The Leaky Nitrogen Cycle Across Scales, from Farms to Food Systems to Ecosystems

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Reducing the Health Impacts of the Nitrogen Problem

A Virtual Workshop from the Environmental Health Matters Initiative

New sessions every Thursday
from 2:30–5:30 PM (ET)
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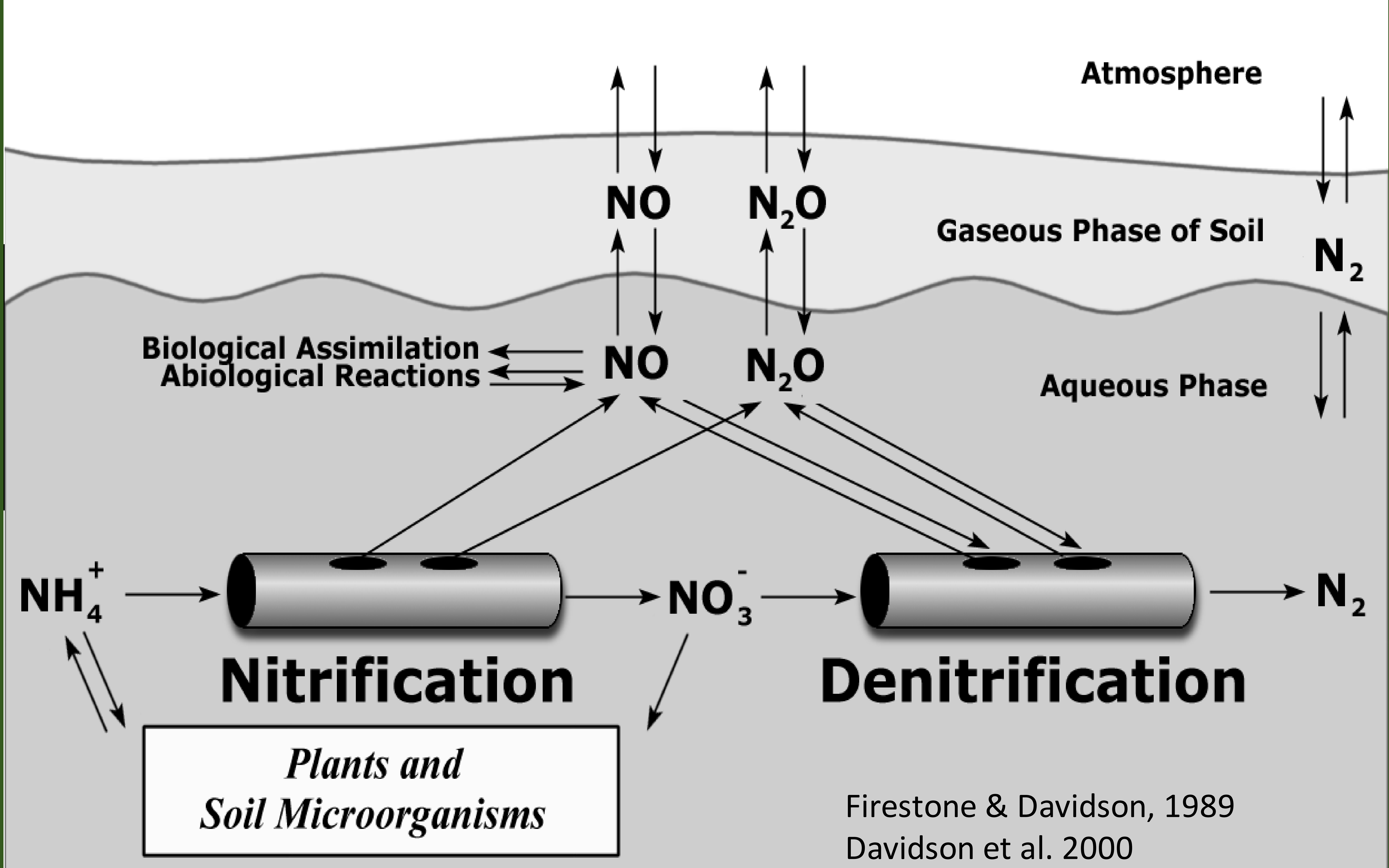
Nitrogen: A Very Leaky Element



Firestone & Davidson, 1989
Davidson et al. 2000

What can we control?

- The ***inputs*** of N into the crop and animal production systems
- The ***efficiency*** of converting those inputs into edible ***crop N*** and animal N products
- The "sizes of the holes" in the production pipeline and when and where they "leak" ***surplus N***
- Engineer treatments of losses at edge of field

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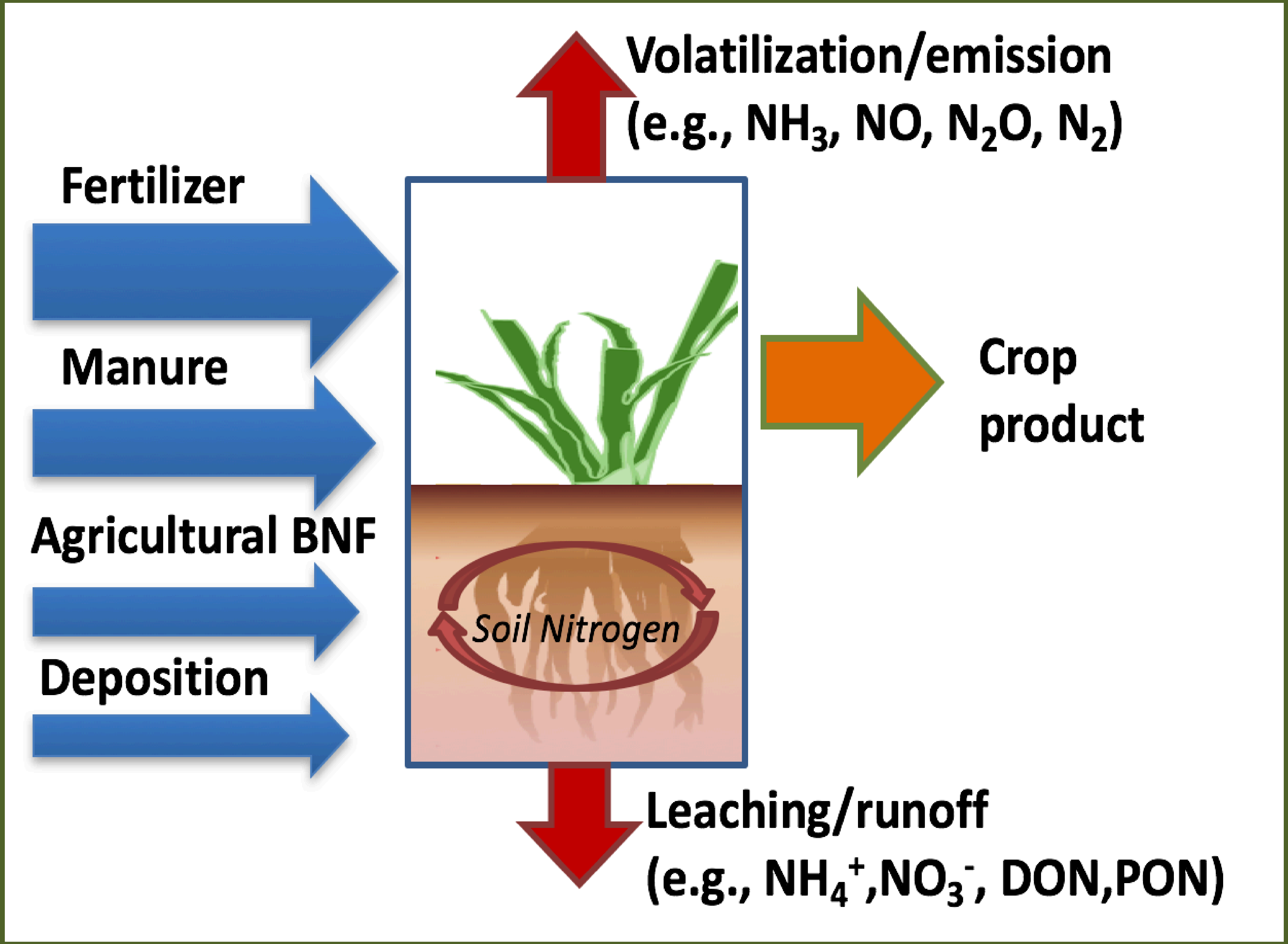
Nitrogen Use Efficiency (NUE) for Crop Production



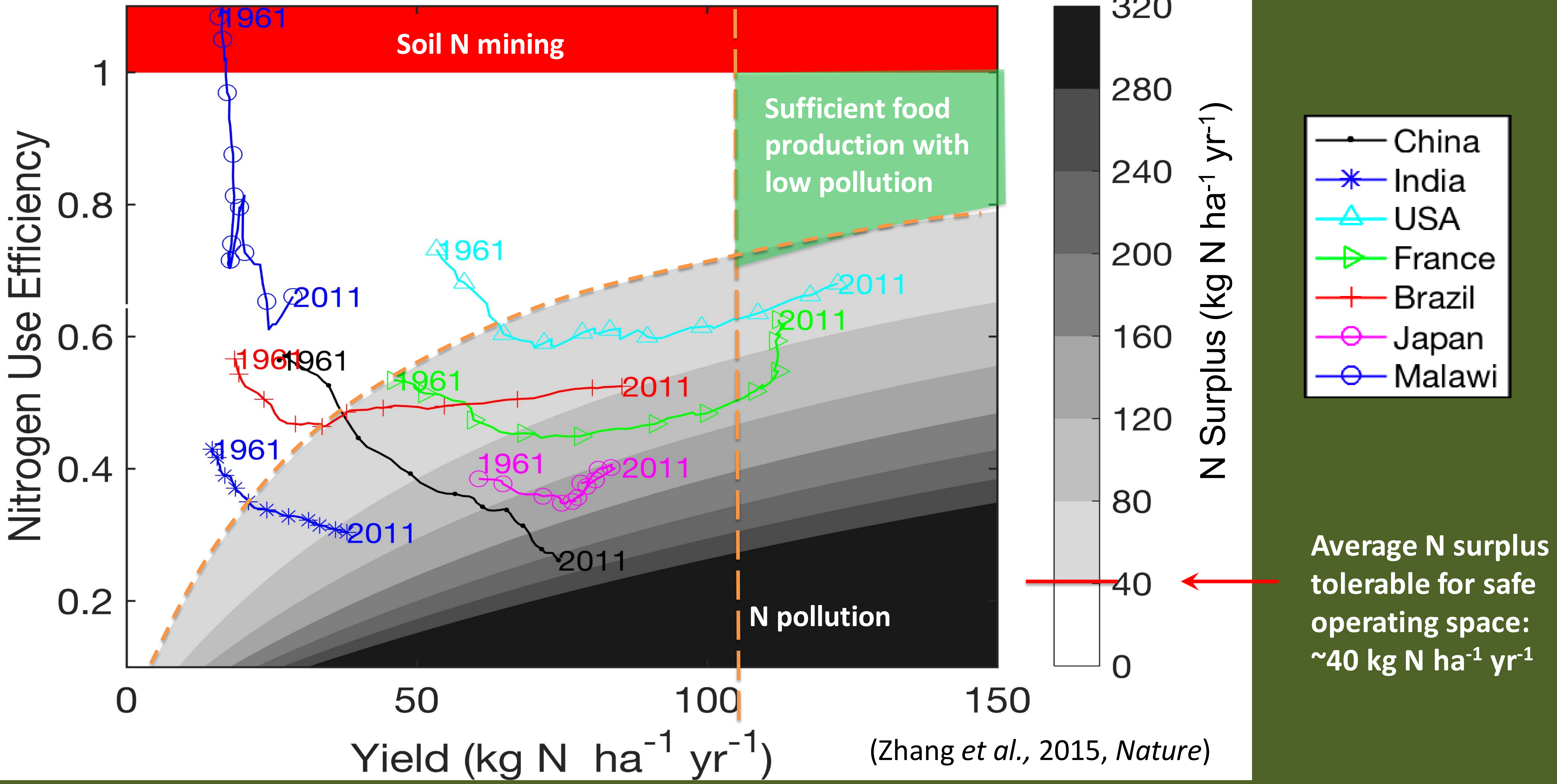
(Zhang *et al.*, 2015, *Nature*)

$$NUE = Crop\ N / Inputs$$

$$N_{sur} = Inputs - Crop\ N$$

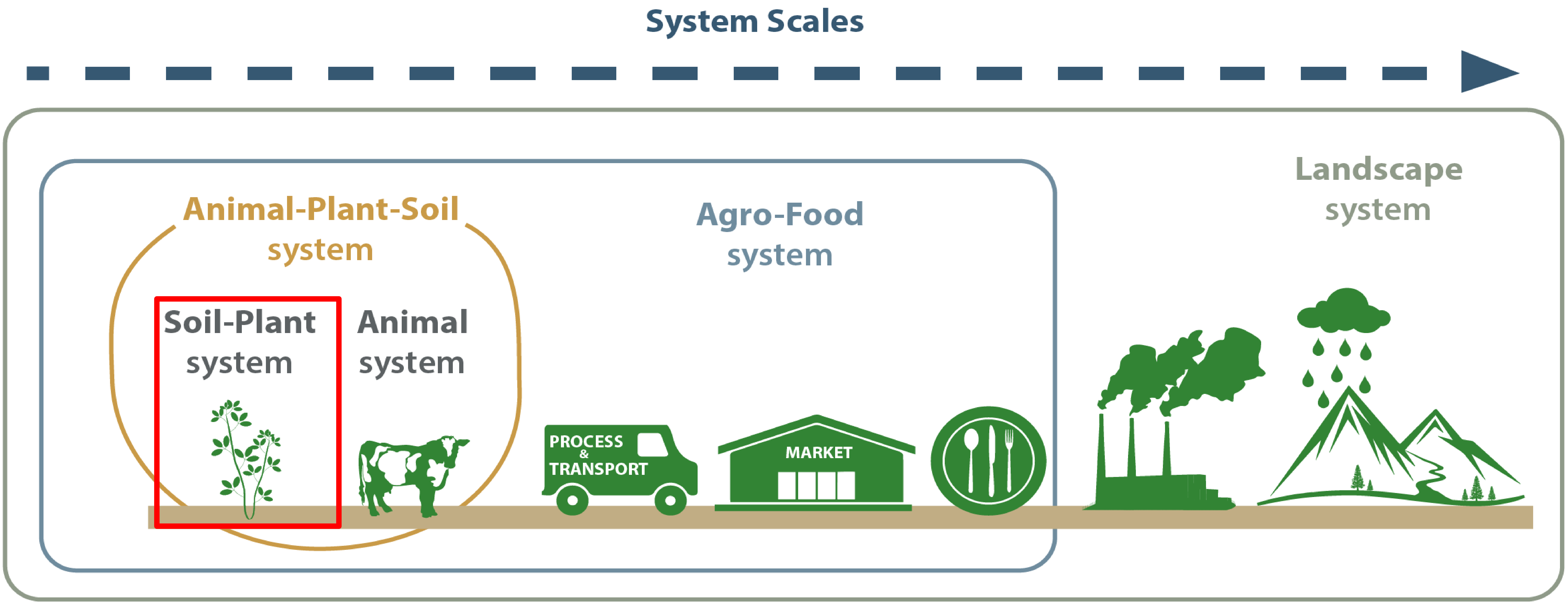
$$N_{sur} = Crop\ N\ (\frac{1}{NUE} - 1)$$

107 Tg N in global crop products needed in 2050 (FAO, 2012)

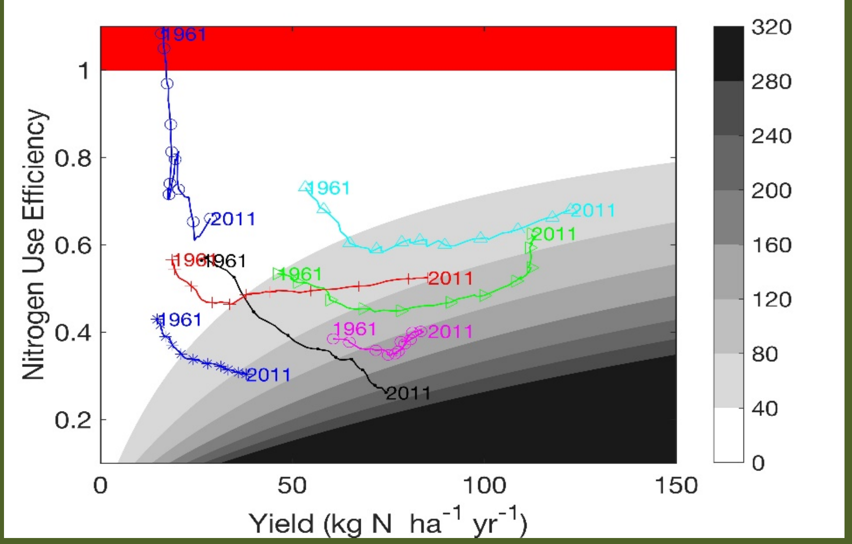


(Zhang *et al.*, 2015, *Nature*)

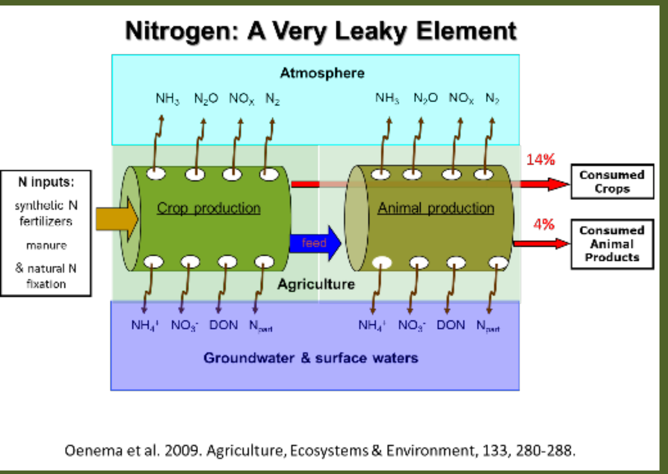
NUE beyond crop production



NUE beyond crop production

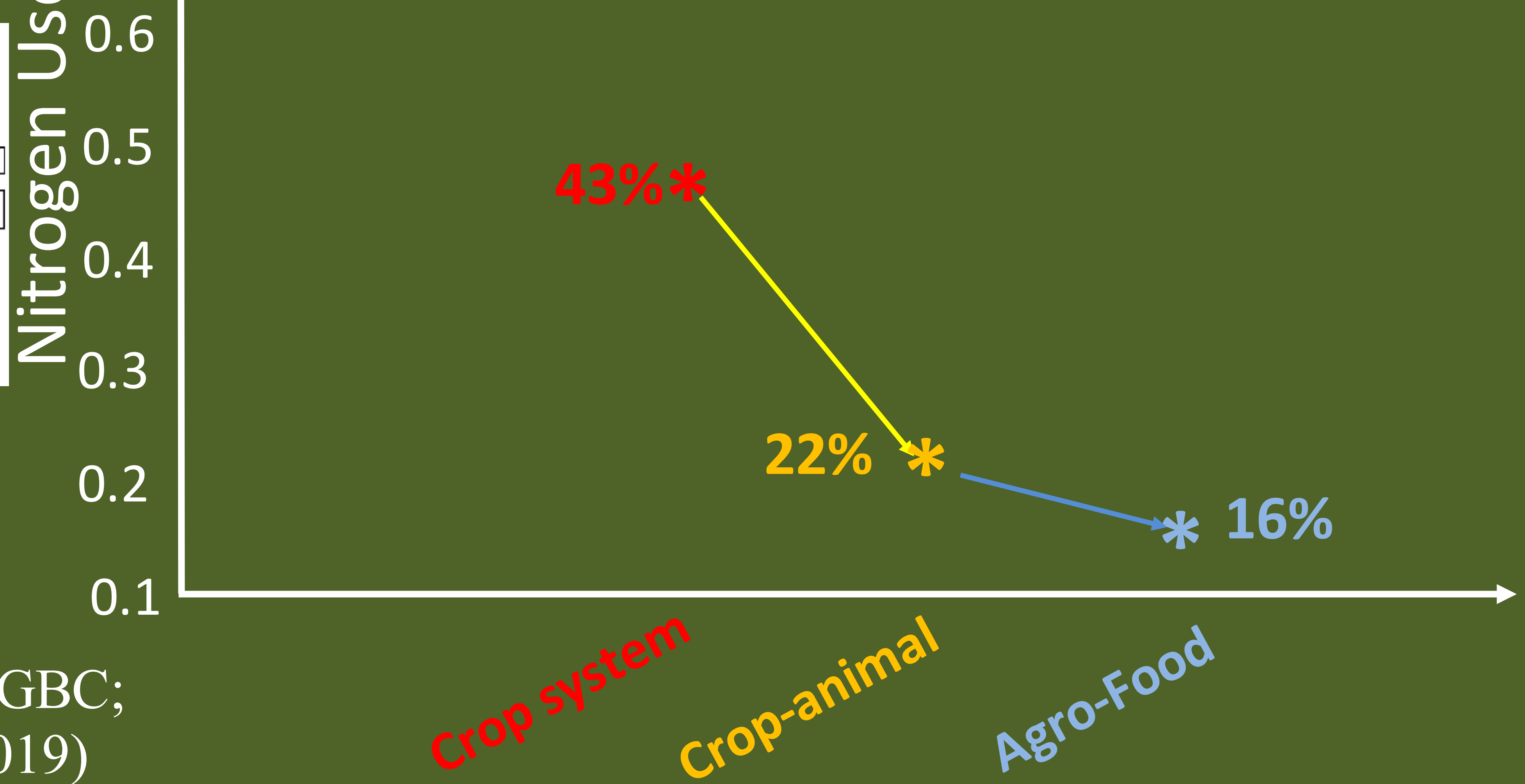


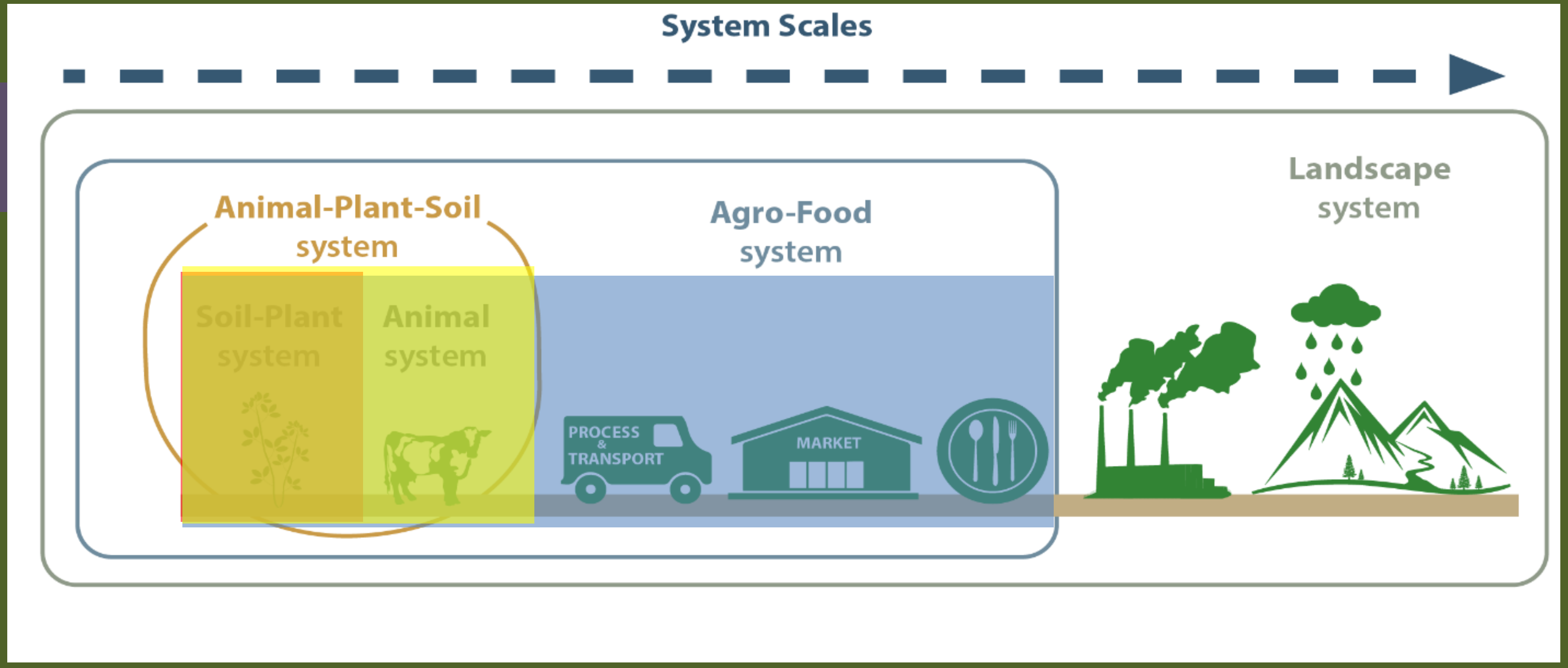
Global average
NUE = 43%



Crop-livestock system has two leaky pipes

(Zhang *et al.*, 2020, GBC; Li & Zhang *et al.*, 2019)





Challenges and opportunities for improving N management

- ➢ Technologies and management practices
- ➢ Market and policy incentives
- ➢ Shifts in crop mix

- ➢ Livestock management
- ➢ Insufficient recycling of livestock manure

- ➢ Food waste throughout the supply chain & by consumers
- ➢ Dietary choices

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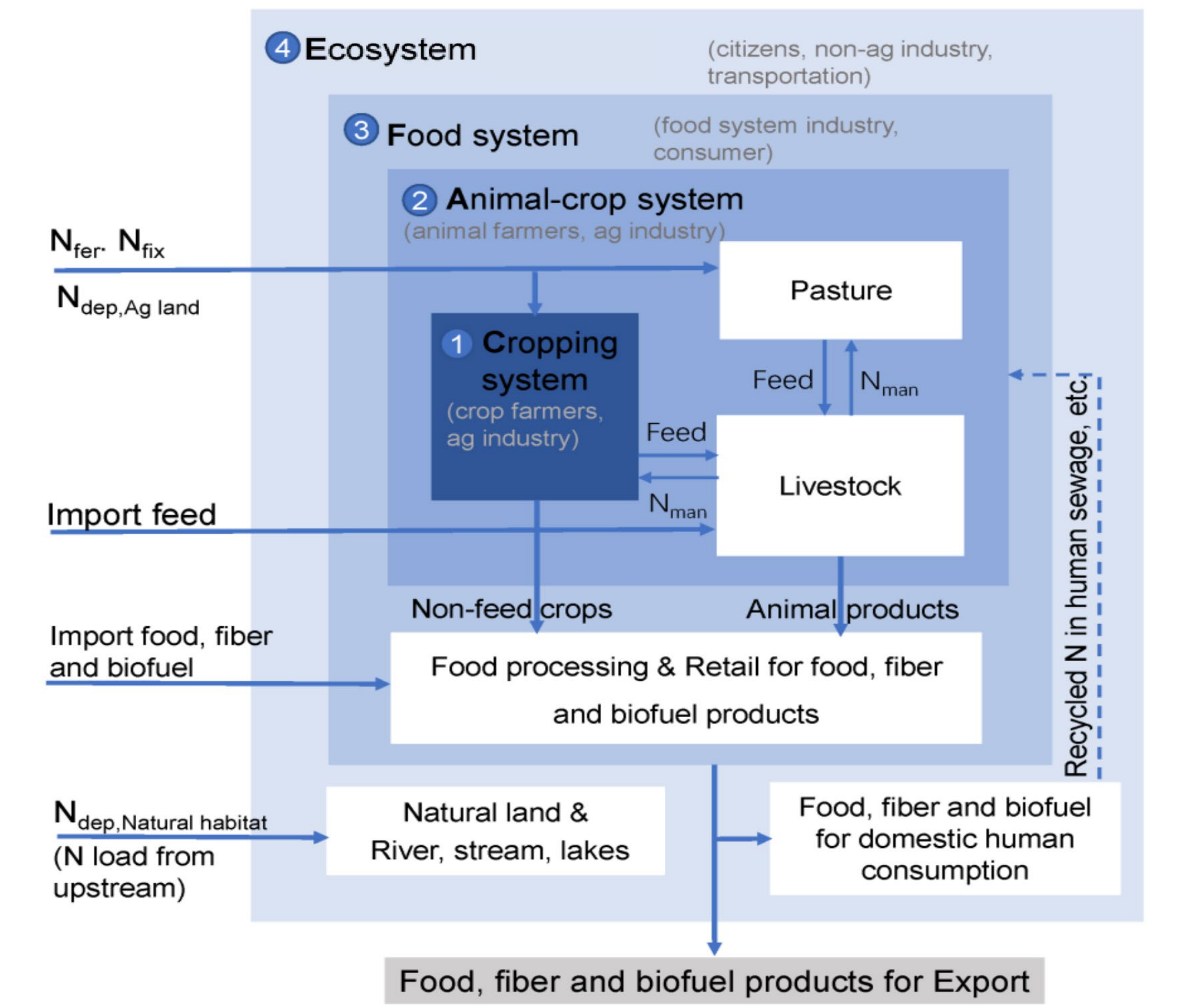
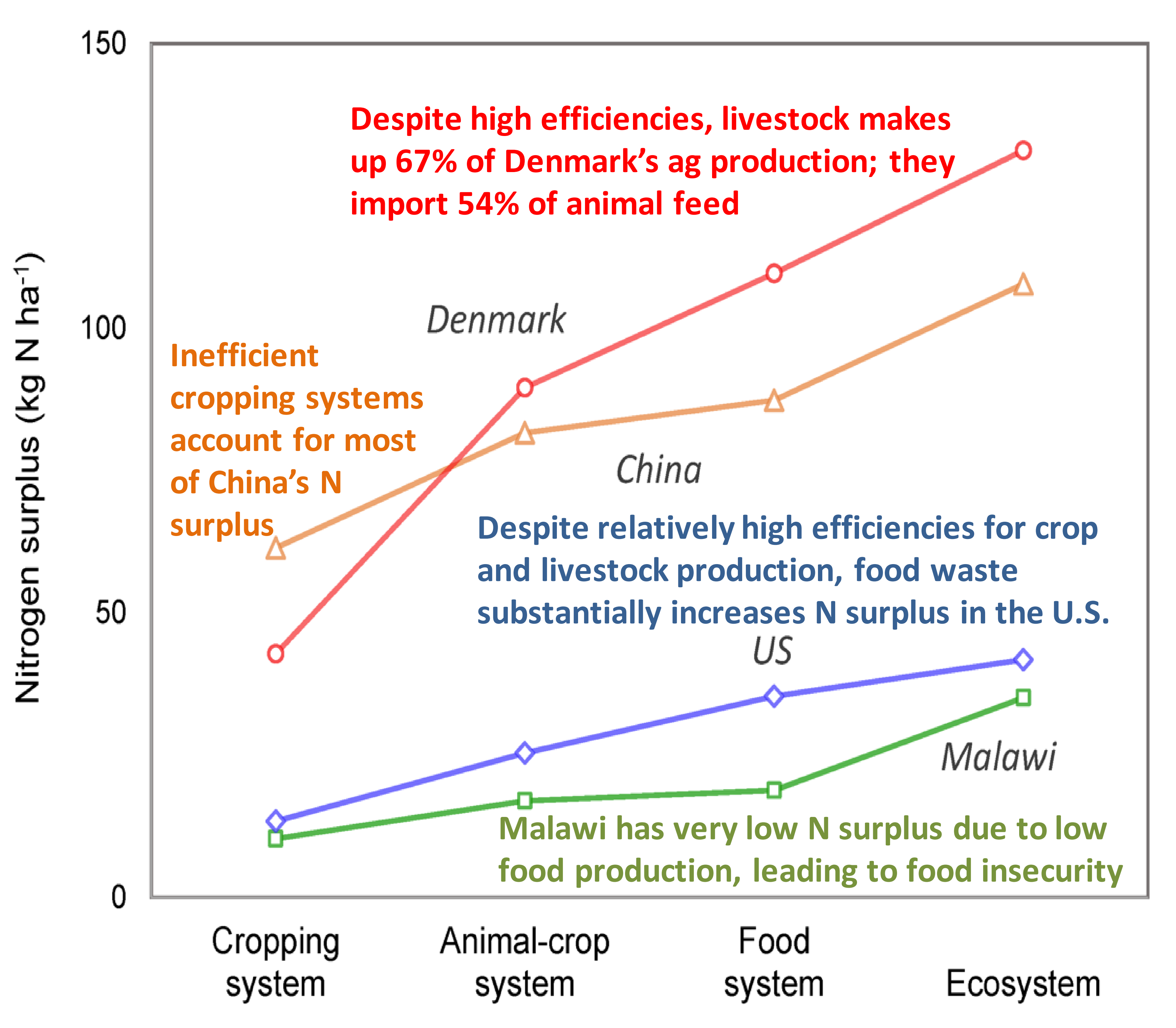
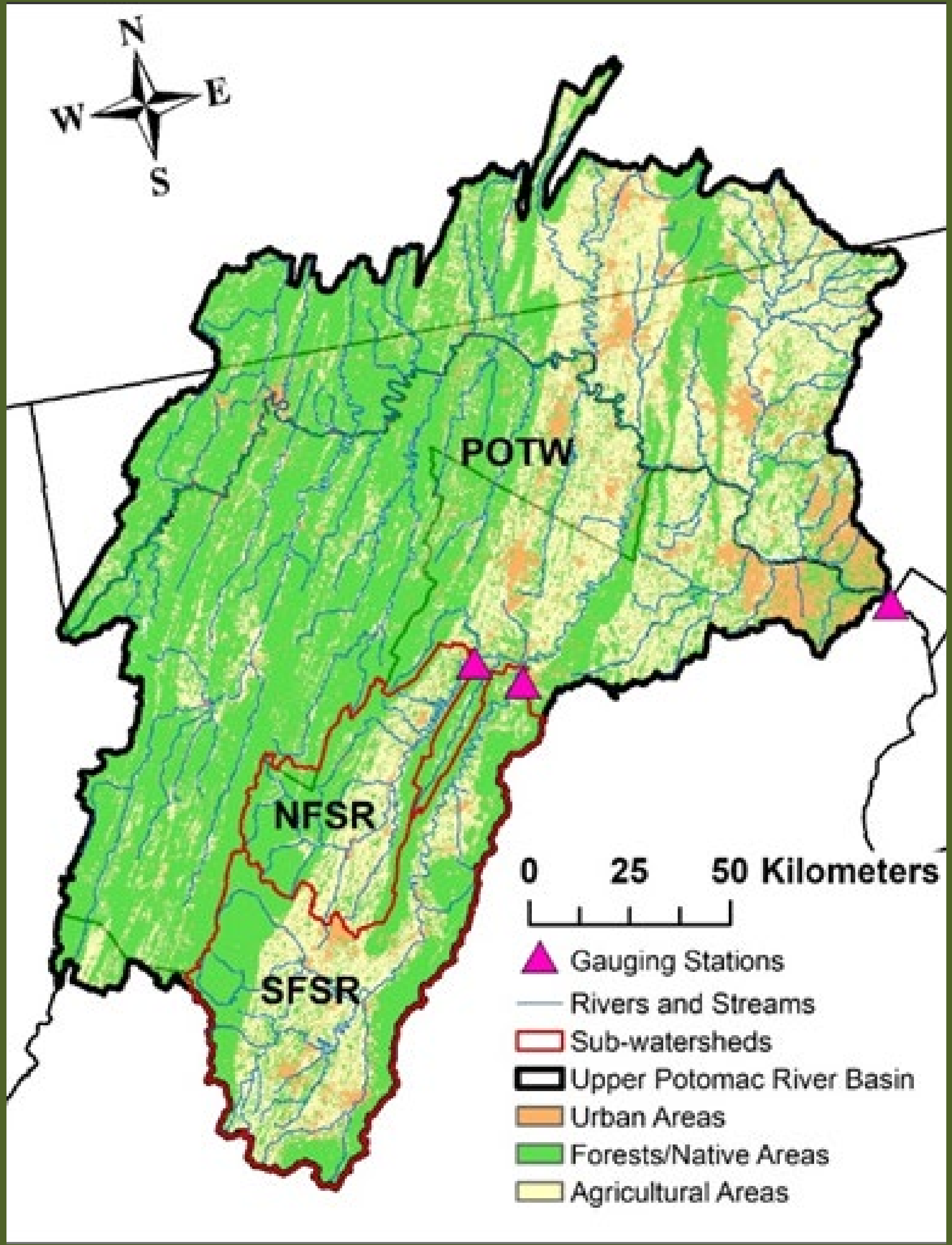
CAFE Framework for nutrient management

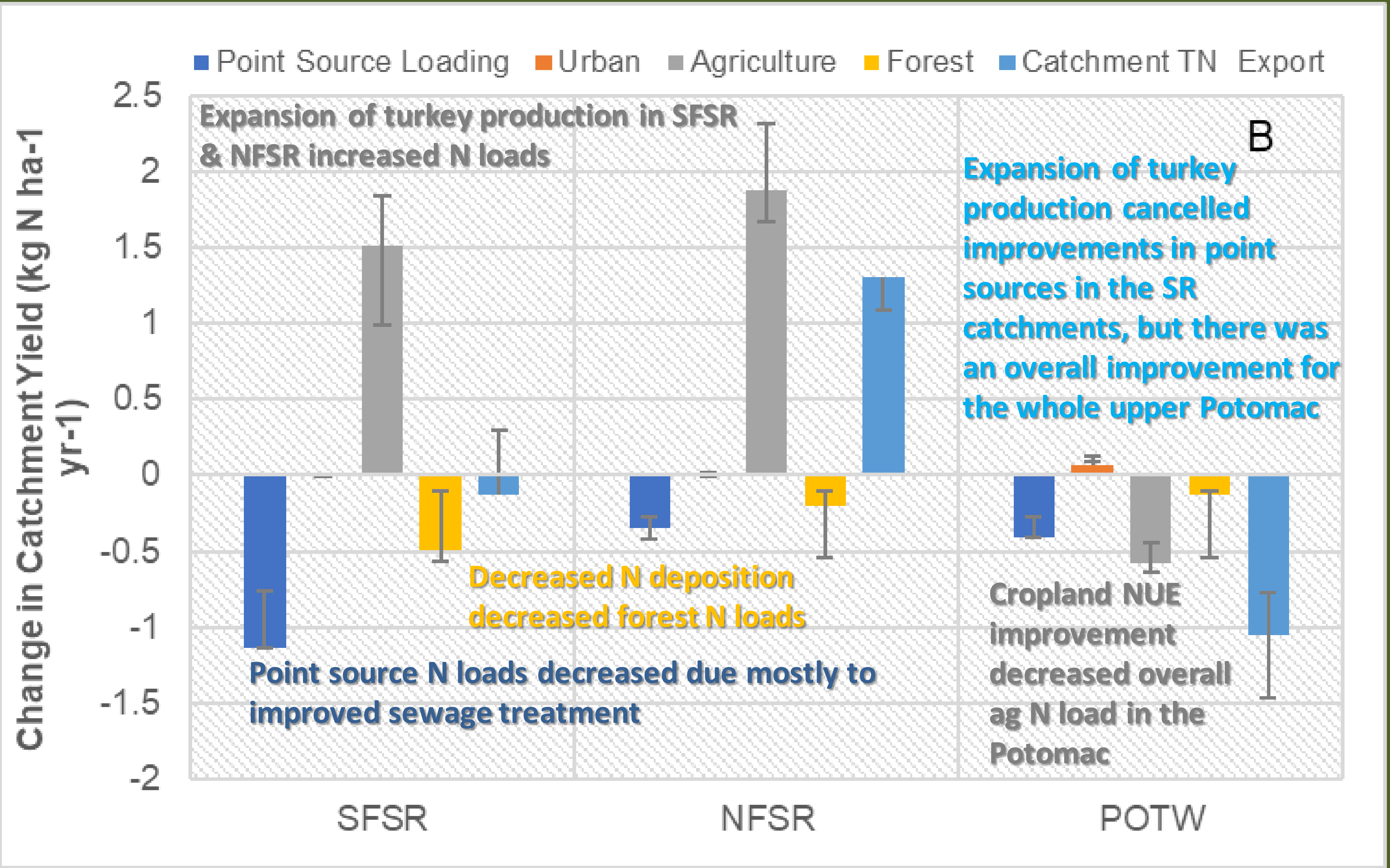




(Li & Zhang *et al.*, in review)



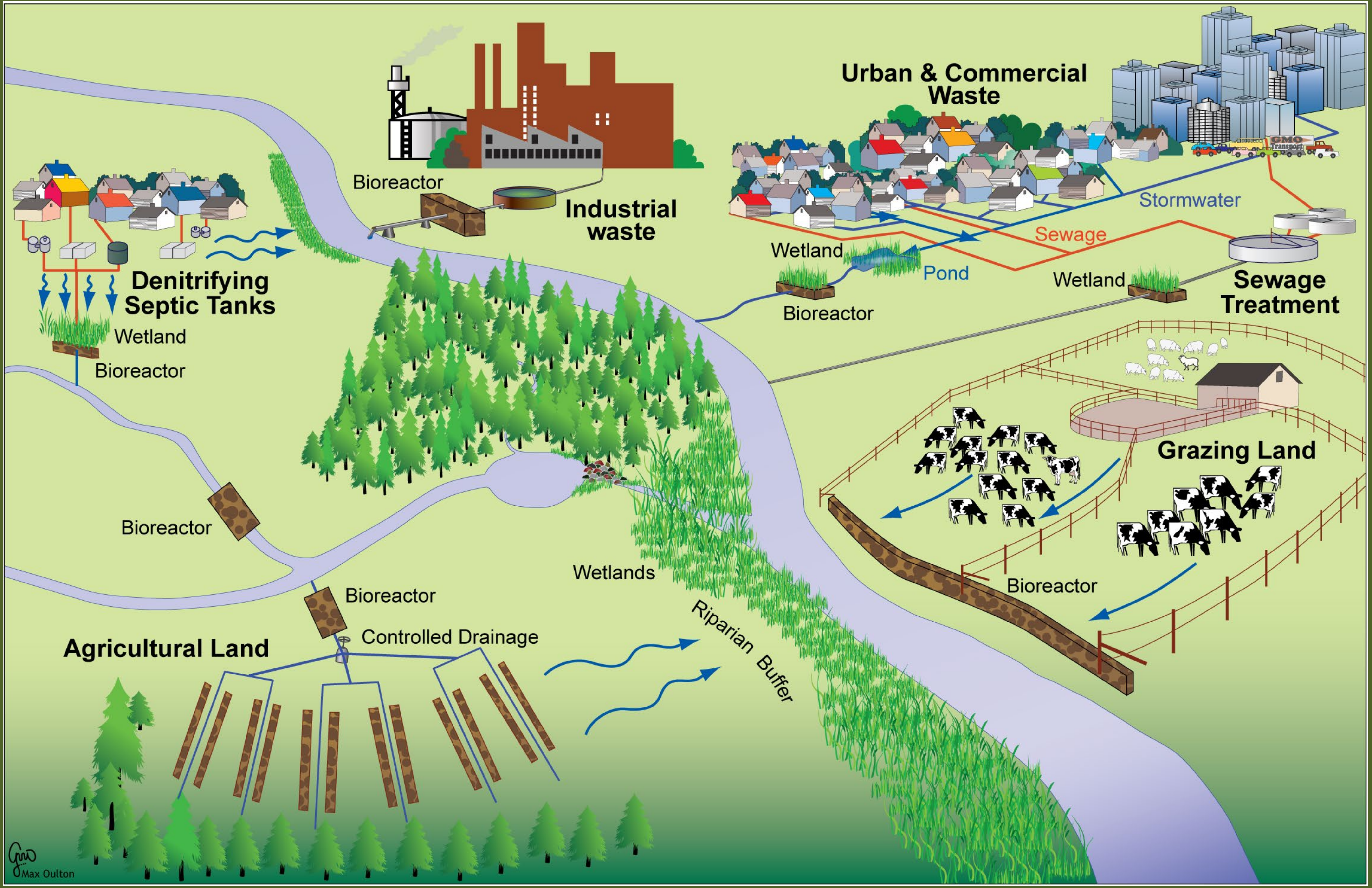
Contributions to Riverine N Load by Sector and Subwatershed



POTW: Upper Potomac River catchment above Chain Bridge near Washington, D.C.
NFSR: North Fork Shenandoah River
SFSR: South Fork Shenandoah River

Estimated change in point and non-point source load contributions to catchment total N yield and export from 1986 to 2012. Sabo et al. in review

Engineering the Fate of Surplus N Lost to Ecosystems



Schipper, Gold, & Davidson. 2010. Managing denitrification in human-dominated landscapes. Ecological Engineering, 36: 1503–1506.

Take home messages

- Inputs, efficiencies, and leaks of N into the environment can be managed
- Efficiencies decline and surpluses increase moving along the Crop-Animal-Food-Ecosystem (CAFE) continuum
- The CAFE framework helps identify the scales where policies may be most effective in mitigating N losses at each scale