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Poster # 373

"Crop Coefficients" Evapotranspiration/Grass Reference Evapotranspiration (ETo) for Forests in the Southeastern U.S.

*Contact: Ge Sun ge.sun@usda.gov

Ge Sun[1*], M. Aguilos[2], B. Mitra[3], J-C Domec[4], K. Minick[2], P. Prajapati[3], A. Noomets[3], M. Gavazzi[1], J Boggs[1], S. McNulty[1], Y. Yang[5], J. King[2]

[1]USDA Forest Service, Research Triangle Park, NC; [2]North Carolina State University, Raleigh, NC [3]Texas A&M, College Station, TX, [4]Duke University, Durham, NC [5]USDA ARS Beltsville, MD

INTRODUCTION

- **Forests cover over 60% of land areas in the southern US and are important in regulating water supply, flood mitigation, heat waves, drought.**
- **Although over 60% of precipitation returns to the atmosphere as Evapotranspiration (ET) in southern forests, the concept of potential ET for forests is unclear.**
- **Forests are believed to use more water than grass due to large biomass and deep rooting systems.**
- **ET is the key linkage among energy, water and carbon fluxes, productivity and biodiversity.**
- **ET is least measured and most costly to quantify in the water budget**
- **Estimating ET remains challenging due to large spatial and temporal variability of forests for all methods (mathematical models, remote sensing, sapflow, Eddy Covariance methods)**

OBJECTIVES

- **Compare standard FAO56 Grass Reference ET (ETo) with actual ET in southern forests.**
- **Explore key controls of forest ET by type, age, and structure.**
- **Develop practical ET models to improve regional modeling of water supply and demand under climate and land cover change.**

DATA SOURCES & METHODS

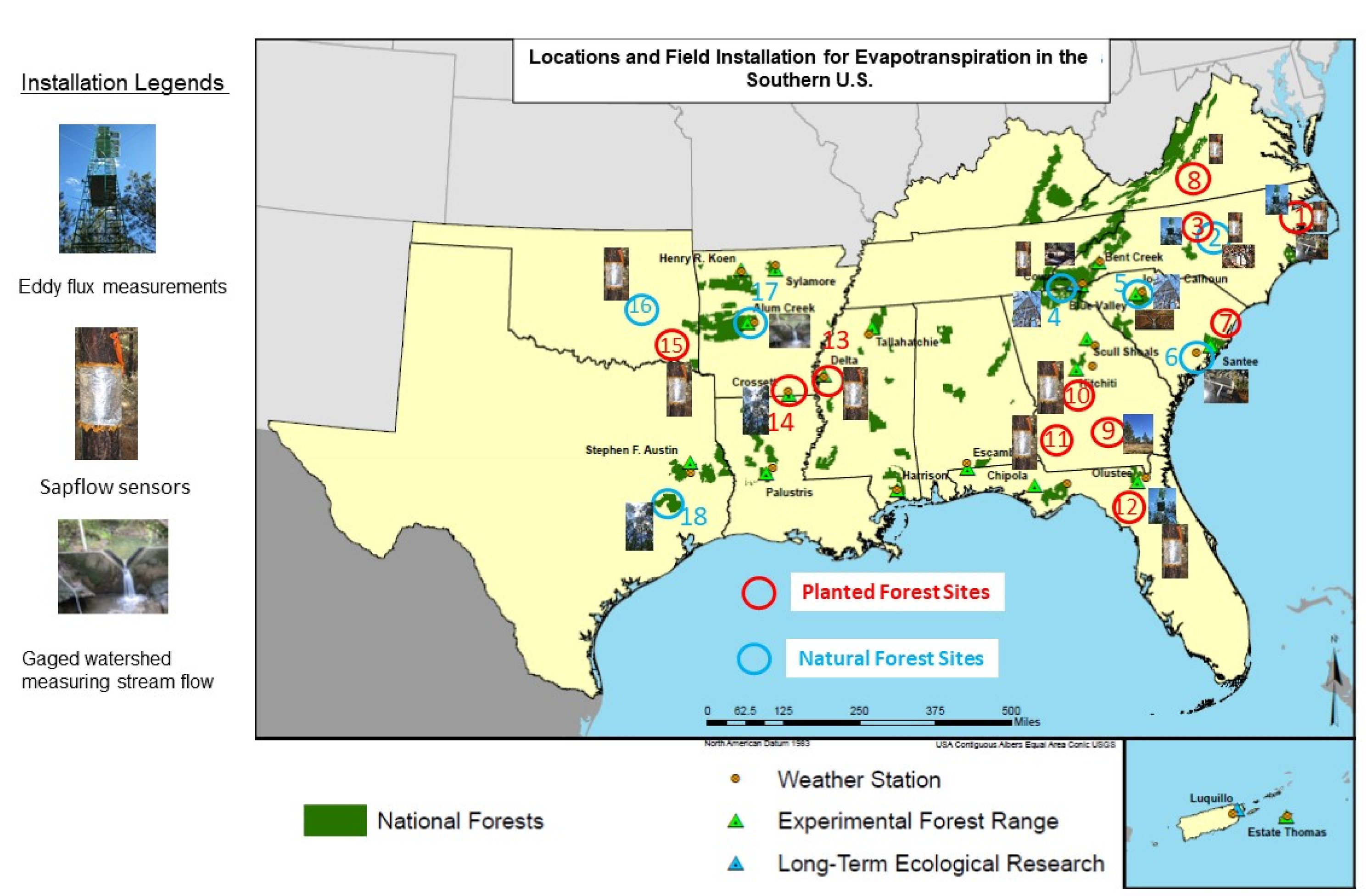


Fig 1. ET research sites in southern forests using multiple methods

DATA SOURCES & METHODS

- FLUXNET daily eddy flux ET and meteorology data
- Watershed hydrology data: ET= Precipitation – Runoff + Storage Change
- Sap flow data: sap flux-based ET estimates for forest stands
- Remote sensing (Lansat,MODIS) Two-Source Energy Balance Model
- Machine leaning developing regression models to relate monthly ET and environmental factors ; models developed based on land cover type (deciduous forest, conifer forest, crop, grassland, shrublands, savanna).

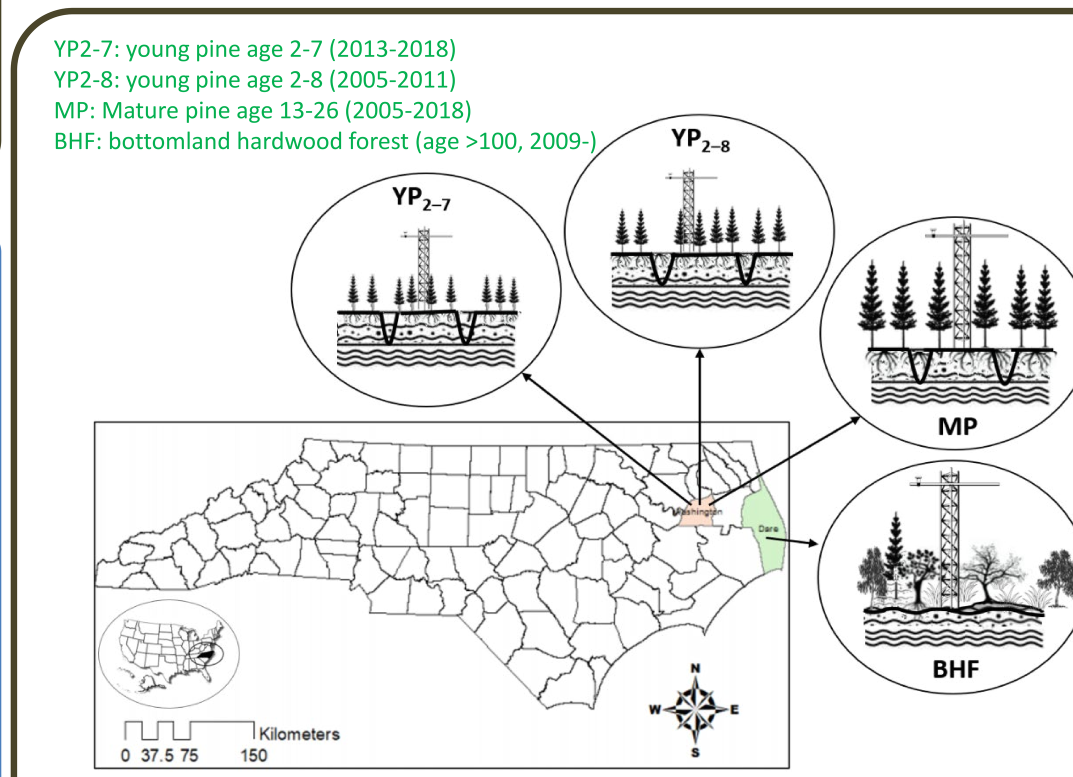


Fig 2. An example of eddy flux ET measurement installation in coastal NC.

(AmeriFlux Core Site, *Aguilos et al., 20020 a, b*)

Fig 3. Monthly ET/ETo and Normalized Annual Water Balance *(Aguilos et al., 20020 b)*

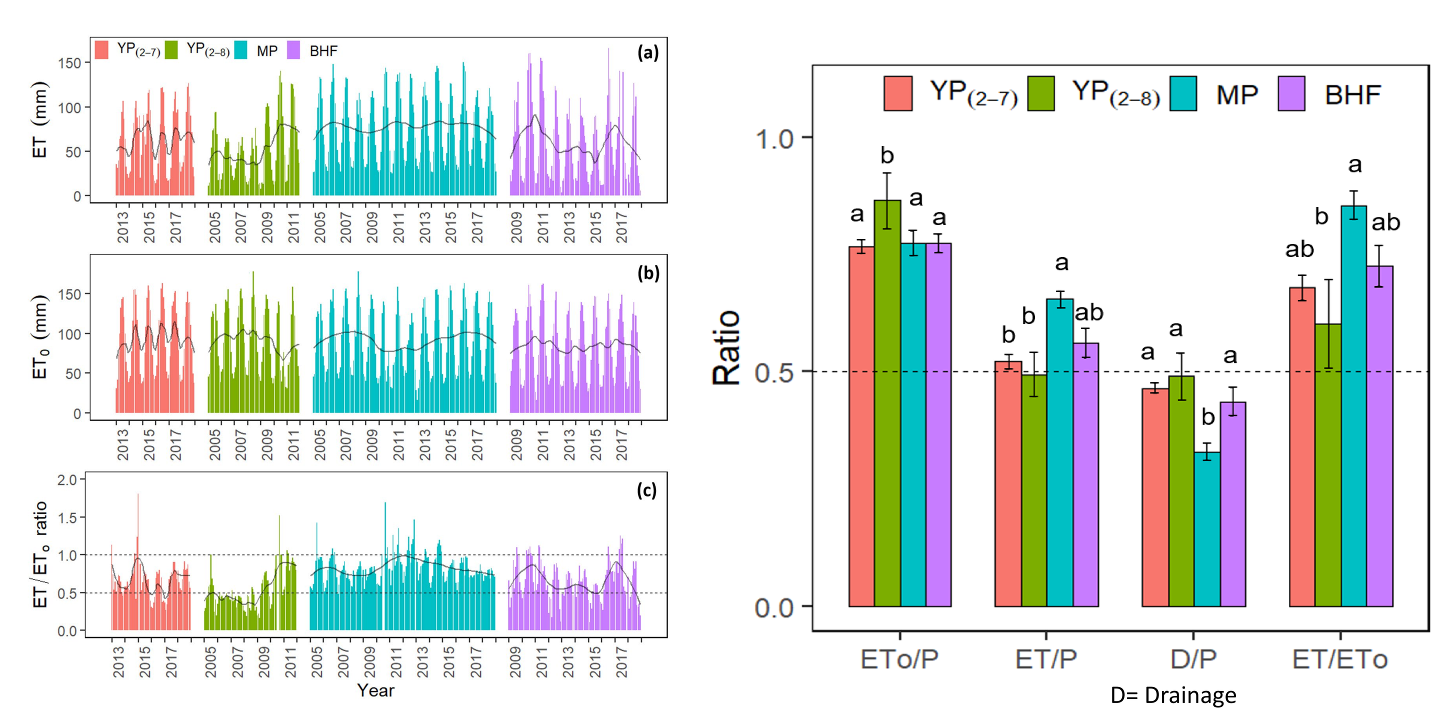
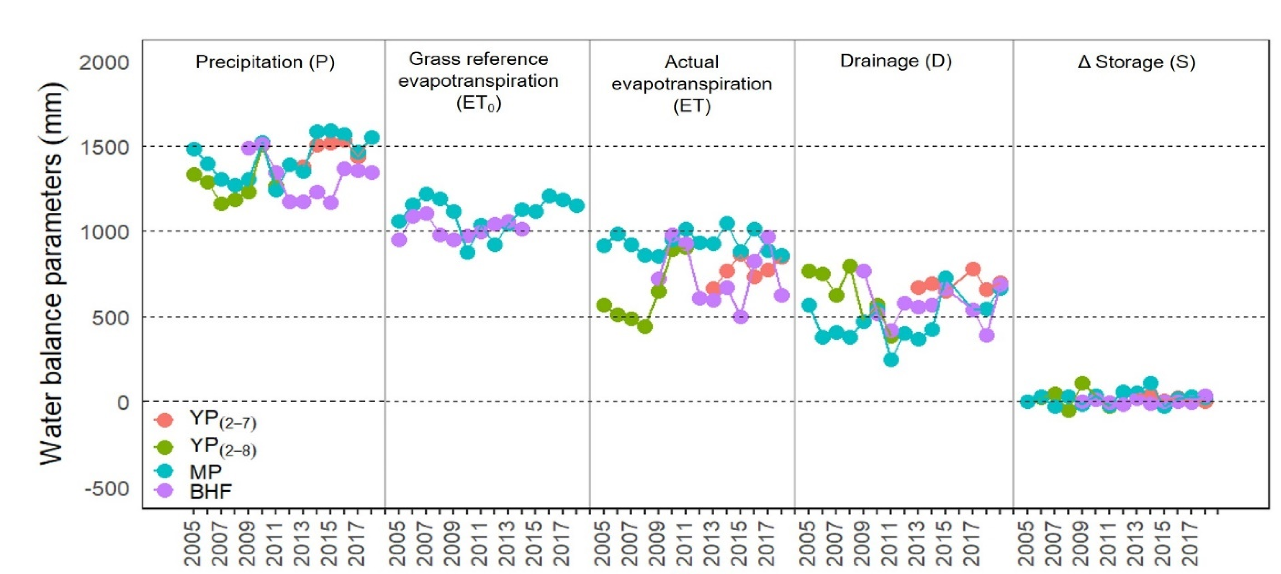
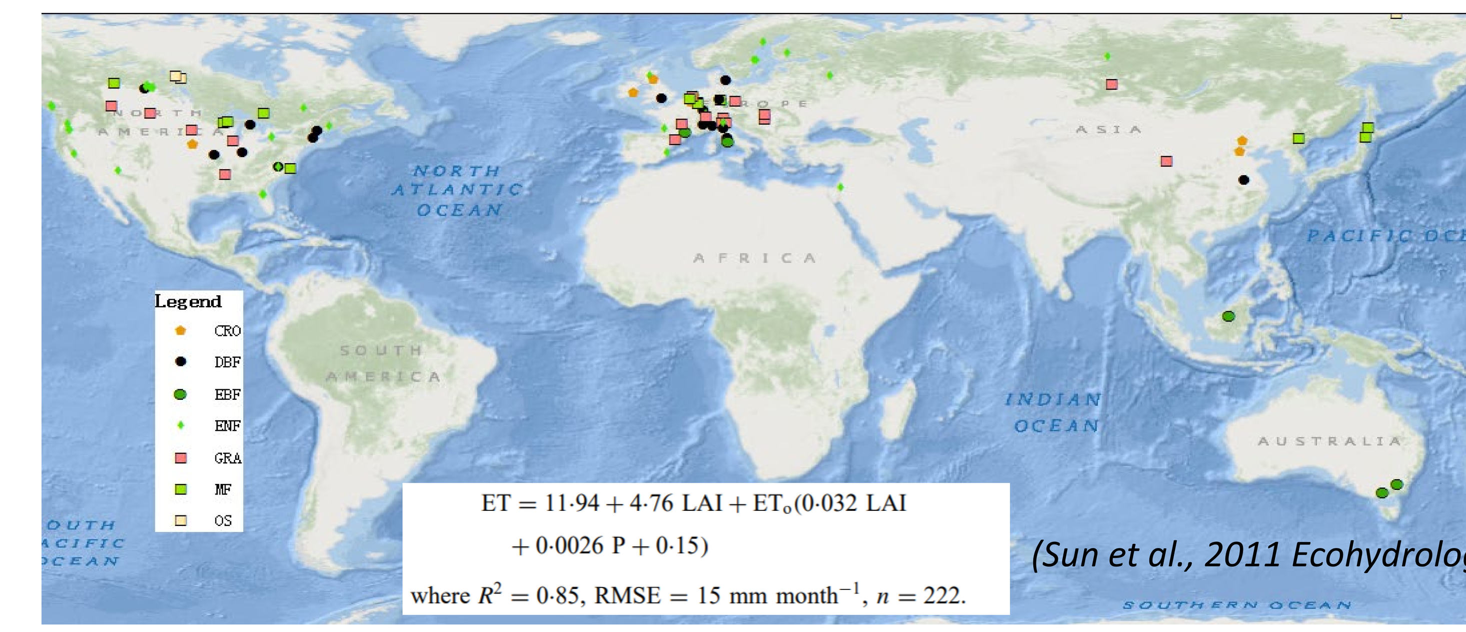


Fig 4. A comparison of annual water balance *(Aguilos et al., 20020 b)*



GLOBAL SYNTHESES ET/ETo (Liu, Sun et al., 2017, HESS)



(Sun et al., 2011 Ecohydrology)

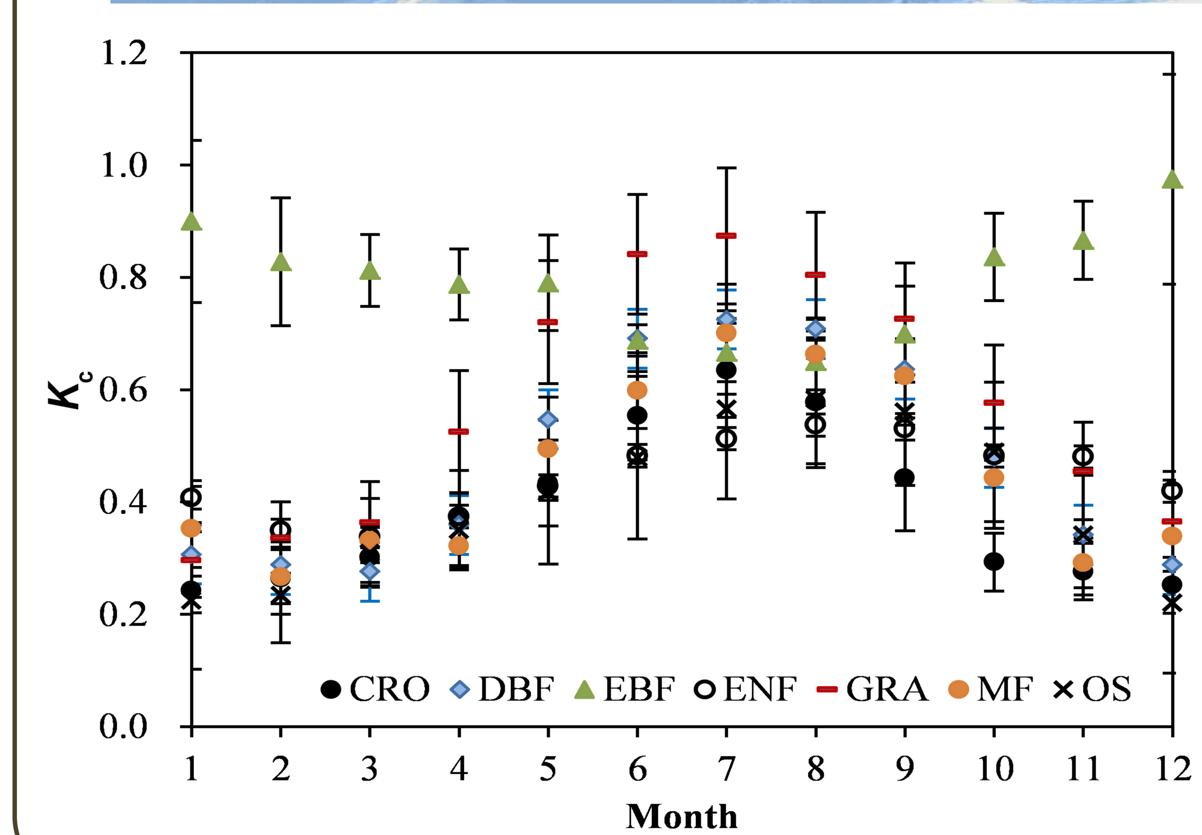


Fig 5. Mean 'Crop Coefficient' *Kc* for 7 biomes

CRO: Croplands
DBF: deciduous forest
EBF: Evergreen broad leaf forest
ENF: Evergreen broad needle leaf forest
GRA: Grassland
MF: mixed forest
OS: Open shrubs

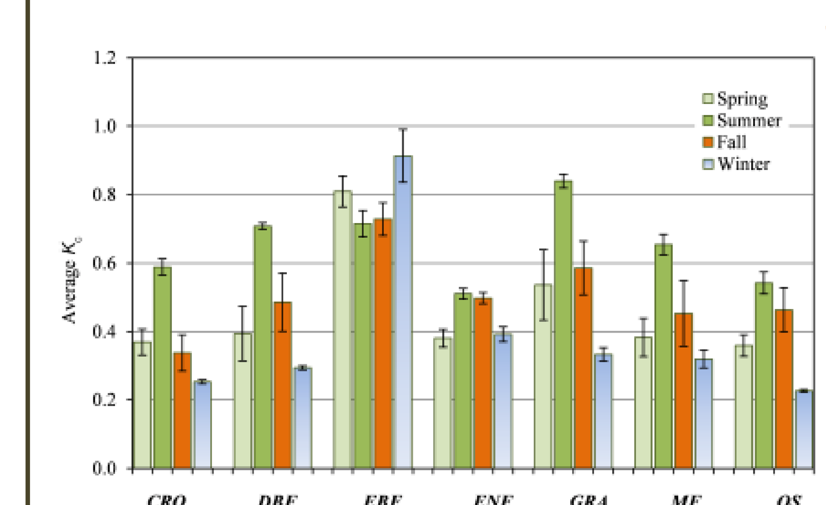


Table 1. Multiple linear regression relationships among crop coefficient and LAI, precipitation, and site latitude in different seasons.

IGBP	Season	N	R^2	K_c	b	a_1	a_2	a_3
CRO	Spring	24	0.16	0.31	0.242***	0.141*		
	Summer	24	0.21	0.57	0.331**			0.0033*
	Fall	23	0.78	0.48	0.036	0.472***		
	Winter	21	0.36	0.26	0.920***		−0.0141**	
DBF	Spring	39	0.49	0.30	0.479**		−0.0076*	0.0022***
	Summer	39	0.42	0.65	0.536***			0.0011***
	Fall	39	0.13	0.60	0.462***			0.0014*
	Winter	39	0.15	0.30	0.713***		−0.0094*	
EBF	Spring	15	0.25	0.74	0.875***		−0.0050*	
	Summer	15	–	0.91	0.911***			
	Fall	15	–	0.80	0.798***			
	Winter	15	0.42	0.72	0.676***	0.050*	−0.0050**	
ENF	Spring	96	0.39	0.37	0.225***	0.060***		0.0017***
	Summer	99	0.59	0.49	0.211***	0.053***		0.0020***
	Fall	98	0.55	0.52	−0.040	0.066***	0.0049*	0.0025***
	Winter	92	0.21	0.44	0.293***	0.084*		0.0010*
GRA	Spring	27	0.48	0.45	0.237***			0.0052***
	Summer	27	0.23	0.86	0.572***	0.110*		
	Fall	27	0.30	0.76	0.499***	0.123**		
	Winter	27	0.26	0.41	0.256**			0.0038**
MF	Spring	30	0.67	0.31	0.099**	0.188***		0.0012***
	Summer	30	0.40	0.61	0.372***			0.0029***
	Fall	30	0.54	0.58	0.250***	0.071***		0.0018***
	Winter	30	0.13	0.33	0.961**		−0.0136*	
OS	Spring	6	–	0.23	0.230***			
	Summer	6	0.90	0.35	−5.419*		0.1005*	0.0026*
	Fall	6	0.88	0.42	−9.921*	0.051*	0.1828*	
	Winter	6	0.99	0.14	−4.919*	0.629*	0.0882*	0.0032*

Fig 6. Seasonal 'Crop Coefficient' (Kc) models by biome

$Kc = a_1*LAI + a_2*Latitude + a_3*Precip + b$

CONCLUSIONS

- Forest ET rates generally are less than ETo even for wetlands conditions; Peak growing season Kc (ET/ETo) could exceed 1.0 in mature forests.
- Forest Kc values increase with age; evergreen broadleaf forests have the highest Kc.
- Seasonal Kc can be modeled by Latitude, Precip, and LAI.