Managing excess water in the high-precipitation zone

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Growers in the wetter eastern annual-cropping region of the Pacific Northwest do not have a problem with too little winter precipitation, but instead must find ways to manage excess soil moisture conditions during the early spring months. Not only does the precipitation increase in the eastern edges of the REACCH region, but the soils in the wetter, eastern borders of the region also generally have higher clay content and develop dense, restrictive soil horizons, further exacerbating the problem of excess moisture. The dense horizons are called argillic (Argixerolls) and fragipan (Fragixeralfs), with the latter horizons often being nearly impermeable to water (Figure 1). In fields with steep converging topography, toe-slope positions often remain completely saturated for weeks on end during early spring months, due to poor drainage through these horizons. The depth of these argillic and fragipan horizons generally varies throughout a field, with very shallow (~0.7-feet) horizons in eroded ridge locations and much deeper ones in toe-slope deposition regions (~3 to 5 feet).

IMPACT

Future climate projections suggest that increased winter precipitation will exacerbate runoff and erosion problems in the high-precipitation zones of the Palouse, most significantly for those growers in the annual cropping region where soils have restrictive horizons. With an increase in spring moisture predicted for the late spring months, growers may need to consider incorporating more fall-seeded crops into their rotations and relying on more spring fertilizer applications, as overwinter nitrogen losses will also likely increase.

Since these restrictive horizons are often too deep and thick to be broken down by most tillage implements, little can be done to increase water flow through these layers. In many regions, these toe slopes are artificially drained using tile lines or 4-inch perforated artificial drains to allow growers to access their fields earlier in the spring.

In the REACCH and Site-Specific Climate-Friendly Farming projects, we are using physically based, hydrologic sediment transport and cropping systems models to investigate the impact of various management strategies on sediment and nutrient transport in this high-precipitation zone. We are using the Water Erosion Prediction Project (WEPP) model to evaluate the impact of management on surface runoff, drainage, soil erosion, and carbon loss. Similarly, we have been using a newly developed 3-D version of the CropSyst model called MicroBasin to investigate the importance of the depth of a restrictive layer for the hydrology, crop production, and nutrient transport within a field. By using downscaled future climate data, we can use these models to evaluate the effects of management and soil properties on both current and future climates. Future climate projections indicate that the region will experience a 3° to 7°F increase in temperature and wetter (by ~1.5 to 3 inches) winters and slightly drier summers.

Both the WEPP model and the MicroBasin model suggest that the presence of restrictive soil horizons greatly affects the distribution of water throughout a field. WEPP model simulations indicate that surface runoff from soil having a restrictive layer at 2.3 feet (1.4 inches per year) can be nearly 2.5 times greater than

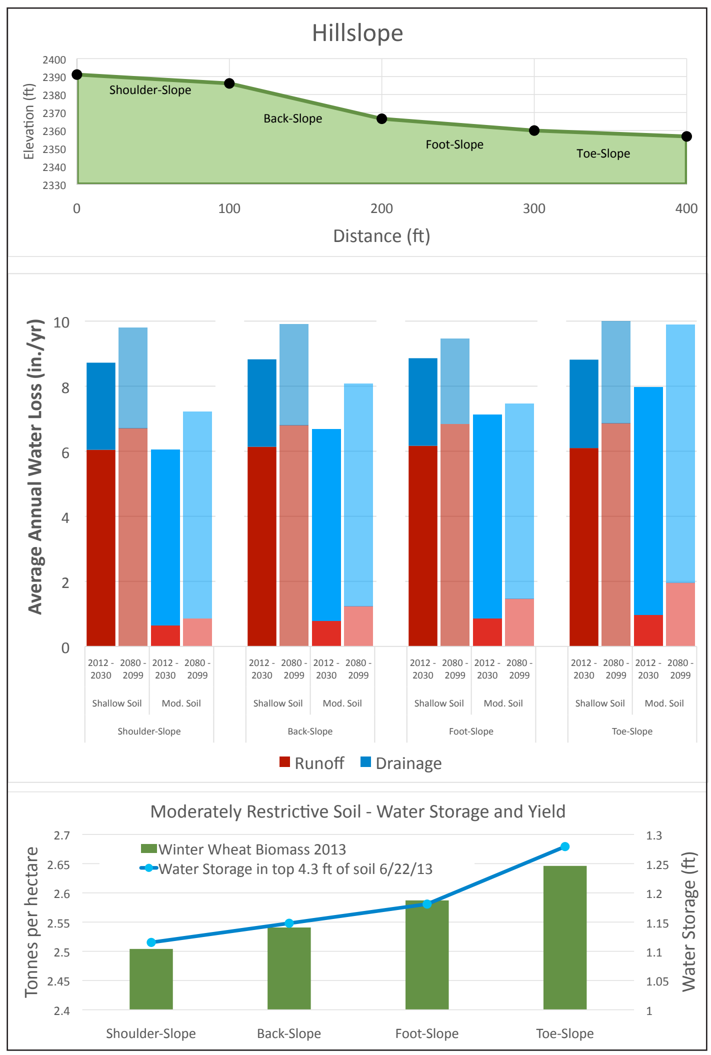

Figure 2. *Simulated runoff, drainage, and crop biomass production from soils that have a restrictive soil horizon at depths of 0.7 meter and 1.3 meter (2.30 and 4.27 feet) for early-century and late-century climates in the high-precipitation zone of the REACCH region.*

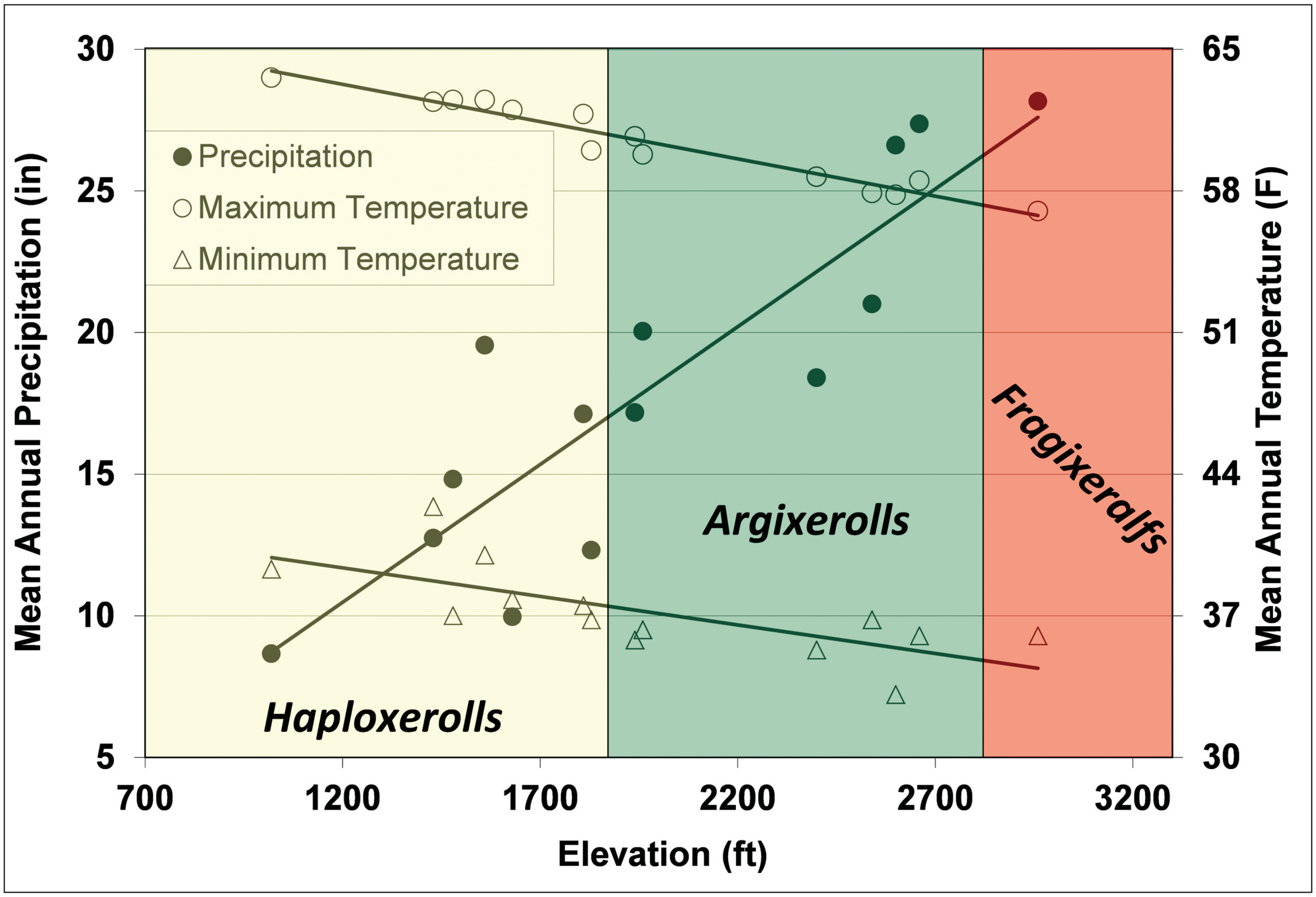

Figure 1. *Relationships among soils, mean annual precipitation, maximum temperature, minimum temperature, and elevation for distributed locations in Whitman County, WA, and Latah County, ID.*

surface runoff from a deep soil (3.3 inches per year), despite both soils being managed using no-till practices. Interestingly, the model shows that there is little difference in annual surface runoff from conventional tillage and no-tillage fields when the soils have a shallow restrictive layer. Despite high runoff, however, the adoption of no-till practices is very effective, nearly eliminating soil erosion in these shallow soils. This suggests that adoption of no-till practices can effectively reduce soil erosion and pollutants bound to soil particles by protecting the soil. However, no-till practices may be minimally effective at reducing runoff or any soluble pollutants carried along with runoff.

Both of these models also provide insight into the distribution of runoff and soil moisture throughout a landscape. Figure 2 shows the effect that the depth of a restrictive layer through a hill slope has on surface runoff, drainage, and crop biomass production, using the MicroBasin model. As seen in the figure, surface runoff from a shallow soil having a restrictive layer is much greater than that from a soil where the restrictive layer is located 4.3 feet (1.3 meters) below the soil surface. The model also demonstrates that the soil moisture is much more uniform throughout the hill slope for the shallow soil than for the 4.3-foot soil. The variability in soil moisture with the deeper soil is caused by more subsurface lateral redistribution of water from the shoulder and back slopes to the flatter toe-slope position. The increased soil moisture in the toe slope results in greater overall crop production, in contrast to the low crop production in the water-limited shoulder-slope area.

Interestingly, both the WEPP and MicroBasin models indicate that surface runoff, spring soil moisture levels, and soil erosion will increase in the latter half of the 21st century. With increased temperatures, summers will be drier, but the increase in winter precipitation will result in an overall annual increase in excess water. Over the next year we will be using the MicroBasin model to investigate the implications of this spatial variability in crop production on nitrogen fertilizer strategies and nitrate losses. With an increase in spring moisture predicted for late spring months, growers may need to consider incorporating more fall-seeded crops into their rotations and relying on more spring fertilizer applications, as overwinter nitrogen losses will also likely increase.