Growth pattern analysis of Korean tree species using national forest inventory data

Forest Ecophysiology Lab., Seoul National University

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Minjee Park, Juhan Park, Sungsik Cho

Hyun Seok Kim

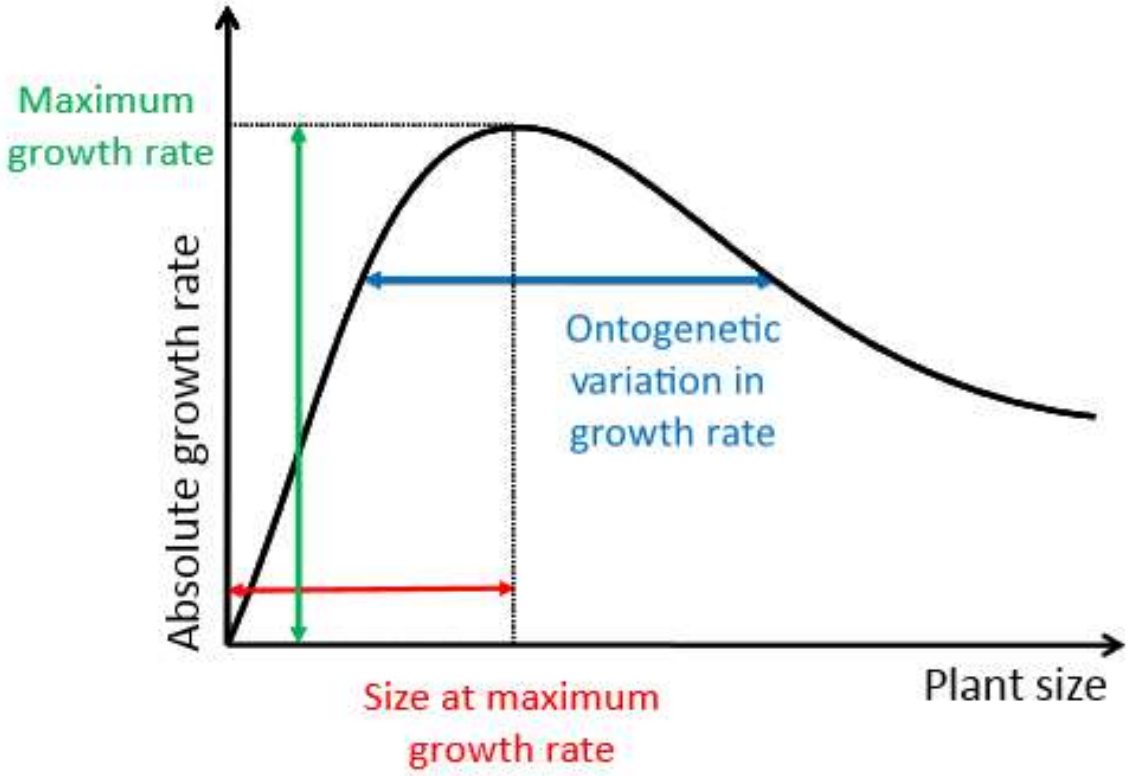
(Source: Google image)

Introduction

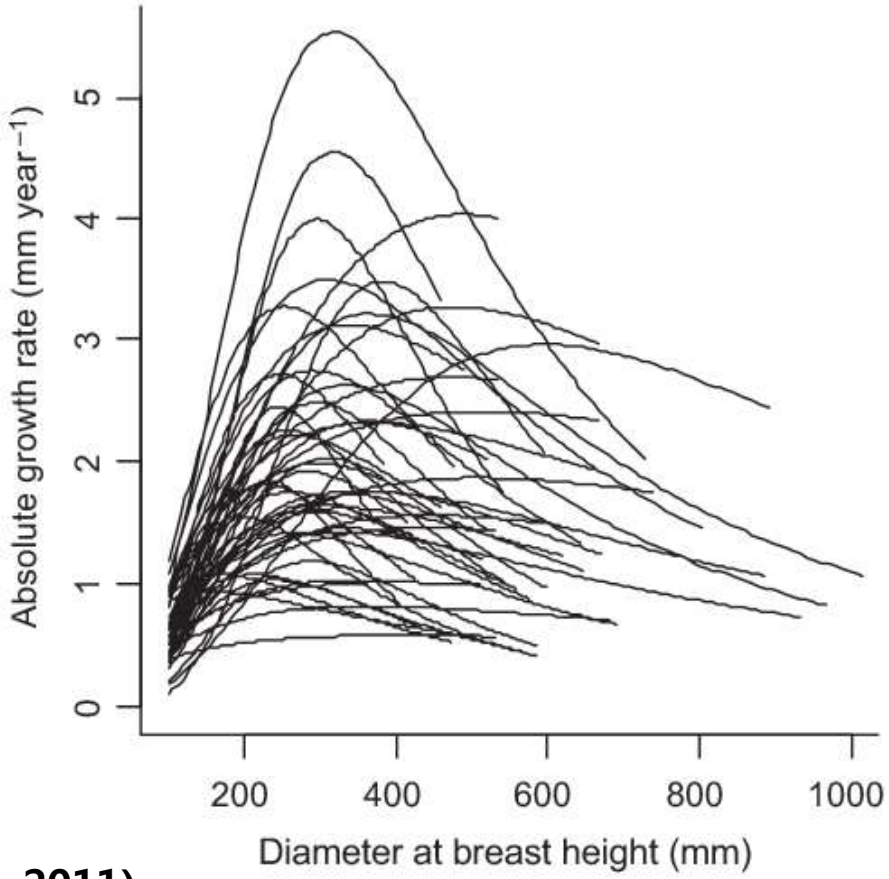
- Between 1954 and 1999, the mean annual temperature in the Korean Peninsula rose with the rate of +0.23 °C/10yrs, which is greater than the global mean change. The warming has been strengthened with 0.41 ℃/10yrs from 1981 to 2010 (Korea Meteorological Administration ,2012).
- To evaluate which trees are growing better than their expected growth pattern in current, we examined the long-term growth trend affected by gradual environmental changes (e.g. precipitation, temperature, or CO_2 concentration).
- A large data of tree-ring series on a national level that has been recently released from national forest inventory enabled us to analyze long-term retrospective growth trend.

Tree species-specific growth pattern

<General pattern>

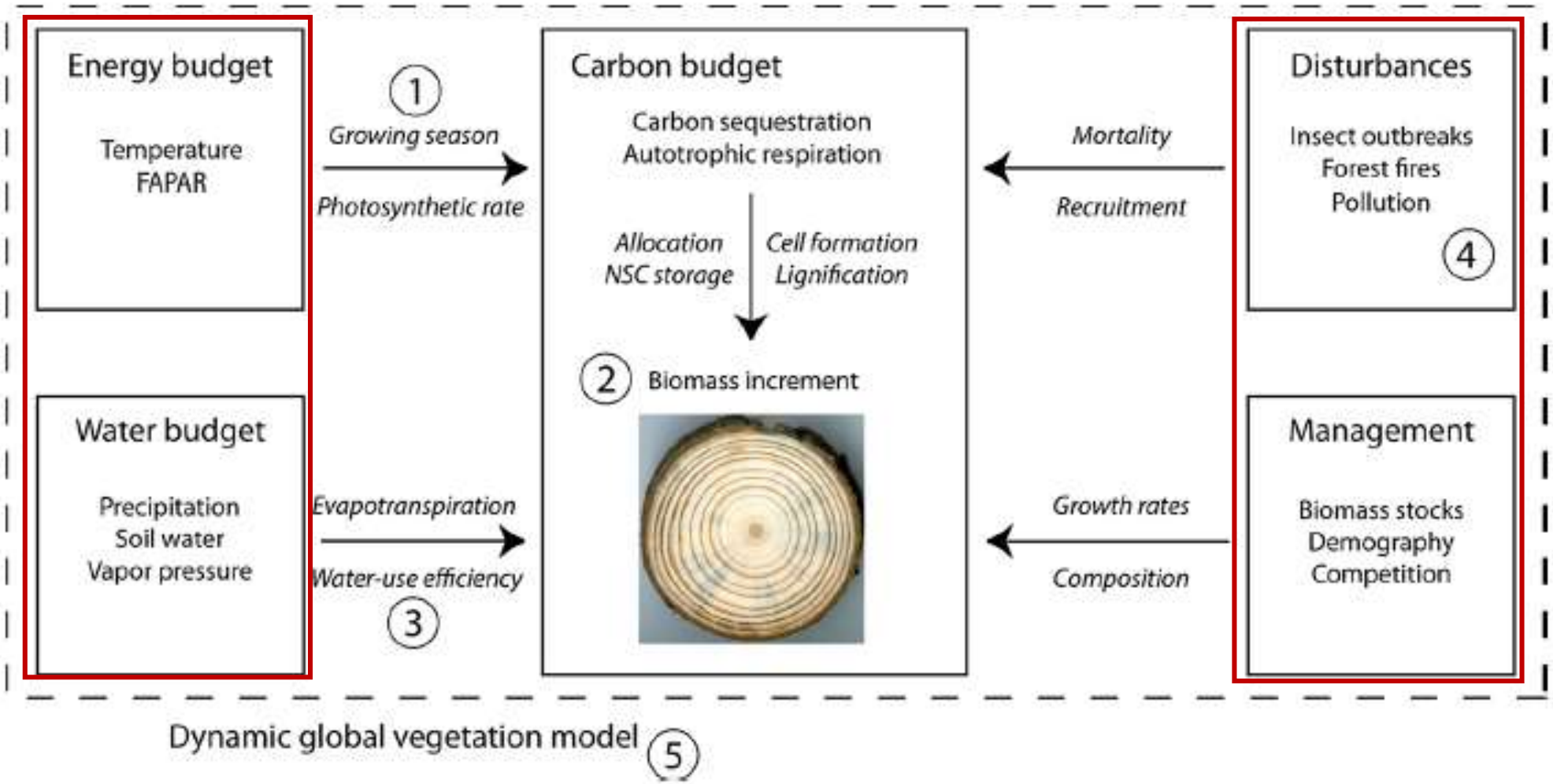


<50 neo-tropical tree species of French Guiana>



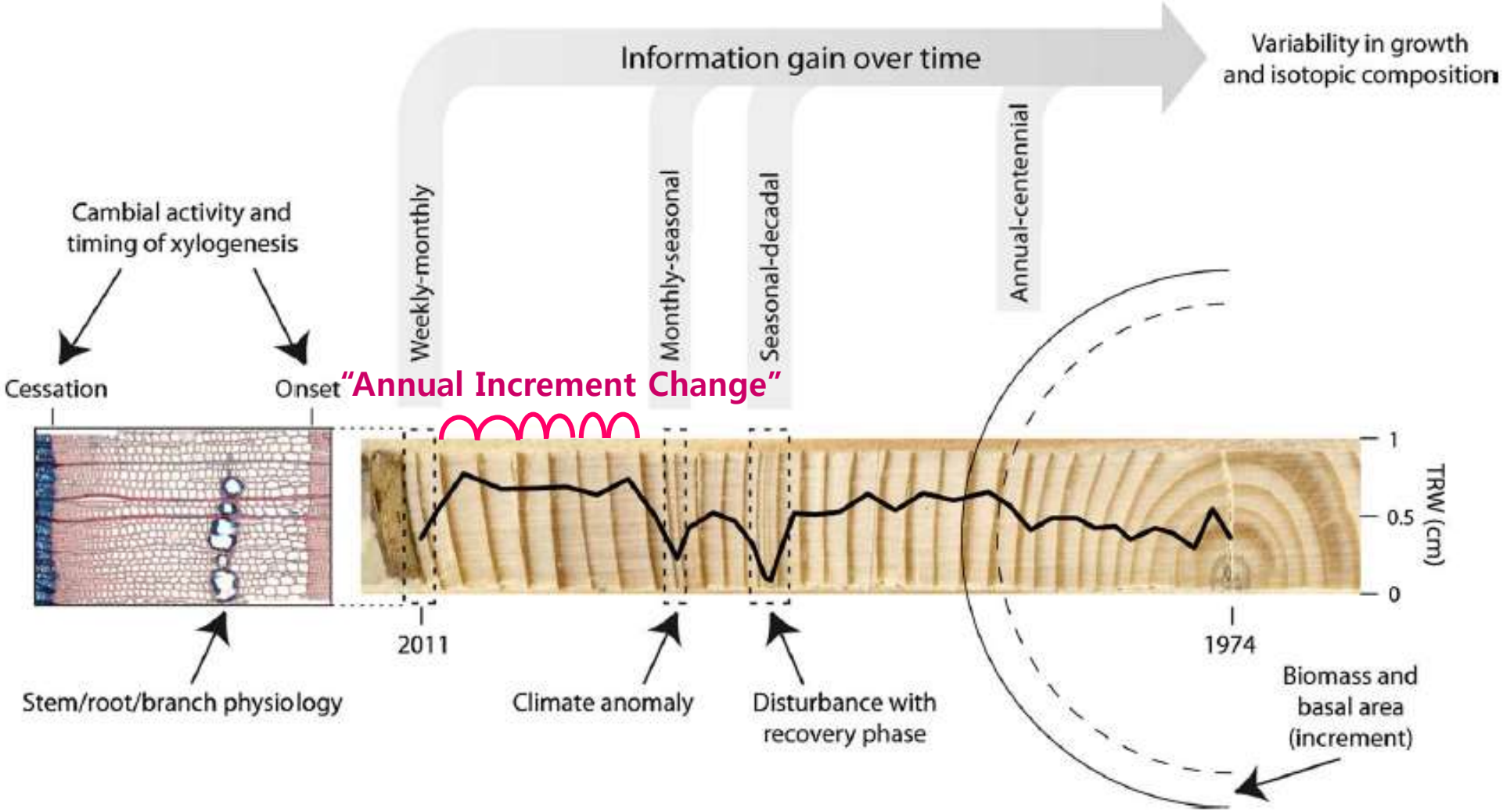
(Bruno He´rault et al, 2011)

Tree growth responses to different environmental drivers



(Flurin Babst *et al.*, 2014)

Tree-growth information in tree ring series

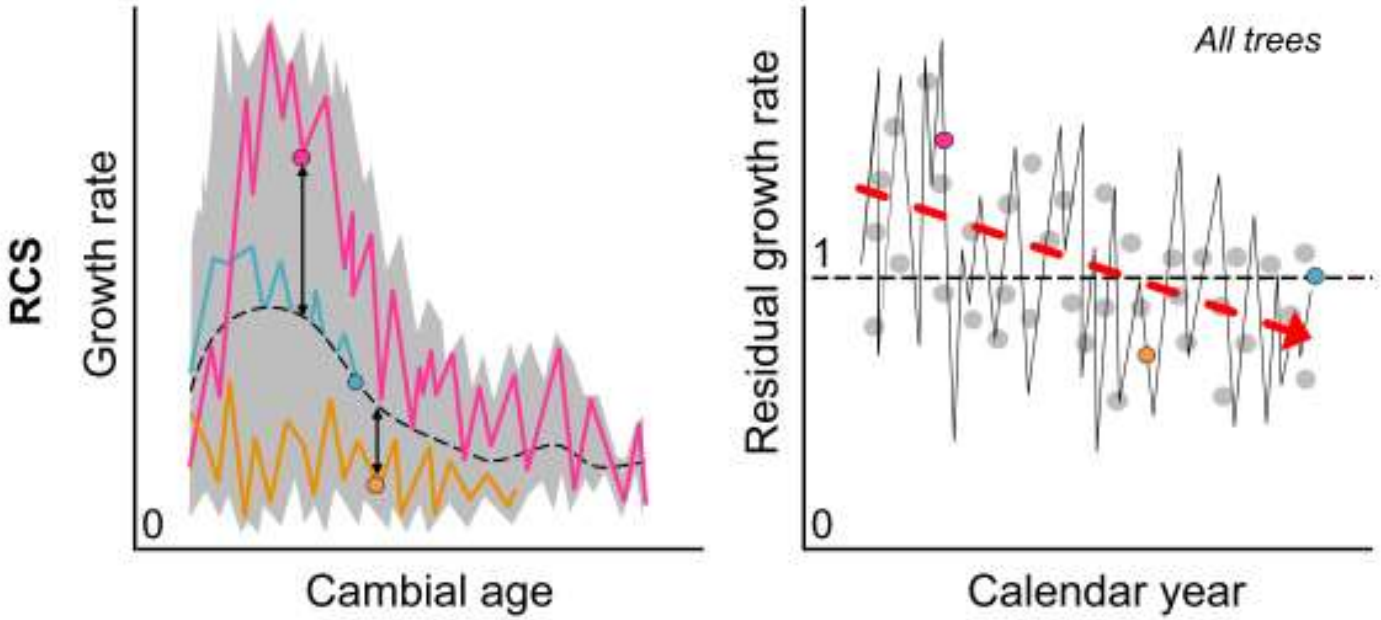


(Flurin Babst *et al.*, 2014)

Long-term growth trend analysis by detrending

- **Detrending, Standardization**: Removal of age-related ontogenetic growth pattern

- **Regional curve standardization (RCS)**
  - Draw average age/size trend (regional curve)
  - Calculate temporal trends in growth are calculated over the residual chronology



(RICHARD et al., 2015)

Objectives

This study aims..

1. to find out the growth pattern of various Korean tree species,
2. to evaluate growth trend of individual species for last thirty years after detrending the effect of age on growth and classify trees into positive, negative and no trend groups
3. to examine how the trees in different groups responded to different climate zones

Korea national forest inventory(NFI) tree ring data

- Systematic sampling: 4 x 4 km (~4000 sampling plots)
- Cluster plots with four subplots
- Basic (11.3m in radius >> 0.04 ha), large tree(>30cm in DBH) , sapling, understory, soil plots

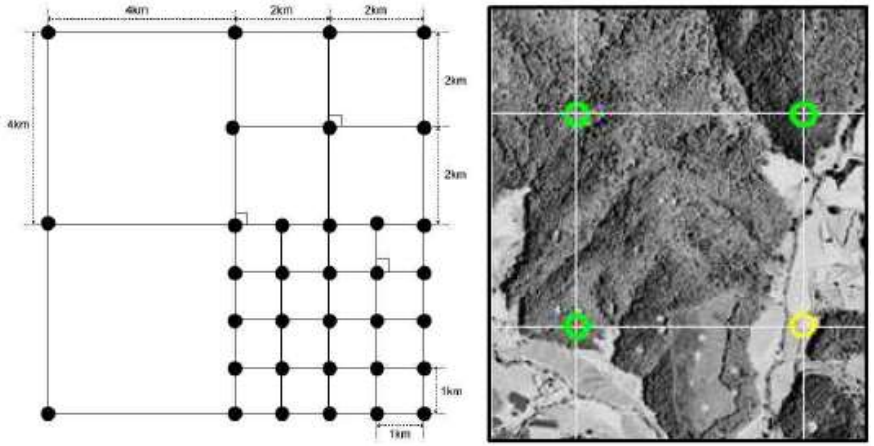


그림 3. 계통적 추출법에 의한 고정표본점의 배치 방법

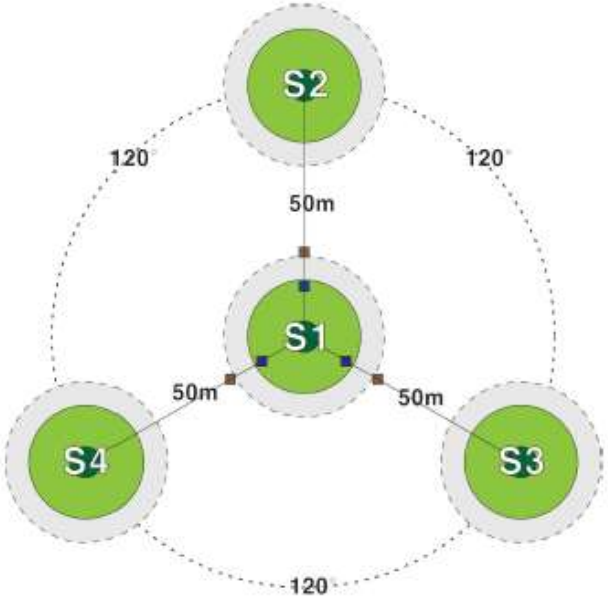


그림 4. 집락표본점의 구조

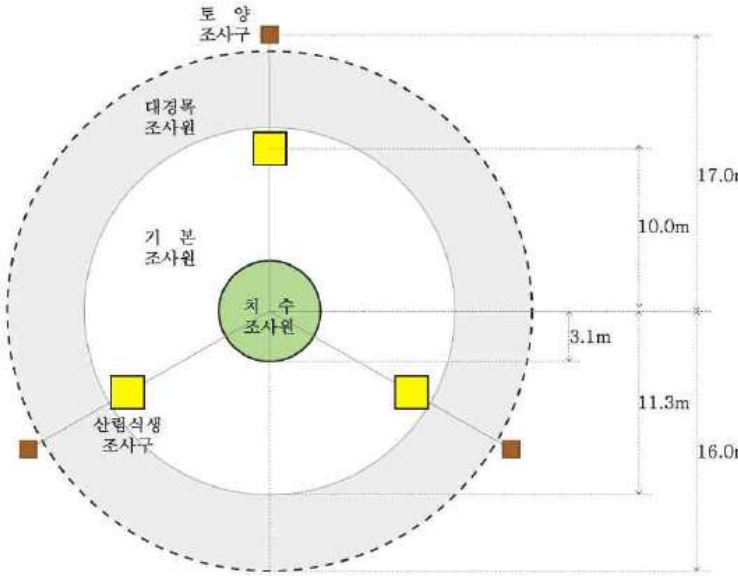


그림 5. 중앙표본점(S1)의 구조(산림식생표본점 예시)

Korea national forest inventory(NFI) tree ring data

- 5th national forest inventory(NFI) (2006-2010)
  185 tree species; 69,128 tree ring series
  → only 52 tree species have >100 tree ring series

- The tree-ring series consist of annual ring widths(mm*100) of the year

Ex)

year	plot#	species	dbh	age(+5)	2011	2010	2009	2008	2007	2006
2010	32032	상수리나무	8	9		506	714	942	703	0

(***Quercus acutissima***)

Korea national forest inventory(NFI) tree ring data

Species	# of rings	Species	# of rings
중부지방소나무 (*P. densiflora*)	14749	박달나무 (*B. schmidtii*)	375
신갈나무 (*Q. mongolica*)	9278	물오리나무 (*A. sibirica*)	369
굴참나무 (*Q. variabilis*)	6320	편백 (*C. obtusa*)	347
강원지방소나무 (*P. densiflora*)	3719	쪽동백나무 (*S. obassia*)	302
리기다소나무 (*P. rigida*)	3016	사방오리 (*A. firma*)	301
졸참나무 (*Q. serrata*)	2960	팽나무 (*C. sinensis*)	231
일본잎갈나무 (*L. kaempferi*)	2040	가래나무 (*J. mandshurica*)	228
상수리나무 (*Q. acutissima*)	2016	물박달나무 (*B. davurica*)	227
곰솔 (*P. thunbergii*)	1998	삼나무 (*C. japonica*)	211
밤나무 (*C. crenata*)	1828	느티나무 (*Z. serrata*)	207
아까시나무 (*R. pseudoacacia*)	1675	버드나무 (*S. koreensis*)	200
갈참나무 (*Q. aliena*)	1633	노간주나무 (*J. rigida*)	185
잣나무 (*P. koraiensis*)	1612	자귀나무 (*A. julibrissin*)	184
산벚나무 (*P. sargentii*)	1071	찰피나무 (*T. mandshurica*)	180
물푸레나무 (*F. rhynchophylla*)	1048	다릅나무 (*M. amurensis*)	168
떡갈나무 (*Q. dentata*)	782	팥배나무 (*S. alnifolia*)	156
굴피나무 (*P. strobilacea*)	772	들메나무 (*F. mandshurica*)	152
서어나무 (*C. laxiflora*)	742	대팻집나무 (*I. macropoda*)	134
때죽나무 (*S. japoncus*)	738	신나무 (*A. tataricum*)	132
층층나무 (*C. controversa*)	623	은사시나무 (*P. tomentiglandulosa*)	131
산뽕나무 (*M. bombycis*)	573	개서어나무 (*C. tschonskii*)	130
고로쇠나무 (*A. pictum*)	569	말채나무 (*C. walteri*)	130
느릅나무 (*U. davidiana*)	549	노각나무 (*S. pseudocamellia*)	116
당단풍나무 (*A. pseudosieboldianum*)	411	고욤나무 (*D. lotus*)	111
피나무 (*T. amurensis*)	402	개벚나무 (*P. verecunda*)	109
비목나무 (*L. erythrocarpa*)	385	까치박달 (*C. cordata*)	109

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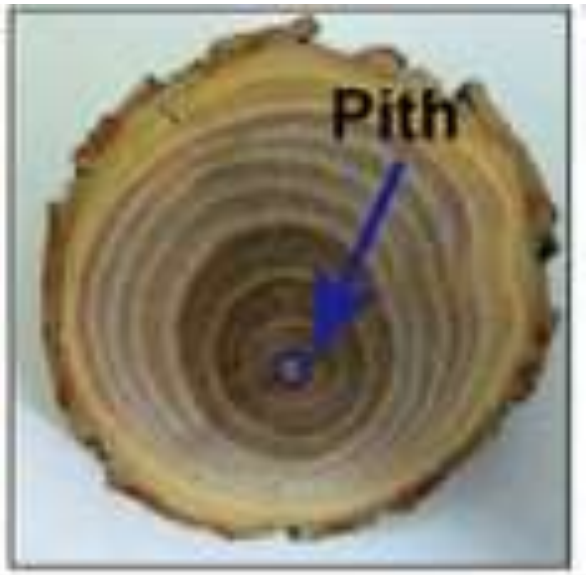
(***Quercus acutissima***)

Data screening

Tree-ring eccentricity data

Sampling plots known to have had anthropogenic disturbance

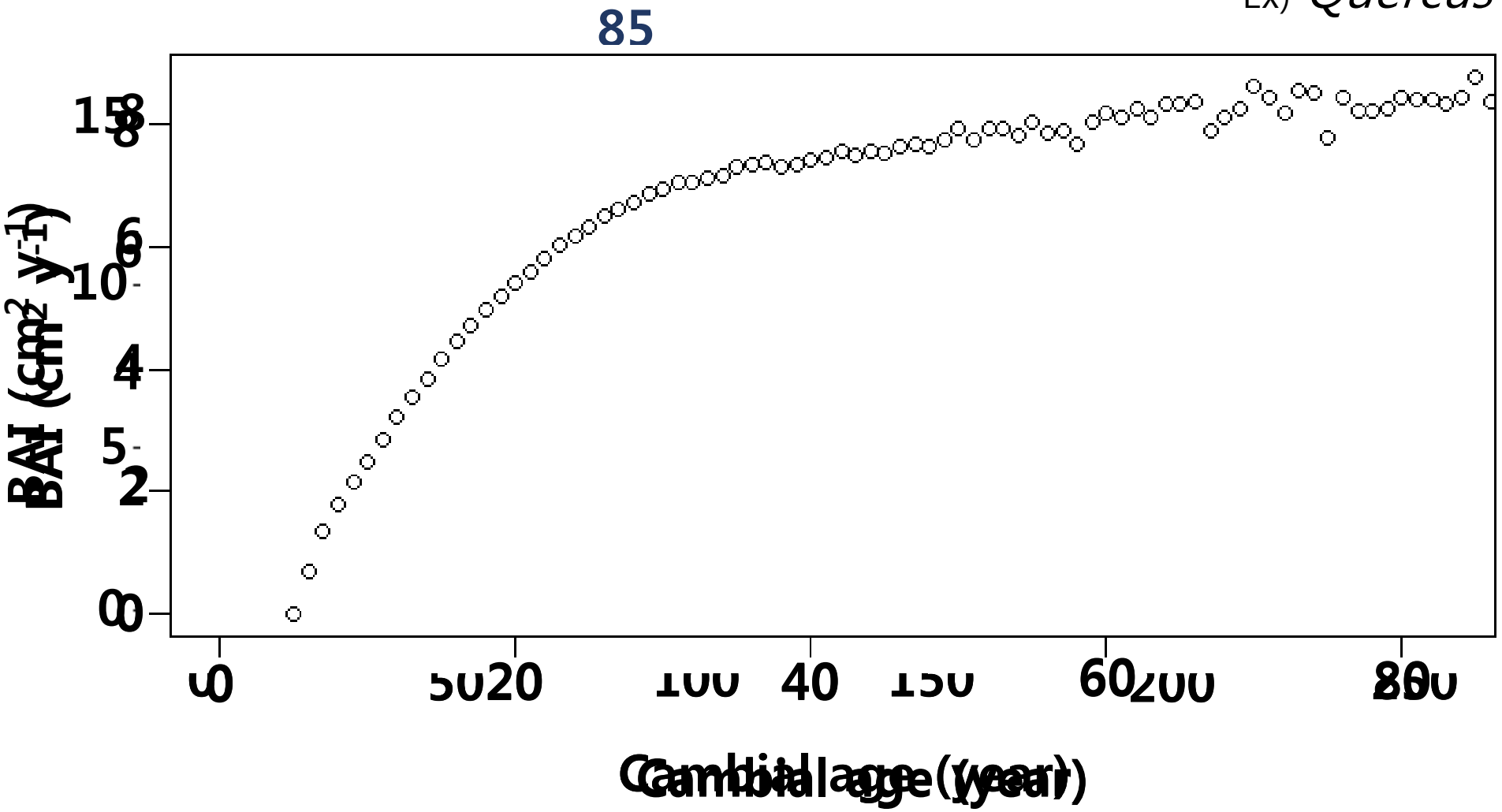


(Source: Zhiwu Han, 2013)

Species' regional curve(RC)

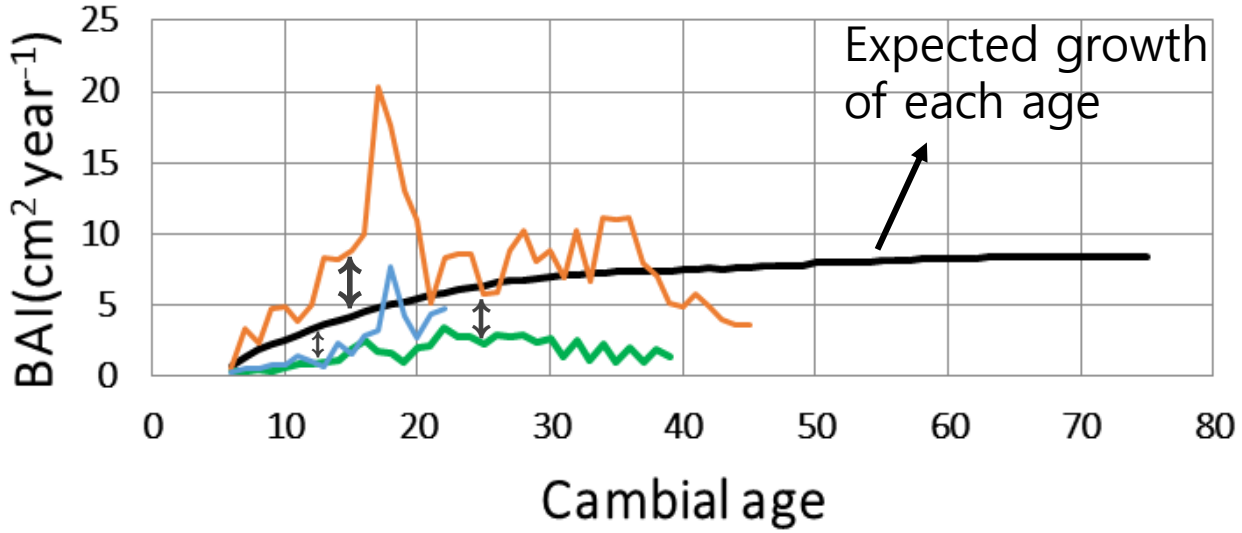
The mean basal area increment(BAI) as a function of age

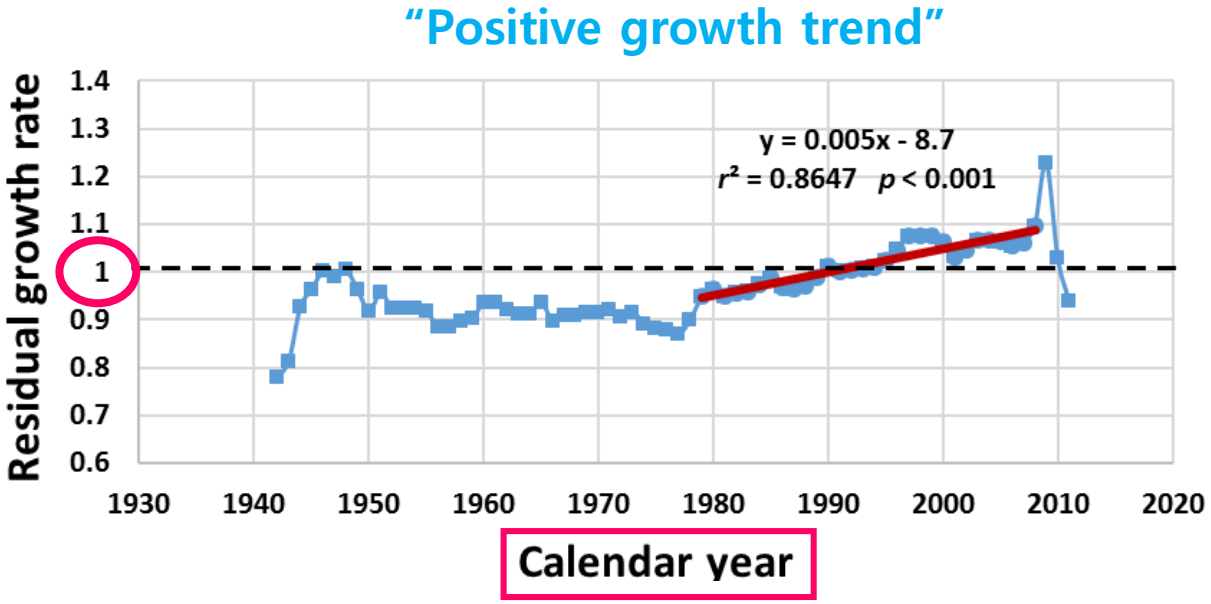
Ex) *Quercus mongolica*



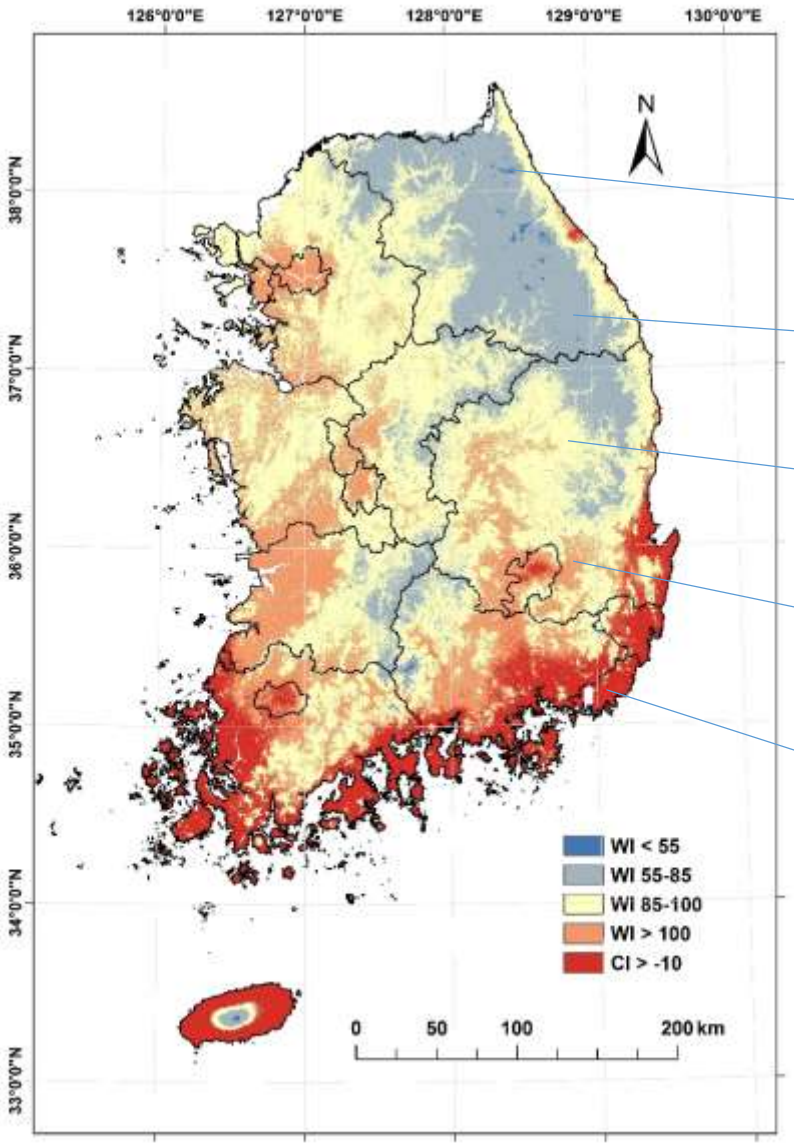
Detrending and Trend analysis

Ex) *Quercus mongolica*





Classification of 5 forest climate zones by Warmth Index (WI) and Coldness(CI)(Yim and Kira, 1975)



Boreal Zone

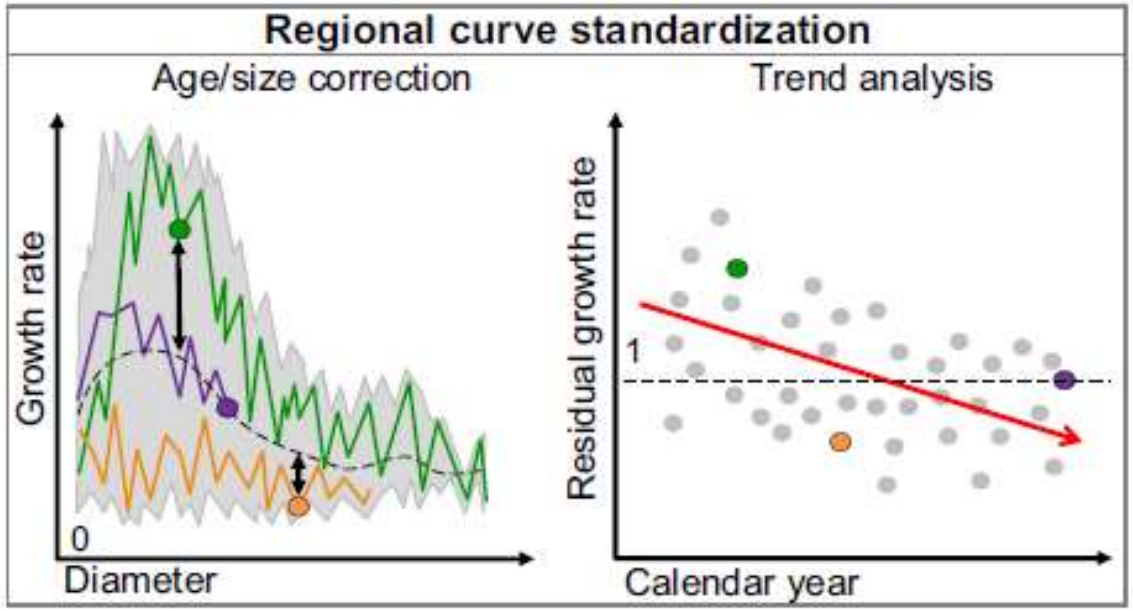
Northern Temperate Zone

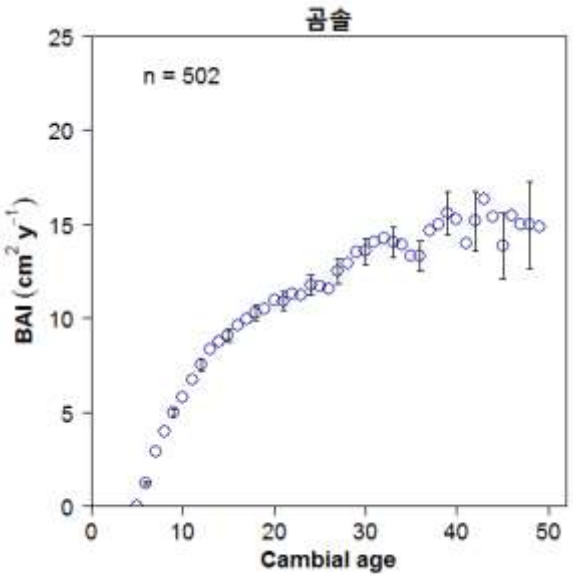
Middle Temperate Zone

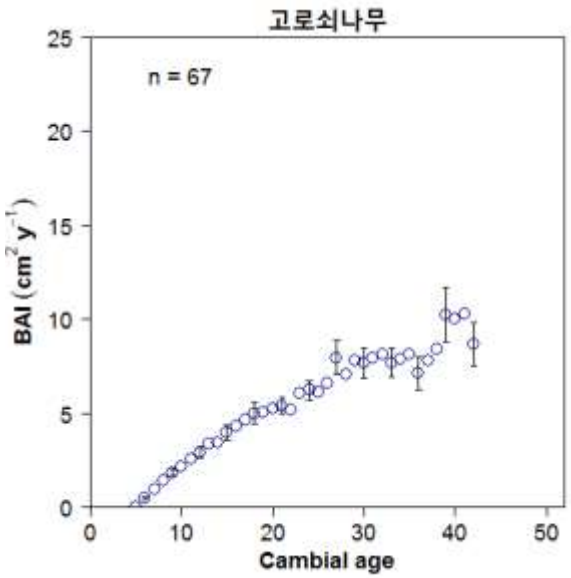
Southern Temperate Zone

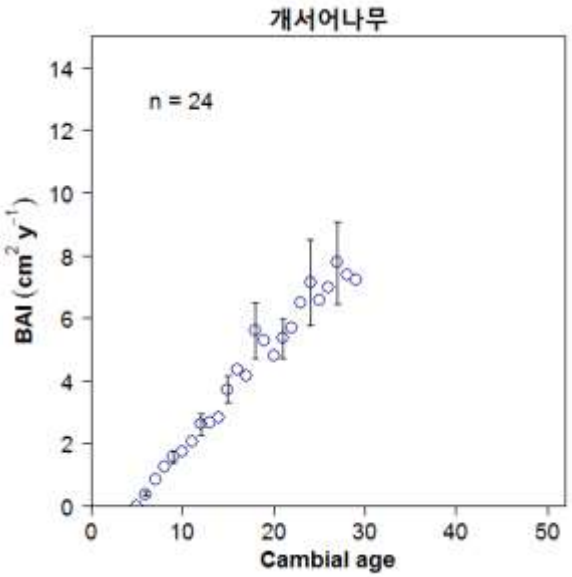
Warm Climate Zone

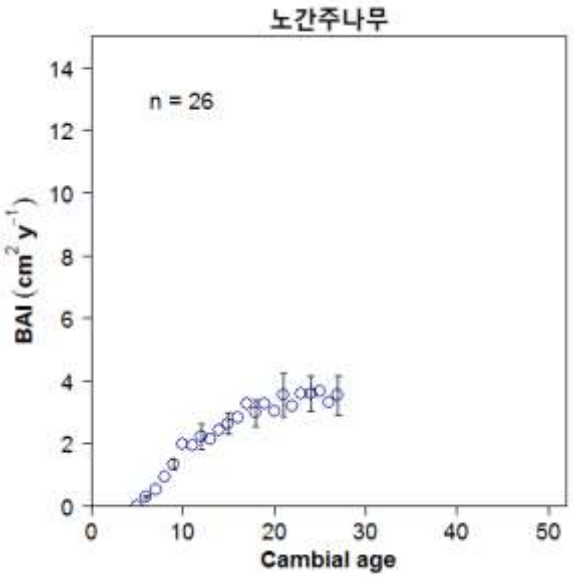
Result

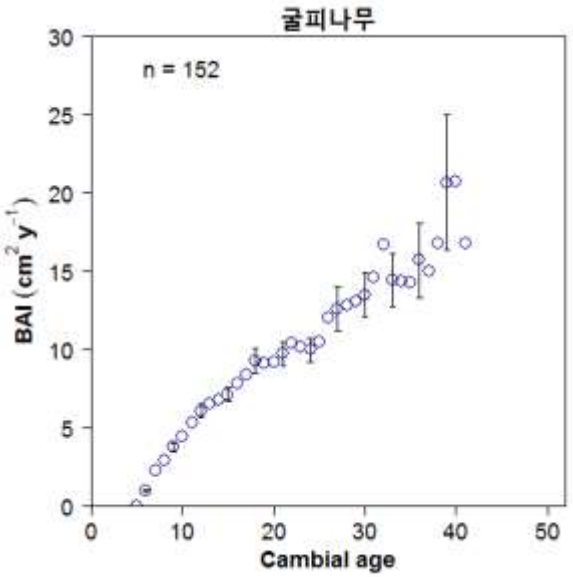

Regional curve standardization
Age/size correction
Trend analysis
Growth rate
0
Diameter
Residual growth rate
1
Calendar year

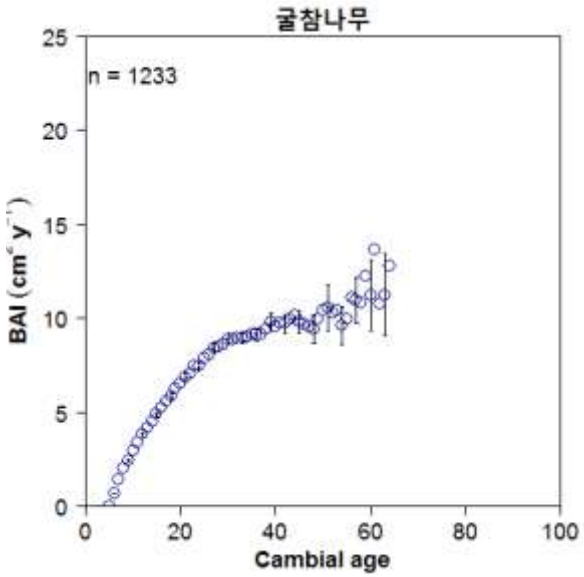

곰솔
n = 502
BAI (cm² y⁻¹)
Cambial age


고로쇠나무
n = 67
BAI (cm² y⁻¹)
Cambial age

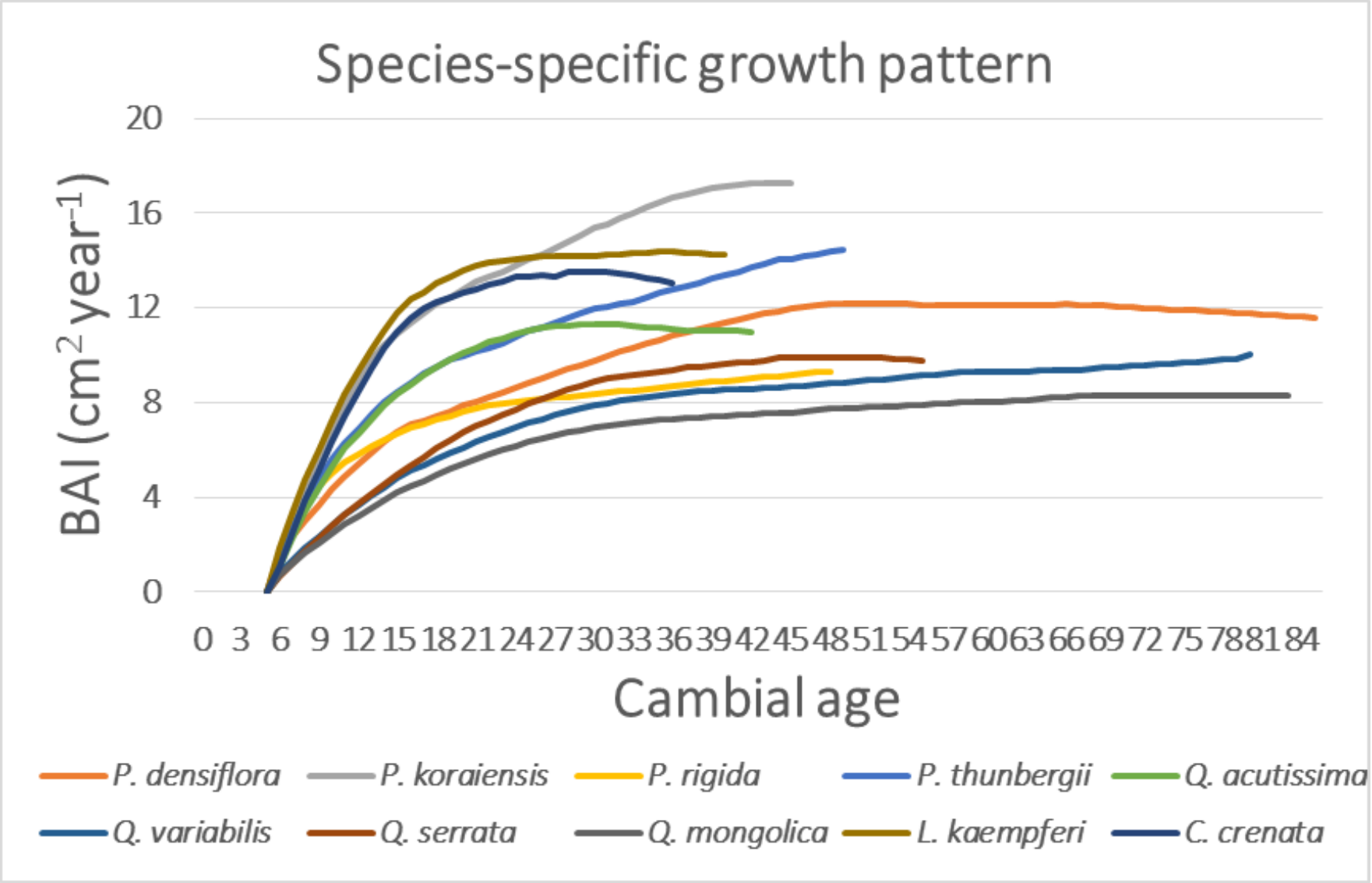

개서어나무
n = 24
BAI (cm² y⁻¹)
Cambial age


노간주나무
n = 26
BAI (cm² y⁻¹)
Cambial age

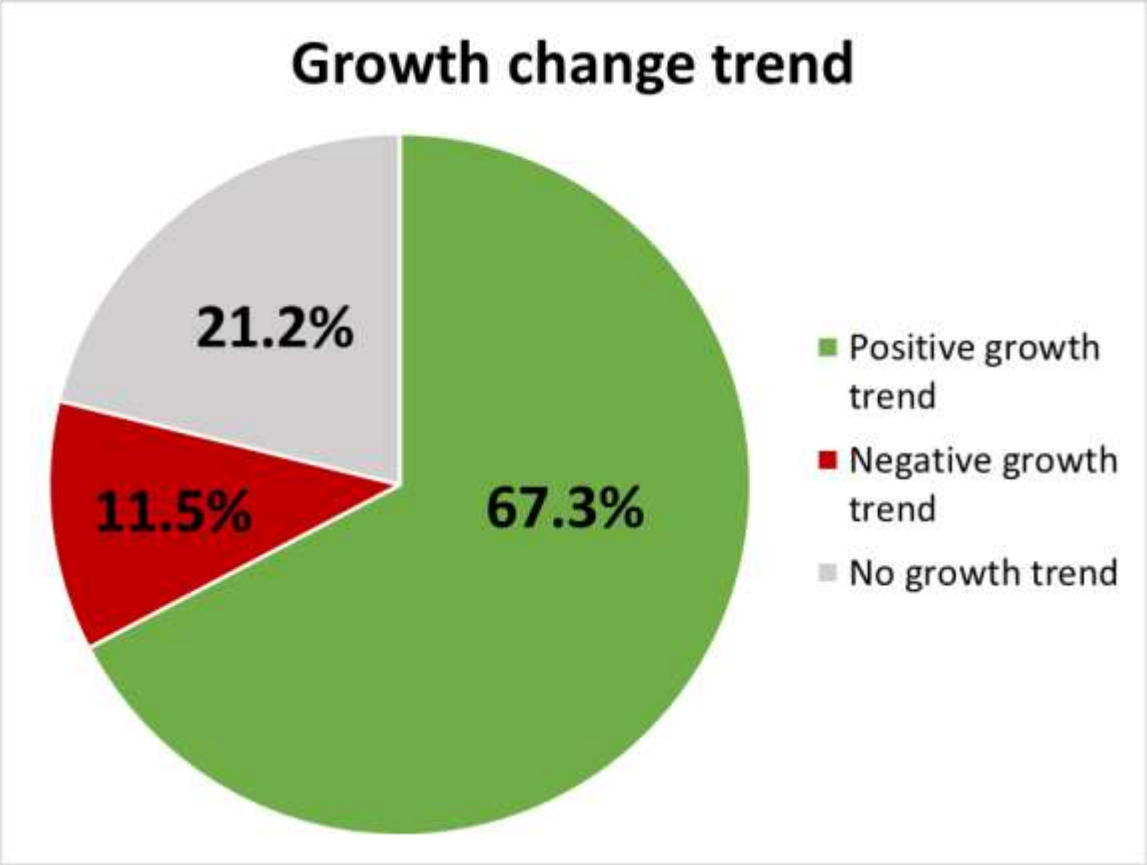

굴피나무
n = 152
BAI (cm² y⁻¹)
Cambial age


굴참나무
n = 1233
BAI (cm² y⁻¹)
Cambial age

Result

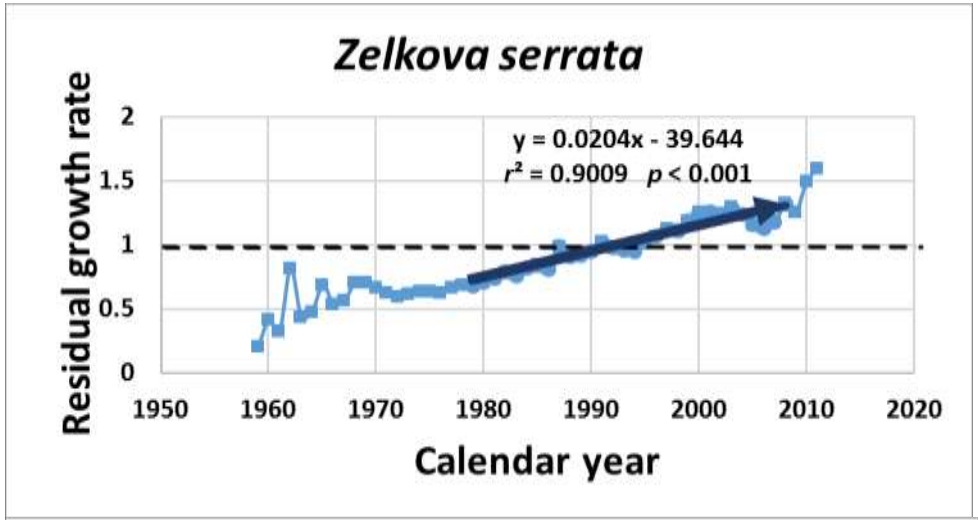

Species-specific growth pattern
BAI (cm2 year-1)
20
16
12
8
4
0
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84
Cambial age
P. densiflora
P. koraiensis
P. rigida
P. thunbergii
Q. acutissima
Q. variabilis
Q. serrata
Q. mongolica
L. kaempferi
C. crenata

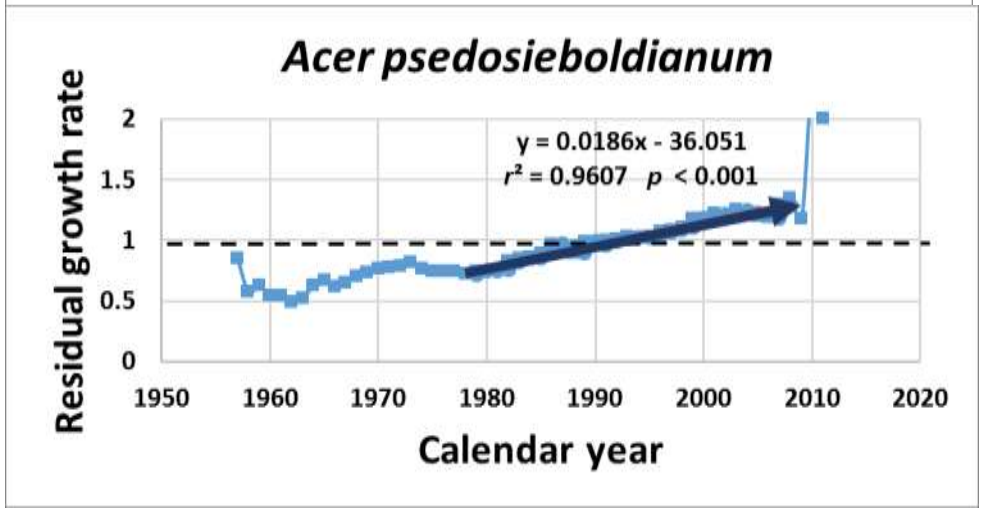
Tree species' recent growth trend(1979-2009)



52 species
(+) : 35 species, (-) : 6 species, (0) : 11 species

Positive growth trend

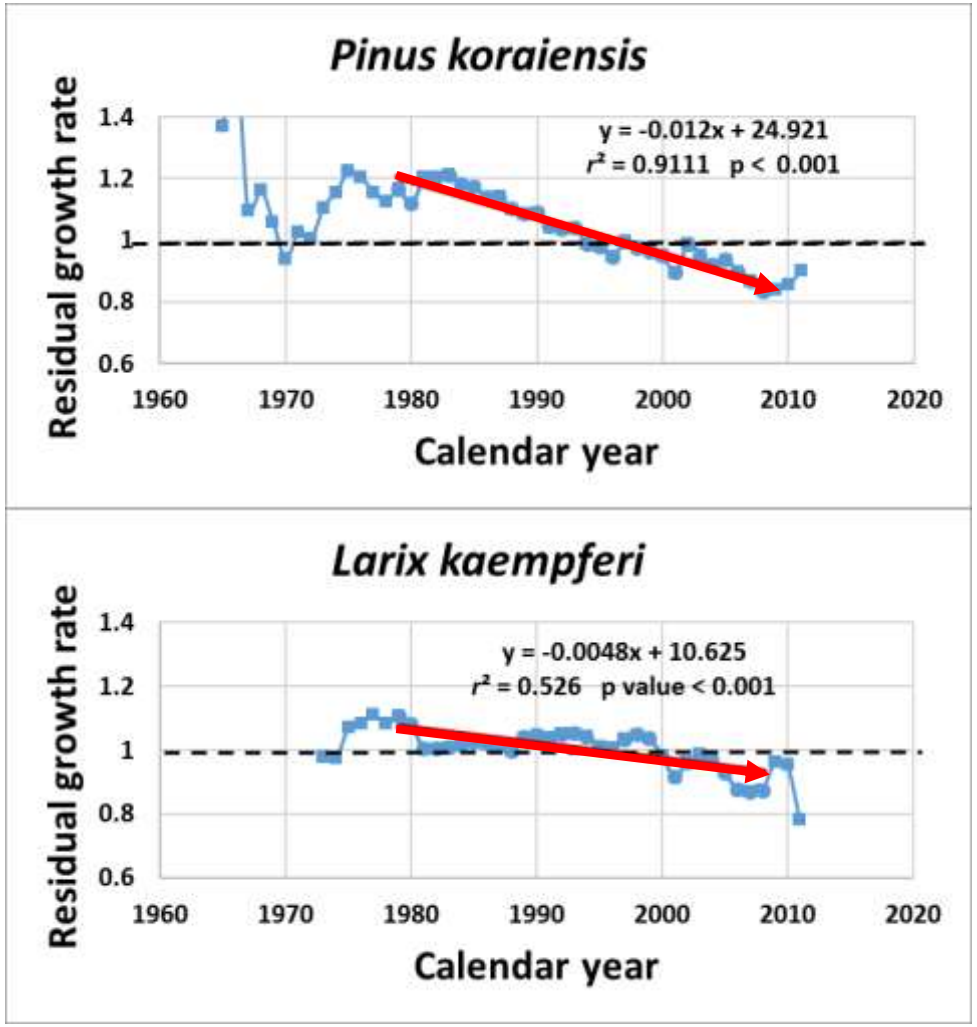




"Growth pattern for last 30 years"
2009, 2010, 2011 are excluded
due to the decrease of sample #

species	slope	species	slope
Z. serrata	0.0204 ***	*A. firma*	0.0070 **
A. pseudosieboldianum	0.0186 ***	*C. controversa*	0.0068 ***
A. tataricum	0.0182 ***	*M. amurensis*	0.0065 ***
C. sinensis	0.0181 ***	*S. japoncus*	0.0057 ***
M. bombycis	0.0166 ***	*D. lotus*	0.0055 **
J. rigida	0.0131 ***	*B. davurica*	0.0053 ***
R. pseudoacacia	0.0116 ***	*S. alnifolia*	0.0052 ***
I. macropoda	0.0107 ***	*C. japonica*	0.0051 *
P. strobilacea	0.0105 ***	*C. cordata*	0.0051 ***
F. mandshurica	0.0104 ***	*Q. acutissima*	0.0051 ***
C. crenata	0.0102 ***	*Q. mongolica*	0.0048 ***
P. tomentiglandulosa	0.0101 ***	*Q. serrata*	0.0047 ***
L. erythrocarpa	0.0097 ***	*Q. variabilis*	0.0046 ***
F. rhynchophylla	0.0096 ***	*T. amurensis*	0.0041 ***
S. obassia	0.0089 ***	*B. schmidtii*	0.0039 ***
C. tschonskii	0.0079 ***	*A. pictum*	0.0034 ***
S. koreensis	0.0078 ***	*U. davidiana*	0.0021 ***
C. laxiflora	0.0073 ***		

Negative growth trend

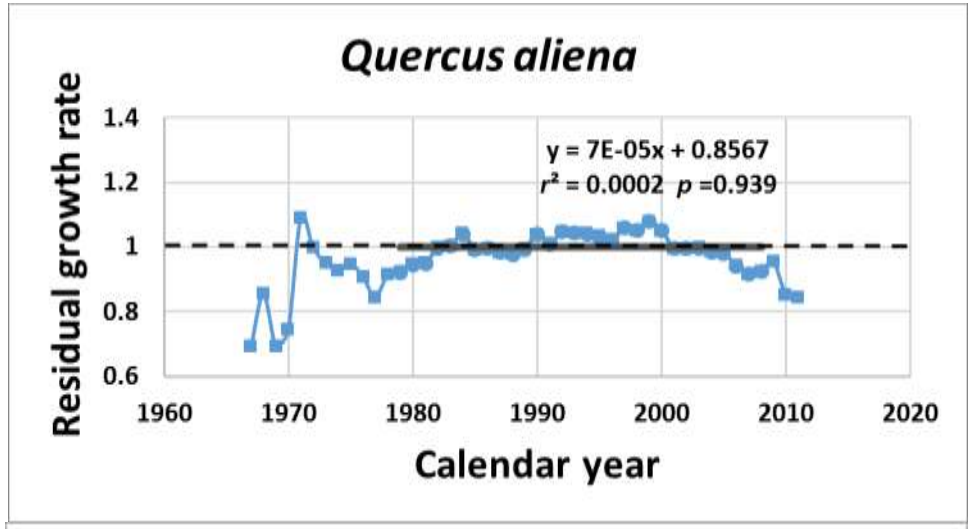


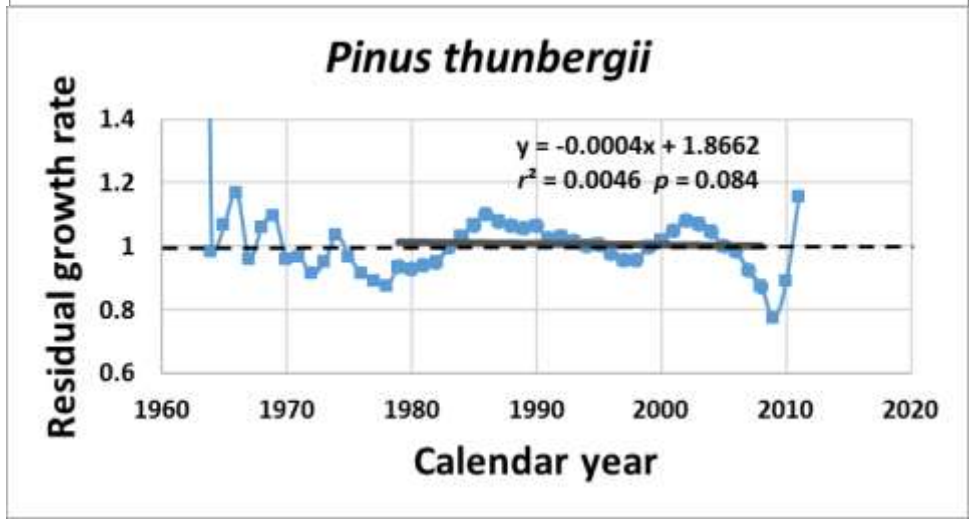
species	slope
P. koraiensis	-0.0120 ***
L. kaempferi	-0.0048 ***
P. rigida	-0.0043 ***
S. pseudocamellia	-0.0023 *
P. densiflora	-0.0052 ***

"Growth pattern for last 30 years"

2009, 2010, 2011 are excluded
due to the decrease of sample #

No growth trend



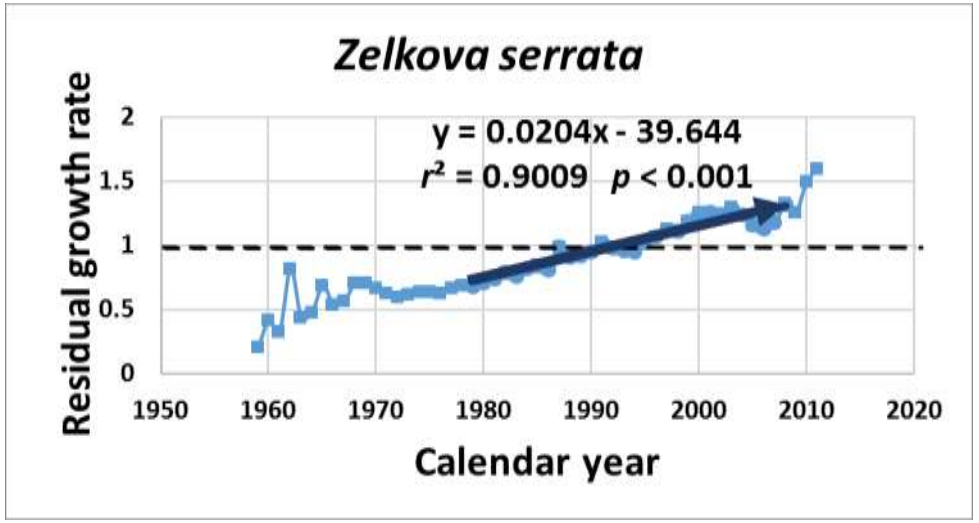


species	slope	*p* value
A. julibrissin	0.0038	0.063
C. walteri	0.0026	0.092
P. verecunda	0.0014	0.249
J. mandshurica	0.0013	0.079
A. sibirica	0.0010	0.402
P. sargentii	0.0007	0.298
Q. aliena	0.0001	0.939
C. obtusa	-0.0102	0.722
T. mandshurica	-0.0008	0.270
Q. dentata	-0.0008	0.432
P. thunbergii	-0.0004	0.084

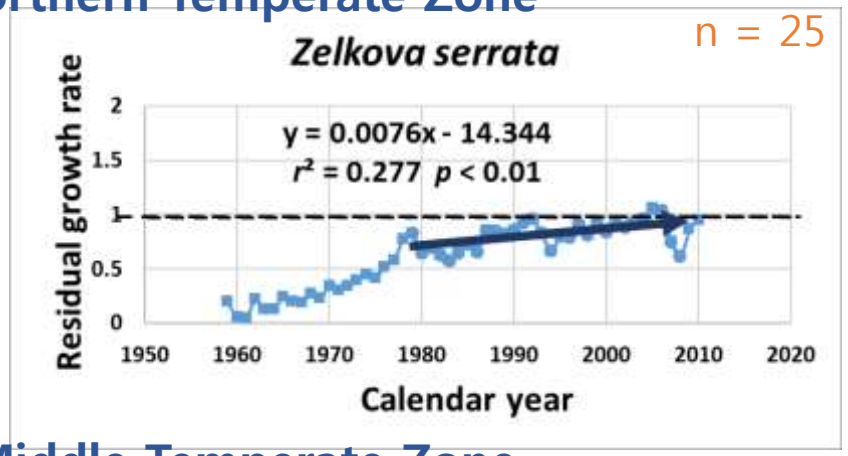
"Growth pattern for last 30 years"

2009, 2010, 2011 are excluded
due to the decrease of sample #

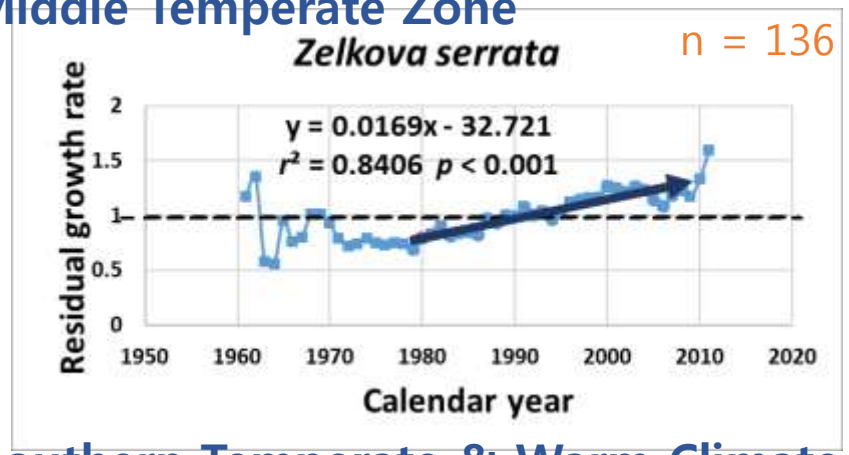
Positive growth trend



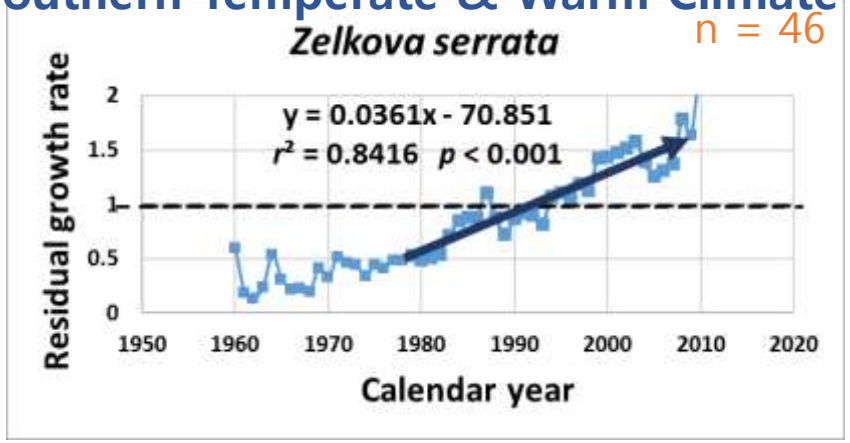
Northern Temperate Zone



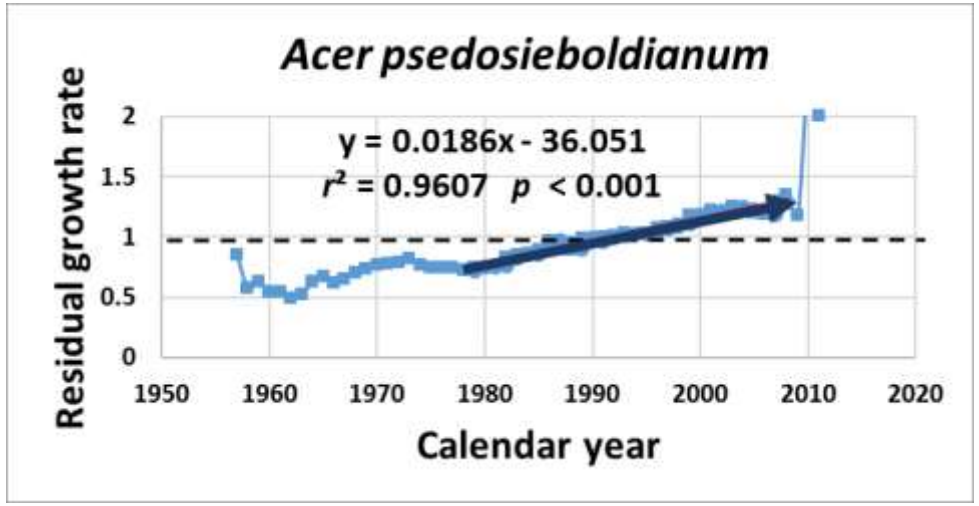
Middle Temperate Zone



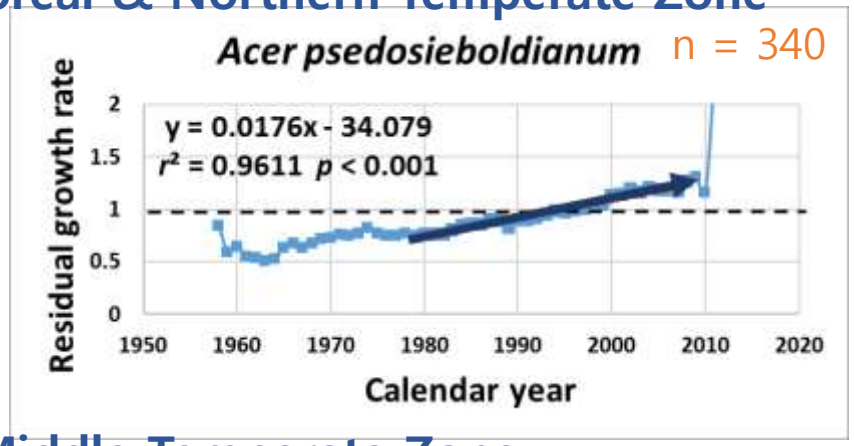
Southern Temperate & Warm Climate Zone



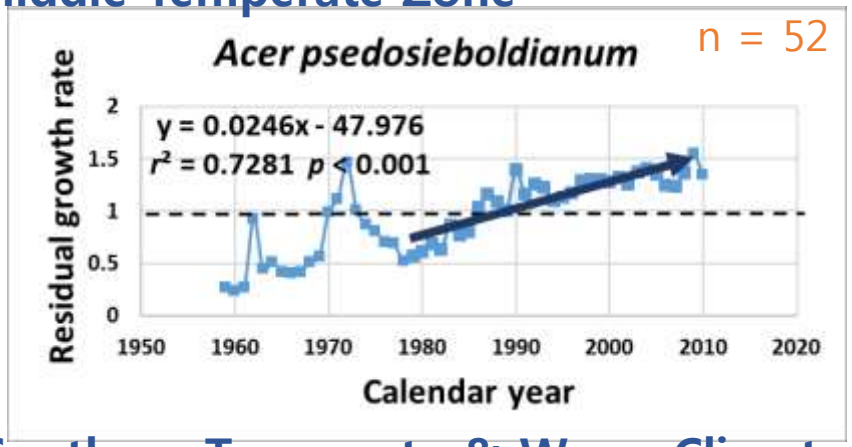
Positive growth trend



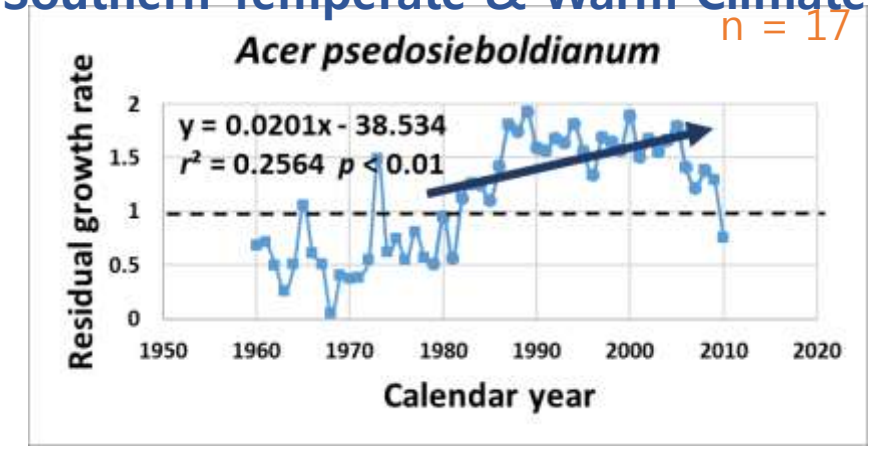
Boreal & Northern Temperate Zone



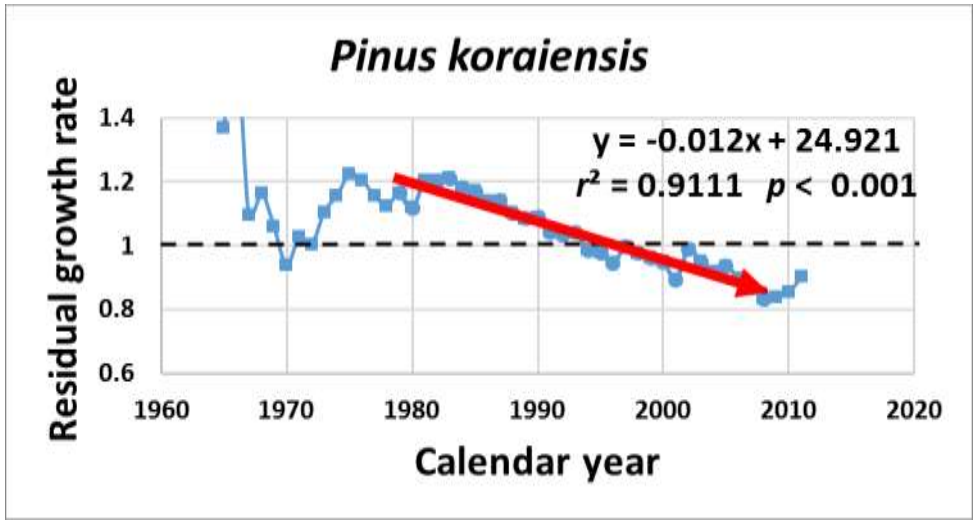
Middle Temperate Zone



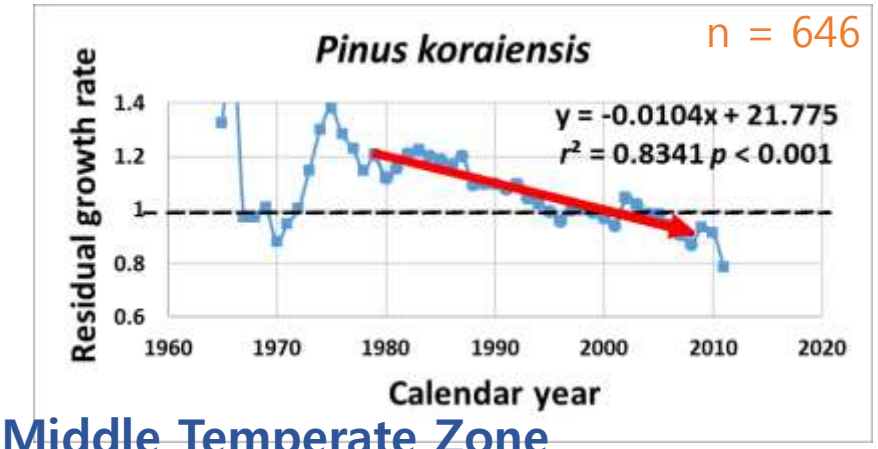
Southern Temperate & Warm Climate Zone



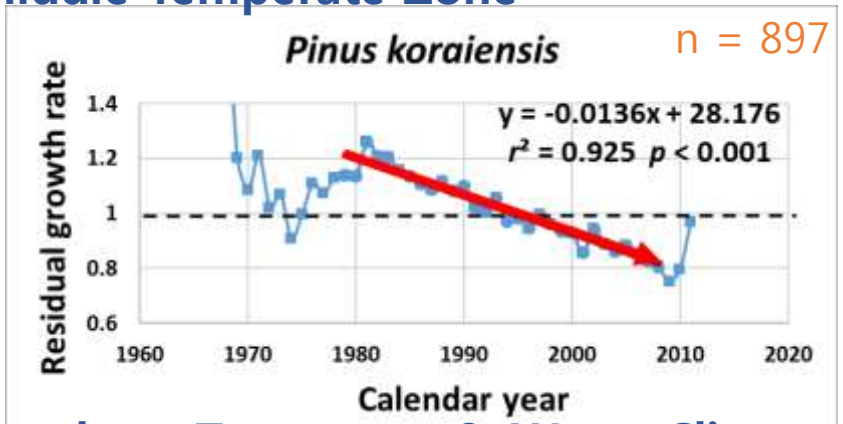
Negative growth trend



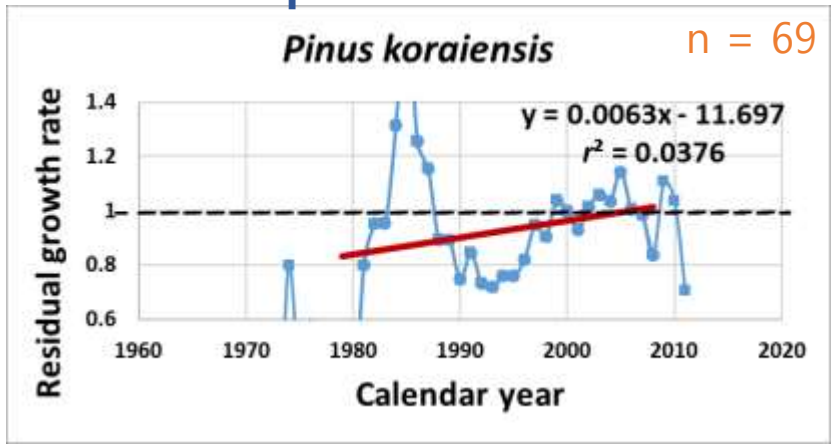
Boreal & Northern Temperate Zone



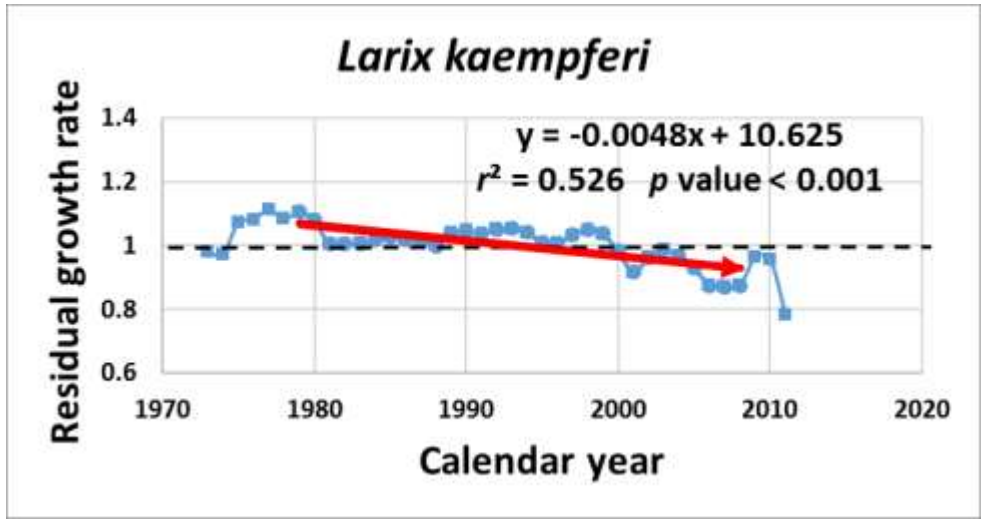
Middle Temperate Zone



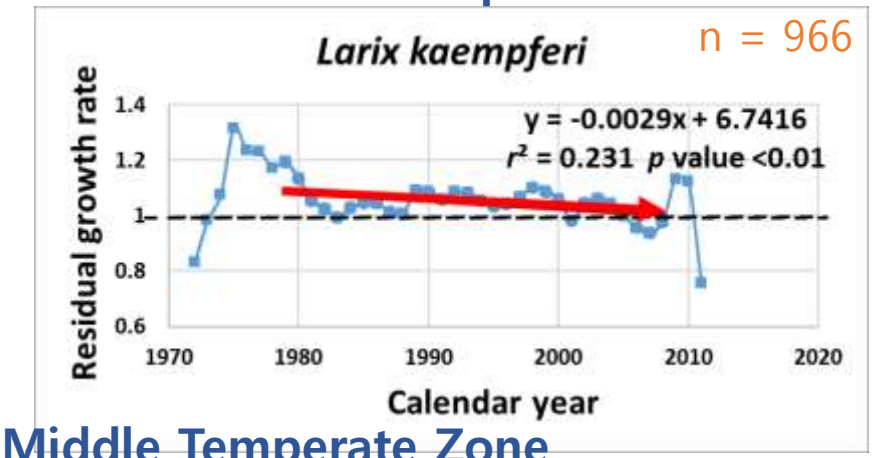
Southern Temperate & Warm Climate Zone



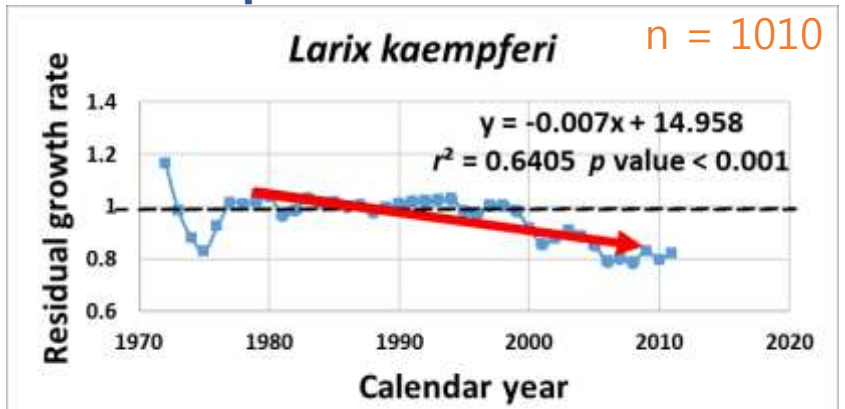
Negative growth trend



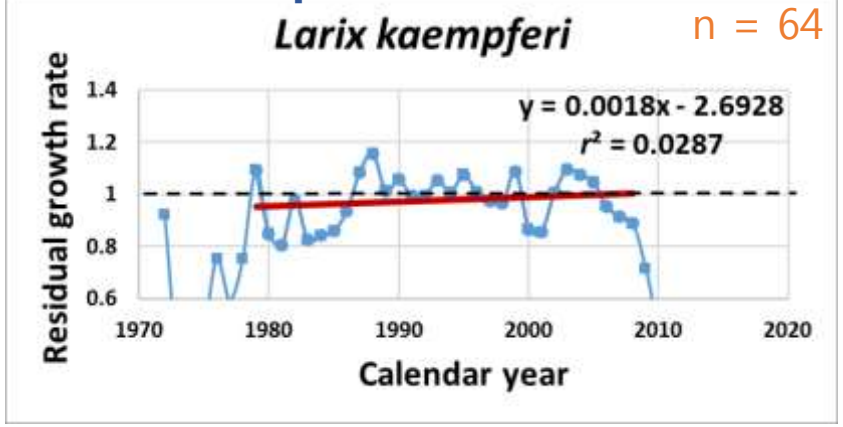
Boreal&Northern Temperate Zone



Middle Temperate Zone



Southern Temperate&Warm Climate Zone



Summary

Among 52 Korean species

- 67.3%; (+) trend (*Z. serrata*, *Quercus* species, *F. mandshurica* etc.)
- 11.5%; (-) trend (*L. kaempferi*, *P. koraiensis*, *P. densiflora* etc.),
- 21.5%; no trend **(***Q. aliena, P. thunbergii* etc.)

- Species growth trend was different along climate zones

Therefore it is important to investigate the response of growth trend to environmental factors.

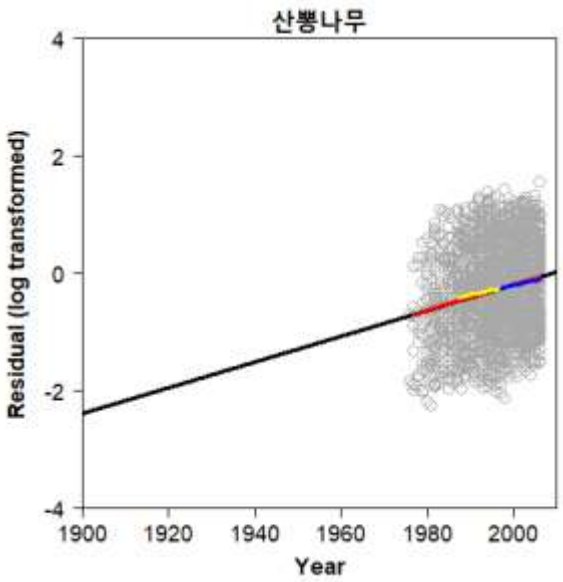
- This result can provide tree species' growth characteristic information as one of selection standards for plantation

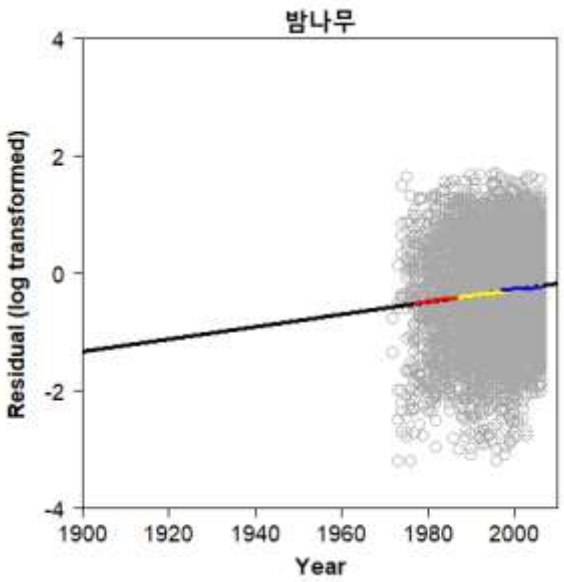
- In the future study, we need to find relationships b/t each species' functional trait and environmental variables

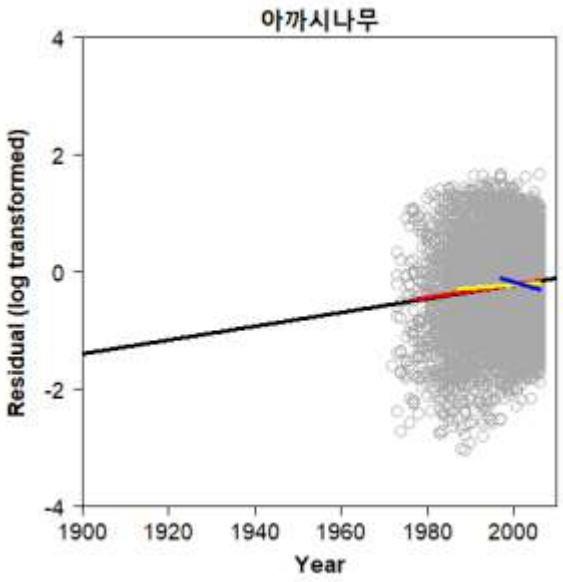
Thank you very much

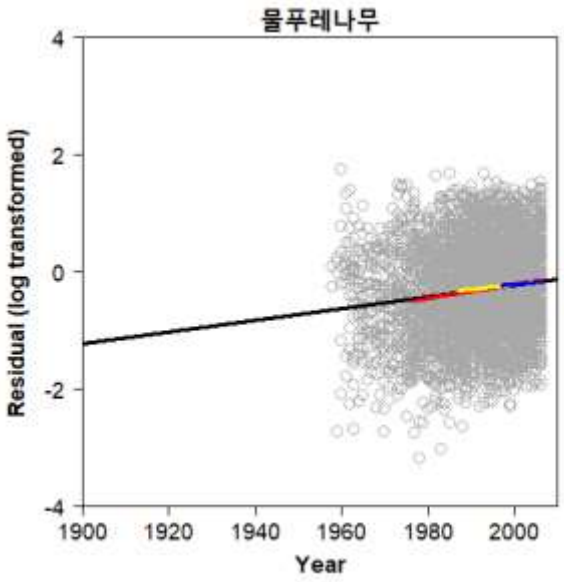
The primary funding for this study was provided by the Korea Forest Service
(project number: S211315L020120)

Positive growth trend



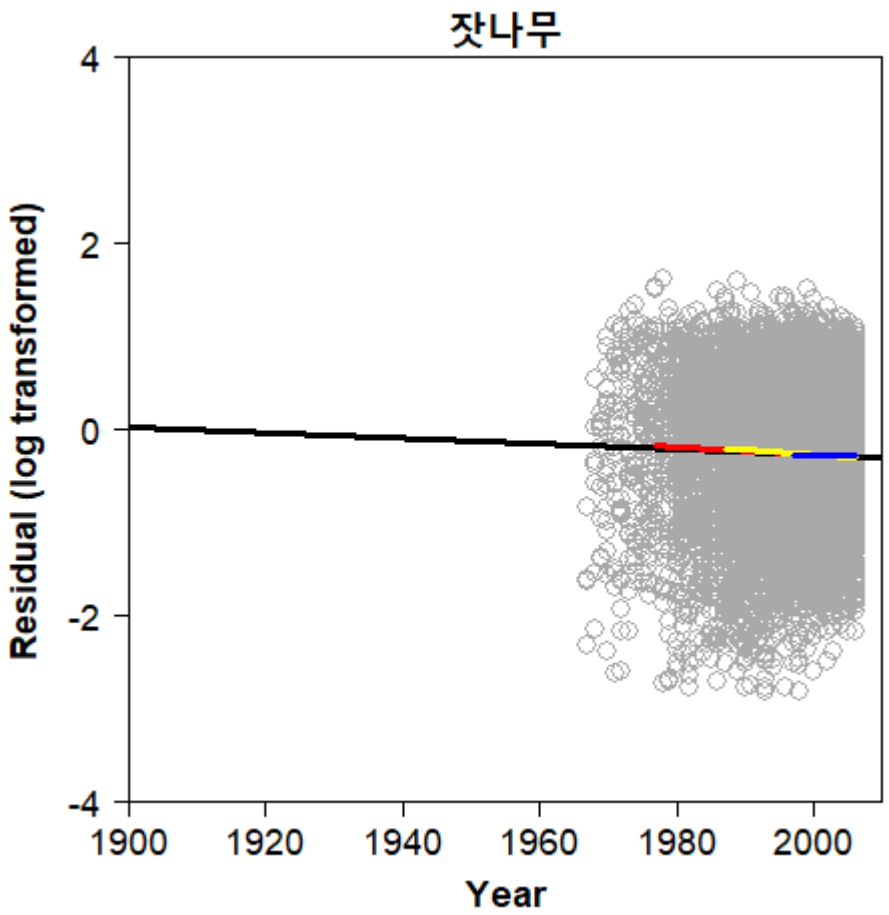






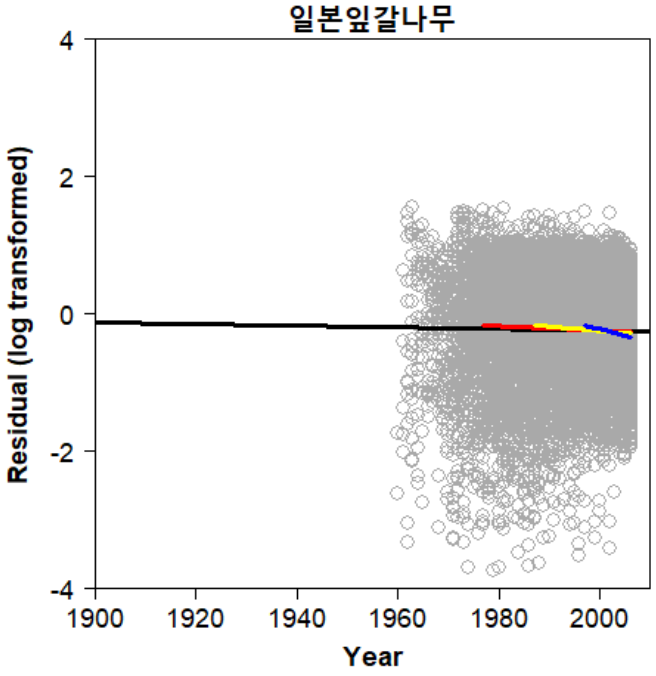
species	slope	Species	slope
신나무	0.0443 ***	밤나무	0.0106 ***
편백	0.0315 ***	상수리나무	0.0104 ***
예덕나무	0.0307 ***	물푸레나무	0.0101 ***
다릅나무	0.0253 ***	졸참나무	0.0101 ***
함박꽃나무	0.0252 ***	삼나무	0.0095 **
느티나무	0.0245 ***	느릅나무	0.0091 ***
당단풍나무	0.0234 ***	사방오리	0.0088 ***
비목나무	0.022 ***	팽나무	0.0088 ***
산뽕나무	0.0219 ***	굴피나무	0.0082 ***
버드나무	0.0213 ***	개서어나무	0.0078 *
쪽동백나무	0.0212 ***	피나무	0.0078 **
층층나무	0.0188 ***	물박달나무	0.0074 *
팥배나무	0.0187 ***	서어나무	0.0066 ***
대팻집나무	0.0164 ***	고로쇠나무	0.0062 ***
말채나무	0.0147 ***	박달나무	0.0055 *
은수원사시나무	0.014 *	굴참나무	0.0054 ***
들메나무	0.014 ***	신갈나무	0.0041 ***
자귀나무	0.0137 **	산벚나무	0.0036 ***
아까시나무	0.0117 ***	소나무	0.003 ***
개벚나무	0.0114 **	곰솔	0.0027 ***
때죽나무	0.0109 ***		

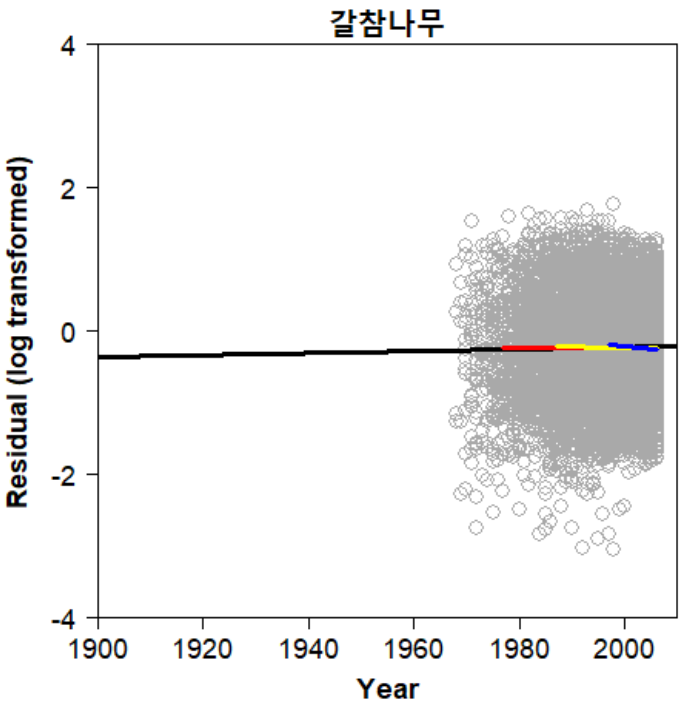
Negative growth trend



species	slope
P. koraiensis	-0.003 ***

No growth trend





species	Slope	*p* value
일본잎갈나무	-0.001	0.095
리기다소나무	-0.0007	0.263
가래나무	-0.0003	0.908
떡갈나무	0.0007	0.597
갈참나무	0.001	0.189
찰피나무	0.004	0.457
물오리나무	0.004	0.115
노간주나무	0.009	0.007