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Environmental Controls of Ecosystem Evapotranspiration (ET): Why Generalized ET Models Do Not Work for Forests?

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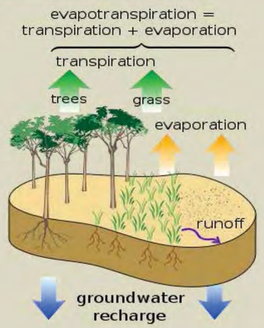
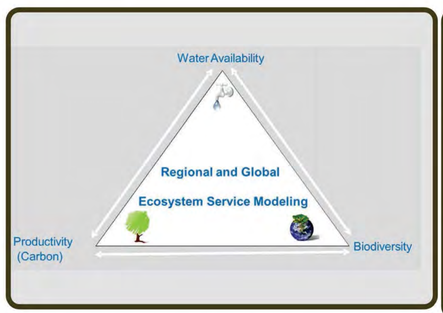
INTRODUCTION

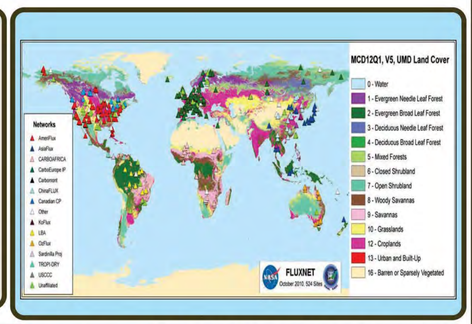
- Over 60% of precipitation returns back to the atmosphere as Evapotranspiration (ET).
- ET is the key linkage among energy, water, and carbon fluxes in ecosystems.
- Biodiversity linked to ET and potential ET.
- ET is least measured and most difficult to quantify in the water budget.
- ET quantification remains an imprecise science due to large spatial and temporal variability
- Uncertainty exists in modeling ET, and thus hydrology at multiple scales.
- Feedbacks between vegetation, landcover and climate change through ET.

OBJECTIVES

- Explore relationships between ecosystem ET and environmental controls (potential ET, LAI, vapor pressure deficit , precipitation, air temperature, wind speed , radiation , soil moisture content);
- Develop practical monthly ET models by separating land cover types for regional water and carbon balance modeling and water supply and demand analysis;
- In addition, understand other effects of other factors effects (Ozone, hydraulic redistribution) on forest water use.

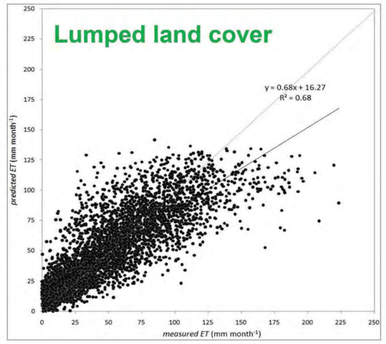


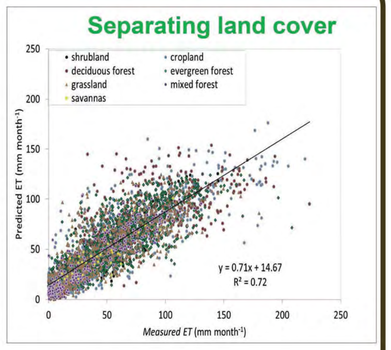




DATA SOURCES and METHODS

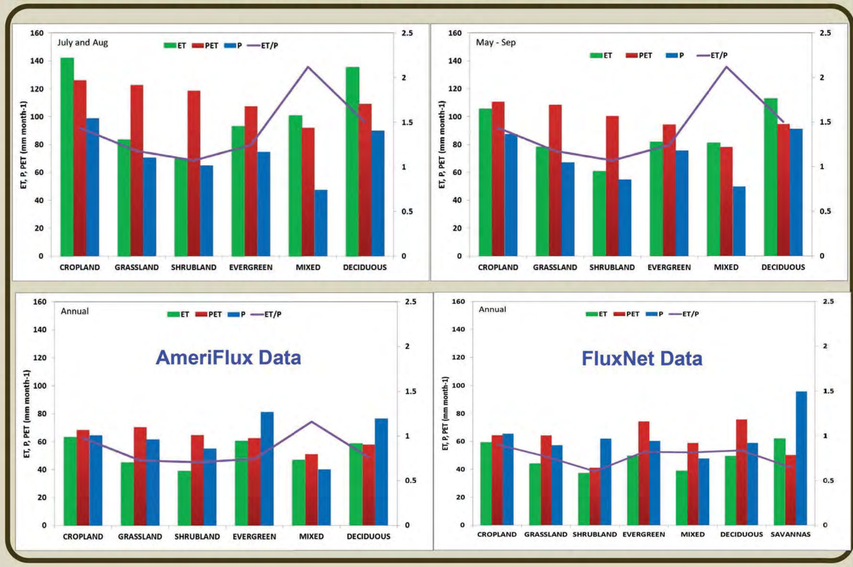
- FLUXNET daily eddy flux ET and meteorology data (252 sites, > 1200 site-years)
- Watershed hydrology data: ET= Precipitation – Runoff + Storage Change
- Sap flow method: sap flux-based ET estimates for forest stands
- MODIS leaf area index (LAI) dynamics for each eddy flux site
- FACE Site tree transpiration under ozoneexposure
- Develop regression models to relate monthly ET and environmental factors ; models developed based on land cover type (deciduous forest, conifer forest, crop, grassland, shrub, savanna).



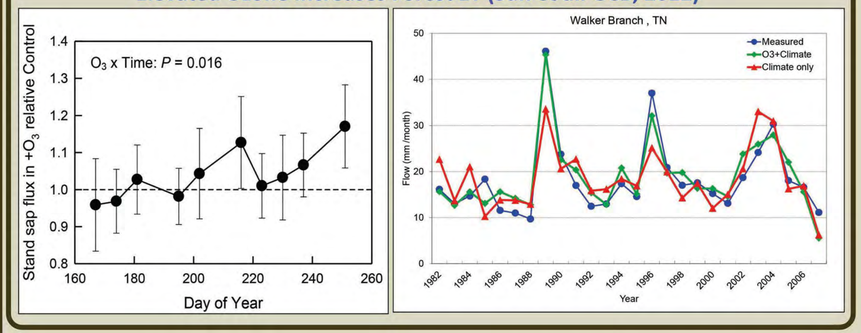


Land cover type	Complex ET Models	RMSE	R^2	n
Shrubland	ET=-5.78+13.22*LAI+0.10*Rn+0.11*P	11.2	0.86	182
Cropland	ET=-2.69+0.20*Rn+21.69*LAI+0.07*P	19.9	0.81	291
Grassland	ET=-24.55+34.65*LAI+0.67*SWC+0.15*Rn	15.7	0.83	98
Deciduous Forest	ET=-12.12+1.30*PET-4.76*VPD+7.71*LAI	15.6	0.91	154
Evergreen Forest	ET=7.56+0.84*PET-3.51*VPD+0.10*Rn	15.7	0.74	395
Mixed Forest	ET=-13.09+1.63*PET-4.58*VPD	8.3	0.96	52
Simple ET Models				
Shrubland	ET=-3.64+0.40*PET+0.09* P +11.05*LAI	12.7	0.80	182
Cropland	ET=-3.93+0.74* PET +0.06* P +17.78*LAI	21.1	0.78	294
Grassland	ET=-4.29+0.26*PET+0.19*P+38.78*LAI	17.1	0.79	123
Deciduous Forest	ET=-13.80+0.83*PET+10.38*LAI	18.1	0.88	187
Evergreen Forest	ET=5.34+0.65* PET +0.04*P +3.43*LAI	16.9	0.67	394
Mixed Forest	ET=-13.69+1.11* PET +1.81*LAI	8.8	0.95	51

RESULTS



Elevated Ozone Increases Forest ET (Sun et al. GCB, 2012)



KEY FINDINGS

- Forests use more water than grass ecosystem, especially during the growing season (May-Sep); Irrigated crop lands use similar or more water than any other ecosystem types;
- Ecosystems consume more water than precip during the growing seasons;
- Commonly used PET models may underestimate forest ET and can cause large errors in seasonal watershed water balance modeling;
- Elevated ozone increased forest ET, not decreased it in mature forests.

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