Gully Erosion

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Gully erosion is a problem world-wide. Enormous amounts of time and money are used by international, national, state, and local agencies attempting to arrest the growth of gullies and thus prevent the destruction of roads, structures, and valuable range and farmland. In addition, gully growth and associated piping and soil erosion yield immense volumes of sediment that clog streams and degrade the quality of surface waters far downstream from the gully.

A gully is a relatively deep, vertical-walled channel, recently formed within a valley where no well-defined channel previously existed. Gullies typically range from 5 to over 80 feet in depth and from 3 to 100 feet in width. Some gullies are several miles long while others are as short as a hundred feet. All have nearly vertical walls and contain streams having extreme variations in discharge throughout a year. Gullies in

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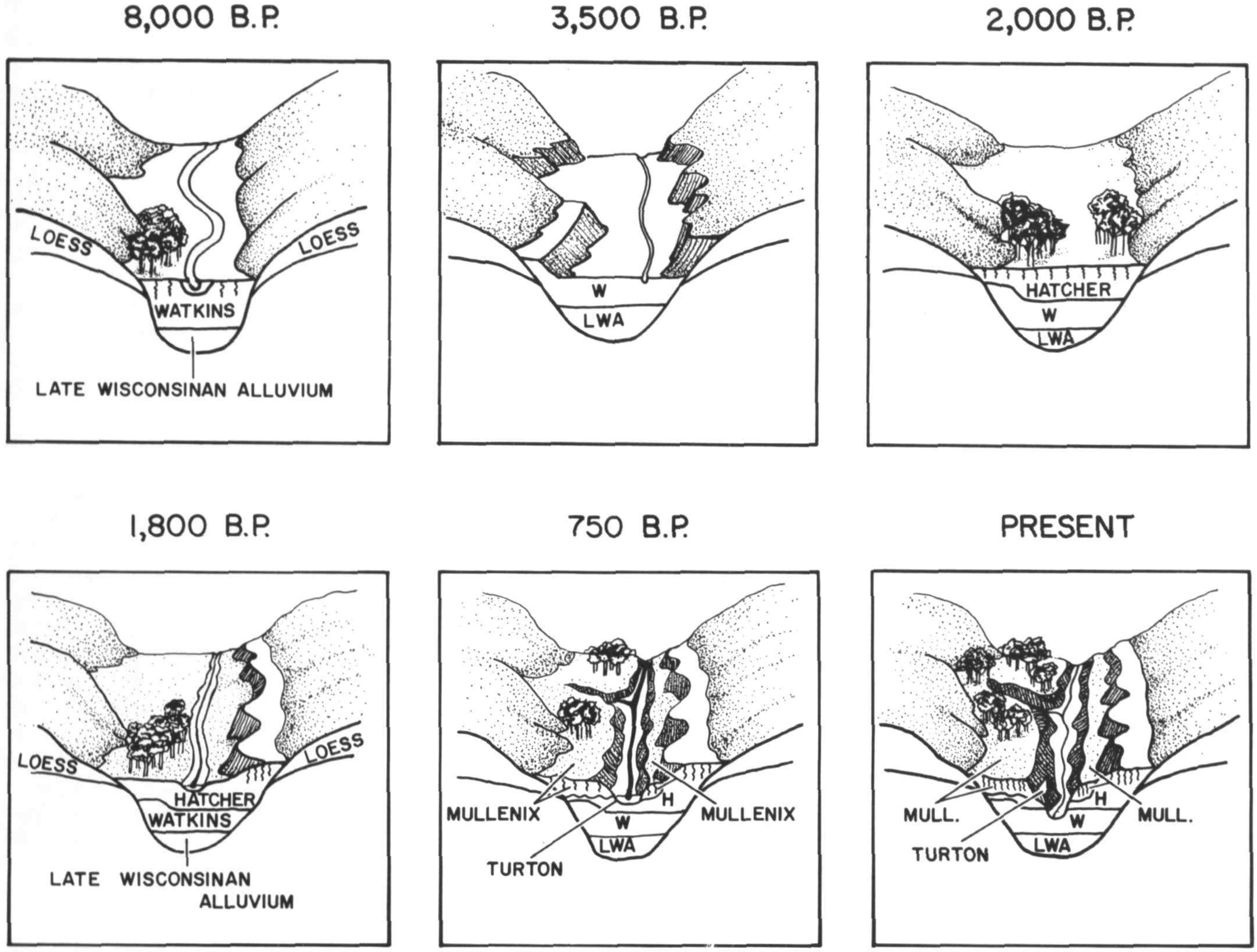


Episodes of valley development in western Iowa during the last 8,000 years. The names Watkins, Hatcher, Mullenix, and Turton refer to alluvium that accumulated in gullies during the episodes.

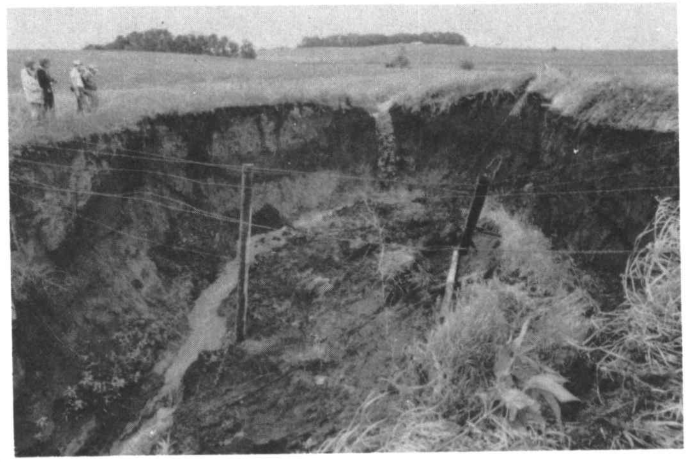
large valleys may contain streams which flow year round, but streams in most gullies are dry during portions of the year.

Gullies develop where there is a decrease in the erosional resistance of the land surface or an increase in the erosional forces acting on the land surface. Precisely what causes gullies to form, when and where they do is poorly understood. Field and laboratory studies indicate that certain reaches of a valley are more prone to gully development than others. However the timing of the initial entrenchment and which of the "most gully-prone" reaches develops a gully cannot be predicted with certainty, despite decades of study into this problem.

Typical western Iowa gully. Note the nearly vertical sidewalls and slump accumulated in the gully bottom.

Once a gully forms, the processes whereby it lengthens and widens are better understood. The upper end of a gully is marked by a headwall, a vertical scarp separating the ungullied portion of the valley floor from the gully further downstream. Water flows over the headwall during runoff and falls into a plunge pool, undercutting the headwall. When undercutting reaches an advanced stage, the headwall fails and topples into the gully, thereby lengthening the trench. This process is repeated many times as a gully advances up the drainageway.

When first formed, most gullies are quite narrow and have vertical sidewalls. Increased pore pressure from groundwater moving toward the gully, coupled with undercutting of the sidewalls by streamflow in the gully channel produces deep rotational slumps along the sidewalls. If sufficient water is flowing through the gully to carry away the slumped material additional slumping can occur, causing the gully to widen. Widening also occurs when upper portions of gully walls separate and topple into the gully. This phenomena often occurs following heavy rains and during freeze-thaw or wet-dry cycles. If water intermittently flowing through the gully continues to clean out debris derived from the headwall and sidewalls, the gully continues to grow. When more debris accumulates than is transported away, the gully stabilizes and begins to fill.



Soil slumping and water cascading over the headwall advanced this gully beyond a fence. Several distinct alluvial fill layers are evident in this gully wall.

Numerous researchers have pointed the finger at agriculture and urbanization as the cause of gully problems. Specifically, they cite the increases in runoff that result from land clearing, overgrazing, stream channelization, and impermeable surfaces. In the United States federal, state, and county agencies spend millions of dollars each year to control gullies and promote land management practices that reduce runoff in an attempt to alleviate the gully problem.

Many of today's gullies are cut into alluvium, the sediment transported and deposited by flowing water in streams. Vertical gully walls, such as those shown in the accompanying photograph, usually expose several distinct layers of alluvium. Layers of similar sediments can be traced within a single valley and also can be recognized from one valley to the next, a process called correlation. A joint SCS-Iowa State University Agronomy Department study has recognized and mapped six distinct layers, or alluvial fills, in small and moderate-sized valleys (drainage areas of less than 8 to 450 mi^2) throughout western Iowa. Extensive core drilling in these valleys and interpretation of gully wall exposures have established that these alluvial fills accumulated in old gullies.

Occasionally, buried tree stumps, logs, or charcoal are found within old alluvial fills where they are exposed along modern gully walls. Numerous localities containing organic remains have been radiocarbon-dated and a chronology of gully cutting and filling has been constructed. More than one-hundred such radiocarbon dates indicate that the six major alluvial fills in western Iowa valleys represent synchronized episodes of gully cutting and filling during the last 12,000 years throughout the region. Four of these episodes occurred during the last 4,000 years and the deposits associated with them are rather well preserved and understood. Accompanying illustrations graphically illustrate changes in the valley landscape during these four episodes.

About 3,500 to 4,000 years ago, deep gullies much larger than today's dominated the landscape in small and moderate-sized western Iowa valleys. In many cases these gullies occupied the entire valley floor. Beginning shortly after 3,500 and continuing until about 2,000 years ago, gully growth stopped and alluvium accumulated in the gullies. By 2,000 years ago the gullied areas were completely filled with sediment slumped and falling from the gully walls and washed in from the adjacent valley slopes.

Another gully cycle began sometime during the 200-year period between 2,000 and 1,800 years ago. Gullies extended up all moderate-sized valleys and some of their smaller tributaries. Gullying did not extend into small drainages at the upper end of the drainage network as it had during the previous cycle. In extent, depth, and width of gullying, this cycle is analogous to modern gullying in the area. Shortly after 1,800 years ago alluvium again began to accumulate in the gullies, almost filling them by about 1,000 years ago.

The third gullying cycle began about 800 years ago. In this cycle, gullying was restricted to moderate-sized and larger valleys and did not extend as far up valleys or into smaller valleys as it had during both previous episodes. These new gullies were restricted to central portions of the area gullied during the previous cycle. Further, they were neither as deep nor as wide as earlier gullies had been. Shortly after the gullies developed they began to fill with alluvium. Sediment accumulated until the gullies were completely filled and portions of the surfaces bordering the gullies were buried a few feet. Counts of growth rings in trees growing on alluvium filling these gullies indicate that sedimentation may have continued until about 100 years ago.

The most recent western Iowa gully cycle began around 100 years ago. Numerous accounts in local histories, original land surveys, and early reports of the Iowa Geological Survey indicate that until about 1860 gullies were not widespread in the area. By 1900 reports of problems arising from gully growth such as the need for bridges at crossings were common and indicated that the historic period of gully growth was in full swing. In some valleys, gullies formed and filled several times during this historic cycle, a process which doubtlessly occurred during the prehistoric episodes but is too obscure to be interpreted in detail from the geologic record.

The geologic record contained in western Iowa valleys shows that major gullying is not new to the area. Several episodes, some more widespread than today's, occurred prior to Euroamerican settlement and the spread of modern agriculture. Gullying is part of the natural process of landscape evolution in western Iowa. The modern gullying which causes so much concern is also part of this natural process. Landuse changes accompanying the spread of agriculture and urbanization have aggravated and possibly accelerated the growth and extension of gullies in western Iowa. However, the geologic record suggests that the area was "due" for an episode of gullying prior to the 1850's. Gullies grew and filled several times in the past when man was not significantly influencing runoff or vegetation patterns. This indicates that man affects gullies in this area but is not the sole cause of them.

Our investigations were conducted in western Iowa but the general conclusions are applicable to other gully-prone regions. Studies conducted in Mississippi, North Dakota, and Oklahoma, as well as many other portions of the U.S. and other countries, have demonstrated repeated episodes of gully growth and degradation prior to modification of the landscape by modern agriculture and urbanization.

Recognition of the fact that gullies are "native" to many areas is important because it indicates that gullies are not a unique phenomena resulting entirely from man's modification of the landscape. Through recognition of gully-prone valley sections and promotion of landuse aimed at preventing or lessening the factors causing gullies in those areas, we can inhibit gully growth and lessen its impacts. Former gullies and the erosion resulting from their growth have molded many landscapes. This process is active today and will continue to be far into the future. Our understanding of factors contributing to gully initiation is inconclusive. Somewhat better understood are the processes and factors involved in gully growth and degradation. Both subjects are urgent research needs. Through a better understanding of the processes affecting gully development and growth we can reduce the likelihood of their formation or take appropriate action to inhibit their continued growth, thereby lessening resultant damages to valuable soil and water resources. Such an understanding would also benefit landuse planners. It would provide a balanced view of problem areas that can be remedied, and others that are either too costly or infeasible to solve.