7th International Nitrogen Initiative Conference (INI2016)

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Nitrogen input to croplands and its environmental impacts in China

Xiaoyuan Yan

Institute of Soil Science

Chinese Academy of Sciences

Xuejun Liu

College of Res. & Env. Sci.

China Agricultural University

Outlines

- Spatial and temporal changes in N input and NUE
- Efforts in improving NUE
- Environmental impacts
  - Biodiversity loss
  - Soil acidification
  - Greenhouse gas balance
  - Eutrophication
  - Air pollution

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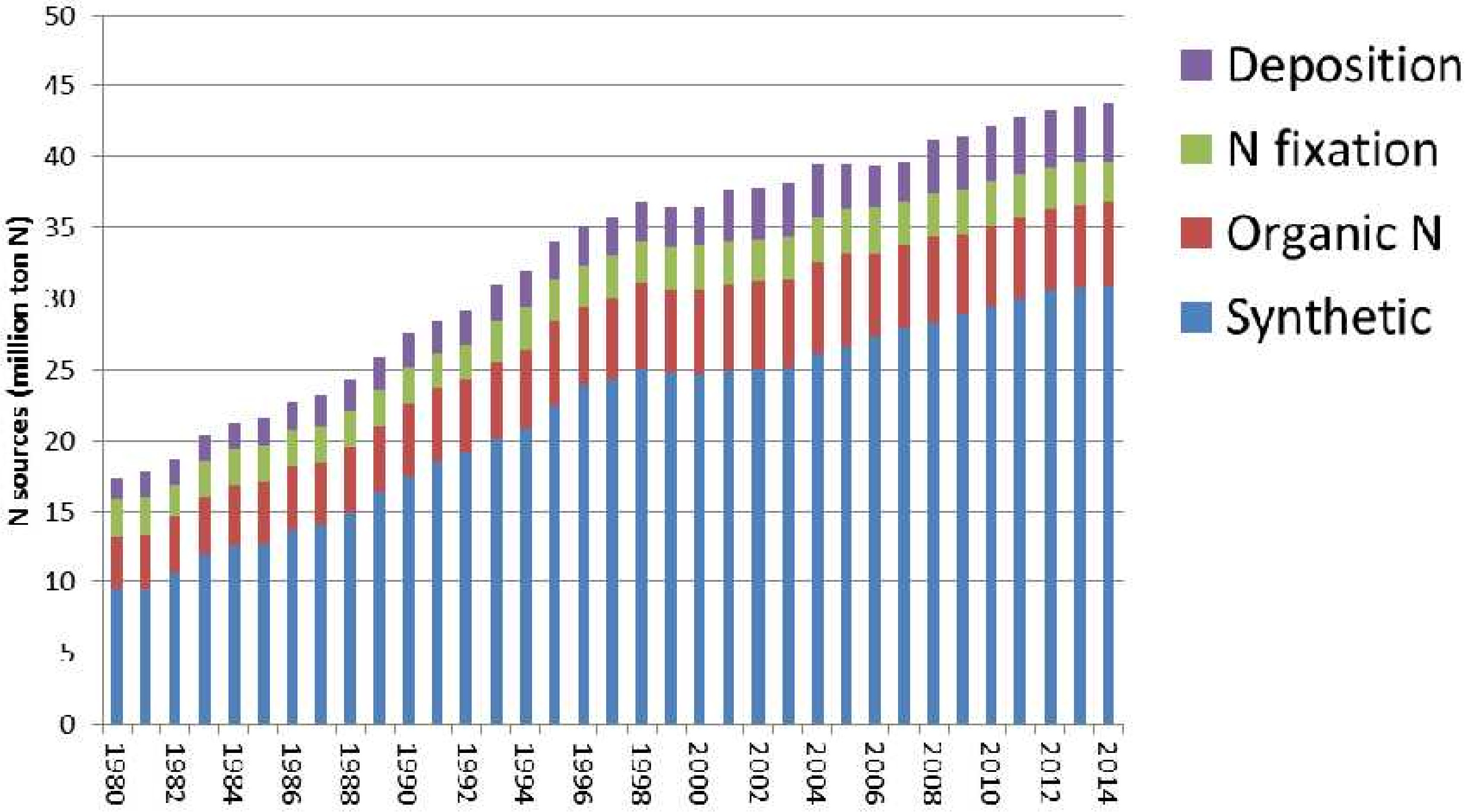
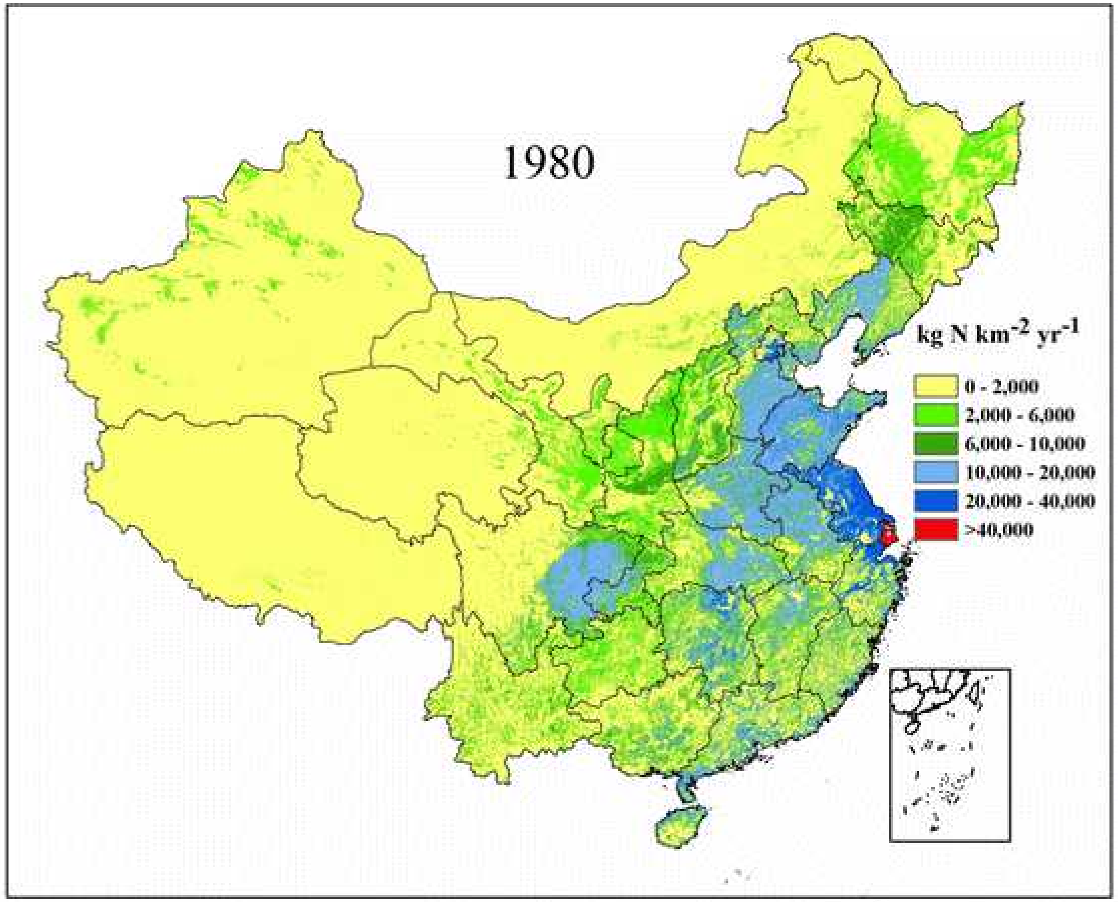
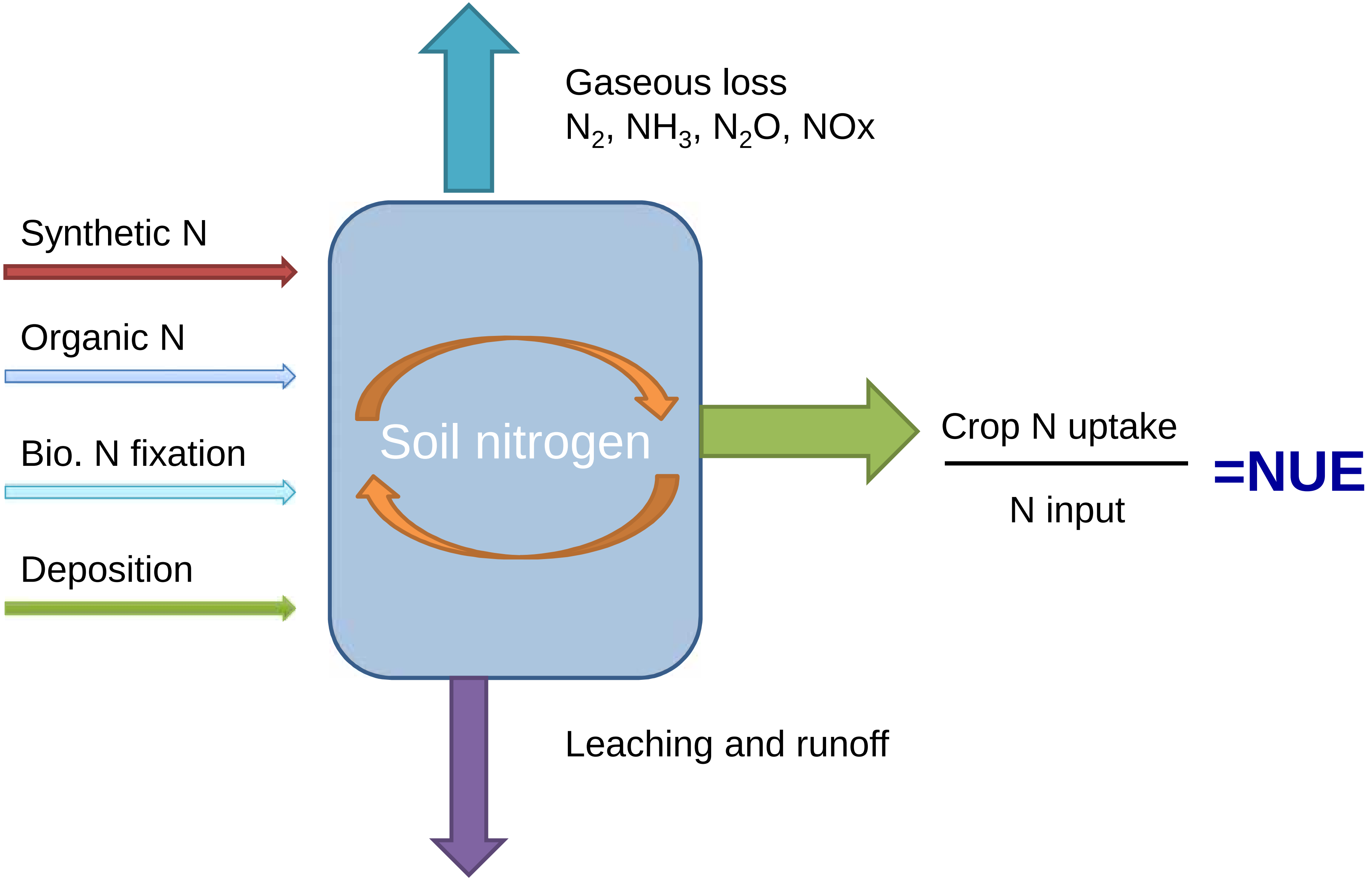
Nitrogen input to croplands



Spatial and temporal variation of N input to croplands

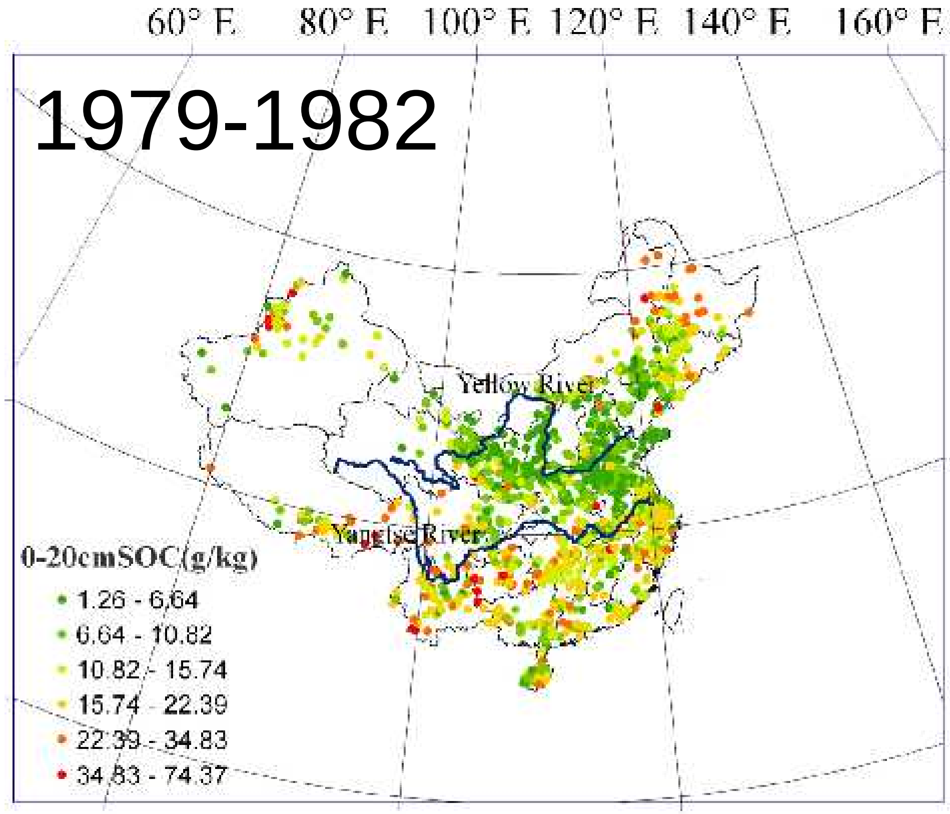


Nitrogen use efficiency (NUE)

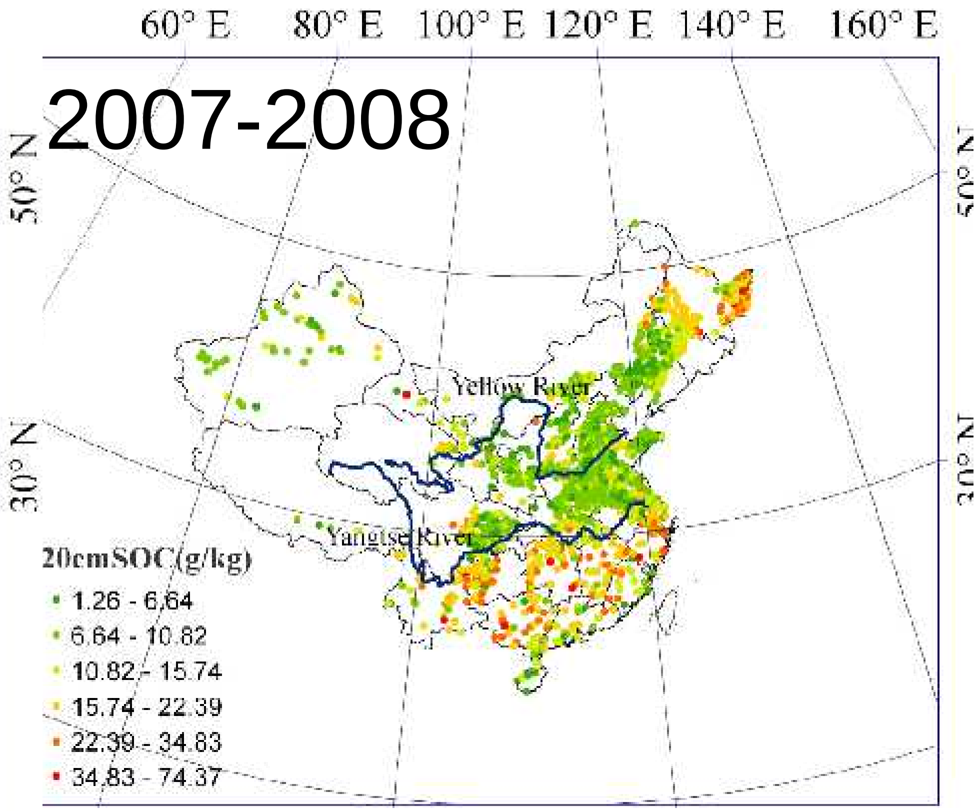


SOC and soil N content changes

National soil survey



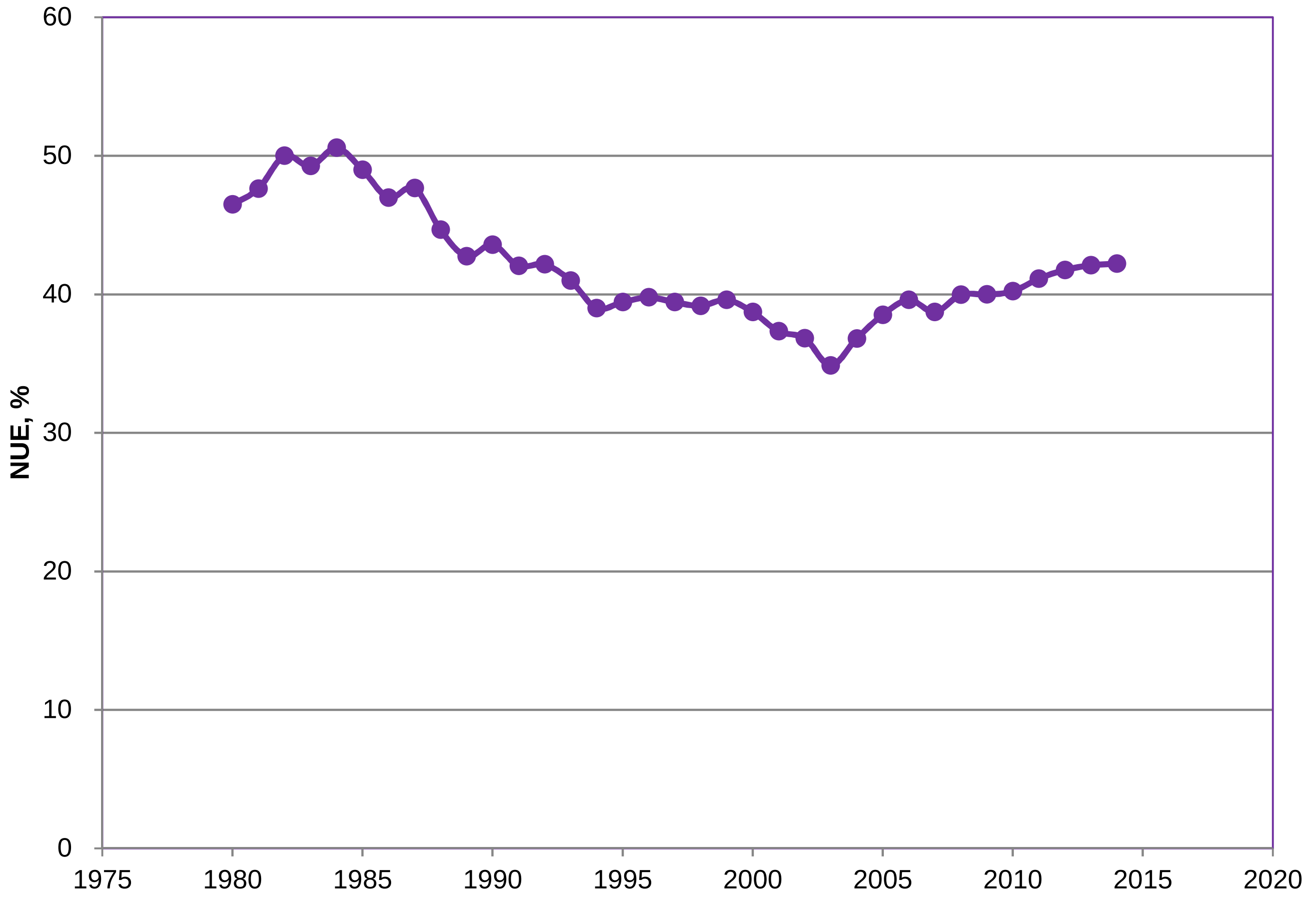
Soil sampling campaign



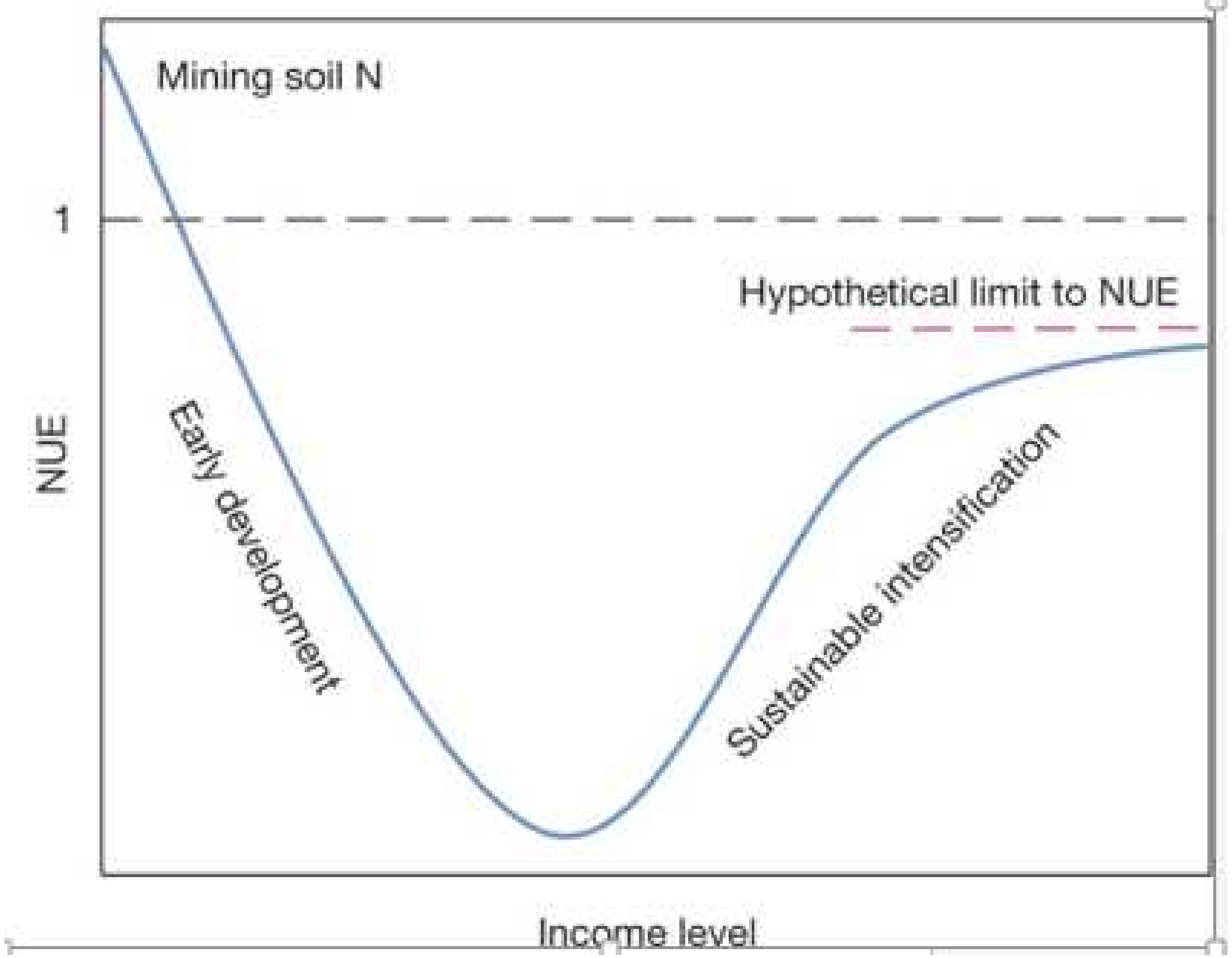
C:+8.8%

N:+5.1%

Change in NUE with time

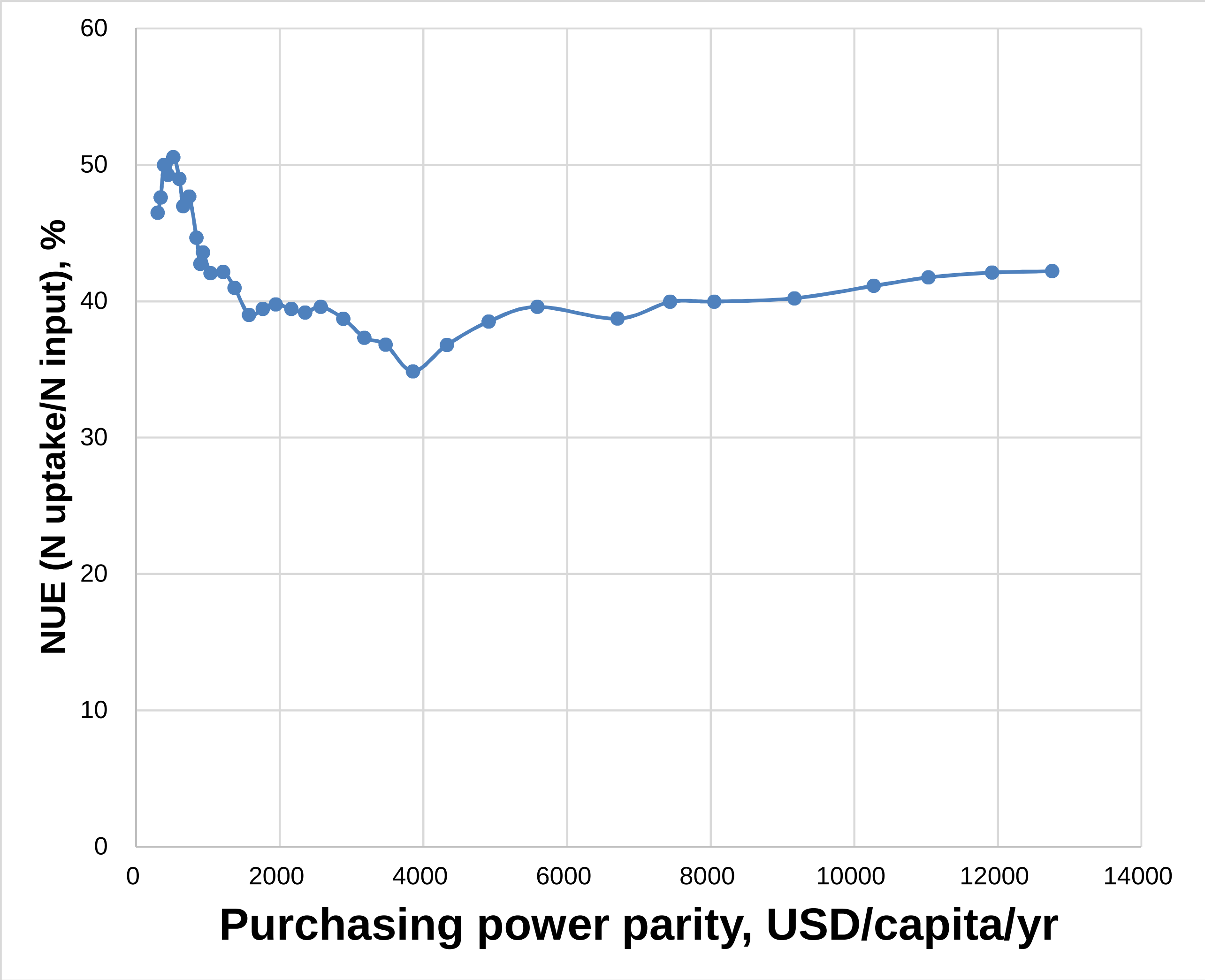


Environmental Kuznets Curve



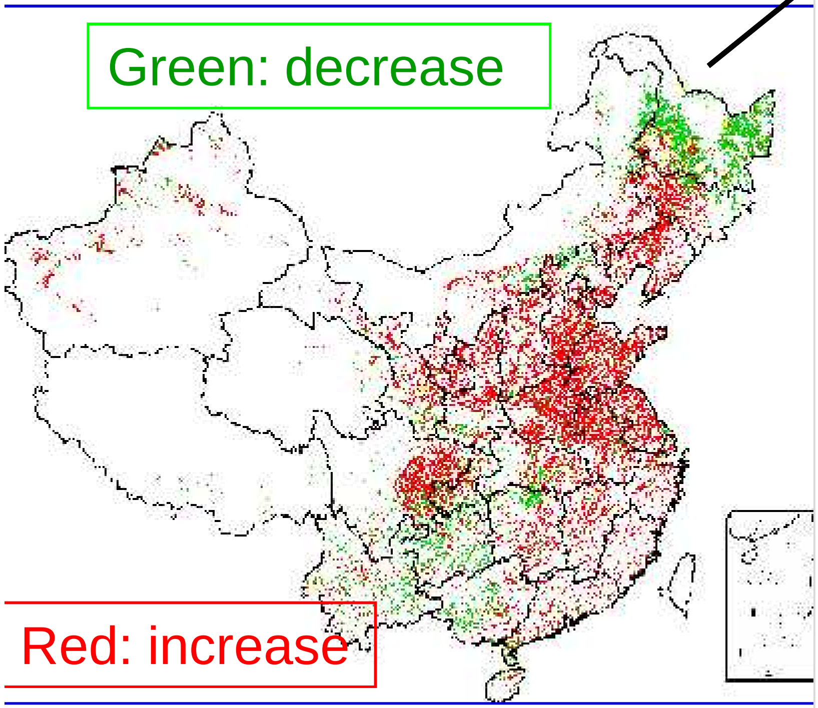
Zhang et al., 2015, Nature 528, 51–59

Changes in NUE with economy growth

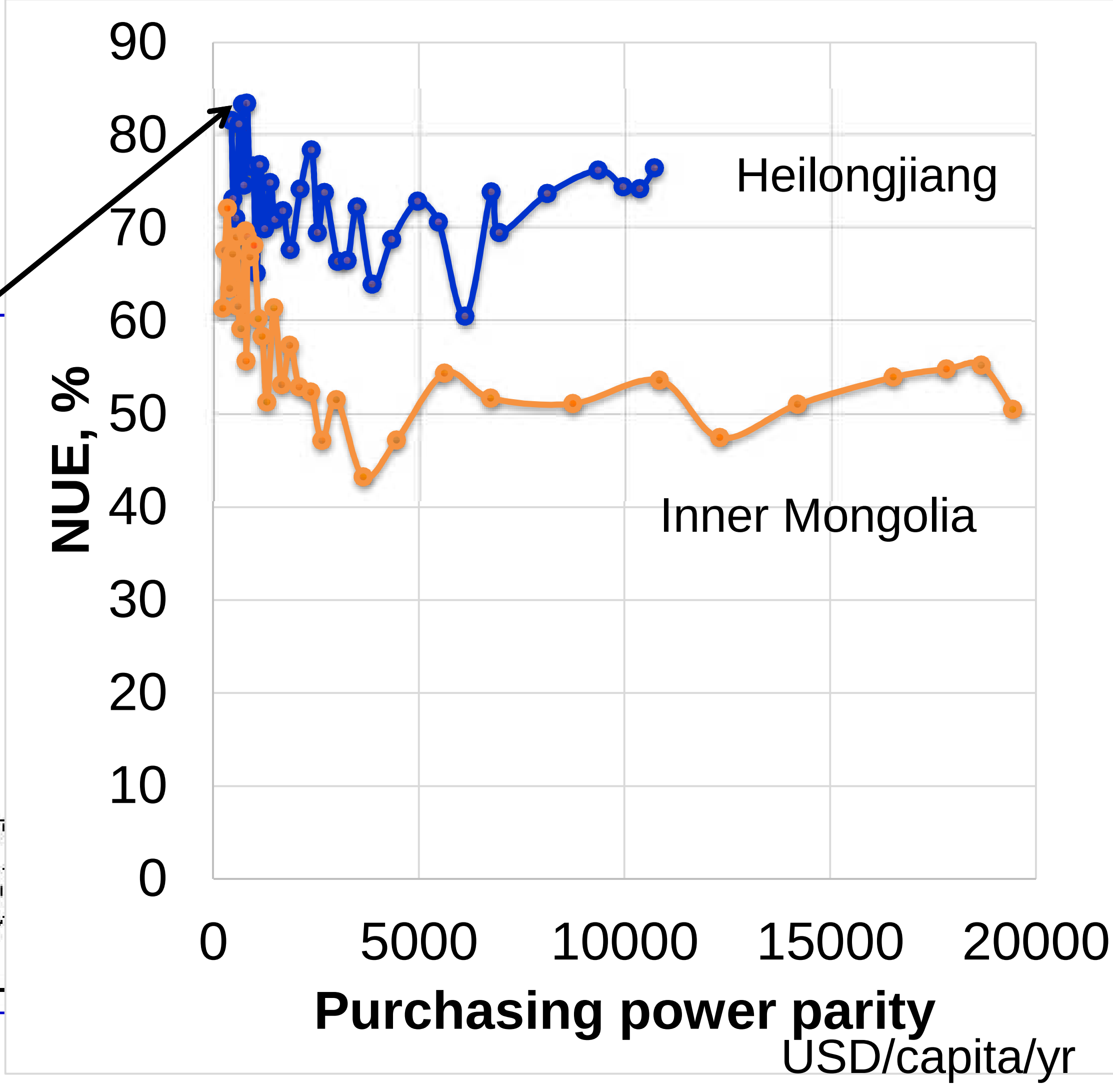


Heilongjiang and Inner Mongolia

Consistent high NUE
Loss of soil nitrogen

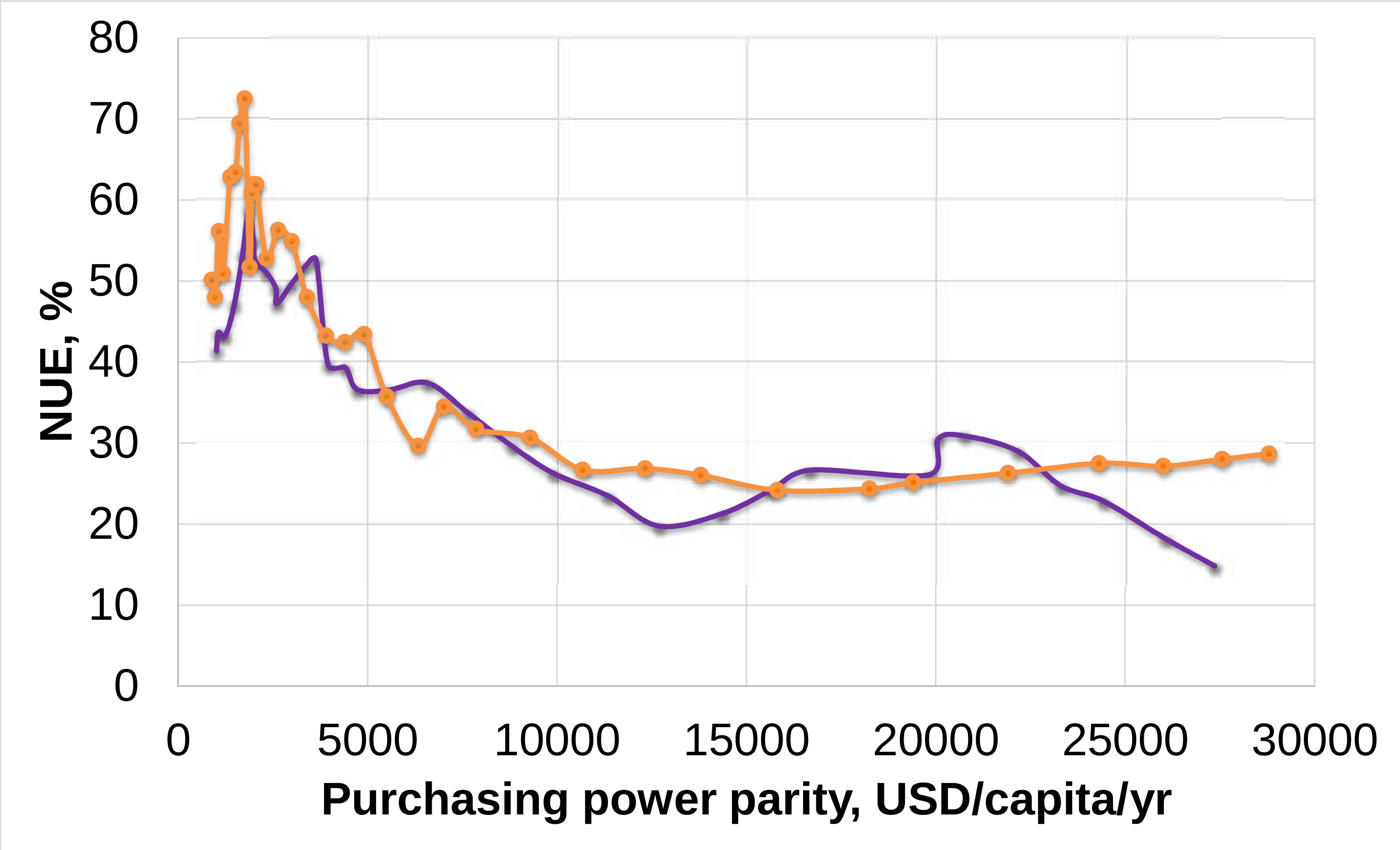


Courtesy of Huang Yao



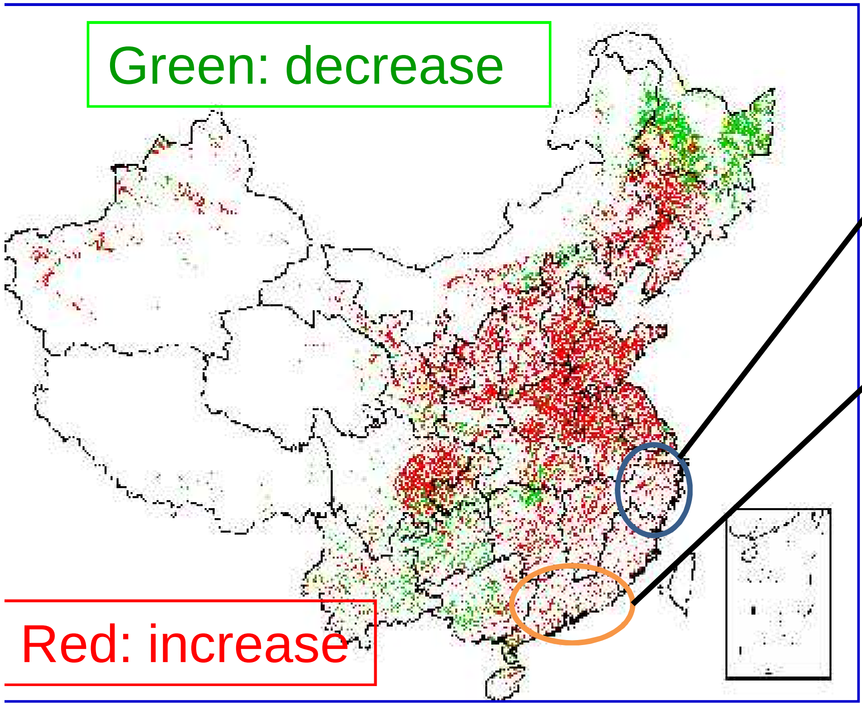
Shanghai and Beijing

Urban area, economically developed, consistent low NUE

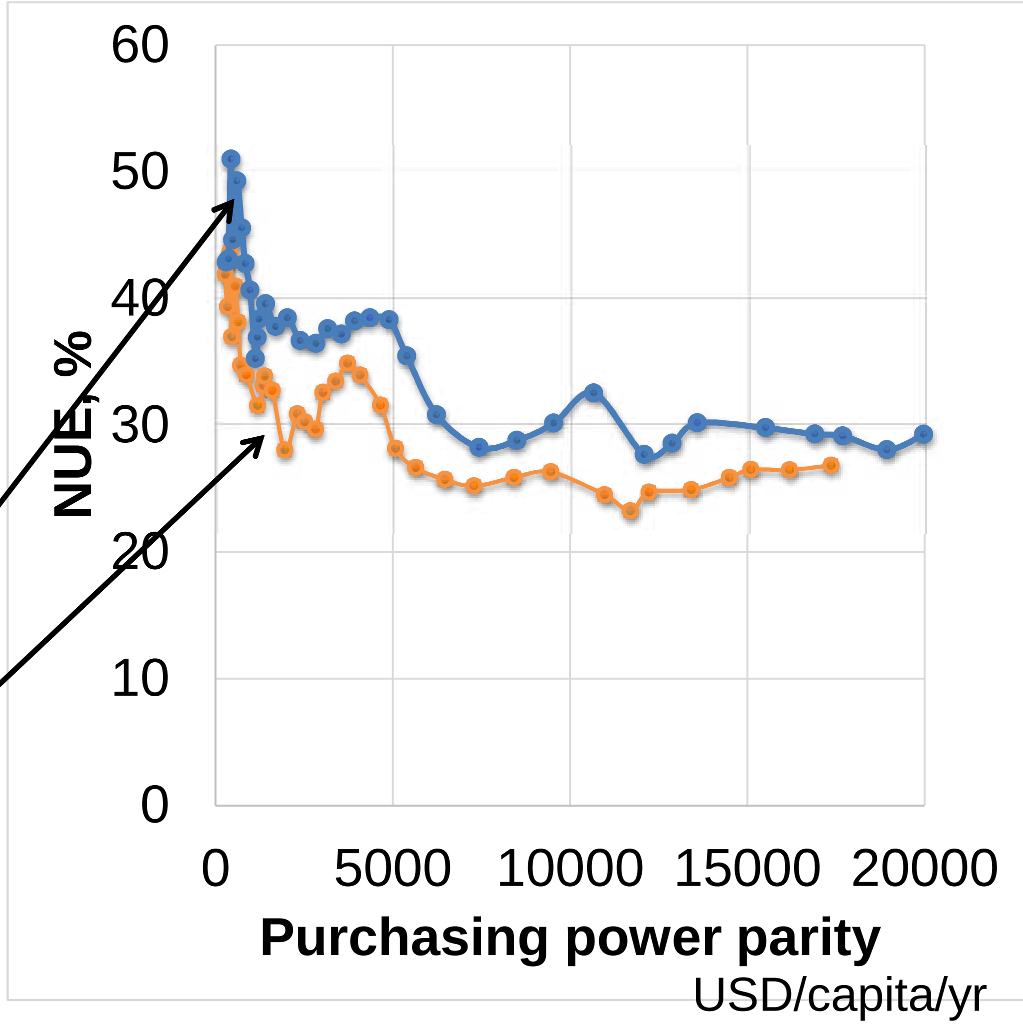


Zhejiang and Guangdong

Economically developed
Soil N little change
Low NUE
Not increasing yet

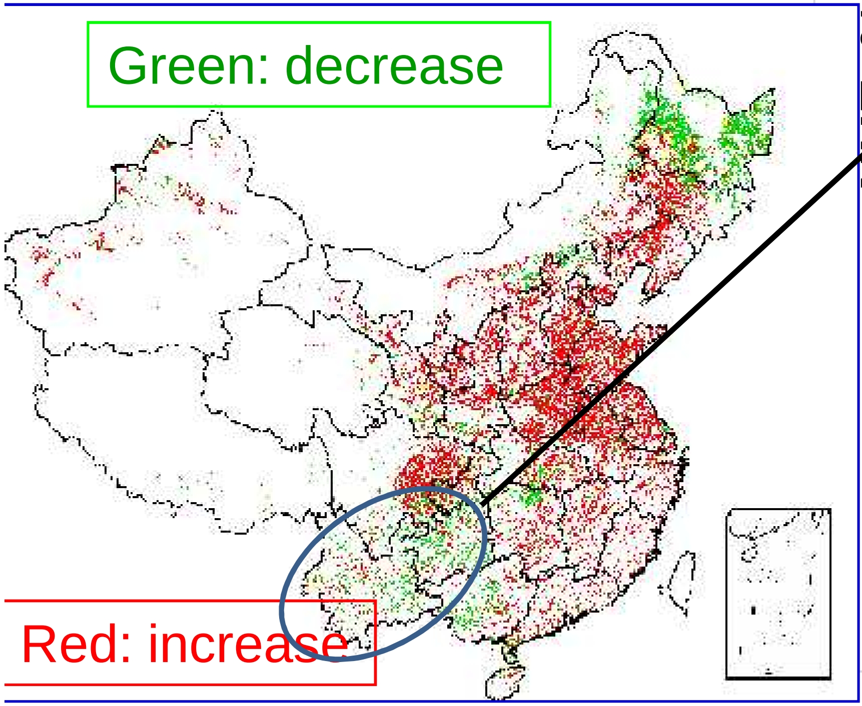


Courtesy of Huang Yao

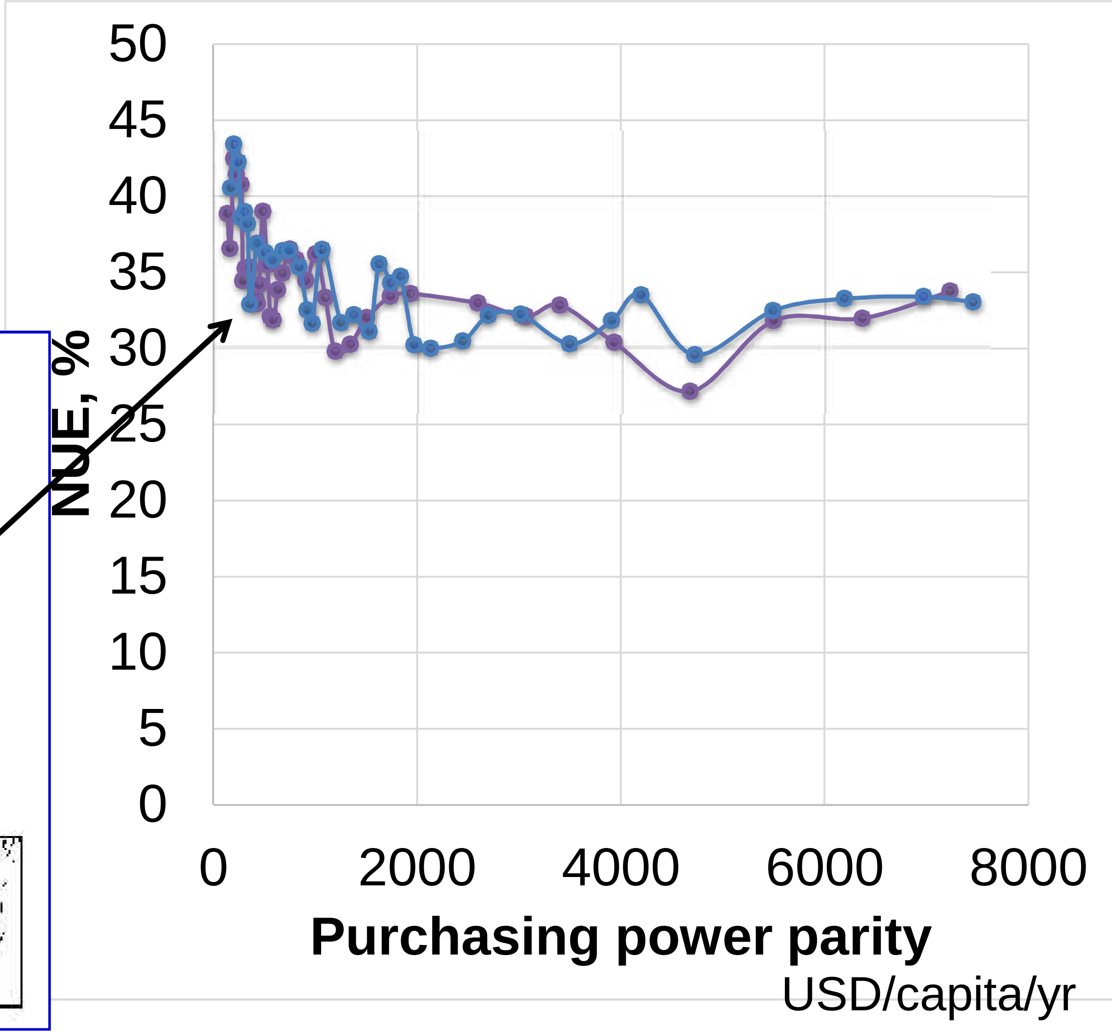


Yunnan and Guizhou

Economically undeveloped
Slight decrease in soil N
Low and stable NUE

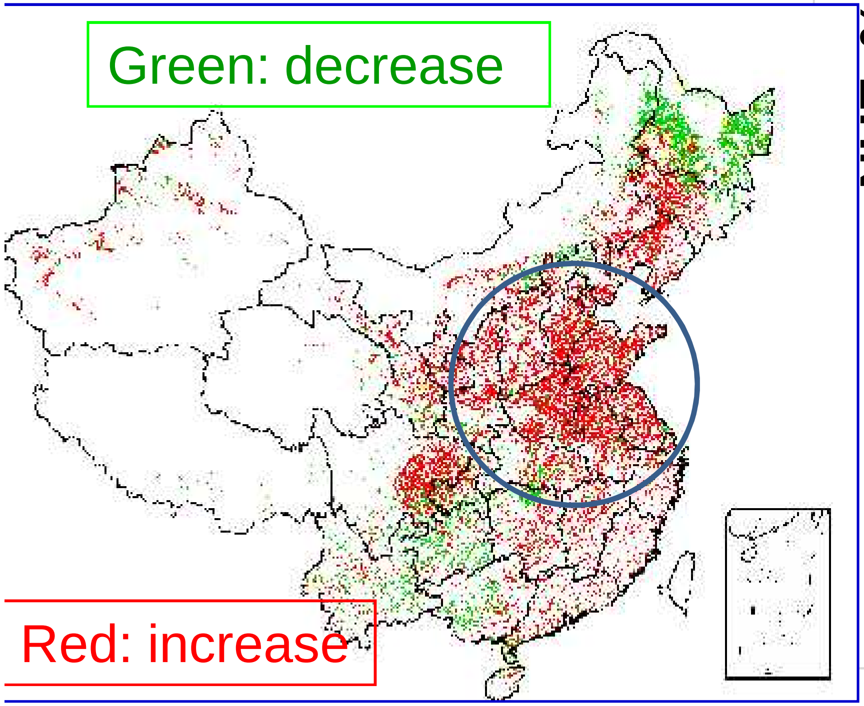


Courtesy of Huang Yao

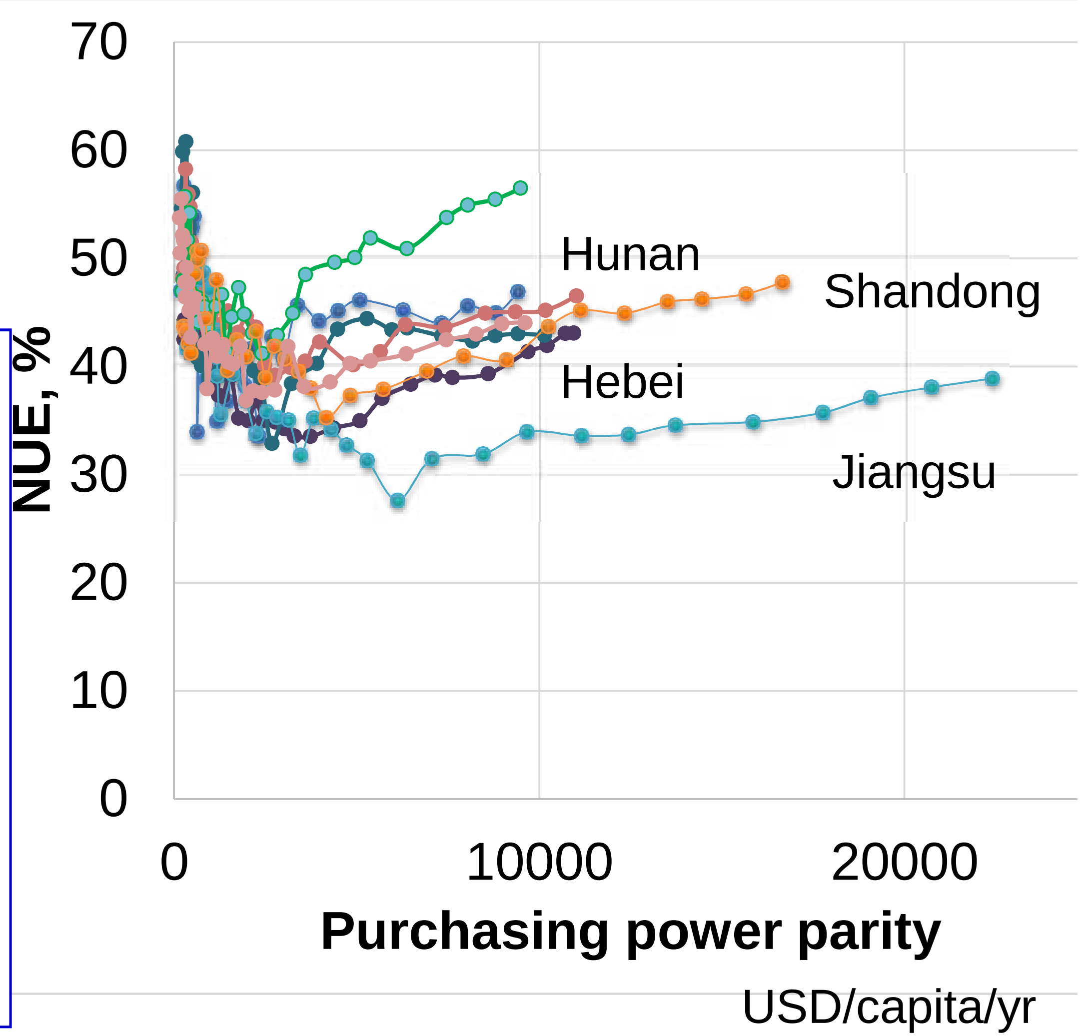


Major agricultural region

High or middle level economy
Major agricultural provinces
Largely increased soil N
Increasing NUE



Courtesy of Huang Yao



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Knowledge-based N practices

- **Enhanced efficiency N fertilizers**
  - **Controlled release N fertilizer**
  - **Nitrification inhibitor**
  - **Urease inhibitor**

- **Optimized N application**
  - **Reducing basal fertilizer N ratio**
  - **Increasing N splitting frequency**
  - **Deep placement of fertilizer**
  - **Fertilizer recommendation based on soil test**

Fertilization based on soil test program

An accumulative area of 100 million hector by 2015

Fertilizer recommendation systems

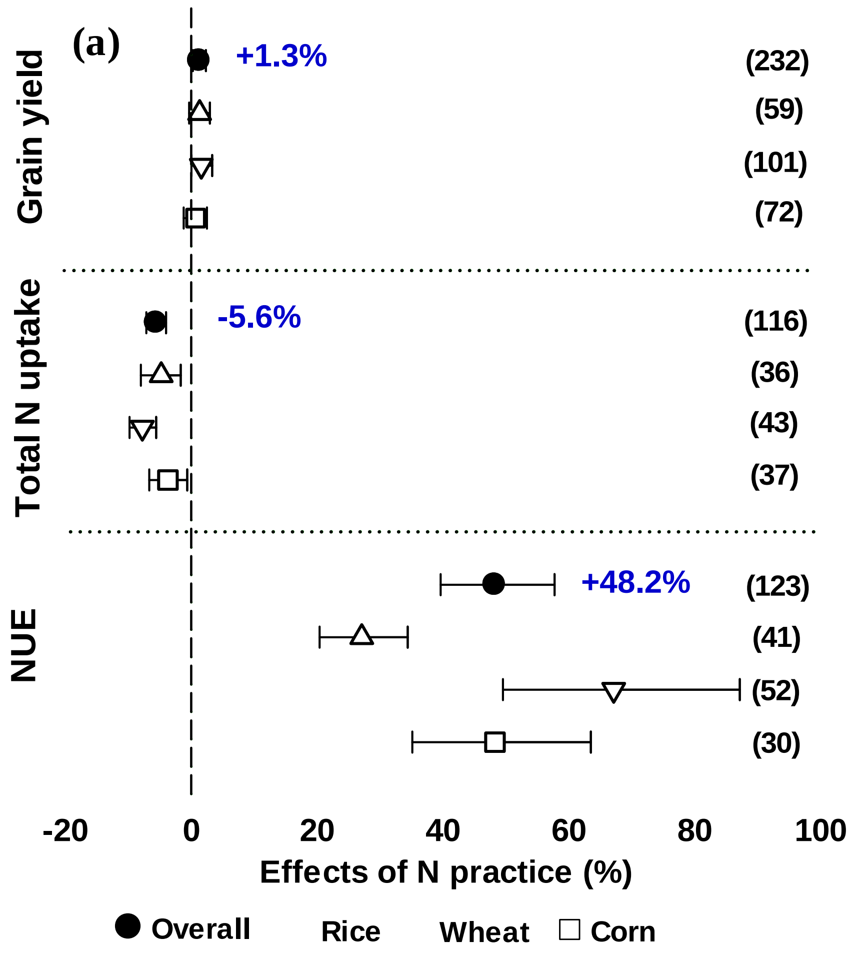
Computer access

Touching panel

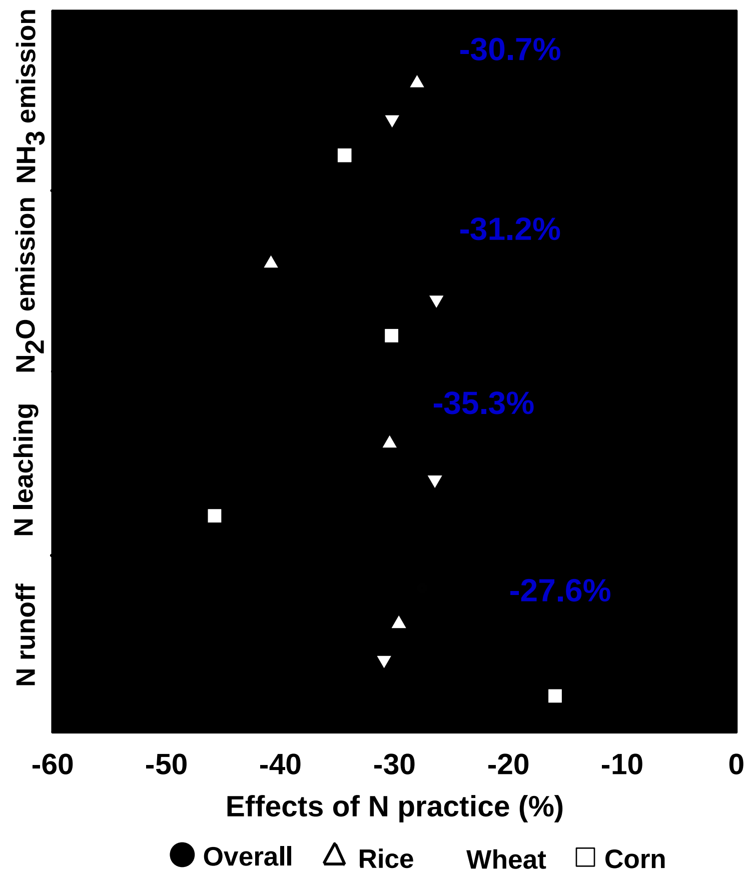
Palm access

Effects on productivity and N loss

Productivity indexes



Loss indexes



Achieved on an average N reduction of 28%

Barriers

- **Effects of these N practices varied among different crop species and soil properties.**
- **Many farms are still small scale, farmers' knowledge, environmental awareness still need to improve**
- **Opportunity cost (time, labor, training/education costs) for implementing**
- **Lack of mechanization**

National geography, 2011

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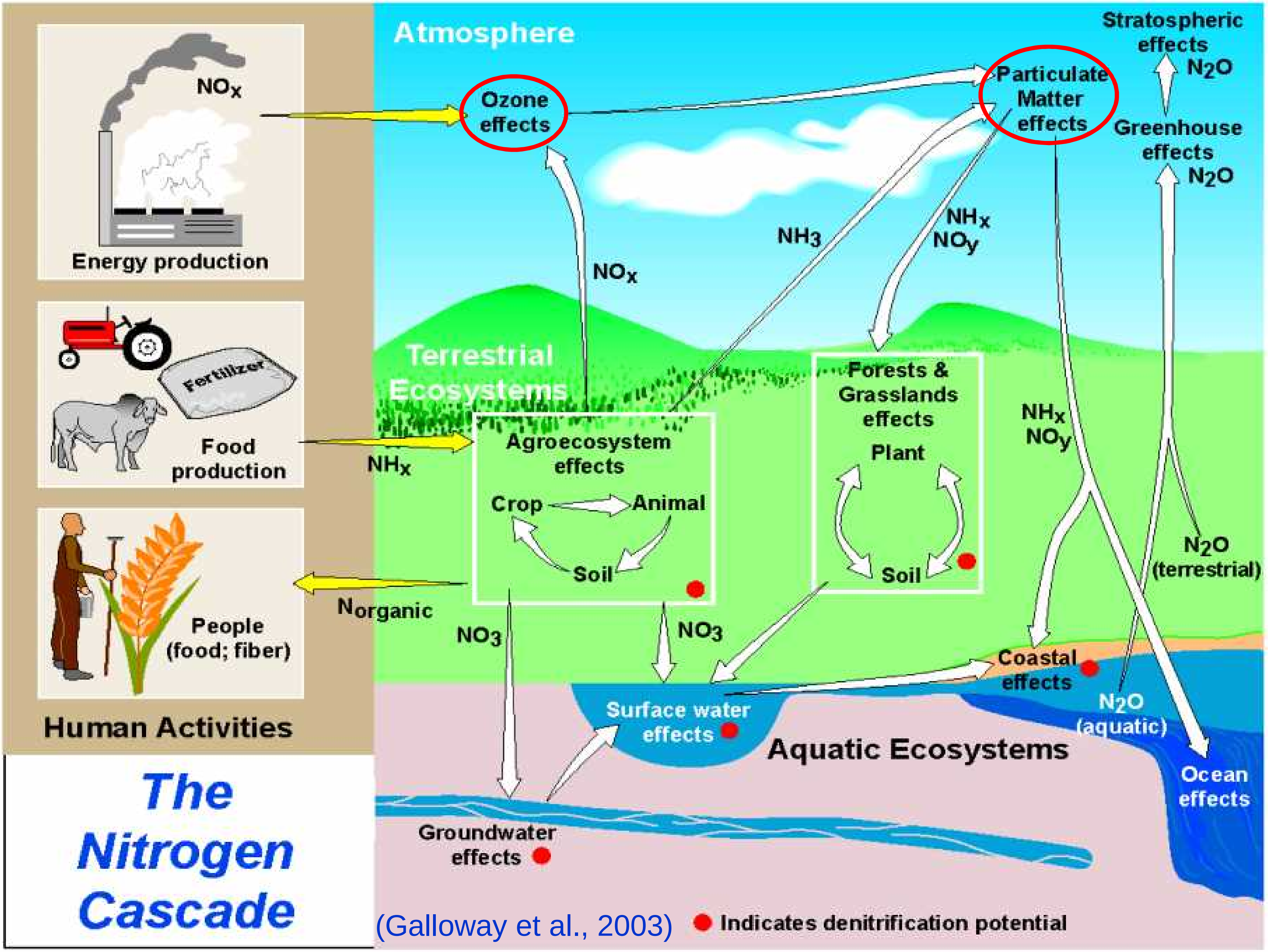
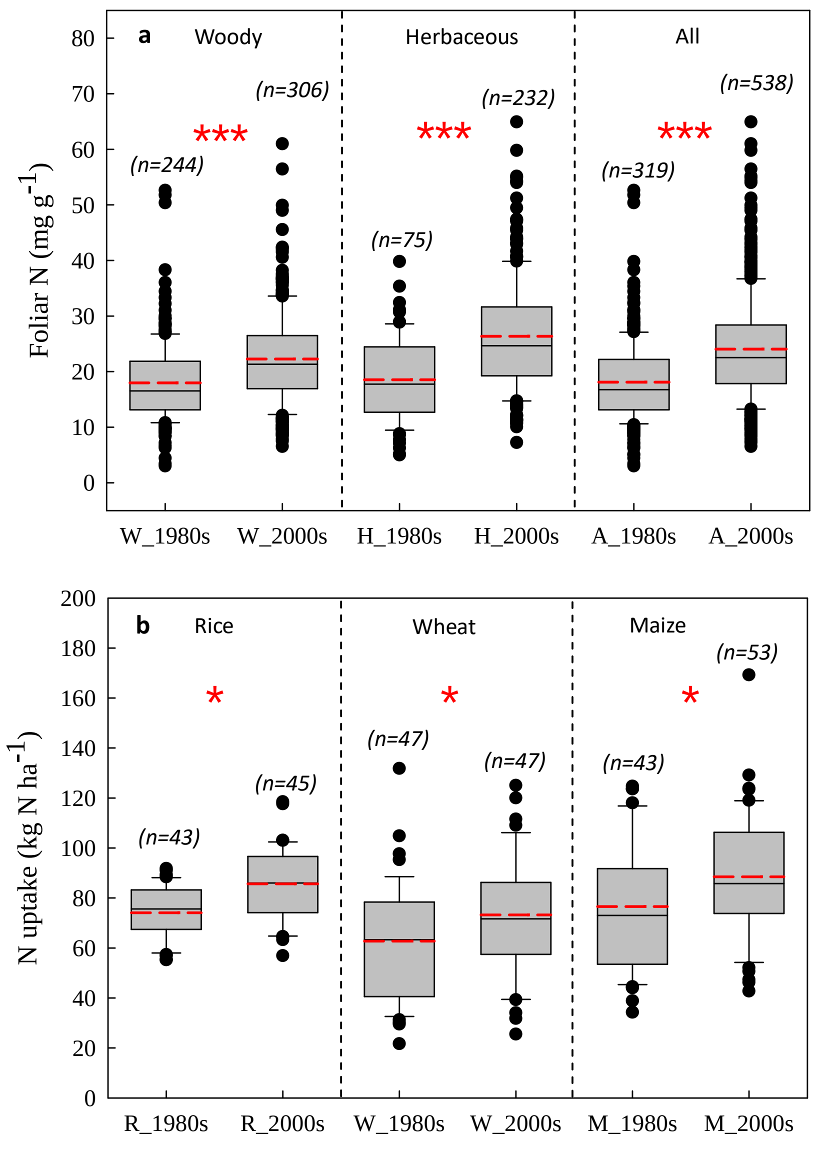


(Galloway et al., 2003)

Significant increase in leaf N in natural vegetation (a) and N uptake in long-term unfertilized croplands (b) during 1980s and 2000s.



Foliar N concentration
1980s: 18.1±7.2 mg/g
2000s: 24.0±9.2 mg/g
Increase: 5.9 mg/g (+30%)

Crop N from zero-N plots
1980s: 71.1 kg N ha^{-1}
2000s: 82.4 kg N ha^{-1}
Increase: 11.3 kg N ha^{-1} (+15%)

These results suggest N enrichment in China's terrestrial ecosystems since 1980.

, ** denote significant difference at 0.05, 0.001 level.

(Liu et al., 2013. Nature, 494:459-462)

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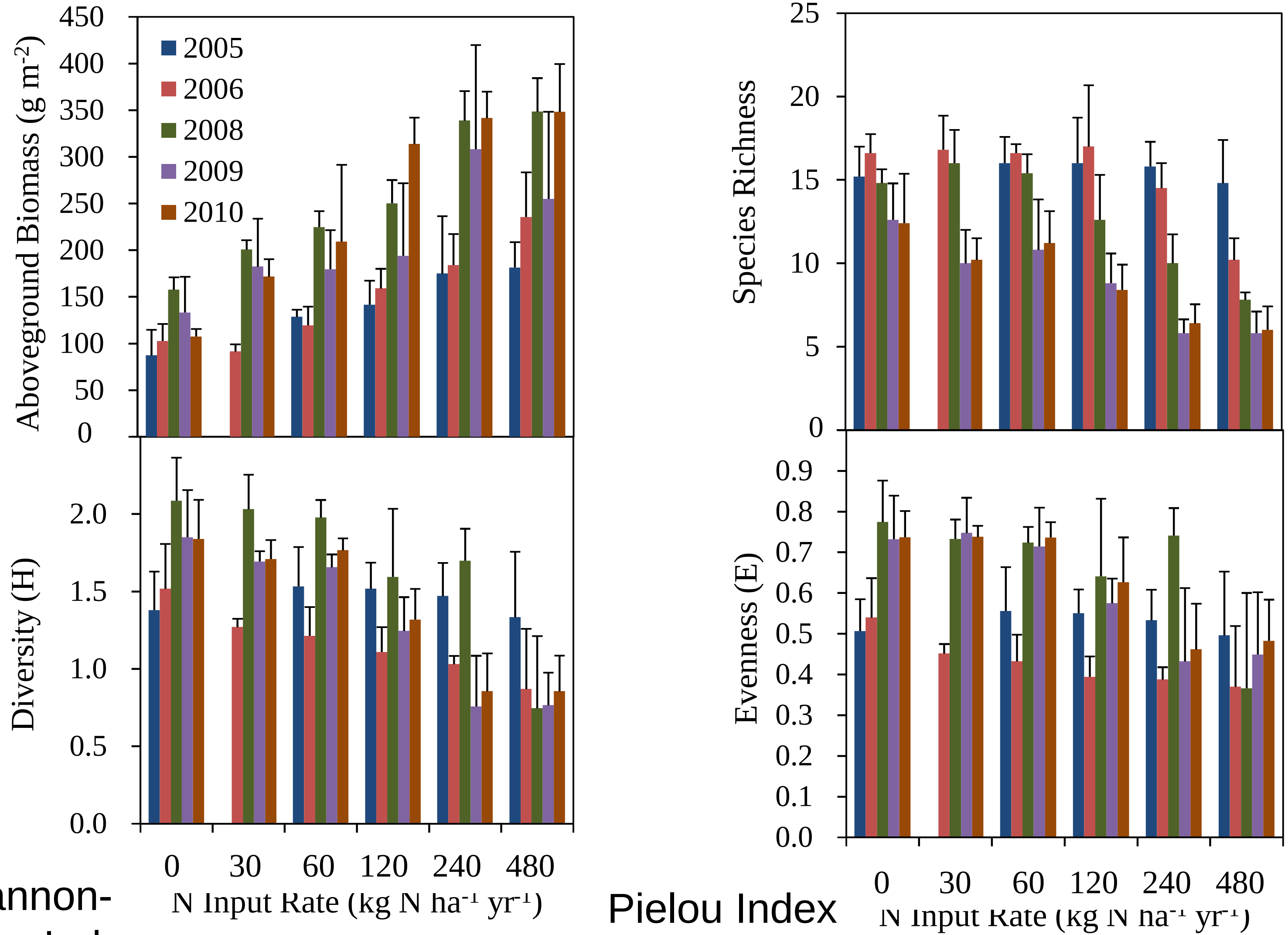
Impact of N addition on grassland plant community

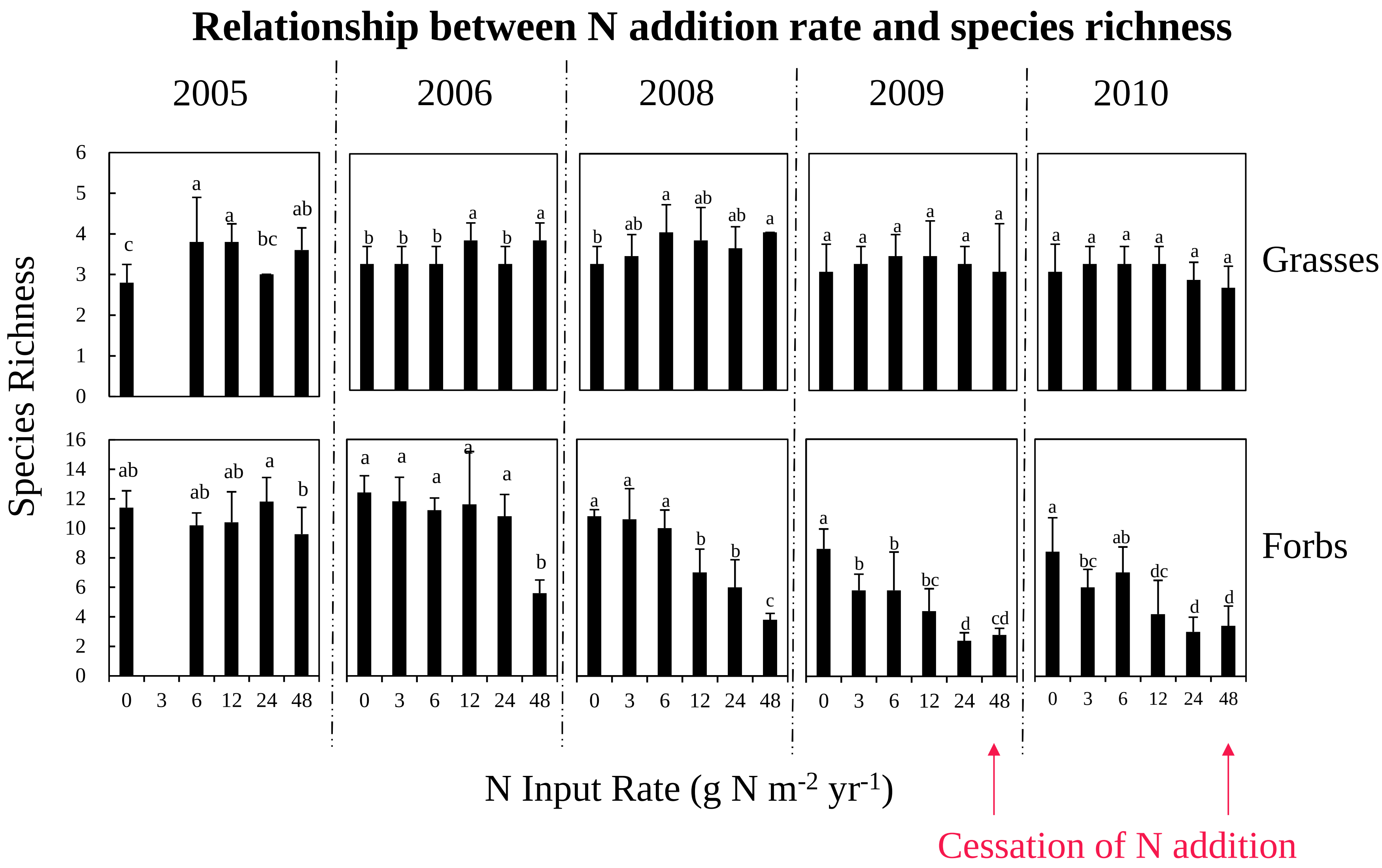


Shannon-Wiener Index

Pielou Index Evenness

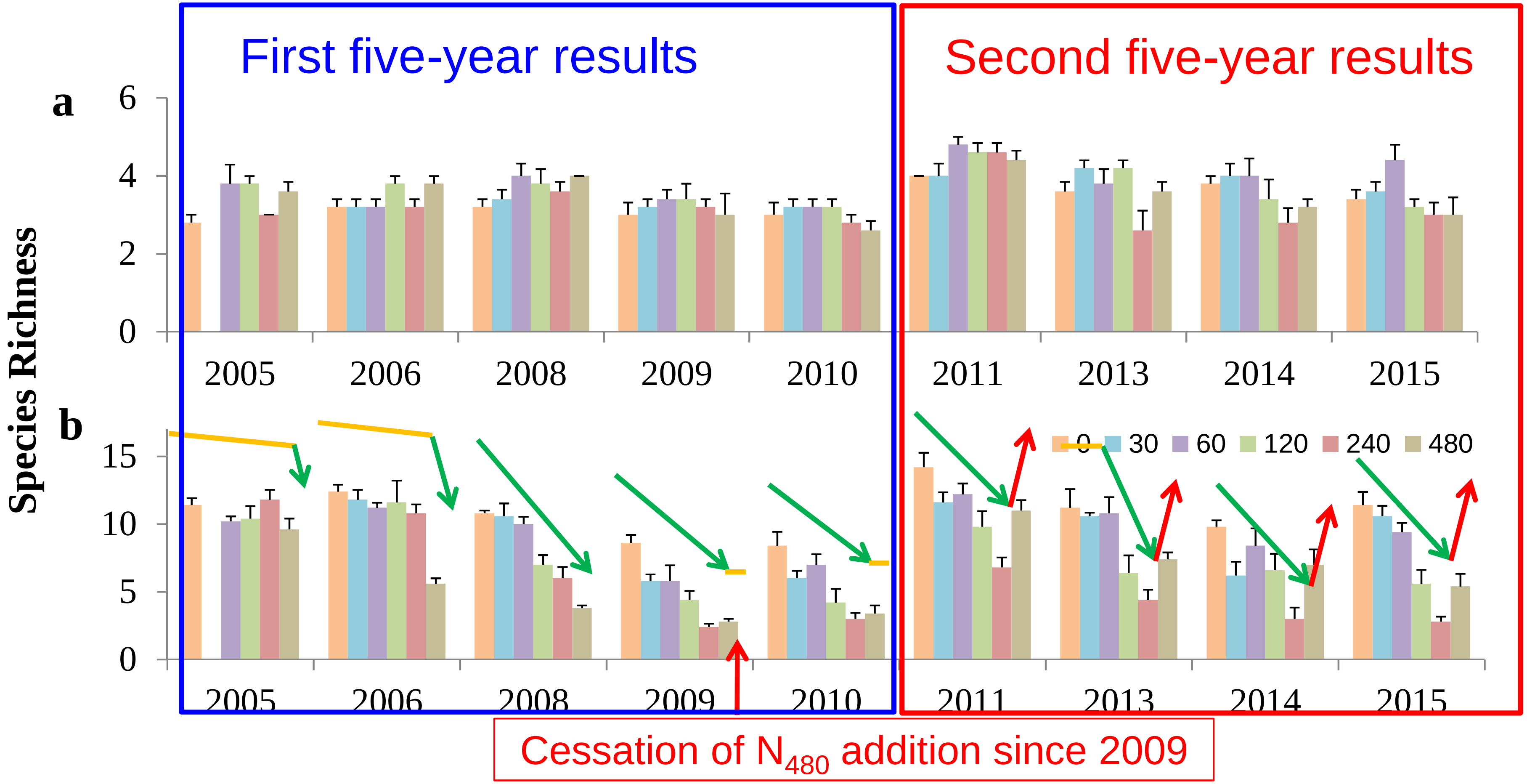
(Song et al, 2012. J. Arid Land)

Elevated N deposition (e.g. 30 kg N ha^{-1}) led to significant decline in forb species richness in temperate grassland (Duolun, IM)



(Song et al, 2011, Biogeosciences)

Biodiversity loss and recovery under various N addition conditions



Relationship between N addition rate and species richness for grasses (a) and forbs (b) from 2005 to 2015.

(Hao et al., 2016. unpublished)

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Science AAAS

Significant Acidification in Major Chinese Croplands
J. H. Guo, *et al.*
Science **327**, 1008 (2010);
DOI: 10.1126/science.1182570

- **Average pH decline was 0.5 units during 1980s and 2000s**
- **Soil pH decline: Cash crop systems > Cereal crop systems**

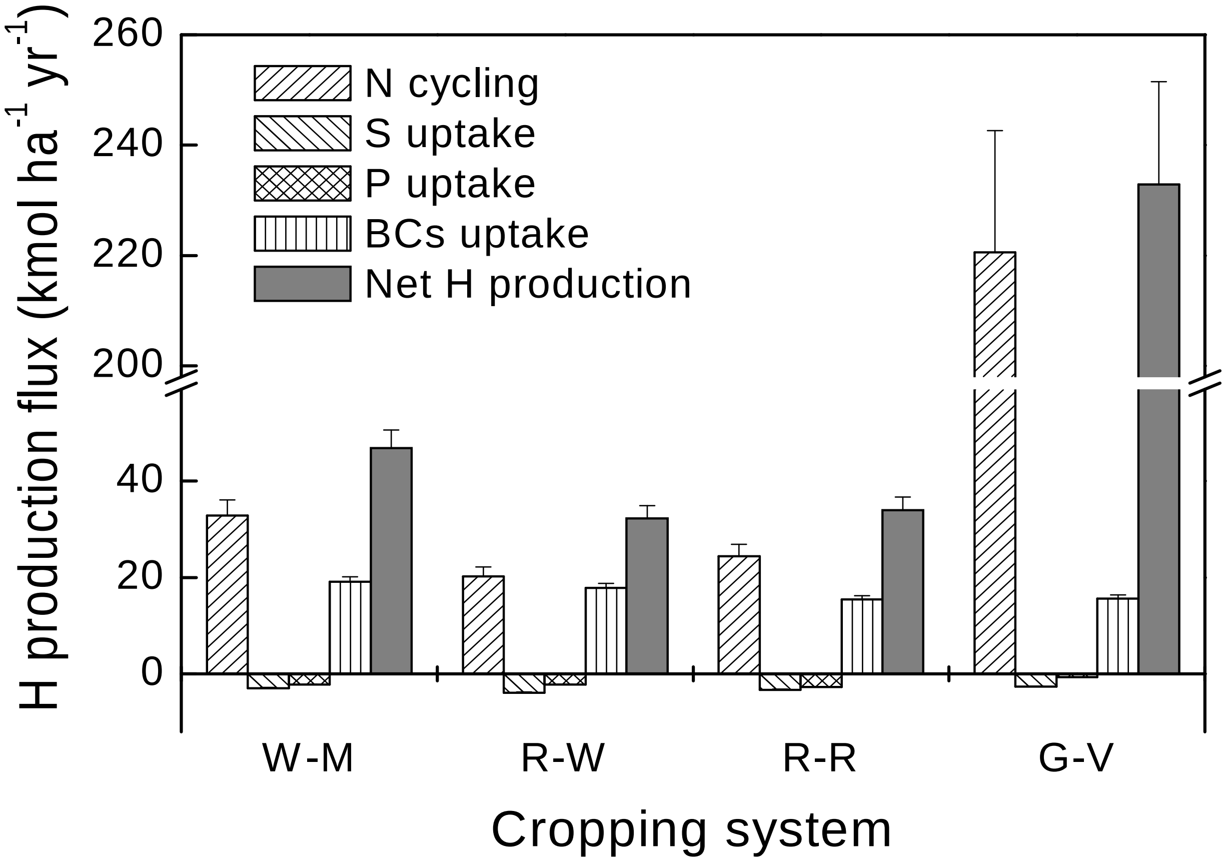
Table 1. Topsoil pH changes in major Chinese croplands between the 1980s and 2000s. The soil groups are defined in (*13*). NS, not significant; pH range is an average (5 to 95 percentile).

	1980s		2000s					
			Cereal crop systems*			Cash crop systems†		
Soil group	Sample number	pH value	Sample number	pH value	pH change	Sample number	pH value	pH change
I	301	5.37 (4.40–6.60)	505	5.14 (4.17–6.52)	–0.23‡	337	5.07 (3.93–6.44)	–0.30‡
II	1157	6.33 (5.00–8.04)	1101	6.20 (5.00–7.70)	–0.13‡	413	5.98 (4.58–7.49)	–0.35‡
III	297	6.42 (4.50–8.30)	211	5.66 (4.27–8.06)	–0.76‡	98	5.62 (4.27–7.73)	–0.80‡
IV	562	6.32 (5.10–7.89)	537	6.00 (4.84–7.60)	–0.32‡	238	5.60 (4.07–7.42)	–0.72‡
V	995	7.96 (6.39–8.80)	850	7.69 (5.37–8.70)	–0.27‡	520	7.38 (5.69–8.20)	–0.58‡
VI	493	8.16 (7.10–8.80)	250	8.16 (7.49–8.82)	–0.00 (ns)	10	8.17 (7.43–8.93)	0.01 (ns)

*Cereal/fiber crops (such as rice, wheat, maize, and cotton). †High-input cash crops (such as vegetables, fruit trees, and tea). ‡$P < 0.001$.

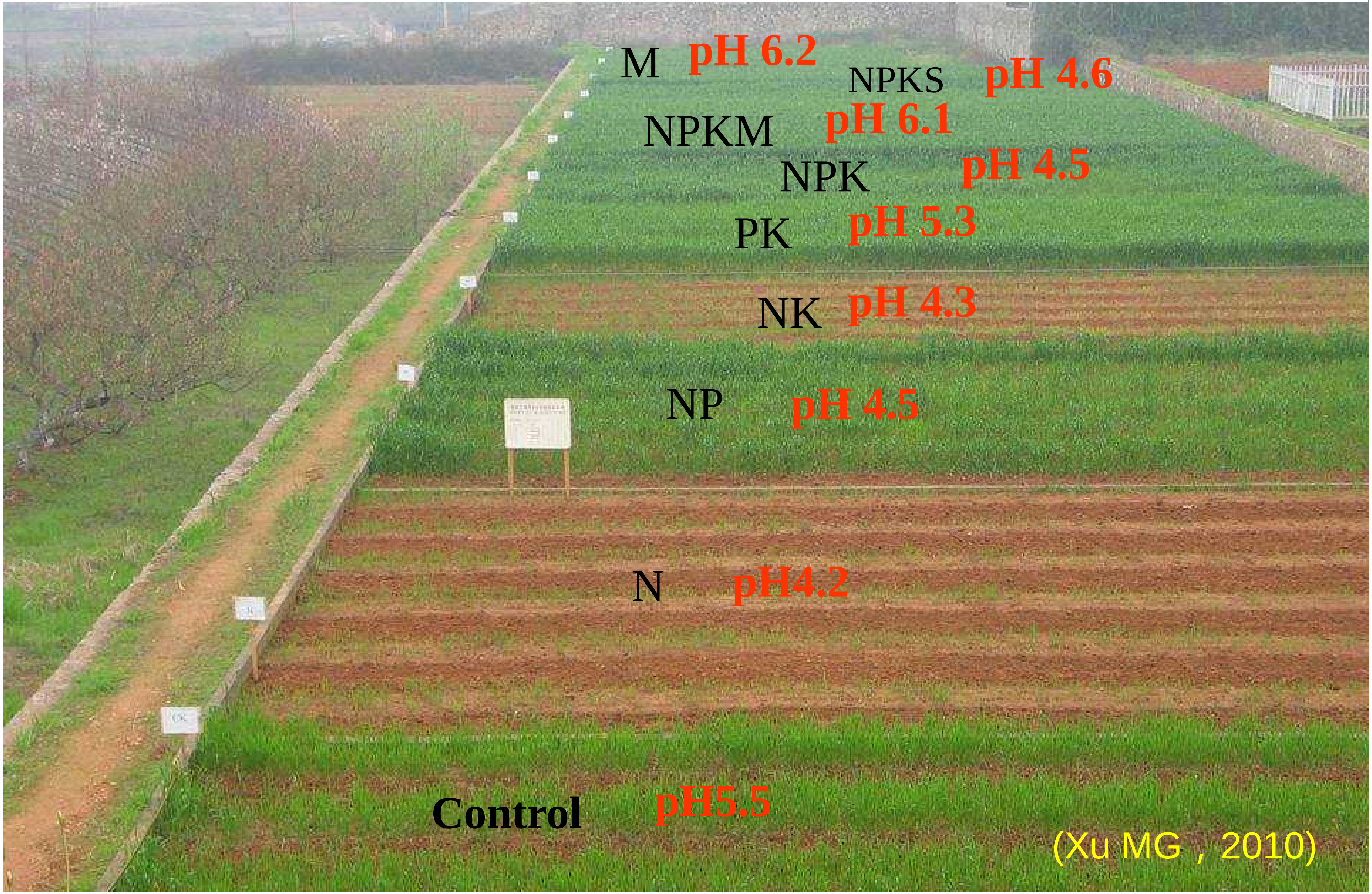
(Guo, Liu, Zhang, et al., 2010. Science 327: 1008-1010)

H^+ production budget of main factors in four typical Chinese cropping systems. W-M: Wheat–maize; R-W: Rice-wheat; R-R: Rice-rice; G-V: Greenhouse vegetables.



(Guo, Liu, Zhang et al., 2010. Science, 327: 1008-1010)

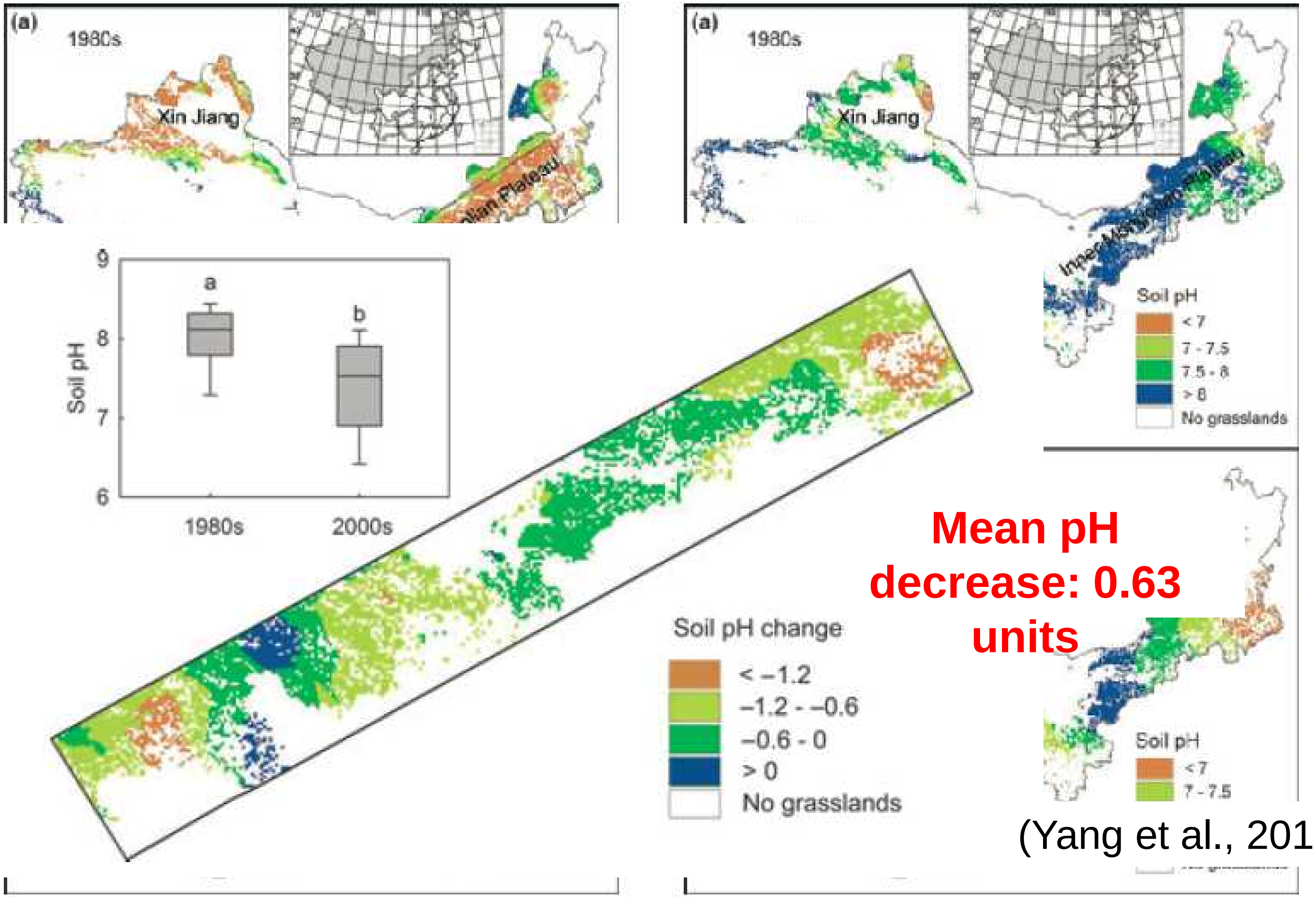
Changes of soil pH after 12-year fertilization in a wheat-maize cropping system (Annual N input 300 kg N/ha, Initial pH 5.7 in 1990)



Global Change Biology (2012) **18**, 2292–2300, doi: 10.1111/j.1365-2486.2012.02694.x

Significant soil acidification across northern China's grasslands during 1980s–2000s

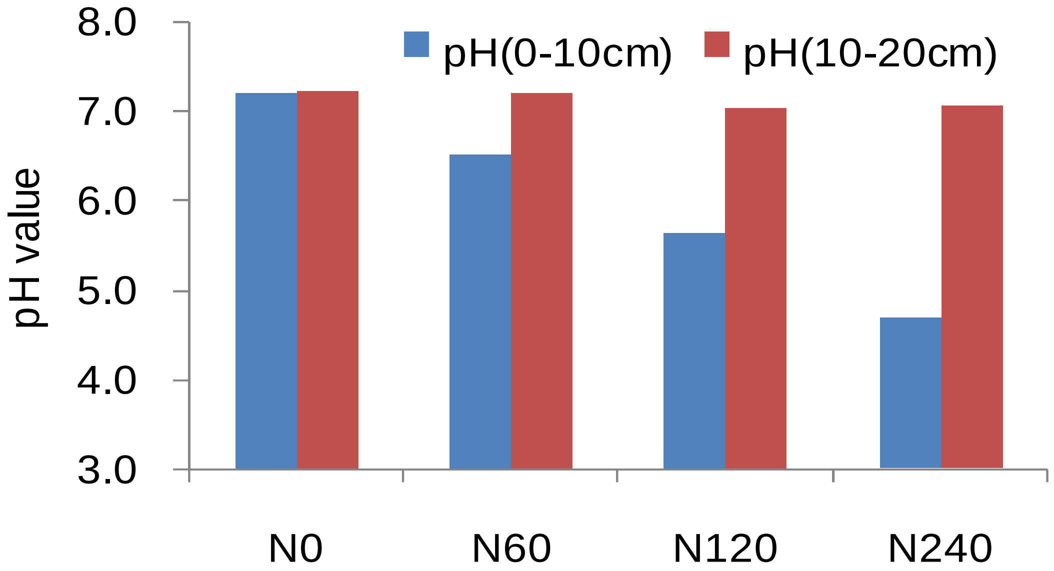
YUANHE YANG*†‡, CHENGJUN JI*, WENHONG MA§, SHIFENG WANG‡, SHAOPENG WANG*, WENXUAN HAN¶, ANWAR MOHAMMAT||, DAVID ROBINSON‡ and PETE SMITH‡



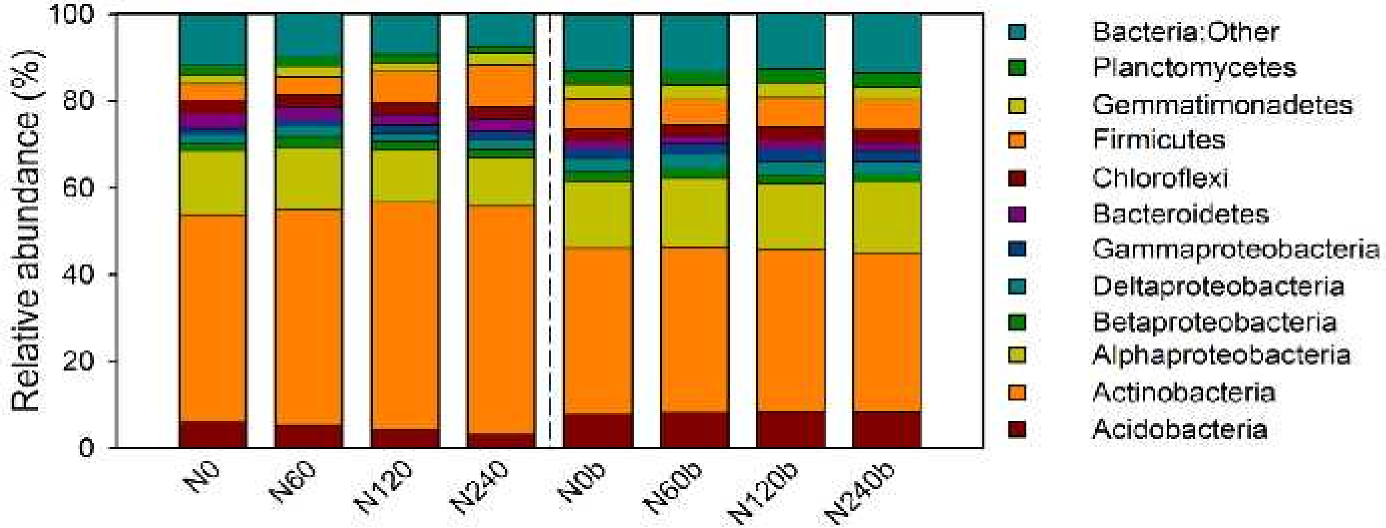
Mean pH decrease: 0.63 units

(Yang et al., 2012. GCB)

Continuous N addition led to significant soil acidification and changes in microorganism communities



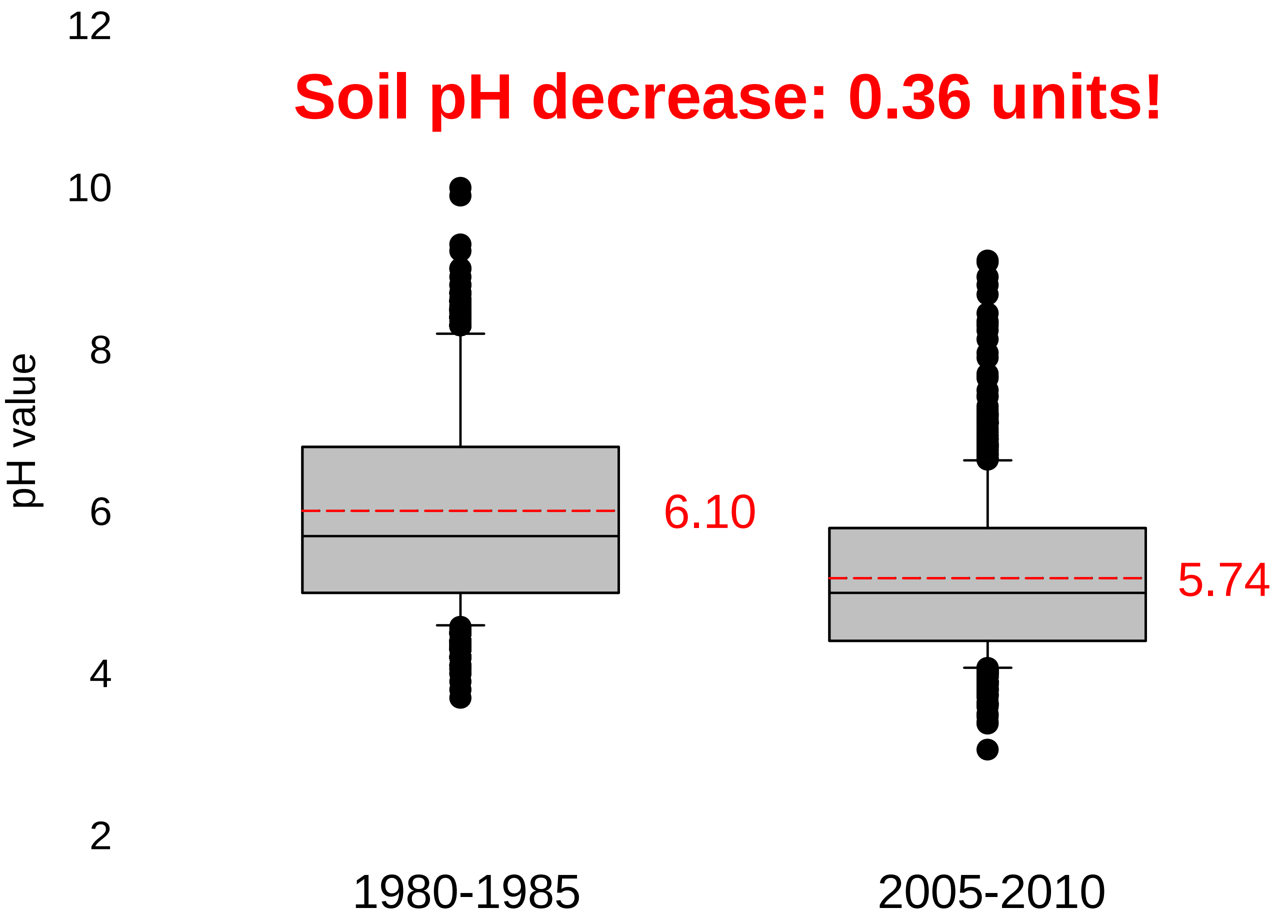
(Duolun, Inner Mongolia, China)



Topsoil (0-10 cm) **Subsoil (10-20 cm)**

(Zeng et al., 2016. SBB)


Atmospheric Environment 146 (2016) 215–222
Contents lists available at ScienceDirect
Atmospheric Environment
journal homepage: www.elsevier.com/locate/atmosenv
The contribution of atmospheric deposition and forest harvesting to forest soil acidification in China since 1980
Qichao Zhu [a, b], Wim De Vries [b, c], Xuejun Liu [a, *], Mufan Zeng [a], Tianxiang Hao [a], Enzai Du [d], Fusuo Zhang [a], Jianbo Shen [a]



Number of data：1679 3919

Atmospheric deposition contributes to 84% of H^+ production in forest soils.

(Zhu et al. 2016. AE)

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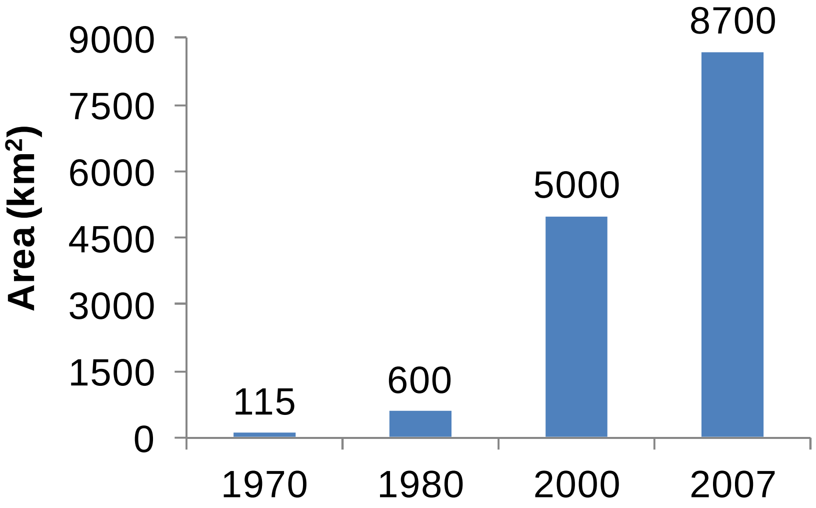
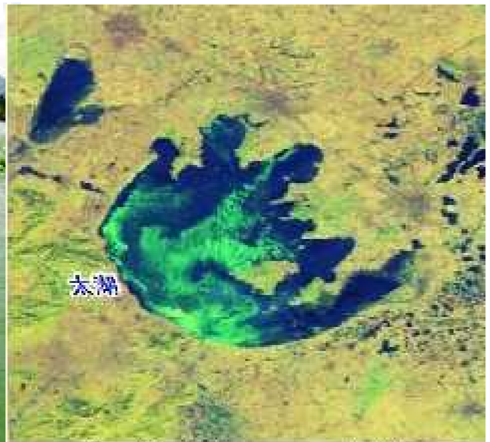
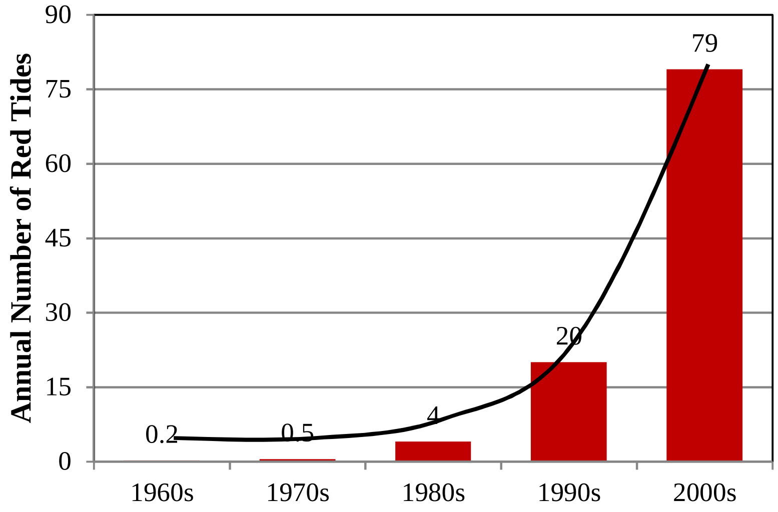
China's eutrophied lake area has increased from 135 (1970) to 8700 km^2 (2007).



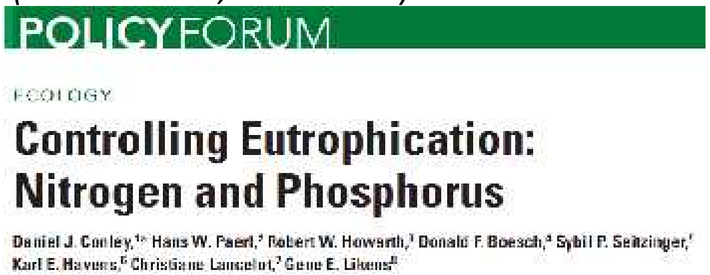
(Jin, 2009)





(the State Oceanic Administration, 2009)

(Science 2009, 1014-1015)


POLICY FORUM

ECOLOGY

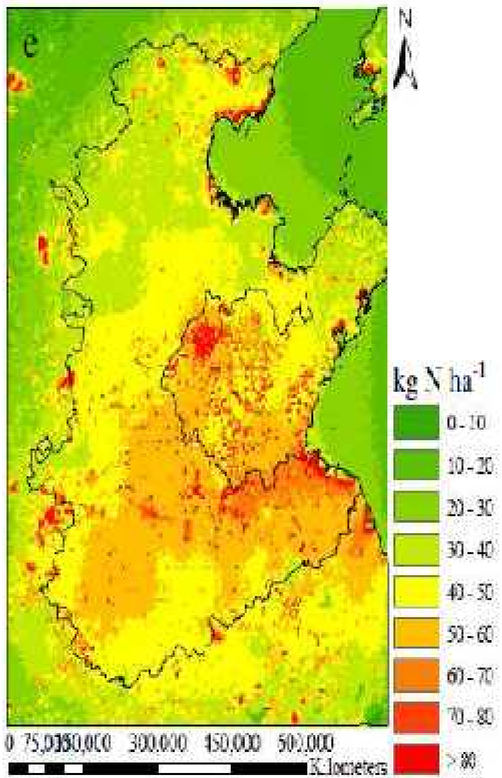
Controlling Eutrophication: Nitrogen and Phosphorus

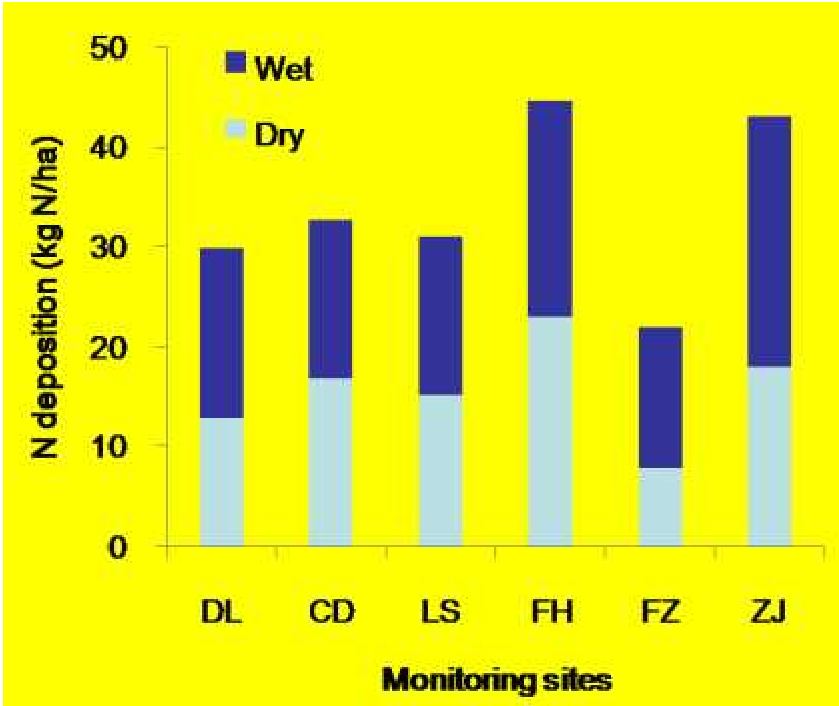
Daniel J. Conley, Hans W. Paerl, Robert W. Howarth, Donald F. Boesch, Sybil P. Seitzinger, Karl E. Havens, Christiane Lancelot, Gene E. Likens

N deposition onto coastal seas of China

Total N deposition to Bohai Sea: 22 kg N ha^{-1} yr^{-1}

Annual N deposition in coastal zone: 34 kg N ha^{-1}





Assuming half of coastal N deposition rate (¼17 kg N/ha) onto Bohai, Yellow, East China and South China Seas (3ò10^6 km^2), total N deposition amounts to 5 Tg N yr^{-1} to the 4 marine ecosystems surrounding China.

(Zhang et al., 2013; Luo et al., 2014)

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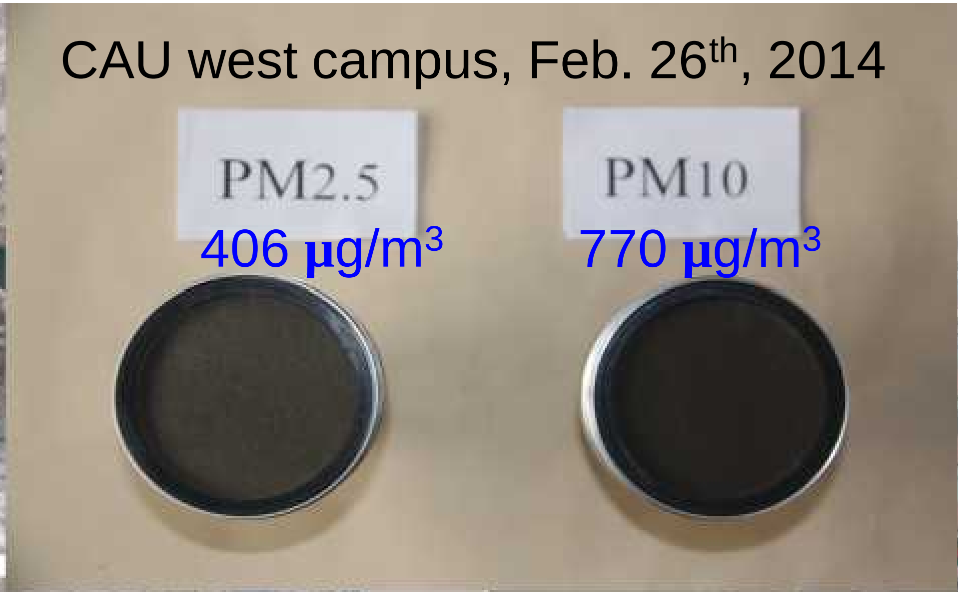
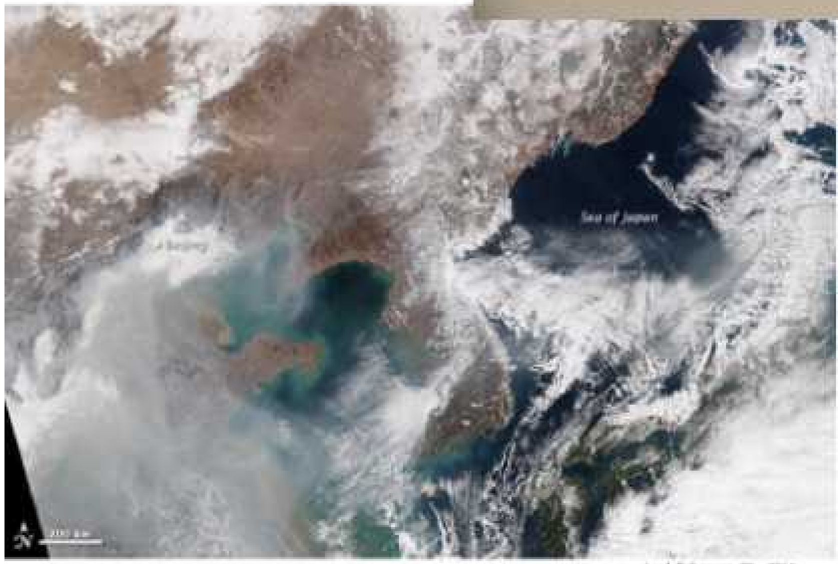
Beijing Smog 2014





LETTER

28 FEBRUARY 2013 | VOL 494 | NATURE | 459

doi:10.1038/nature11917

Enhanced nitrogen deposition over China

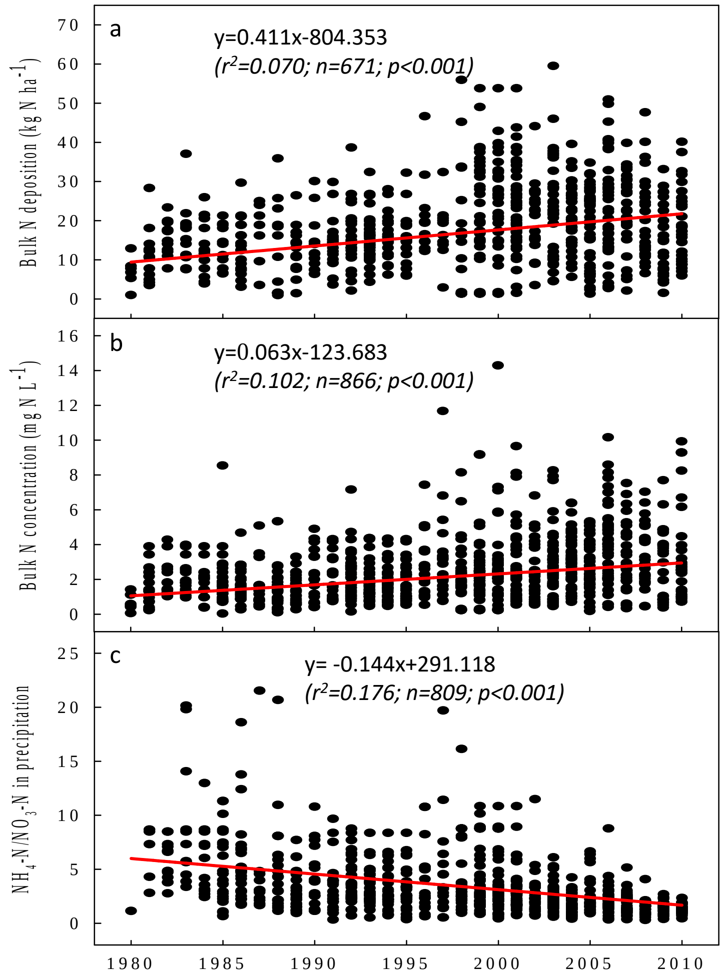
Xuejun Liu[1*], Ying Zhang[1*], Wenxuan Han[1], Aohan Tang[1], Jianlin Shen[1], Zhenling Cui[1], Peter Vitousek[2], Jan Willem Erisman[3,4], Keith Goulding[5], Peter Christie[1,6], Andreas Fangmeier[7] & Fusuo Zhang[1]

1980s: 13.2 kg N ha^{-1}

2000s: 21.1 kg N ha^{-1}

Increase: ¼ 8 kg N ha^{-1} or 60%

(Liu and Zhang et al., 2013. Nature 294: 259-262)



LETTER doi:10.1038/nature13774

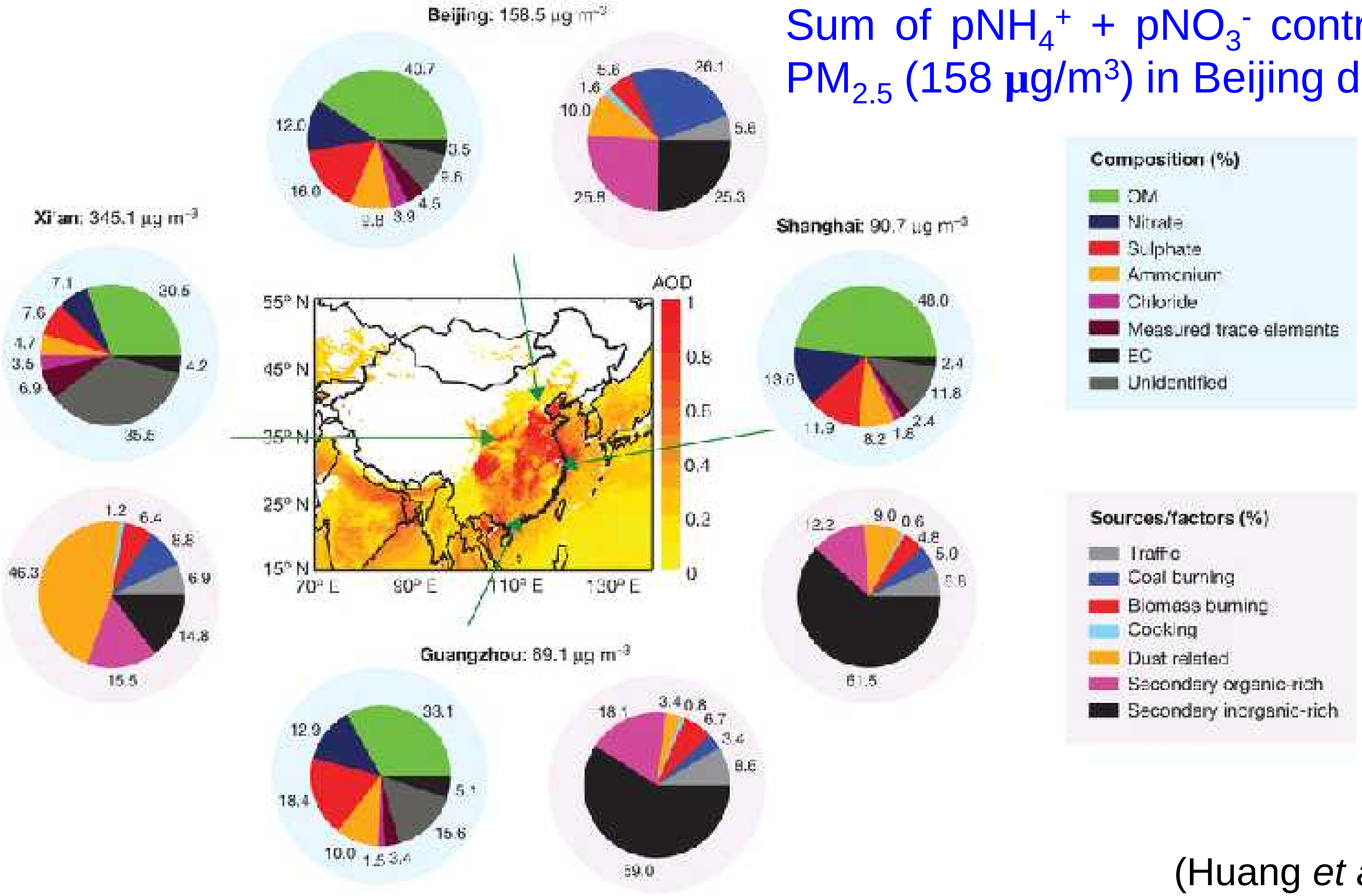
Nature

High secondary aerosol contribution to particulate pollution during haze events in China

Ru-Jin Huang, Yanlin Zhang, Carlo Bozzetti, Kin-Fai Ho, Jun-Ji Cao, Yongming Han, Kaspar R. Daellenbach, Jay G. Slowik, Stephen M. Platt, Francesco Canonaco, Peter Zotter, Robert Wolf, Simone M. Pieber, Emily A. Bruns, Monica Crippa, Giancarlo Ciarelli, Andrea Piazzalunga, Margit Schwikowski, Gülcin Abbaszade, Jürgen Schnelle-Kreis, Ralf Zimmermann, Zhisheng An, Sönke Szidat, Urs Baltensperger, Imad El Haddad & André S. H. Prévôt

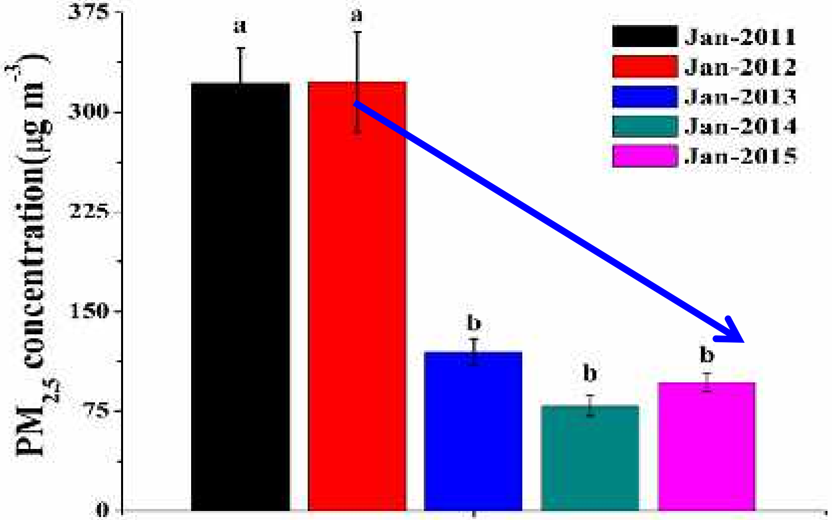
Chemical composition and **source apportionment** of $PM_{2.5}$ during the high pollution events of 5–25 January 2013 in Beijing, Shanghai, Guangzhou and Xi'An cities

Sum of pNH_4^+ + pNO_3^- contributed to 23% of $PM_{2.5}$ (158 µg/m³) in Beijing during Jan. 2013.

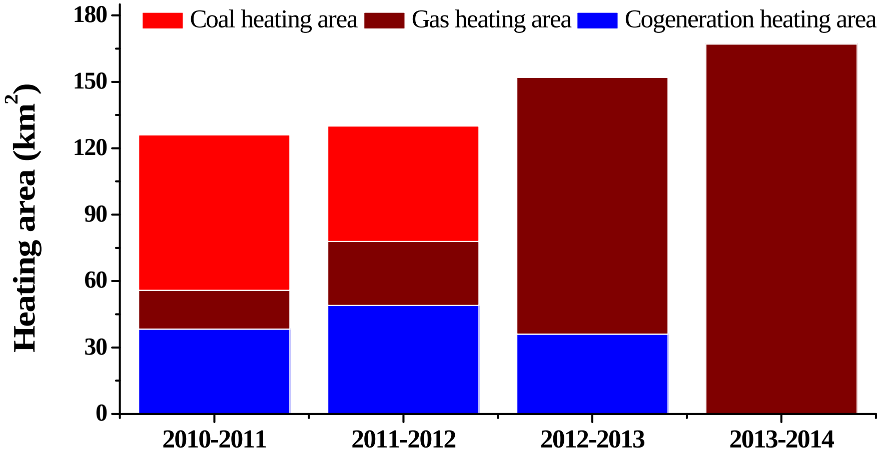


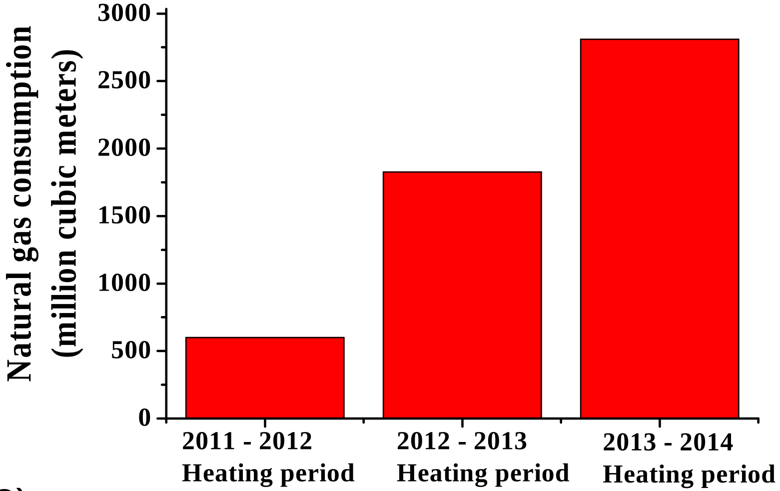
(Huang *et al., 2014.* Nature)

A successful example at Urumqi: Shift of coal to natural gas for heating



N dry deposition decreased from 26 kg N ha^{-1} (2012) to 16 kg N ha^{-1} (2015).





(Song et al., 2015. EST 49: 2066-2072)

Conclusions and outlook

- Overall N input/output ratio is 43% currently, with an slight increasing trend in recent years;
- Huge regional differences in the trend exist due to various agricultural structure and soil conditions;
- Enhanced N cycling has impacted largely to both agricultural and natural ecosystems, including biodiversity loss, soil acidification, eutrophication, air pollution, etc.;
- Knowledge based practices in improving N use are promising, although barriers still exist.

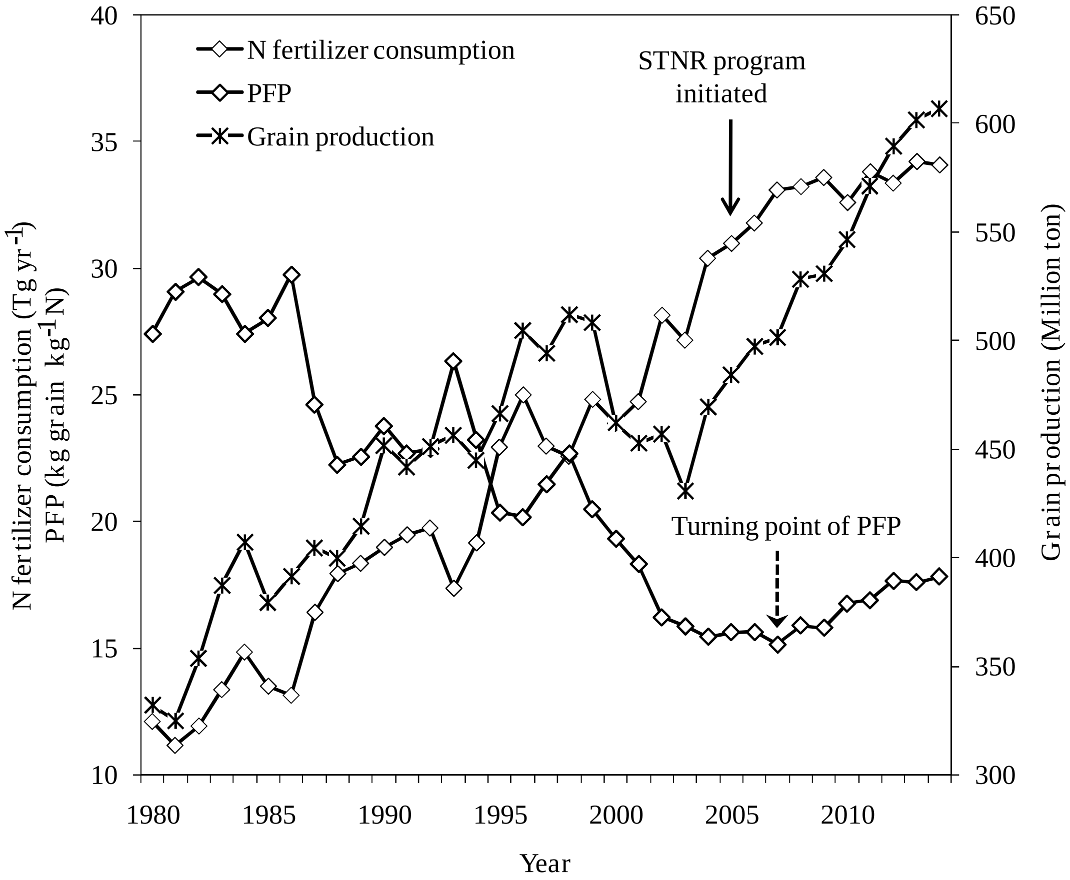
Environmental Science & Technology

Viewpoint

pubs.acs.org/est

Evidence for a Historic Change Occurring in China

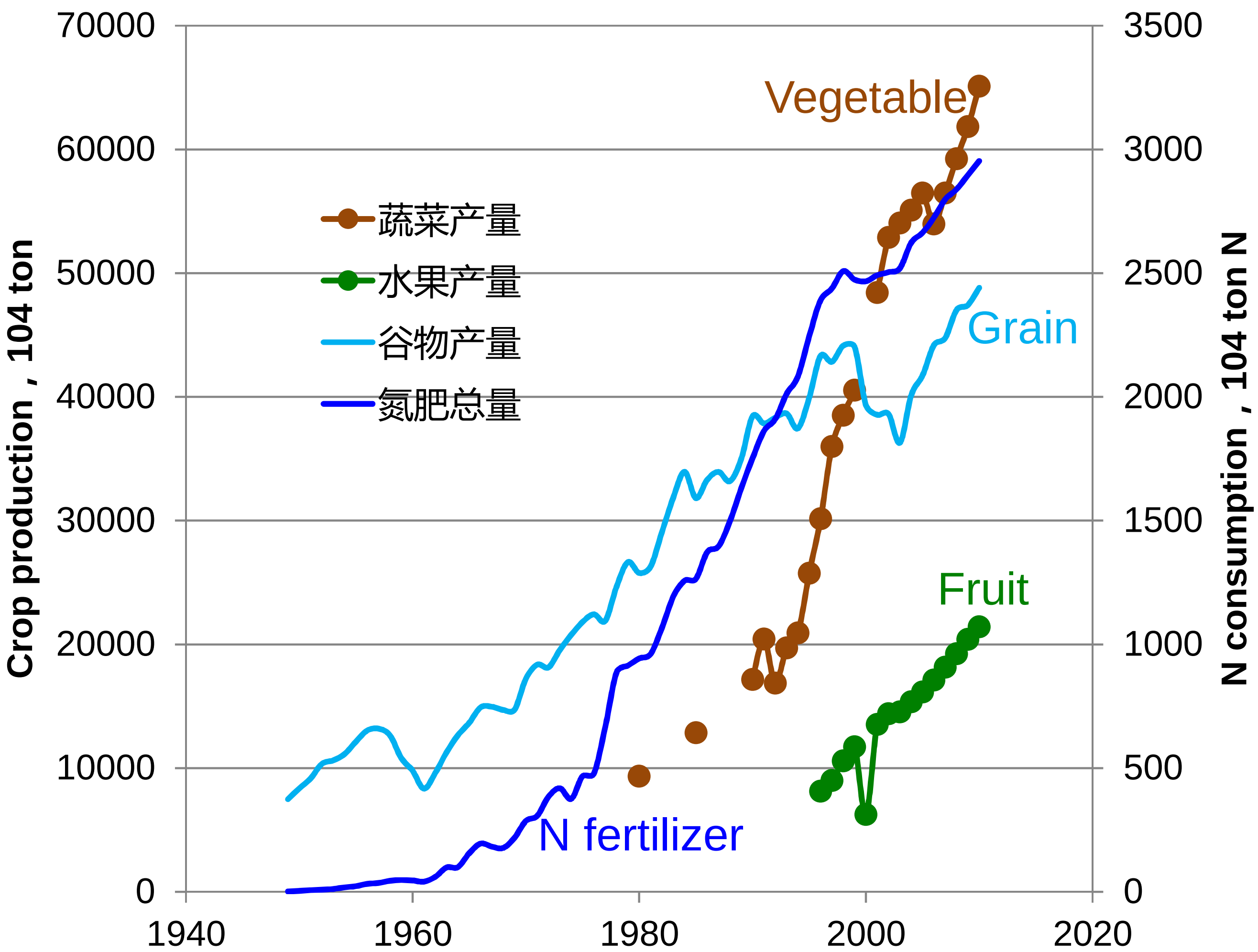
Xuejun Liu,*,† Peter Vitousek,‡ Yunhua Chang,§ Weifeng Zhang,† Pamela Matson,∥ and Fusuo Zhang†



China is now at a historic turning point to increase NUE and crop production meanwhile reducing its N environmental impact.

(Liu et al., 2016. EST)

Thanks for your attention!



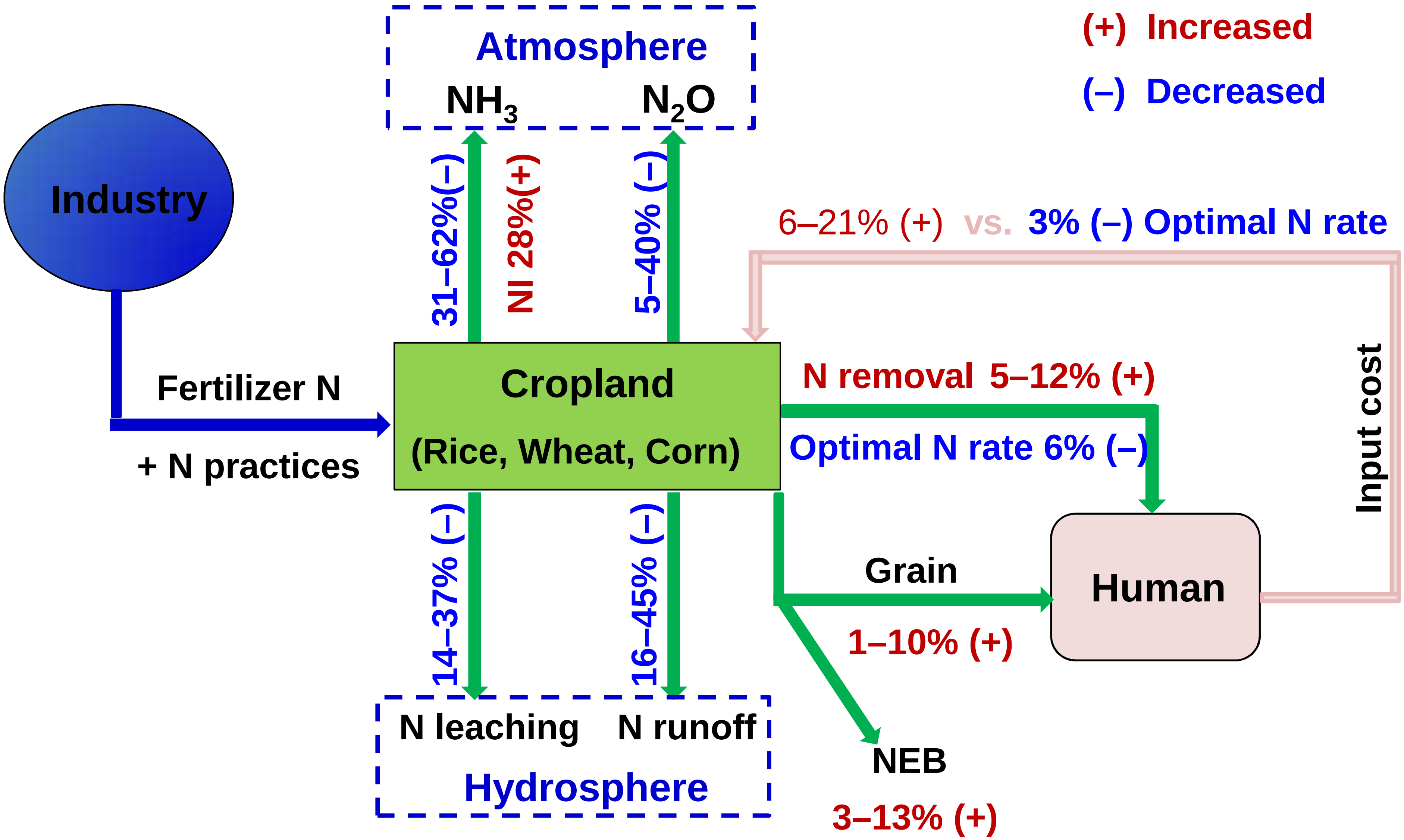
Crop production，104 ton
N consumption，104 ton N
70000
60000
50000
40000
30000
20000
10000
0
3500
3000
2500
2000
1500
1000
500
0
1940
1960
1980
2000
2020
蔬菜产量
水果产量
谷物产量
氮肥总量
Vegetable
Grain
Fruit
N fertilizer

Implementation

County Level Arable Land Resource Management Information System

Developed by
Yangzhou Soil and Fertilizer Station

Overall effects of N practices



Nitrogen input to croplands