HAS THE US SEDIMENT POLLUTION PROBLEM BEEN SOLVED?

Jerry M. Bernard, Natural Resources Conservation Service, Washington, DC
Lyle L. Steffen, Natural Resources Conservation Service, Lincoln, NE
Thomas A. Iivari, Natural Resources Conservation Service, Chester, PA.

Introduction

The solution to sediment pollution problems is simple: control erosion. Controlling all soil erosion is probably not possible and would effect significant ecosystem changes. Conservation farming practices significantly reduce amounts of sediment produced, but the sediment that is produced is of smaller particle size that is an efficient carrier of some chemicals. Additionally, some sources of sediment are not easily controlled, such as classic gullies and streambank erosion. These are often beyond the capabilities or control of individual land users to fix. Western parts of the country also experience high rates of "geologic" erosion, on lands that are not cultivated or disturbed by human activities. The Badlands of South Dakota are an example of very high natural, geologic, or background erosion rates.

The mental linkage of sediment damages to erosion processes is fundamental to any plans formulated to protect ecosystems. Published literature, as well as resource protection plans, use a variety of terms with ambiguity, such as *soil loss, erosion, sediment, siltation, sediment production, sediment yield,* and *sediment delivery.* The solution to the confusion is to provide both sides of the equation: when *sediment* is reported, then the reader should also have a sense of the magnitude and distribution of erosion processes that produced it.

Statement of US Sedimentation Problem

- **Sediment continues to be the greatest pollutant of waters of the US by volume.**

The presence of sediment in suspension causes abrasion of turbines and delicate plant and animal tissues. It takes up space and thereby depletes usable water volume. Sediment covers spawning areas, coats aquatic plants and floodplain crops and vegetation, and changes the quality of covered topsoil.

The USEPA concluded in its "Final Report to Congress on Section 319 of the Clean Water Act (1989)" (USEPA, 1992) that:

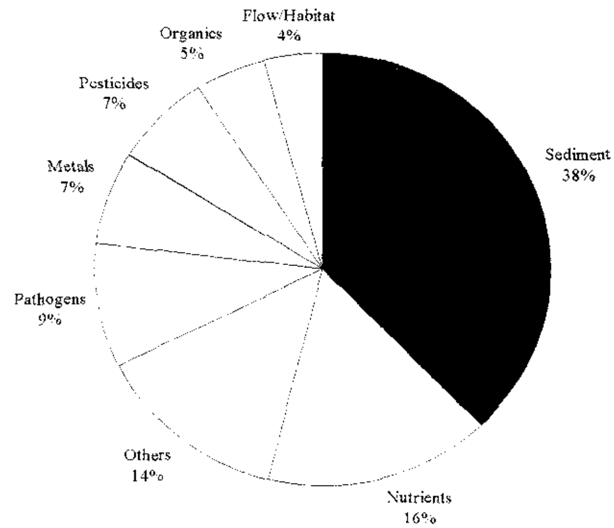
- o *Agriculture continues to be the single largest contributor to nonpoint source problems in the nation. It is the leading source of impacts to rivers, lakes, and wetlands.*

- o *Siltation and nutrients are the pollutants responsible for most of the nonpoint source impacts to the nation's surface waters. Rivers, lakes, estuaries, and wetlands are all affected primarily by one of these two pollutants.*

According to the same report, agriculture is the nation's largest contributor to nonpoint source pollution, with 41% of all nonpoint source pollution attributed by states to this source. The 305(b) report of 1988 also showed that agriculture is the leading source of water pollution in the United States, even when point source impacts are included in the analysis. Non-irrigated crop production and livestock are the primary contributors and are highest in the Midwest. Range land and irrigated cropland are significant sources of pollution in Western states.

In its 1992 Water Quality Inventory Report to Congress, USEPA indicates that sediment affects 45% of over 220,000 impaired stream miles in the states reporting causes of pollution (USEPA, 1994). The same report indicates that agriculture affects 72% of impaired river miles.

Figure 1. Pollutants Impacting Use Support to Rivers (33 States Reporting). Source: USEPA, 1992



The National Academy of Sciences states that agriculture contributes 64% of all pollution to rivers, and sediment comprises 47% of all pollutants in rivers (National Academy of Sciences, 1993).

Sediment is the major pollutant affecting rivers and streams in the country, as shown in Figure 1, with the greatest state share of the sediment problem in Missouri (USEPA, 1992).

US Erosion Rates

- **Sheet and rill erosion rates have decreased significantly for the period 1982 through 1992.**

About one billion tons of soil have been saved due to soil conservation plans implemented on highly erodible land (HEL) and the Conservation Reserve Program (CRP) under the provisions of the Food Security Act of 1989 (USDA, 1994). The changes in the landscape are visible and striking and represent a large source of sediment and attached chemicals that is now being held in place.

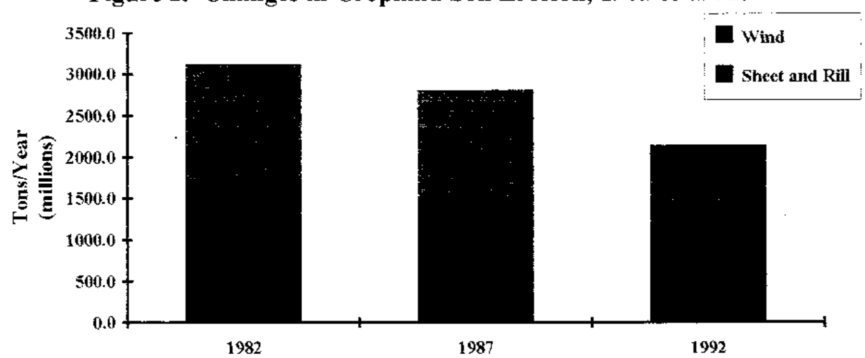
The Conservation Technology Information Center collected information on the adoption of conservation tillage during the period 1982 to 1988. These surveys showed increases in the use of conservation tillage practices as follows: Northeast, from 18 to 42%; Midwest, from 34 to 42%; Great Plains, from 10 to 23%. These areas correspond to the USGS-measured decreases in suspended sediment yields.

Figure 2 shows that cropland erosion has decreased by about one billion tons or about 31% for the ten-year period, 1982 through 1992. The decrease in erosion is attributable to conversion of cropland for less erosive uses, such as (CRP), and an overall increase in the use of conservation tillage methods.

Figures 3 and 4 show changes in cropland acreage, which amounts to about a 9 percent reduction for the 10 year period. Most of these acres became CRP land and other rural land, as shown in Figure 4. Through the provisions of the Conservation Reserve Program, permanent vegetative cover is maintained, which dramatically reduces soil erosion rates.

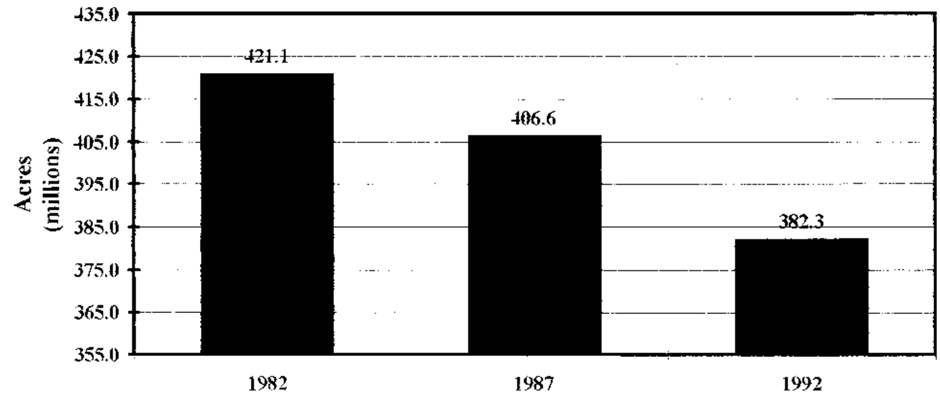
The Natural Resources Inventory (NRI) data, however, only describe the magnitudes of wind erosion and sheet and rill forms of water erosion. Gully erosion and streambank erosion are not included. Ephemeral gully erosion on cropland is essentially eliminated on CRP lands, which has been documented by plot studies at rates as high as 250 tons per acre. All forms of upland erosion are reduced on croplands under conservation tillage management or those enrolled as CRP land.

Figure 2. Changes in Cropland Soil Erosion, 1982 to 1992.



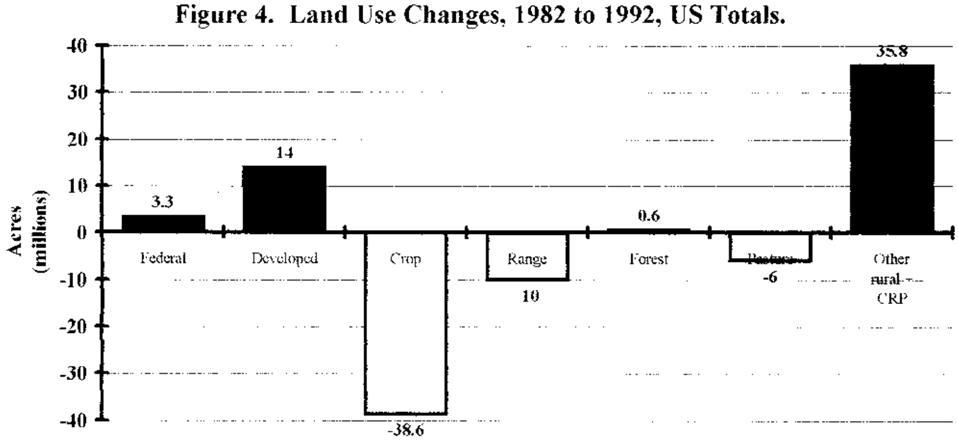
Source: 1992 National Resources Inventory

Figure 3. Change in Cropland Acreage, 1982 to 1992, US Totals.



Source: 1992 National Resources Inventory

Figure 4. Land Use Changes, 1982 to 1992, US Totals.



Source: 1992 National Resources Inventory

USGS Sediment Measurements

- **Overall, suspended sediment loads have decreased in the US for the period 1980 through 1989.**

Table 1 shows the changes in suspended sediment yield in tons/square mile/year and annual percent changes during the 1980 to 1989 time period (USGS, 1993), for which the USGS analyzed suspended sediment data collected at 324 stations and concluded the following:

- Highest suspended sediment concentrations were in the west-central part of US.
- Average concentrations were in the 100 to 500 mg/l range.
- Highest concentrations of sediment were recorded in drainage areas with high percentage of range and agricultural land (Alexander, written communication, 1994)(SCS, 1989).
- Stations with downward trends in concentrations are greater than those with increasing concentrations.
- Steepest downward trends in sediment concentrations were in areas dominated by range land and agricultural land, in areas where increased local, state, and federal soil conservation efforts were planned and implemented.
- Sheet and rill erosion decreased by 13 percent on rural land between 1982 and 1987 (SCS, 1989).

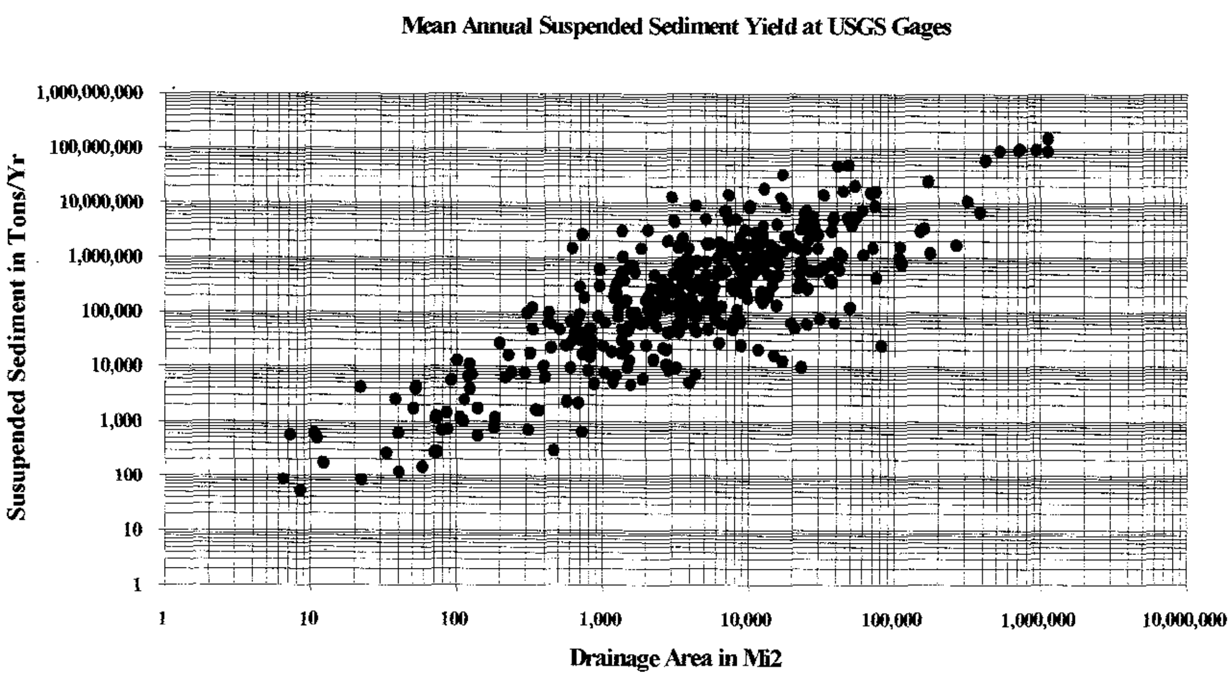
Table 1. Change in Yield of Suspended Sediments in the United States, 1980--1989

Water Resources Region	Yield in tons per square mile per year	Percentage change per year
North Atlantic	32	-0.4
South Atlantic-Gulf	20	+0.2
Great Lakes	36	+0.5
Ohio-Tennessee	85	-1.3
Upper Mississippi	102	-1.3
Lower Mississippi	111	-1.2
Souris-Red-Rainy	4	+1.2
Missouri	45	-0.2
Arkansas-White-Red	31	-0.7
Texas-Gulf-Rio Grande	15	-0.6
Colorado	92	-0.8
Great Basin	21	-0.2
Pacific Northwest	40	-0.1
California	21	-0.6

Source: National Water Summary 1990-91, USGS Water Supply Paper 2400, 1993.

Figure 5 displays the mean annual suspended sediment yield in tons for the period 1990 through 1991. The data show a good correlation between sediment yield and drainage area.

Figure 5. Mean Annual Suspended Sediment Yield at USGS Gages by Drainage Area, in Tons/Yr.



Reservoir Sedimentation Surveys

- **Reservoir sediment surveys show increasing sedimentation rates for the period 1970 through 1985, but surveys are limited for the last ten years.**

It has been estimated that "about 880 million tons of agricultural soils are deposited into American reservoirs and aquatic systems each year" (Pimentel, et. al., 1995).

Based on over 4,000 sediment survey records, sediment deposition rates are increasing (Steffen, 1994). The rate of accumulation in reservoirs in the United States averaged about 0.11 acre-feet per square mile per year (acre-feet/mi^2/year) prior to 1930. One acre-foot is equal to a prism of sediment 1 foot thick over one acre, or 43,560 cubic feet. From 1930 to 1950, this rate almost doubled to 0.20 acre-feet/mi^2/year. The rate for the 1970 to 1985 period is 0.66 acre-feet/mi^2/year, which is six times the pre-1930's rate (Table 2 and Figures 6 and 7).

Figure 6. Number of Surveyed Reservoirs by Drainage Area Class

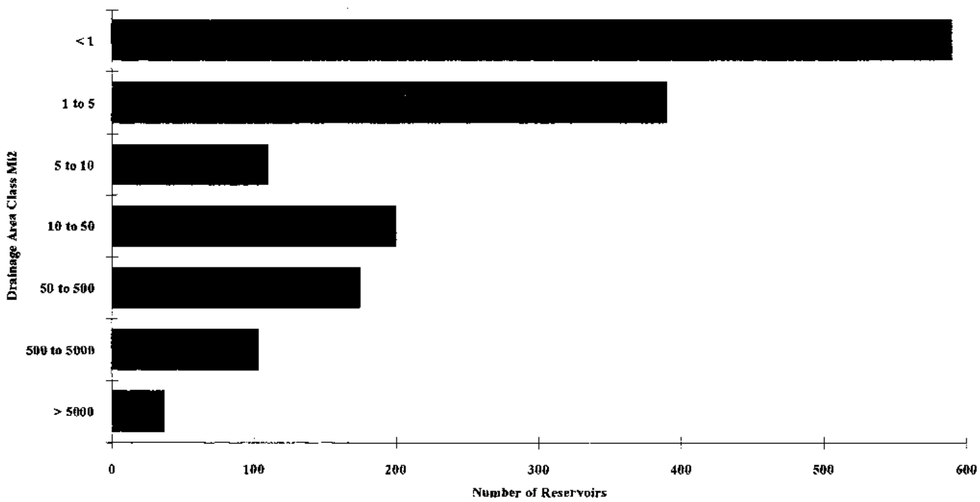


Table 1 showed changes in suspended sediment loads measured at USGS gages, with most water resources regions showing decreases of from 1 to 12 percent for the period 1980 through 1989. Three regions, however, showed increased sediment loads of from 2 to 12 percent for the same period. Direct comparison of these measured sediment loads to the changes in cropland erosion shown in Figure 2 is not possible since rates of erosion are not equal to the amount of sediment yielded from that erosion. This is due to sediment entrainment in fields, along drainageways, and in water bodies in watersheds.

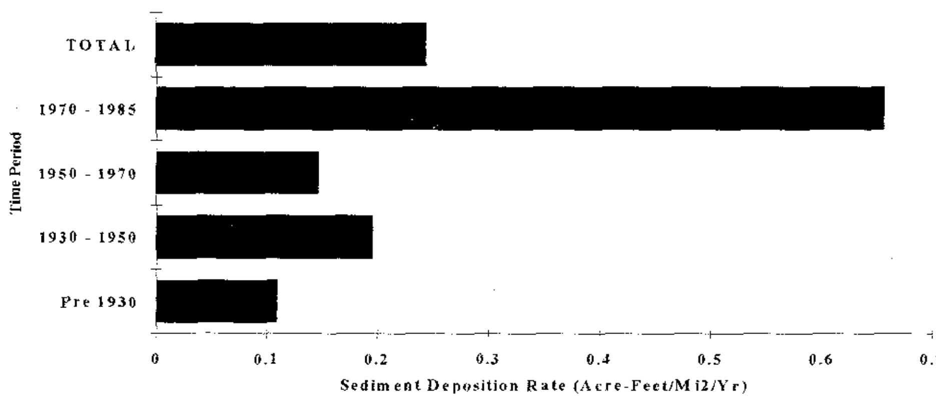
Table 2. Reservoir Sediment Deposition Rates by Time Periods.

Time Period	Sediment Deposition Rates		Number of Reservoir Surveys
	(ac-ft/yr)	(ac-ft/mi^2/yr)	
Pre 1930	15,001	0.109	19
1930 - 1950	181,624	0.196	871
1950 - 1970	201,096	0.147	2,257
1970 - 1985	191,613	0.657	994
TOTAL	459,154	0.244	4,141

The dramatic increase in the unit-area rate of sediment production during the 1970 through 1985 time period can be attributed to the rapid adoption of soybeans and farm policies that promoted maximum agricultural production (Figure 7). The continuation of these rates, or increases or decreases, is largely unknown due to the sparse amount of reservoir sediment survey data since 1985.

Surveys of sediment accumulations in reservoirs in the US have declined significantly since the early 1980's. Increased labor cost is likely one of the main reasons that fewer surveys are performed. Advanced technology such as global positioning systems linked with modern fathometers and computers is available to perform surveys faster, more efficiently, and more accurately, but these systems are not yet in widespread use.

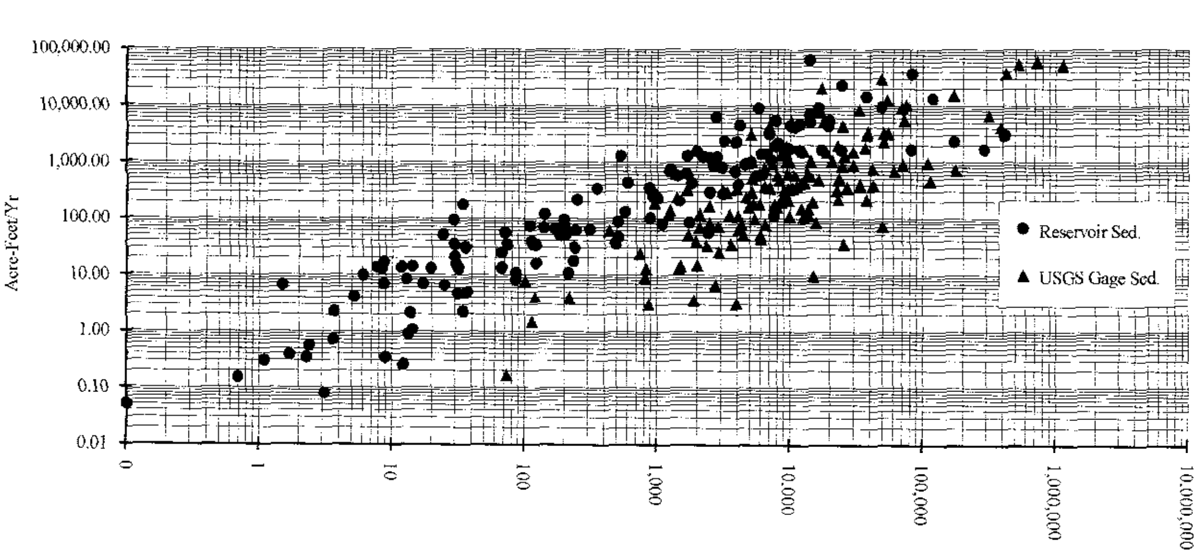
Figure 7. Reservoir Sedimentation Rates by Time Period in Acre-Feet per Square Mile per Year.



Sediment Measurements Compared: USGS Gages and Reservoir Surveys

Figure 8 shows that, in general, reservoir sedimentation rates have been at higher rates than for sediment loads measured at USGS gage stations. The reasons for this include (1) the reservoir sedimentation survey data are older than the USGS gage data, and (2) reservoirs trap a high percentage of all of the sediment that is transported into them, including bedload and suspended load. Note also that reservoir sediment accumulation rates are available for much smaller drainage areas.

Figure 8. Reservoir Sediment Deposition Rates and USGS Gage Suspended Sediment Loads



Conclusions

- Sheet and rill erosion rates on agricultural lands have decreased significantly for the period 1982 through 1992 due to increased adoption of conservation tillage methods, increased soil erosion protection afforded by the Food Security Act of 1989, and land use conversions. Inventories do not provide information on changes in rates of other erosion (streambank, gully, etc.).
- Suspended sediment loads have decreased for the period 1980 through 1989, according to USGS gage measurements.
- Reservoir sediment surveys show a dramatic increase in sedimentation rates for the period 1970 through 1985. Sediment survey records since the early 1980's are sparse, however, and do not provide a clear picture of the magnitude of current sedimentation rates.

Bibliography

Alexander, Richard B., 1994; written communication; U.S. Geological Survey.

National Academy of Sciences; *Soil and Water Quality, An Agenda for Agriculture,* by National Academy Press, Washington, DC, 1993.

Pimental, David, et. al., 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science, Vol. 267, pp. 1117-1122, 2/24/95.

Steffen, Lyle, NRCS, 1994; U.S. Reservoir Sedimentation Analysis with RESIS

USDA Soil Conservation Service, 1989, Summary report 1987--National resources inventory: USDA Soil Conservation Service Statistical Bulletin no. 790

USDA Soil Conservation Service, 7/1994. Summary Report, 1992 National Resources Inventory.

USEPA, 1992; Managing Nonpoint Source Pollution, Final Report to Congress on Section 319 of the Clean Water Act (1989); United States Environmental Protection Agency, Office of Water, Washington, DC, January 1992

USEPA, 1994; National Water Quality Inventory, 1992 Report to Congress; United States Environmental Protection Agency, Office of Water, Washington, DC; March, 1994.

USGS, 1993. National water summary 1990-91, Hydrologic events and stream water quality, pp. 111-140.