

Toward an Improved Understanding of the Role of Transpiration in Critical Zone Dynamics. An improved understanding of how tree transpiration varies across the critical zone (CZ) will help to elucidate how the vertical water flux modulates the soil moisture balance which in turn influences the subsurface biogeochemical and landscape evolution process across the CZ. Within subalpine mixed conifer ecosystems in the Jemez River Basin (JRB) and Santa Catalina Mountains (SCM) multiple sets of sap flux sensors are proposed or have been established. We will be synthesizing these data to address critical zone questions.

Installation. photos by M. Cavanaugh



Bark is cleared from installation site. Two 30-mm holes are drilled vertically about 40 mm apart and probes are inserted.



Foam quarter-eggs are taped on either side of the probe needles to protect the sensor wiring and to add thermal insulation.



Reflective bubble wrap is wrapped around the tree/sensor, to prevent the sun from causing large local gradients on the stem.

Santa Catalina Mountains:



Mount Bigelow Tower

- ☐ Installed in June 2010
- ☐ 8 Trees, North and South Sides
 - 3 Mexican White Pine (PIAY)
 - 3 Arizona Pine (PIAR5)
 - 1 Douglas Fir (PSME)
 - 1 Dead Tree



Marshall Gulch Schist Drainage

- ☐ Installed in April 2011
- ☐ 9 Trees, North Sides
 - 4 White Fir (ABCO)
 - 4 Bigtooth Maple (ACGR)
 - 1 Dead Tree

Jemez River Basin:



Jemez Mixed Conifer Tower

- ☐ Installed in 2005
- ☐ 8 Trees, North and South Sides
 - 8 Engelmann Spruce (PIEN)



Mixed Conifer Zero Order Basin

- ☐ Installed in February 2011
- ☐ 8 Trees, North Sides
 - 4 White Fir (ABCO)
 - 4 Engelmann Spruce (PIEN)

Granier-Style Thermal Dissipation Probe (TDP) Sap Flow Sensors:

The empirical Granier TDP method is based on liquid velocity heat dissipation theory. Two needles are inserted radially into the sapwood, one needle placed above the other. The upper needle contains a line heat source and a thermocouple junction which is referenced to another junction in the lower needle. The difference in temperature (dT) between the two needles is dependent on sap velocity: heat is dissipated more quickly when sap velocity increases and so dT decreases as a result of the cooling of the heat source.

This synthesis project is being led by JRB-SCM CZO post-doc Bhaskar Mitra.

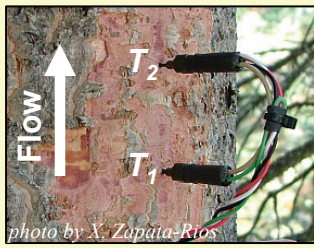
Calculating Sap Flux Density.

Probe needles measure the dT between the heated needle T_2 and the sapwood ambient temperature T_1 below. Sap flux density (F_s) is calculated with the following empirical equation:

$$F_s = 0.0119K^{1.231} \times 3600 \text{ [cm}^3 \text{ cm}^{-2} \text{ hr}^{-1}\text{]}$$

$$K = (dT_M - dT) / dT$$

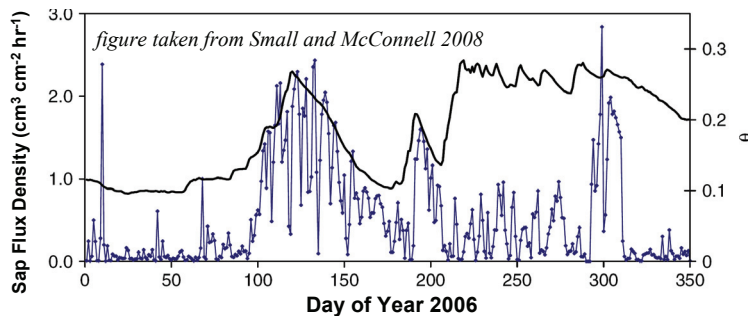
$$dT_M = dT \text{ when no sap is flowing } (\sim 1 \text{ pm to } 3 \text{ am})$$



Sap Flow in Mixed Conifer Ecosystems. Start dates of sap flow records range from 2005 to 2011. Species are also variable. We plan to investigate at the environmental controls (soil moisture, aspect) on species and stand level transpiration at each of these sites.

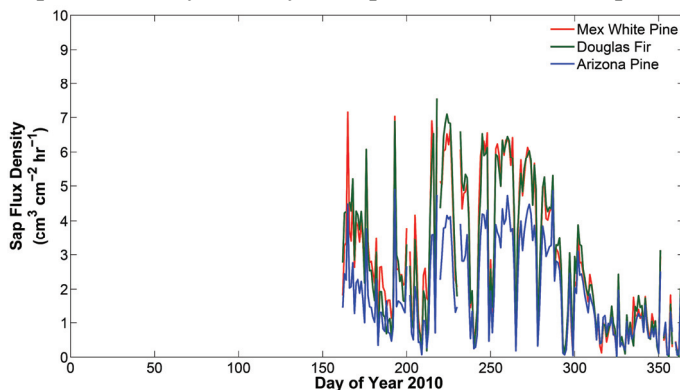
Jemez Mixed Conifer Tower (Spruce):

- Soil moisture is a strong control on spruce transpiration.



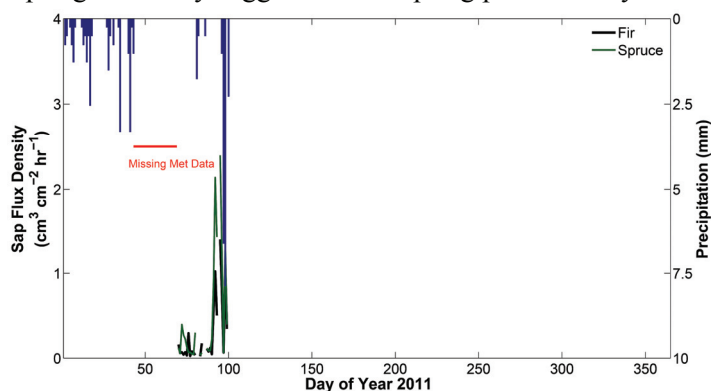
Mount Bigelow Mixed Conifer (Pine and Fir):

- Species density is likely to impact stand level transpiration.



Jemez Mixed Conifer Zero Order Basin (Spruce & Fir):

- Spring rains may trigger onset of spring plant activity.



Calculating Stand-Level Transpiration (T_{stand}).

Typically the a version of the following equation is used:

$$J_{tree} = F_{s-tree} \times A_{s-tree} \text{ [cm}^3 \text{ hr}^{-1}\text{]}$$

$$J_{species} = \left(\sum_{i=1}^m J_{tree_i} \right) / m \text{ [cm}^3 \text{ hr}^{-1}\text{]}$$

$$T_{stand} = \left(\sum_{i=1}^n J_{species_i} \right) / A_G \text{ [cm}^3 \text{ hr}^{-1} \text{ m}^{-2}\text{]}$$

F_{s-tree} = sap flux density of tree

A_{s-tree} = sapwood area of tree

m = number of trees of each species

n = number of species

A_G = ground area

Because not all trees in the stand are measured, often allometric relationships for sapwood areas are used, e.g.:

$$A_{s-species} = a \times DBH^b$$

a and b = empirical coefficients

DBH = diameter at breast height

To determine T_{stand} at each of the sites, we plan to combine field campaigns and LiDAR to determine our allometric relationships for upscaling.

Sap flow papers resulting from these sites:

- ❑ Small, E.E., McConnell, J.R., 2008. Comparison of soil moisture and meteorological controls on pine and spruce transpiration. *Ecohydrology* 1:205-214.

Contact. For collaboration or to learn more about sap flow sensors in the JRB or SCM, please contact:

- ❑ **Mixed Conifer Zero Order Basin**

- ❑ **Marshall Gulch Drainages**

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