FACT SHEET No. 36

Rangeland Watershed Program

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Interception on Rangeland Watersheds

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Not all of the precipitation which falls to a watershed reaches the soil surface to become available for plant growth, stream flow, or groundwater recharge. *Interception* is the process by which falling precipitation interacts with the vegetation covering a watershed. The result of this interaction is dependent upon vegetation and precipitation characteristics.

Several things can happen to precipitation as it falls on a rangeland watershed: 1. it may land directly on bare soil; 2. it may be intercepted by the canopy (trees, shrubs, forbs, and/or grasses standing above ground) and be detained there long enough to evaporate; 3. it may drip from the canopy; 4. it may collect in the canopy and run down tree, shrub, forb, and/or grass stems; 5. it may pass directly through gaps in the canopy; and 6. if it finally reaches the litter layer (mulch covering the soil surface) it can be detained long enough to evaporate or pass through the litter and reach the soil surface. Once precipitation reaches the soil surface, the process of interception is complete and the process of infiltration begins. The litter layer is extremely important to both interception and infiltration.

Interception serves two roles on a watershed. First, interception is an important part of the water balance of a watershed, serving as either a loss or gain of water to the watershed. Second, interception plays an important role in protecting the mineral soil surface from the energy of rainfall. Reduction of raindrop energy by interception minimizes soil detachment and subsequent erosion as well as protects soil structure and infiltration capacity. Interception can be impacted by management which effects the amount, type, and distribution of vegetation on a watershed. This fact sheet will discuss the process of interception and how it impacts watershed water balance. The role of interception as it relates to infiltration and erosion and how management can impact these processes will be discussed in later Rangeland Watershed Program fact sheets.

Definition of Terms

Interception capacity is the volume of precipitation the canopy and litter on a watershed can store. *Gross Precipitation* (P_g) is the precipitation which falls to a watershed, measured above the canopy or in an open area. *Interception loss (I)* is the portion of gross precipitation retained by the canopy or litter and lost from the watershed as evaporation without adding moisture to the soil. Interception loss equals the sum of *canopy interception loss* (I_c) and *litter interception loss* (I_l). *Net precipitation* (P_n) is the precipitation which reaches the soil surface, theoretically measured under the canopy and litter. *Throughfall* (P_t) is the precipitation which reaches litter, or bare soil, by passing directly through, or dripping from, the canopy. *Stemflow* (P_s) is the precipitation which reaches litter or bare ground by flowing down the stems of trees, shrubs, forbs, and grasses. In some cases stemflow can pipe water directly into the soil. Figure 1 (Hewlett 1982) illustrates these terms. Throughfall and stemflow are most often associated with forest watersheds, but they can be important processes on rangeland watersheds.

Factors Affecting Interception

Interception is effected by vegetation and storm characteristics. The concept of interception capacity is important. There is some amount of water or snow which the canopy and litter on a watershed can hold. Think of interception capacity as a cup. When the cup is full, any additional input of precipitation runs over the cup to become runoff, soil moisture, streamflow, or ground water. No water can be added to the cup until some of the water in the cup is removed by evaporation. Evaporation from the cup takes place both during and after a storm.

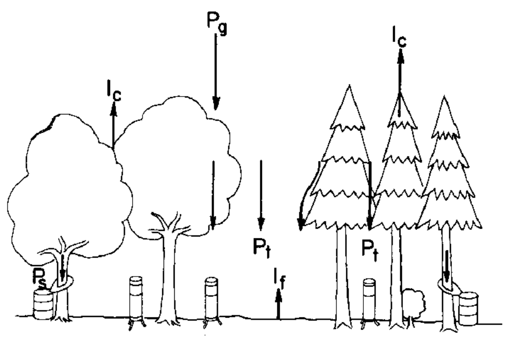

Figure 1. Process of interception (after Hewlett 1982)

Vegetation

Table 1 (see page 4) provides a summary of several studies of interception loss, throughfall, and stemflow under forest and range vegetation. Vegetation factors affecting interception can be examined at an individual plant or at a watershed level. At the individual plant level, factors of interest are: 1. species, 2. canopy density, 3. leaf area, 4. seasonal characteristics (deciduous vs. evergreen), and 5. leaf surface and bark roughness. Variation in species characteristics creates variation in interception between species. For instance, conifers (trees with needles) tend to have a greater interception capacity than broadleaf species. On broad-leaves, raindrops can run together forming large drops which fall from the leaf as throughfall, but the needles of conifers do not allow this. It is important to note that there is significant variation in interception between plants of the same species.

Density and leaf area refer to canopy area per unit land area. Generally, the denser the foliage the greater the interception. There is seasonal fluctuation in interception capacity, a deciduous tree will have a lower interception capacity when it is dormant (no leaves) than when it is growing. An evergreen maintains a fairly constant interception capacity throughout the year. Leaf surface roughness is important because a "rough" leaf will hold more water than a smooth leaf. Pubescence, or hair, on grass blades contributes to leaf roughness. Bark roughness influences stemflow; smooth barked species will produce more stemflow than rough barked species. The angle and number of stems and branches on woody species influences stemflow.

At a watershed level, the spatial arrangement or pattern of vegetation across the watershed becomes important: 1. canopy density and closure, 2. species mix, 3. presence or absence of understory. Canopy density and closure refer to how closed the foliage is across the watershed. Species mix is the composition and patchwork of vegetation across the watershed. A watershed comprised of a solid stand of slick-barked, broad-leaved aspen will behave differently than a watershed comprised of rough-barked ponderosa pine (Table 1). The presence or absence of understory relates to foliage density, under brush adds density.

There is limited information available on the interception capacity of litter. Generally, it is dependent upon the thickness and water holding capacities of the litter. The water holding capacity of litter is largely a function of the vegetation type and species from which it came, as well as upon its decomposition rate. Litter under hardwoods tends to have a slightly lower interception capacity than litter under conifers. (Table 1). A study in Canada determined that litter in mixed grass prairie had a lower water holding capacity than litter in a fescue grassland. Water holding capacity increased with litter particle size and was higher in standing and fallen litter than in organic matter.

Precipitation

Storm type plays a role in determining interception loss. For instance, a low-intensity, long-duration frontal storm will generate different interception loss than a high-intensity, short-duration convectional storm. In general, the precipitation and storm factors which affect interception loss are (Rangeland Watershed Program Fact Sheet #34 defines the following terms): 1. precipitation amount, 2. storm frequency, 3. precipitation intensity, 4. storm duration, 5. type of precipitation, 6. wind during storm, and 7. wind during evaporation.

Interception loss, as a percentage of gross rainfall, decreases as rainfall amount increases. This is because rainfall amount has little effect on interception loss once the interception capacity is filled. Assume that interception capacity of a watershed is 0.1 inch, if 0.2 inch of rain falls interception loss will be about 50%, but if 1.0 inches of rain falls interception loss will be about 10%. Storm frequency (timing) impacts interception capacity through time. Assume a storm occurs that fills the interception capacity of a watershed, following the storm it will take some period of time (roughly 12 hours) for that intercepted water to evaporate and return interception capacity to its maximum. Less interception loss will occur if the second storm occurs before, rather than after, the water intercepted during the first storm has evaporated. A high intensity precipitation event will have lower interception loss than a low intensity event. Storm duration affects interception loss in much the same way as amount.

Precipitation type is important, but due to the difficulty in measuring snow interception loss, most research has focused on rainfall interception loss. Although snow interception is highly visible, most intercepted snow reaches litter or bare soil due to wind or melt. In general, there is greater interception loss under rainfall than snowfall. This is not to say that snow interception loss is insignificant. High winds during a storm event can mechanically shake precipitation from the canopy and thus reduce interception loss. Winds during evaporation can either shake precipitation loose or increase the rate of evaporation and decrease the time until maximum interception capacity is attained.

Interception is NOT Always a Loss!

So far this discussion has focused on the loss of water from a watershed due to interception. However, in coastal or high mountain regions which have a high number of foggy or cloudy days, interception can add water to a watershed. Fog drip occurs when water droplets coalesce on vegetative surfaces and drop to the ground. Fog drip adds substantial water to forestlands in coastal California. Rime ice forming on trees at high elevations on the eastern slopes of the Cascade mountains in Washington has been found to add 3-4 inches of precipitation to watersheds during the winter season.

Measurement of Interception Loss, Throughfall and Stemflow

Estimation of interception loss requires direct measurement of gross precipitation, throughfall, stemflow, and change in litter moisture content before, during, and after storms (Figure 1). Measurement of gross precipitation at a point or across a watershed is detailed in Rangeland Watershed Program Fact Sheet #34. Throughfall is measured by randomly placing rain gauges under a canopy. Throughfall is highly spatially variable both under a single tree and under an entire canopy. At least 10 gauges under canopy are required for every gauge in the open (gross precipitation). Trough type gauges "cut across" the spatial variability and provide a better measurement of throughfall than traditional cylindrical gauges. Stemflow is measured by fixing collars around tree or shrub main stems and funneling the water into a collection gauge.

Although throughfall and stemflow occur with forbs and grasses, they are almost impossible to measure accurately in the field. Canopy interception loss is calculated as [Gross precipitation - (Throughfall + Stemflow)]. Litter interception loss is generally estimated by collecting litter from a plot of known area immediately before, after, and X days after a storm. The litter is weighed, dried, and weighed again. The difference between the wet weight and the dry weight is the water content of the litter. The change in litter water content over time is determined and litter interception loss calculated. Some of the moisture may have entered the soil by infiltration, so paired soil and litter moisture content measurements are required for accurate litter interception loss estimation.

References

Hewlett, J.D. 1982. Principles of forest hydrology. University of Georgia Press. Athens, GA.

Table 1. The values presented here are at best rough estimates of interception loss, throughfall, and stemflow as a percent (%) of annual gross precipitation taken from the literature. Much variation exists. Interception Loss + Throughfall + Stemflow need not equal 100, throughfall or stemflow may be intercepted and lost from litter. Where Interception Loss + Throughfall + Stemflow = 100, the study may have ignored interception loss from litter.

Vegetation	Interception Loss	Throughfall	Stemflow
Conifer Forest	30.0	67.0	3.0
Second Growth Ponderosa	12.0	85.0	3.0
Ponderosa	32.0	-	-
Lodgepole	23.0	-	-
Conifer Litter	5.0	-	-
Eastern Hardwood Forest	13.0	82.0	5.0
Oak Canopy (CA)	21.4	77.1	1.5
Live Oak (TX)*	46.1	71.3	3.3
Apsen w/ Grass Understory	15.8	-	-
Grass w/ Aspen Removed	10.5	-	-
Hardwood Litter	3.0	-	-
Utah Juniper (AZ)	17.0	83.0	1.0 - 2.0
Chaparral (CA)	11.0	81.0	8.0
Big Sagebrush (UT)	4.0 - 31.0	-	-
Shadscale (UT)	4.0	-	-
Grassland	10.0 - 20.0		
Mixed Prairie (Great Plains)	14.0 - 24.0	-	-
Big Bluestem (OK)	57.0 - 84.0	-	-
Buffalo Grass (OK)	17.0 - 74.0	-	-
Kentucky Bluegrass	56.0	-	-
Annual Grassland (CA)	26.0	-	-
Sideoats Grama (TX)	18.1	-	-
Curlymesquite (TX)	10.8	-	-