Do limited cold tolerance and shallow depth of roots contribute to yellow-cedar decline?

アラスカヒノキ衰退に根の耐寒性と浅根性がどう影響しているか

Paul G. Schaberg, David V. D'Amore, Paul E. Hennon, Joshua M. Halman, Gary J. Hawley

Forest Ecology and Management 262 (2011) 2142–2150

Introduction (yellow cedar)

Yellow-cedar【アラスカヒノキ】

- Widely grown in the north (ex. Alaska)
- tolerate poor growing sites
- resistance to biotic stress

  【貧栄養や生物ストレスに対して強い耐性がある】

But decline! (200,000ha in Alaska)

⇒Decrease in snow depth is involved in the decline (Hennon et al.,2006・2010)

【積雪深が影響？】

Introduction(why only yellow cedar?)

yellow-cedar may utilize a shallow rooting habit in organic soils(D'Amore et al.,2009)

【アラスカヒノキは他の種に比べて浅根性である】

benefit the cedars by providing access to a form of N that is less exploited by competing species.

【他と比べ表層の養分獲得に有利】

Introduction (Experiment)

Experiment by seedling【実生での実験】

Cold tolerance of root : -5℃

1.Covered with snow (protection)

【雪で覆う】⇒soil temperature : 0℃

No damage to the fine roots

2.Not covered with snow (without protection)

【覆っている雪を除く】⇒soil temperature : -5℃以下

⇒Damage to the fine roots

⇒foliar decline, Deterioration of mortality

Hypothesis(衰退の仮説)

predisposing factor【素因】

wet soils (limit rooting depth)

open canopies (increase exposure ambient freeze thaw cycle)

Reduce the depth of winter snowpack

due to global warming【積雪深の減少】

⇒increase the likelihood of soil freezing

⇒utilize a shallow rooting habit【浅根性】

⇒fine root injury

⇒chronic foliar water shortages

⇒decline!

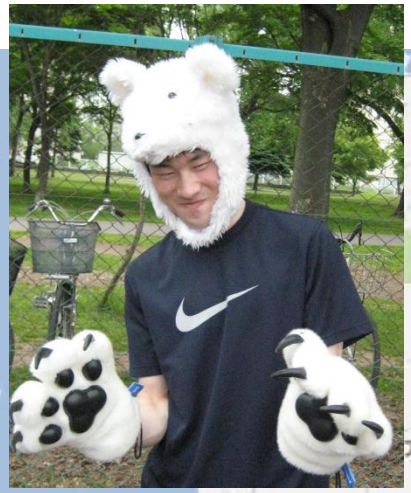
Purpose

Assess if limited cold hardiness and/or a shallow depth of rooting contribute to yellow-cedar's vulnerability to decline.

根の耐寒性・浅根性がアラスカアカマツの衰退現象の原因となるかを調査

Materials and method

- Study site



Material and method

Trees (DBH>20cm):selected along transect

- YC: yellow-cedar【アラスカヒノキ】(decline)
- RC: western redcedar【ベイマツ】
  (similar ecologycal niche as YC)
- MH: mountaion hemlock【アメリカツガ】
- WH: western hemlock【ベイツガ】
- SS ：Sitka spruce【アラスカトウヒ】

(Not decline)

Materials and method

Sampling(2007.11～2008.5)

- Soil

  ⇒fine roots(< 2mm), soil cation(Ca,Al)

  ⇒Cold tolerance【根の耐寒性】,

  Membrane electrolyte leakage【電解質漏出】

- Leaves

  ⇒foliar cation(Ca,Al)

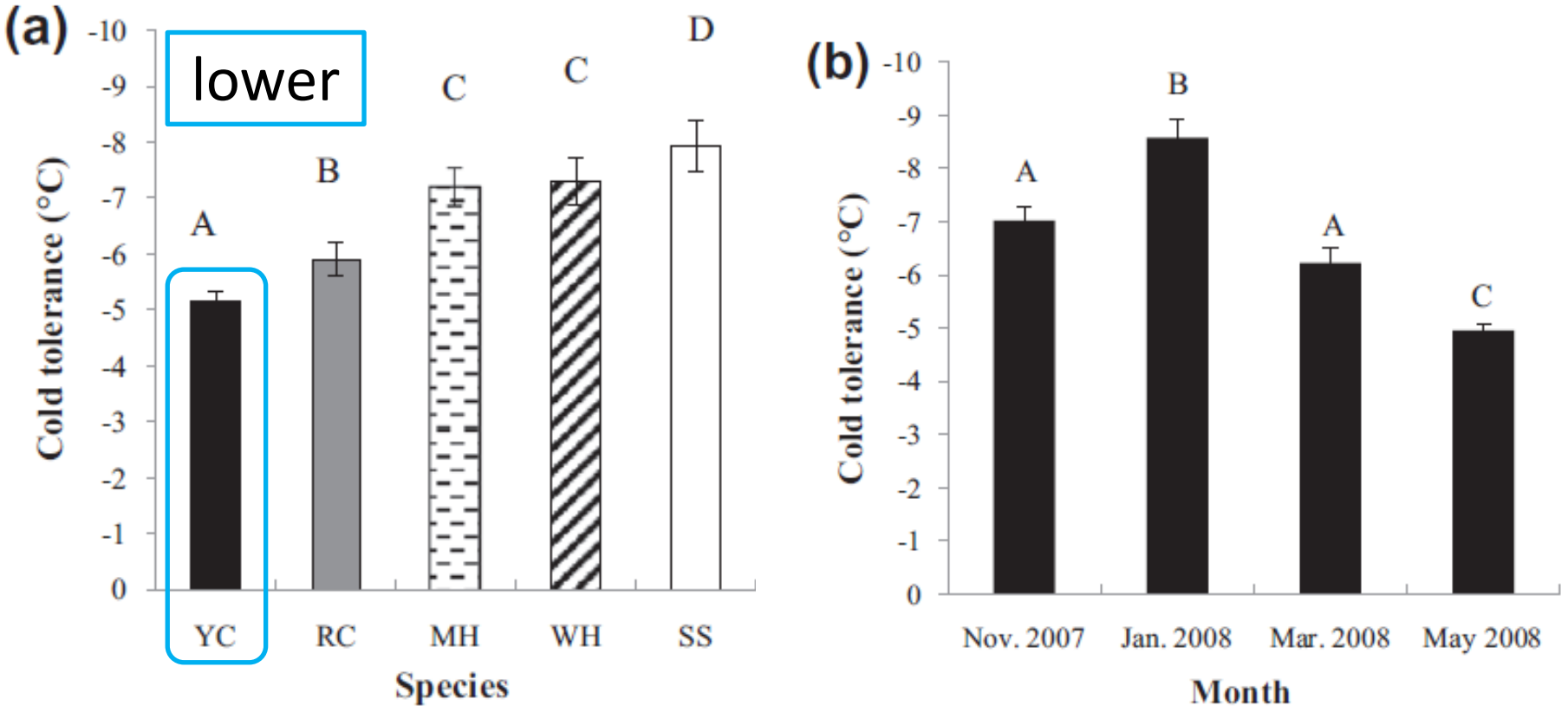
Temperature monitoring

⇒air, soil(depth:7.5cm・15cm)

Results and discussion

- Cold tolerance of roots【根の耐寒性】
- Temperature【気温・地温】
- Membrane electrolyte leakage【電解質漏出】
- foliar and soil cation【葉と土壌の養分】

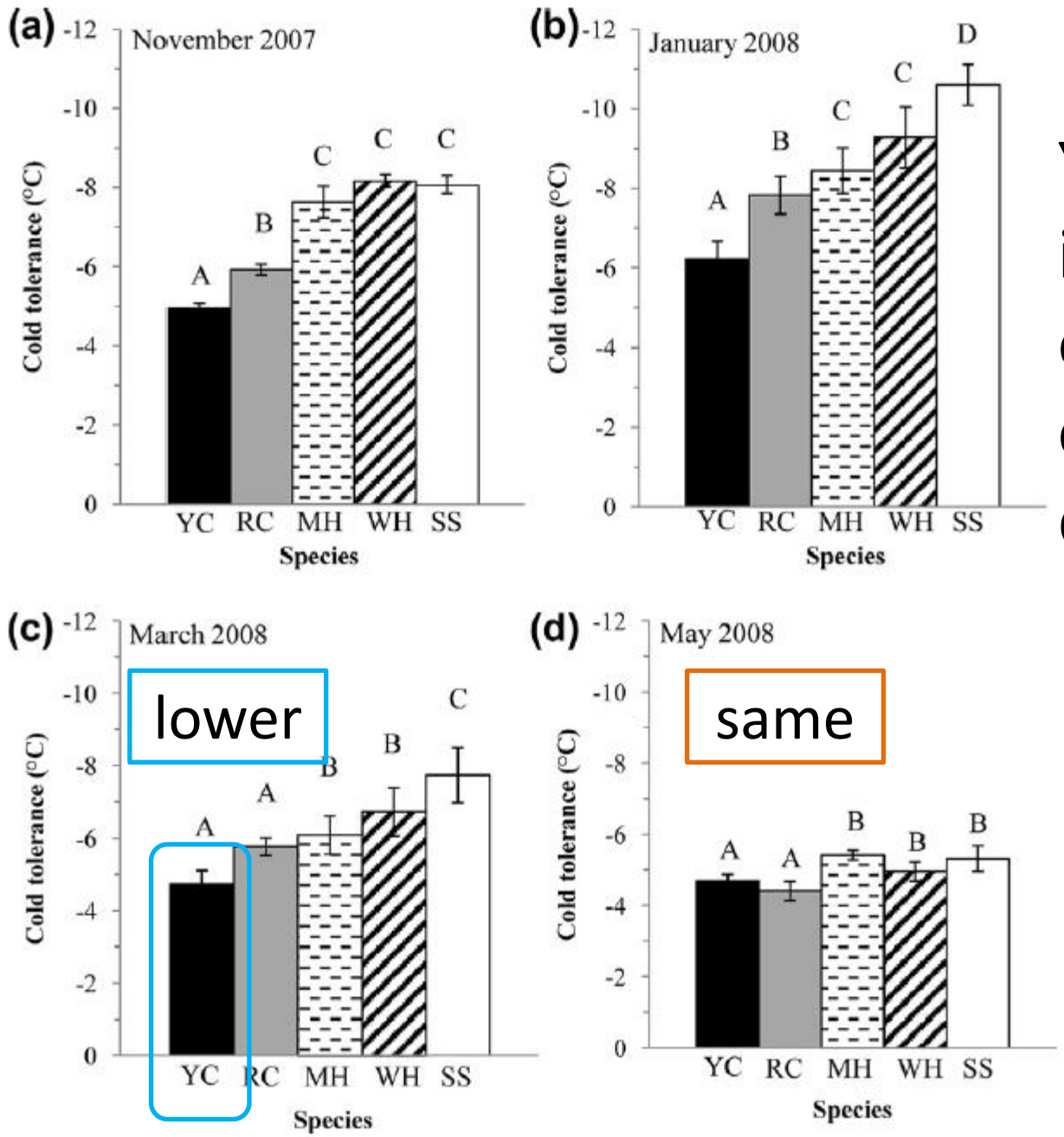
Results and discussion (cold tolerance)



Cold tolerance of YC is the lowest

アラスカヒノキは特に低い

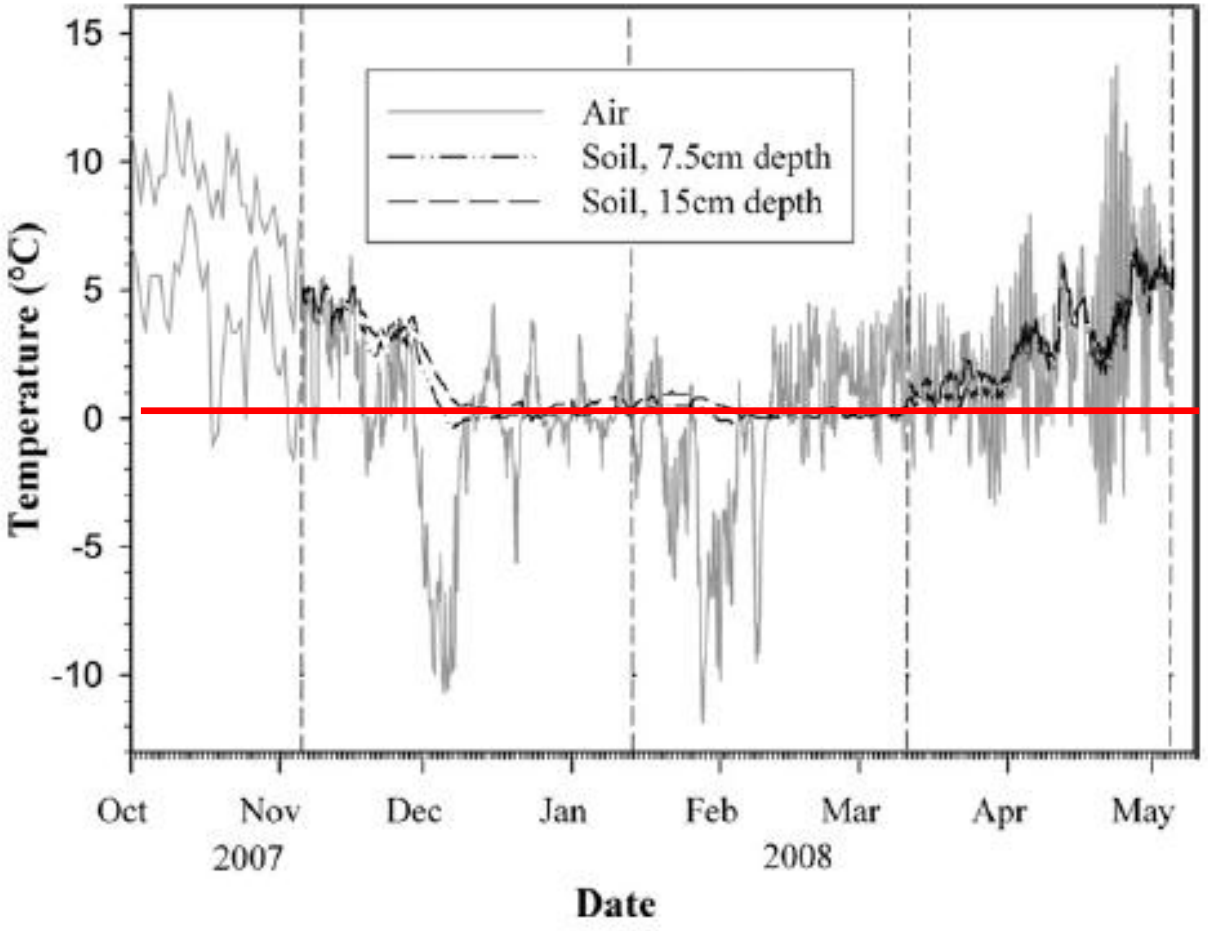
Results and discussion (cold tolerance)



YC was dehardened in March.
other species continued to deharden into May.

YCは3月まで
他は5月まで

Results and discussion (temperature)

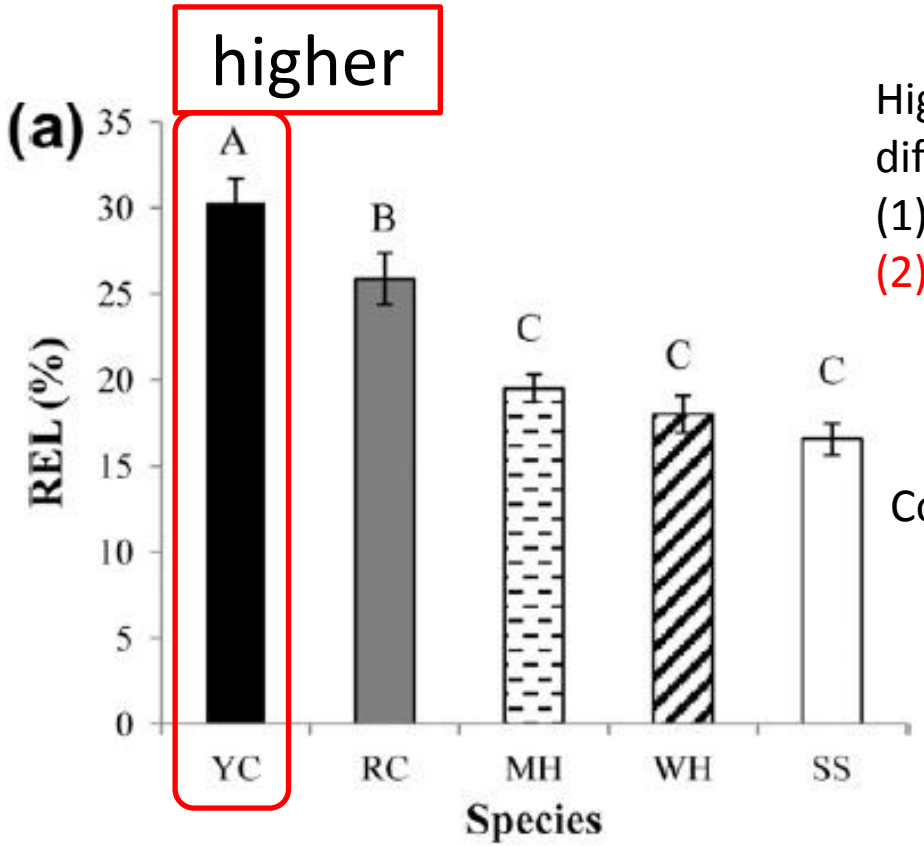


Almost over 0℃

all species escaped freezing injury

根への凍害は深刻ではない

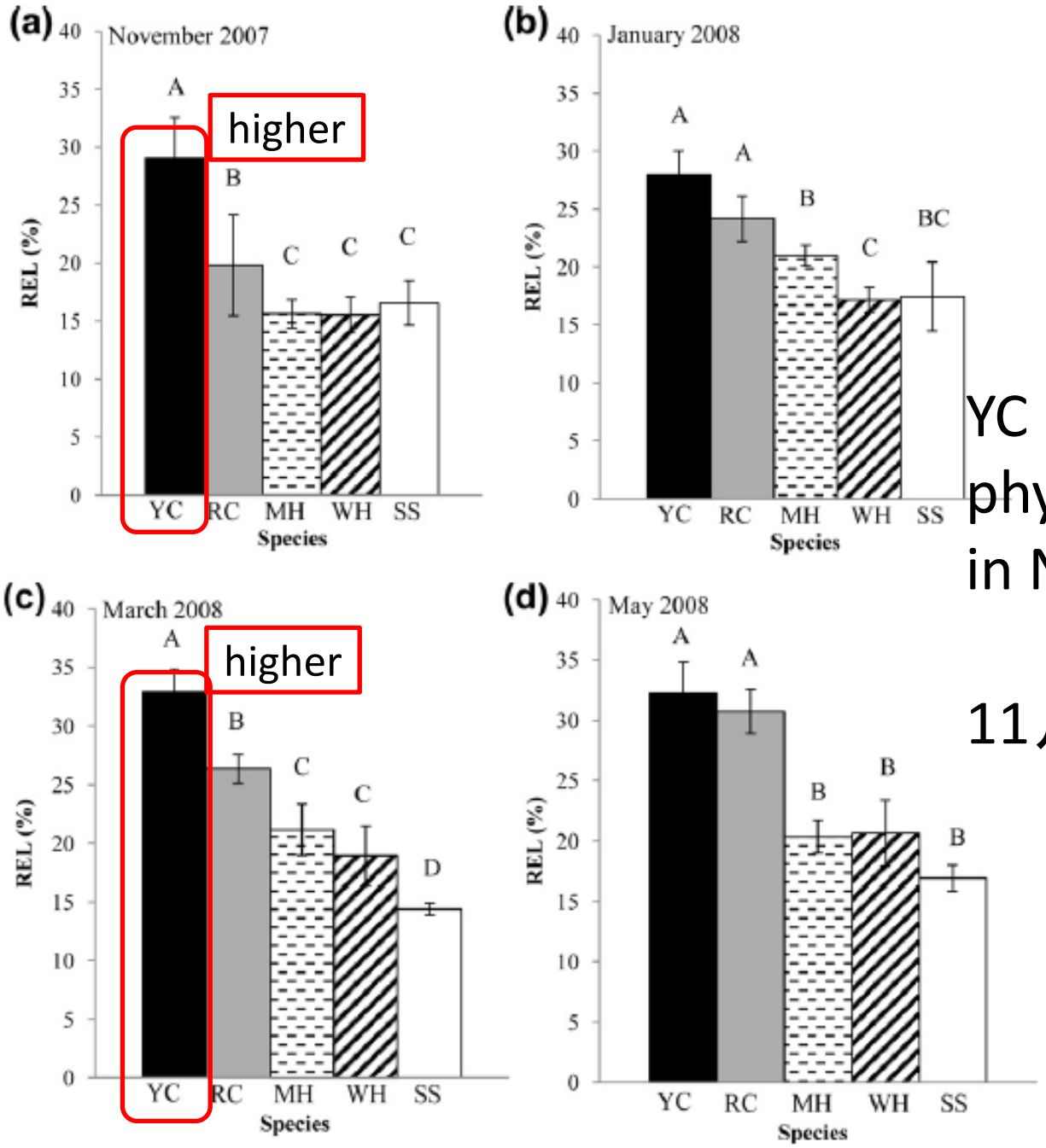
Result and discussion
(Membrane electrolyte leakage)



High REL measurements can reflect various differences in physiology, notably including
(1) root injury
(2) greater electrolyte loss associated with the growth and activity of non-suberized roots

Cold tolerance is higher than soil temperature

高いRELの理由①根にダメージ(Schaberg et al., 2008)
②成長活動 (McKay, 1998)
※根の耐寒性が保たれてるから



YC roots were more physiologically active in November and March

11月と3月にYCのREL高い

Discussion
(Membrane electrolyte leakage)

- YC roots were more physiologically active in November and March

(trade-off between cold tolerance and activity)

【耐寒性とのトレード･オフ】

- YC takes up N as NO3- when other species exhibit less uptake capacity【養分獲得に有利】

- But risky tradeoff for YC when roots are not protected from low air temperatures without snowpack. 【積雪減少したらヤバイ】

Results and discussion (foliar cation)

Foliar cation	Species mean ± SE				
	YC	RC	MH	WH	SS
Ca (mg/kg)	10570.8 ± 1028.9	7110.6 ± 339.4	1874.6 ± 190.2	2449.6 ± 267.5	2170.9 ± 410.8
Al (mg/kg)	22.3 ± 4.2	24.1 ± 3.6	512.6 ± 160.6	182.8 ± 17.2	76.0 ± 53.3
Ca:Al	333.9 ± 38.0	213.6 ± 29.5	3.5 ± 0.9	8.7 ± 0.6	54.1 ± 19.1

5倍

20倍

YC had significantly higher Ca, lower Al, and
higher molar ratios of Ca:Al than foliage from the other species

【YCは他に比べてCa高く、Al低い】

Results and discussion (soil cation)

Soil cation	Sampling depth		*P*-value
	Surface horizon	Subsurface horizon	
Ca (mg/cm^3)	0.602 ± 0.097	0.253 ± 0.081	0.009
Al (mg/cm^3)	0.026 ± 0.004	0.047 ± 0.007	0.014
Ca:Al	29.88 ± 8.71	10.05 ± 4.35	0.001

There are many Ca to the soil surface【表層にCa多い】
(Kranabetter and Banner, 2000)
There are many Al to the subsurface【中層にAl多い】

⇒foliar cation
higher Ca : greater rooting in the upper organic horizon
higher Al : greater rooting in the lower horizon
【Ca多いと土壌表層に根、Al多いと土壌下層に根】

Results and discussion (foliar cation)

Foliar cation	Species mean ± SE				
	YC	RC	MH	WH	SS
Ca (mg/kg)	10570.8 ± 1028.9	7110.6 ± 339.4	1874.6 ± 190.2	2449.6 ± 267.5	2170.9 ± 410.8
Al (mg/kg)	22.3 ± 4.2	24.1 ± 3.6	512.6 ± 160.6	182.8 ± 17.2	76.0 ± 53.3
Ca:Al	333.9 ± 38.0	213.6 ± 29.5	3.5 ± 0.9	8.7 ± 0.6	54.1 ± 19.1

5倍

20倍

YC has more fine roots concentrated in surface soil horizons than others

【YCは他の樹種に比べて表層に根が多い】

Conclusion

① YC roots are less cold tolerant than the roots of others.【YCは根の耐寒性が低い】

② YC has more fine roots concentrated in surface soil horizons than others.【YCは浅根性】

① + ② =

A)allowing for cold season nitrate uptake

B)risk of broad-scale root freezing injury

our data indicate that ① and ② likely contribute to YC to freezing injury and decline relative to sympatric conifers.【この2つでYCの根に凍害⇒枯死している可能性】