# Korean Fir (*Abies koreana*) Decline in Mt. Halla -A Linkage with Photosynthesis and Water Use Efficiency Caused by Climate Change-

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## Background

- Increased atmospheric temperature during this century due to the global warming is not always one of the positive factors in plant growth environments.
- The regional decline of this species was recognized in 1980s. Unfortunately, with an increasing argument on the decline phenomenon of this species, there has been little consensus on the detail causes of the dieback.
- Korean fir (*Abies koreana*) is valuable tree species for ornamental purpose and one of the endemic species in Korea
- This species was recorded as Lower Risk/Near Threatened (LR/NT) category in the IUCN Red List of Threatened Species. Concern about Korean fir is in large part due to their severe and recent dieback.

## Objectives

·To test the hypothesis that elevated temperature in high elevation will reduces photosynthesis, impacts water use efficiency during growing season and alters the water budget on Korean fir stands growing Mt. Halla.

·This fact causes the physiological imbalance on the individual trees and ultimately shown the visible phenomenon either dieback or healthy Korean fir stands.

## Materials and Methods

(33˚ 13-36˚ N, 126˚ 12-57˚ E). 1, 950m a.s.l.
Location map of the Jeju island, Mt. Halla and study sites.

Site description of the permanent plots

| Site Name | Altitude (m) | Topographical position | Aspect | Slope (°) | DBH (cm) | Height (m) | Age (year) |
|---|---|---|---|---|---|---|---|
| Site 1:YS (Youngsil) | 1,633 | Near cliff | SWS | < 3 | 10.0 (2.9-27.5) | 3.0 (1.7-3.6) | 40-60 |
| Site 2: WS (Witseoreum) | 1,672 | Small ridge | SWS | < 3 | 9.8 (3.1-22.1) | 4.0 (1.7-5.6) | 40-60 |
| Site 3: SP (Sungpanak) | 1,748 | Flat area | SES | < 3 | 12.7 (3.6-26.4) | 3.4 (2.0-4.8) | 40-60 |


Vitality assessment using leaf characteristics for Korean fir

| Vitality grade | | Leaf characteristics | | |
|---|---|---|---|---|
| | | Amount of leaves | Leaf length | Oldest leaf age |
| 1 | Almost dieing | Less than 10% | Mostly shorter than 1 cm | Mostly 2-3years |
| 2 | Very unhealthy | 10-40% | Mostly shorter than 1 .5cm | Mostly 3years |
| 3 | Unhealthy | 40-60% | About 1.2-1.6 cm | Mostly 3-4years |
| 4 | Vigorous | 60-90% | Mostly longer than 1.5 cm | Mostly 4 years, some 5 years |
| 5 | Full vigor | More than 90% | Mostly longer than 1.5 cm | Mostly more than 5 years |

Frequency by mean vitality grade

| Mean vitality | Number of individuals |
|---|---|
| 1.0 | 12 |
| 1.5 | 12 |
| 2.0 | 38 |
| 2.5 | 20 |
| 3.0 | 26 |
| 3.5 | 6 |
| 4.0 | 10 |

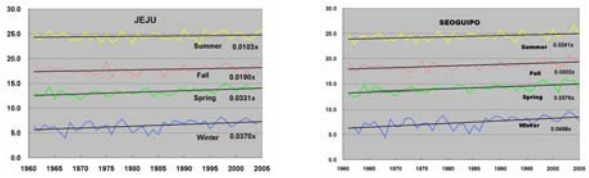
### Measurement of Net photosynthesis

- Light response curves were determined on three different temperature regimes; 15℃, 20℃ and 25℃. At each of the different light intensities, the trees were acclimated for two to three minutes before the measurement was taken.
- Net photosynthesis was measured with a broad-leaf cuvette of the Licor-6400 Portable Photosynthesis System (Li-cor Inc., USA)
- Net Photosynthesis was calculated as:

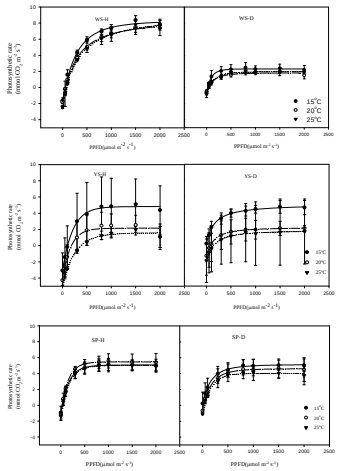
$$A_n = \frac{U_e(C_e - C_c)}{100\,s} - C_c E$$

where *An*; Net Photosynthesis (μmol $CO_2$ $m^{-2}$ $s^{-1}$), *Ue*; mole flow rate of air entering the leaf chamber (μmol $s^{-1}$), *Ce*; mole fraction of $CO_2$ in the leaf chamber (μmol $CO_2$ $mol^{-1}$ air), *Cc*; mole fraction of $CO_2$ entering in the leaf chamber (μmol $CO_2$ $mol^{-1}$ air), *s*; leaf area ($cm_2$), *E*; transpiration (mmol $H_2O$ $m^{-2}s^{-1}$).

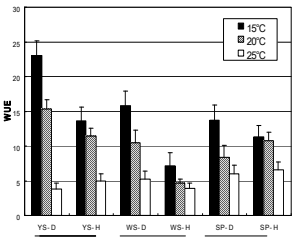
## Results



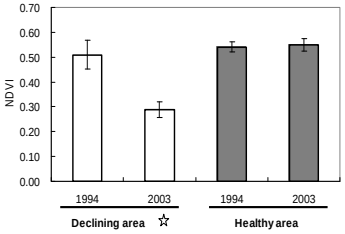

Changes of seasonal mean air temperature of Seoguipo and Jeju city. We assumed spring is from March to May, summer from June to August, autumn from September to November and winter from November to February.



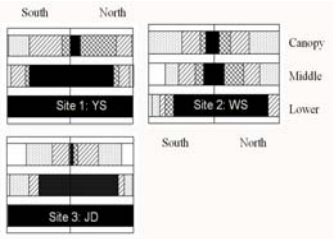

Irradiance response curves in net photosynthetic rate on June at the three different temperature regimes; 15, 20 and 25℃. CO2 concentration was 360 ppm. D means damaged or unhealthy individual, and H is healthy individual. These curves were developed for each site at different temperature by non linear regression using the photosynthetic rates measured at the 11 light levels. Solid line: 15℃ (●); heavy dashed line: 20℃ (○); thin dotted line: 25℃ (▾). Bars indicate standard deviation.




Water use efficiencies on June on three different temperature regimes. D means damaged or unhealthy Korean fir populations, and H is healthy populations. Bars indicate standard deviation.




Changes between 1994 and 2003




Mean vitality profile of the three sites by foliage layers (canopy, middle and lower), and crown aspect (north and south). Vitality grade ranged from 0 to 5 expressed as black to blank continuum.

## Conclusions

Obviously, mean air temperatures of study areas during last 40 years have been increased, especially in winter and spring season. Irradiance response curve of healthy Korean fir population were higher than unhealthy population at all three sites. In contrast, damaged trees showed higher WUE than those of healthy tress. The both irradiance response curve and WUE showed higher values in lower air temperature.

As evidences of Korean fir dieback, climatic change and physiological characteristics have been emerging to explain the cause of decline in this area. It may seem to result in winter desiccation and frost in this area.

Warmer climate should have affected on the water balance regime of Korean fir population in case available soil moisture was not enough.

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