Erosion from Ephemeral Gullies

Ephemeral gullies are common on cropland in Kansas. Excess rainfall flows rather uniformly on the soil surface and causes sheet and rill erosion. As water continues downhill, small rills gather into rivulets until they accumulate enough energy to erode soil in small channels, called ephemeral gullies. These small channels are short-lived, since tillage can cover and fill them in. But ephemeral gullies often reappear in the same location after subsequent rains. Ephemeral gullies generally form in cultivated soils during seedbed preparation, planting, and early crop establishment when the soils are bare, or have less vegetation or surface residue cover.

Why are ephemeral gullies important?

Ephemeral gullies often form in a similar location every year and add to producers' management efforts. They erode topsoil, but tillage fills them in, often with less-productive subsoil. If not corrected, ephemeral gullies may grow into permanent gullies. Ephemeral gullies may contribute more to soil loss each year than sheet and rill erosion. Identifying fields with ephemeral gullies and implementing conservation practices to reduce ephemeral gully erosion is crucial to improving water quality.

How do ephemeral gullies form?

Basically, a stream starts to form within the field. In other words, overland runoff water concentrates into small channels that gain enough energy to detach and transport sediment along the flow path.

Many factors play a role in whether ephemeral gullies will form and how big they become. These include storm factors, such as rainfall intensity and total depth; site factors, such as drainage area, slope, and land curvature; soil factors, such as soil type and soil moisture level at the time of the storm; and surface factors, such as surface roughness, land cover, tillage depth, and crop residue levels.

Management of ephemeral gullies

Management practices that reduce the amount of flow and energy in small channels can reduce ephemeral gullies. Terraces or stiff grass hedges reduce the flow energy for ephemeral gully formation by reducing the downhill flow length and drainage area. Grass waterways increase vegetative cover in areas susceptible to ephemeral gully formation. To a lesser extent, practices that reduce runoff, increase infiltration, or increase evapotranspiration may lead to reduced ephemeral gully occurrence or size. Increased crop residue left on the surface may reduce ephemeral gully erosion, but only if it does not wash away.

This project

K-State received a USDA Conservation Effects Assessment Project (CEAP) grant to study the effectiveness of conservation practices intended to reduce erosion from croplands and sediment in the stream in the Cheney Lake Watershed. One important source of sediment is ephemeral gullies, but it is not well understood how much ephemeral gullies contribute to the total sediment found in streams or lakes.

The overall goal of this study was to better understand what causes ephemeral gully erosion. It was planned to achieve that understanding in several steps:

- Map and count ephemeral gullies in Cheney Lake Watershed and how much sediment they might contribute;
- Survey numerous ephemeral gullies in Cheney Lake Watershed to determine when and under what conditions they form;
- Track a few selected ephemeral gullies in Cheney Lake Watershed to measure detailed site, soil, and surface factors that contribute to ephemeral gully formation; and
- Develop a model to help identify areas susceptible to ephemeral gully erosion and predict ephemeral gully contribution to watershed sediment loads.

Mapping ephemeral gullies in the watershed

Satellite images from 2002, 2003, and 2004 were analyzed to find evidence of ephemeral gullies throughout Cheney Lake Watershed. The location, drainage area, and land use were digitized (Figure 1).

- 990 ephemeral gullies were found in the watershed.
- The average contributing drainage area was 34 acres.
- More than 55 percent were in low-residue wheat cropland without terraces.

Survey of ephemeral gully formation

After driving all the roads within the Goose Creek Watershed (a sub-watershed within the Cheney Lake Watershed) and recording the fields that had ephemeral gullies, field boundaries

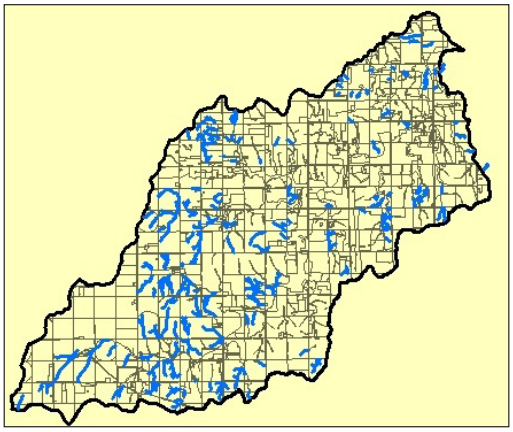

Figure 1. *Digitized map of ephemeral gullies in Goose Creek Watershed.*

Figure 2. *Measuring the depth of ephemeral gullies.*

were edited in ArcGIS, and information on ephemeral gullies and fields were entered digitally. In the lab, the shapefile of fields that had ephemeral gullies was overlaid on a corresponding aerial image, and the ephemeral gullies were digitized. Google Earth was used to verify the location and extent of ephemeral gullies. The length and volume of each ephemeral gully was calculated.

- The ephemeral gullies that were monitored in the study area formed after some kind of tillage operation in the field, and when the residue cover in the field was low (typically less than 5 percent). This suggests that conservation practices in other, nearby fields appear to have been effective in reducing ephemeral gully erosion.
- The digitized results show that there were about 178 active ephemeral gullies in Goose Creek Watershed, with lengths of individual ephemeral gullies ranging from 110 to 3,540 feet. Total ephemeral gully length was 46 miles in the watershed, averaging 730 feet of ephemeral gully per 100 acres.

Tracking specific factors of the ephemeral gullies

Permission was granted to enter seven fields for more detailed monitoring and measuring of erosion resulting from specific ephemeral gullies, to estimate ephemeral gully erosion volumes for the entire watershed. Tracking began by characterizing the hourly rainfall intensity during the summers of 2009 and 2010 using data from the nearest hourly weather station (in south Hutchinson, 25 miles north of the study area). Farmers in this watershed till the land before planting wheat and therefore, several ephemeral gullies were seen after summer rains. Simple measurements of top width, depth, and length were found to be sufficient to estimate ephemeral gully volume. The ephemeral gullies were not observed after every rain, but measurements were taken of the ephemeral gullies during September 2009 and July 2010.

The average cross sectional area of nine ephemeral gullies that were measured was used to estimate the volume of each ephemeral gully in the Goose Creek Watershed. The bulk density at each of the ephemeral gully locations was derived from the NRCS Soil Survey Geographic Database. The total sediment mass from each gully was estimated and the erosion rate (tons per acre) and total sediment yield (tons) were calculated to evaluate the effect of ephemeral gully erosion in the watershed.

The detailed management operations in the study area were obtained from the watershed specialists working in the watershed. The fields will be monitored until July 2011 and monitoring results used for analysis.

- Preliminary monitoring results showed that a total rainfall depth of 1.0 inch or greater and peak intensity of 0.4 inches per hour or greater were associated with ephemeral gully formation.
- Total sediment leaving ephemeral gullies after rainfall events: 9,500 tons.
- Ephemeral gully erosion rate after rainfall events: 1.1 ton per acre. Average annual erosion rate in Kansas (NRCS, 1997): 1.3 tons per acre (ephemeral gully) vs. 3.6 tons per acre (sheet/rill).

Modeling erosion from ephemeral gullies

Several methods to estimate the location and size of ephemeral gullies are being assessed. This study and others, have information about hundreds of ephemeral gullies along with the storm, site, soil, and surface factors that caused them to form. By analyzing these data, a tool will be developed that simulates where ephemeral gullies form and how much soil is eroded for a given set of storm, site, soil, and surface conditions.

Accurate ephemeral gully modeling requires an accurate topographic map to plot water flow paths in fields. To support this project, USDA collected high-resolution elevation data to create a 1-meter resolution digital elevation map. This information and a model based on data collected from fields in Cheney Lake Watershed will allow an estimate of how much soil loss is caused by ephemeral gullies and how effective different management practices will be in reducing these losses.

Kyle Douglas-Mankin, Water Quality and Environmental Engineer, Department of Biological and Agricultural Engineering

Prasad Daggupati, Graduate Student, Department of Biological and Agricultural Engineering

Aleksey Sheshukov, Research Associate, Department of Biological and Agricultural Engineering

Philip Barnes, Water Quality Engineer, Department of Biological and Agricultural Engineering

Daniel Devlin, Director, Kansas Center for Agricultural Resources and the Environment

Nathan Nelson, Agronomist, Soil Fertility and Nutrient Management, Department of Agronomy

This project is funded by the USDA-CSREES Integrated Grant Program Conservation Effects Assessment Projects (CEAP) project number 2006-51130-30707.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF3030 August 2011