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Overcoming the Challenges of Estimating Water Use in Temperate, Mixed Deciduous Forest of S.Korea

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Introduction

Understanding tree species richness and functional diversity is necessary to examine mixed forest ecosystem processes, but functional diversity is more strongly linked with ecosystem processes than species diversity. Therefore, we focused on functional diversity in temperate, mixed deciduous forest, especially in tree water use, and tried to build an idea of functional convergence among different species. To estimate tree water use, Thermal Dissipation Probe (TDP) techniques have been employed in 5 different species at our Gyebang-san, South Korea, study site. The measurements were conducted during June, between 2007 and 2008.

OBJECTIVES

(1) identify simple tree parameters that can easily define transpiration of single trees in a mixed temperate deciduous forest,

(2) build a general mechanism that can define mixed stand transpiration based on simple functional relationships established in 1

(3) attempt simple up-scaling procedures based on short-term sap flux density measurements in a temperate mixed forest.

Site and Materials

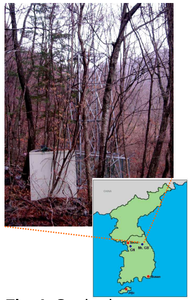


Fig. 1. Study site: Gyebang-san (Mt.), Kangwon-do (Province), South Korea

Table. 1. Studied trees in Gyebang-san, 2008. Sapwood depth was estimated by empirical regression model.

Species	Sample Trees	DBH (cm)	Tree Height (m)	Sapwood Depth (cm)
Quercus mongolica	Q1	27.6	14	2.9
	Q2	28.4	14	3.1
	Q3	20.3	13	2
	Q4	13.3	12	1.4
	Q5	38.2	15	4.9
Tilia amurensis	T1	29.2	17	1.5
	T2	18.9	14	0.8
	T3	26.8	15	1.3
	T4	13.2	12	0.6
	T5	17.8	13	0.8
Ulmus davidiana	U1	23.1	15	1.6
	U2	23.4	14	1.7
	U3	28.6	16	2.2
	U4	26.1	15	1.9
	U5	18.7	15	1.3
Cornus controversa	C1	25.3	15	1.2
	C2	22.3	15	1.0
	C3	17.6	15	0.7
Acer mono	A1	15.0	13	0.3
	A2	22.0	14	0.5
	A3	13.8	11	0.3

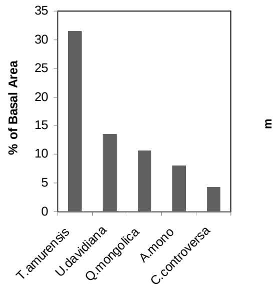


Fig. 2. Relative basal area contribution of sample tree species in the study plot

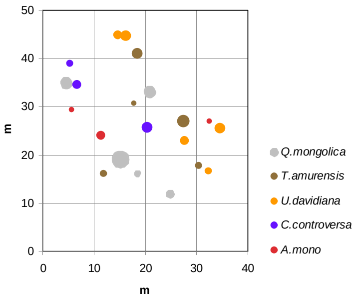


Fig. 3. Sample tree map with specific location and relative size of trees

Measurements

$$J_s = \left[\frac{1}{\alpha}\left(\frac{\Delta T_{max}-\Delta T}{\Delta T}\right)\right]^{\frac{1}{\beta}} = \left[\frac{1}{\alpha}K\right]^{\frac{1}{\beta}} = 118.99K^{1.231}$$

$$Q_t = \sum_{i=1}^{i=n}(J_{si}\cdot A_{si})$$

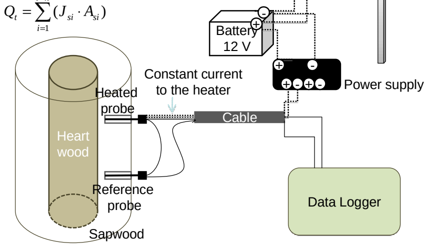


Fig. 4. Sapflow measurement, Thermal Dissipation Probe (TDP), introduced by Granier (1987)

Results and Discussion

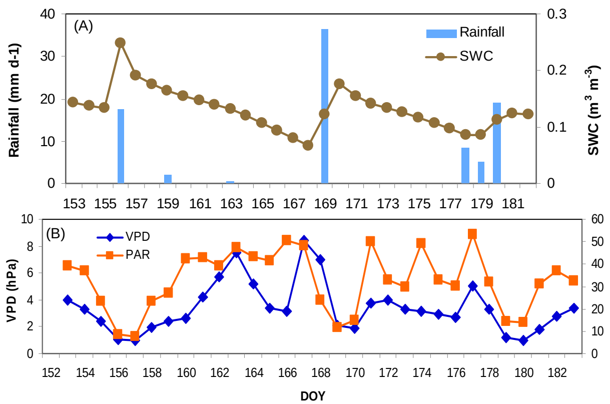


Fig. 5. Daily mean vapour pressure deficit (VPD, hPa) and daily amounts of photosynthetically active radiation (PAR, mol m^{-2} d^{-1}) (A), rainfall (mm d^{-1}) and soil water contents (m^3 m^{-3}) (B) recorded at the study site during June 2008 when sapflow measurements were conducted.

Mean daily sap flux density (*SFD*) of *Q. mongolica*, *T. amurensis*, *U. davidiana*, *C. controversa*, and *A. mono* were 40.88 kg m^{-2} h^{-1} (s.d. = 17.76, n = 5), 49.48 kg m^{-2} h^{-1} (s.d. = 26.09, n = 5), 49.23 kg m^{-2} h^{-1} (s.d. = 8.42, n = 5), 59.54 kg m^{-2} h^{-1} (s.d. = 24.46, n = 3) and 55.41 kg m^{-2} h^{-1} (s.d. = 17.78, n = 3). The highest measured maximum daily tree water use reached 101.24 kg d^{-1} for one sample tree (*Q. mongolica*, DBH = 38.2 cm). The maximum *E* of 0.97 mm d^{-1} during the measurement period was observed on 26 June, coinciding with highest daily total *PAR* of (53.1 mol m^{-2} d^{-1}). *Q. mongolica*, *T. amurensis* and *U. davidiana* contributed roughly 25% of total *E*, while *C. controversa* and *A. mono* accounted for about 3% of total E. Transpiration rates increased with increasing *VPD* and maximized for *VPD* higher than ca. 0.5 kPa. Similarly, stand transpiration increased with increasing PAR and the relationship was not asymptotic. This is evident that when PAR is sufficient VPD can be the critical limiting factor.

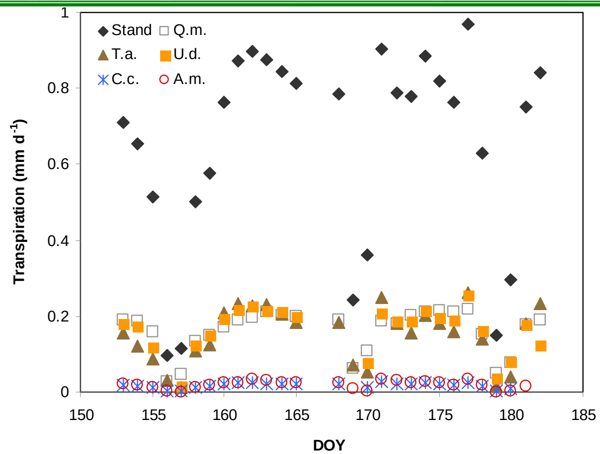


Fig. 6. Estimated stand transpiration (Ec, mm d^{-1}) and contribution of each measured species for Ec.

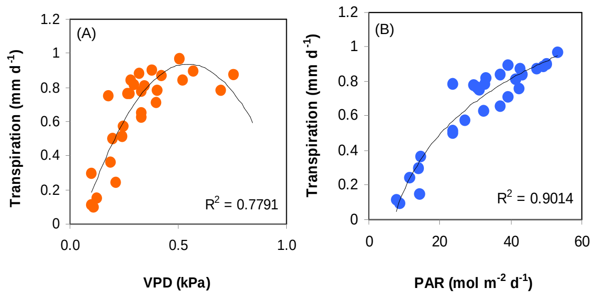
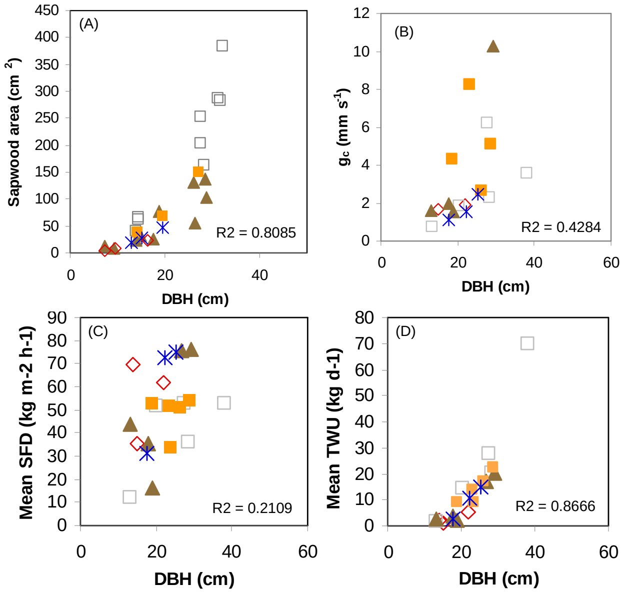


Fig. 7. Relationship between stand transpiration (Ec, mm d^{-1}) and vapour pressure deficit (VPD, kPa) (A) and photosynthetically active radiation (PAR, mol m^{-2} d^{-1}) (B)



Relationship between *DBH* and mean *SFD* (kg m^{-2} h^{-1}) was not significant (R^2 = 0.21, Fig. 8C), but mean daily *TWU* (kg d^{-1}), which was an estimate of whole tree transpiration, was strongly (R^2 = 0.87) correlated with *DBH* for all measured species (Fig. 4D). There was an exponential (R^2 = 0.81) relationship between DBH (Fig. 4A) and SA (cm^2). Even though each tree species has specific behavior in physiological processes, tree water use was significantly correlated with diameter at breast height (DBH) for all over-story species in similar meteorological condition. SA and DBH are auto-correlated because DBH is used to convert sapwood depth and from sapwood depth SA can be calculated (Oren et al. 1998).

Fig. 8. Relationships between diameter of breast height (DBH, cm) and sapwood area (A), canopy conductance (g_c) (B), mean sapflux density (mean SFD) (C) and mean tree water use (mean TWU) (D).

DBH is more efficient and effective parameter to measure compared to sapwood depth and leaf area since it is easy to determine in a relatively short period of time and it is also a non-destructive method. Therefore, we chose *DBH* as a size-dependent factor to compute the relationships between transpiration rates and tree size.

References

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