HILLSLOPE EROSION RATES IN THE OAK SAVANNAS OF THE SOUTHWESTERN BORDERLANDS REGION

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Hillslope soil erosion on watershed landscapes can lower the productivity of upland sites and adversely impact water quality and downstream (off-site) areas. It is not surprising, therefore, that excessive soil erosion and the consequent sedimentation can represent significant costs to the land and people that are affected. The first known estimates of hillslope soil erosion rates on a watershed-basis in the oak savannas of the southwestern borderland region of the United States have been obtained on the Cascabel Watersheds. Initial estimates of soil erosion rates following the monsoon season of 2004 were reported by Ffolliott et al. (2005) and more complete annual estimates are presented in this paper. Comparable measurements will be made following prescribed burning treatments on the watersheds (Gottfried and Edminster 2005) to evaluate the impact of prescribed fire on hillslope soil erosion rates.

STUDY AREA

Twelve small watersheds established in the oak savannas on the eastern side of the Peloncillo Mountains of southwestern New Mexico to evaluate the impacts of prescribed burning treatments on hydrologic and ecological characteristics are (collectively) the study area. The aggregate area of these watersheds - called the Cascabel Watersheds - is 451.3 acres. They are located between 5,380 and 5,590 feet in elevation.

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The bedrock geology is Tertiary rhyolite lava overlain by Oligocene-Miocene conglomerates and sandstone (Robertson et al. 2002, Neary and Gottfried 2004). The shallow soils on the Cascabel watersheds are Lithic Argustsolls, Lithic Haplustolls, or Lithic Ustorthents. The nearest long-term precipitation station at the Cascabel Ranch headquarters indicates that annual precipitation in the vicinity of the watersheds averages about 23.5 inches with nearly 55 percent occurring in the monsoon season of late June through the middle of September. Other characteristics of the watersheds have been described by Gottfried et al. (2000a, 2000b), Neary and Gottfried (2004), Ffolliott and Gottfried (2005), and Gottfried and Edminster 2005) and, therefore, will not be presented in this paper.

STUDY PROTOCOL

Between 35 and 45 sample points are permanently located along transects perpendicular to the main stream system and situated from ridge to ridge on each of the Cascabel Watersheds. Intervals between these sample plots vary on the watersheds depending on the size and configuration of the watershed sampled. A total of 421 sample points are located on the 12 watersheds. Three erosion pins were installed around every third sample point on each of the watersheds in late May 2004 to form a basis to estimate hillslope soil erosion rates. Two erosion pins were placed 6 feet upslope and one erosion pin was placed 6 feet downslope of the points. A total of 438 erosion pins were installed on the study area. Initial measurements of hillslope soil erosion were made in October 2004 following the monsoon season of that year (Ffolliott et al. 2005).

Subsequent measurements were made following the winter rains and monsoon seasons of

2005 and 2006 with these measures forming a basis to estimate seasonal and annual hillslope erosion rates in 2005 and 2006. The erosion pins are re-set after these measurements to facilitate estimates of future soil loss. A bulk density value obtained from soil samples collected on the watersheds is the basis to convert measurements of average soil loss on a watershed to corresponding hillslope erosion rates in terms of tons per acre. The estimates of soil erosion rates are presented at the 90% level of significance.

Measurements of average precipitation recorded at two gages located on the Cascabel watersheds provide a basis for analyzing possible precipitation-erosion relationships. Physiographic characterizations (slope position, slope percent, and aspect) of the sample plots were obtained through earlier inventories.

RESULTS AND DISCUSSION

Average hillslope erosion rates with 90% confidence intervals on the Cascabel watersheds following the monsoon season of 2004, the winter rains and monsoon season of 2005, and the winter rains and monsoon season of 2006 are shown in Figure 1. Accumulated precipitation for the intervening time periods between the estimates of hillslope erosion is also shown in this figure. The estimate of hillslope soil erosion rates following the monsoon season of 2004 reported earlier by Ffolliott et al. (2005) represents only a partial year, while the other estimates presented in Figure 1 provide a basis to estimate annual hillslope erosion rates in 2005 and 2006. There is a large difference in these latter estimates in 2005 relative to 2006 with values of 21.5 ± 0.46 tons per acre and 5.85 ± 0.26 tons per acre, respectively. The greater precipitation amount affecting the soil erosion measurements made in 2005 (26.8 inches) than in 2006 (17.1 inches) could help to explain some of the difference in annual hillslope soil erosion rates for these two years. The main difference in the annual soil erosion rates, however. is attributed to the comparatively high soil erosion rate observed following the monsoon season in 2005 relative to the comparatively low value in 2006. This difference might be the result of the difference in rainfall intensities and durations of rainfall events for the two monsoon seasons. Monsoonal rainfall intensities were generally higher in 2005 than in 2006 with the individual storms in 2005 often lasting for longer time periods (Gottfried et al. 2006).

It is also possible that the storms of 2005 flushed "easily-moved" soil particles from the hillslopes of the watersheds leaving "less-loose" materials on the slopes in 2006. Furthermore, the variability of the data illustrated in Figure 1 might reflect the range of normal variability in hillslope erosion rates that is associated with the irregular and unpredictable summer rainstorms in the southwestern borderlands region. Within the context of these conditions, however, the data shown in Figure 1 provide insight into the inherent variability of annual hillslope soil erosion rates that might be expected in the oak savannas of the region. A longer period of measurement is needed to verify this possibility.No relationships between the magnitude of the estimated hillslope soil erosion rates on the individual Cascabel watersheds in the study area and the corresponding watershed size, physiographic features (slope position, Slope percent, or aspect), or stream-channel networks of the watersheds were evident in this analysis. Further measurements are needed to detect these relationships if they exist.

SUMMARY

The estimates reported in this paper represent initial estimates of annual hillslope soil erosion rates in the oak savannas of the southwestern borderlands region. Whether the magnitudes and variability of these estimates continue into the future is unknown. Large variations in seasonal and annual soil erosion rates are reported but the relationships of these rates to precipitation patterns and other conditions are unclear.

ACKNOWLEDGMENT

This study and the preparation of this paper was supported by the Southwestern Borderlands Ecosystem Management Project of the Rocky Mountain Research Station, U.S. Forest Service, and the Arizona Agricultural Experiment Station, University of Arizona.

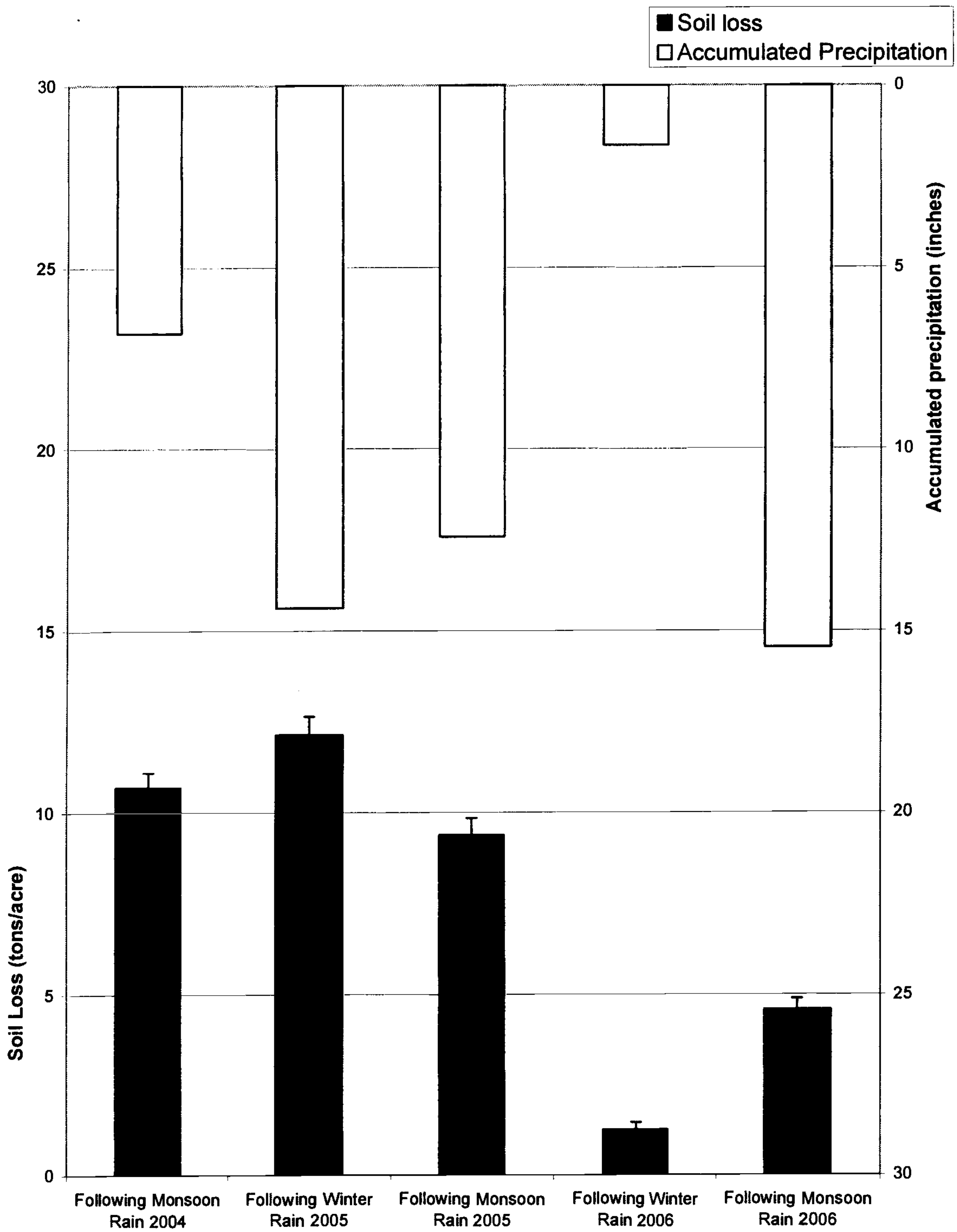

Figure 1. Annual hillslope erosion rates with 90% confidence intervals on the Cascabel watersheds following the monsoon season of 2004, the winter rains and monsoon season of 2005, and the winter rains and monsoon season of 2006 are shown in the lower portion of this figure. Accumulated precipitation for the intervening periods between estimates of hillslope erosion rates is depicted on the upper portion of the figure.

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