Lecture 10—The fate of rain

Sounds kinda like a Robert Frost poem. Maybe more William Carlos Williams. Anyway, we need some way of talking about the various things that can happen to rain once it leaves the Mother Cloud and heads for the ground. Among the possibilities:

--It can never quite reach the ground (it can hit trees or fall directly into bodies of water)
--It can reach the ground and settle into small temporary pools (like vernal pools, for instance)
--It can hit the ground and sink in
--It can run downslope into streams

Here's the problem. One of the big things I said we'd like to be able to do is relate a rainfall hyetograph to stream discharge. Ok, that said, three of the four possibilities mention won't contribute to discharge! We need to estimate those quantities and remove them from the hyetograph in order to have the right sort of input to a model connecting rainfall to discharge.

We're going to handle the first two today. These are called *interception* and *depression storage* respectively. These are relatively minor effects in the overall scheme of things, and for major storms, they are often discounted entirely.

Interception—Some rain never quite makes it to the ground at all. It hits trees, buildings, whatever, and stays put. This rain is *intercepted*, and believe it or not, it can have a huge effect on plant growth. Yep, the reason coastal redwoods exist is because most of their water needs are met in the summer because fog gets intercepted on the redwood needles. Soooo, mostly interception is important for either people worried about water availability for plants or in places where intense rainfall isn't the norm.

There have been many many attempts to estimate the amount of intercepted rain for various ground covers. One of the easiest to understand is an early equation by Horton, who felt that the amount of rain stored as interception would be proportional to the amount of rain:

$$L_i = A + BP^n$$

Where Li is the amount of intercepted rain, P is the amount of rain, and A, B, and n are empirically derived constants. This is, incidentally, a *beautiful* example of a tuning equation—we know there must be a relationship, but we have *no idea* what that relationship might be. When you see equations that look like this, someone's fishing.

That said, this is not uncommon for estimating interception loss. n is commonly taken to be 1, and the other two constants are determined by actual measurement. Some examples follow:

	A (cm)	B (cm)
Ash	0.038	0.23
Oak	0.076	0.22
Red Pine	-0.10	0.89
Loblolly Pine	-0.08	0.88
Shortleaf Pine	-0.10	0.91
Eastern White Pine	-0.13	0.91

Intuitively, interception is only going to affect the very beginning of rainfall, because fairly quickly the available storage (on leaf surfaces, for example) is going to be filled and you'll have water hitting the leaf balanced by water dripping off the leaf. As a result, interception losses are commonly removed from the very front of the hyetograph in a process called "initial abstraction."

Depression storage—Some water that actually strikes the ground gathers in small topographic depressions and does not enter runoff; it either evaporates once the storm is over, or it infiltrates. *Depression storage* is handled in a manner analogous to interception; because these depressions are filled early in the storm, an abstraction for depression storage is commonly taken off the front of the storm. An expression for the volume of water in storage at any given time during a storm is given as:

$$V_s = S_d\left(1 - e^{\frac{-P_e}{S_d}}\right)$$

Where V_s is the volume of water in depression storage, S_d is the maximum depression storage capacity for the basin, and P_e is the rainfall excess (after interception, infiltration, and evaporation have been removed). This still doesn’t get us any closer to having an actual *volume*, since we don’t know what the total storage capacity for a basin is. This is not a simple problem, but answers generally range from about 0.5 to 2 inches of storage for a basin. Note that, properly, you’d want to first remove interception, then infiltration, *then* depression storage, since only after the infiltration capacity of the soil has been exceeded will depression storage begin to fill. We’ll talk more about infiltration next time.