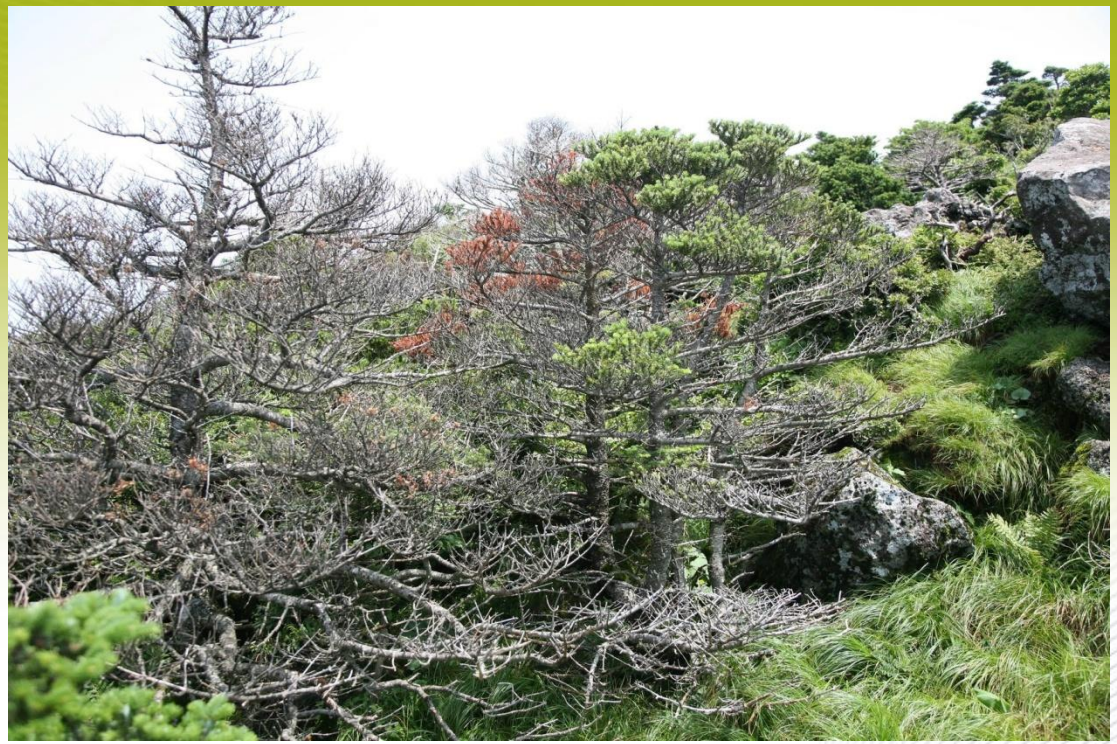
Decline of Evergreen Coniferous Forests Due to Global Warming in Korea



J-H Lim, JH Shin and SK Kim

Korea Forest Research Institute

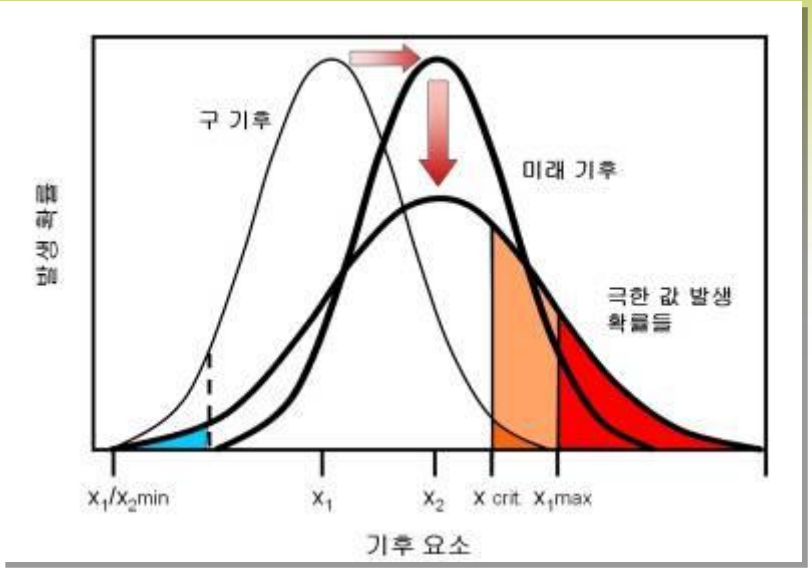
Related On-going Research Project

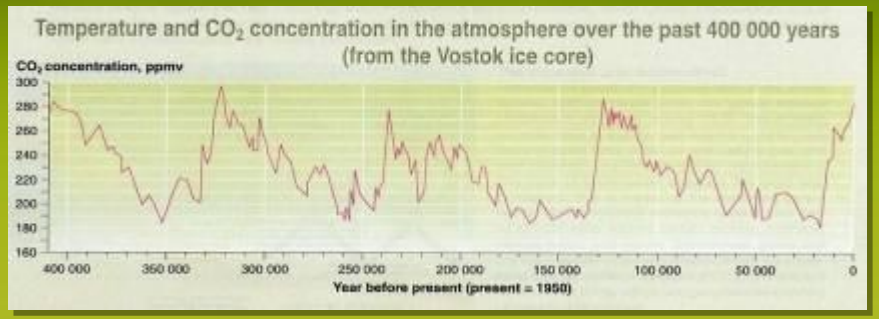
- Long-term monitoring of forest ecosystems (1995-)
- Climate change impacts on forest ecosystem and adaptation (2009-2014)

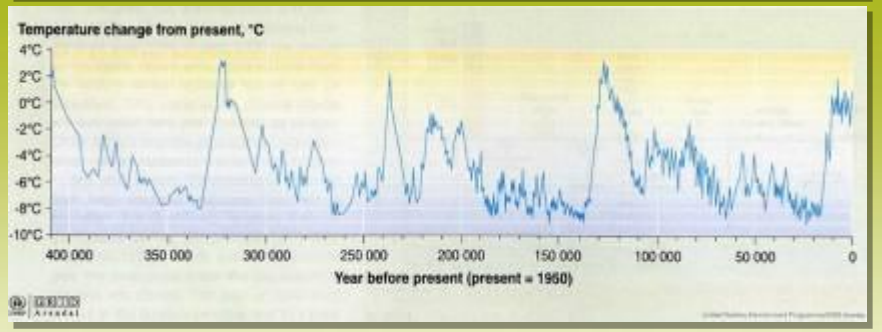
Climate Change

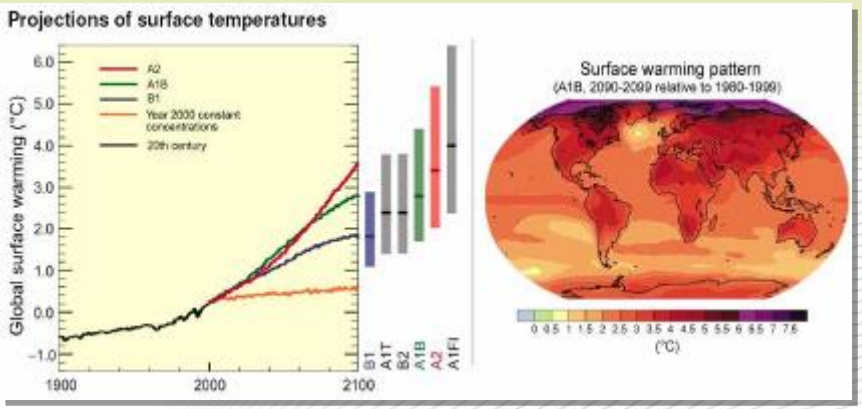
- Global warming and GHG
- Natural vs. Anthropogenic
- Air temp & precipitation changes
  + Atmospheric CO2 concentration
  + Other pollutants

Seasonal pattern change,
Abnormal Extreme events



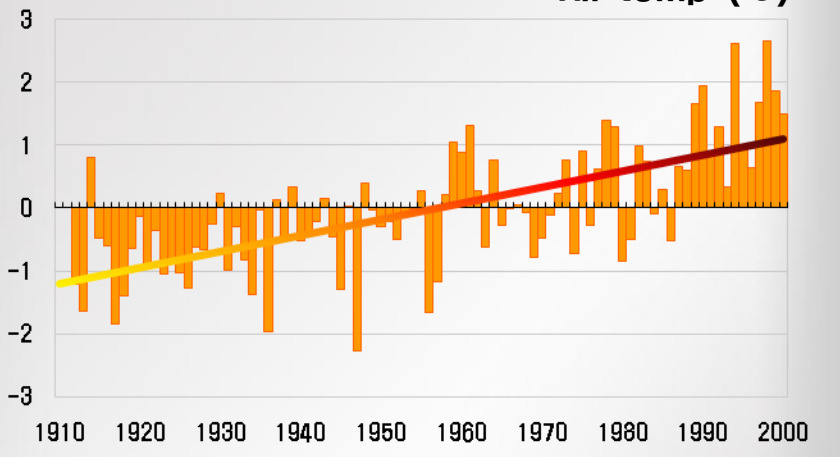




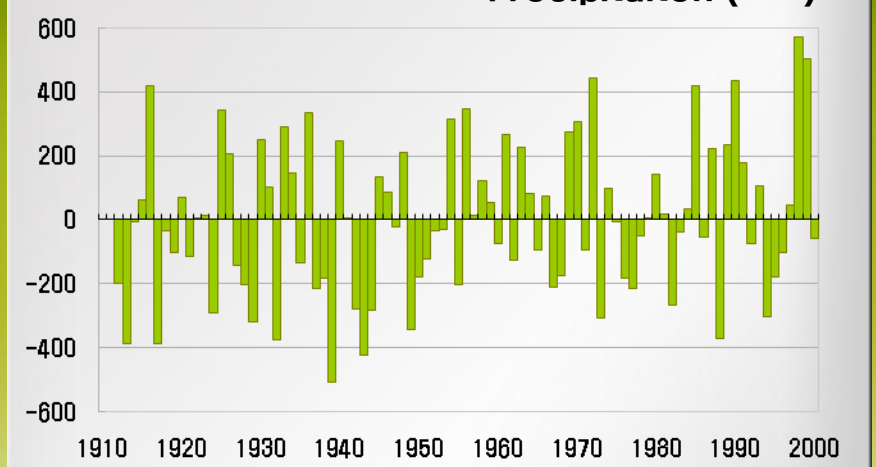


IPCC, 2007

Climate Change in Korea (1912~2005)



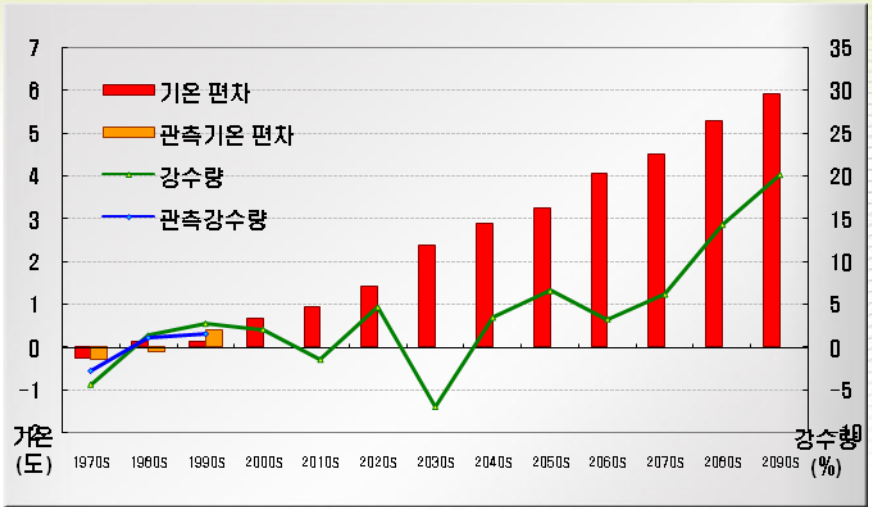
- 1.5℃ increase (winter > summer), urbanization effect: 20–30%
- No. of tropical nights: 1.4 days/yr. increase



- Decreased rainy days,
- Increased prep. 10%, (summer 18%)
- Increased flood hazards

Future senarios

- Temp. increase up to 1.1–6.4℃
  winter > summer
- Precipitation increase
  winter < summer



KMA, 2004

- Global warming is speed up in 20th and 21st century

- Forest ecosystems are already affected by climate change

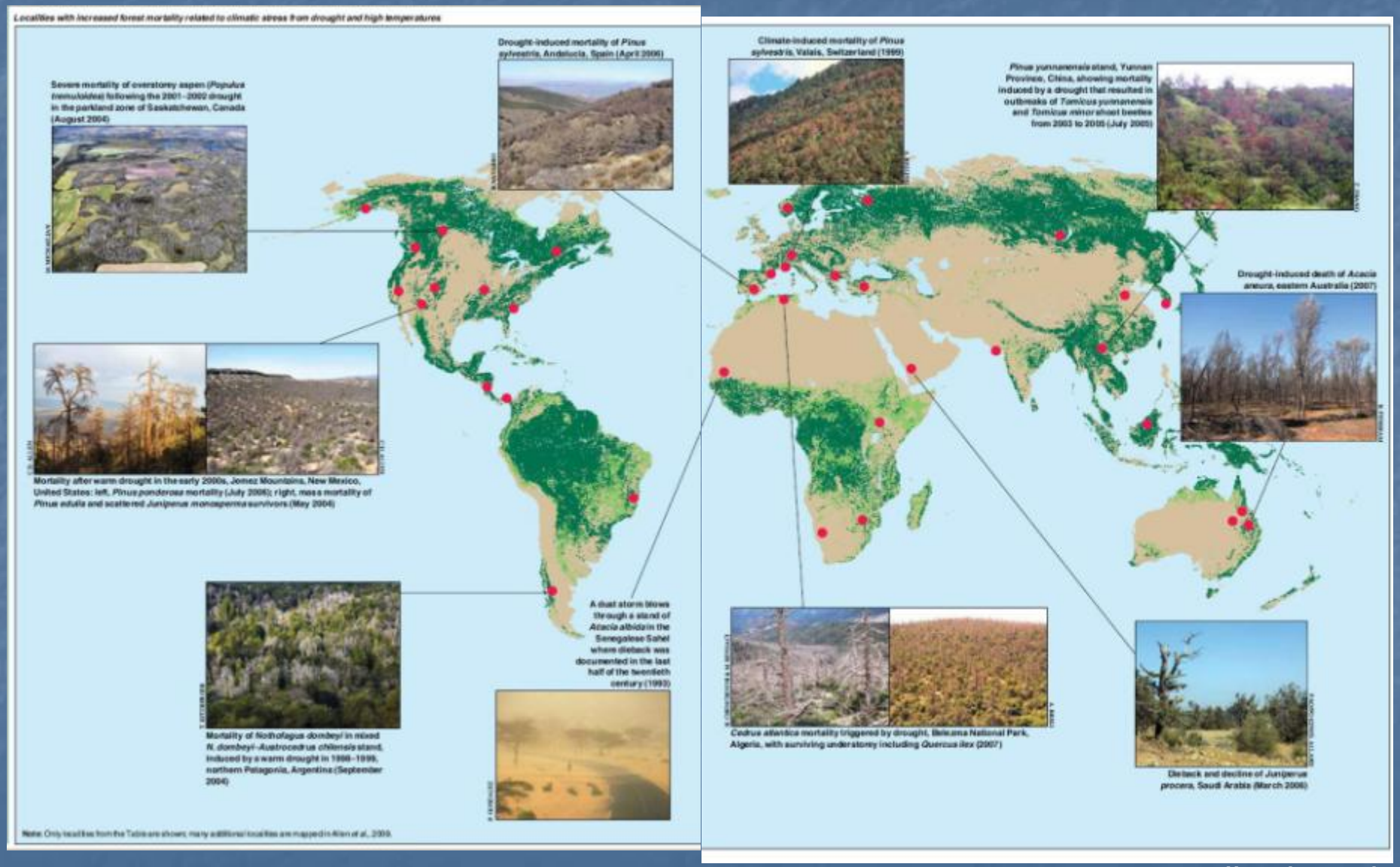
  - species range shift, phenology, NPP,….

- Recent increase of background mortality

  - Western North America (Mantgem *et al*. 2009, Science)

    High temp. + drought + biotic agent

Forest dieback is occurring at the diverse forest types globally



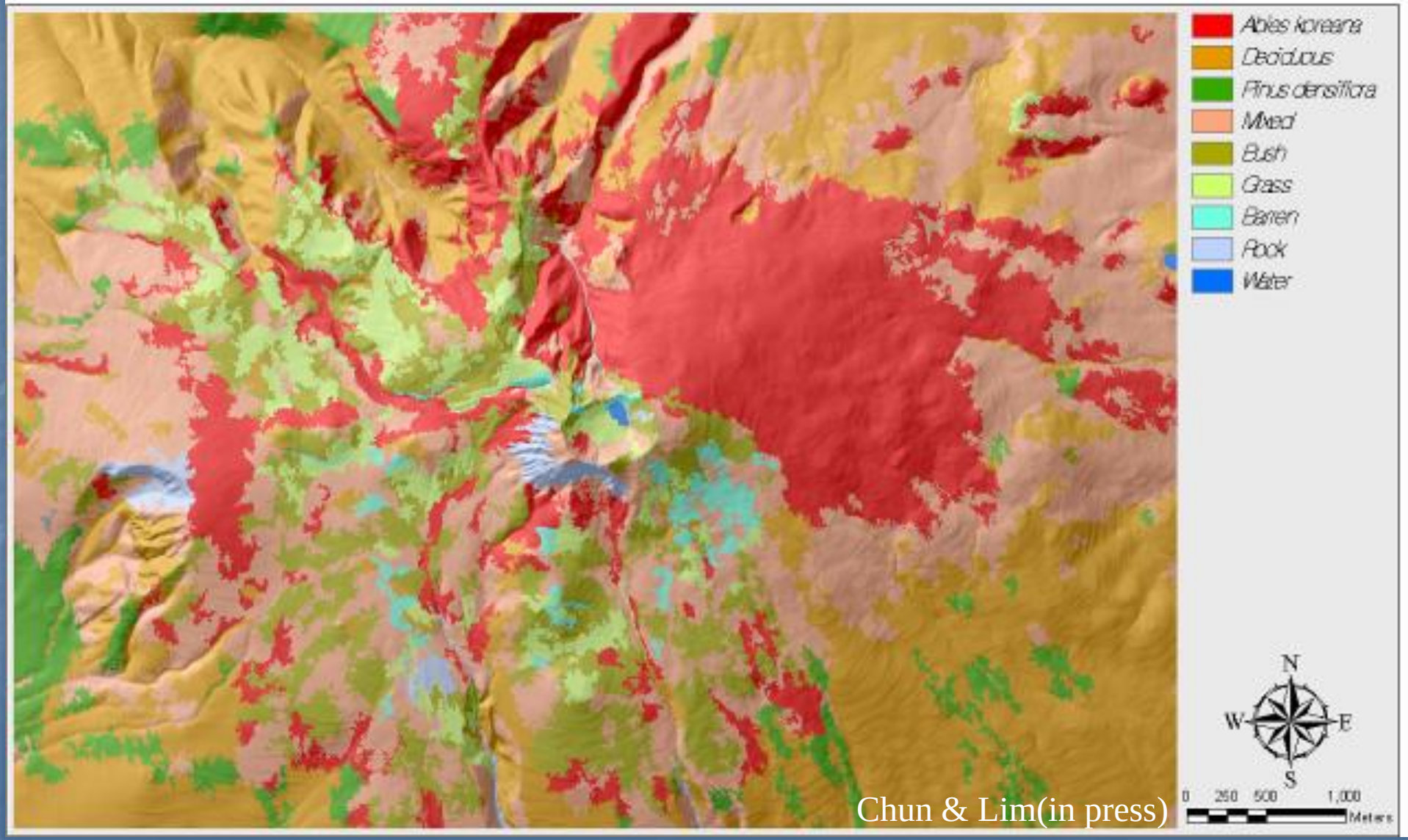
Allen(2009)

Korean fir (*Abies koreana*)

- Endemic in Korea
- 4 types (forma) by cone colors
- Valuable for ornamental use
- Genetically diversified from *A.nephrolepis*
- Distributed at high mountains in S.Korea including Mts. Halla, Jiri, Dukyu, Gaya
- 1,400-1,900m a.s.l in Mt. Halla

Vegetation Map of Mt. Halla

(IKONOS based classification)

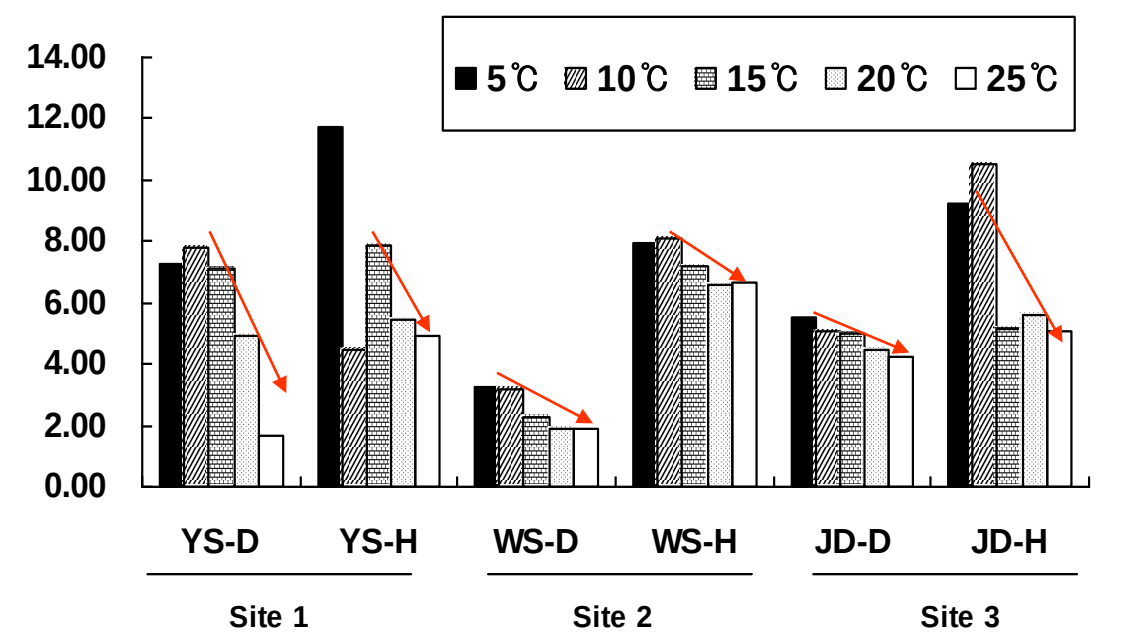



건전
쇠약
고사

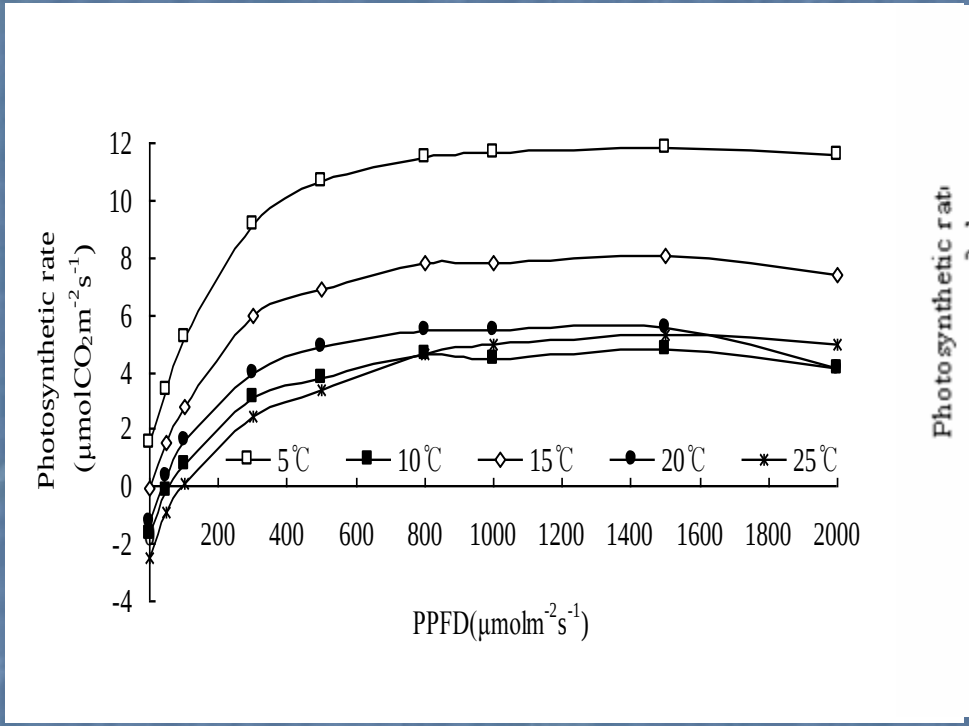
High temp. in winter is stressful, physiologically. Mortality was increased by winter warming

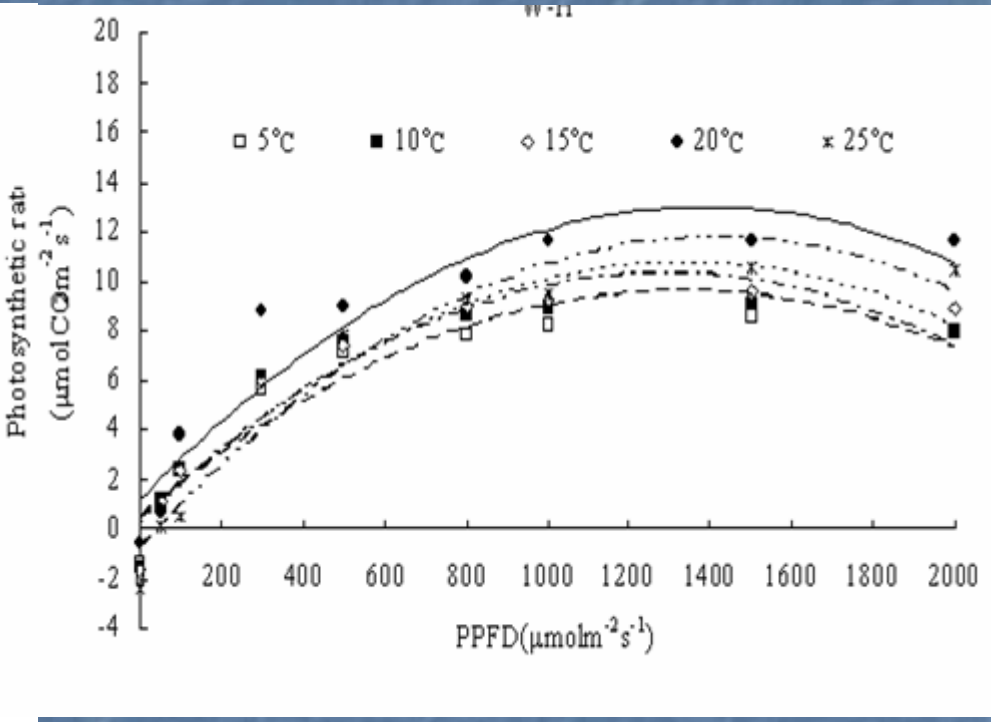
Light, Temp. ⇒ high
Soil ⇒ frozen, low avail. water

Net photosynthesis rate in June



Net photosynthesis rate: seasonal difference





June: Low temp. > High temp.

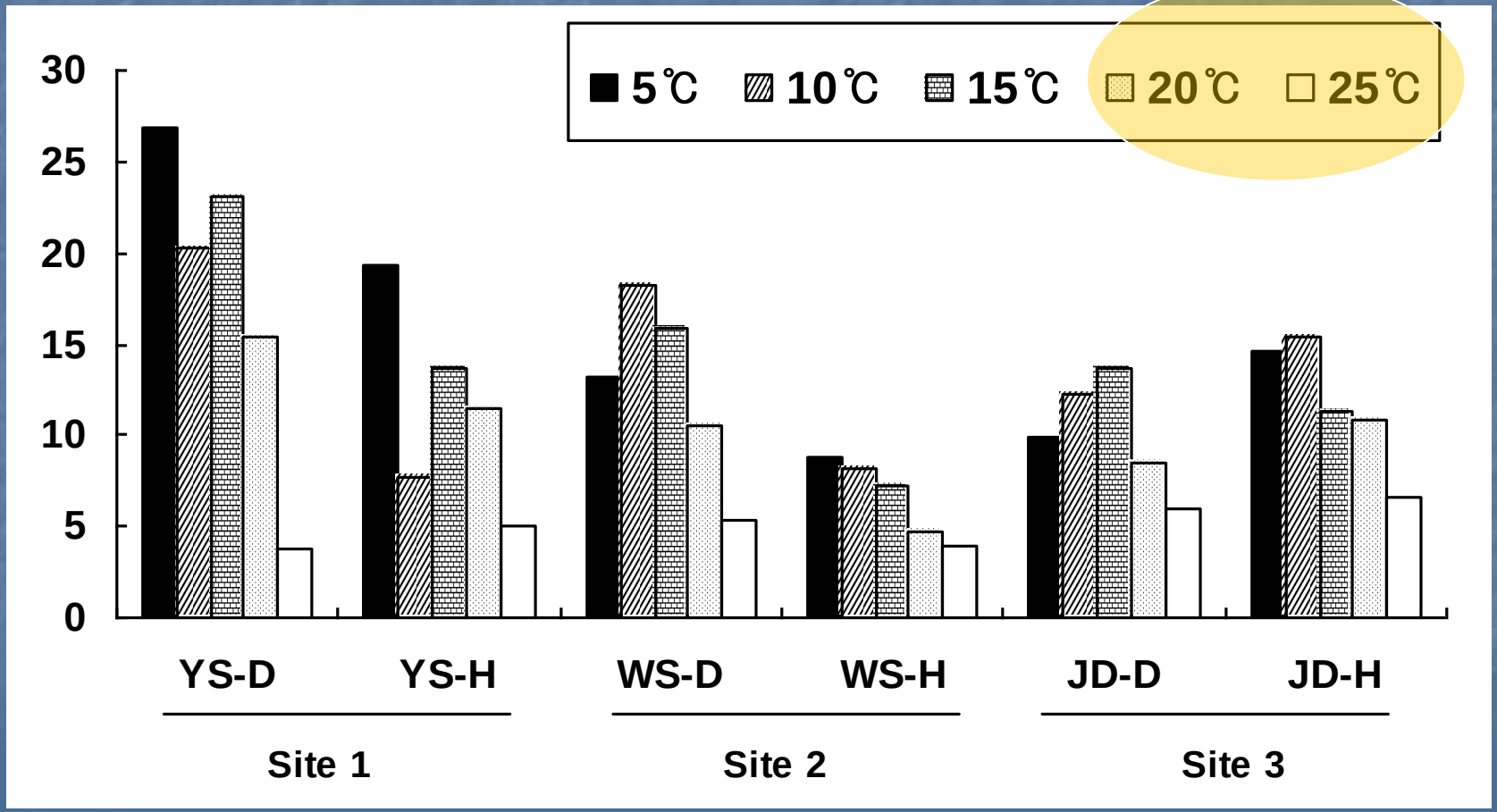
September: No difference
highest at 20℃

Until early summer, high air temperature is stressful

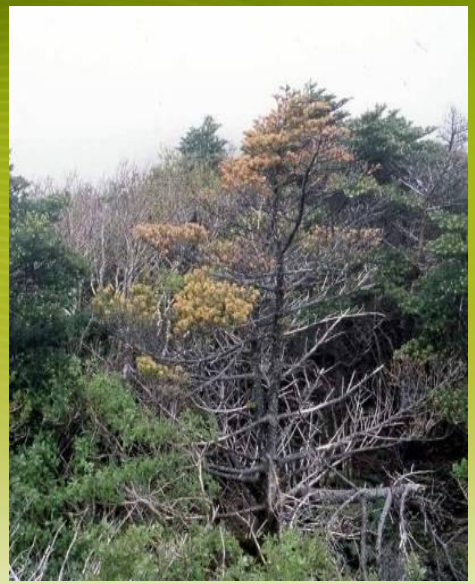
Water use efficiency

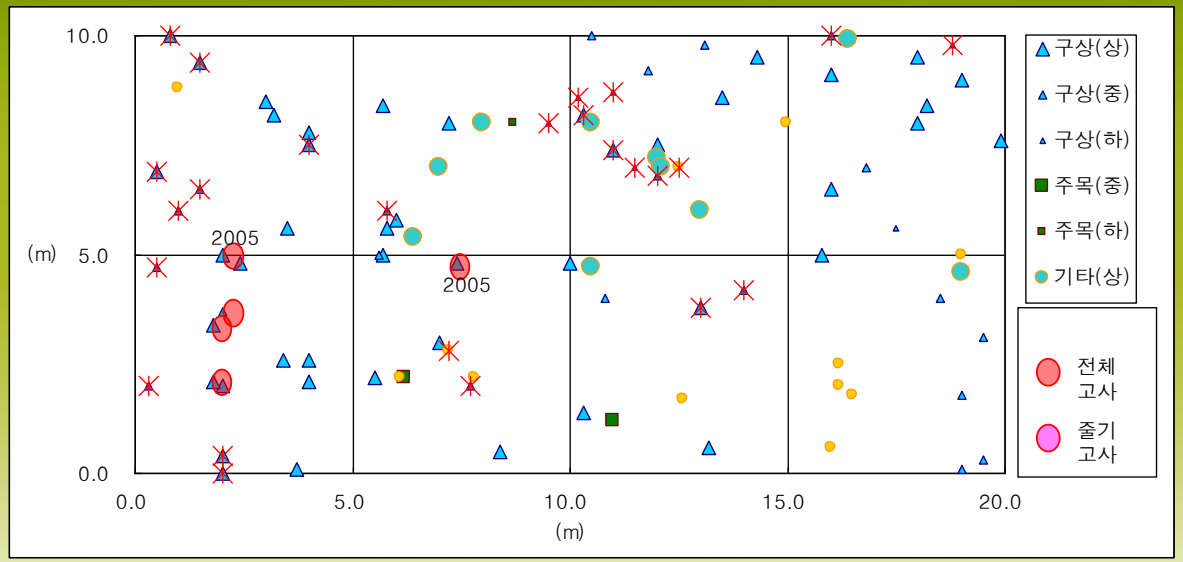
- Weak one > healthy one
- Site 1 > Site 2,3
- Low temp. > high temp.

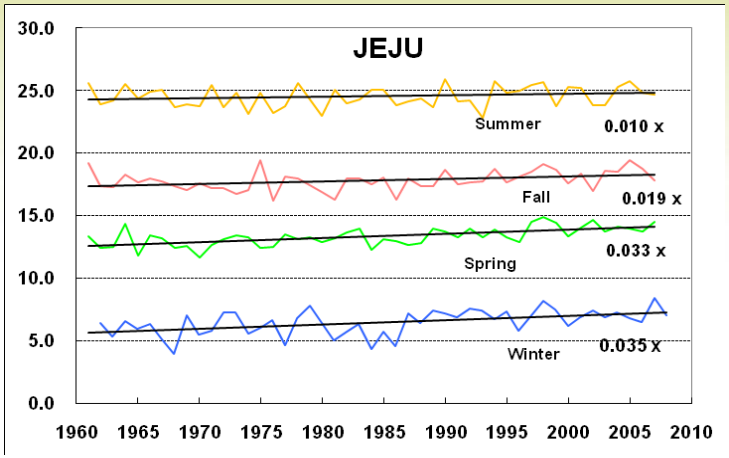
Adaptability to temp.

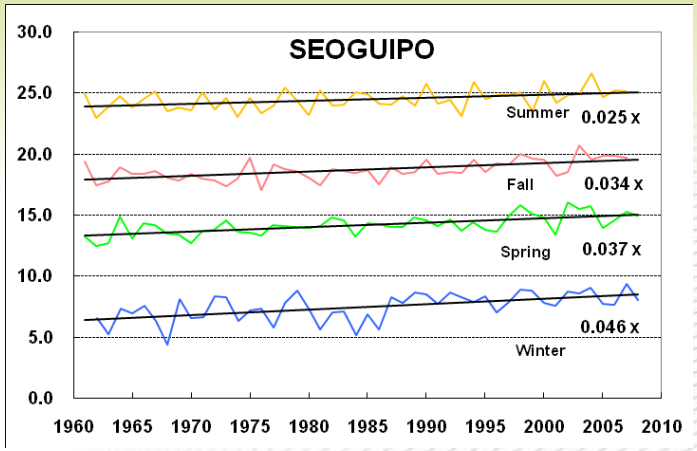


Monitoring of tree mortality







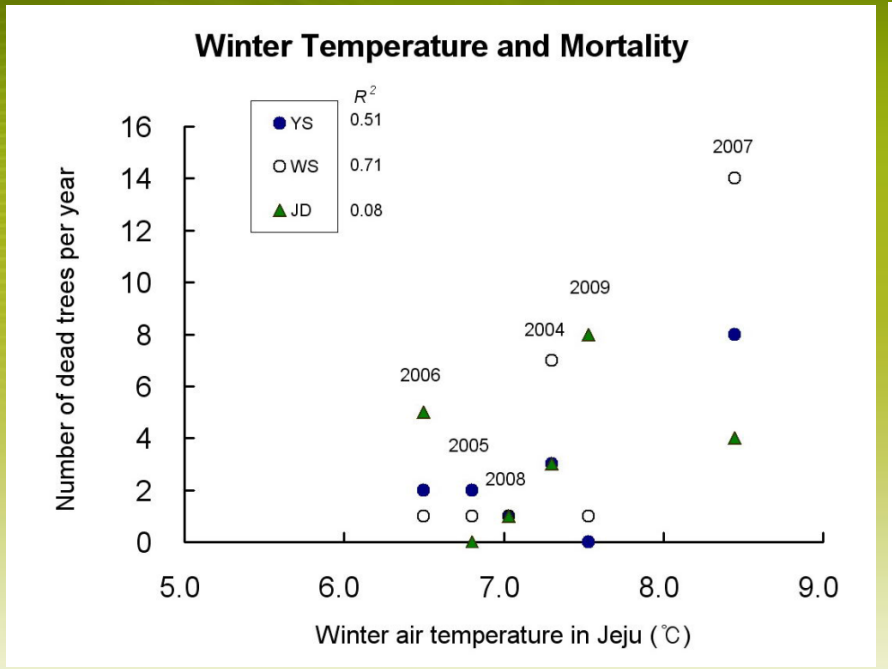


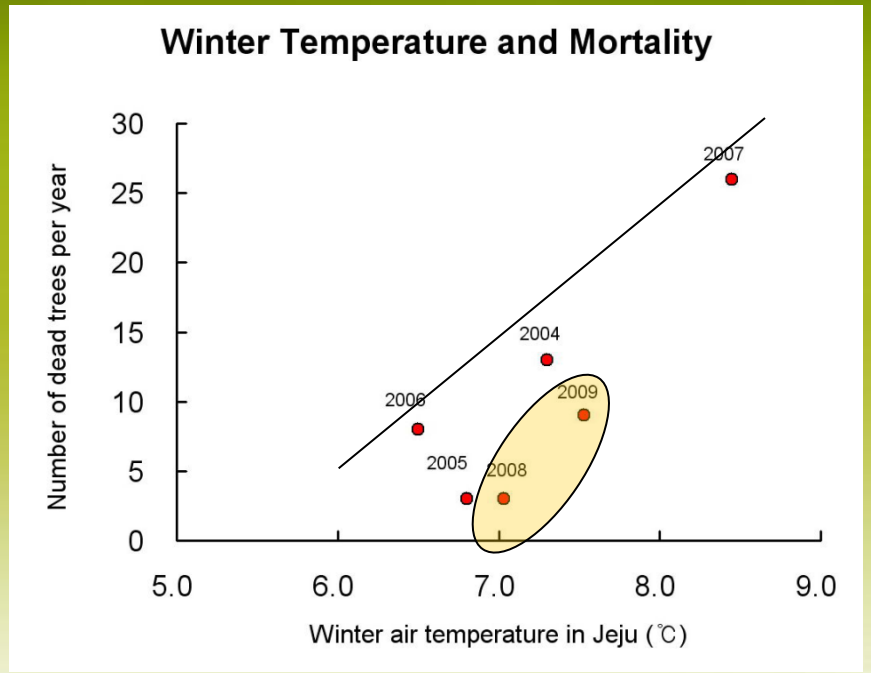
- 지난 **45**년간 연평균 **1.24**℃, 겨울 **1.57** ℃, 봄 **1.50** ℃

- 연평균 **1.68**℃, 겨울 **2.05** ℃, 봄 **1.66** ℃

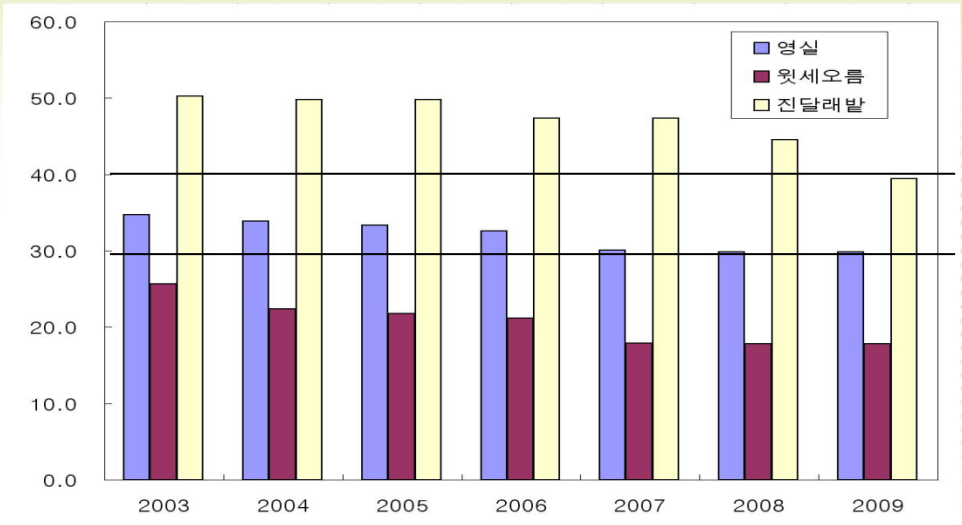
국립산림과학원
KOREA FOREST RESEARCH INSTITUTE

Winter temperature vs. Tree mortality





Basal area

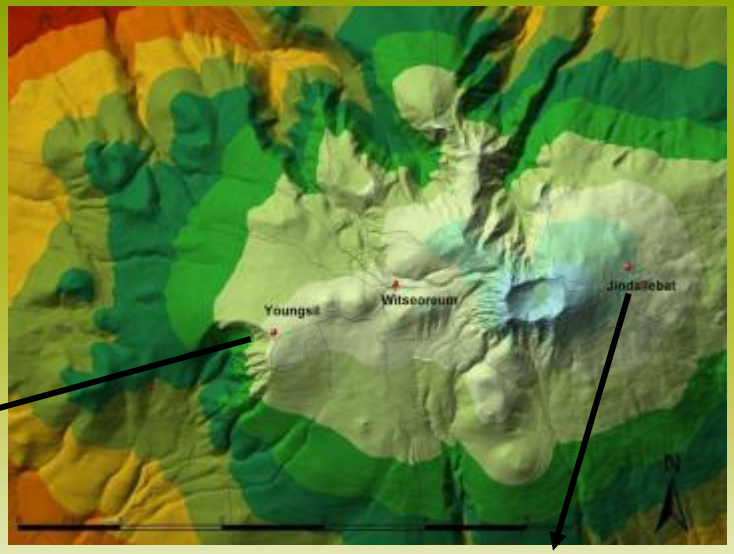


Mt, Gyebangsan

Gwangneung

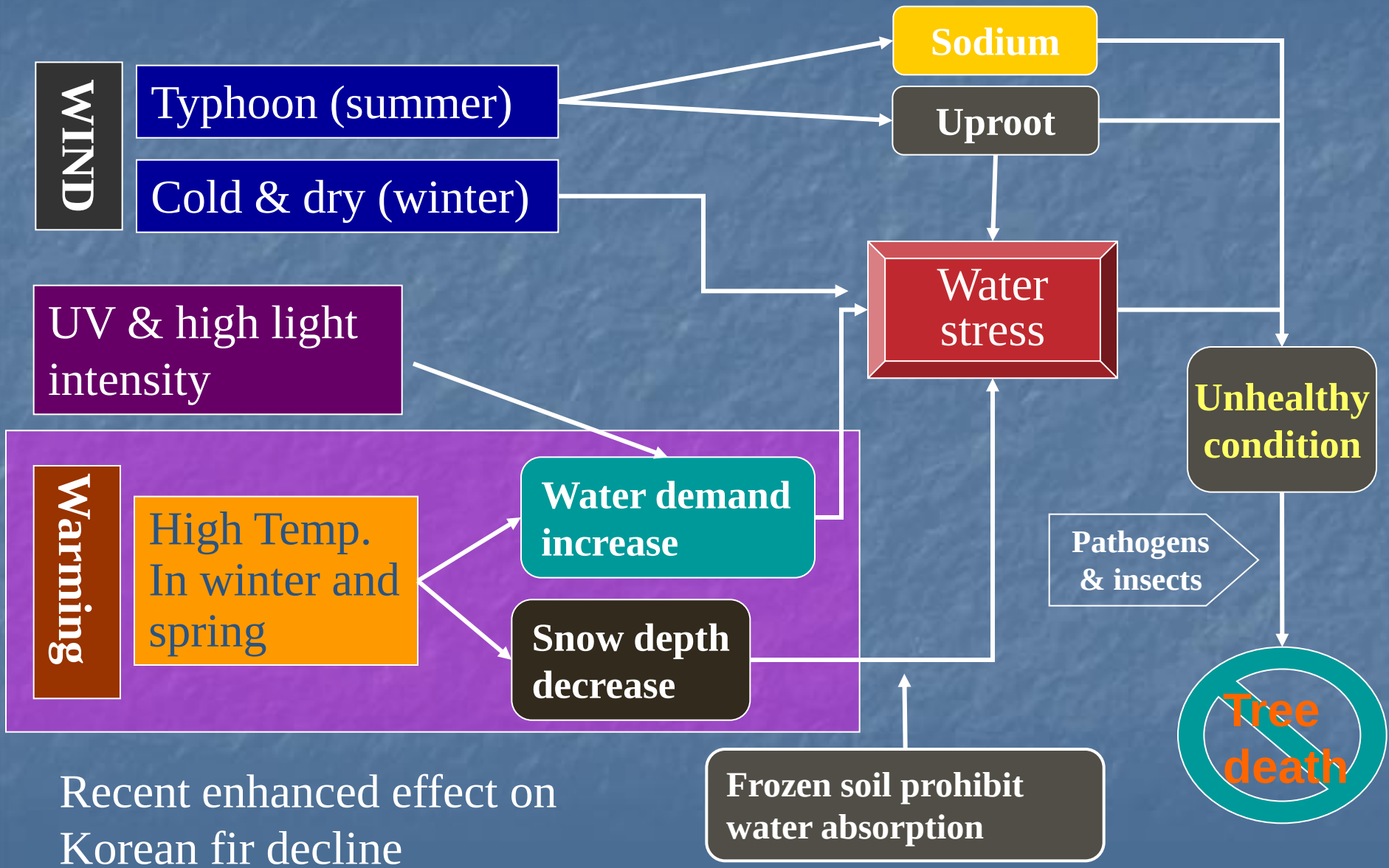
Spatial differences

South/West: poor
North/East: healthy



Solar radiation, wind, soil

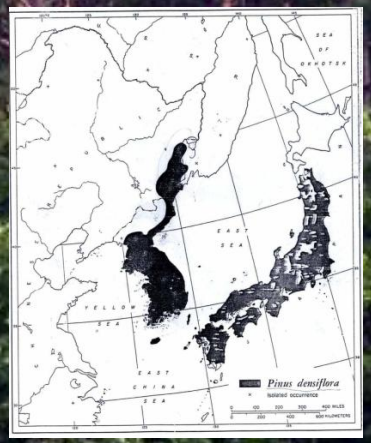
Mechanism of Korean fir decline



Recent enhanced effect on Korean fir decline

Pines

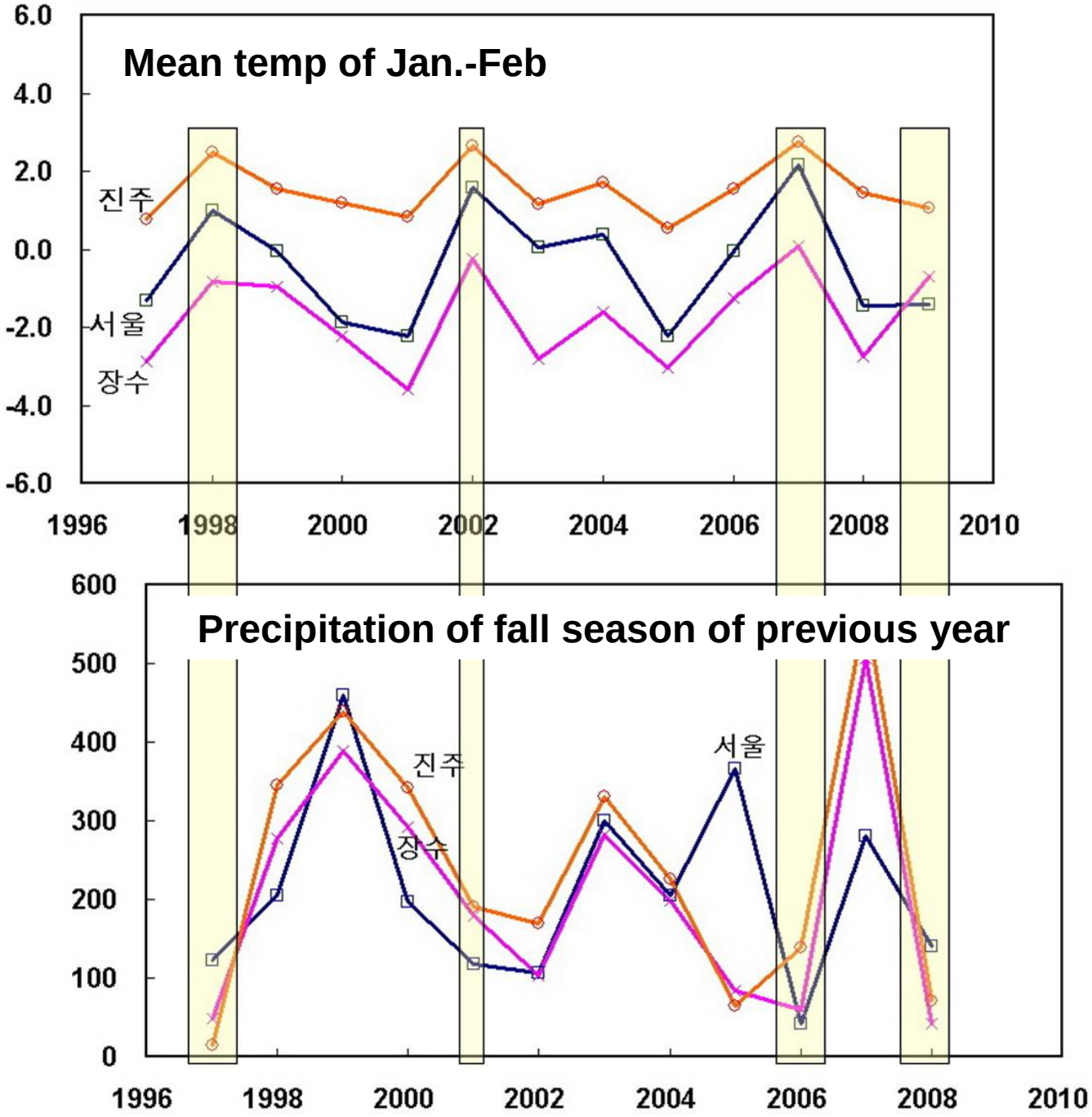
- *Pinus densiflora, P. koraiensis*



Critchfield and Little, 1966

Dieback of Pines

- **Mass mortality years: 1998, 2002, 2007, 2009**
- **Damaged species: *P. densiflora, P. koraiensis***

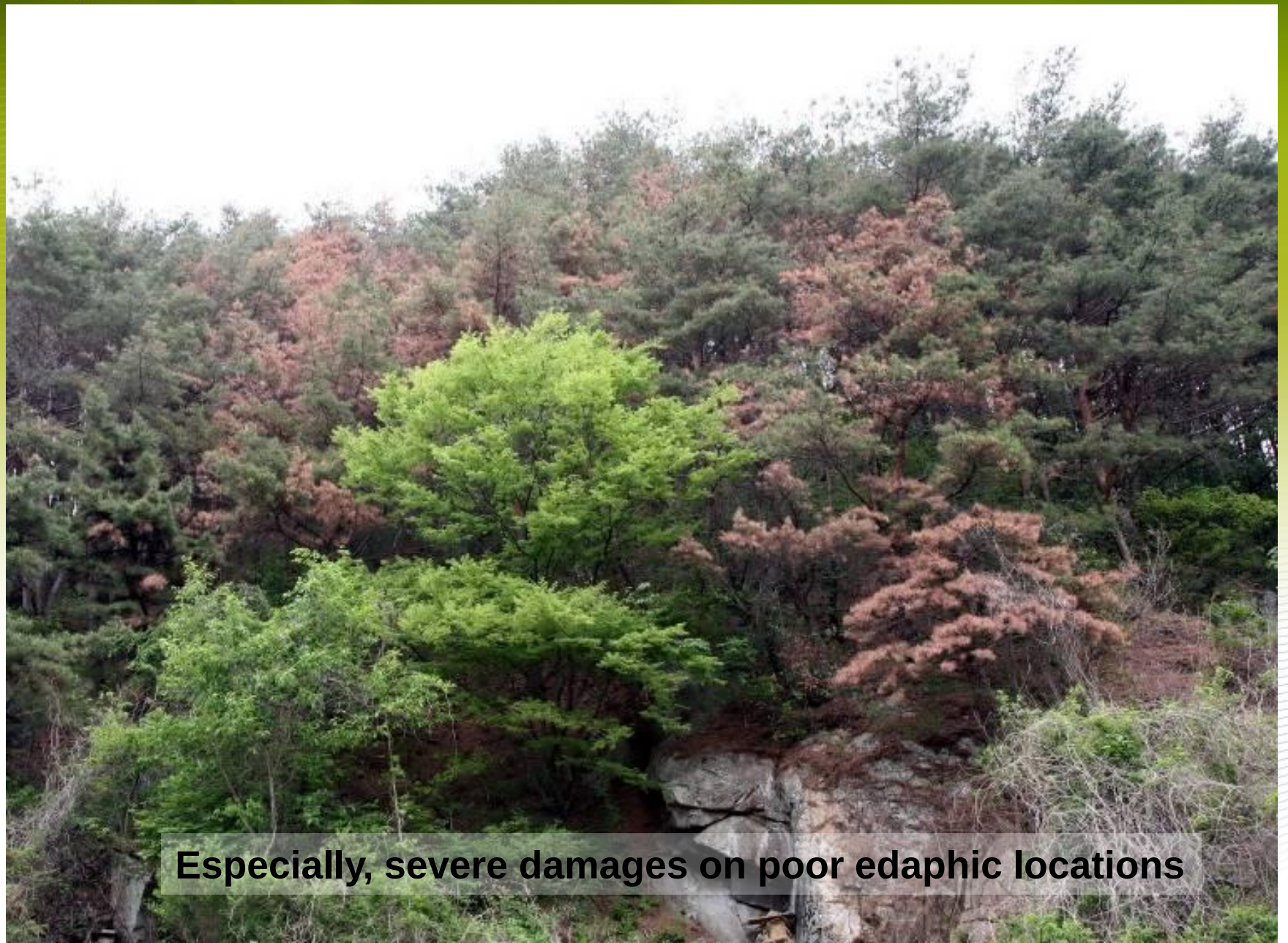

Mean temp of Jan.-Feb
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
진주
서울
장수
1996
1998
2000
2002
2004
2006
2008
2010
Precipitation of fall season of previous year
600
500
400
300
200
100
0
진주
서울
장수
1996
1998
2000
2002
2004
2006
2008
2010

In 2009, more than 1 million pine trees were dead in Korea

- P. densiflora, P. thunbergii, P. koraiensis

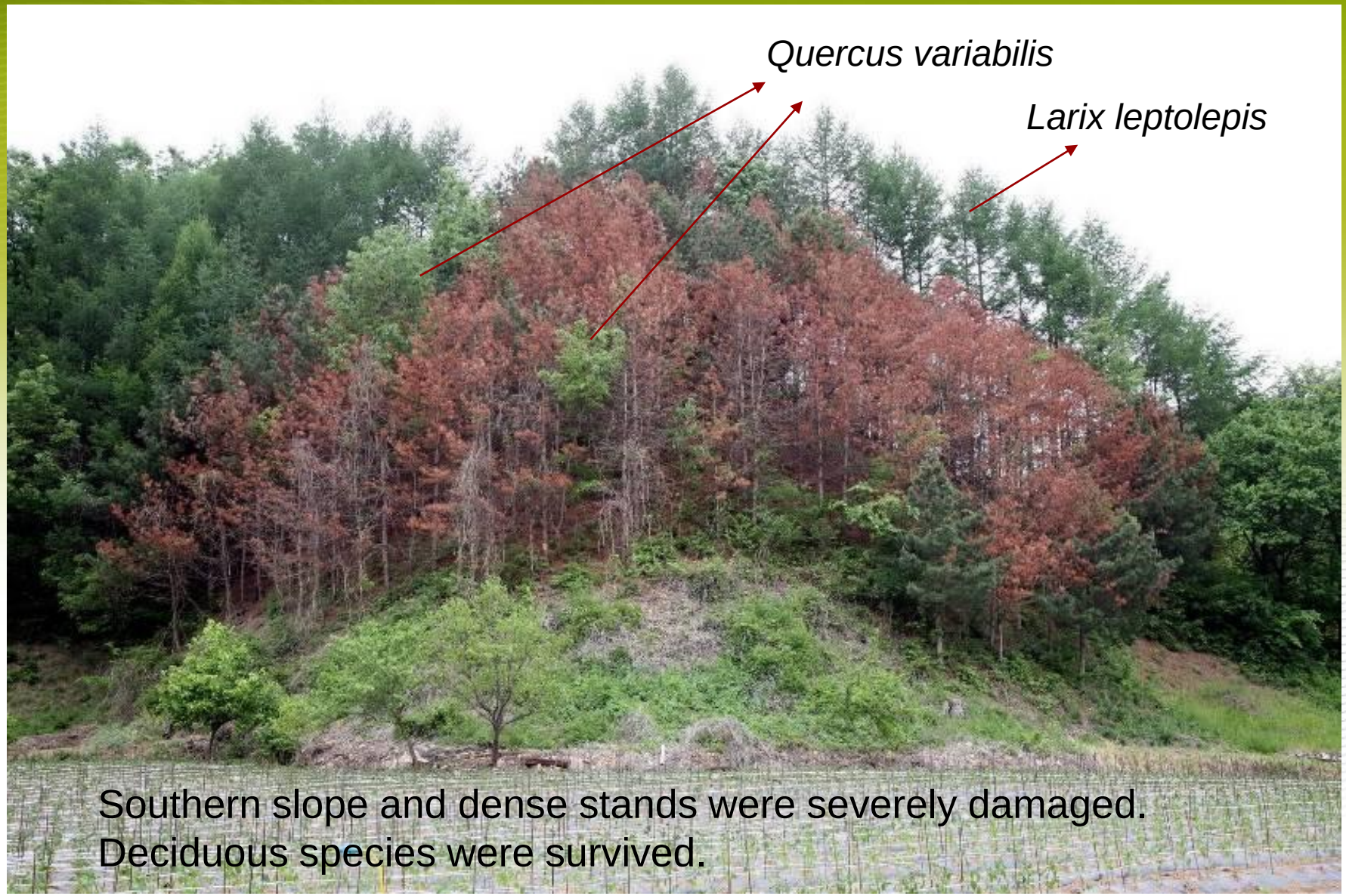
Dieback of Pine trees

Pinus densiflora



Especially, severe damages on poor edaphic locations

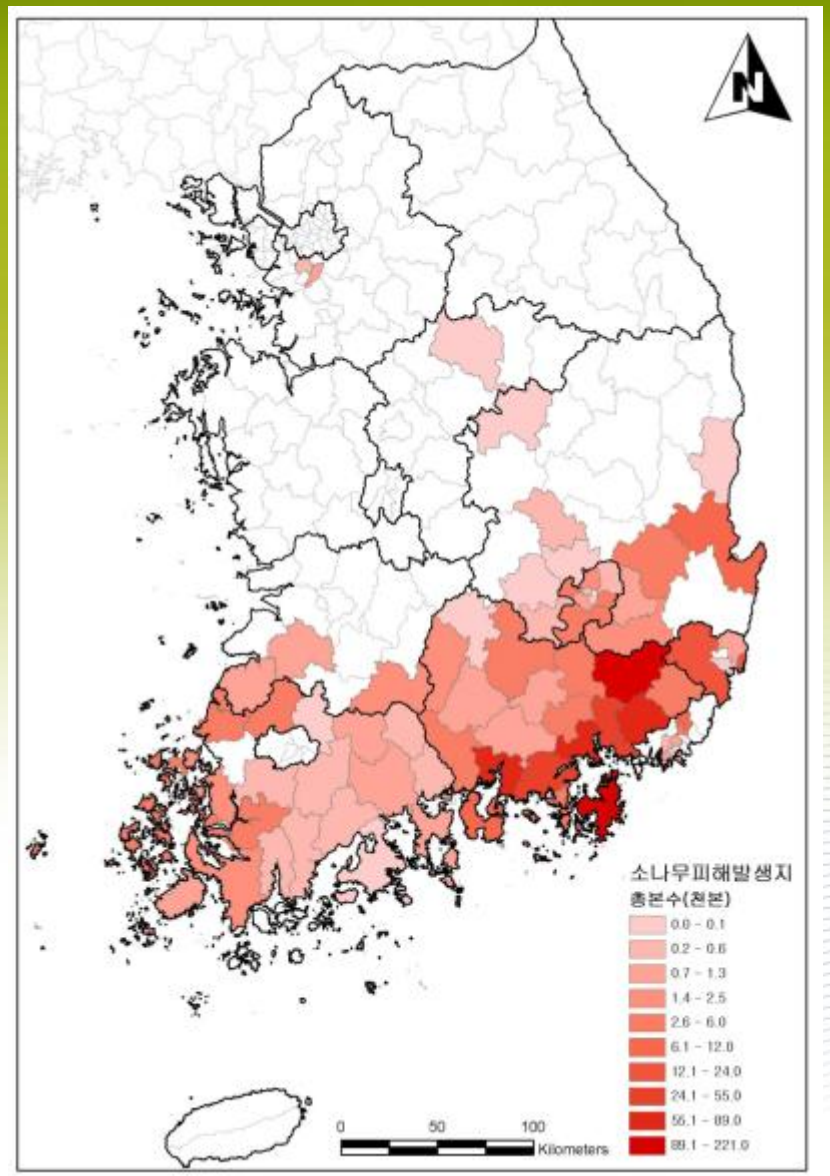
Pinus koraiensis plantation



Southern slope and dense stands were severely damaged.
Deciduous species were survived.

Actual distribution area of *P. densiflora*

Number of dead trees of *P. densiflora* in 2009

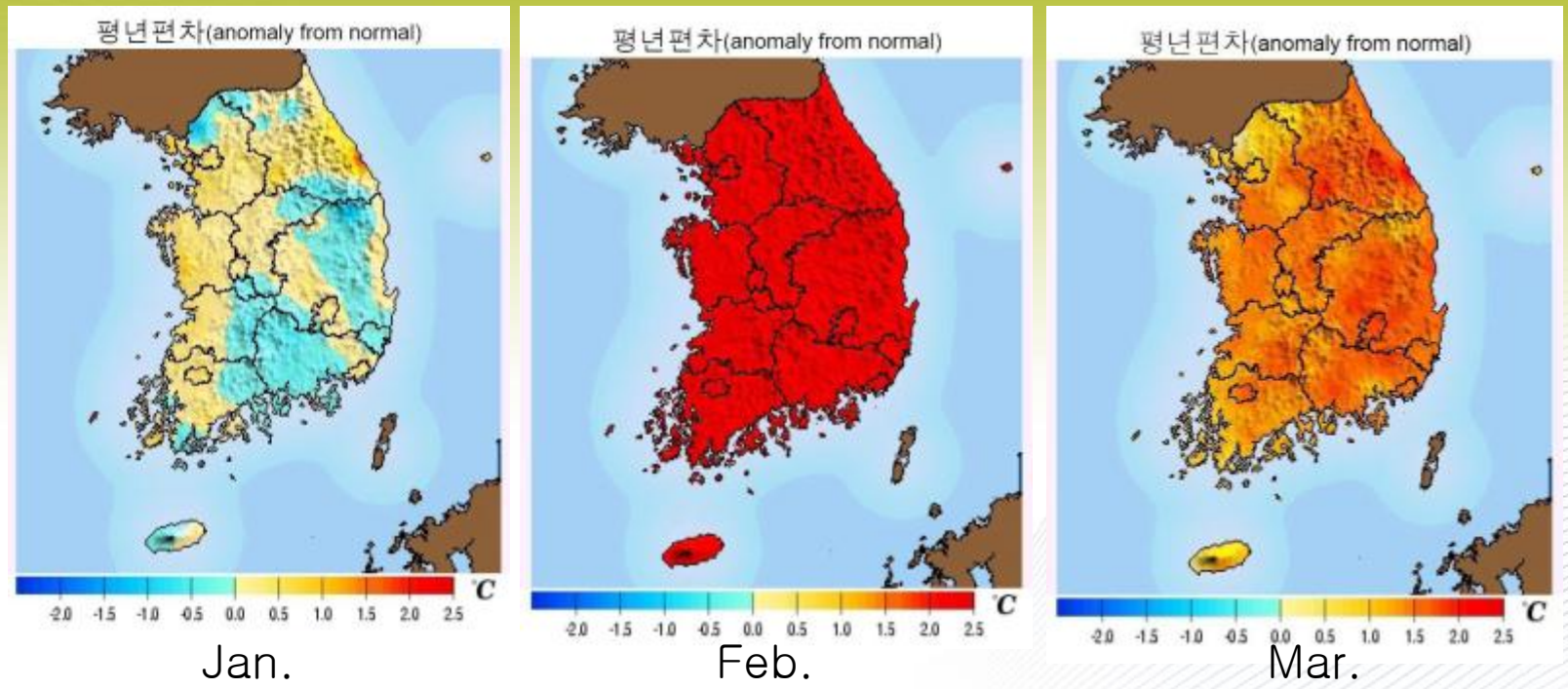


Causes of Dieback of Pines in 2009

1) Severe drought from Sep. 2008 to Apr. 2009

2) High temp. in winter, especially on Feb. and Mar. 2009

- Previously, pines were dead in 1998, 2002, 2007



Anomaly of mean monthly temperature in 2009 (KMA 2009)

Differences of monthly precipitation to normal

주요 피해지역 월강수량의 평년강수량 대비 편차 (평년강수량: 1971-2000, ㎜)

구분		거제	밀양	진주	울산	통영	마산
2008년	9월	-100.0	-117.0	-119.7	-116.1	-105.5	-132.4
	10월	-17.9	-28.6	-17.5	-51.3	-31.6	-22.5
	11월	-19.9	-19.0	-37.5	-34.0	-37.7	-36.7
	12월	-11.6	3.6	-17.6	-13.4	-17.0	-15.7
2009년	1월	-5.7	-6.7	-21.6	-23.3	-21.6	-25.8
	2월	61.5	59.6	24.6	6.4	17.2	20.2
	3월	31.6	20.9	-5.6	-36.6	-11.8	0.2
	4월	35.9	-25.4	-5.1	-45.3	-14.9	11.5
	5월	162.0	147.5	11.5	-8.3	53.2	36.6

자료: 기상청 기상월보

Drought related dieback mechanisms

Allen et al (2010)

1) Extreme drought and heat kill trees through **cavitation of water columns** within the xylem (Rennenberg et al., 2006; Zweifel and Zeugin, 2008);

2) Protracted water stress drives plant carbon deficits and metabolic limitations that lead to **carbon starvation** and reduced ability to defend against attack by biotic agents such as insects or fungi (McDowell et al., 2008; Breshears et al., 2009; Adams et al., 2009);

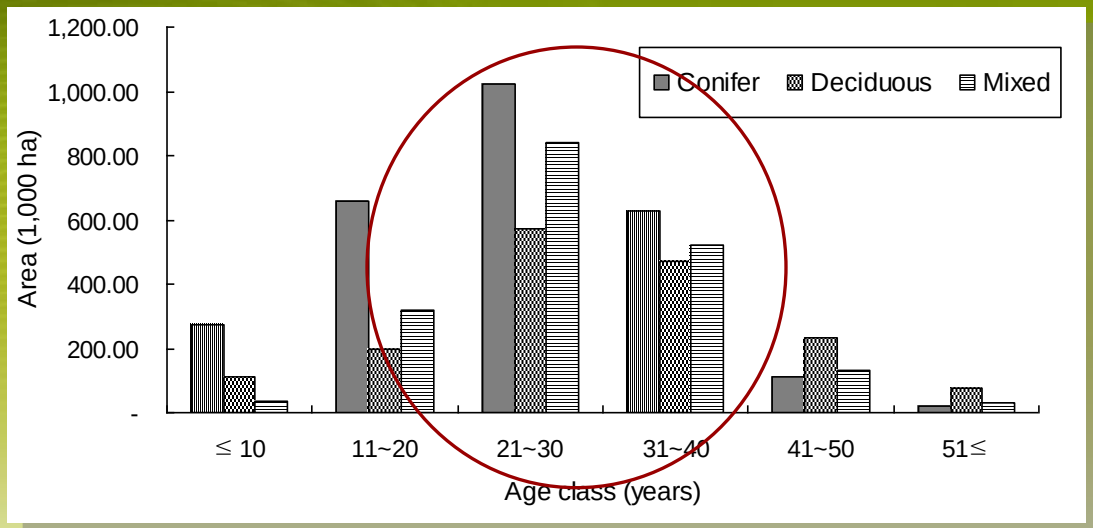
3) Extended warmth during droughts can drive increased population abundance in these **biotic agents**, allowing them to overwhelm their already stressed tree hosts

Comparison of dieback mechanism

	Abies koreana	*Pinus* spp.
Stressor	Drought (from fall to spring)	Drought (from fall to spring)
Amplifier	High temperature during drought period	High temperature during drought period
Stomatal response	Anisohydry (drought tolerance)?	Isohydry (drought avoidance)
Biotic agent	No	Yes

Cenangium ferruginosum

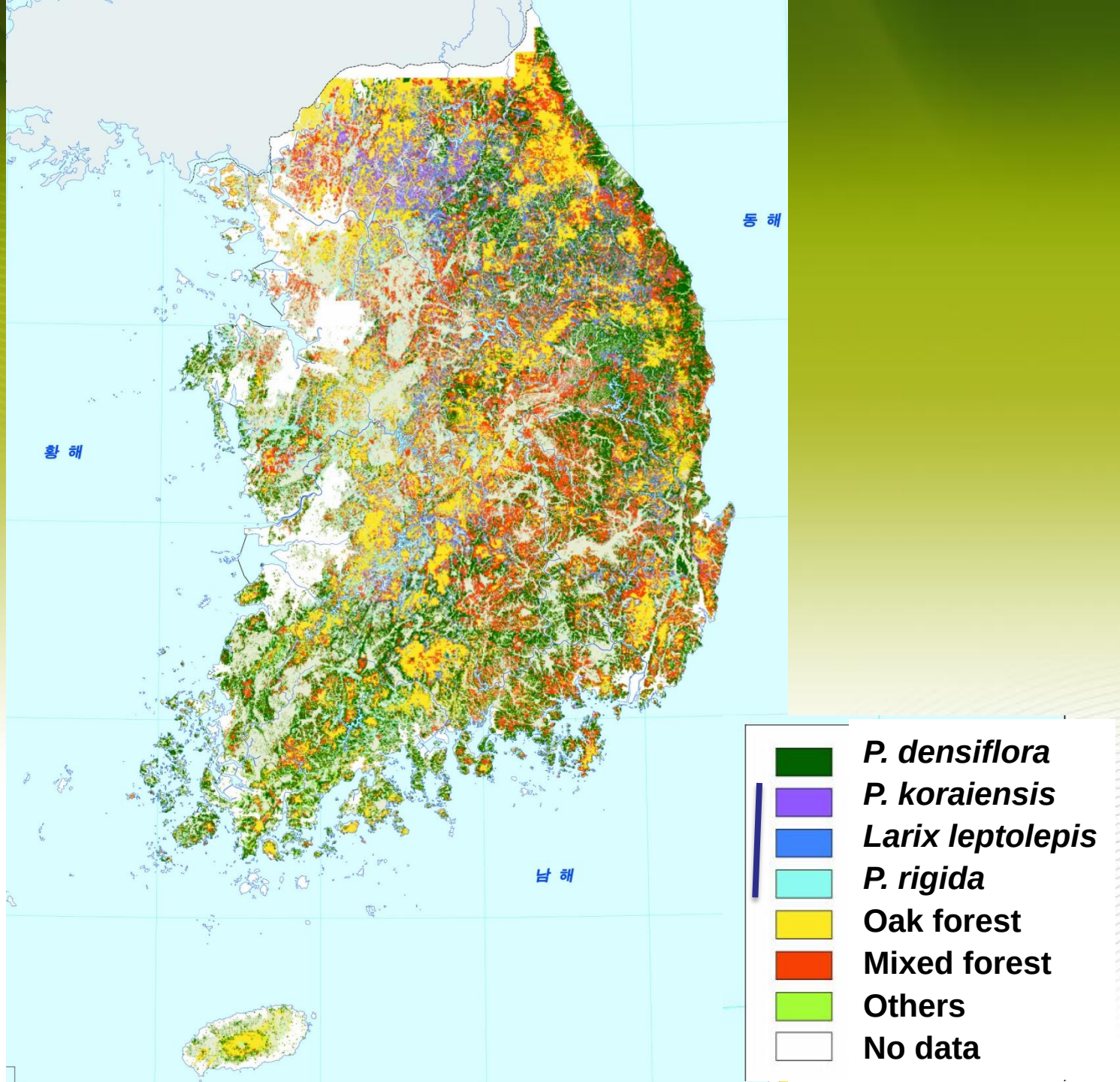
Needs of Forest Structure Improvement



-Most of the forests are 20 to 40 years old
(age class diversity is low)

- Density is high
- Topography: steep & complex

So, Korean forests are vulnerable not only to drought stresses of evergreen conifers, but also to fire, landslides, insects & disease, e.g. oak wilt disease


동 해
황 해
남 해
P. densiflora
P. koraiensis
Larix leptolepis
P. rigida
Oak forest
Mixed forest
Others
No data

Climate Change

- Temp. rise: 2–6℃
- Temp. increase rate: winter >> summer
- Prep. Inc. rate: winter << summer
- Variability of rainfall will increase

- Decline of evergreen conifers by drought in warm winter
- Insects outbreaks
- Fire and landslide

Adaptation

- **Density control**
  - competition release
  - increase forest health
  - reduce forest fire
- **Diversity enhancement**
  - forest type, age diversity
  - stand structural diversity
- **Selecting planting sp.**
  - consider future climate
- **Conservation of genetic resources**

Thank You!

Welcome to 2010 IUFRO Seoul Conference