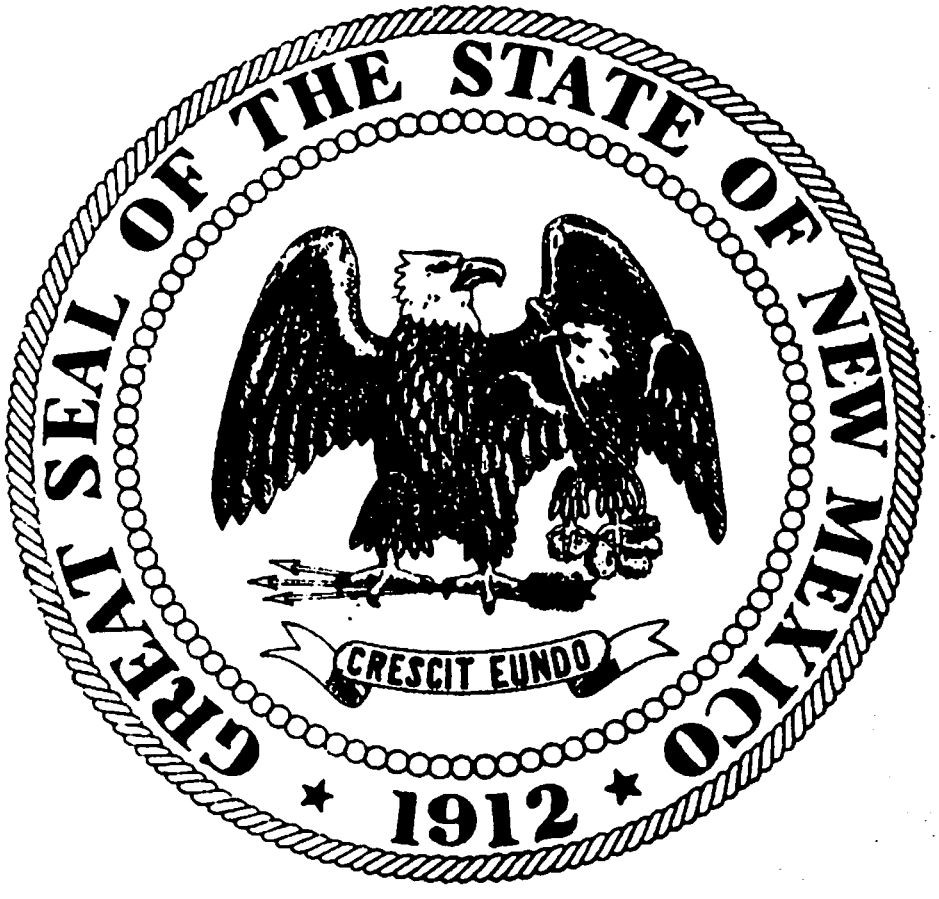
STATE of NEW MEXICO

#179



Proceedings

THE GOVERNOR'S CONFERENCE on Sedimentation and Erosion Control

22 March 1974
The Hilton Inn
Albuquerque, New Mexico

The Honorable Bruce King
Governor of New Mexico

EROSION - SEDIMENT PROBLEMS AND CORRECTIVE MEASURES

Sediment is well recognized as one of the largest pollutants of the United States streams and lakes, and the convening of this conference certainly indicates interest in the need for solutions to the problem. Your Governor, the Honorable Bruce King, is to be commended for this excellent session and for his interests in preserving our environment.

As a representative of the research agency of USDA, my comments are directed to the erosion-sedimentation problem as seen by a researcher. Special emphasis in the report is directed to methods that might be used to alleviate the problem and what types of investigations are in progress in this area.

Sediment, as a pollutant, can be transported by either wind or water. In many parts of the country, wind erosion isn't serious, but states such as New Mexico, with generally sparse vegetation and deficient moisture, do have wind erosion problems. Control measures such as windbreaks and increased vegetative cover reduce wind erosion hazards. Maintaining adequate cover without irrigation is often difficult in semiarid and arid areas. Scientists on the Agricultural Research Service's Jornado Experimental Range near Las Cruces, New Mexico, have found that brush invasion (particularly honey mesquite) can result in severe wind erosion and deposition around the plant base, which ultimately leads to sand dunes with mesquite foliage protruding from the top. Aerial spraying with herbicides (or other approved chemicals) can alter the cycle, and the range grasses can be reestablished in a few years (a series of four slides were shown to illustrate the problem).

Now let's return to the erosion problem where water is the transporting agent. Langbein and Schumm [1] (Figure 1) showed that sediment yield (erosion minus deposition occurring before the sediment reaches a measuring point) can be related, in a broad sense, to the annual precipitation required to produce some threshold runoff. Their work illustrates, in a striking way, the importance of erosion in the arid and semiarid regions and the difficulty of controlling it.

---

(1) Langbein, W.B., and S.A. Schumm, 1958. "Yield of Sediment in Relation to Mean Annual Precipitation", Am. Geophys. Union Trans. 39:1076-1084

Kenneth G. Renard, Director, Southwest Watershed Research Center, USDA, Agricultural Research Service, 442 East Seventh Street, Tucson, Arizona 85705

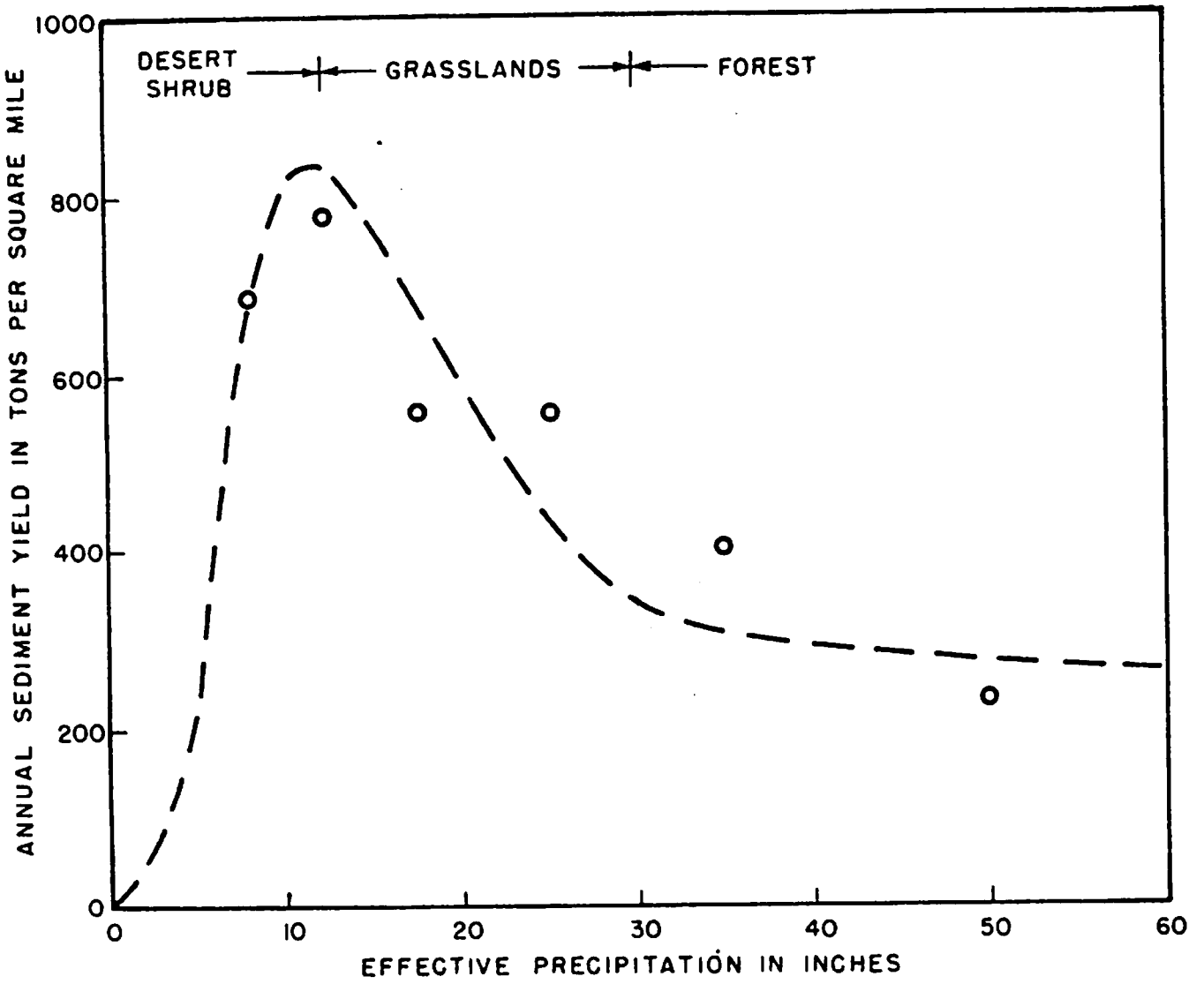


FIGURE 1. The importance of erosion in the Southwest and the relation of peak sediment yields to vegetation types (from Langbein and Schumm).

The Langbein and Schumm results demonstrate the delicate ecological balance in the arid Southwest and the importance of cover for erosion control. Generally, these lands have sparse vegetation to protect the land surface from the erosive force of the falling raindrop and this poor cover undoubtedly explains the peak erosion for the region where mixed grass-brush cover is dominant. High-intensity thunderstorms are common throughout the Southwest and, although such storms may be infrequent, the low infiltration rates result in large amounts of water moving over the land surface and exerting extreme erosive shear forces. Thus, although the annual water yields from arid watersheds are generally low, high-intensity storms, sparse vegetation, steep land slopes, and in some areas, rain on snow with frozen ground, all contribute to high sediment concentrations in streams and high sediment yields.

Sedimentation problems can generally be divided into three distinct phases: detachment, transport, and deposition. Let's discuss each separately but recognize that they all act concurrently.

DETACHMENT:

The importance of soil eroded from hillslopes is often overlooked. For example, scientists have estimated that it takes nature between 1,000 and 10,000 years to replace an inch of soil by chemical and physical weathering. H.H. Bennett used this important point as the basis for establishing erosion control work in the USDA in the 1930's. Not to be overlooked as part of the problem, is the large amount of nutrients lost with this erosion. The need for erosion control work is more acute today as increasing pressures for food production and urban uses intensify our demands for the land.

One of the most commonly used tools for estimating hillslope erosion is the Universal Soil Loss Equation(2) (USLE), which was developed for the areas east of the Rocky Mountains. Scientists of the Agricultural Research Service are working to extend this prediction equation to the remainder of the country.

---

(2) Wischmeier, W. H., and I. D. Smith, 1956. "Predicting Rainfall Erosion Losses from Cropland East of the Rocky Mountains", Ag. Handbook 282, USDA-ARS, 415 pages.

The equation is:

$$A = R\ K\ L\ S\ C\ P$$

where

A is the computed soil loss per unit area

R is the rainfall factor

K is a soil erodibility factor

L is the slope length factor

S is a slope gradient factor

C is a cropping management factor

P is the erosion control factor

Numerical values for these factors have been determined from research data but the almost complete absence of data in the West are compounding the problem. The equation is interesting to explore because it illustrates that as land managers, we can't control most of the terms. Only the "C" (cropping management) term or the "P" (erosion control) term can be manipulated to reduce hillslope erosion.

Most of the difficulty connected with the USLE equation involves the rainfall factor "R" and the cropping management factor "C". Foster(3) is modifying this "R" term to reflect not only the impact of raindrops but also the erosion from water moving over the land. Thus, he proposes expanding "R" with an energy term "E" as follows:

$$E = \left(aR + bcQ(q_p)^{1/3}\right)$$

where

$a+b = 1$ are weighting terms

c = equality coefficient

R = rainfall factor as used in USLE

Q = runoff volume

q_p = runoff rate

(3) Foster, G.R. Personal Communication.

Work at the Southwest Watershed Research Center has indicated that when the USLE equation is used for areas larger than plot size, an additional term must be used to reflect additional sediment erosion for stream channels and their peripheries. Thus the equation becomes:

$$A = (R\ K\ L\ S\ C\ P)\ E_c$$

where all terms are as defined previously and E_c = a parameter greater than 1 reflecting channel erosion.

The cover term in the USLE equation has been well documented by experiments in the Eastern United States but not in the sparse vegetation of rangeland areas of the Western U.S. Table 1, reproduced from the Soil Conservation Service's Technical Release #51, illustrates a proposed set of C values for different densities of ground cover and for different vegetation covers. Much work remains to prove the validity of this table. Although some work is in progress, a more concerted effort will be needed if the deadlines of the 1972 Water Quality Improvement Act (PL 92-500) are to be met and if this concept (USLE) is to play a role in implementing this law. The table illustrates nicely the magnitude of erosion associated with variations in vegetation cover. On the first line, erosion would be expected to be reduced more than 100 times in going from a bare soil (the C value is 0.45) to a 95% cover (the C value is 0.003).

TRANSPORT:

Sediment transport is the link between erosion and deposition. Much laboratory work has been completed using hydraulic flumes to develop relationships for the sediment concentration in a flowing stream. The predicted sediment concentration in a stream using these laboratory and field relationships is generally related to physical properties of the stream (such as width, depth, velocity, water temperature, etc.) and the properties of the individual sediment grains. In these approaches, field data to calibrate the models are generally required. Because of the high costs associated with collecting such information, it is often not available. (A few slides were shown to illustrate some of the problems associated with collecting such field information.)

C VALUES FOR PERMANENT PASTURE, RANGELAND, AND IDLE LAND
FROM SCS T.R. 51

VEGETAL CANOPY			COVER CONTACTS SURFACE					
TYPE AND HEIGHT OF RAISED CANOPY 2/	CANOPY COVER % 3/	TYPE 4/	PERCENT GROUND COVER					
			0	20	40	60	80	95-100
COLUMN NO.	2	3	4	5	6	7	8	9
NO APPRECIABLE CANOPY		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
CANOPY OF TALL WEEDS OR SHORT BRUSH (0.5m. FALL HEIGHT)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
APPRECIABLE BRUSH OR BUSHES (2m. FALL HEIGHT)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011

1/ All values assume : (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.

2/ Average fall height of waterdrops from canopy to soil surface.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection.

4/ G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds).

Work at the Southwest Watershed Research Center has revealed that the sediment yield can be obtained using the Laursen sediment transport relationship given as:

$$Q_s = B \int_T q_s dt = B \int_T \frac{\bar{c} q_w}{265} dt$$

where Q_s = sediment yield

B = stream width

q_s = sediment discharge rate per unit width

q_w = water discharge rate per unit width at time t

T = time of an individual hydrograph

$\bar{c}$ = sediment concentration obtained from a complicated relationship involving computing the shear of the moving water relative to individual grains, the total shear and the shear necessary to create motion.

The equation is shown not to impress or confuse, but rather to illustrate that the problem is complicated. The entire analysis is predicated on the assumption that information on the water discharge or watershed runoff is known. In ephemeral stream country (such as washes, gulches, and arroyos in New Mexico), losses of water due to absorption in the streambed add another element of uncertainty to sediment transport.

Thus, despite decades of study, the mechanics of sediment transport is still not well understood. A further problem of this uncertainty results from the various ways the sediment may move. Large material may roll along the streambed, whereas coarse material may be distributed in suspension with high concentrations near the streambed. Fine material, on the other hand, is generally uniformly distributed throughout the stream depth.

DEPOSITION:

Sediment deposition creates unsightly and troublesome accumulations at the bottom of long slopes, along streams, in valleys, and in reservoirs. The deposits may contain large amounts of chemical, organic, and biological meterials that are potential pollution sources.

Reservoirs in the U.S. have an approximate storage capacity of 500 million acre-feet. The average measured depletion rate from sediment in these reservoirs is 0.2 per cent, which represents an annual storage loss of 1 million acre-feet. The cost of removing this sediment, assuming it were possible, has been estimated at about $1 billion[4].

STREAM CHANNEL EROSION

The formulation of channel systems is a highly complicated process, often entailing all three facets of the sedimentation process mentioned previously. Although a meandering stream with vegetated banks may be aesthetically most desirable, it may be inefficient for carrying flood discharges. Conversely, straightened channels may accelerate degradation and bank erosion, thereby presenting stabilization problems.

On the Upper Alamogordo Creek Experimental Watershed near Santa Rosa, New Mexico, we have had some success arresting headcut development in highly erodible materials using hydraulic energy dissipators. An uncontrolled 15-foot headcut which was moving up a grass swale in a 6-square-mile watershed was controlled with a drop box structure (shown on the slide). The control measure has also kept the valley from being segregated by the steep arroyo and has enabled continued cattle access for grazing in the area.

Engineering criteria for these design applications are only beginning to be understood. The improvement works must be based on design methods unique to each channel condition to be corrected and the solutions (if known) for many of the problems are not economically feasible.

Intensive land uses for urban and recreational uses are also creating sedimentation problems. Disturbed soil profiles at urban construction sites with no vegetation protection can result in severe erosion. Public awareness of such obvious problems can lead to corrective actions such as temporary sediment detention basins below construction sites, with the eroded material subsequently restored to slopes before reseeding.

---

(4) Robinson, A.R., 1971. "Sediment", J. of Soil & Water Conservation, V 26:61-62

Off-road vehicles are creating increasingly serious erosion problems. Being an enthusiast of trail bike riding, I appreciate the thrill of such recreation. I recognize, however, that the delicate ecological balance of arid and semiarid areas perhaps will require limitating such activities to specified areas. Information on the extent of such programs in accelerative erosion is not generally available, although the Geological Survey has initiated some pilot work in the Southern California area.

SUMMARY

Complete elimination of erosion is virtually impossible; therefore, guidelines must be developed to design acceptable levels for watersheds or river basins. With improved technology, environmentalists, engineers, and scientists can reduce sedimentation to tolerable levels, but unless we can eliminate the energy of moving water, erosion must be recognized as a necessary part of the geologic formation of the landscape.

Unfortunately, at current levels for investigating new methods for controlling the erosion-sedimentation problem, new problems are emerging faster than old ones are being solved. Thus efforts to control the erosion, transport, and deposition of sediment will probably be perplexing many future generations.