Why Soil P Increases

In many states, confined animal feeding operations (CAFOs) are now the major source of agricultural income. However, the rapid growth of the animal industry in certain areas of the United States has been coupled with an intensification of operations, driven by an increased demand for animal products and an improved profitability in terms of transportation, processing, and marketing. Also, it has created regional and local imbalances in P inputs and outputs. On average, only 30% of the fertilizer and feed P input to farming systems is output in crops and livestock produce.

Before World War II, farming communities tended to be self sufficient; they produced enough feed locally to meet livestock requirements and could recycle the manure nutrients effectively to meet crop needs. As a result, sustainable nutrient cycles tended to exist in relatively localized areas (Figure 34-6). After World War II, increased fertilizer use in crop production contributed to specialized farming systems, with crop and livestock operations in different regions of the country (Figure 34-7). By 1995, over

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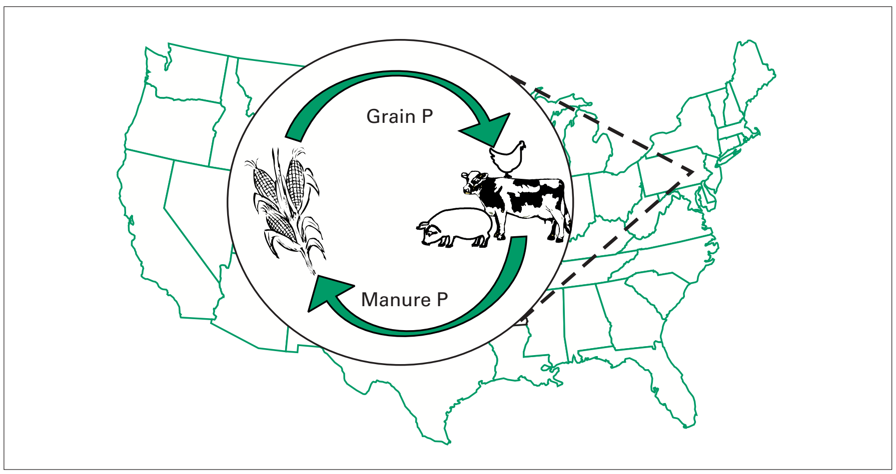

Figure 34-6. Before World War II, nutrient cycling was localized and sustainable within watersheds.

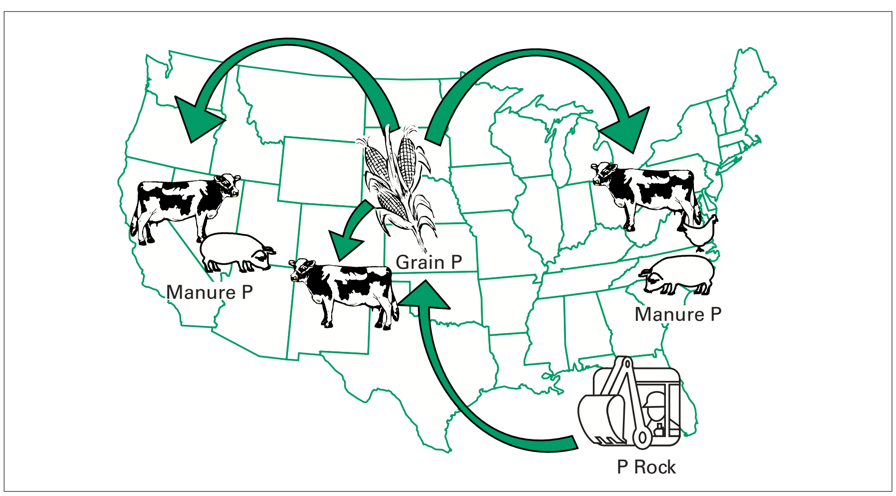

Figure 34-7. Since World War II, the nutrient cycle has been broken on a national level, with P tending to move from areas of grain production to areas of livestock production.

half of the corn grain produced in the Cornbelt was exported as animal feed. Today, less than a third of the grain produced on farms is fed on the farm where it is grown.

The evolution of our agricultural system is resulting in a major transfer of nutrients from grain-producing areas to animal-producing areas, and consequently, P accumulation in soils of those areas. For example, the potential for P and N surplus at the farm scale can be much greater in CAFOs than in cropping systems when nutrient inputs become dominated by feed rather than fertilizer (Table 34-3). With a greater reliance on imported feeds, only 30% of P and 55% of N in purchased feed for a 74,000-layer operation on a 30-acre farm in Pennsylvania could be accounted for in farm outputs (Table 34-3). These nutrient budgets clearly show that the largest nutrient input to CAFOs, and thus the primary source of any on-farm nutrient excess, is in animal feed.

Continual long-term application of fertilizer or manure at rates exceeding crop needs will increase soil P levels.

Continual long-term application of fertilizer or manure at rates exceeding crop needs increases soil P levels. In many areas of intensive confined livestock production, manures are normally applied at rates designed to meet crop N requirements to avoid groundwater quality problems created by leaching of excess N. This often results in a buildup of soil test P above amounts sufficient for optimal crop yields. As Figure 34-8 illustrates, amounts of P added in "average" dairy manure (8-10 tons/acre and 0.5% P) and poultry litter (4 tons/acre and 1.5% P) applications are considerably greater than are removed in harvested corn for example; the result is an accumulation of soil P.

The resulting P accumulation is evident from soil test results. A 1997 survey of several state soil test laboratories revealed that high soil P levels are a regional phenomenon, and that soils of high P content unfortunately tend to be located near sensitive bodies of water such as the Great Lakes, Lake Champlain, Chesapeake and Delaware Bays, Lake Okeechobee, the Everglades, and other freshwater bodies and estuaries (Figure 34-9). Most soils analyzed in these areas had soil test P levels in the high or very high

Table 34-3. Farming system and nutrient budget.

Farming System	Nutrient Input In			
	Feed	Fertilizer	Output	Balance
	lbs/acre/yr			
Phosphorus budget				
Cash crop [1]	—	20	18	+2
Dairy [2]	28	10	13	+25
Hog [3]	95	—	60	+35
Poultry [4]	1,390	—	470	+920
Nitrogen budget				
Cash crop [1]	—	85	82	3
Dairy [2]	138	9	68	79
Hog [3]	350	9	230	129
Poultry [4]	5,200	—	2,940	2,260

[1] 75-hectare cash crop farm growing corn and alfalfa.
[2] 100-hectare farm with 65 dairy Holsteins averaging 14,550 lbs milk/cow/yr, 5 dry cows, and 35 heifers. Crops were corn for silage and grain, and alfalfa and rye for forage.
[3] 75-hectare farm with 1,280 hogs; output includes 40 lbs P and 132 lbs N/acre/yr manure exported from the farm.
[4] 30-hectare farm with 74,000 poultry layers; output includes 7 kg P and 80 lbs N/acre/yr manure exported from the farm.
Adapted from Lanyon and Thompson 1996 and Bacon et al. 1990.

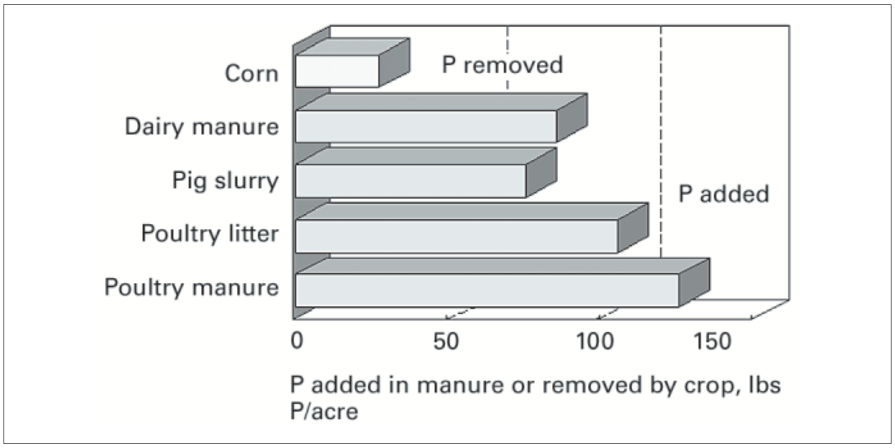

Figure 34-8. Applying manure to meet crop N needs (about 200 lbs available N/acre) will add much more P than corn uses annually.

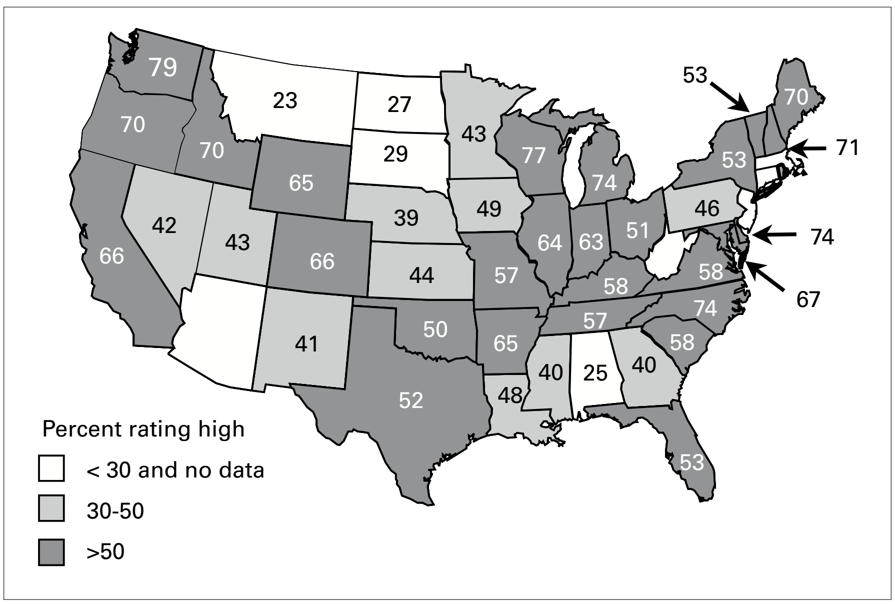

Figure 34-9. Percent of soil samples analyzed in state laboratories that tested high or above for P in 1997. Highlighted states had more than 50% of soil samples testing in the high or above range.
Adapted from Fixen 1998.

categories, indicating that little or no supplemental P was required for the current crop and possibly for several future crops. Most soils in other regions of the country tested medium or low; most Great Plains soils, for example, still require P for optimum crop yields.

Within states and regions, distinct areas of general P deficit and surplus exist. For example, soil test summaries for Delaware indicate the magnitude and localization of high soil test P levels that can occur in areas dominated by intensive livestock production (Figure 34-10). In Sussex County, Delaware with a high concentration of poultry operations, 87% of fields tested in 1992 to 1996 had optimum (25-50 ppm) or excessive soil test P (> 50 ppm; as determined by Mehlich-1); while in New Castle County, Delaware with only limited livestock production, 72% of fields tested were rated as low (< 13 ppm) or medium (13-25 ppm).

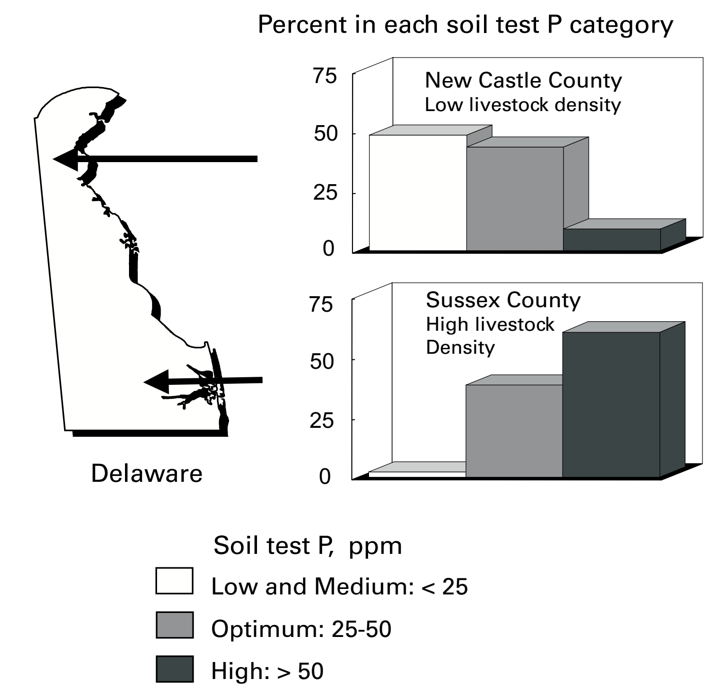

Figure 34-10. Elevated soil test P levels (as Mehlich-1 P) are usually localized in areas of confined animal operations.

Though rapidly built up by P fertilizer applications, the decline in available soil P by crop removal is slow once further applications are stopped.

Though rapidly built up by P fertilizer applications, the decline in available soil P by crop removal is slow once further applications are stopped. Thus, the determination of how long soil test P will remain above crop sufficiency levels is of economic and environmental importance to farmers who must integrate manure P into sustainable nutrient management systems. For example, if a field has a high potential to enrich agricultural runoff with P due to excessive soil P, how long will it be before crop uptake will lower soil P levels so that manure can be applied again without increasing the potential for P loss? Studies in North Carolina found that it would take almost 20 years of corn and soybean production without further P additions to decrease soil test P (Mehlich-1 P) from 100 ppm to the agronomic threshold of 20 ppm for a Portsmouth fine sandy loam (McCollum 1991).