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Supplement of

Production and application of manure nitrogen and phosphorus in the United States since 1860

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Table S1. Excreted manure nutrients rates per unit weight of livestock

| Livestock | N excretion rate (kg N / ton animal weight /day) | P excretion rate (kg P / ton animal weight / day) |
|-----------|--|---|
| Beef cows | 0.315 | 0.105 |
| Milk cows | 0.400 | 0.060 |
| Heifers | 0.310 | 0.040 |
| Steers | 0.315 | 0.105 |
| Hogs | 0.280 | 0.150 |
| Sheep | 0.450 | 0.070 |
| Horses | 0.280 | 0.050 |
| Chickens | 0.830 | 0.310 |
| Pullets | 0.620 | 0.240 |
| Broilers | 1.100 | 0.340 |
| Turkey | 0.740 | 0.280 |

Note: The excreted rate parameters derived from Puckett et al., (1998)

Table S2. Nutrient assimilative capacity of cropland and pastureland

| Land-use type | N | P |
|---------------|------------------------|------------------------|
| | kg N / km ² | kg P / km ² |
| Cropland | 13792 | 1626 |
| Pastureland | 6937 | 2768 |

Note: Assimilative capacities of cropland and pastureland were calculated based on the data in Kellogg et al., (2000)

Table S3. Nutrient assimilative capacity of 13 types of crop

| Crop type | N | P |
|-------------|--------------------|--------------------|
| | kg N / ton product | kg P / ton product |
| Maize | 12.96 | 2.43 |
| Soybeans | 53.67 | 5.44 |
| Sorghum | 15.88 | 2.92 |
| Cotton | 27.56 | 3.43 |
| Barley | 17.01 | 3.40 |
| wheat | 18.65 | 3.27 |
| Oats | 16.73 | 3.12 |
| Rye | 17.33 | 2.92 |
| Rice | 11.34 | 2.63 |
| Peanuts | 36.29 | 2.72 |
| Sugar beets | 2.16 | 0.43 |
| Tobacco | 28.43 | 2.00 |
| Potatoes | 3.27 | 0.54 |

Note: Assimilative capacities of crops were derived from Kellogg et al., (2000)

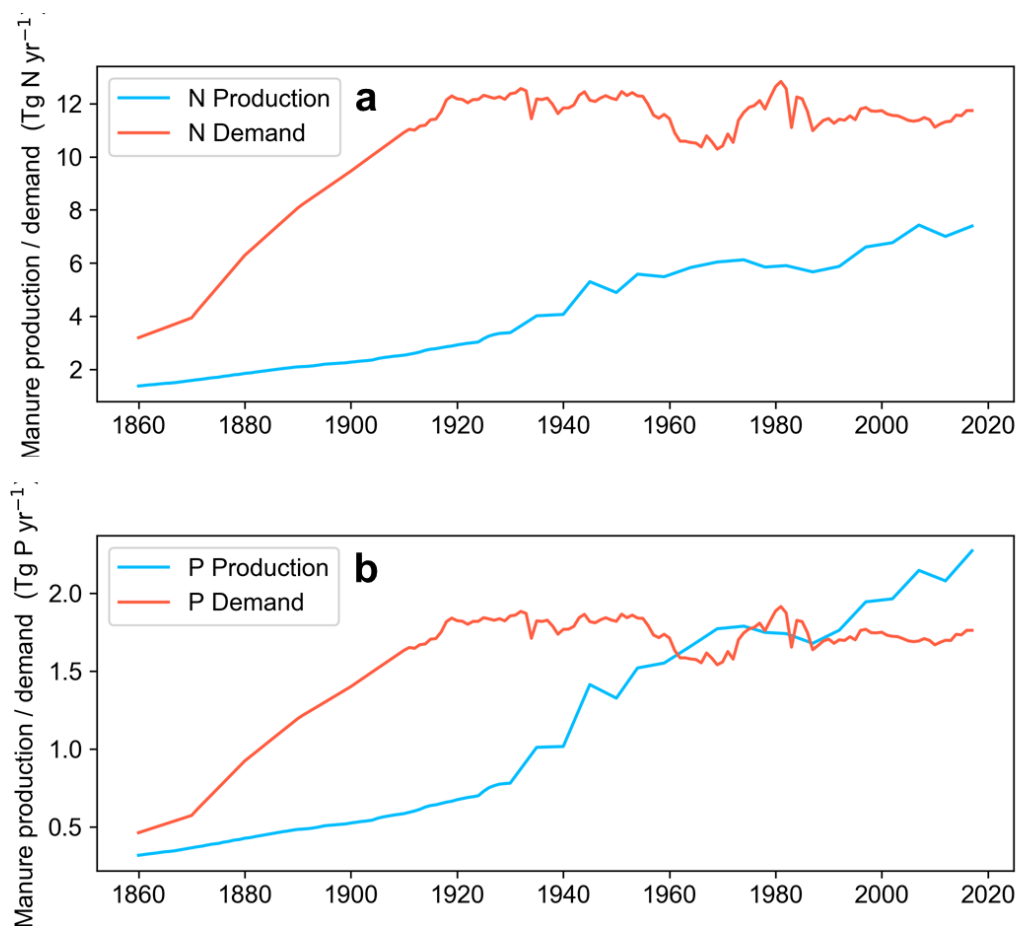


Figure S1. Comparing total productions and demands of manure (a) N and (b) P in the contiguous U.S. from 1860 to 2017

For the contiguous U.S., the total demand for manure N was higher than the production over the study period while the total production of manure P started to exceed demand after the 1980s (Fig.S1). The gap between production and demand has considerably narrowed since the 1920s due to the cease of the increase in nutrient demand. In 2017, total manure N and P productions reached 7.4 Tg N yr⁻¹ and 2.3 Tg P yr⁻¹, while total demands were 11.7 Tg N yr⁻¹ and 1.8 Tg P yr⁻¹. However, the total numbers here only displayed limited information on the relationship

between production and demand due to the difficulty of collecting and transporting manure for widespread application in cropland.

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