Supplement of

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

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This supplementary material includes the following:

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

2) Table S2. Nutrient assimilative capacity of cropland and pastureland

3) Table S3. Nutrient assimilative capacity of 13 types of crop

4) Figure S1. Spatial distribution of manure N demand of crops in 1860, 1930, 1980, and 2017

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

Livestock	N excretion rate (lb N / l000 lb animal weight /day)	P excretion rate (lb P / l000 lb 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 lb N / acre	P lb P / acre
Cropland	123.05	14.51
Pastureland	61.89	24.70

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
	lb N / ton product	lb P / ton product
Maize	28.57	5.36
Soybeans	118.33	12
Sorghum	35	6.43
Cotton	60.76	7.56
Barley	37.5	7.5
wheat	41.11	7.22
Oats	36.88	6.88
Rye	38.21	6.43
Rice	25	5.8
Peanuts	80	6
Sugar beets	4.76	0.94
Tobacco	62.67	4.4
Potatoes	7.2	1.2

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

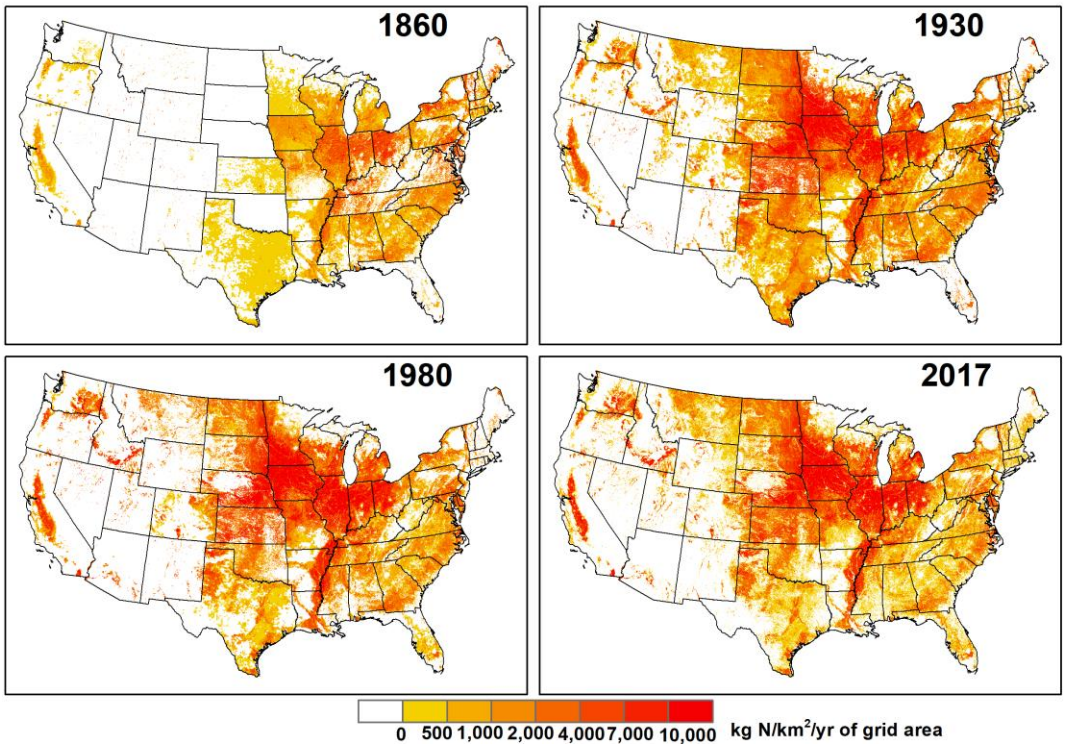

Figure S1. Spatial distribution of manure N demand of crops in 1860, 1930, 1980, and 2017.

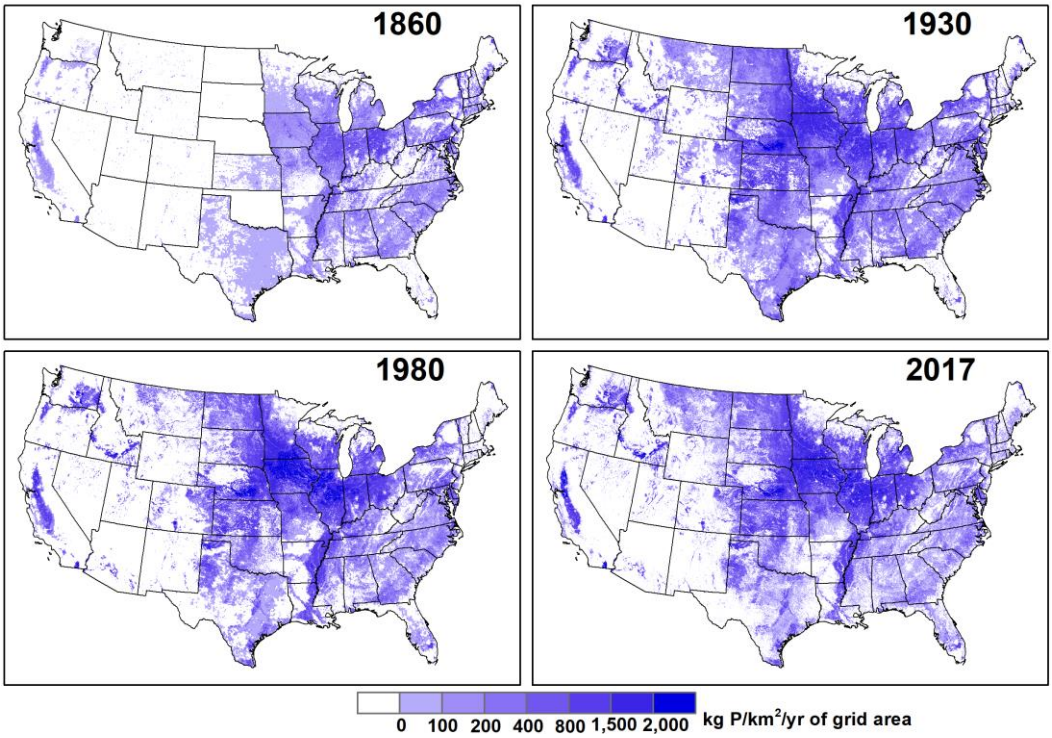

Figure S2. Spatial distribution of manure P demand of crops in 1860, 1930, 1980, and 2017.

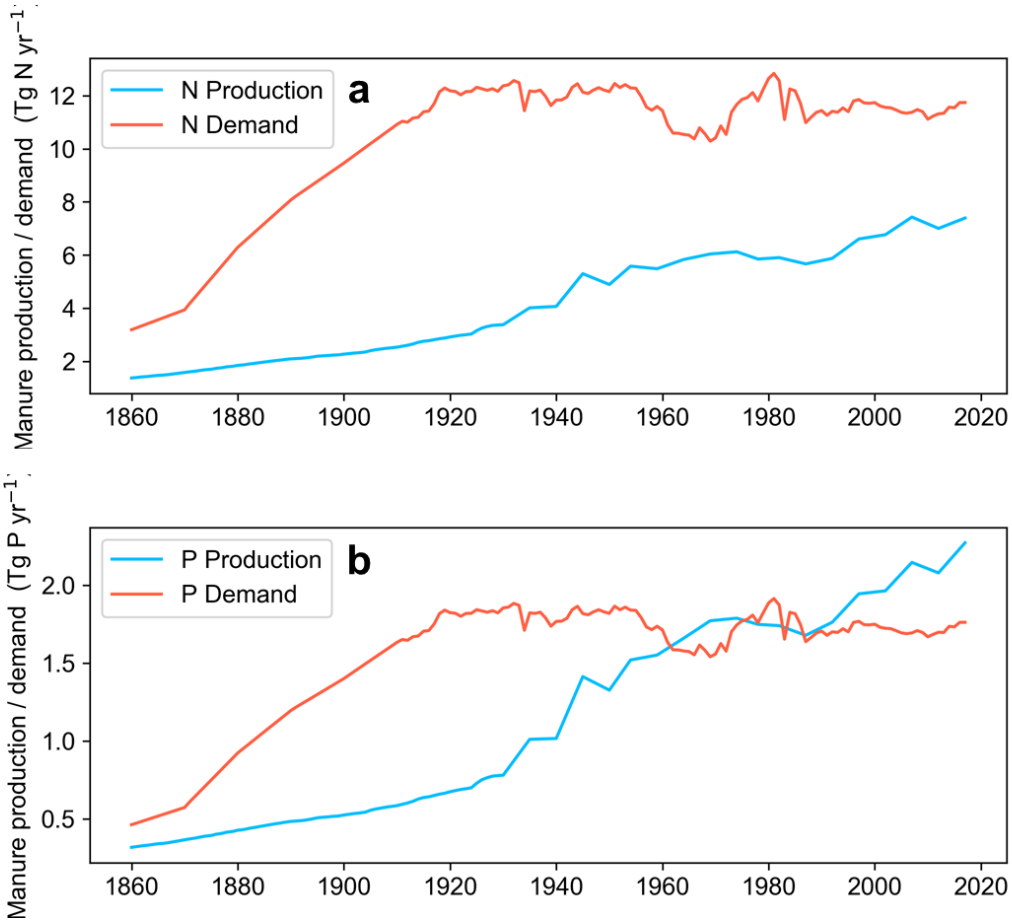

Figure S3. Comparing total productions and demands of manure (a) N and (b) P in the contiguous U.S. from 1860 to 2017

For the contiguous U.S., the total demand of 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.S3). The gap between production and demand 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 of the relationship between production and demand due to the difficulty of collecting and transporting manure for widespread application in cropland.

References

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