Application of sap flux measurements for carbon balance comparison after thinning of 50-year-old *Pinus Koraiensis* stands

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Abstract

Understanding the response of a forest ecosystem's productivity to artificial or natural environmental changes is essential to predict future carbon uptake capacity of a forest ecosystem. Atmospheric carbon is assimilated into tree biomass through photosynthesis, but direct measurement of photosynthesis is still difficult because of hard accessibility to tree canopy and its heterogeneity within canopy. On the other hand, sap flux measurement can provide integrated information of canopy photosynthetic response to environmental changes through the connection of water and carbon exchange *via.* stomata. In this study, we used Granier's type thermal dissipation sensors on a 50-year-old *Pinus koraiensis* stand to understand the response of sap flux and photosynthesis to artificial thinning. Thinning was conducted at two intensities (20%-thinned and 40%-thinned based on tree density) on March, 2012. Net photosynthesis is estimated by a 4C-A (Canopy Conductance Constrained Carbon Assimilation) model and validated with net primary production estimated by diameter increment and allometric equations. Mean sap flux density was similar among treatments, thus stand transpiration was highest in the control stand and lowest in the 40%-thinned stand. Estimated total stand carbon assimilation was also highest in the control stand (1360.5 g m^{-2} yr^{-1}), and followed by 20%-thinned (1082.2 g m^{-2} yr^{-1}) and 40%-thinned stand (832.0 g m^{-2} yr^{-1}), but trees in thinned stands showed higher carbon gain (ca. 37.8 kg tree^{-1} yr^{-1}) than trees in control stand (ca. 30.7 kg tree^{-1} yr^{-1}). Tree diameter increment, which indicates the net primary production of stands, was also higher in thinned stands (3.48 mm yr^{-1}) than control stand (2.68 mm yr^{-1}). This study shows that sap flux measurement can be used to monitor the responses of a forest ecosystem's water use patterns and productivity to environmental changes.

Introduction

- **Importance of monitoring carbon uptake ability of trees**
- **Difficulties in measuring amount of carbon assimilation**
- **Advantages of sap flow measurements**
- **Connection between water and carbon cycle**

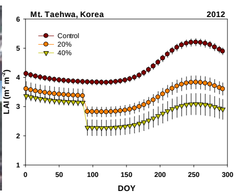
Methods

- **Thinning experiments (2 intensities) – Mar 2012**

Fig 1. Photos which show (a) thinning experiment, and environmental changes before (b) and after thinning (c).

- **Site characteristics**

Mt. Taehwa, South Korea	
Thinning area (ha)	0.54
Elevation (m)	129~219
Aspect	NE 50~60
Mean annual precipitation(mm)	1329.2
Mean air temperture(℃)	10.3
Mean height (m)	19.1
Mean D.B.H. (cm)	27.9
Stand density (no./ha)	440



	Control	20%-thinned		40%-thinned	
		Before	After	Before	After
Stand density (no./ha)	452	421	320	388	245
Mean D.B.H. (cm)	29.52	28.44	30.02	29.54	30.91

- **Sap flux measurement – Thermal Dissipation probe method**
- **4C-A (Canopy Conductance Constrained Carbon Assimilation) Model – Calculation of Net photosynthesis**

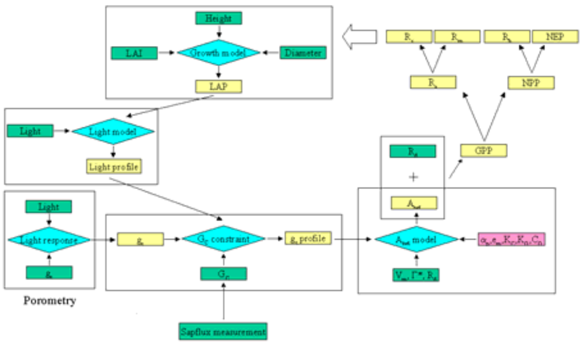


Fig 3. Schematic diagram of 4C-A model

Results

- **Effects of thinning on sap flow density and stand transpiration**

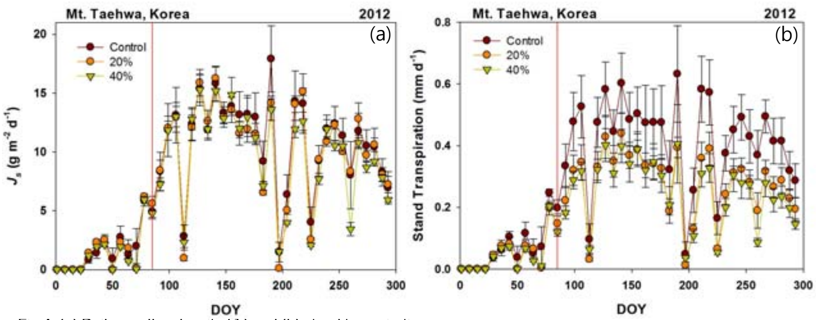


Fig 4. (a) Daily sap flux density (J_s) and (b) stand transpiration

- **Modelled stand net photosynthesis**

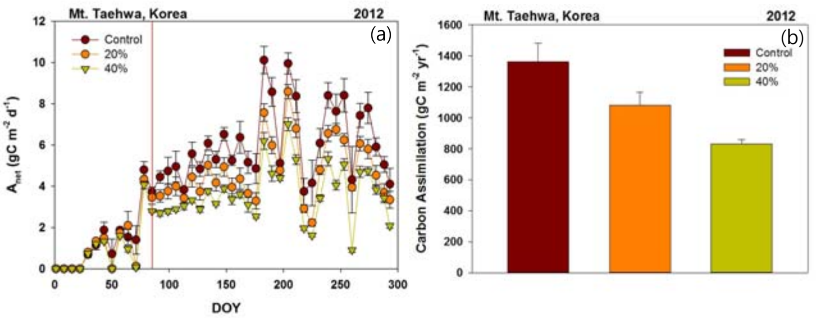


Fig 5. Modelled (a) daily net photosynthesis and (b) annual stand carbon assimilation

- **Modelled tree level carbon assimilation and actual diameter growth**

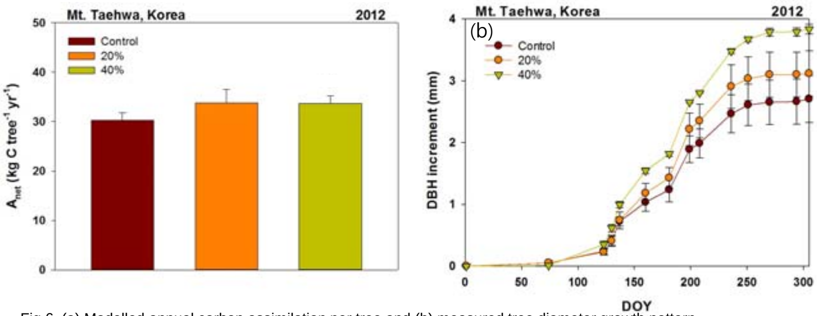


Fig 6. (a) Modelled annual carbon assimilation per tree and (b) measured tree diameter growth pattern

Summary

- **There was no difference in sap flux density among treatment, but stand transpiration was reduced by thinning**
- **Thinning increased amount of tree level carbon assimilation**
- **This carbon assimilation trends was successfully modelled with 4C-A model, which uses stomata conductance calculated from sap flux density**