Sustainability Week
Hokkaido-Finland
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Simulated warming effects on plant-insect interactions in a cold temperate region

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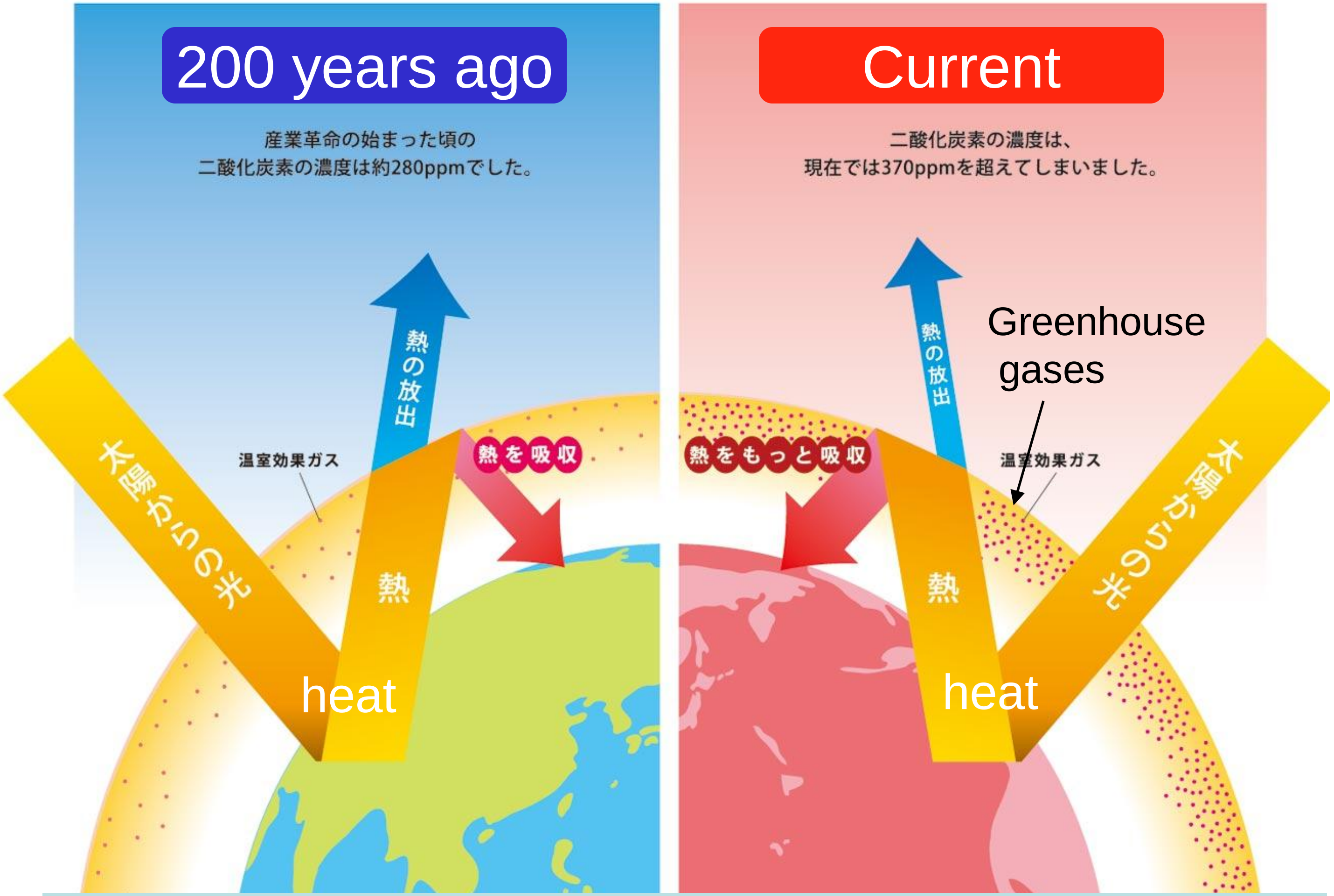
Photo by Onno Muller

Mechanism of global warming



Greenhouse gases (atmospheric concentrations of CO_2, CH_4, and N_2O) have increased dramatically.

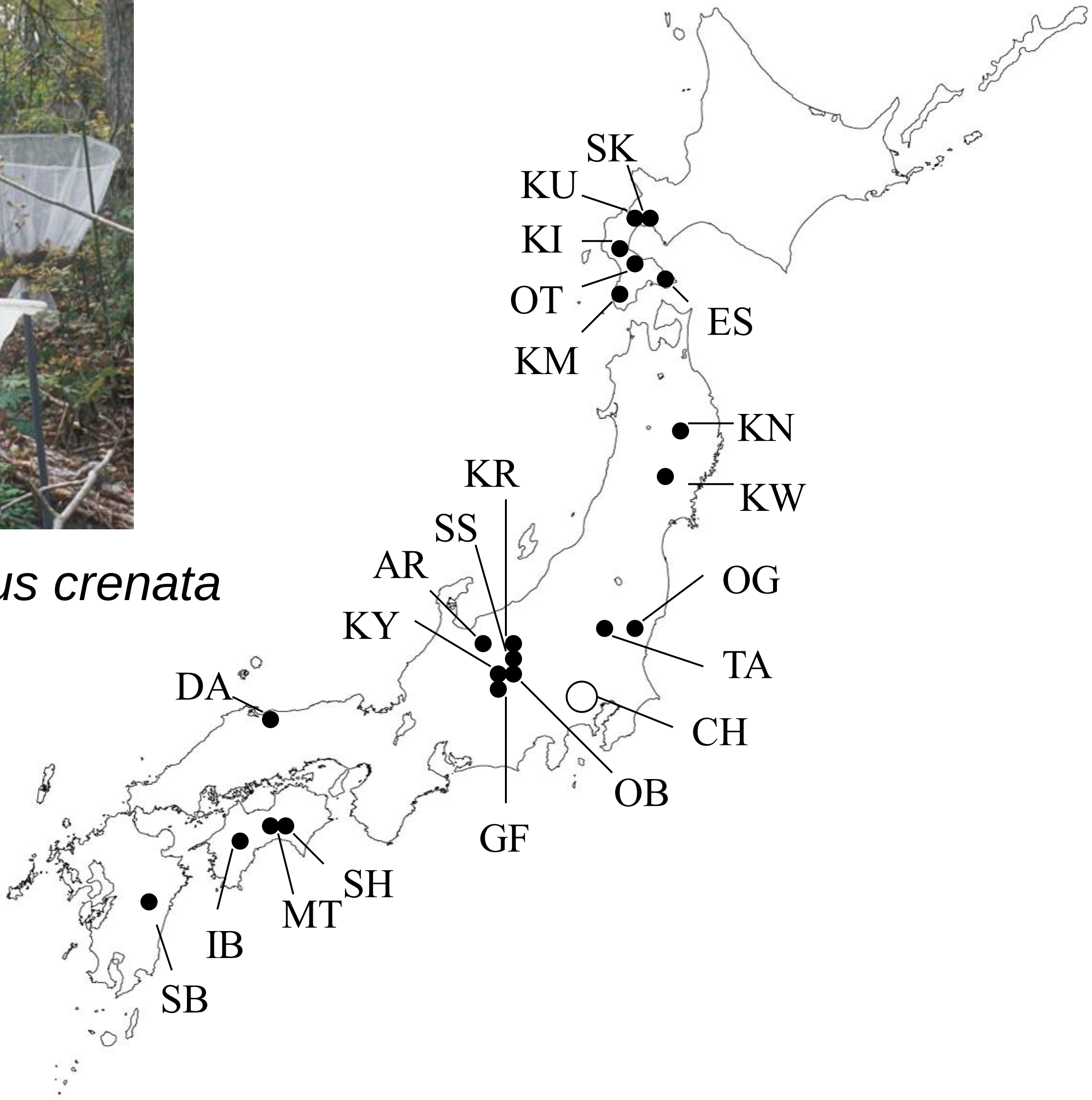
26th Sep. 1986

23rd Oct. 2006

The peak of autumn foliage is behind for one month in TOEF

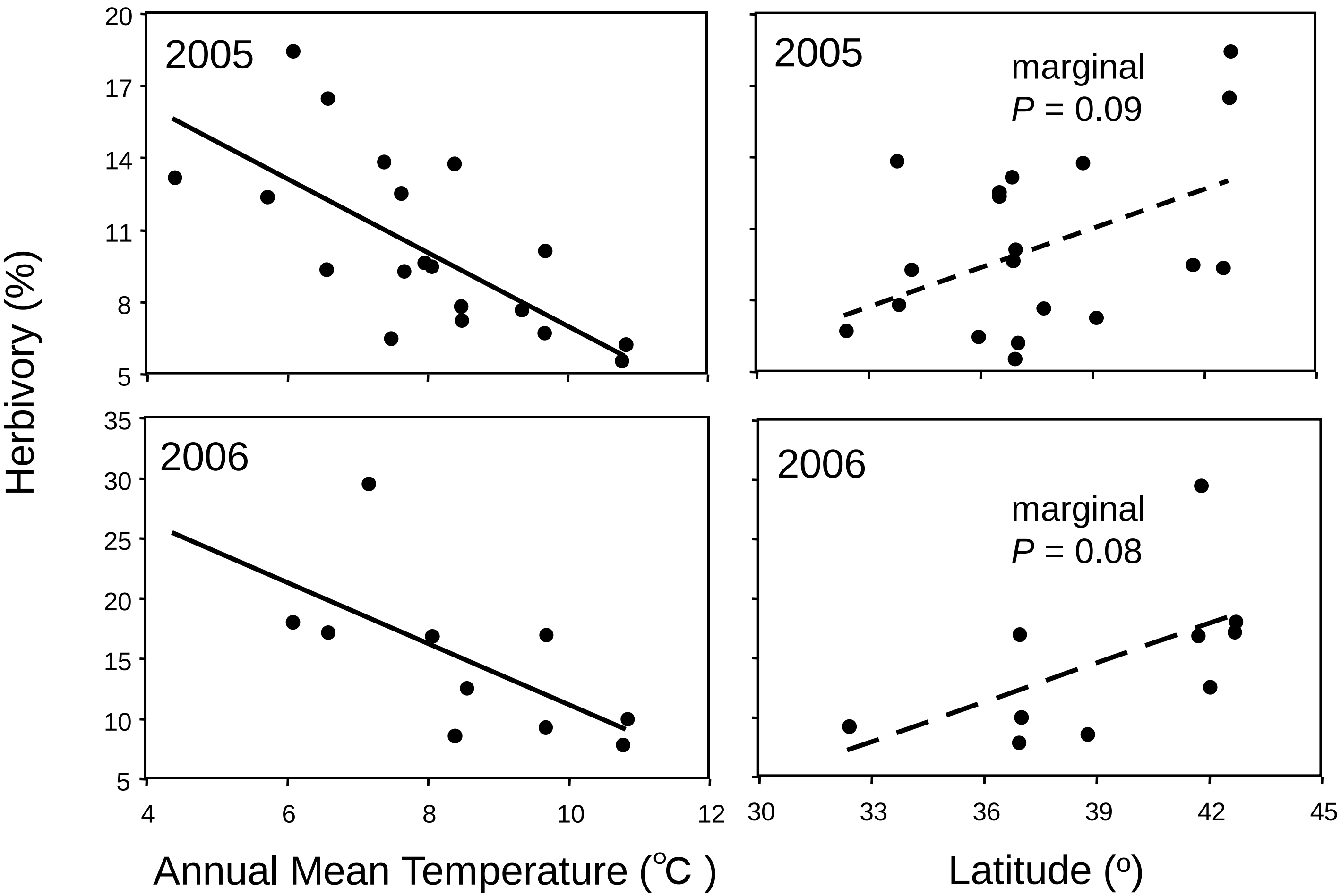
Latitudinal gradient study

Litter traps of *Fagus crenata*

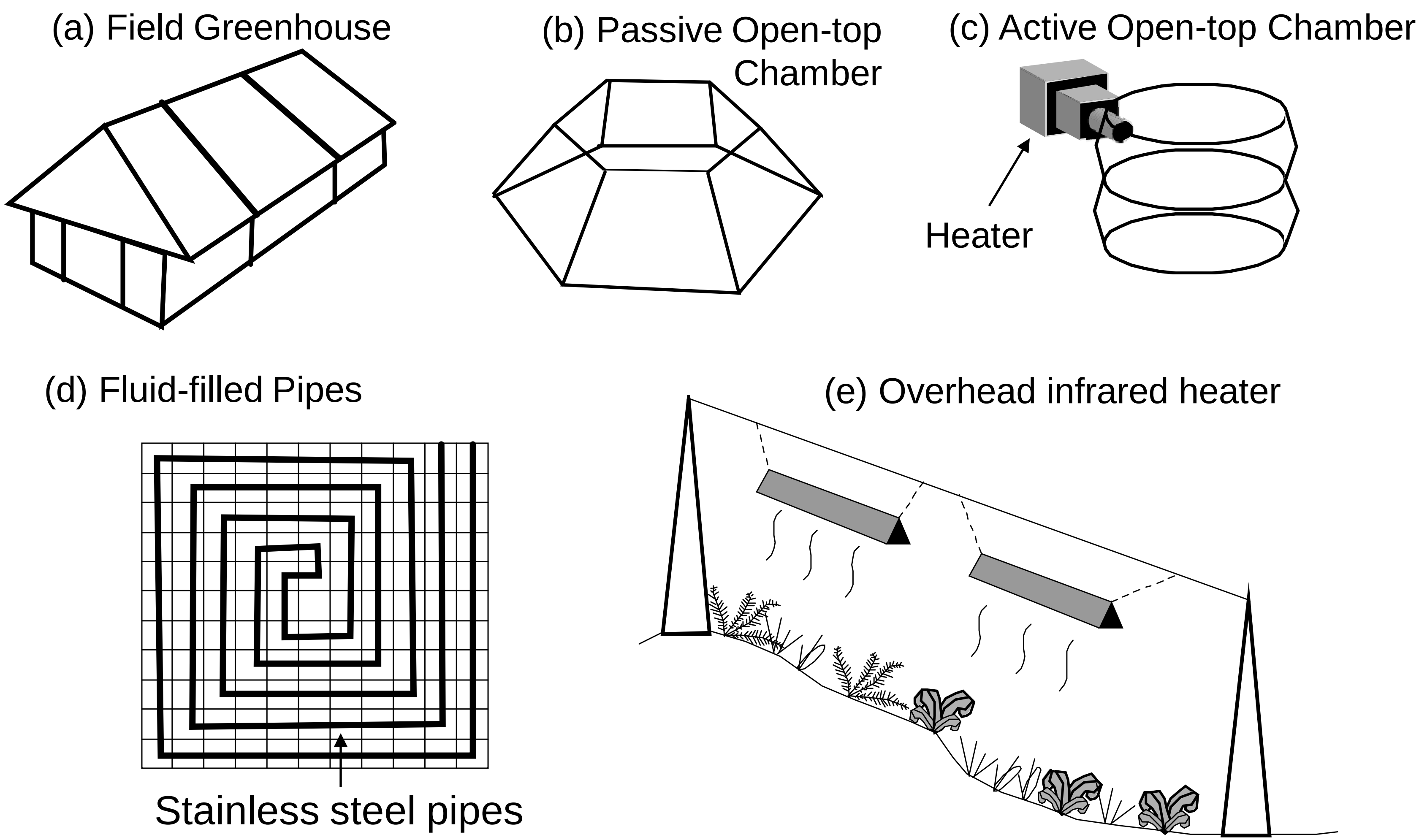


Latitudinal variation in herbivory

Chewing herbivory decreased for southern beech forests

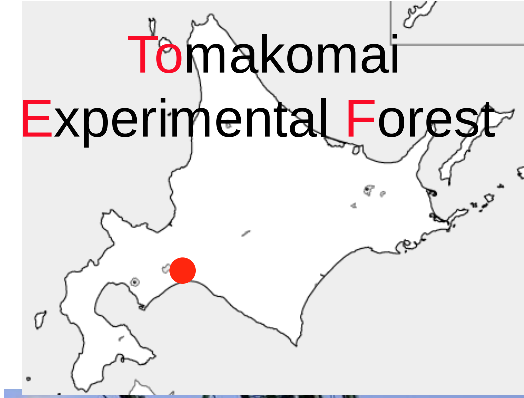


Warming experiments



There are no warming experiments using canopy trees.

Canopy facilities in TOEF



More than 10 scaffolding systems
(height = 12-18m)

One canopy crane
(height = 25m,
length of jib = 41m)

Question

How do **soil and branch warming** affect forest ecosystem of canopy oak trees?

Measurements

- Leaf pheonology
- Acorn production
- Leaf traits (LMA, Nitrogen, CN ratio)
- Herbivory rate

Using canopy crane, we can directly observed canopy foliage.

Leaf traits

▸ **Nutrient:** Nitrogen (Schoonhoven et al. 1998)

▸ **Physical defense:** LMA (leaf toughness) (Coley 1983)

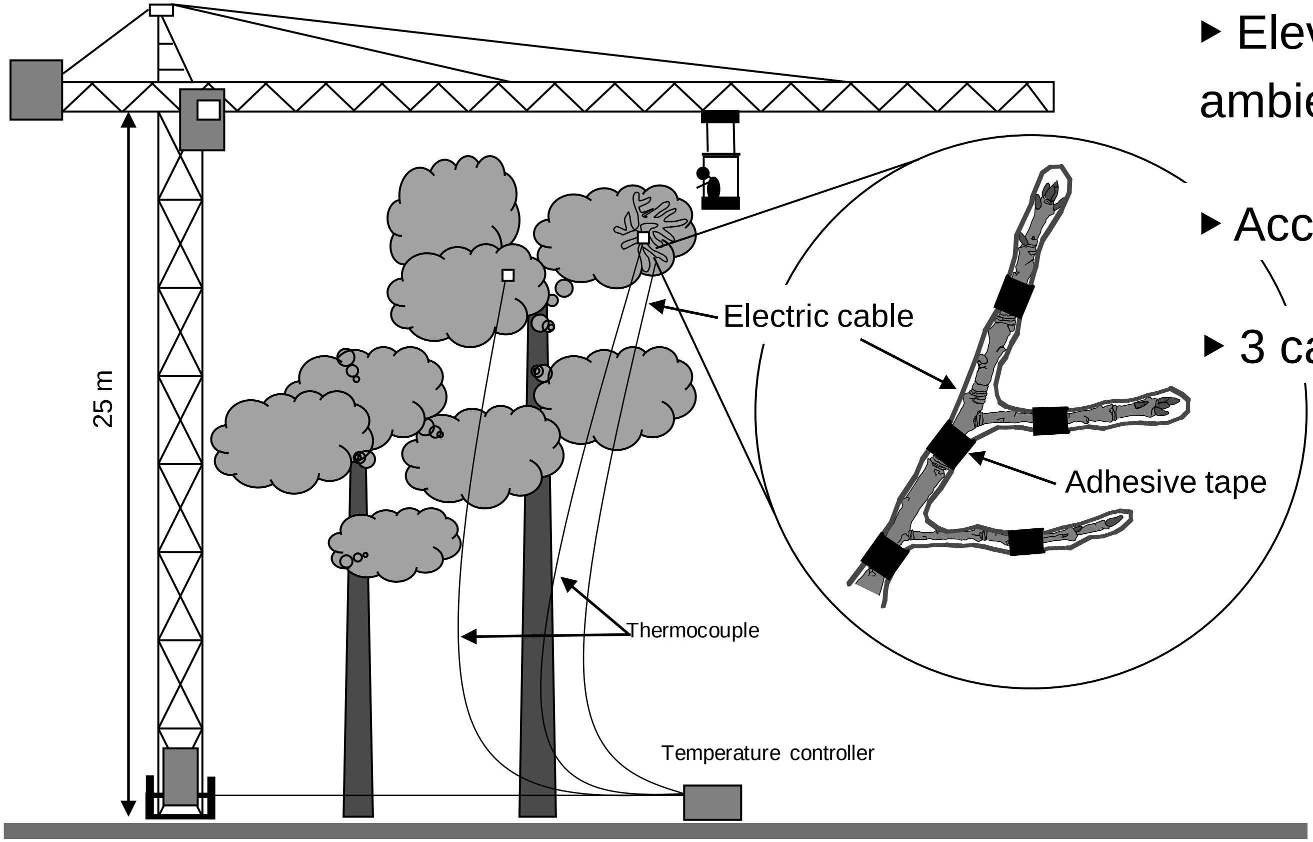
▸ **Chemical defense:** CN ratio (Bryant 1983)

The CNB hypothesis suggest that increase in the CN ratio implies that carbon becomes more available for **carbon-based chemical defense**.

Environments
(e.g. light, soil nutrient)

These leaf traits are often changed by environments
(e.g. Bryant 1983, Nakamura 2008).

Branch warming experiment

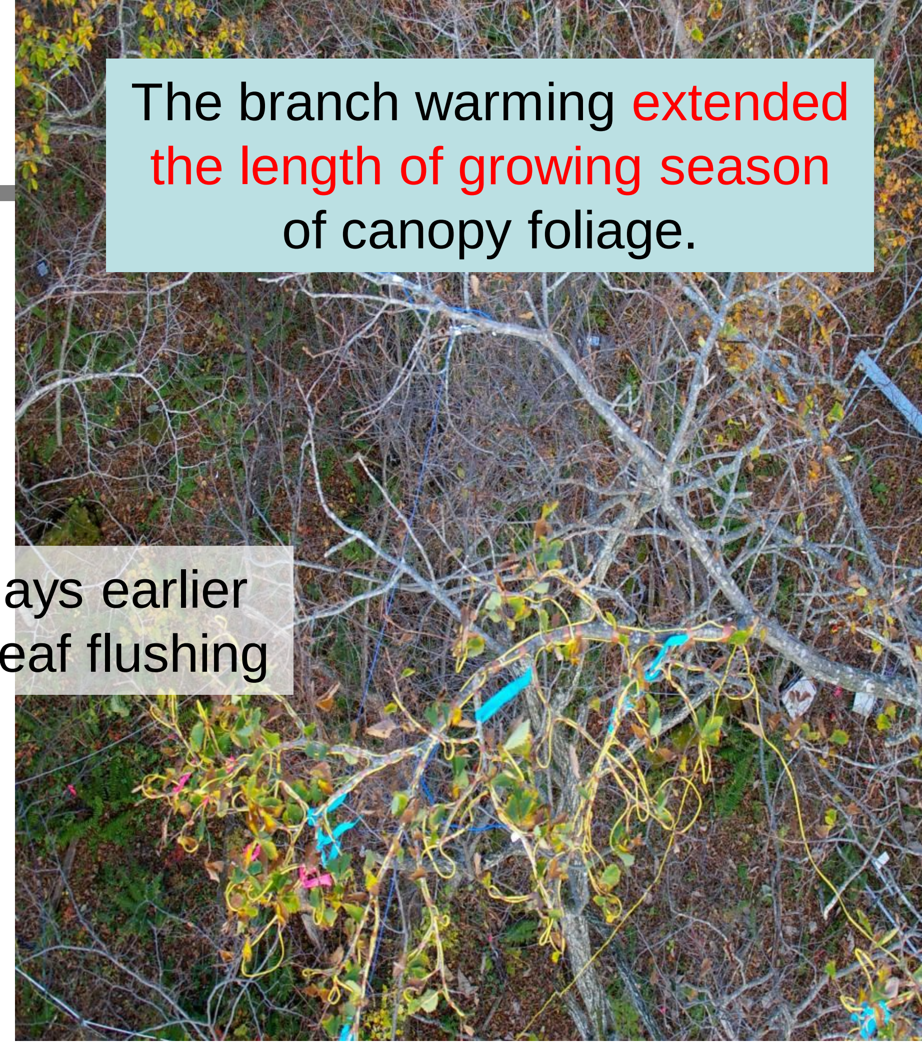


- Attached heating cables to top canopy branches
- Elevated 5°C above ambient using heating cables
- Access using canopy crane
- 3 canopy trees

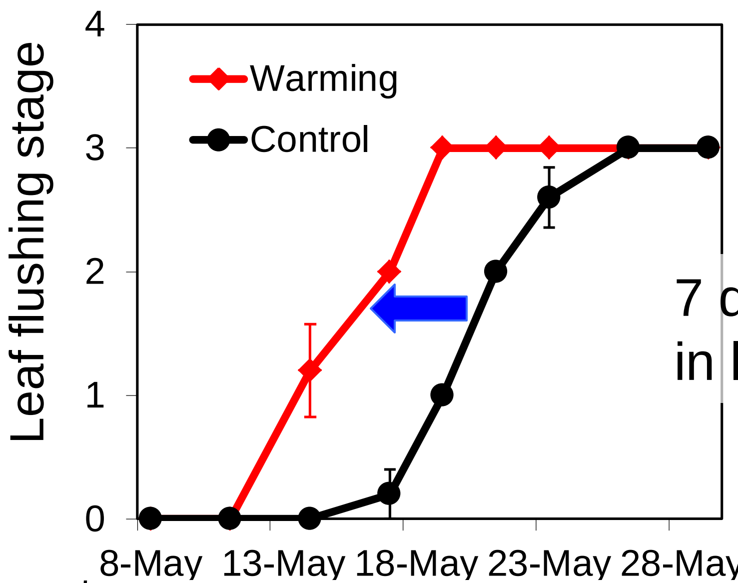
Branch warming experiment

Photo by Onno Muller

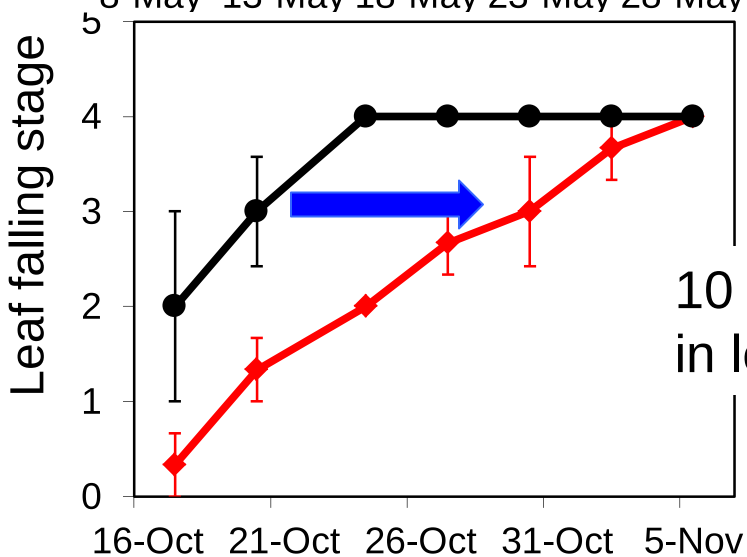
Leaf phenology



The branch warming extended the length of growing season of canopy foliage.



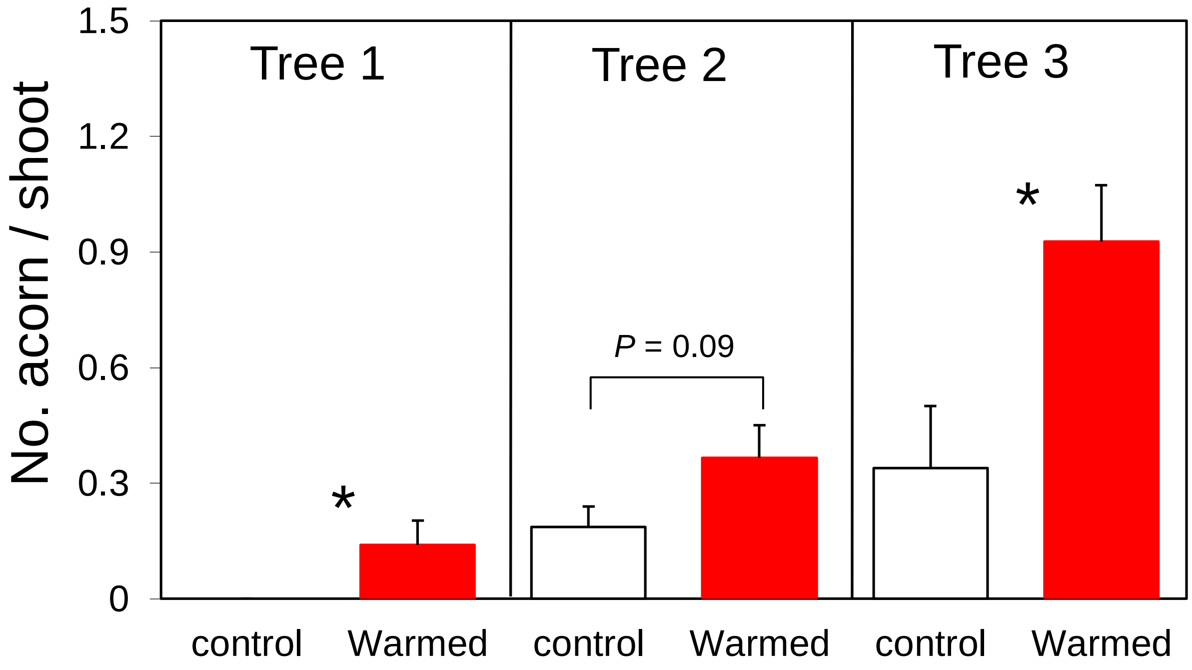
7 days earlier in leaf flushing



10 days later in leaf falling

Acorn production

The branch warming increased acorn production.



Student's t-test, Significance: * *P < 0.05*

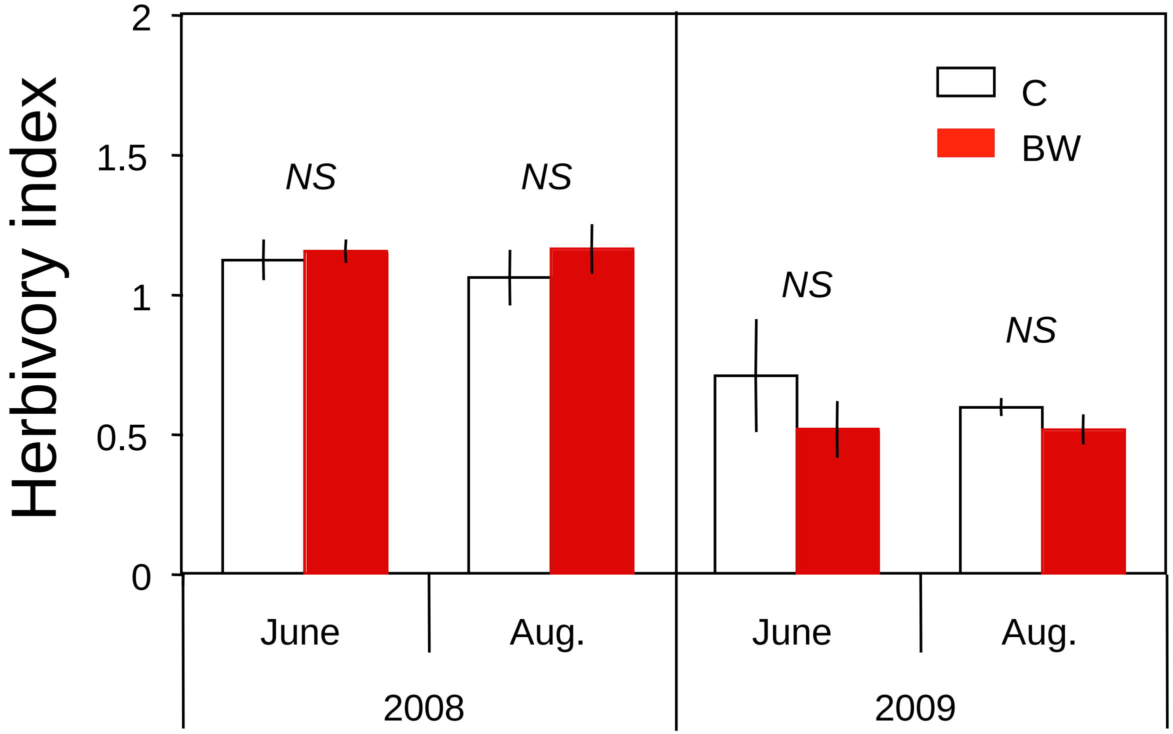
This result may lead to the mechanism elucidation of acorn masting

We visually scored herbivory

Six ranked indices	Percentage of herbivory
0:	0%
1:	1-10%
2:	11-25%
3:	25-50%
4:	51-75%
5:	76-100%

Herbivory (branch warming: BW)

The branch warming did not affect herbivory of canopy foliage.



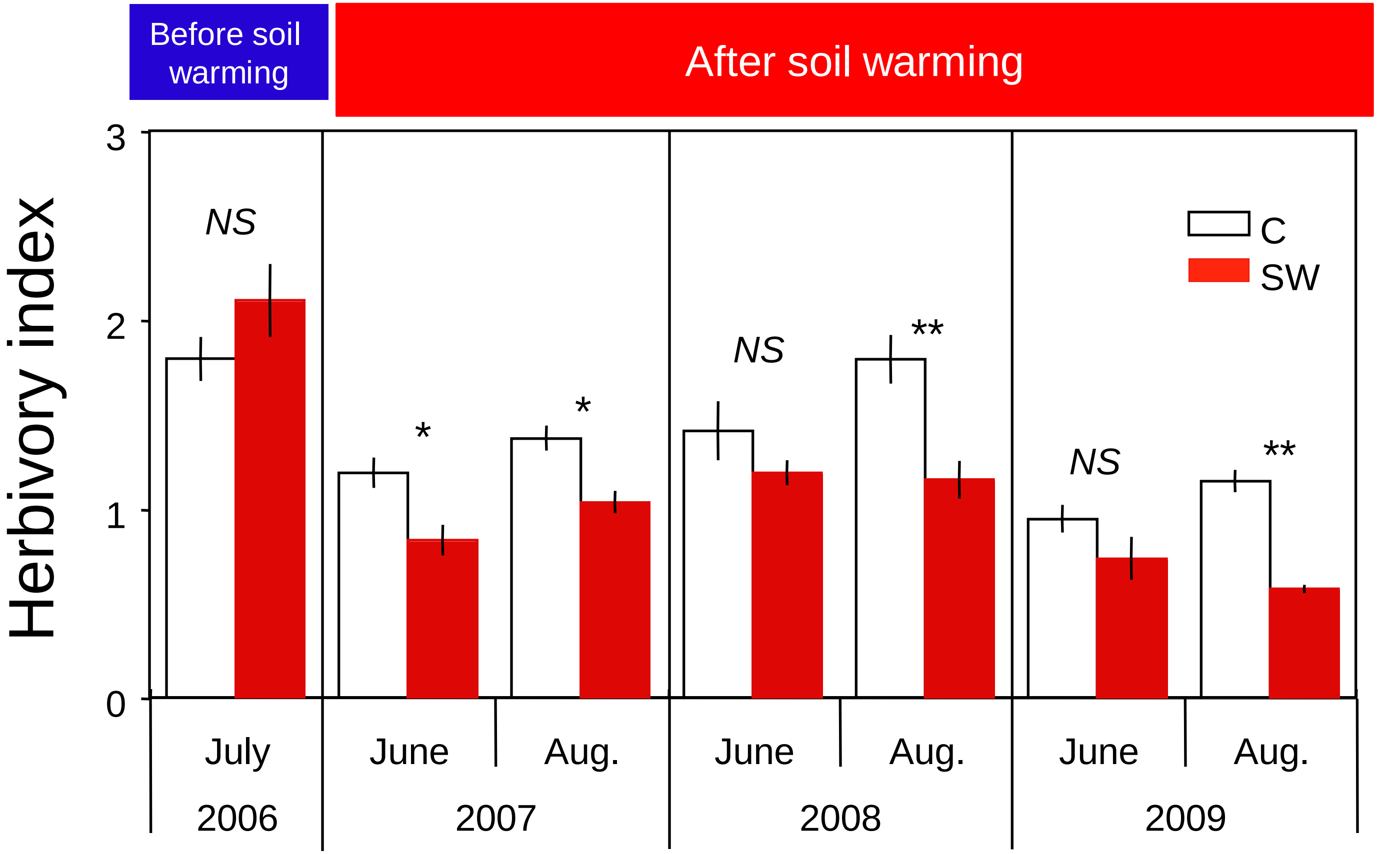
Student's t-test, Significance: * *P* < *0.05*, ** *P* < *0.01*

Soil warming

- 5m x 5m square plots
- Buried heating cables and spaced 20 cm apart
- Elevated 5°C above ambient using heating cables

Herbivory (soil warming: SW)

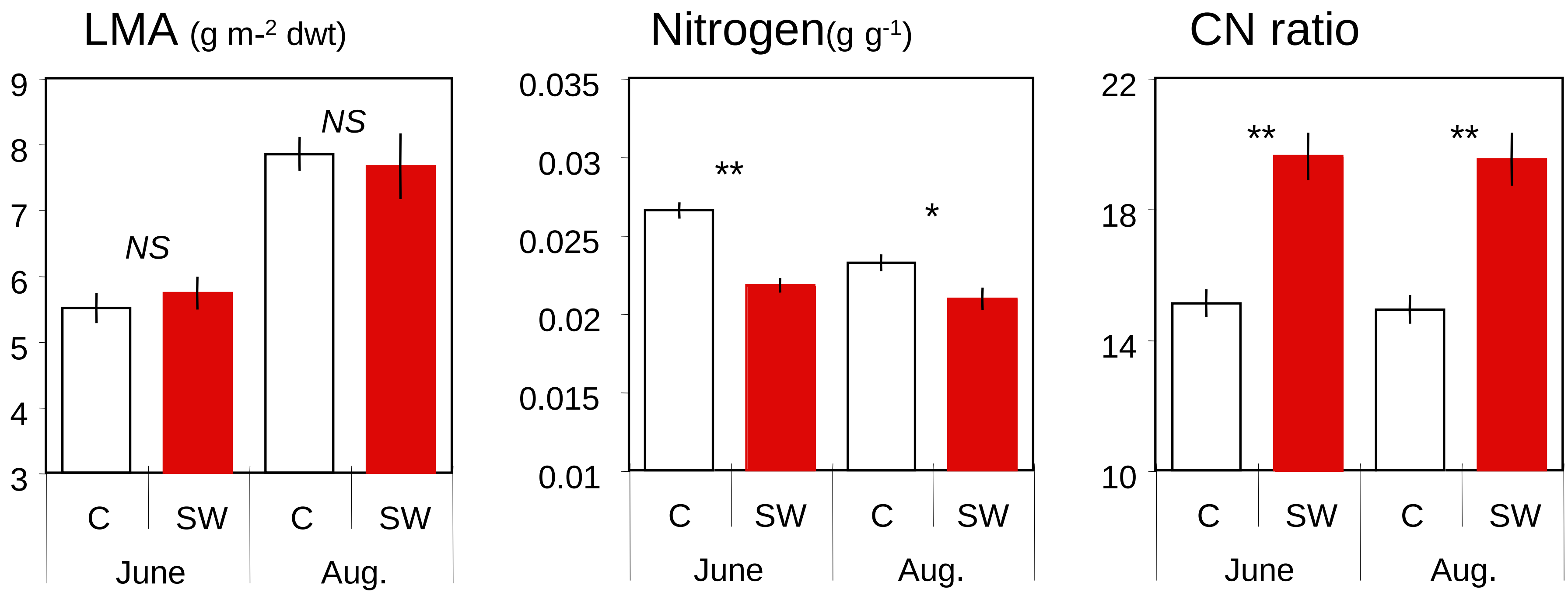
The soil warming decreased herbivory of canopy foliage.



Student's t-test, Significance: * *P* < *0.05*, ** *P* < *0.01*

Leaf traits (2007)

The soil warming decreased nitrogen concentration and increased CN ratio in canopy foliage.



Student's t-test, Significance: * *P < 0.05*, ** *P < 0.01*

What leaf traits affect herbivory ?

	LMA (June)	Nitrogen (June)	CN (June)	LMA (Aug.)	Nitrogen (Aug.)	CN (Aug.)	Intercept	P value
Herbivory (June)	-	-	-0.045				0.711	< 0.01
Herbivory (Aug.)	-	-	-0.031	-	58.746	-	-0.623	< 0.01

Generalized linear models (GLMs).

LMA, Nitrogen, and CN ratio in June and August were fixed effects

- LMA: **Leaf toughness**
- Nitrogen: **Nutrient**
- CN ratio: **Carbon-based defense**

Summary

1. The branch warming extended the length of growing season of canopy foliage by earlier leaf flush and later leaf fall.

2. The branch warming increased acorn production.

3. The branch warming did not affect herbivory of canopy foliage.

4. The soil warming decreased herbivory of canopy foliage.

5. The soil warming decreased nitrogen concentrations and increased CN ratios in canopy foliage.

6. The decrease in herbivory by soil warming can be explained by changes in nitrogen and CN ratio of canopy foliage.

These results implies that herbivore insect abundance would decrease on canopy oak trees, if this global warming last.

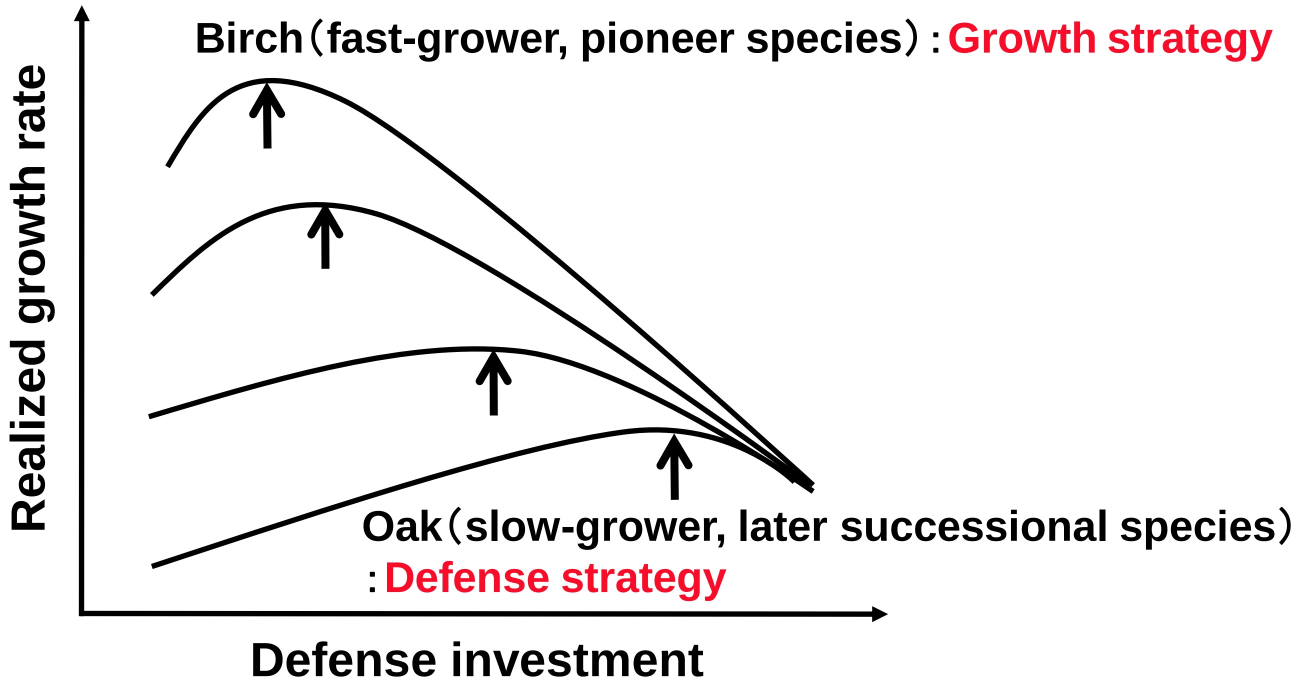
Future works

To solve the response of northern forest ecosystems to global warming, we added other tree species to warming experiments.

Birch Experiment

Oak Experiment

- Defense investment affects realized growth.
- Each curve represents a plant species with different maximum inherent growth rate.
- Levels of defense that maximize realized growth are indicated by an arrow (Coley *et al.* Science 1985).



<u>Final Goal</u> is to determine that the response to global warming may depend on life history of each tree species

Thank you.
Kiitos.
ありがとうございます。

Collaborators

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