Foliar N contents and dynamics of representative woody plants seedlings in Northern Japan grown under elevated O_3 with a free-air enrichment system

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Introduction & objective

Increasing of N-deposition & ground-level O_3

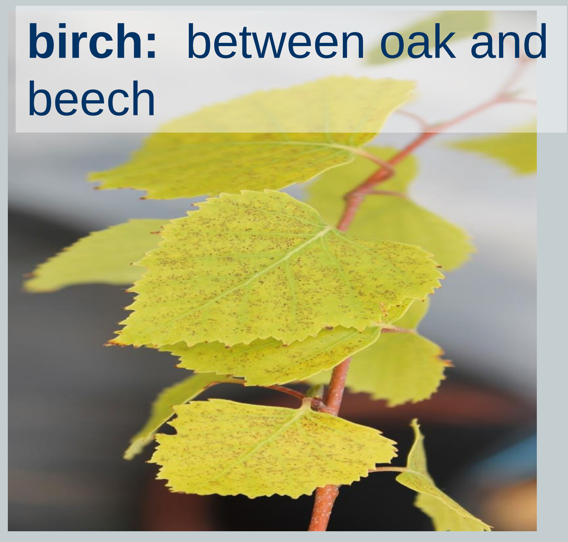
- N-deposition and ground-level (tropospheric) O_3 concentration are continuously increasing in East Asia due to the rapid increase of precursor gases emissions

Negative impacts of O_3

- The present O_3 concentration in Japan has a negative impact on the growth of forests and reduce health of tree species
- Elevated O_3 (eO_3) may **ACCELERATE** foliar senescence
- Little attention has been given to effects of O_3 on foliar N alteration, Will foliar N increase O_3 sensitivities among species?

Visible O_3 injury examples:

Wilt disease



Bronze stippling

Leaf miner trails

Hypothesis

Elevated O_3 has an adversely effect on foliar N dynamics, resulting in decline of N acquisition, thereby influence foliar physiological and biochemical processes

Objectives

- Investigate effects of eO_3 on foliar N in the live and senescing leaves as well as the O_3 sensitivity related to foliar N changes
- Estimate the correlation interactions between foliar N contents and other mineral nutrients in leaves as well as the relations between leaf N and leaf mass per area (LMA) among different tree species in Northern Japan

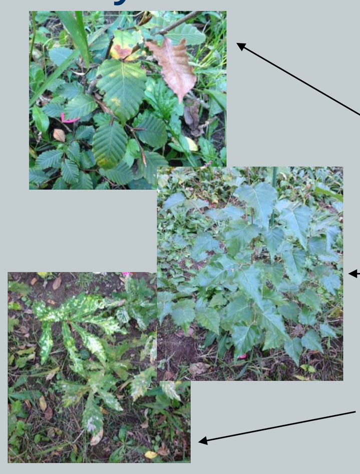
Materials and methods

Location

Sapporo research forest experimental nursery, Hokkaido University (N43.07, E141.38, 15m a.s.l.)

Plant materials and O_3 sensitivity

Two-year old seedlings were planted in 2014;



O_3 Sensitivity	Leaf habit	Ever VS Deci	Species
High	Broad-leaved	Deciduous	*Populus maximowiczii, Populus nigra, Siebold's beech (Fagus crenata), Zelkova serrata*
		Evergreen	*Castanopsis sieboldii*
	Coniferous	Deciduous	*Larix kaempferi*
		Evergreen	*Pinus densiflora*
Moderate	Broad-leaved	Deciduous	*Quercus serrata, Betula platyphylla var. japonica*
		Evergreen	*Quercus myrsinaefolia, Cinnamomum camphora*
	Coniferous	Evergreen	*Abies homolepis*
Low	Broad-leaved	Deciduous	*Quercus mongolica var. crispula*
		Evergreen	*Lithocarpus edulis, Machilus thunbergii*
	Coniferous	Evergreen	*Pinus thunbergii, Cryptomeria japonica, Chamaecyparis obtusa*

Based on Yamaguchi *et al* 2012

Experimental period

July 2014 ~ December 2015 (two growing seasons)

Samples collection

- Live leaves collected at mid-Sept. with peak nutritional activities
- Senescing leaves collected at end-Oct.

Conclusion

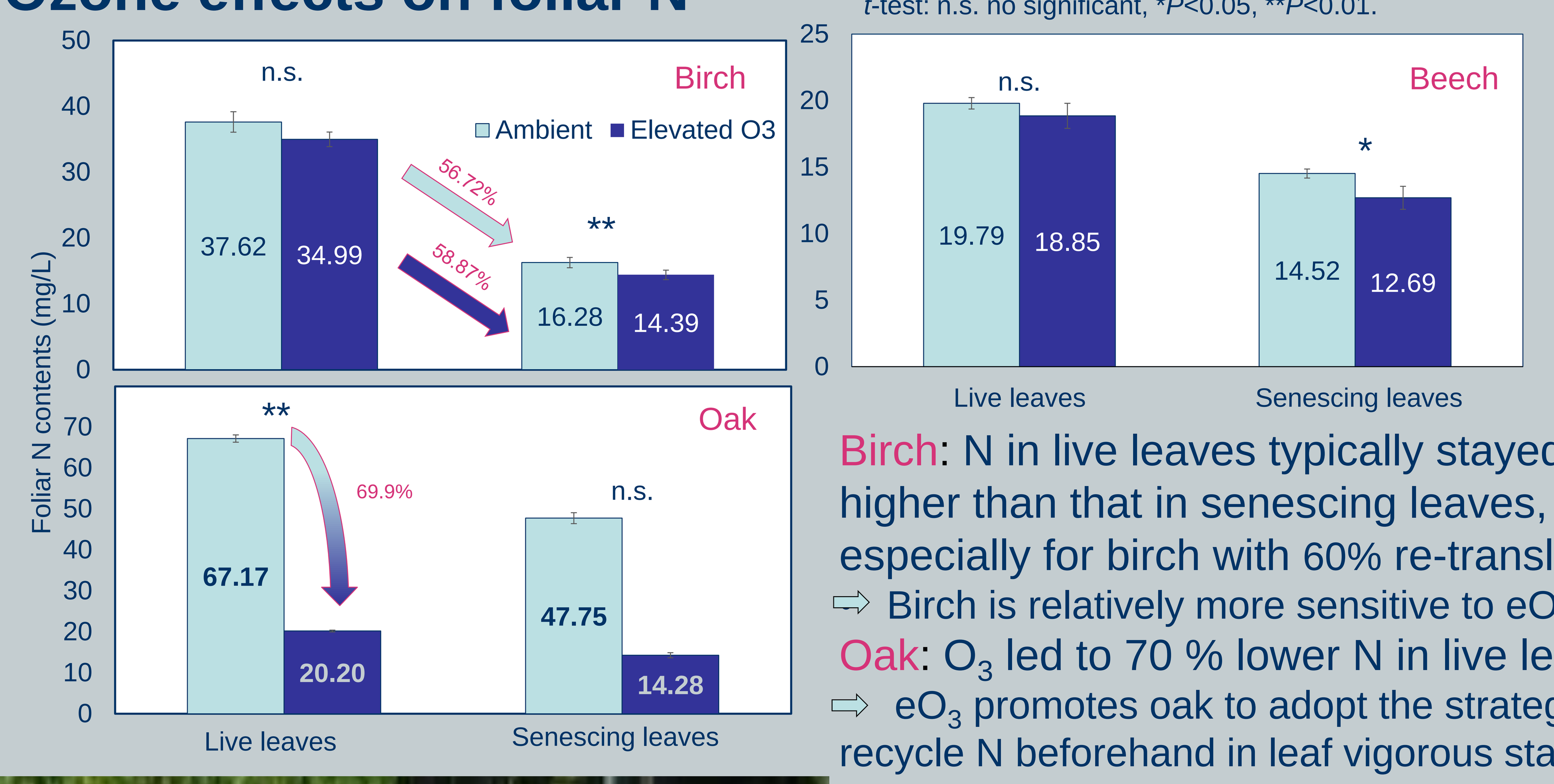
O_3 impacts on foliar N varies with different species:

- O_3 affects more effectively on birch
- O_3 has positive effects on oak to promote recycling N beforehand in leaf vigorous stage
- **O_3** has negative effects on beech to obtain N from N cycling in leaf
- Foliar N can be detected as an indicator to evaluate O_3-induced modification in leaf traits

Results

Ozone effects on foliar N

Data are represented as mean ± SD (n=4-6). *t*-test: n.s. no significant, *P<0.05, **P<0.01.



Birch: N in live leaves typically stayed higher than that in senescing leaves, especially for birch with 60% re-translocate

⇨ Birch is relatively more sensitive to eO_3

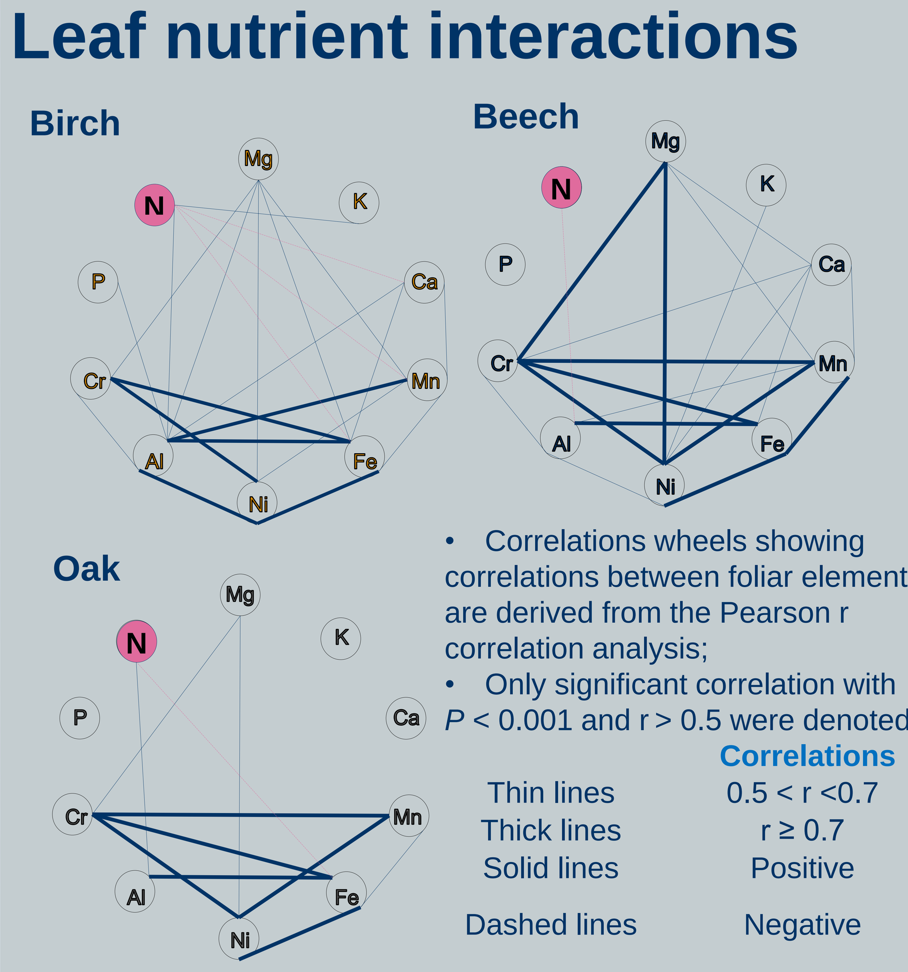
Oak: O_3 led to 70 % lower N in live leaves

⇨ eO_3 promotes oak to adopt the strategy to recycle N beforehand in leaf vigorous stage

Beech: O_3 effects on senescing leaves in beech was less than that in birch.

⇨ Beech is easier than birch to obtain N from N cycling at eO_3 since its litter decomposition become faster with O_3 induced accelerant process of defoliation (Kavvadias et al., 2001)

Leaf nutrient interactions



- Correlations wheels showing correlations between foliar elements are derived from the Pearson r correlation analysis;
- Only significant correlation with P < 0.001 and r > 0.5 were denoted

	Correlations
Thin lines	0.5 < r <0.7
Thick lines	r ≥ 0.7
Solid lines	Positive
Dashed lines	Negative

- **Negative correlations** with foliar N:
  - → Ca, Mn, Fe in birch; (Non-mobile mineral elements in leaf)
  - → Fe in oak
  - → Al in beech
- **Positive correlations** with foliar N:
  - → K, Al in birch
  - → Al in oak
  - → none in beech

⇨ Interactions between foliar N and a non-essential element (*e.g.* Al) varied with different species.

⇨ Birch is more sensitive may concern with the sensitive interactions among foliar nutrients.

⇨ Fewer effects of eO_3 on foliar N in birch may due to the hormone control regulated by K

Correlation of leaf N & LMA

- ✓ Birch and oak: (--) at Amb → (x) at eO_3
- ✓ Beech: (x) at Amb → (+) at eO_3
- ✓ Main effects: (--) at Amb

⇨ eO_3 greatly affects the correlations between leaf N & LMA

⇨ O_3 induced modification in leaf traits can be evaluated by detecting leaf N

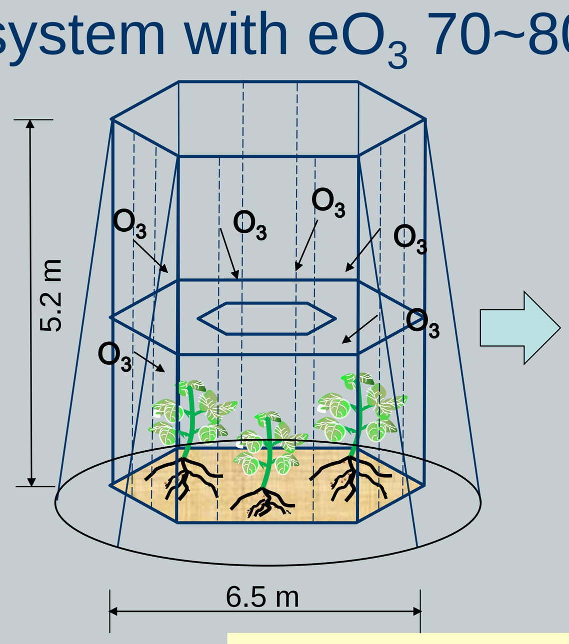
Table: correlation coefficients between foliar N and LMA; **pooled**=main effects of gases

Foliar N	Ambient				Elevated O_3			
	Birch	Oak	Beech	Pooled	Birch	Oak	Beech	Pooled
N_{live}	-0.29*	-0.14**	0.02	-0.46**	-0.07	0.01	0.23*	0.27
$N_{senescing}$	-0.51*	0.47	0.03	-0.56**	-0.34	-0.63	0.34	0.41

Free-air O_3 enrichment & measurements

Experimental design

- Two O_3 levels X 3 plots with 3 individual seedlings in each
- Free-air O_3 enrichment system with eO_3 70~80 ppb and ambient control 35~45 ppb



Field view

Measurements

- Foliar N contents: NC analyzer (NC - 900)
- Other elements: **ICP-MS** ⇨

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