Sperry's supply-demand-loss model

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1 Introduction

Sperry and Love (2015 (What plant hydraulics can tell us about responses to climate-change droughts)) developed a model where a supply function ($E_{p-canopy}$) is derived which calculates the potential rate/amount of water able to be supplied from the soil to the atmosphere, i.e. potential transpiration. Transpiration is influenced by xylem pressure (ψ_{xylem}), hydraulic conductivity of the plant (K_{plant}), the hydraulic conductivity of the soil K_{soil} and the rate at which hydraulic conductivity is reduced as xylem pressure increases or soil conductivity decreases.

Below are parameters for the vulnerability-conductance curve.

```
p50 <- 2.5 # the matric potential where conductance is reduced by 50%
K_max <- 8 # maximum plant conductance - this is a trait in aDGVM2
res <- 1/K_max # resistance is simply the inverse of conductance
psi_canopy <- seq(0.0, 5, length=1000)
predawn_soil_mat_pot <- seq(0,2, by=0.5) # initial plant matric potential = soil matric potential
cum_can_transport <- matrix(0,0,nrow=1000, ncol=5) # this is the supply function
```

with the the conductance vulnerability curve we use in aDGVM2, which is analagous to Sperry's curve, defined as:

```
sperry_cond <- function(psi_canopy) { ((1 - (1 / (1 + exp(3.0*(p50 - psi_canopy)))))) / res }
```

The transpiration rate is the integral of the vulnerability-conductance curve between any the soil (pre-dawn) matric potential and $(p - canopy)$(canopy sap pressure) and is calculated as follows:

```
for(j in 1:length(predawn_soil_mat_pot))
  {
    for(i in 1:1000)
      {
        ffx <- integrate(sperry_cond, predawn_soil_mat_pot[j], psi_canopy[i] )
        cum_can_transport[i,j] <- pmax(0, ffx$value)
      }
}
```

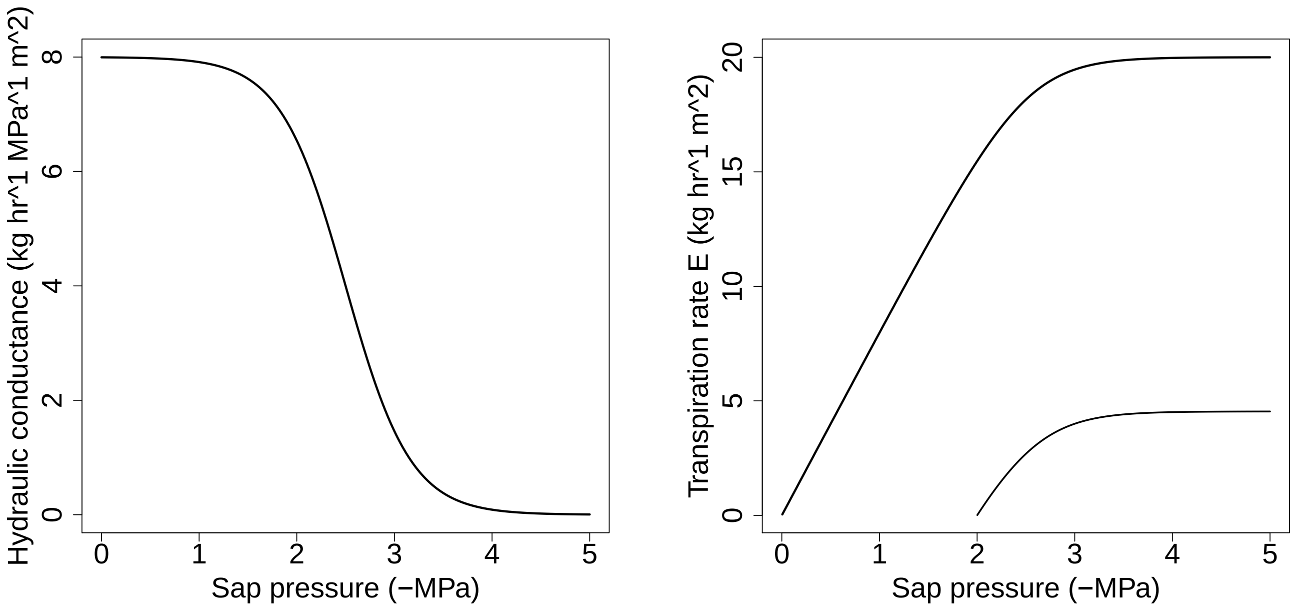

Figure 1: Hydraulic conductance and transpitation as a function of sap xylem pressure.