tea Ammunet
Gregor Kalinkat	Madeleine Barton
Pekka Niemelä	et al.



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Future Forests



The Lamm foundation
Stiftelsen Oscar och Lili Lamms Minne



Chironomids on a moss sporangium
© John Hallmén