Physical Hydrology for Ecosystems
BEE 371

Some Useful Soil Physics Relationships

Using mechanistic equations for vadose zone water flow, like Green and Ampt's infiltration equation, requires estimates of hydraulic conductivity and matric potential. Luckily there are a few accepted approximations for these quantities that can be determined from moisture content and general, published parameters. Here are two for matric potential, ψ_m, and hydraulic conductivity, K_s:

$$\psi_m = \psi_e \left(\frac{\theta}{\theta_s} \right)^{-b} \text{ and } K = K_s \left(\frac{\theta}{\theta_s} \right)^{2b+3}$$

Some common values for the parameters in the above expressions for various soil textures[1]:

Texture	%silt/%clay	ψ_e (cm water)	K_s (cm hr^{-1})	b	θ_{fc}/θ_{wp}	$n \approx \theta_s$*
Sand	5/3	7.1	20.5	1.7	0.09/0.03	0.33-0.48
Loamy sand	12/7	9.2	6.0	2.1	0.13/0.06	0.36-0.48
Sand loam	25/10	15.3	2.5	3.1	0.21/0.10	0.42-0.47
Loam	40/18	11.2	1.3	4.5	0.27/0.12	0.43-0.47
Silt loam	65/15	21.4	0.67	4.7	0.33/0.13	0.44-0.48
Sandy clay loam	13/27	28.5	0.42	4.0	0.26/0.15	0.43-0.5
Clay loam	34/34	26.5	0.23	5.2	0.32/0.20	0.44-0.5
Silty clay loam	58/33	33.6	0.15	6.6	0.37/0.32	~0.5
Sandy clay	7/40	29.6	0.12	6.0	0.34/0.24	~0.5
Silty clay	45/45	34.7	0.09	7.9	0.39/0.25	~0.5
Clay	20/60	37.7	0.06	7.6	0.40/0.27	~0.5

The matric suction at the wetting front is often calculated using:

$$\psi_{mf} = \frac{2b+3}{b+3} \psi_e \left[1 - \left(\frac{\theta_i}{\theta_s} \right)^{b+3} \right] \approx \frac{2b+3}{b+3} \psi_e$$

where θ_i is the initial water content of the soil and the far right expression is for $\theta_i << \theta_s$.

[1] Adapted from: G.S. Campbell and J.M. Norman, *An Introductions to Environmental Biophysics*, Springer, New York, 1998 (p.130)

* Adapted from T. Dunne and L. Leopold, *Water in Environmental Planning*, W.H. Freeman & Co. San Francisco.(p. 175)