Supplement of Earth Syst. Sci. Data, 11, 175–187, 2019
https://doi.org/10.5194/essd-11-175-2019-supplement

Open Access Earth System Science Data

Supplement of

Increased nitrogen enrichment and shifted patterns in the world's grassland: 1860–2016

Rongting Xu et al.

Correspondence to: Hanqin Tian (tianhan@auburn.edu)

1. Regional classifications

According to the Intergovernmental panel on Climate Change the fifth assessment (IPCC AR5) and Tian et al. (2016), we divided the world into seven regions including North America, South America, Africa, Europe, southern Asia, northern Asia, and Oceania. To be clarified, southern Asia was divided into five parts (i.e., West, South, East, Central and Southeast Asia) since sub-regions within it have become hotspots for nitrogen inputs and greenhouse gas emissions (e.g., South and East Asia) (Fig. S1, Table S1).

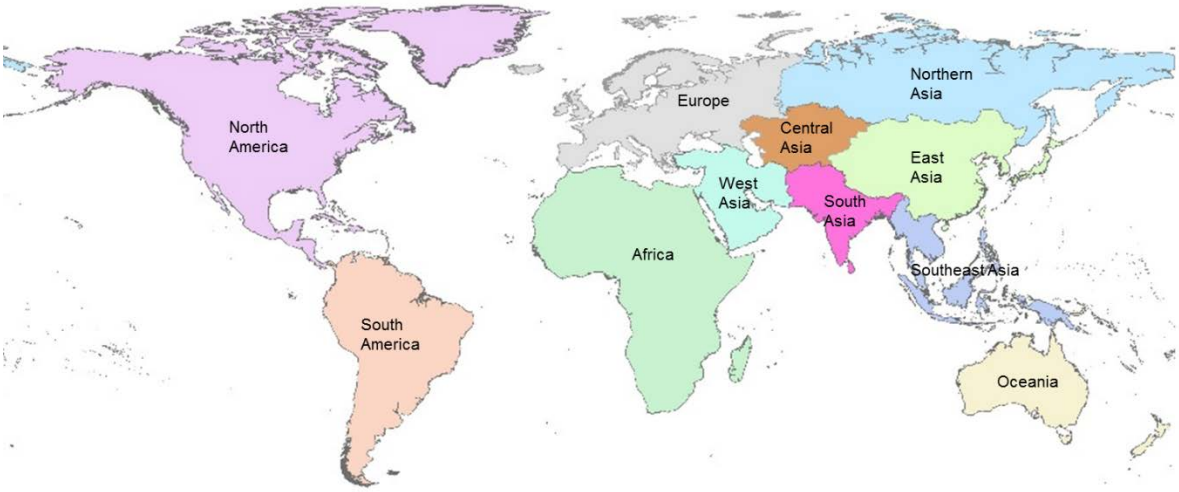

Figure S1. The classification of regions in the world.

Table S1 The countries included in eleven regions across the globe.

Regions		Countries
North America		Bahamas, Belize, Canada, Costa Rica, Cuba, Dominican Republic, EI Salvador, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Puerto Rico, Saint Lucia, Saint Vincent and the Grenadines, the US, and Trinidad and Tobago
South America		Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, French Guiana, Paraguay, Peru, Suriname, Uruguay and Venezuela
Europe		Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Ukraine and the UK
Africa		Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Democratic Republic of the Congo, Republic of the Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Malvinas, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, and Zimbabwe
Oceania		Australia and New Zealand
northern Asia		Russian Federation
southern Asia	Central Asia	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan
	East Asia	China, Japan, Mongolia, North Korea, and South Korea
	South Asia	Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka
	Southeast Asia	Cambodia, Indonesia, Laos, Malaysia, Myanmar, Papua New Guinea, Philippines, Thailand, Timor-Leste, Vietnam
	West Asia	Armenia, Azerbaijan, Georgia, Iran, Iraq, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, and Yemen

2. Global and regional grassland area changes over the period 1860-2016 (adapted from HYDE 3.2, Klein Goldewijk, 2017)

We aggregated 5-arc minute HYDE 3.2 land use dataset to 0.5 degree. Since HYDE 3.2 only provided every 10 years land use data during 1860-2000, we used the linear interpolation to produce annual maps for pastures and rangelands for each 0.5 grid cell. Grassland area increased from 1250 to 3295 Mha during 1860-2016, as shown in Fig.S2. The pasture area was increasing from 268 to 803 Mha during the study period (Fig.S2, Table S2). Compared with the area in the 1860s, Oceania and South America experienced a substantial expansion of pastureland, roughly 3136% and 2228%, respectively. North America, Africa, and southern Asia also exhibited a huge increase of pastureland, 760%, 381%, and 140%, respectively. In contrast, pastureland in Europe exhibited a slight decrease (13%). The rangeland area was increasing from 982 to 2492 Mha during 1860-2016 (Fig.S2, Table S3). Similar to the pastureland expansion, Oceania and South America experienced a substantial increase in rangeland area, 1656% and 521%, respectively, followed by North America (350%) and southern Asia (123%). In contrast, northern Asia exhibited a slight decrease, about 7%.

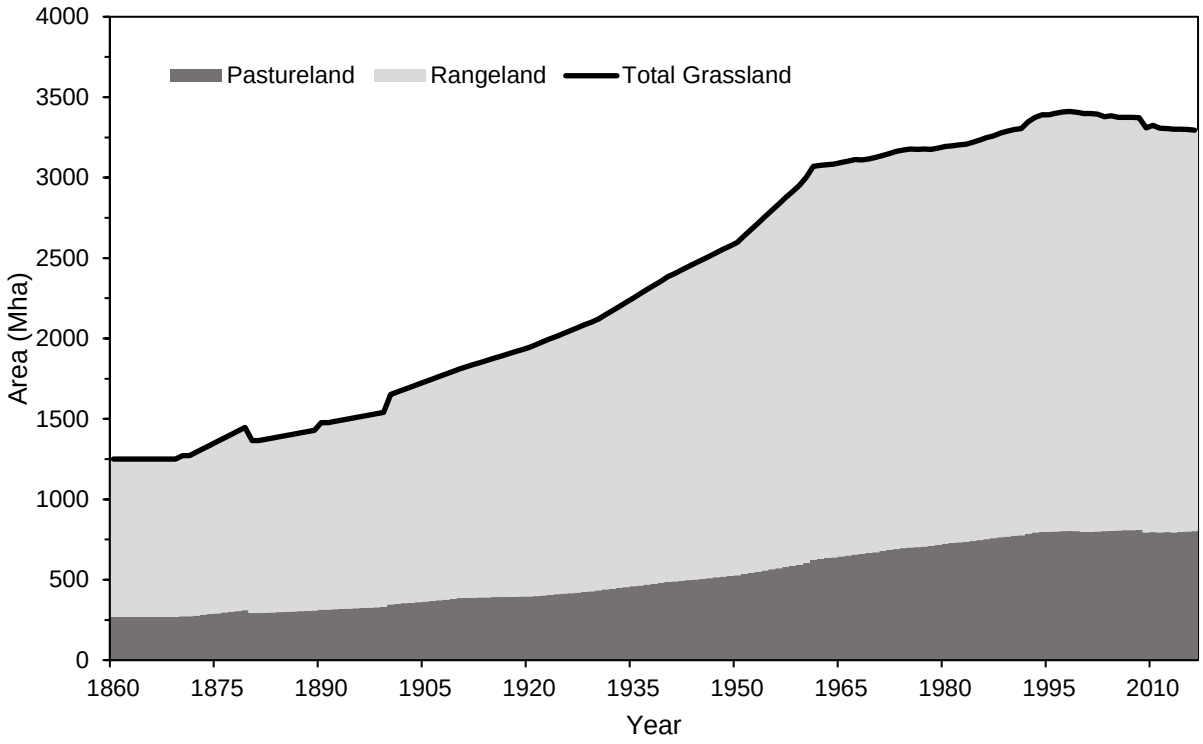

Figure S2. The temporal variations of global total grassland, pastureland, and rangeland areas during 1860-2016 (adapted from HYDE 3.2, Klein Goldewijk, 2017).

Table S2 Pasture area changes (Mha) during the period 1860-2016 (adapted from HYDE 3.2, Klein Goldewijk, 2017).

Pasture (Mha)	North America	South America	Europe	Africa	Oceania	Southern Asia	Northern Asia	Total
1860s	9.9	5.6	109.3	60.9	0.2	69.8	7.7	263.4
1880s	18.0	9.0	121.7	69.9	0.5	64.1	10.9	294.1
1900s	38.4	18.0	134.2	79.2	1.1	70.9	16.2	358.0
1920s	46.3	32.5	133.8	92.8	2.6	80.7	16.4	405.1
1940s	66.5	54.3	133.2	123.9	4.4	90.9	24.1	497.3
1960s	86.8	89.4	107.1	213.3	7.4	116.8	12.0	632.8
1980s	83.2	118.7	105.0	258.4	8.1	149.8	13.0	736.2
2000-2016	85.3	131.2	94.6	293.1	7.6	167.9	11.6	791.3

Table S3 Rangeland area changes (Mha) during the period 1860-2016(adapted from HYDE 3.2, Klein Goldewijk, 2017).

Rangeland (Mha)	North America	South America	Europe	Africa	Oceania	Southern Asia	Northern Asia	Total
1860s	61.0	54.1	31.8	372.0	20.1	404.2	33.1	976.3
1880s	89.4	69.7	36.0	402.9	45.6	406.9	37.8	1088.3
1900s	157.5	107.7	37.7	433.8	100.8	472.8	43.2	1353.5
1920s	174.3	158.1	38.7	466.8	178.1	545.4	43.7	1605.1
1940s	242.6	223.0	37.7	526.9	277.8	607.4	51.3	1966.7
1960s	287.9	291.4	31.6	674.2	389.7	734.1	23.2	24312.1
1980s	265.7	312.5	32.8	634.8	394.6	810.3	24.6	2475.3
2000-2016	274.8	335.7	36.4	598.0	353.4	903.3	30.8	2532.4

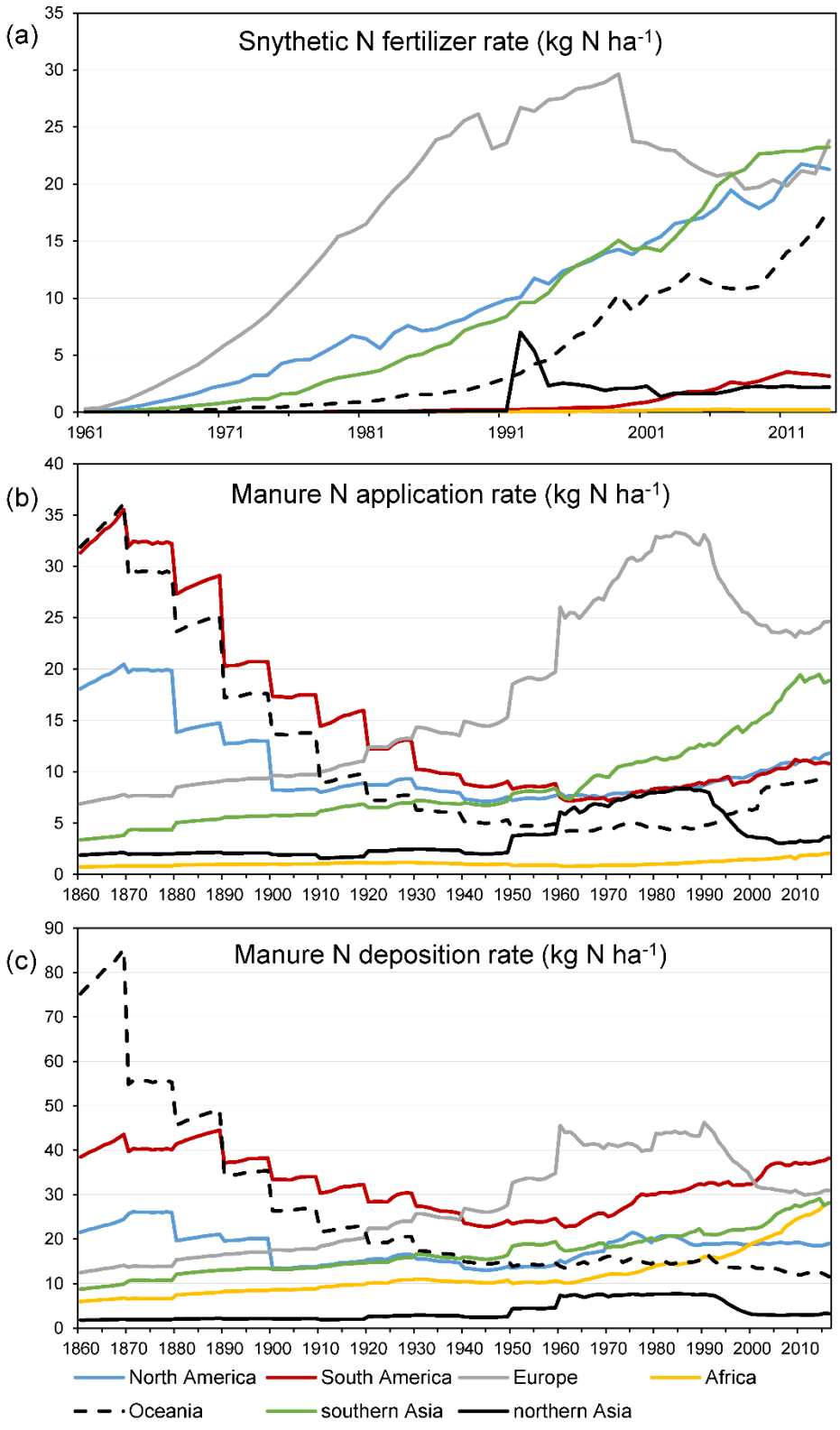

Figure S3. The temporal patterns of average N input rates (kg N ha^{-1}) in regional pastures and rangelands during 1860-2016.