Forestry Note:

STABILIZING GULLY WALLS AND BOTTOMS WITH DEFLECTORS AND TREES

Introduction

Numerous large gully systems are active in Oklahoma, causing heavy damage to soil resources, agricultural production, stream channels and water quality.

Large gully systems typically begin with the development of a headcut in a shallow drainage on deep, silty or sandy soils as a result of drainage system changes. In such conditions, gullies may develop very rapidly. The Tillman County (Figure 1) and McClain County (Stinson Creek) (Figure 2) gully systems, discussed in this Forestry Note, were caused in each case by a deep headcut advancing up the channel through a distance of almost two miles within a period of 20 years. In both cases, the resulting erosion increased the channel cross-section ten-fold or more through their full length.

Figure 1. Large gully near Grandfield in Tillman County. Photo taken in 1990 before installation of the main drop-structure. The arms of this gully below the channel drop-structures range from 15 to 30 feet in depth and 50 to more than 300 feet in width.

In the early stages of formation, a large gully in deep, silty or sandy soils may widen rapidly, sometimes to more than 50 feet in less than 10 years (Figures 1 and 2). Widening occurs mainly because of sloughing of sections of the gully wall when the soil becomes saturated during wet weather, and high runoff flows occur (Figure 3).

Figure 2. View of the Stinson Creek gully, McClain County, near its mid-point. The gullied channel ranges from 15 to 18 feet in depth and 70 to 120 feet in width.

In the early stages, the sloughed soil will be washed away. The general conditions of vertical walls and flat bottoms may persist for years, as was the case in Tillman County, resulting in large volumes of soil being washed into the Red River.

Initial Headcut and Runoff Control

Stabilizing a large gully is very expensive, usually requiring a large drop-structure to control the headcut, or diversion of runoff water, or both, as the first step.

On the main arm of the Tillman County gully, this control was achieved by constructing a large pipe-and-dam drop-structure about 1/4 mile below the main headcut. This created a pond above the structure (Figure 4a). The water detention provided by this structure and pond reduces flow volume through the channel (Figure 4b) and accelerates development of stable toes on the lower parts of the gully walls (note gully-wall toes in Figures 8a-8h).

Figure 3. Fresh sloughing on the Tillman County gully, prior to the main drop-structure installation and tree planting and deflector treatments

Figure 4a. Pond above the main pipe-and-dam drop-structure on the Tillman County gully system

Figure 4b. Plunge pool and gully below the Tillman County drop-structure

Most of the sediment load of surface runoff is now deposited in the pond. This results in an increase in the erosive and sediment-transport energy of flows in the gully below the dam. These changes, in turn, accelerated development of a natural meandering channel in the gully bottom (Figure 5).

Figure 5. Small meandering stream channel developing on the Tillman County gully below the main drop structure

While controlling the main headcut and runoff water are the primary stabilization measures, additional practices are needed to accelerate the stabilization of gully walls and bottoms in order to minimize soil loss and reduce sediment contribution to the basin. This Forestry Note describes the application and effectiveness of cattle-panel deflectors and tree planting for this purpose. Forestry Services applied the practices on gully systems in Tillman County and McClain County as part of a project designed to demonstrate low-cost erosion control methods.

Deflector Design and Installation

Each deflector consists of a 4-foot by 16-foot cattle panel, held in place by four posts. Most deflectors were installed with 6½-foot steel T-posts (Figures 6a and 6b).

The panels were installed at an angle of about 15 degrees from the gully wall. Where a gully-wall toe exists, the deflector should be placed on the toe. The deflectors in Figure 6b were spaced at 18 feet center to center. Spacing depends on the expected velocity and depth of flows, and bank curvature. Proper spacing for most installations may vary from 15 to 35 feet, center to center. The downstream end of the deflector may need to be braced with a post or pole.

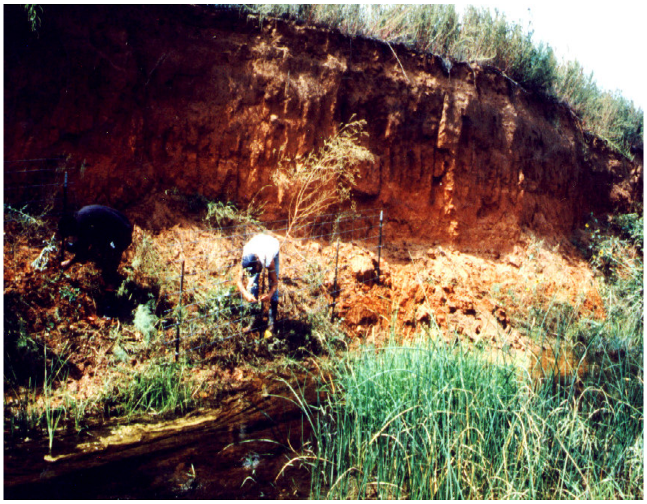

Figure 6a. Installation of deflector on the Stinson Creek gully, immediately above the Figure 2 location

Figure 6b. Deflectors installed on the Stinson Creek gully. These are replacements (see Figure 8g). These deflectors are spaced 18 feet apart, center to center.

Where the deflector is installed on a wet site in early spring, fresh-cut willow posts can be used. Under favorable conditions, willow posts will root and grow into trees (Figure 6c).

Figure 6c. Willow post growth at deflector

Total cost of materials per deflector (in 1997), using steel posts, was approximately $35. Installation labor using a two-person crew is about one-half hour.

Install deflectors on the outside walls of bends and other locations where sloughing and erosion by high flows is occurring. On the Tillman County gully system, six sections of gully walls were treated. Forty deflectors were installed (Figure 7). On the Stinson Creek site in McClain County, deflectors were installed on eight sections of gully walls and 107 deflectors were installed.

Tree Planting

Seedlings were planted between the deflectors and the wall of the gully, and along the gully rim (Figures 8a-8f). Plantings consisted mainly of black locust, because of its rapid growth, drought resistance and rooting characteristics. Plantings in some locations included a mixture of bur oak, shumard oak, green ash, red mulberry, sand plum, American plum and baldcypress.

Seedling survival in the first growing season is often a problem, particularly on deep, sandy soils where the water-holding capacity needed for initial root development is low. Success is highly dependent on spring and summer rainfalls. Plantings on the Tillman County system had a favorable growing season and were successful. Some of the McClain County deflector sites had to be replanted, in some cases for a third time, due to poor survival because of dry weather.

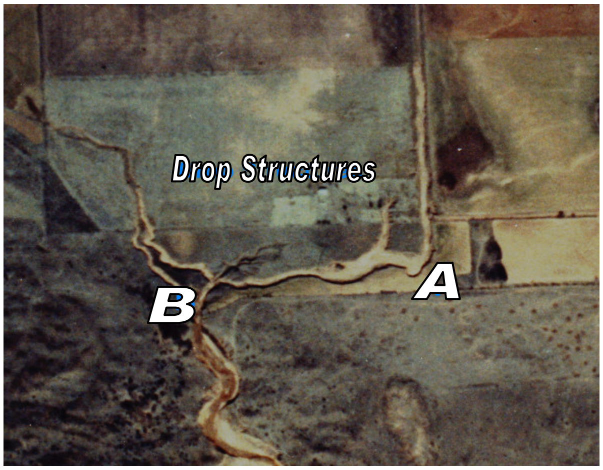

Figure 7. Deflector locations on the Tillman County gully. The deflectors on the Stinson Creek system were located similarly.

Effectiveness and Maintenance of Practices

Figures 8a through 8f (Page 5) demonstrate the effectiveness of the deflector and tree planting practices.

All of the deflectors and the tree planting on the Tillman County gully were effective with the exception of installations on the middle arm of the gully system. The emergency spillway of the main drop-structure is located to empty into this arm of the system. A catastrophic storm, having a 2,000-year return frequency, caused major erosion, increasing the cross-section area of this arm at the deflector locations about five-fold.

The deflectors on the Stinson Creek system were installed later, and a complete evaluation of effectiveness is ongoing. However, it is clear that where major runoff flows are not controlled by diversion or a pipe-and-dam drop-structure, as is the case on Stinson Creek, the deflectors are more subject to damage or being washed out, particularly when the trees are not yet established (Figure 8g). The need for considerable replacement and repair under such conditions should be expected. Success is dependent on weather conditions from the standpoints of moisture for tree survival and growth, and the chance of major stormflow events before the trees become established. The likelihood of washout is greatly reduced following the third growing season. With repair and replacement as needed, complete protection appears likely.

Management of Trees and Other Vegetation

The primary objectives in the use of trees with other practices in gully control are to accelerate and maximize stabilization and erosion control. Proper tree species, tree spacing and management of the tree stands and other vegetation are essential for long-term success. For these objectives, the use of black locust as the principal tree species is essential, because of its special characteristics.

Black locust is particularly effective in erosion control because of its hardiness, drought resistance, high seedling survival rates, rapid growth and rooting characteristics. The rapid growth improves the microclimate for early development of grasses and other surface vegetation. Black locust, a legume, also benefits other plants by fixing nitrogen. Its strong branching root system is very effective in stabilizing banks and limiting erosion (Figures 9a and 9b). The trees typically develop large lateral and downward branch roots that are several times longer than tree height, forming a network of branching roots.

While gullies are often part of a drainage system in which other tree species are desirable for other riparian area management objectives, base the selection of species on the primary objective. Other species can be intermixed with black locust, particularly on sites with good tree survival and growth potential. In such cases, other species need more space, and early thinning of the black locust may be needed because of its more rapid growth.

Black locust stands may need thinning to promote and maintain ground cover vegetation. The stands often deteriorate, sometimes rapidly, beginning at 20 to 30 years of age, because of borers and fungus disease. When this occurs, cut the diseased trees to promote sprouting and new root development. Grazing control is essential for early development and maintenance of ground cover vegetation.

Figure 8a. Deflectors and black locust trees at location A on Figure 7. The trees are four years of age.

Figure 8b. Deflectors and black locust trees at location B in Figure 7. The trees are one year old.

Figure 8c. Deflector at location B in Figure 7, pushed over by sloughing of the gully wall. The trees are two years old. The deflector and trees remain effective.

Figure 8d. Deflectors and trees on Stinson Creek early in 2nd growing season after installation. Plantings consist of black locust, ash, mulberry and shumard oak. The surviving trees are mostly black locust.

Figure 8e. Deflectors on Stinson Creek, using willow and steel posts. Note new branching on the willow posts. Black locust planted the previous season failed to survive because of dry weather.

Figure 8f. The deflectors in Figure 8e, one year after installation. The black locust seedlings on the slope are in the first growing season, under favorable moisture conditions.

Figure 8g. Effective deflector installations on Stinson Creek in need of repair. The willow posts did not grow and more tree planting is needed. Deflectors on the toe in the left center were washed out and later replaced (see Figure 6b).

Figure 9a. Sprouting of exposed black locust roots on a Tillman County gully wall. These sprouts will become trees.

Figure 9b. Strong branching root system of black locust. Trees are 5 years of age on a moderately favorable site, and are about 4 inches in diameter at the base.

In most cases where the deflectors remained in place and helped the planted seedlings become established, gully erosion and bank sloughing have essentially stopped (Figures 10a and 10b).

Figure 10a. Cattle panel deflector and trees on Tillman County gully effectively trapping sediment and stabilizing gully wall (photo taken in 2006)

Figure 10b. Cattle panel deflector partially obscured by collected soil and planted trees, Tillman County gully (2006)

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(Before Treatment) Original plunge pool and expansive, raw gully below Tillman County drop-structure in 1998

(After Treatment) Pipe outlet and stabilized gully under canopy of black locust trees below Tillman County drop-structure in 2006

Other Information Sources

Additional information on these gully control treatments and other gully erosion control using trees in combination with other practices can be obtained from the local offices of Forestry Services and the Conservation Districts or by calling Forestry Services at 405-522-6158. *Stabilizing Gully Walls and Bottoms With Deflectors and Trees* is one of a series of Forestry Notes produced by the Oklahoma Department of Agriculture, Food, & Forestry - Forestry Services Division on low-cost practices to control soil erosion. Additional Forestry Notes in this series include:

- Side-Gully Control Using Trees, Hand Labor, Rock and Other Materials
- Low-Cost Gully Control Using Fiber Mat and Trees

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