Grassland Carbon Study in Inner Mongolia, China

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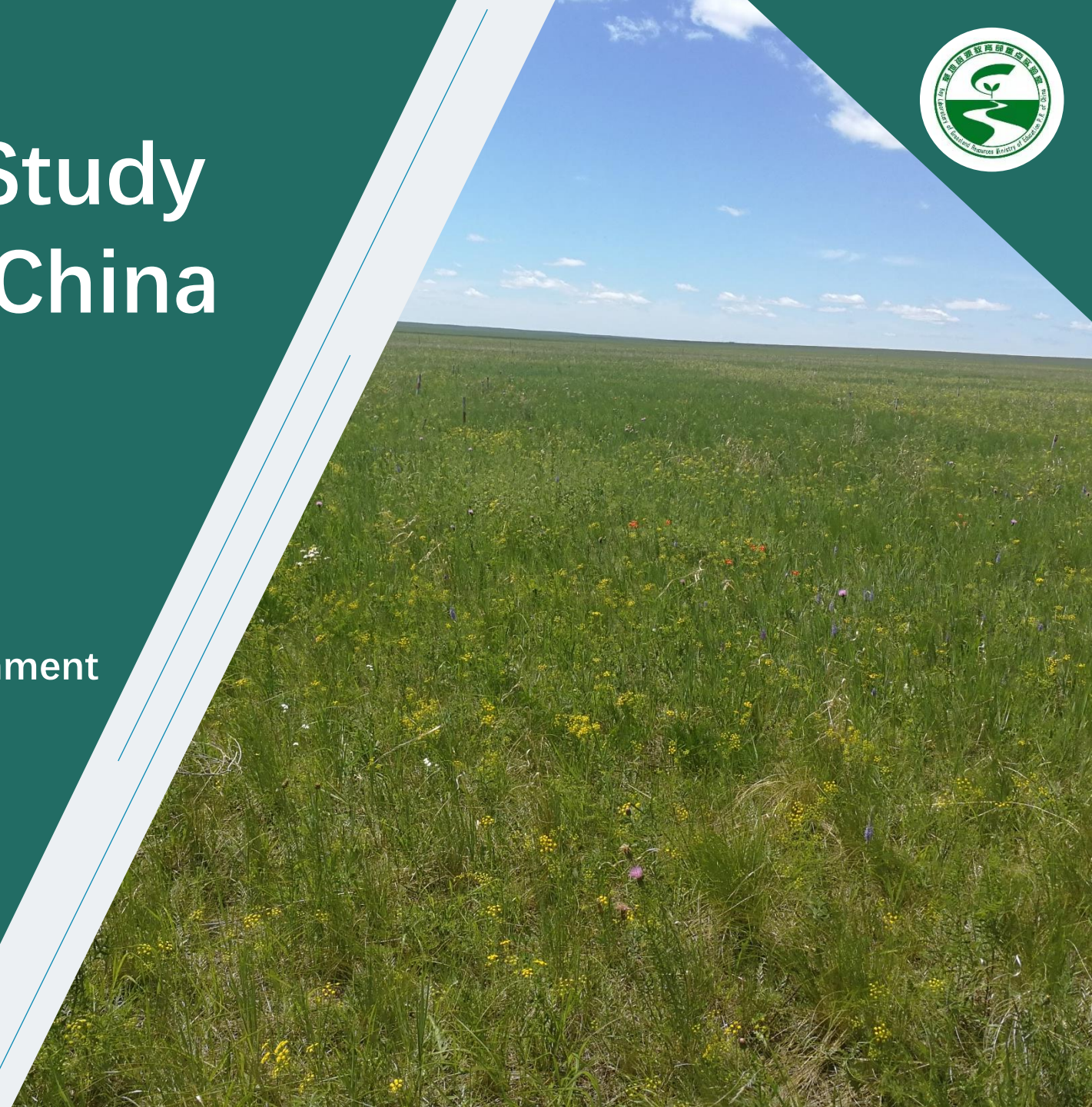


Outline

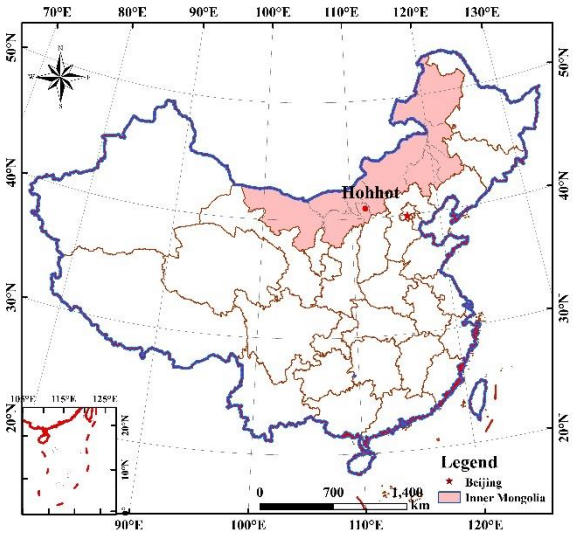
- Introduction of our university
- An overview of grassland carbon study of China and Inner Mongolia
- Grassland carbon storage and sequestration under grazing disturbance
- Carbon smart grassland and livestock system in pastoral areas of China

Introduction to our university

Inner Mongolia Agricultural University

College of Grassland, Resources, and Environment, Inner Mongolia Agricultural University

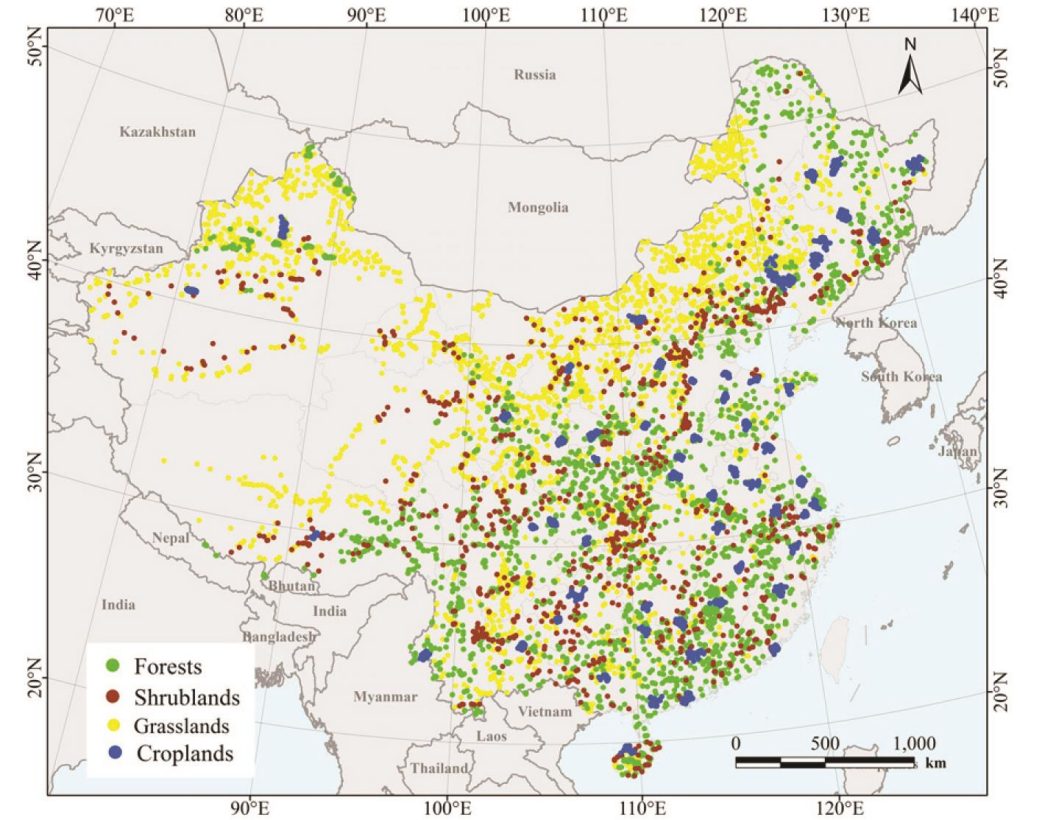
- Founded in 1952, Hohhot, Inner Mongolia, China
- 128 faculty, 1115 undergraduate students and 412 graduate students
- Programs: Grassland Science, Soil Science and Ecology
- Focus on: Grassland Ecology and Management, Forage Genetics and Breeding, Grassland Environment and Conservation



An overview of grassland carbon study in China and Inner Mongolia

Strategic Priority Project of Carbon Budget was funded and carried out in forests, grasslands, shrublands and croplands in total of 17090 field plots of China.

(Fang et al. 2018, PNAS, 115 (16)：4015-4020).



Forests: 7800 field plots
Shrublands: 1200 field plots
Grasslands: 4030 field plots
Croplands: 4060 field plots

Total C stock of these terrestrial ecosystems amounts to 79.24 Pg C, with 38.9% in forests, 32.1% in grasslands, 8.4% in shrublands, and 20.6% in croplands.

Table 1. Summary for C pools and the changes in each ecosystem C sector: that is, vegetation biomass, dead organic matter (DOM), and SOC, in four major ecosystems (forests, shrublands, grasslands, and croplands) in China from 2001 to 2010

	Ecosystem						
Item	Forest	Shrubland	Grassland	Cropland	Total	Area-weighed mean	Source
Area (10^6 ha)	188.2	74.3	281.3	171.3	715.1		(20)
C pool (PgC)							
Vegetation C	10.48	0.71	1.35	0.55	13.09		(20)
DOM C	0.37	0.06	0.02	0.00	0.46		(20)
SOC	19.98	5.91	24.03	15.77	65.69		(20)
Subtotal	30.83	6.68	25.4	16.32	79.24		
C stock change (Tg C/yr)							
Vegetation C	116.7	3.5	−0.80	0.00	119.4		(30, present study)
DOM C	9.0	0.0	0.00	0.00	9.0		(31, present study)
SOC	37.6	13.6	−2.56	23.98*	72.6		(14, 24, 32, 33)
Subtotal	163.4	17.1	−3.36	23.98	201.1		
C density (Mg C/ha)							
Vegetation C	55.7	9.6	4.8	3.1		18.3	(20)
DOM C	1.9	0.8	0.1	0.0		0.61	(20)
SOC	106.1	79.5	85.4	92.0		91.8	(20)
Subtotal	163.7	89.9	90.3	95.1		110.7	
C stock change per area (Mg C/ha·yr)							
Vegetation C	0.62	0.05	-2.84×10^{-3}	0.00		0.17	(13, 30)
DOM C	0.05	0.00	0.00	0.00		0.01	(31, present study)
SOC	0.20	0.18	-9.09×10^{-3}	0.14		0.10	(14, 24, 32,33)
Subtotal	0.87	0.23	-11.93×10^{-3}	0.14		0.28	

Note that we developed approaches to estimate the changes in biomass C stocks in shrubland and grasslands in China by combining field measurements obtained from this project with remote-sensing data.

*Topsoil 20 cm.

Grassland conservation increased carbon sequestration

Table 1. Areas and ecosystem C densities (area weighted mean ± SD) at the beginning (PR-B) and in the year 2010 (PR-2010) and the reference sites (RS-2010) for six key ecological restoration projects in China

	National key ecological projects					
Properties, C densities and sequestrations of the projects	Forest Protection	Grassland Conservation	North Shelter Forest fourth	Sand Control	GGP	River Shelter Forest second
Area, 10^6 ha	72.9	60	5.2	3.3	9.2	2.3
Duration	1998–2010	2003–2010	2001–2010	2001–2010	2000–2010	2001–2010
C densities, Mg C per ha						
Biomass						
PR-B	43.7 ± 19.3	2.6 ± 1.1	37.3 ± 16.9	3.1 ± 2.9	0*	5.9 ± 3.5
PR-2010	50.3 ± 17.4	3.7 ± 1.62	56.6 ± 15.6	16.2 ± 4.5	19.7 ± 5.9	27.9 ± 8.8
Increment	6.6	1.1	19.3	13.1	19.7	22.0
RS-2010	—†	2.6 ± 1.8	41.6 ± 18.3	3.5 ± 2.2	0*	7.7 ± 2.8
Soil						
PR-B	144.8 ± 42.7	82.5 ± 50.2	44.8 ± 16.3	35.9 ± 7.3	44.0 ± 29.3	63.5 ± 12.2
PR-2010	150.5 ± 25.8	83.5 ± 50.5	49.3 ± 20.1	38.7 ± 10.4	53.7 ± 26.3	66.7 ± 18.9
Increment	5.6	1.0	3.2	2.9	9.7	3.2
RS-2010	—†	82.6 ± 50.0	41.4 ± 20.7	30.3 ± 8.9	—‡	51.3 ± 41.8
Total						
PR-B	188.5 ± 53.9	85.1 ± 51.3	82.1 ± 28.3	39.0 ± 10.3	44.0 ± 29.3	69.4 ± 13.0
PR-2010	200.7 ± 49.0	87.2 ± 52.2	105.9 ± 31.6	54.8 ± 14.2	73.4 ± 28.0	94.6 ± 19.0
Increment	12.2	2.1	23.8	15.8	29.4	25.3
RS-2010	—†	85.2 ± 51.1	83.0 ± 33.0	33.8 ± 9.9	—‡	59.0 ± 42.9
Total C sequestration rate, Mg C per ha per y	0.94	0.26	2.38	1.58	2.67	2.53

*The GGP is implemented in hilly cropland; therefore, the biomass C density in the project area in 2000 (beginning of GGP) and at reference sites in 2010 were set as 0.

†The contribution of the Forest Protection project to C sequestration was estimated based on the C storage in the newly planted forest vegetation (CPVN), the C retention (CR) resulting from harvest volume reduction, and soil organic C retention (SCR); see Eqs. **10**–**14**. No reference sites were set for estimation.

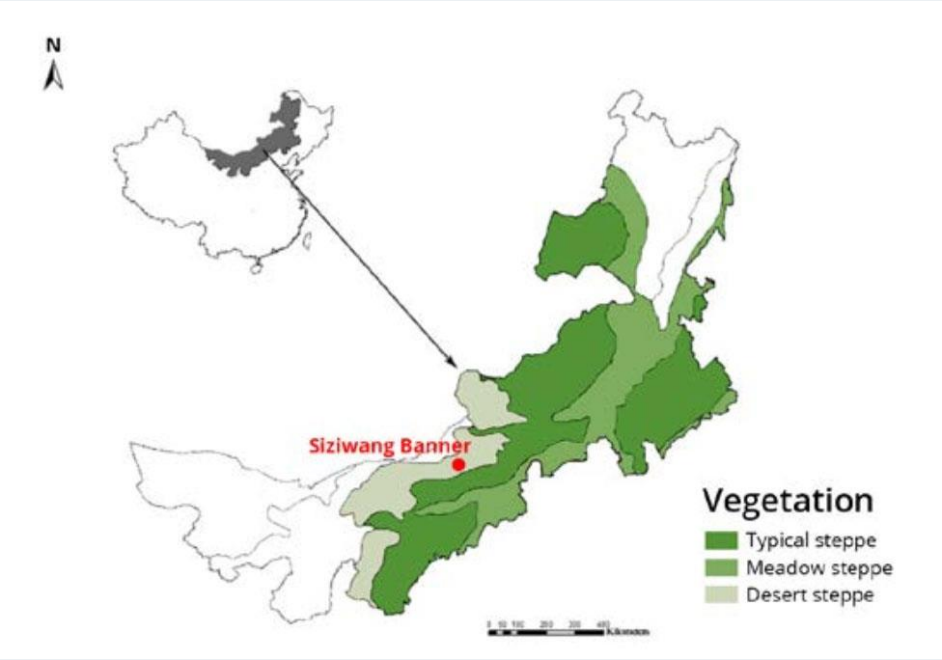
‡The contribution of GGP to C sequestration in soil is considered to be the soil organic C retention (SCR), that is, the reduced C loss due to the control of soil erosion attributed to GGP, which was estimated using the results of Deng et al. (38), as in Eqs. **15** and **16**.

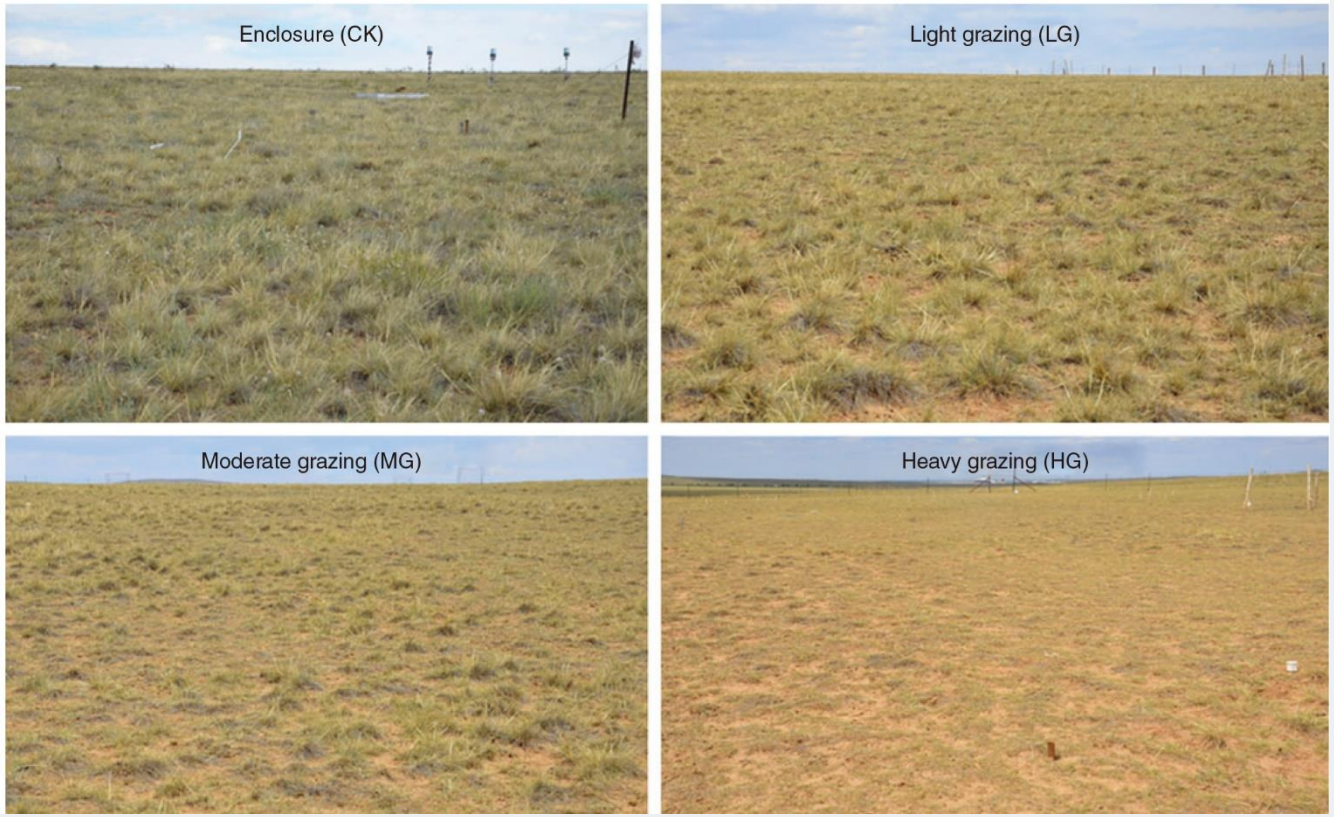
Therefore, the higher population density in these regions in- For example, medium- and long-term experimental studies have

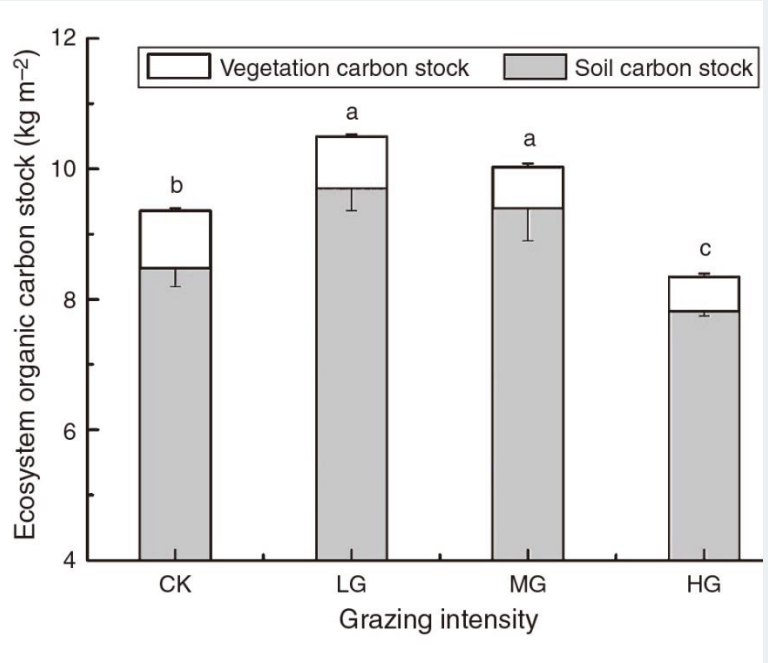
Lu et al. 2018. PNAS，115（16）：4039-4044.

Grassland carbon storage and sequestration under grazing disturbance

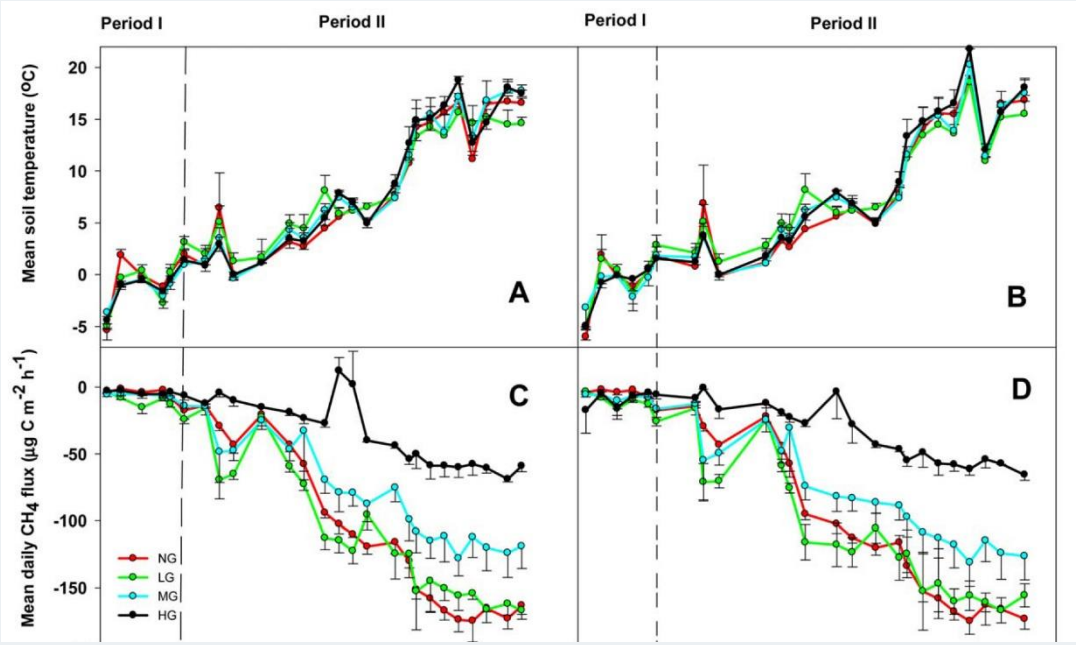
- Long-term sheep stocking rate experiment in desert steppe (2002-)
- Summer grazing
- Four stocking rate levels, three replicates



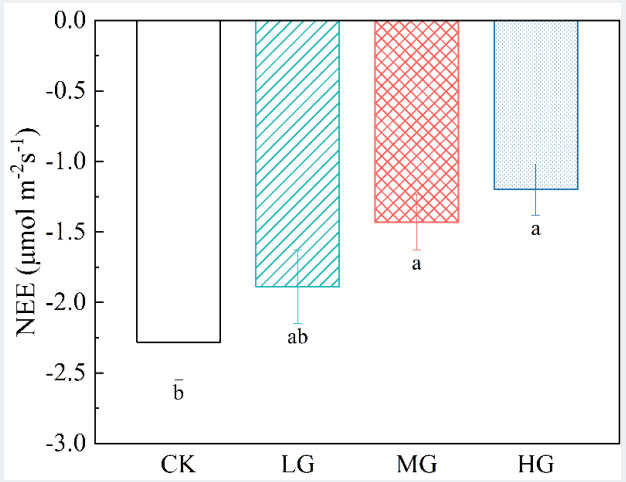


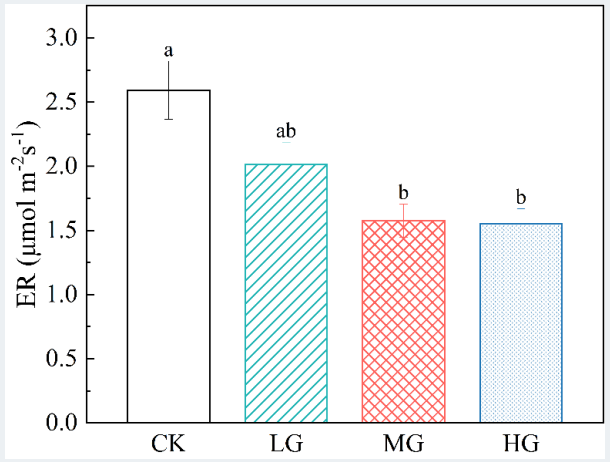


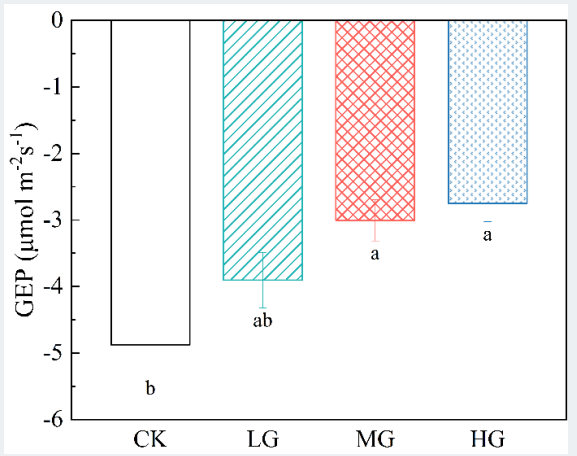
Wang et al. 2017. The Rangeland Journal, 19:169-177.



Wang. 2012. Plose One, 7(5):e36794

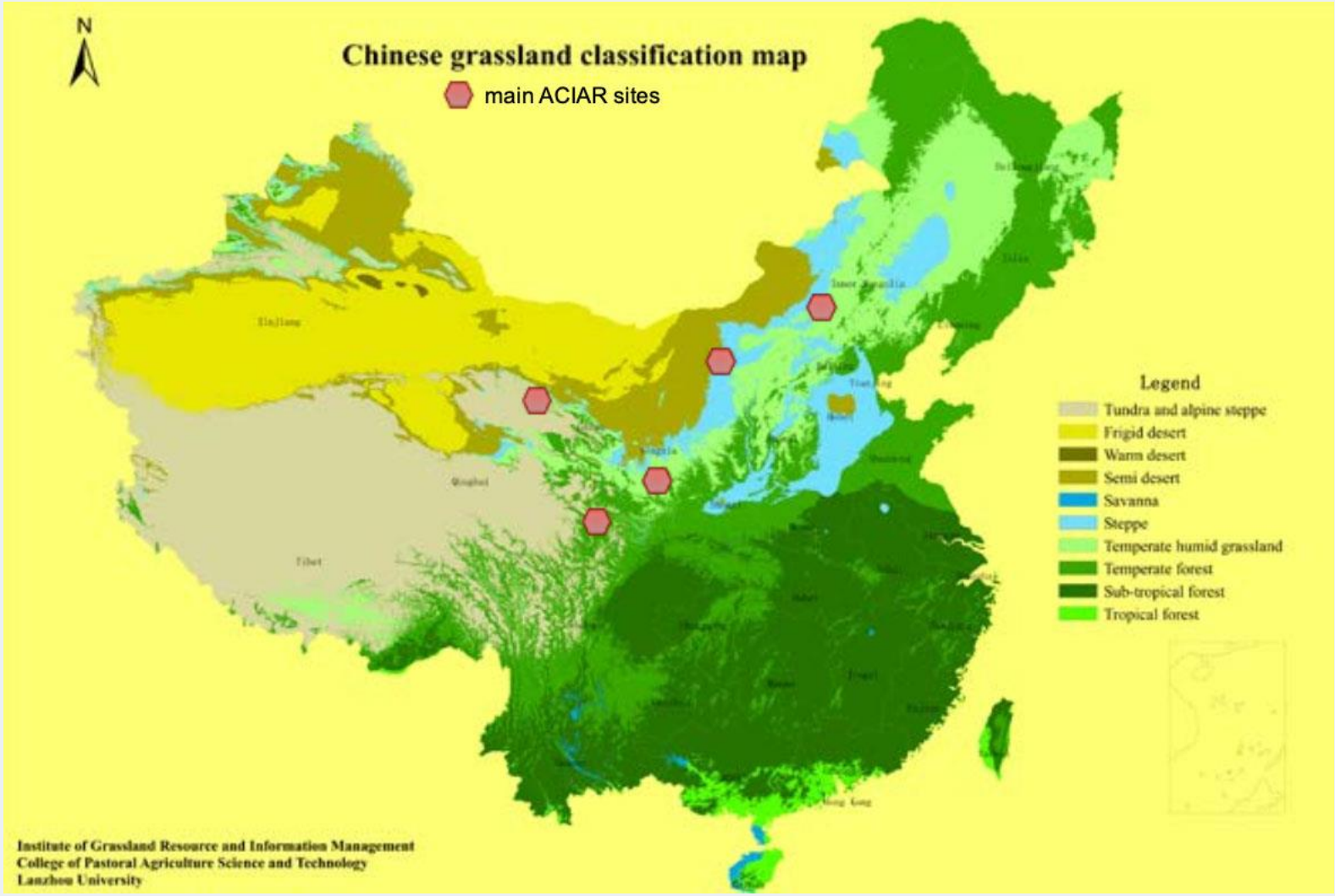






Jin et al. 2022. Unpublished data

Carbon smart grassland and livestock system in pastoral areas of China (2005-)



- Baseline survey of grassland, livestock, and social and economics
- Models development
- Demonstration





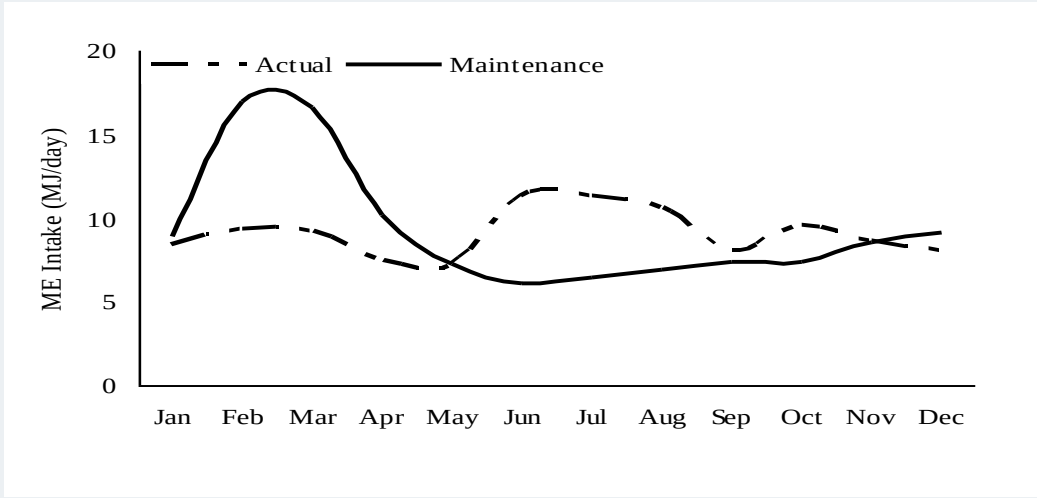


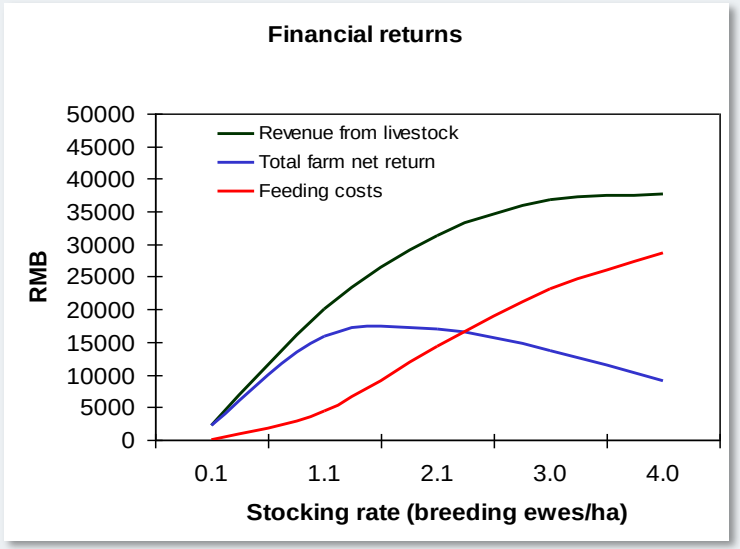


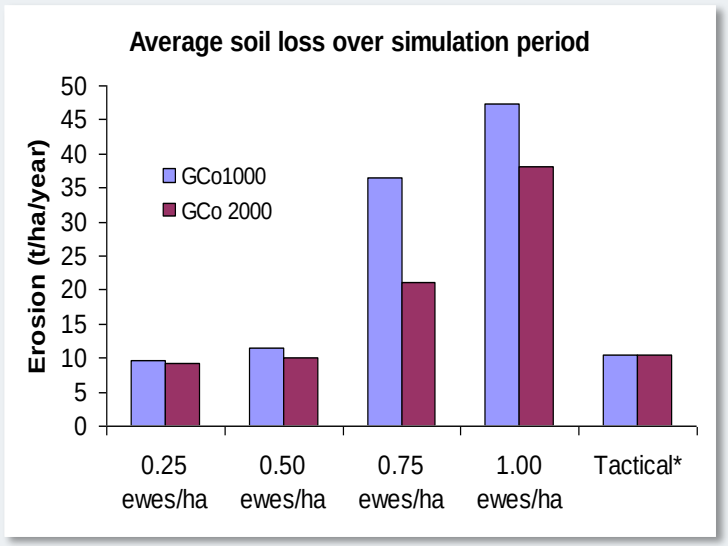


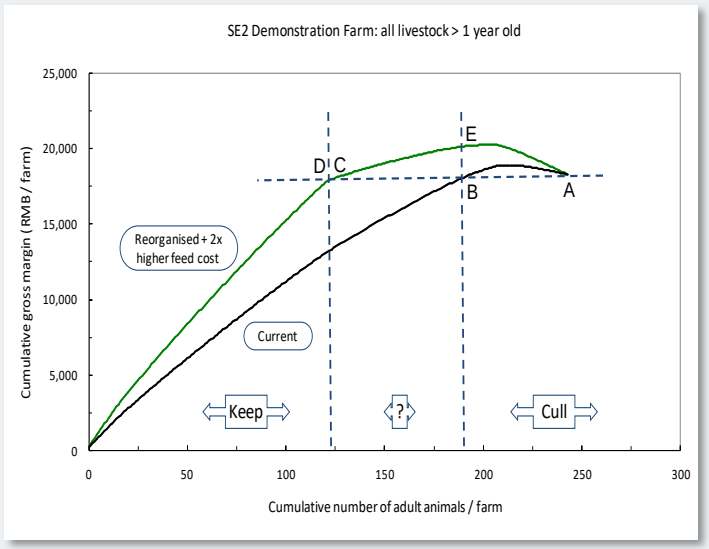
Models development

- Actual forage supply and maintenance of livestock
- Finance optimization
- Sustainable operation with soil erosion
- Precise livestock culling

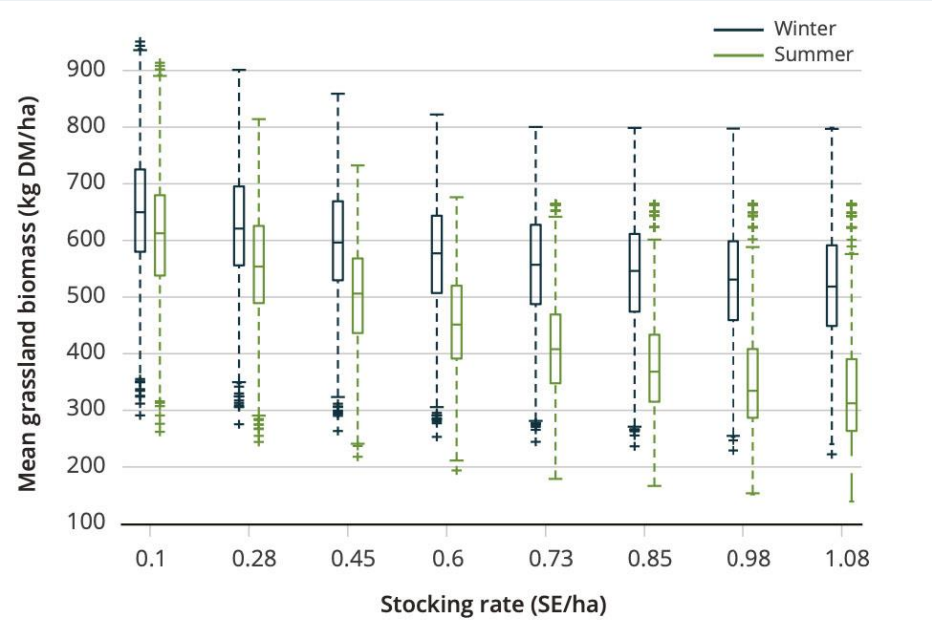


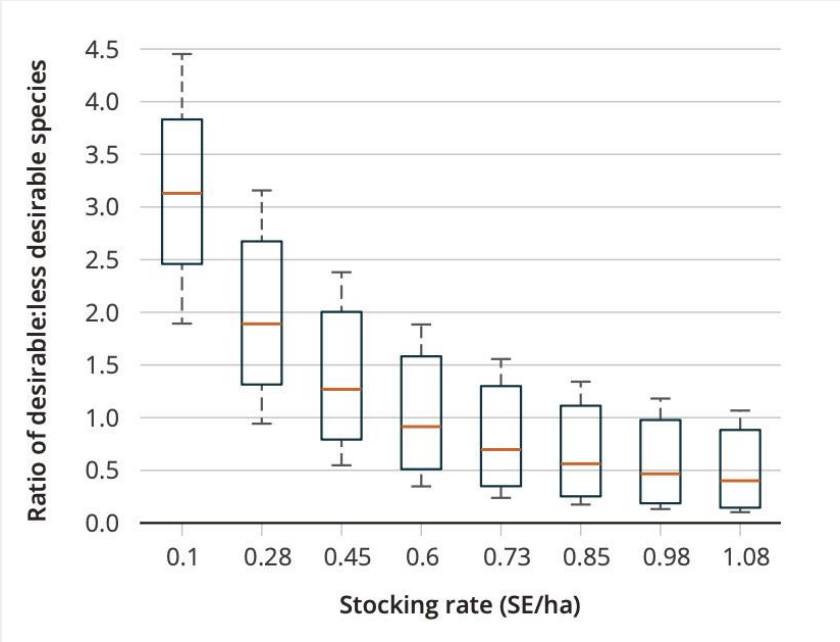


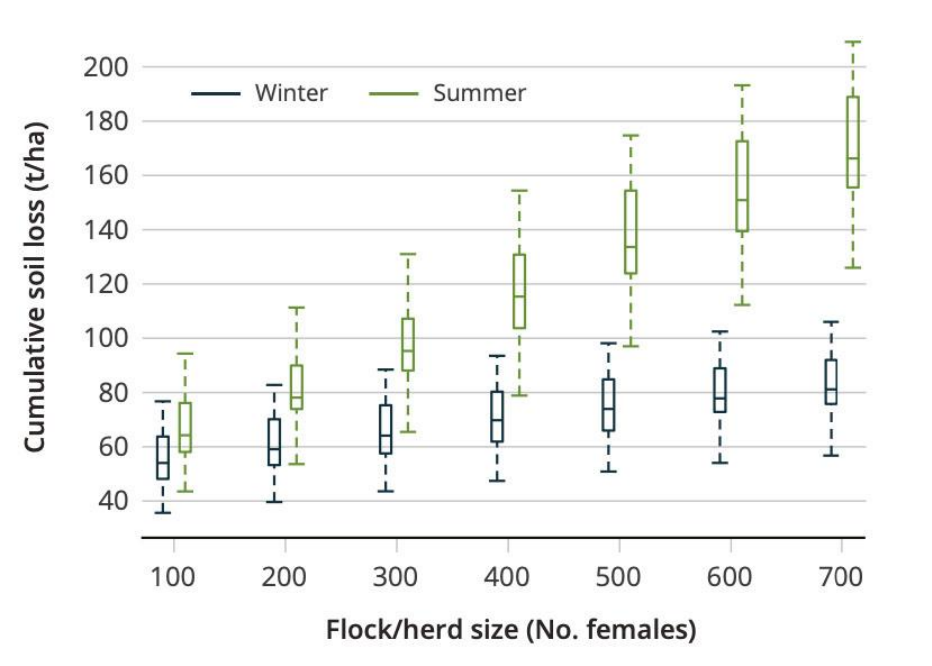


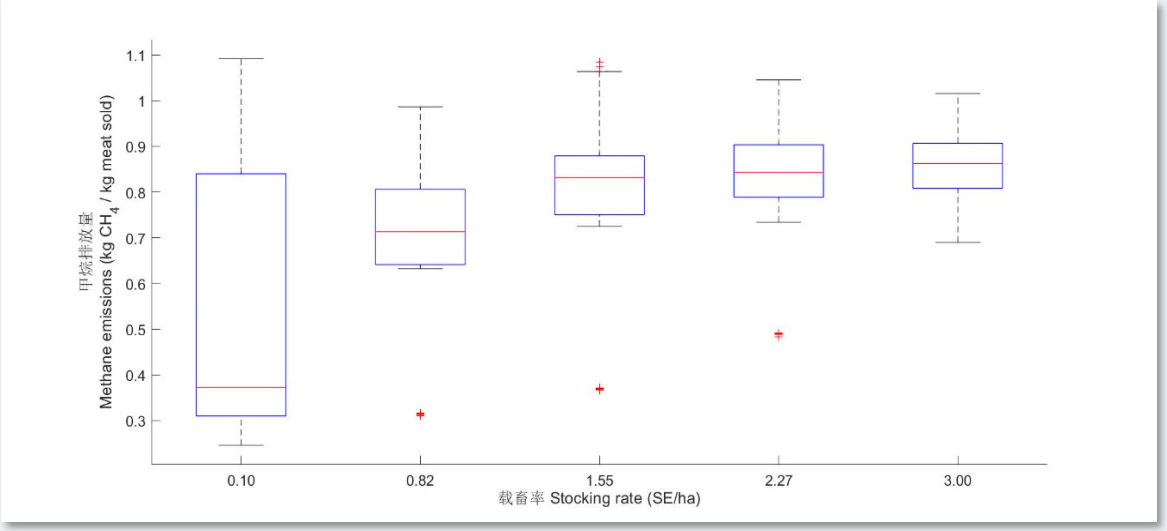


Han et al. 2011 Development of sustainable livestock systems on grasslands in north-western China, 80-96;
Kemp, Han, et al. 2013. PNAS,110 (21): 8369-8374.



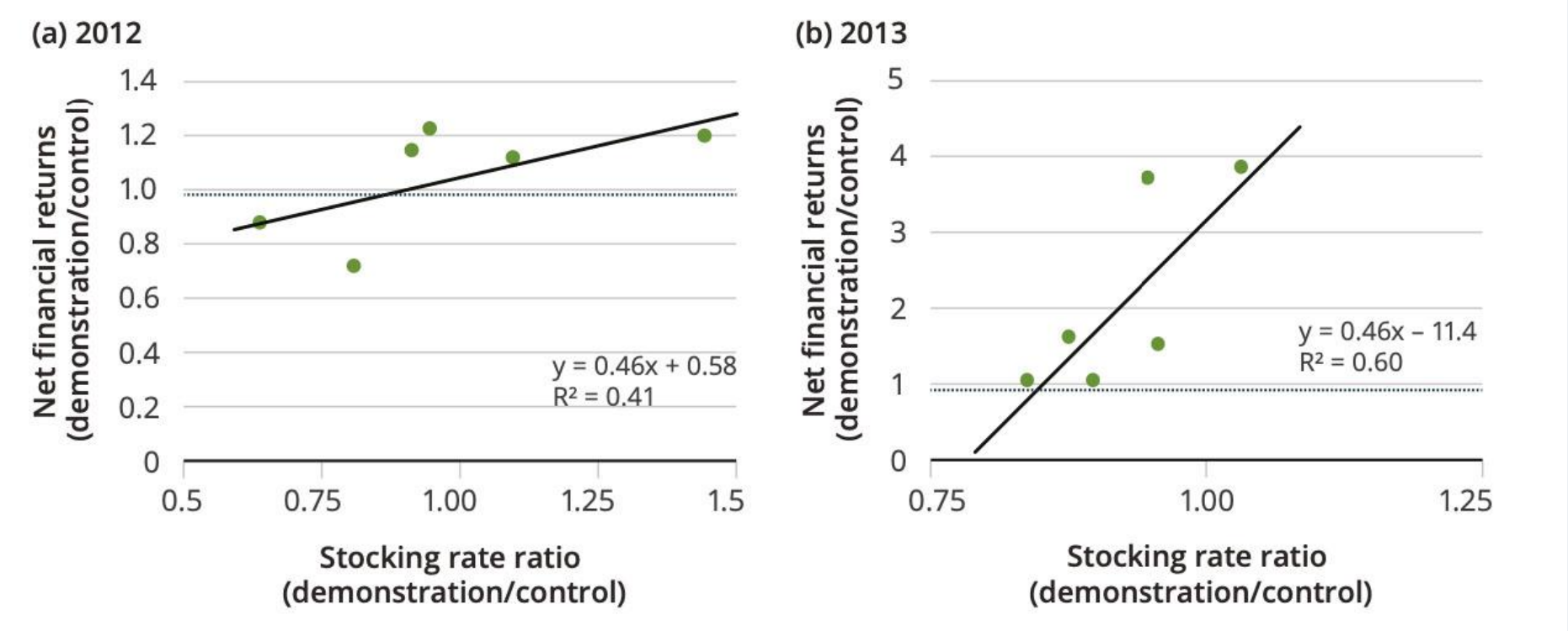




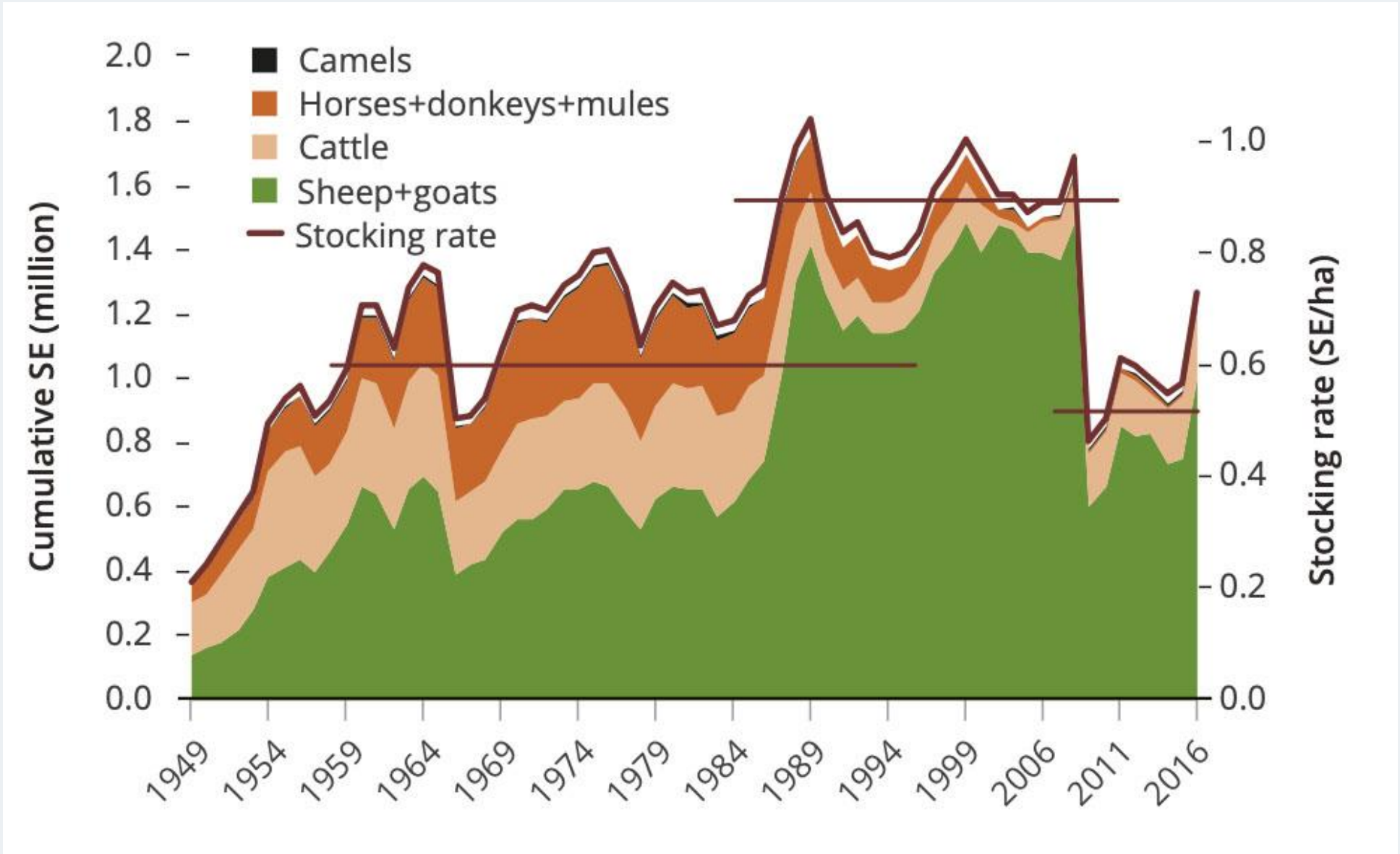


Behrendt et al.2020. The Rangeland Journal. 42:329-338.
Ha, Han et al. Unpublished data

Demonstration
- Scientists
- Government
- Herders
- Enterprises



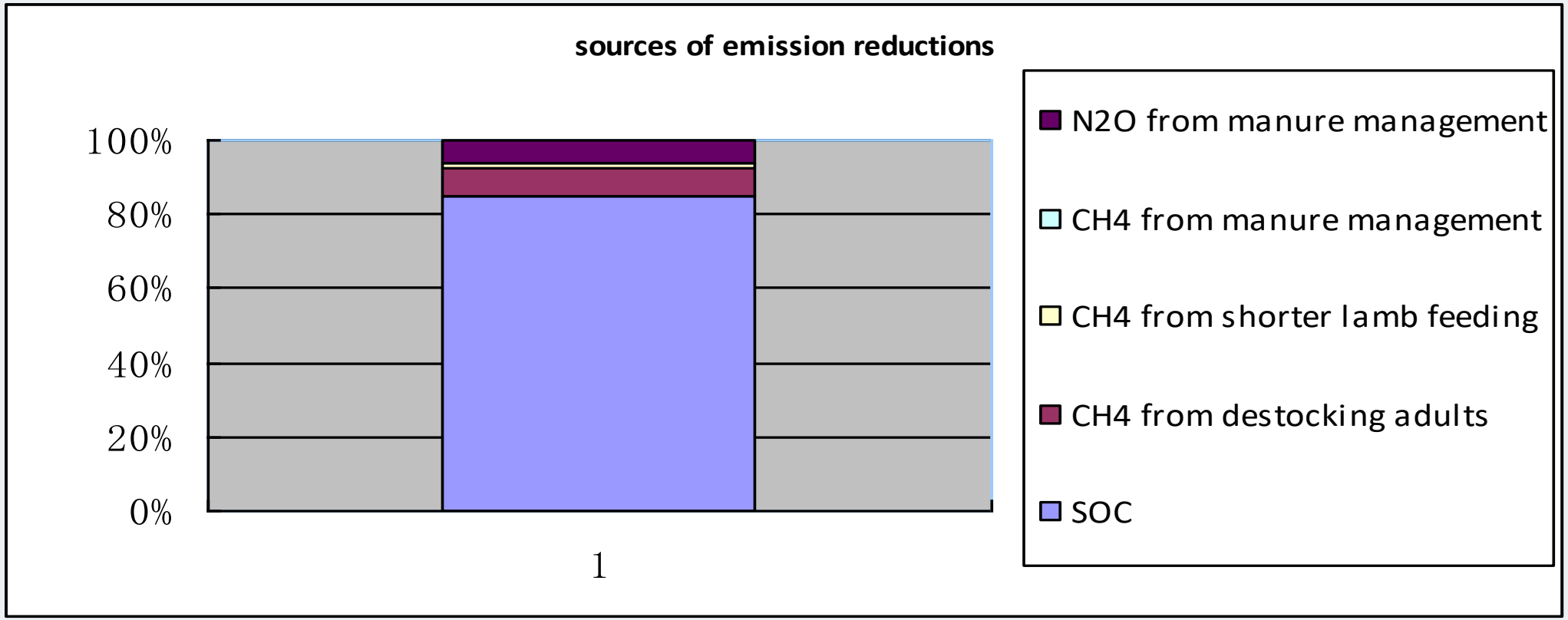
Li, Han et al. 2020. Sustainable Chinese Grasslands. ACIAR MONOGRAPHS. 57-80.



Kemp, Han, et al. 202Sustainable Chinese Grasslands. ACIAR MONOGRAPHS. 17-38.

GHS emission reduction

- 550 ha/household, cooperation: 250 households
- Traditional ranch: 384 SE/household；demonstration ranch: 220 SE/household，
- Annual reduction of GHG：89,000 tCO2e



Wilkes et al. 2011. Feasibility Assessment for Rangeland Carbon Offsets in Inner Mongolia.

Examples of demonstration

Site	Area (ha)	Sheep number	Reduction of stocking rate (%)	Increase of vegetation carbon fixation (%)	Extension area (ha)	Carbon sequestration (10^6 kg C yr-1)	GHG reduction (10^4 kg C yr-1)
Siziwang Banner (desert steppe)	550	390	23	105.4	8000	2.36	0.75
Ewenke Banner (Meadow steppe)	200	350	20	57.3	5000	4	1.1

Han et al. 2022. unpublished data

Thank you
for your attention!