Responses of forest pests to climate change: Tree resistance and herbivore damage along European elevational gradients

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Tackling climate change: the contribution of forest scientific knowledge
21 - 24 May, 2012, Tours (France)

Climate change and insect damage

- Current spatio–temporal environmental changes are expected to alter interactions between plants and insect herbivores in forests

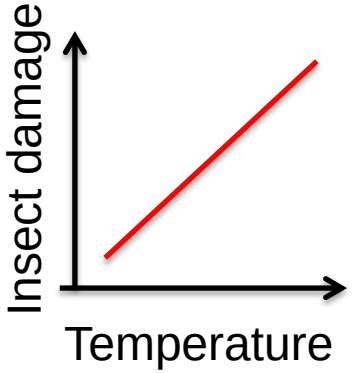
- Among several contributory factors, temperature has been singled out as a major driver of plant–insect interactions and finally forest damages by herbivores

Elevation gradients can be used as a proxy for temperature warming

Plants and herbivores along elevation gradients

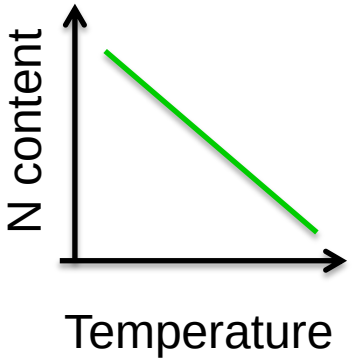
- **Insect damage**:

1. Slow growth rates in cold environments may extend developmental time and reduce survival and consumption rates

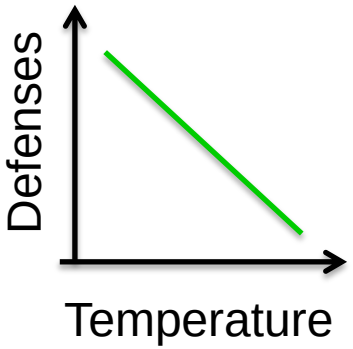


- **Plant traits affecting herbivory:**

2. Low temperatures and a shorter growing season would result in increased leaf nutrient concentrations (both N and P)

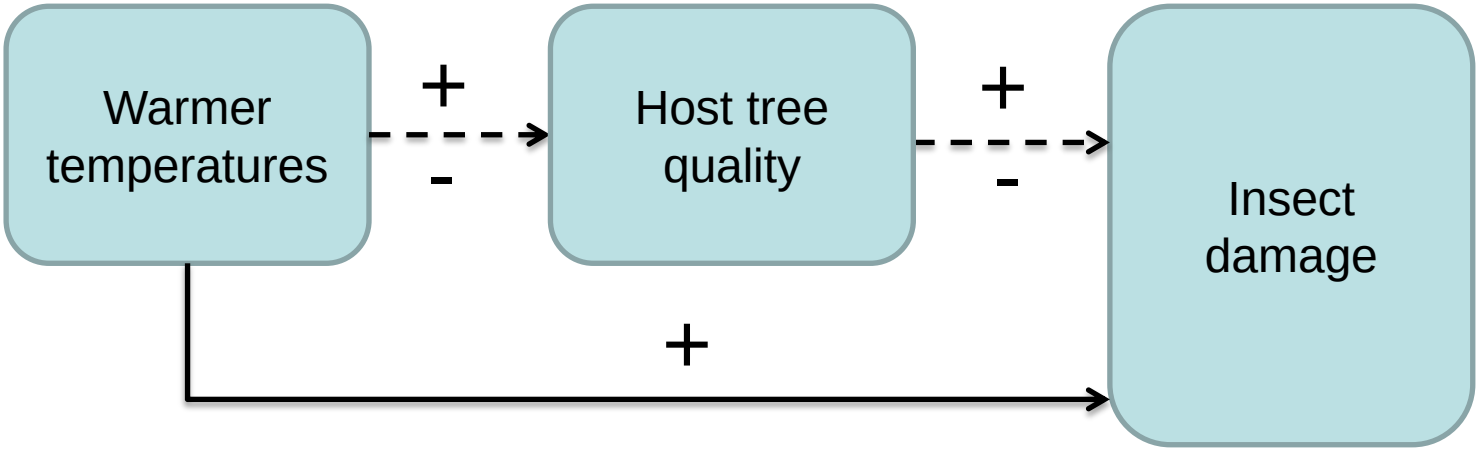


3. Slow-growing plants in cold environment should have better defenses against herbivore (e.g. higher toughness)



Plants and herbivores along elevation gradients

Complex direct and indirect temperature effects on herbivory

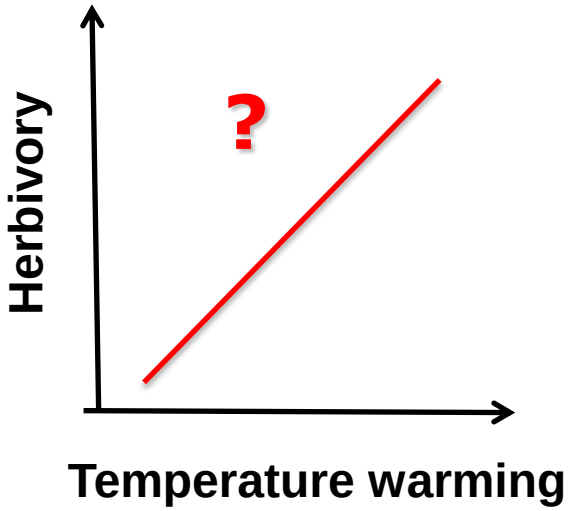


Aims

1. To test the effect of temperature on forest damage by different guilds of insect herbivores

2. To evaluate the relative importance of direct vs. indirect effect of temperature on herbivory via modified host tree quality

Predictions of temperature warming effect on the most important tree species of European forests



Methods: Sampling design

Main tree European species:

Pinus sylvestris

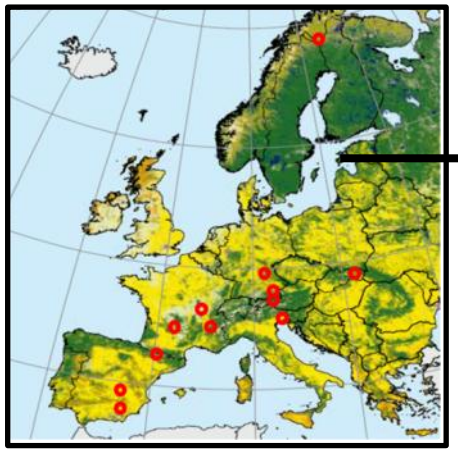
Picea abies

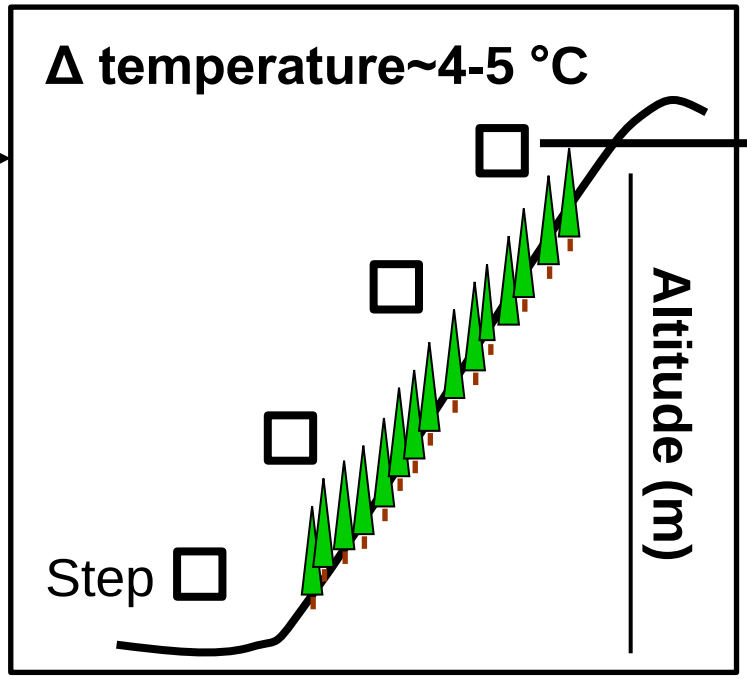
Fagus sylvatica

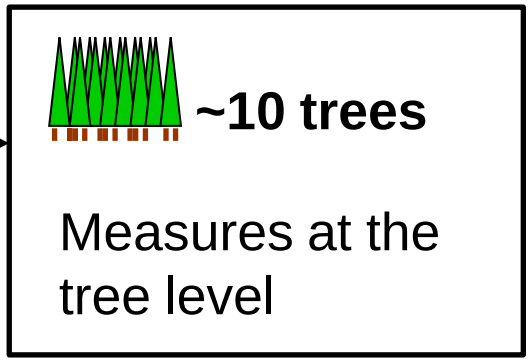
Gradients across Europe

4-5 steps per gradient

10 trees per step







Methods: Measures at tree level

TREE QUALITY

1. Leaf toughness
2. C/N ratio

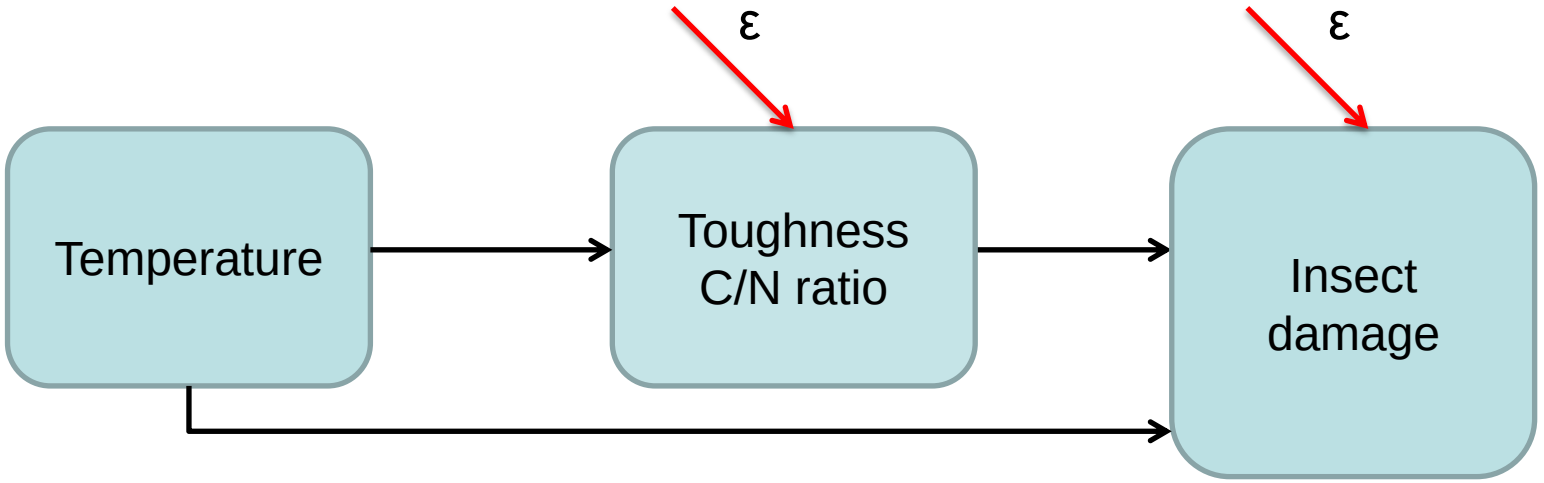
INSECT DAMAGE

Score (0-6) to estimate % of damaged plant tissues

Different guilds:

-Total herbivory
-Chewers
-Sap-feeders
-Gall makers
-Miners
-Cone insects

Data analysis: General linear mixed models



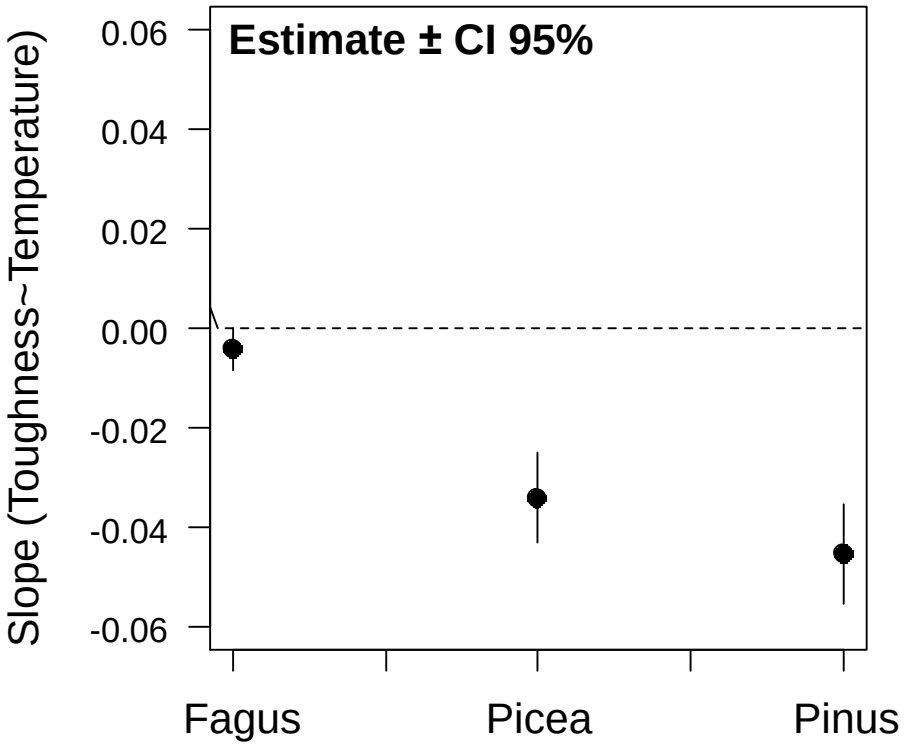
Unobserved causes (e.g. soil fertility, biotic interactions etc.)

We assume that all the relationships are linear in the chosen range

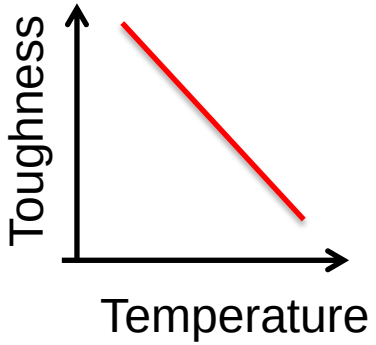
Random intercept models:

Toughness or C/N ~Temperature, random=~1|gradient/tree
Damage~Temperature+Toughness, random=~1|gradient/tree
Damage~Temperature, random=~1|gradient/tree

Temperature and leaf toughness

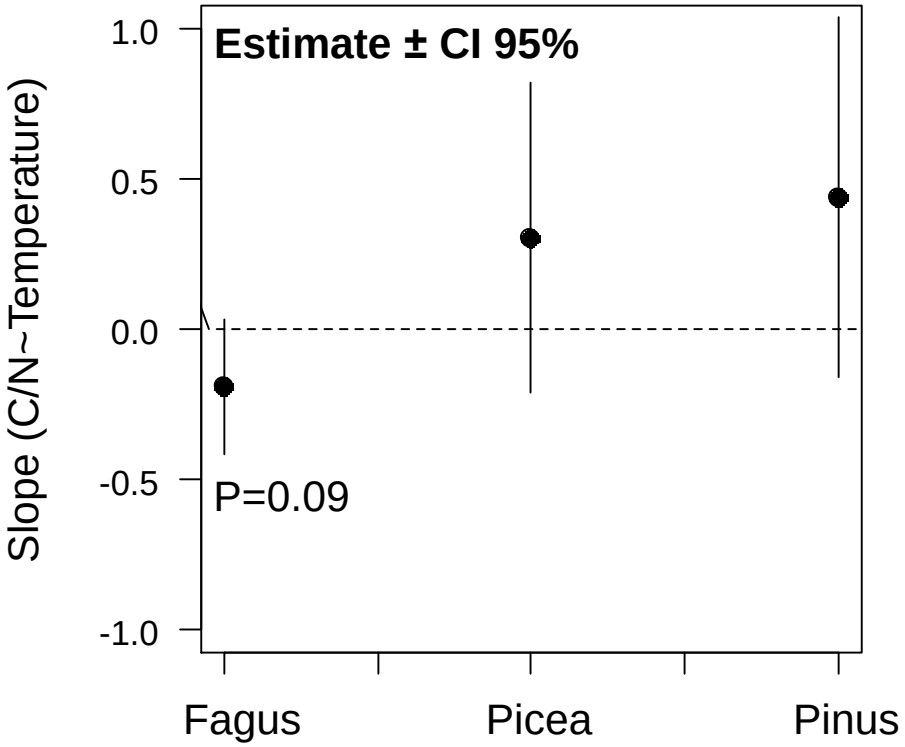


Toughness is lower at low, warmer sites for the three species



- Slow growing trees have more defences
- Higher radiation at high altitudes may increase leaf toughness

Temperature and leaf C/N ratio

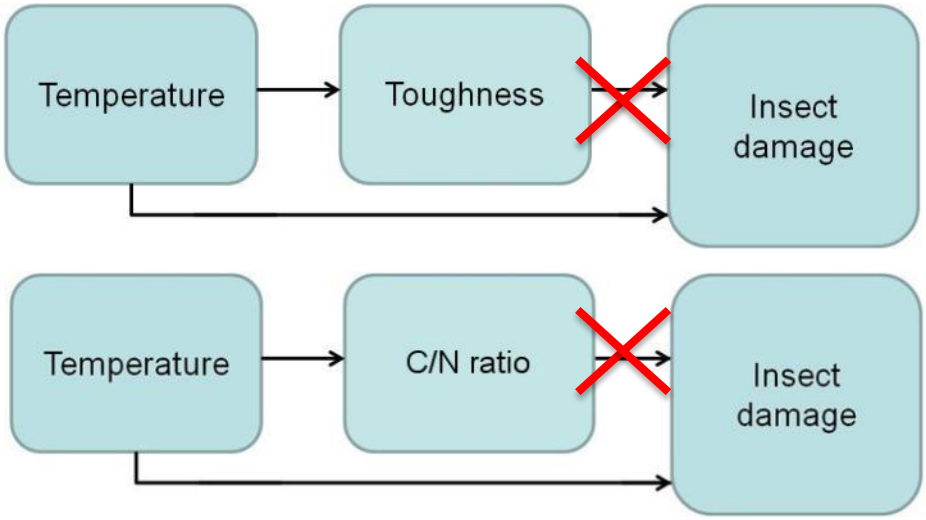


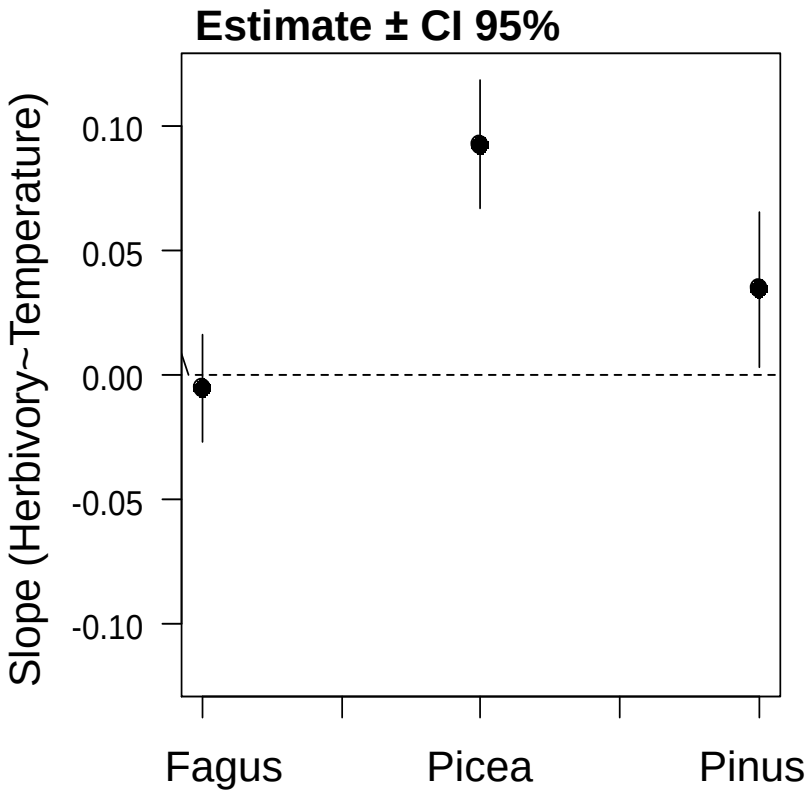
C/N ratio varies in a unpredictable way with temperature for *Picea* and *Pinus*

C/N ratio tends to decline in Fagus

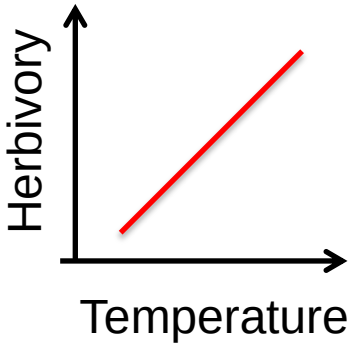
- Soil fertility was not controlled for: potential confounding effect of nutrient availability

Temperature and general herbivory

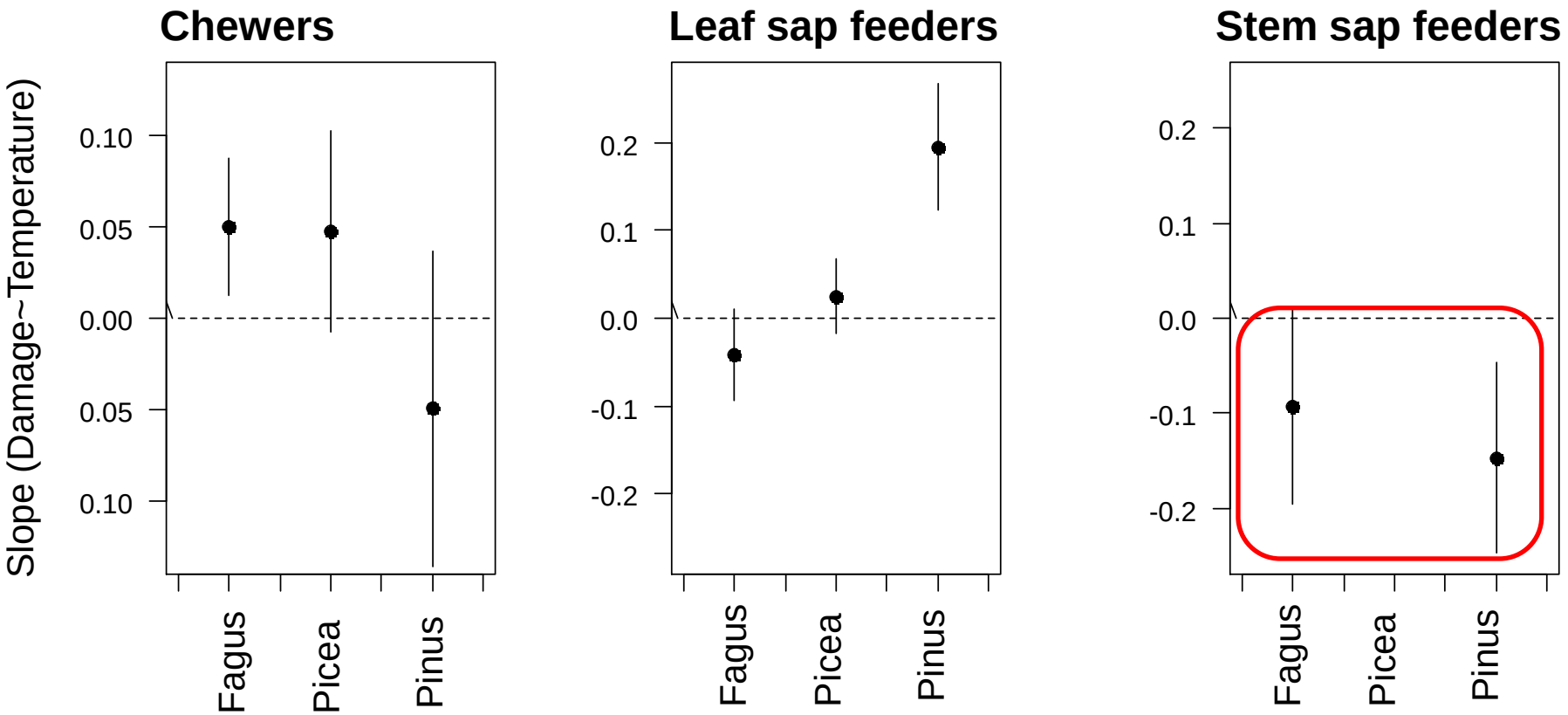




- General herbivory increases with temperature for *Picea* and *Pinus:* lowland forests are more damaged than high altitude forests but not for *Fagus*

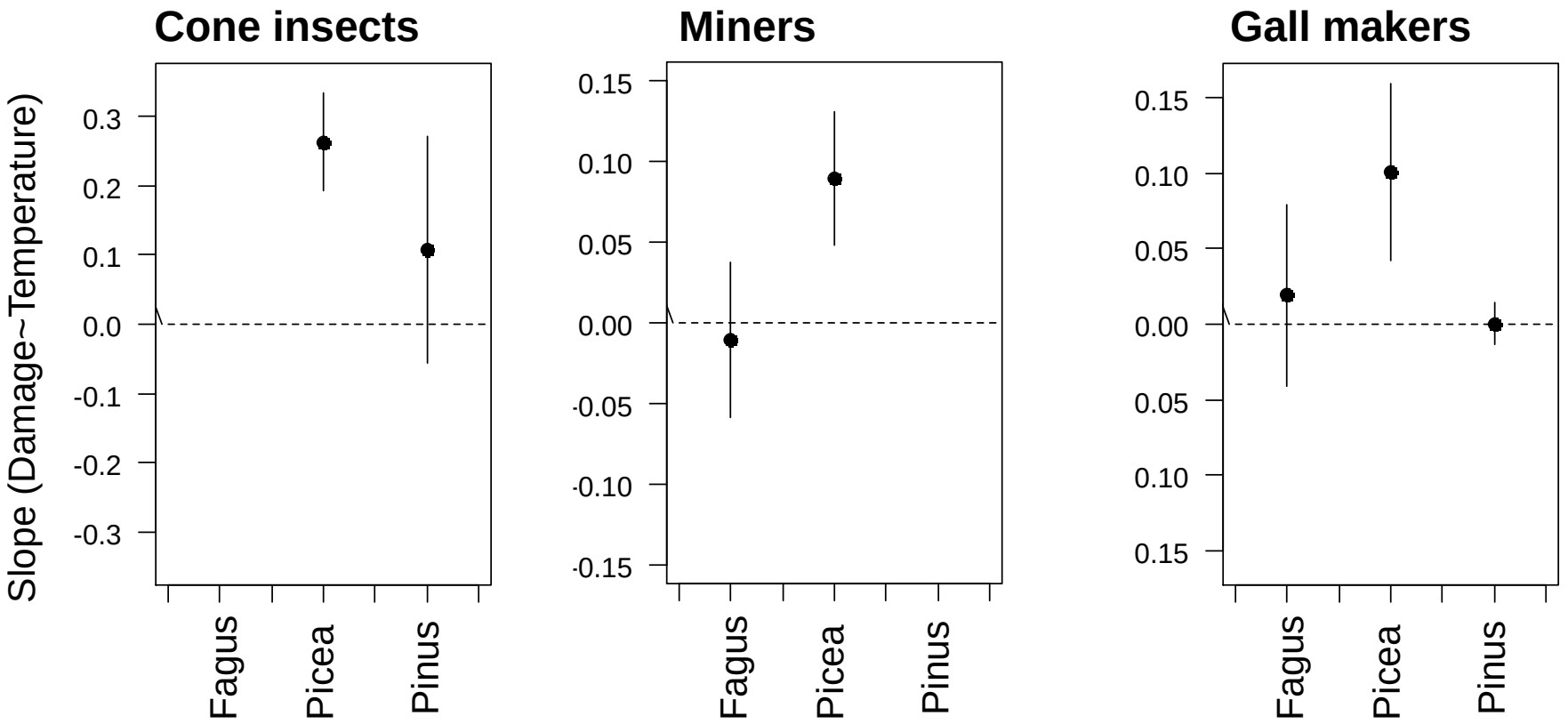


Guild specific response to temperature



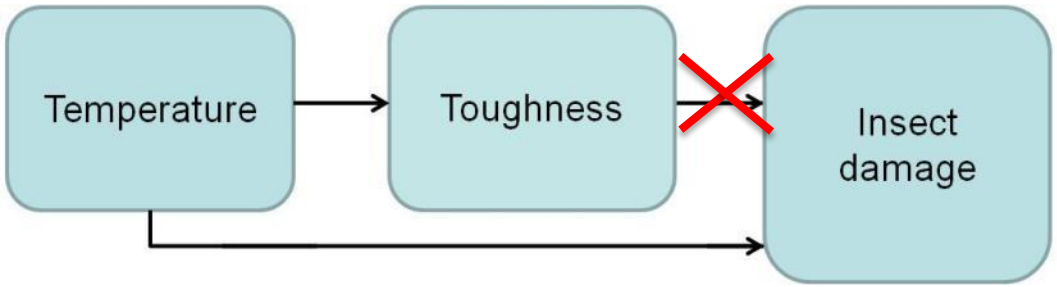
Except for stem sap feeders, neutral or positive response to warmer temperatures

Guild specific response to temperature

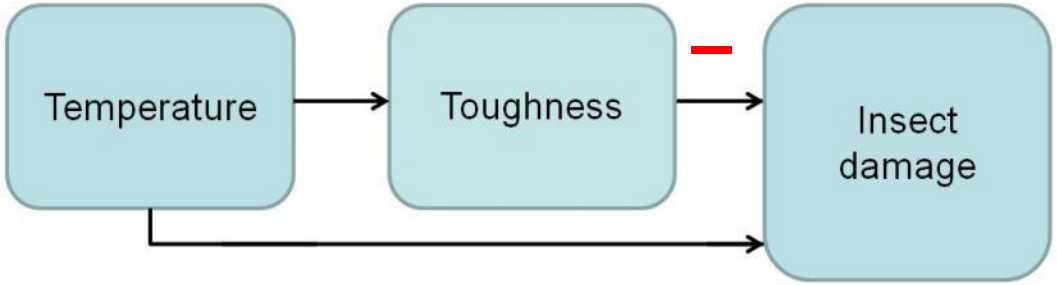


Neutral or positive response to warmer temperatures

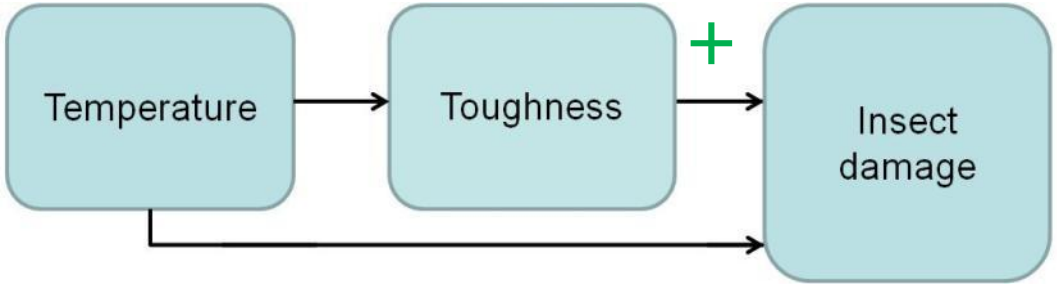
Indirect effects on folivory (toughness)



73% of the cases
(all other cases)



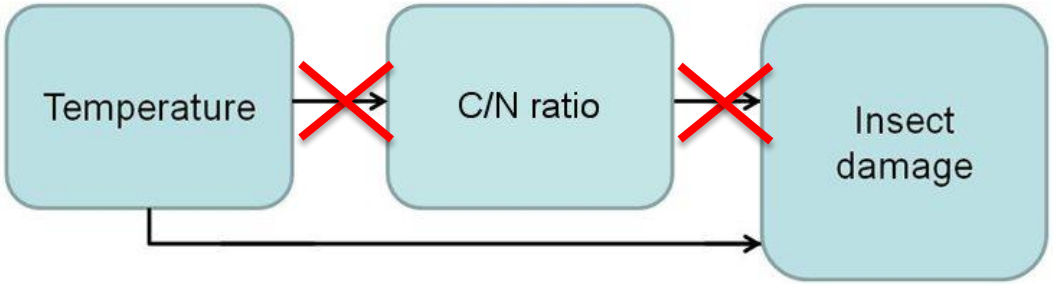
18% of the cases
(*Picea* miners,
Fagus leaf sap-feeders)



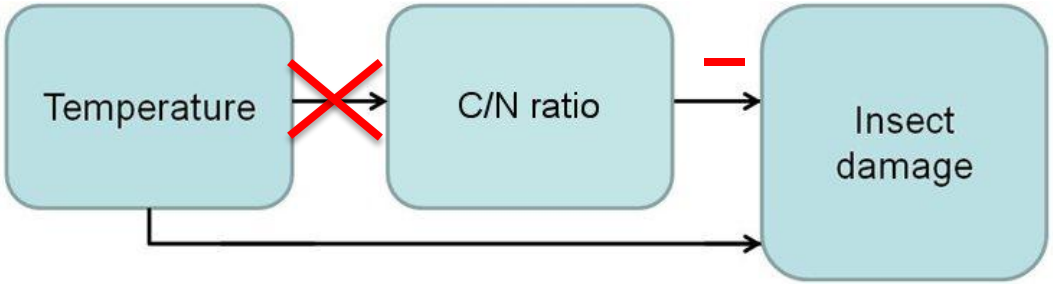
9% of the cases
(*Fagus* chewers)

Dominant direct positive effect of temperature on damage

Indirect effects on folivory (C/N ratio)



All other cases



Pinus chewers

Dominant direct positive effect of temperature on damage

Conclusions

• Our findings anticipate dramatic changes in insect herbivory with temperature warming

• Little apparent effects of leaf toughness and C/N ratio on herbivory

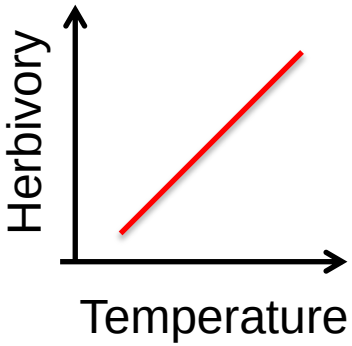
• Dominant role of direct effect of temperature on insect damage: lowland forests are more damaged than high forests

BUT

Herbivore- and tree-specific response to temperature

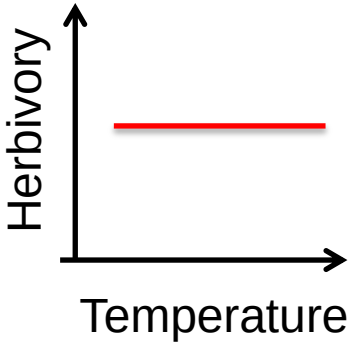
Conclusions

- **Spruce and pine forests seem to be more susceptible than beech to temperature warming**



Picea abies

Pinus sylvestris



Fagus sylvatica

- Herbivory will probably increase with temperature warming in European conifer forests

Thank you for your attention

BACCARA project information
*www.**baccara-project**.eu/*

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