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A Menace to National Welfare Reconsidered, Part 1: Reviewing the Costs of Erosion

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In 1935, as dust storms carried topsoil from the Oklahoma panhandle to the Atlantic Ocean, Congress declared soil erosion to be a "menace to national welfare" and took tentative first legislative steps to address the problem. American agriculture was being consumed by the Great Depression; in the southern Great Plains, multi-year drought and catastrophic soil erosion known as the Dust Bowl compounded the misery (P.L. 74-46; Coppess, 2024; *farmdoc daily*, November 7, 2019; NRCS, History). Nearly ninety years removed, soil erosion remains a challenge central to agricultural resiliency and the overall health of farm fields. It is historically among farming's most prominent natural resource and environmental challenges. Eroding soils are also associated with lost nutrients and pesticides, resulting in water quality degradation. Combined, the losses contribute to damage that extends far beyond the farm gate (see e.g., Bullington, June 19, 2023; *farmdoc daily*, February 8, 2024; INLRS, 2023 Biennial Report; Illinois Department of Agriculture and Environmental Protection Agency, December 1, 2023; Jones, December 11, 2023; Haynes, January 5, 2024; Atkins, January 28, 2024). This article opens a series reviewing research on soil erosion and conservation with a focus on the economic implications and policy analysis.

Background

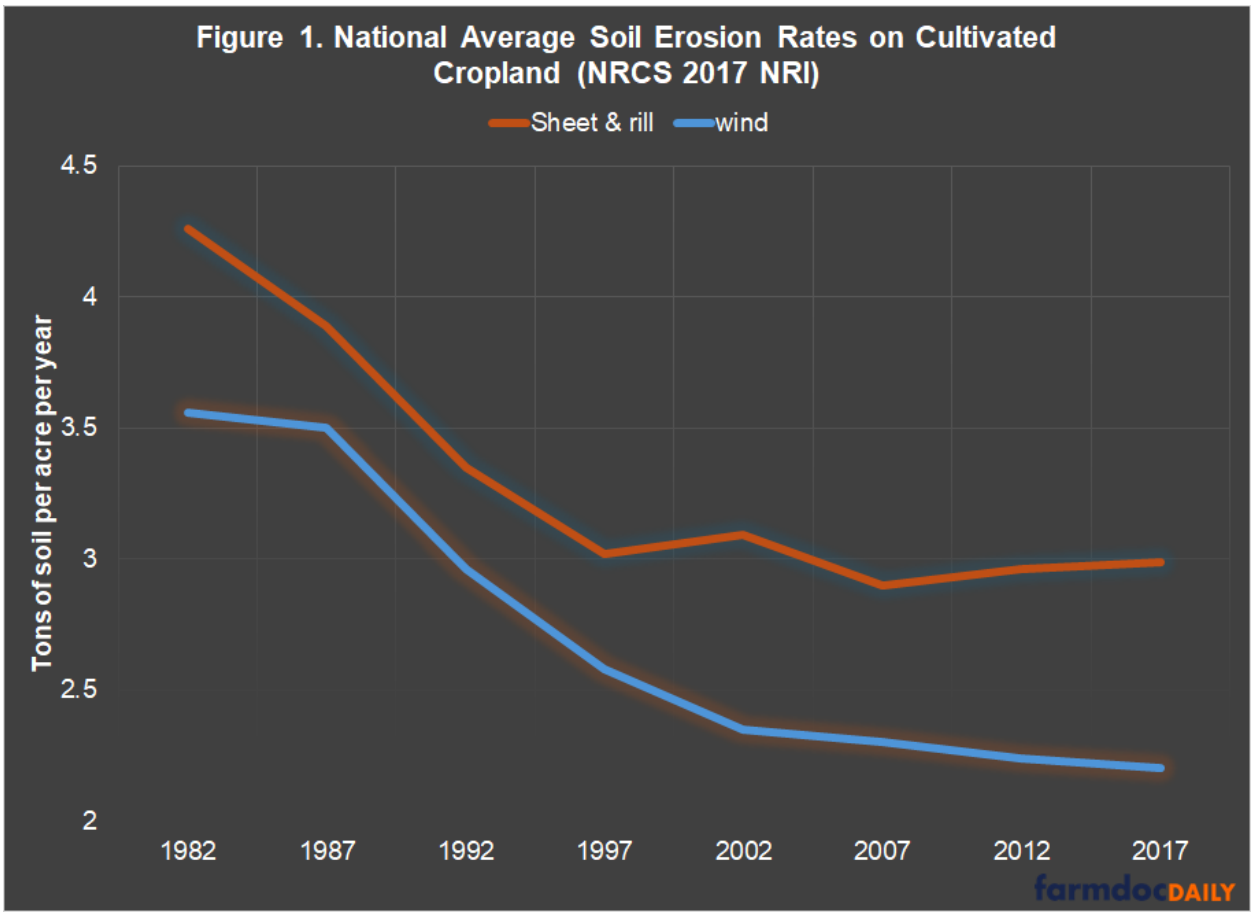
In 1995, a group of researchers led by David Pimentel published a groundbreaking paper on the environmental and economic costs of soil erosion that also projected the benefits of conservation; as of this writing, the paper has been cited over 3,800 times (Pimentel et al., 1995; Derpsch, et al., 2024). The researchers used complex modeling of soil erosion at an average rate of 6.88 tons/acre/year and estimated the cost of erosion at $79.35/acre/year in 1992 dollars. Twenty-five years later, USDA's Natural Resources Conservation Service (NRCS) released the most recent 5-year report on soil erosion as part of the 2017 National Resources Inventory (NRI), finding that U.S. cropland was losing an average of 4.63 tons of soil per acre per year. The 2017 NRI reported that 2.67 t/ac/yr. was estimated due to sheet and rill (water) erosion and 1.96 t/ac/yr. due to wind erosion (USDA-NRCS, September 2020). Despite significant

improvements, the current level of erosion remains a concern; soil regenerates slowly and soil erosion wastes natural resources, costing both the farmer and society.

For the farmer, soil erosion's economic losses begin with the risk of lost productivity but extend to diminished resiliency and sustainability. Farmers can generally seek to overcome or compensate for the productivity losses from soil erosion by increasing the application of expensive inputs such as fertilizer, but those costs are also increasing significantly. Adjusted for inflation and the lower soil erosion estimates in the 2017 NRI, a national average cost of erosion based on the Pimentel study would be $113.92 per acre today, 75% ($85.44/acre) of it borne by the farmer directly. For society, lost productivity on farms increases risk to the food system that may require mitigation in multiple forms. More directly, society also bears the costs of cleaning up soil erosion and lost nutrients. The Pimentel study concluded that 25% ($28.48/acre) of the erosion cost is charged to society.

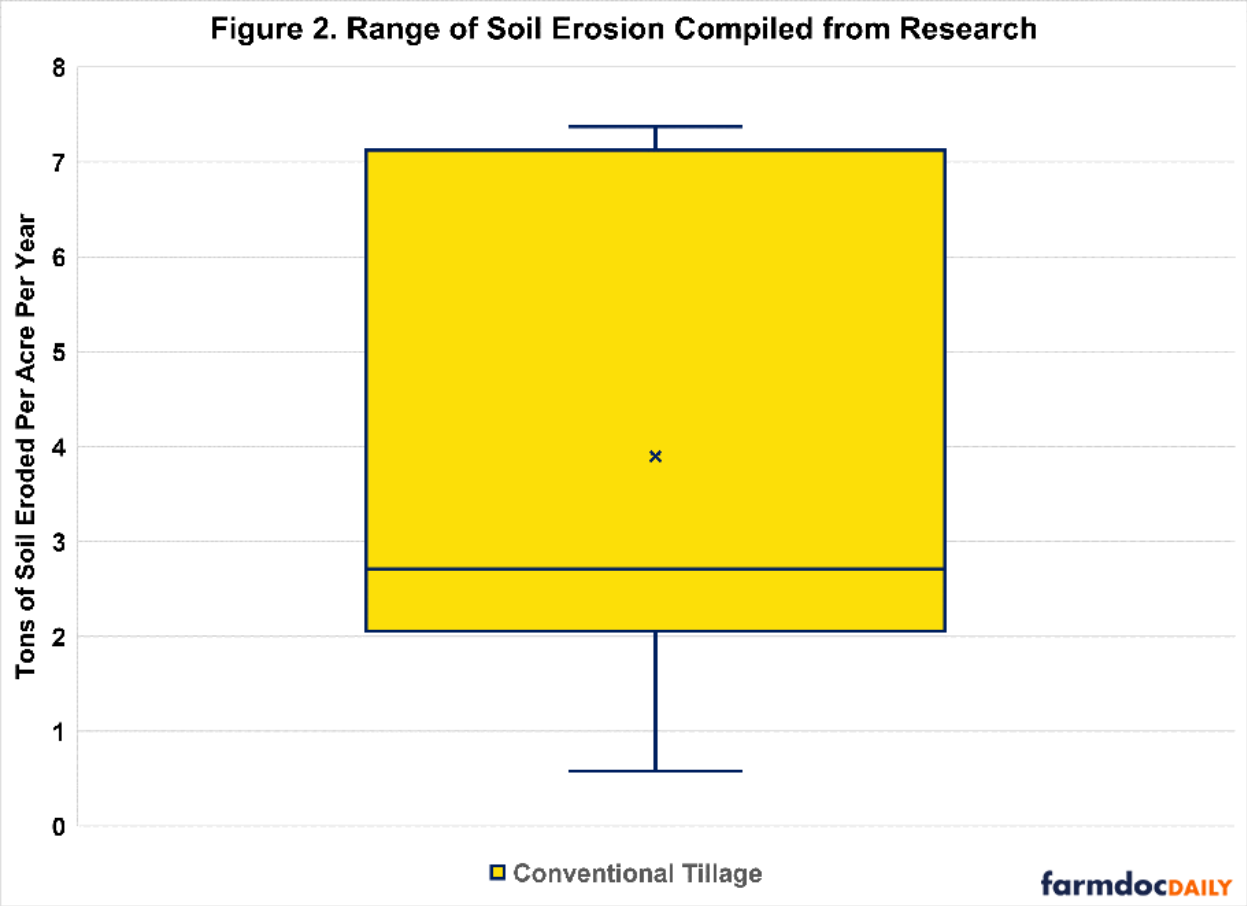
Discussion

The Pimentel study coincided with a reawakening about soil erosion. A substantial expansion of acres under production in the 1970s and early 1980s led to a second economic crisis and problematic increases in soil erosion. In the Food Security Act of 1985, Congress enacted landmark soil conservation policy that included the Conservation Reserve Program (CRP) and conservation compliance. The study preceded major changes in farm policy enacted in the 1996 Farm Bill, including decoupling farm program payments and enactment of the Environmental Quality Incentives Program (EQIP) (see e.g., Coppess, 2024). The 2017 NRI reported a 35% decrease in overall soil loss within the last four decades, attributing reductions to valuable conservation efforts and adoption of more sustainable farming practices. Figure 1 illustrates the national average soil erosion rates for cultivated cropland in each NRI from 1982 to 2017 from water (sheet and rill) and wind (USDA-NRCS, September 2020). Notably, much of the erosion reduction was accomplished from 1982 to 1997 and water erosion rates have increased since 1997.



Not all fields in all areas suffer erosion at the same rate in any given year, however, nor will the same field experience the same rates of erosion each year. As with all aspects of farming, much about soil erosion depends on the weather—hot, dry conditions for wind erosion or heavy precipitation events for sheet and rill erosion—and field conditions. Given these realities, *the range of soil losses found by researchers can be understood as the risk of soil erosion in any given field and year*.

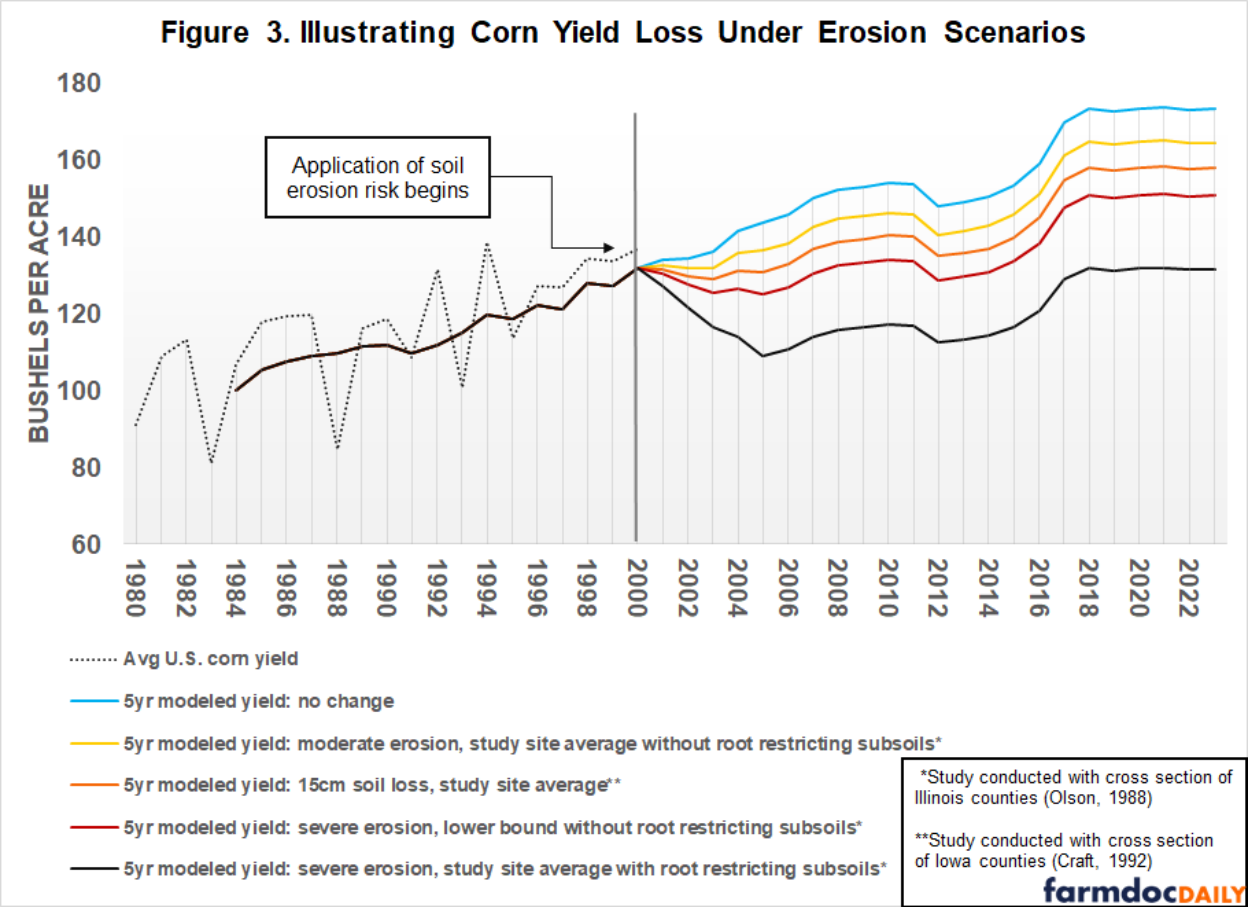
Figure 2 illustrates a single range of soil erosion with conventional tillage compiled from eight different soil erosion research articles (see e.g., Fu, Chen and McCool, 2006; Zhang and Garbrecht, 2002; Lindstrom et al., 1998; Gaynor and Findley, 1995; Seta et al., 1993; Blevins et al., 1990; Mostaghimi, Dillaha and Shanholtz, 1988; McDowell and McGregor, 1984). Even in this limited set of studies, we see a wide range of erosion, from below 1 ton/acre/year to over 7 tons/acre/year.



The range of erosion is a measure of risk to the field's productivity. The soil that erodes first and most is topsoil which is the most fertile part, containing much of the organic matter and nutrients necessary for crop growth (see e.g., Garcia-Ruiz et al., 2015). The stock of critical nutrients accumulates during years of no or low erosion but can be lost quickly in a high erosion year. Each crop year, soil erosion risks lower crop yields, not only in that year but for multiple crop years and yields into the future.

To understand the cost of soil erosion, we need to understand the impact on corn yields and the estimated economic and energy costs. The Pimentel study estimated yield losses beginning with 7.7% for corn, while other researchers found almost 8.8% corn yield loss at lower levels of erosion (15 cm of topsoil removed) and 19.6% at high rates of erosion (30cm soil removed) using a potential yield index model on 45 soils from 16 soil associations in Iowa (Craft, Cruse, and Miller, 1992). Similar research for Illinois soils (eight sites, seven soil series) found yield losses that ranged from 5% to 13% and as high as 24%; the highest yield losses were found for those fields with "root restricting subsoils" or soils with fragipans or clay pans that inhibited root growth and penetration (Olson and Nizeyimana, 1988).

Figure 3 makes an initial application of these research results to illustrate the potential yield loss risk due to soil erosion. Using the national average corn yield as the status quo scenario, we model how a soil erosion event in 2000 translates into potential yield impacts for the next twenty years. Each line below no change (light blue line) represents the increased risk of yield loss projected as a five-year average based on severity of soil erosion. While not a definitive measure of yield loss, this application of research provides a measure of potentially foregone yield. Each bushel actually lost cannot be sold for revenue and is a significant cost.



Finally, note that the research applied in Figure 3 did not include lost nutrients based on the presumption that farmers compensate for lost nutrients with fertilizer applications. Farmers can, to some degree, reduce the risk of yield losses from soil erosion with fertilizers, but that also costs the farmer and may not offset yield losses completely. As all farmers know painfully well, fertilizer costs have increased substantially since the early 1990s and have risen dramatically since 2020, reaching extremely high levels in the fall of 2021. According to the Agricultural Marketing Service, farmer-paid prices for anhydrous ammonia were $487 per ton in 2020 and $746 per ton by July 2021. The price exceeded $1,000 per ton in October 2021 and increased to $1,503 on February 24, the day Russia invaded Ukraine, but have fallen below $1,000 per ton in the first few months of 2024 (see e.g., *farmdoc daily*, August 15, 2023; September 12, 2023; USDA-AMS, March 7, 2024).

Concluding Thoughts

For nearly 90 years, the official policy of the United States has been that soil erosion represents a menace to national welfare. Significant resources have been invested to reduce soil erosion both by many farmers and by society. Research on erosion indicates improvement but with continued concerns and questions whether enough has been invested by policies. For example, research reviewed in this article concluded that the U.S. would need to invest $6.4 billion per year to reduce erosion to a more sustainable rate of less than 0.5 tons per acre per year (Pimentel et al., 1995). For context, the Conservation Reserve Program (CRP), which has been the only conservation program in continuous

operation since that time, has averaged $1.68 billion each fiscal year (USDA-FSA, Conservation Reserve Program Statistics) and the national average erosion rate in 2017 was 4.63 tons of soil per acre per year. Not investing sufficiently in soil conservation has costs as well. Adjusted for inflation and reduced average erosion rates, soil erosion could cost $113.92 per acre per year in losses, 75% of which are borne by the farmer. Critical components of the loss estimates are the potential for reduced crop yields, presented here as a risk from soil erosion, and costs of increasingly expensive fertilizers to compensate for erosion's risk to crop yields.

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