Sediment From a Small Ephemeral Gully in South Carolina

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Since acquired in the 1930s, the Sumter National Forest, South Carolina, U.S.A., has emphasized land stabilization and restoration of eroded landscapes. Public concern over ground disturbance associated with some gully treatments suggested the need to verify sediment contributions, since many ephemeral gullies remain barren. We answered the questions, "Can a gully be barren, actively eroding, and not contribute sediment?" This paper summarizes the sediment measured from a discontinuous valley-side gully approximately 0.10 hectares (0.25 acres) in size. Measurement began in July 1994 with the installation of a filter fabric fence. In August 1994, runoff from Tropical Storm Beryl delivered 4.5 tonnes (5 tons) of sediment. By February 1999, a total to 40 tonnes (44 tons) of sediment accumulated. Remeasurement in March 2004 indicated a total of 48 tonnes (53 tons) with an average annual sediment delivery rate of 51 tonnes/hectare. Soil erosion occurred during intense rainfall events and freeze-thaw cycles; however, only severe storms produced enough stormflow to deliver sediment. During inactive periods, leaf-fall effectively hid the sediment transport path, giving an appearance of stability. Results suggest that small ephemeral gullies can be sources of sediment and should not necessarily be neglected. Carefully selected indicators may help determine if sediment delivery is a concern from ephemeral gullies.

Keywords: *ephemeral gully, filter fence, survey laser, erosion, sediment yield, storms, stream order, stormflow*

Introduction

The Sumter National Forest (SNF) was acquired in the 1930s within the authority granted in the Weeks Law of 1911 to obtain and improve denuded and eroding lands within navigable watersheds to help produce sustained water and timber resources. Historic agriculture, logging and road practices contributed to the severe erosion and declining watershed conditions within the piedmont of South Carolina. National Forest emphasis on controlling erosion began with the Civilian Conservation Corps reforesting denuded lands and stabilizing gully networks. Ongoing efforts continue to address control and improvement of severely eroded lands through reforestation and treatment of actively eroding sites (Hansen 1991; Hansen and Law 1996). Many others have studied or discussed various aspects of gullies (Hoover 1949; Heede 1976, 1982; Singer et al. 1978; Yoho 1980; Schumm et al. 1984; Hansen 1995), reporting a wide range in conditions and sediment delivery. In most cases, sediment delivery was estimated from large ephemeral gully systems as a result of significant runoff or by calculating the volume lost from the gully dimensions.

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This study began in an effort to help address a public concern relative to proposals to treat gullies that are barren, eroding, but with limited apparent effects downstream. A barren, ephemeral gully in Chester County, South Carolina, with unknown downstream sediment delivery was selected in 1994 for measurement of sediment. At that time, leaves covered the downstream channel, and the gully did not appear to be actively delivering sediment. Treatment was not being proposed or contemplated at that time.

Area Description

The study site is in Chester County, east of Union, South Carolina, on formerly farmed land acquired by the SNF in 1992. The ephemeral gully forms a Strahler order 1 channel within the Little Turkey Creek drainage (Figure 1) (Strahler 1957). The gully to be scrutinized is a discontinuous valley-side gully, with a drainage area of about 0.1 ha (0.25 acres). Adjacent to the site are several other barren, ephemeral gullies somewhat smaller in size. Based on examination of aerial photos, the gullies were formed prior to the 1940 aerial photo, but some noticeable headcut migration was visually detected in the measured gully until the 1969 photo. Aerial photos in 1974 (Figure 2) and 1990 (Figure 3) suggested that gully expansion had reached its limit with no major changes in the gully shape or extent during that period. So logically, there was uncertainty in whether the ongoing surface erosion

Figure 1. Gully vicinity LEEDS, S.C. Quadrangle - USGS Topographic Contour Map, Lat. 34°44′N, Long. 81°25′W. Distance from the gully southeast to the sharp bend in the road is about 0.57 km (0.36 miles). Contour interval is 3 meters (10 feet).

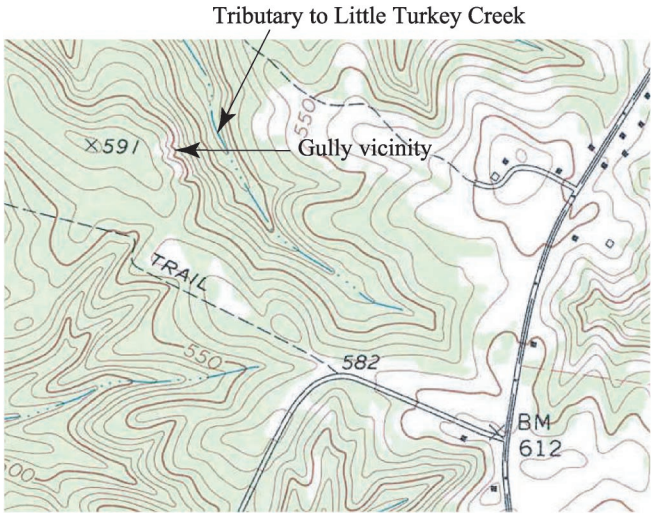

Figure 2. Aerial photo taken in April 1974, with gully marked. Note the 6-meter width of the gravel road at photo bottom.

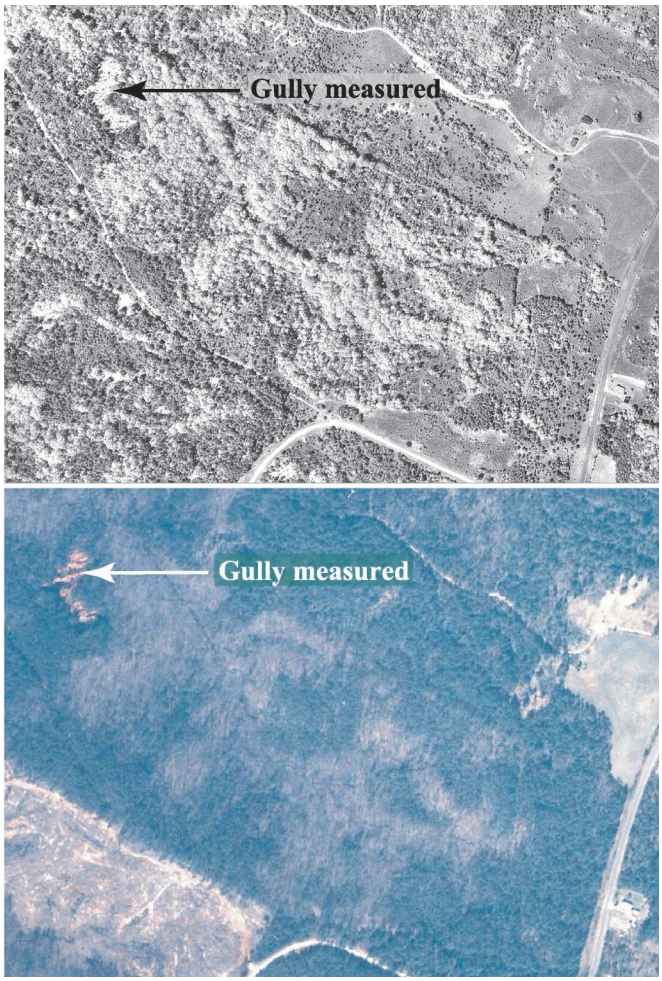

Figure 3. Aerial photo taken in February 1990. No major changes in gully size were noted in comparison to 1974 photo.

associated with the barren soils could be delivered as sediment sufficient to justify treatments. The downstream channel appeared stable and well covered in leaves suggesting limited or no sediment delivery.

Portions of the study area were probably farmed about a century ago. Eventually much of the farmed area on sloping terrain became depleted of nutrients, resulting in poor crop yields, abandonment, severe sheet erosion, and continued exposure to the elements, with gullies forming in areas where flow concentrated (Figure 4). Portions of the landscape were either planted to loblolly pine (*Pinus taeda*), or naturally recovered to mixed pine and hardwood forest after farming ceased. However, the severely eroded soils within the measured gully and adjacent gully barrens have been unable to support significant vegetative cover for many decades (verified at least 65 years). Many of the bottomland trees adjacent to the area are mature timber probably over 80 years old. The skid or temporary roads in the 1940 aerial photo suggested that logging likely occurred in the 1930s. Concentrated flow from skid roads or skidding practices onto heavily eroded soils may have contributed to the localized gully expansion or enlargement noted between 1940 and 1969. However, this is speculation and has not been substantiated beyond observing that a logging road contouring the hillslope, ends abruptly near the gully barrens. The sparse trees within the gully exhibit characteristics of low site conditions such as fusiform disease, chloritic needles, rank branching, rough bark, exposed roots and poor form.

Figure 4. General view of gullied area within tract. Sharp pinnacle-like boundaries separated the individual gully channels.

Rainfall averages about 114 cm (45 inches) per year in this area of the South Carolina piedmont, and is variable, but typically well dispersed through the year with average monthly rainfall between 7 and 13 cm (3 and 5 inches) (NOAA 2004). Water yield averages about 43 cm (17 inches) per year based on the gaged larger streams (Cooney

et al. 2003). The less eroded hillslopes were typically Pacolet soil series that have thin A and B-horizons. Inclusions of Catuala soil series exist locally and have a fragipan-like B-horizon that is noticeable on the exposed upper margins of the gully. Soils within the gully are severely eroded and entrenched about 10 meters at the deepest into the saprolite materials of the C-horizon. Most of the gully has no remaining A-horizon or B-horizon, except for moderately eroded remnants along the gully upper margins near the ridge.

METHODS AND MATERIALS

In July 1994, filter fabric dams were constructed to capture sediment within an ephemeral channel. Materials included steel T posts, wire fencing, filter fabric, and wire C clamps and post ties. Methods were derived from Dissmeyer (1982) but differed from the construction materials and hillslope location described (Figure 5). Steel fence posts (1.8 m or 6 feet long) were initially installed at 0.9 - 1.5 m (3 - 5 ft) spacing, but more posts were added later to handle the weight of the sediment and water. The 1.2 m-high (4 ft) wire fence and filter fabric were buried about 0.15 m (6 inches) beneath the soil surface and oriented across the ephemeral channel to assure that the sediment would be retained and the water filtered through the fabric. The filter fabric was attached to the wire fence with C clamps using hognose pliers. During installation, care was taken to align the designed overflow dip in the fabric with the center of the channel so overflow could occur if needed without going around the edges and damaging the integrity of the structure. Since the initial fabric dam was nearly full within the first year, two other sediment dams were added in 1995 downstream of the initial site to maintain filtering and sediment capacity. The weight of sediment bent some steel posts and pulled the fence from the slope, leaving a gap for water and sediment to escape. The structures were reinforced with more posts and any gaps were filled with cloth bags containing soil, sand, concrete, or a combination of these.

Measurements were made in 1994, 1999 and 2004. Sediment deposits behind the dams were taken by measuring the elevation changes as sediment accumulated at 0.3 - 0.6 m (1 to 2 ft) spacing intervals for cross sections every 0.9 m (3 ft) up the channel. Elevation differences were measured with a Nikon Laser Level[1] with rod sensor, and cross sections were marked with rebar pins. Measurements were located with an expandable 7.6-m (25-ft) survey rod adjusted to fit between the rebar pins

[1]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Figure 5. The fabric dam was installed in July 1994 below the 0.1-hectare ephemeral gully. The filter fabric was supported with steel posts, wire fencing and C clamps.

at either end. Soil samples were taken to determine bulk densities at each measurement time to be sure that any settling was taken into account. In March 2004, a total station survey instrument (Topcon Model GTS-605) was used to survey the area and establish more benchmarks for future needs.

The fine detail of the drainage boundary was surveyed using a Criterion 400 Survey Laser (Griswold 1993) (Figure 6). Traverse (PC) software was used to map station locations by distance, angle and slope from base locations. The survey laser was used to determine the gully boundary including a narrow, pinnacle-like section.

RESULTS AND ANALYSIS

In August 1994, about 13 cm (5 in) of rain from Tropical Storm Beryl delivered over 4.5 tonnes (5 tons)

Figure 6. A Criterion 400 survey laser provided quality measurements to determine gully drainage extent. Laser has selective filter that can detect prism through vegetative cover, or can shoot directly to any solid surface, measuring distance, azimuth, slope and elevation change.

Figure 7. About 4.5 tonnes (5 tons) of sediment were deposited from Tropical Storm Beryl in August 1994. Sediment surface elevations and bulk density measurements were taken to estimate sediment amount.

Figure 8. Additional dams were added to capture sediment. After 4.5 years (February 1999), a total of 40 tonnes of sediment were captured for an average sediment yield of 89 tonne ha^{-1} y^{-1} (36 tons ac^{-1} y^{-1}). Most of the sediment was delivered during three major tropical storm events.

of sediment (Figure 7) (NOAA 2004). The amount of sediment captured from one storm event in such a small drainage area was a surprise. The filter fence was nearly half full of sediment and the steel fence posts were bent from the weight of the sediment and water. Some of the sediment was lost due to overflow. By February 1999, a total of 40 tonnes (44 tons) of sediment accumulated behind the sediment fences indicating an average sediment delivery rate of 89 tonnes ha^{-1} yr^{-1} (39 tons ac^{-1} yr^{-1}) (Figure 8). Tropical Storms Jerry (1995) and Danny (1997) each contributed about 15 cm (6 inches) of rainfall, which produced enough flow to deliver sediment (NOAA 2004). The delivery of sediment was relatively dormant during the period 1997 to 2002 due to extended drought conditions. During the spring and summer of 2003, much higher than normal rainfall reactivated the delivery of sediment within the gully. The March 2004 measurement indicated an additional 8 tonnes (9 tons) of sediment had accumulated since 1999. After 9.5 years, total sediment accumulation was 48 tonnes (53 tons), resulting in an average annual sediment delivery rate of 51 tonnes/ha (22 tons/ac). This amount is probably conservative due to the amount lost in the initial overflow, and the extended drought between 1997 and 2002. During the study, ten storms produced flows in the nearby Enoree River at or above the flows associated with Tropical Storm Beryl, with Tropical Storm Jerry (1995) producing the 30-year flow of record (Cooney et al. 2003). It is likely that most if not all of these storm events, and perhaps a few others, contributed to the sediment captured.

Measurements and site visits after some of the major storms led to our curiosity to find other indicators of gully activity. Erosion of the bare gully surfaces occurred regularly in response to intense rainstorms, freezing rain and freeze-thaw events that dislodged soil particles. During most events of any significance, particles were moved by gravity or water, relocated on-site with moderate events with most accumulating at the toe of the slope or in the ephemeral channel for storage. Much of the gully remained sparsely vegetated or barren during the decade due to continuing erosion of the saprolite materials of the C-horizon. The highly weathered saprolite also has low available nutrients. Without treatment, most gullies and galled barrens in saprolite materials remain exposed for decades. Although erosion events are fairly common, sediment delivery downstream is episodic. Two distinct, buried organic layers were found in the sediment deposits delivered between August 1994 and February 1999 (probably Tropical Storms Jerry in 1995 and Danny in 1997). These layers as well as site visits after major events testify to the episodic nature of sediment delivery. Downstream reconnaissance following severe storm events led to identifying the historic sediment path of the gully onto a nearby stream terrace. Areas were found with recent sediment deposits, buried organic layers, clay stained trees and buried tree trunks in the flow path. It was apparent that the sediment path on the low gradient terrace had changed with time due to the accumulation of materials and occasional woody debris falling, accumulating sediment and diverting the path. The red clay stains on lower tree trunks and the lack of the buttressed root collars in older hardwoods due to their burial were persistent indicators of accumulated sediment in the delivery path.

A summary of the sediment measurements for the study is provided in Table 1. During the March 2004 sampling of the sediments, the bulk densities varied from 1.38 to 2.3 g/cm^3. When comparing the densities with

Table 1. Summary of sediment volume, density and weight measurements with total volume and accumulated weight adjusted for sediment density changes. Data from Wade Tract gully sediment measurements taken from July 1994 to March 2004.

	July - Sept. 1994		Sept. 1994 -Feb. 1999	July 1994 - Feb. 1999	Feb. 1999 - Mar. 2004	July 1994 - March 2004	
Fence	**Added Volume (m^3)**	**Added Weight (metric tons)**	**Added Volume (m^3)**	**Added Weight (metric tons)**	**Added Volume (m^3)**	**Added Volume (m^3)**	**Added Weight (metric tons)**
1	4.16	4.50	11.40	21.09	1.95	17.51	4.29
2			6.92	12.80	0.53	7.45	1.17
3			0.00	0.00	0.00	0.00	0.00
Total Volume (m^3)	4.16		18.32		2.48	24.96	
Accumulated Weight (metric tons)*		4.50		39.92			48.34

** Accumulated metric tons are based on weighted soil densities of sediments resampled for each measurement.*
Sept. 1994 – Density of material averaged 1.08 g/cm³ for the August 1994 storm.
Feb. 1999 – Density averaged 1.45 g/cm³ for August 1994 storm, and 1.85 g/cm³ for Sept. 1994 - Feb. 1999 sediment.
Mar. 2004 – Density averaged 1.5 g/cm³ for August 1994 sediment, 2.0 g/cm³ for 1994 - 1999 sediment, and 2.2 g/cm³ for 1999 - 2004 sediment.

the location and depths of the accumulated sediment, it became apparent that the sediment from the August 1994 event (derived from Tropical Storm Beryl) continued to be substantially lower in bulk density than the rest of the sediments. High winds from unstable air masses documented elsewhere during Tropical Storm Beryl may have caused an unusual amount of tree sway, twist, lean or blowdown, exposing finer soil materials to erosion. The August 1994 sediments initially had bulk densities averaging about 1.08 g/cm³, and these materials settled to 1.45 g/cm³ in 1999 and to 1.5 g/cm³ in 2004. Sediments deposited between August 1994 and February 1999 filled the upstream fabric dam (fence number 1 in Table 1) and part of the second, with bulk densities averaging 1.85 g/cm³ in 1999 and 2.0 g/cm³ in 2004. Sediments added since 1999 and measured in 2004 accumulated primarily at the upper end of the upper fabric dam (fence 1) with a lesser amount added to the second dam, with bulk densities averaging 2.2 g/cm³. With time, the materials captured have increased in their density and the more recent sediments are also denser. Over the study, 70 percent of the captured materials were retained in the upper structure, 30 percent in the middle structure and no measurable quantity in the lower structure.

Sediment accumulated from 1999 to 2004 primarily in the upper reaches of the first dam, suggesting that the coarse or the heavier particles may be settling out before they reach the first fabric dam. It is not known if this is due to storm differences in effective runoff or due channel changes from the fabric dam. The fabric dam and resulting sediment accumulation have changed the channel gradient, width and depth upstream. Perhaps larger storms would be needed to move materials into the second and third fabric dams. But the subtle changes associated with the filling of the first fabric dam may be enough to alter the delivery and lead to the current trend in upstream channel sediment storage.

Besides the sediment measured in the fabric dams, many observations were made over the extended study that provide useful information for assessing small ephemeral gully erosion and sediment delivery. On-site erosion was evident within the exposed gully area basically anytime, but especially following intense rainfall events and freeze-thaw cycles. Rainfall events left areas where soil pedestals were protected by small rocks and roots from raindrop impact and erosion. Freeze events expanded ice crystals that heaved soil and small plants above the surface. During thaw events, particles lifted from the surface were heard and seen tumbling down the slope as their ice support weakened upon melting. Many of the processes eventually undermined the fine surface roots and left them exposed after surface erosion (Figure 9). These processes help to perpetuate the soil exposure that has been maintained for decades without recovery. Only the large magnitude, severe rainfall events generated enough flow energy to transport sediments downstream in the small ephemeral channel to accumulate in the sediment dams. During inactive periods, the seasonal leaf-fall and wind-blown leaves hide much of the sediment accumulation within the channels, giving an appearance of low activity, with no apparent sediment being delivered (Figure 10).

Figure 9. Soil erosion was evident on low to moderate sloping areas with exposure of fine roots and pedestaling of soils are indicators of the raindrop energy and poor infiltration on these barren soils.

Figure 10. Following autumn leaf fall, indicators of gully activity with respect to sediment delivery disregarding the filter fabric fence are masked to the casual observer.

Other indicators of erosion within the gully and adjacent gully areas included headcuts (primary or uppermost nickpoint), cavitation, slope failure, root exposure, tree decline or mortality along gully margins, areas of sediment aggradation and in some instances secondary nickpoints (Figure 11). These indicators obviously helped verify erosion processes, but did little to actually confirm that sediment was being delivered downstream. Indicators of sediment delivery became more obvious after major events, when fresh sediments covered the channel and the sediment path was dominated by the red clay color.

We noted that the red clay stains at the base of trees in the channel persist and appear to be a reliable indicator of sediment delivery (Figure 12). The stains are a result of red piedmont clay materials in sediment laden runoff or rainfall splash from fresh sediment deposits onto trees. Stain depth was sometimes higher and brighter on the portion of the tree facing the flow delivered from the gully channel. Within the sediment path on an alluvial terrace, the trunks of mature bottomland hardwood trees showed no enlargement at their base, another indicator that the sediment had buried their trunks some time ago. The sediment track and stained trees continued to a small perennial stream, several hundred feet away. Red clay deposits along the channel margins continued downstream. Soil cores in the sediment track revealed brighter soil colors of fine alluvial materials, while areas outside of the sediment path had darkened red alluvial soils from historic

Figure 11. Surface erosion along the upper edges of the gully was enough to remove almost all the soil supporting this pine tree during its lifetime.

Figure 12. Sediment marks within the flow path are especially evident from the reddish clay soils onto the base of trees.

gully erosion that has had more time to incorporate organic materials and change colors during weathering processes. Buried organic layers are more likely to be present where flow velocity is low, and less likely where flow has a defined path, velocity and depth sufficient to move organic materials.

Discussion and Conclusions

Our study was a result of public concerns associated with having clear reasons for stabilizing and restoring ephemeral gullies. Upon visiting the site and reviewing the findings, individuals concerned about past gully control measures have a much better appreciation of how ephemeral gullies function. Even small gullies can remain barren and continue to erode and deliver sediment for decades, affecting soil, water and aquatic resources. During the study, we identified many storms and events that produced erosion from a small ephemeral gully and associated gullies and other barren areas nearby. More importantly, we identified that severe tropical storms were necessary to deliver sediments from extremely small ephemeral gullies. Until we evaluated the storm and flow frequency of these type events over the study period, it was not apparent that they recur so frequently. Water quality and aquatic habitat are much more likely to be affected by sediment delivery downstream from small ephemeral gullies than we had thought. Since funding to treat gullies is limited, we can use this information to help prioritize treatments. Gullies that are not only eroding, but also actively and frequently delivering sediments to streams would get a higher priority for treatment.

Gullies have many characteristics that make them difficult to understand. Sometimes a relatively simple study as this can help answer public concerns and be beneficial in forming responsible recommendations and decisions. Although this study was intended to only characterize sedimentation associated with a specific gully, it has provided information on how ephemeral gullies function in the piedmont of South Carolina. Following the gully activity for nearly 10 years demonstrated that ephemeral gullies may have their own timing and activity level, and effects are not always obvious. Ephemeral gullies can erode and not produce measurable sediment. However, as evidenced in this study, severe storms can generate the flow needed to deliver sediment from very small gullies.

Other information of the study is interesting, but in some instances would need more verification. The information collected on differences in sediment density seemed to support the idea that the low-density sediments delivered in the August 1994 storm were unusual, even after almost a decade. Perhaps this could be linked to the severe winds and many localized tornadoes experienced outside of the study area during Tropical Storm Beryl. However, the increase in material density with time should be expected and considered when measuring sediment accumulations over time. The increase in coarse materials settling in the upper reaches of the upper fabric dam may be due to channel changes associated with the accumulating sediments. Changes in channel gradient, width and depth occur with aggradation. In addition, sediments captured by the fabric dam may absorb stormflow and filter particles or organics before they can be delivered as sediment. Although interesting with potential implications to the results, the study was not set up to determine the specific processes that may be associated with sediment deposits, as they may vary with channel changes, storm intensities and time.

This study provides an example of simple but effective sediment observations and measurements that helped address a public issue of concern. The approach has been effective in describing and communicating some of the erosion and sediment delivery processes that may occur in small ephemeral gullies. Even without detailed measurements, the fabric dams with accumulated sediment effectively illustrate these results to varied audiences that visited the site or were shown pictures of the results.

The reader should be aware of some precautions and limitations before applying these methods. Under normal circumstances and construction methods, silt fences and concentrated surface waters in channel systems are incompatible. Careful design and installation are needed to contain concentrated flow and accumulating sediment.

We believe that filter fabric dams may have many potential uses in addressing erosion, sediment and water quality issues. As suggested by Dissmeyer (1982), they are very useful in storing sediments derived from hillslope surface erosion. Under most circumstances, hillslope erosion in forests is very low because ground disturbance and concentrated flow is generally limited. The fabric dams have been used to help determine effects from more severe ground disturbances such as wildfire, bladed fireline and temporary road construction. Ground disturbances may contribute concentrated flow from compacted or exposed surfaces. The fabric dams have been used to determine effectiveness of mitigation measures such as drainage dips and erosion control methods. Sediment effects become more likely to be measurable in affected ephemeral channels than on hillslopes because the drainage area increases. Until this gully study, a turbid watermark to light sediment accumulation would commonly be left across the fabric with little or no accumulation at the base of the fence. In those instances, these observations indicate that a flow event occurred, but little sediment was produced. This is

still valuable information in monitoring the effectiveness of methods.

We have some advice or considerations for those attempting to use fabric dams to measure sediment. Consider low gradient channel sections that offer some reduced stream velocity, more channel storage and stable banks. Tall sediment retention structures are unstable. The effective height of the structures used for this study was about a meter. Reducing the height of the structure will limit the amount of sediment captured, but improve its stability under the force and pressure of the flow and sediment. As sediment fills the structure, detention of flow and filtering capability of the exposed filter cloth is reduced. Adding another filter dam downstream can help maintain the filtering capacity and prevent loss of data during overflow. Do not forget that the accumulated sediments within the structure may alter the channel gradient and dimensions and improve the channel's ability to detain or accumulate sediments upstream. Measure the channel dimensions substantially beyond the elevation of the effective dam height. Under the circumstances of this study, the longevity of the filter fabric dams is at least a decade.

We feel that the fabric dams would be well suited to many other conditions. This study area has some of the most severe land use and erosion history in the piedmont of South Carolina. The severity of conditions is also evident when a 0.1 ha ephemeral gully repeatedly delivers sediment downstream over a decade. The severity is also suggested by the Universal Soil Loss Equation average annual rainfall/runoff index (R-factor) for the area: a relatively high rating at 4,600 (megajoules/ha) (mm/hour) [i.e., 275 in units of 100 (foot tons/ac) (inches/hour)] (Wischmeier and Smith 1978). The R-factors in the southeastern U.S. are substantially higher than most of the rest of the country. We have used the fabric dams in ephemeral drainages in the Blue Ridge Mountains with areas of about 1 ha (2-3 ac), and they withstood severe to record events associated with Tropical Storms Jeanne and Ivan in 2004.

Advantages of the filter fabric dams include low to moderate cost, flexibility of scheduling measurements to fit study details desired, and their ability to provide a visual indicator of the accumulated sediment captured. The study costs over the decade were not closely tracked, but expenditures are estimated at $10 000, which included $1000 to install the three fabric fences, $500 for the boundary survey, $500 for deposition and stream sediment measures, $3000 for the three measurements and data compilation of sediment accumulations and probably about $5000 in analysis, documentation and reporting. The flexibility of scheduling measurements to fit individual schedules and having a visible field demonstration are important considerations. Whether seen in a picture or on a site visit, the filter fences are effective communication tools. Disadvantages may be the time needed to measure the elevation changes in the sediments, sample the sediment density during each measurement, and compile the data. The fabric dams are not permanent structures, and failure may eventually occur. The deposits may need to be stabilized or removed when the study is complete.

Assessment of ephemeral gullies and downstream areas after major disturbance events may be a realistic approach in the southeastern U.S. due to the frequency of events. However, for many other areas, the frequency of disturbance events would make the fences difficult to rely on. Even without field assessment, analyzing gully history using aerial photos can be a viable tool in identifying changes in land use, gully shape, size and extent through time. This approach is more difficult where gullies expand into forested terrain. We recommend the fabric dams as a useful tool if the other erosion and sediment indicators are inconclusive. They provide a low technology approach to monitoring sediment under certain conditions that could be adjusted to produce higher levels of accuracy or detail if required.

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References

Cooney, TW, PA Drewes, SW Ellisor, TH Lanier and F Melendez. 2003. Water Resources Data - South Carolina. Water-Data Report SC-03-1. 691 pp. (*http://water.usgs.gov/pubs/wdr/wdr-sc-03/wy03/pdfs/02160700.2003.sw.pdf*)

Dissmeyer, GE. 1982. How to use fabric dams to compare erosion from forestry practices. Atlanta, GA: USDA Forest Service, Southeastern Area, Forestry Rep. SA-FR 13,.10 p.

Griswold, GW. 1993. Field application and review of hand-held laser survey instrument. Unpublished report, USDA Forest Service, Region 2, Grand Mesa, Uncompahgre and Gunnison National Forests, Gunnison Engineering Zone, pages 7-15.

Hansen, WF. 1991. Land rehabilitation on the Sumter National Forest, In: S. Fan and Y. Kuo (eds) Proceedings of the Fifth Federal Interagency Sedimentation Conference, Las Vegas, Nevada. Volume 1: 3-110 to 3-117.

Hansen, WF. 1995. Gully treatments. In Proceedings of Watershed Assessment and Restoration Workshop, National Advanced Resource Technology Center, USDA Forest Service, Marana, Arizona. 29 p.

Hansen, WF and DL Law. 1996. Watershed restoration after calamity. In Proceedings on Watershed Restoration Management. JJ McDonnell, JB Stribling, LR Neville and DJ Leopold (Editors). AWRA Symposium, Syracuse, New York pp. 187-198.

Heede, BH. 1976. Gully development and control - the status of our knowledge. USDA Forest Service Research Paper RM-169. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 42 p.

Heede, BH. 1982. Gully control: determining treatment priorities for gullies in a network. *Environmental Management* 6(5): 441-451.

Hoover, M.D. 1949. Hydrological characteristics of South Carolina piedmont forest soils. *Soil Science Society Proceedings* 14:353-358.

National Oceanic Atmospheric Administration (NOAA). 2004. Tropical cyclones and storms - historical events. *http://hurricane.ncdc.noaa.gov/cgi-bin/hsei/hsei.pl, http://cirrus.dnr.state.sc.us/cgi-bin/sercc/cliMAIN.pl?sc5232; http://www.dnr.sc.gov/climate/sercc/climateinfo/historical/historical.html*

Schumm, SA, MD Harvey and CC Watson. 1984. Incised channels, morphology, dynamics and control, Water Resource Publications, Littleton, Colorado, U.S. Library of Congress Classification Number 83-050243, 200 p.

Singer, MJ, J Blankard, E Gillogley and K Arulanandan. 1978. Engineering and pedological properties of soils as they affect soil erodibility. California Water Resources Center, Tech. Report No. 166, ISSN 0575-4941. 32 pp.

Strahler, AN. 1957. Quantitative analysis of watershed geomorphology. *Transactions of the American Geophysical Union* 38(6): 913-920.

Yoho, NS. 1980. Forest management and sediment production in the South - a review. *Southern Journal of Applied Forestry* 4(1): 27-35.

Wischmeier, WH and DD Smith. 1978. Predicting rainfall erosion rates - a guide to conservation planning. USDA Agriculture Handbook No. 537. Washington, DC. 58 p.