Ecosystem services impacts associated with environmental reactive nitrogen release in the US

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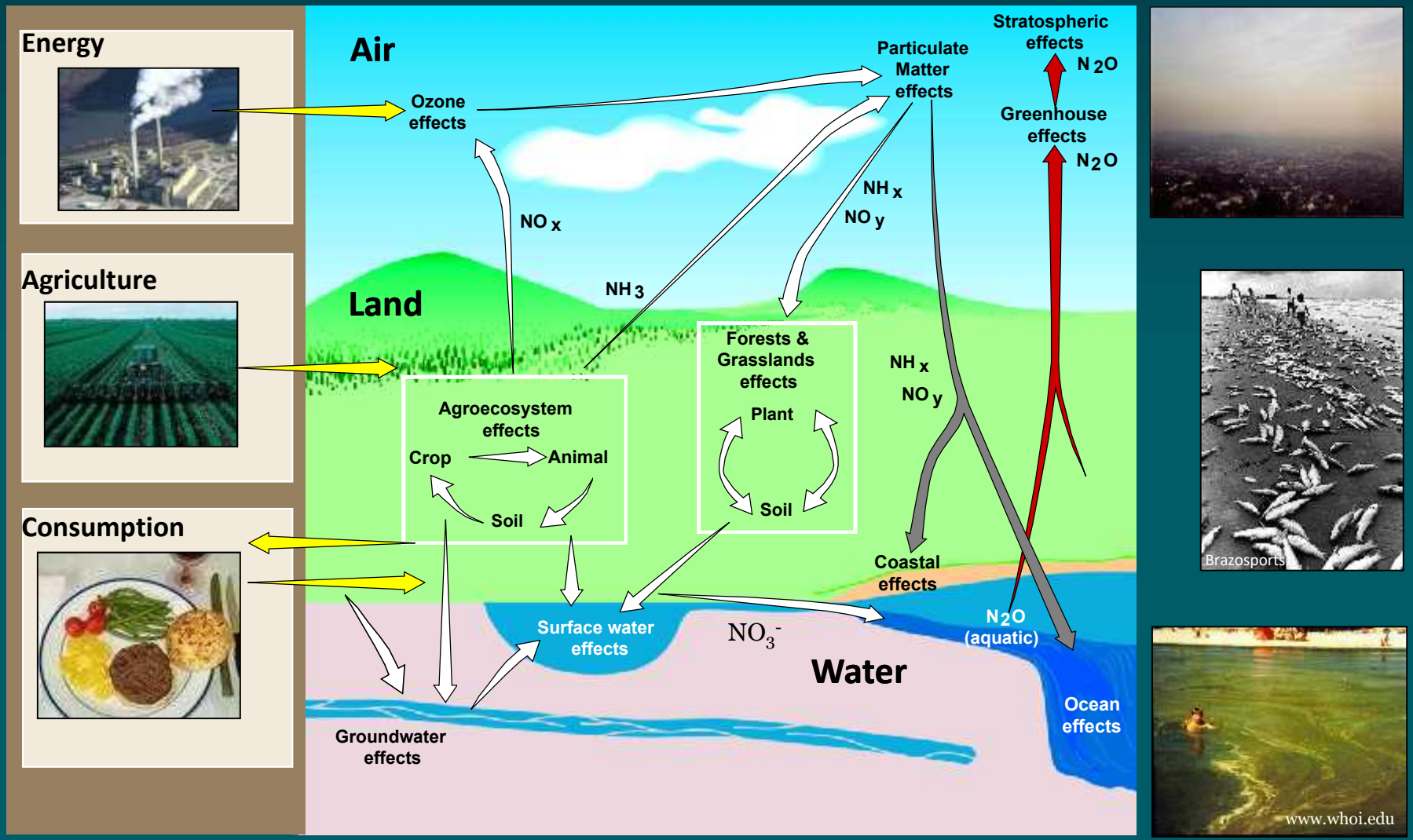
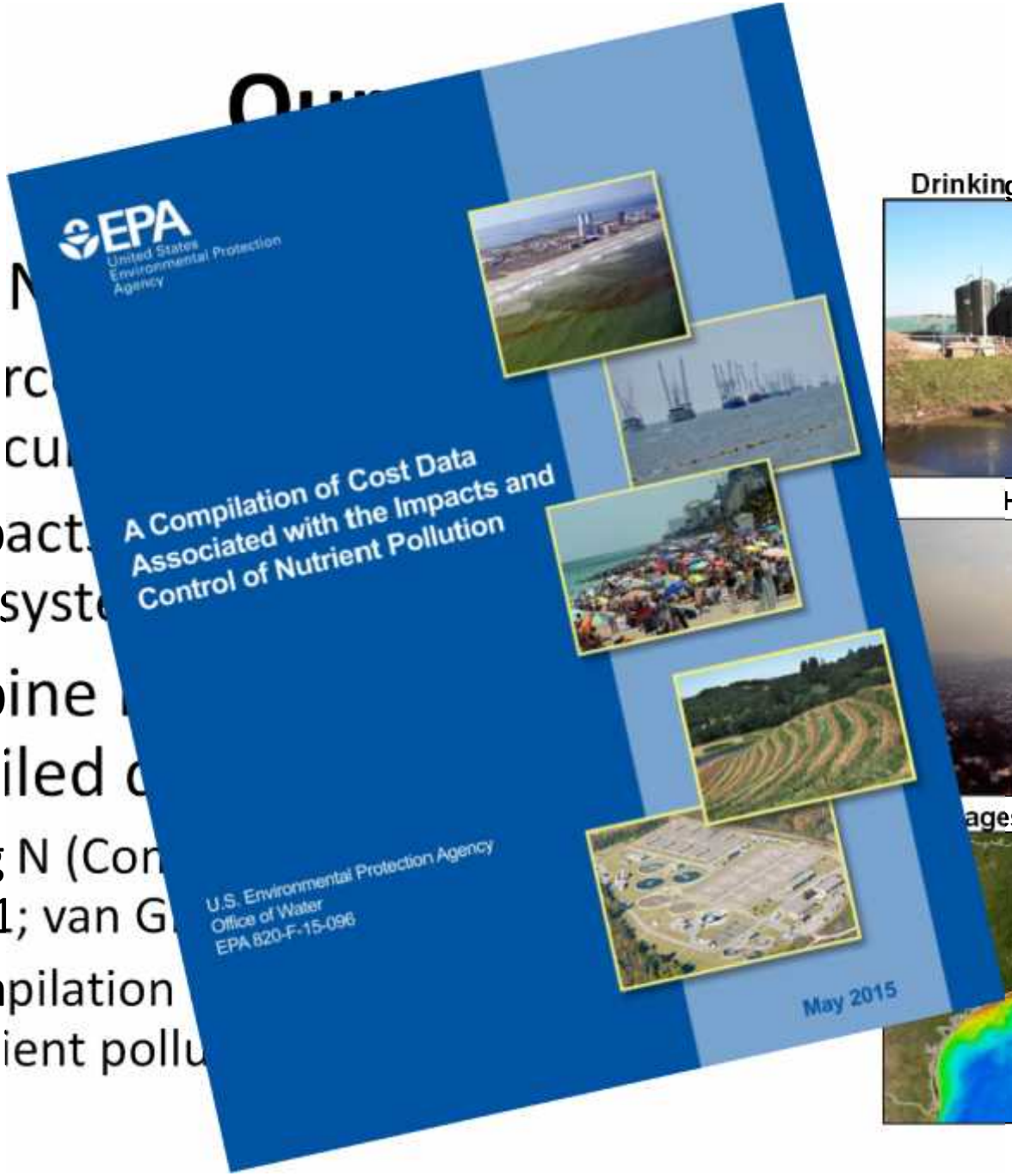
Why N and economics? – The N cascade



Modified from Galloway et al. (2003) and Compton et al. 2011

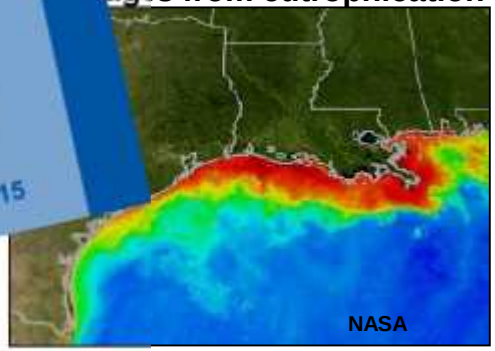
- Trace N
  - Sourc
    agricu
  - Impact
    ecosyst
- Combine
  compiled c
  - $/kg N (Cor
    2011; van G
  - Compilation
    nutrient pollu



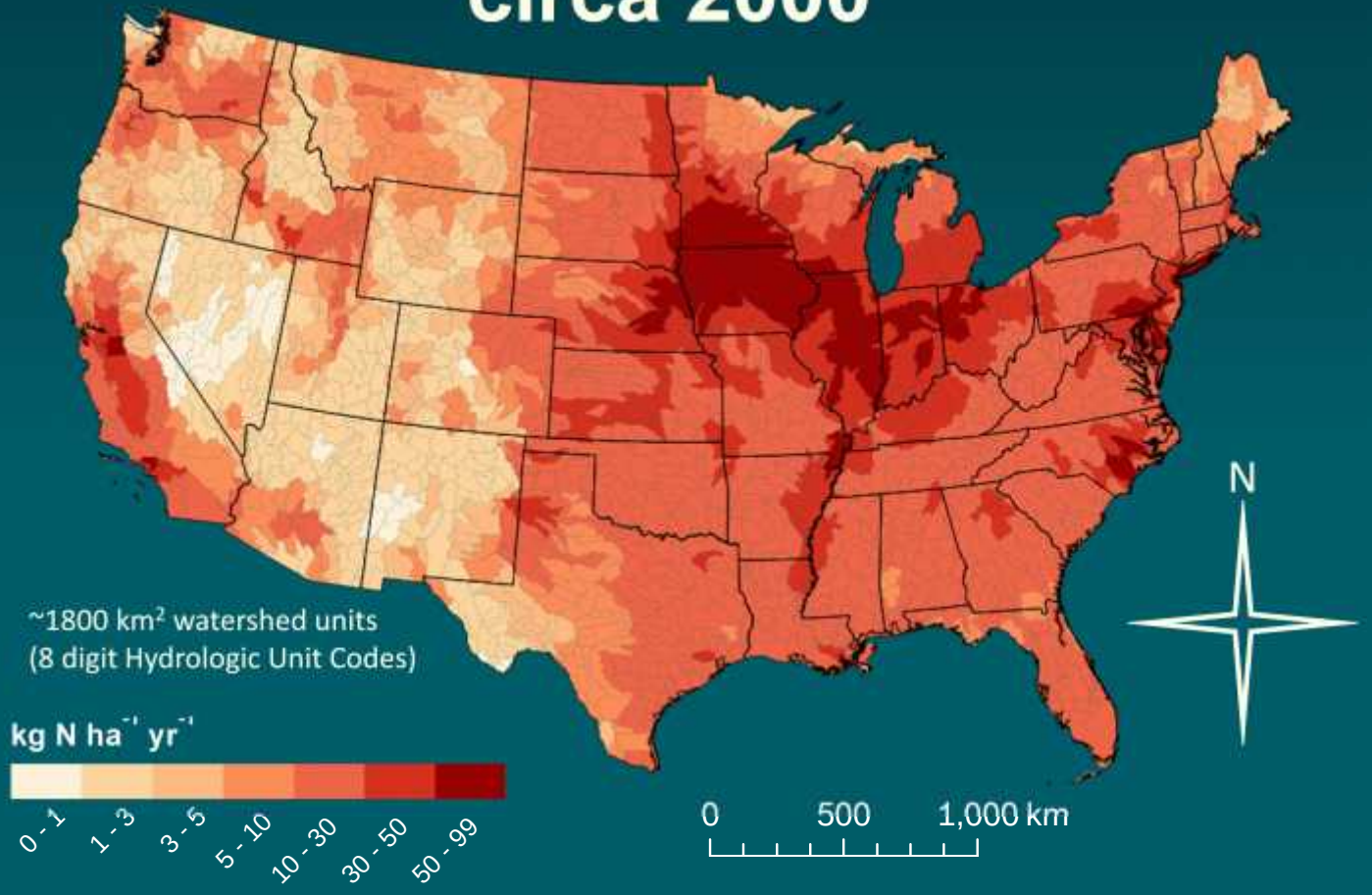
Drinking water contamination

Health effects of smog

ages from eutrophication

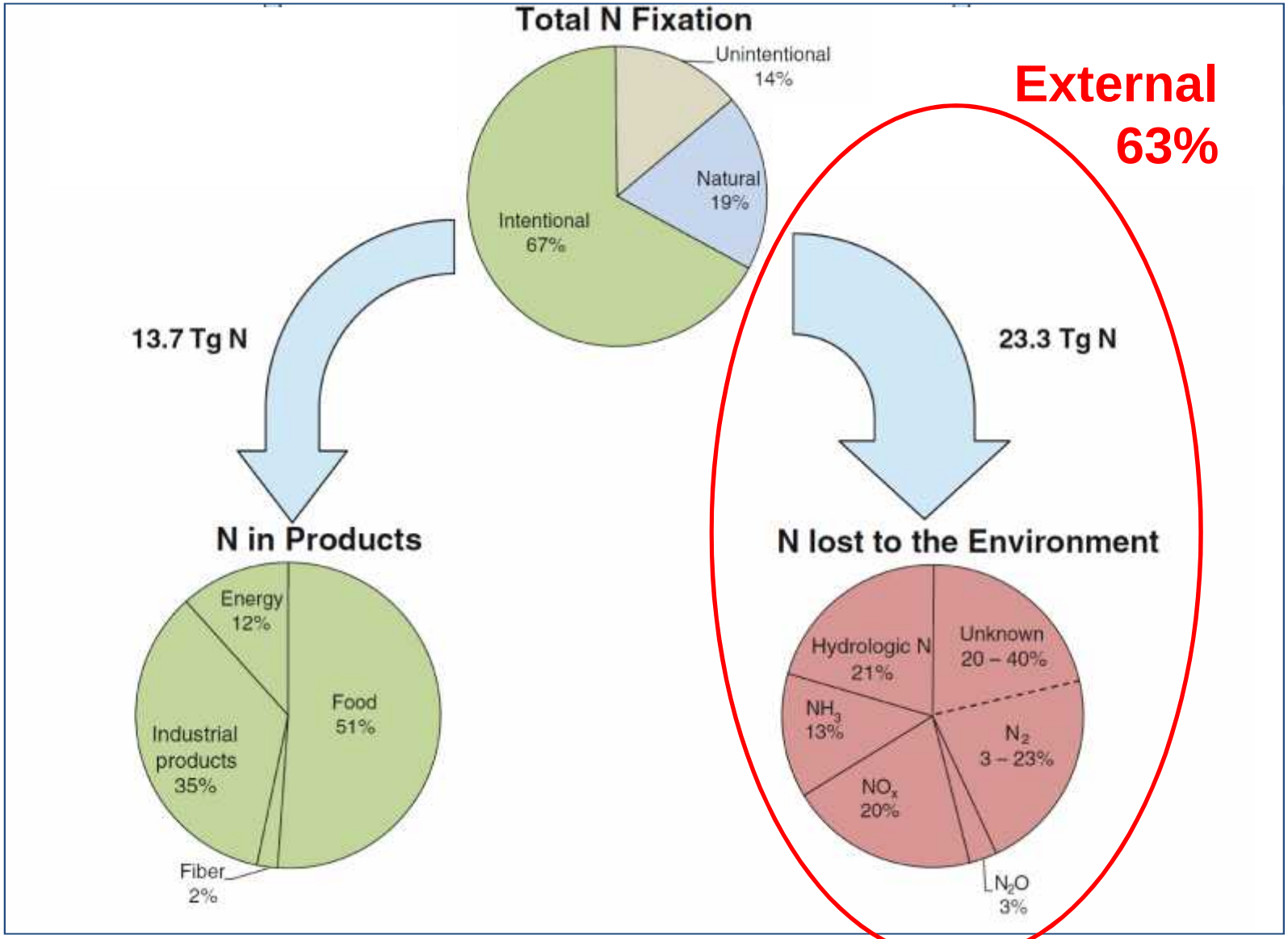


Anthropogenic N leakage to the environment, circa 2000



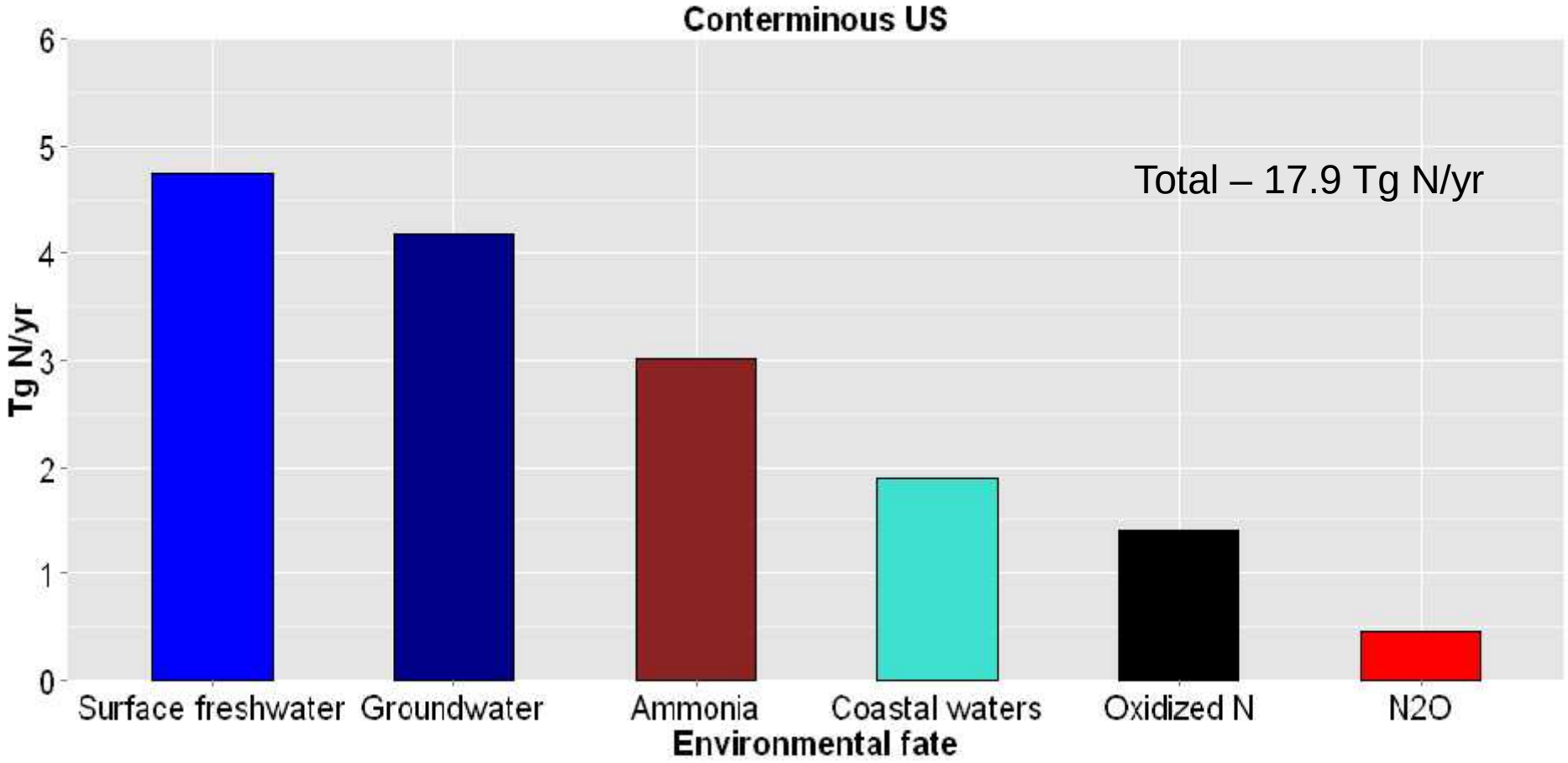
Sobota et al. 2015

What happens to the N inputs?



Houlton et al. 2012, Biogeochemistry

By environmental fate



Sobota et al. 2015

Costs of nitrogen pollution - US

	Damage or benefit associated with reactive N form	Cost ($/kg N)
Air	Human respiratory health - NOx	$ 25.41
	Human respiratory health - NH3	$ 5.42
	Visibility - NOx, NH3	$ 0.34
Land		
Water	Human health - nitrate	$ 1.94
	Lake waterfront property values	$ 0.23
	Recreational Freshwater use	$ 0.19
	Endangered species protection	$ 0.01
	Eutrophication	$ 17.70

No estimate:

N fertilization of forests
Closures by harmful algal blooms
Treatment of public drinking water

Health/Social

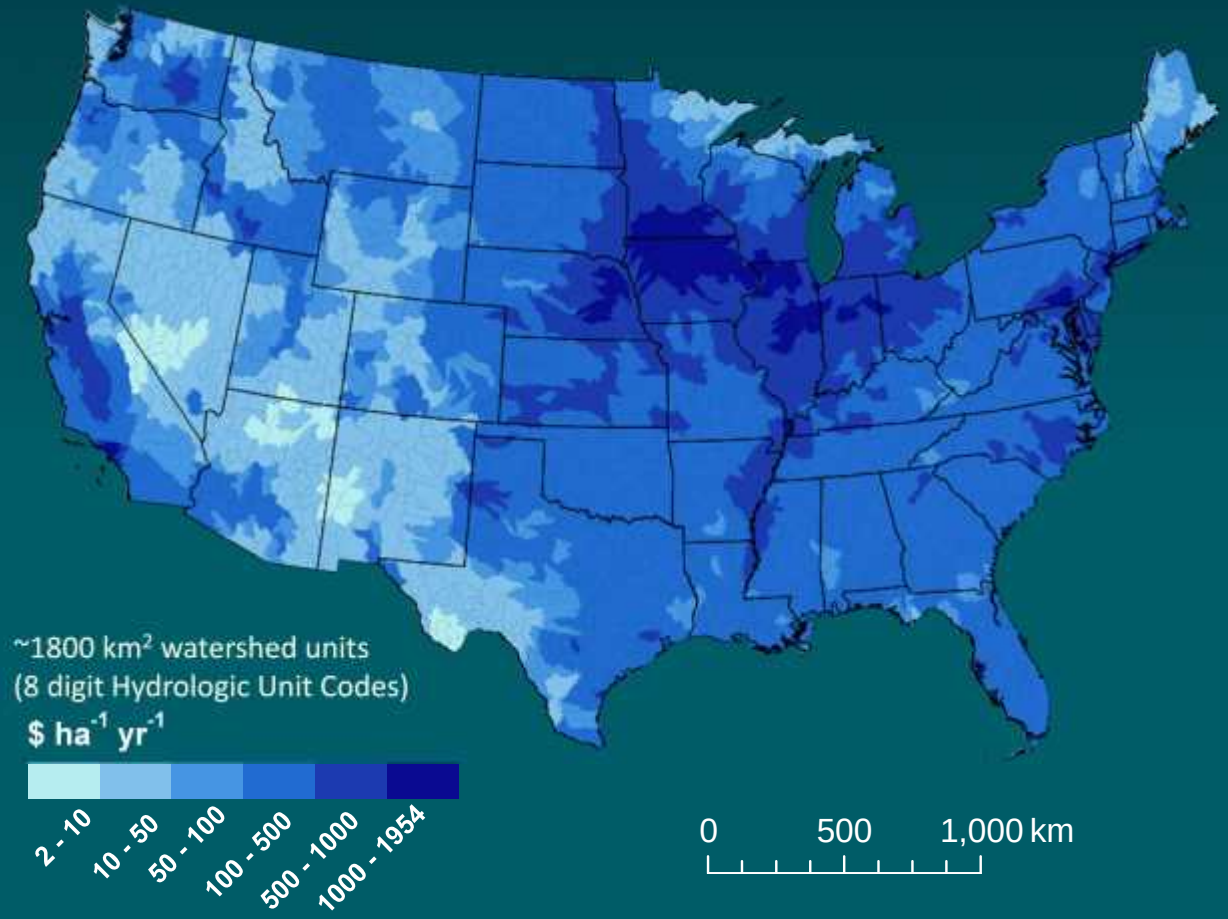
Agriculture

Ecosystems

Climate

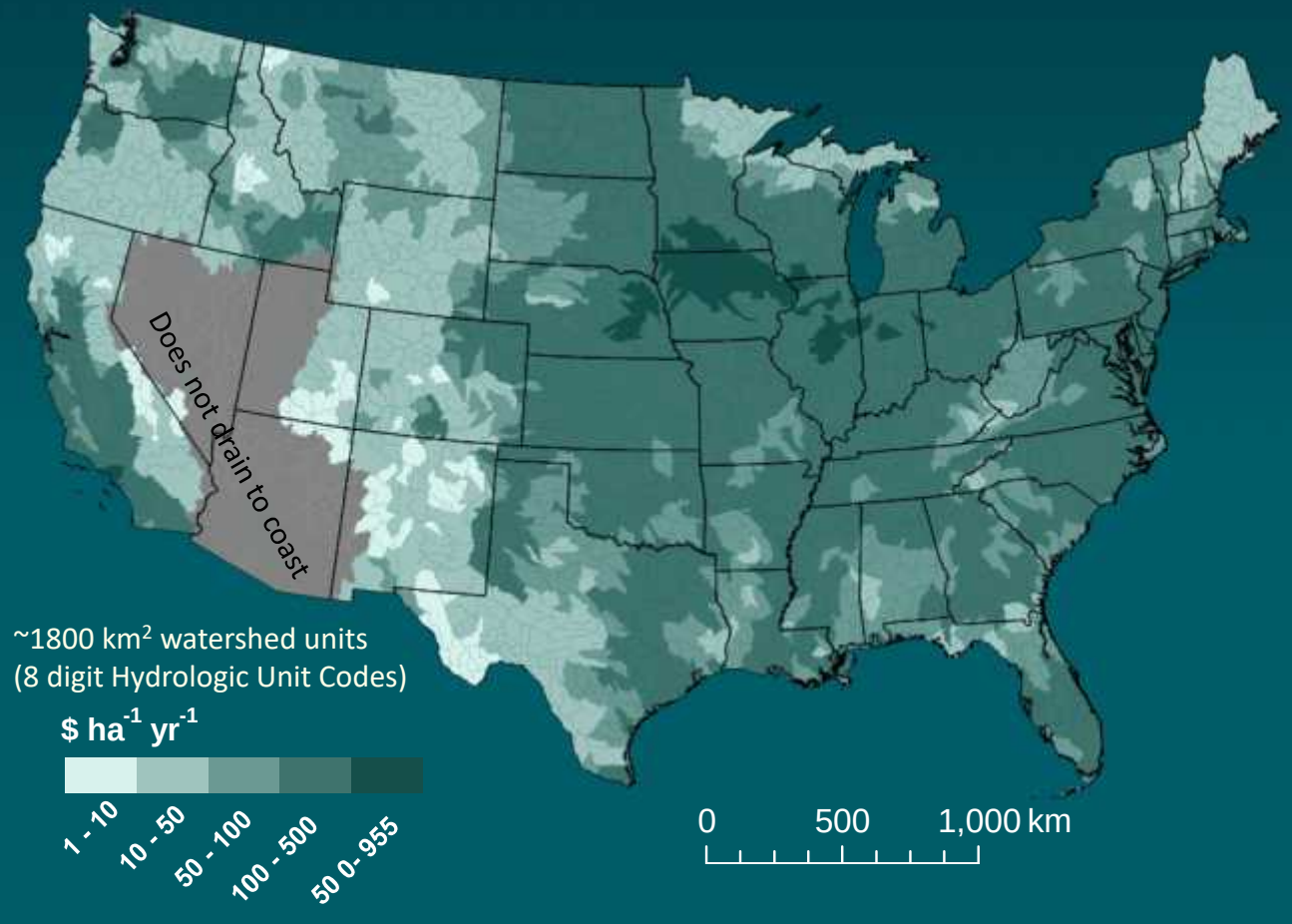
Compton et al. 2011 & Sobota et al. 2015

Freshwater damage costs, US circa 2000



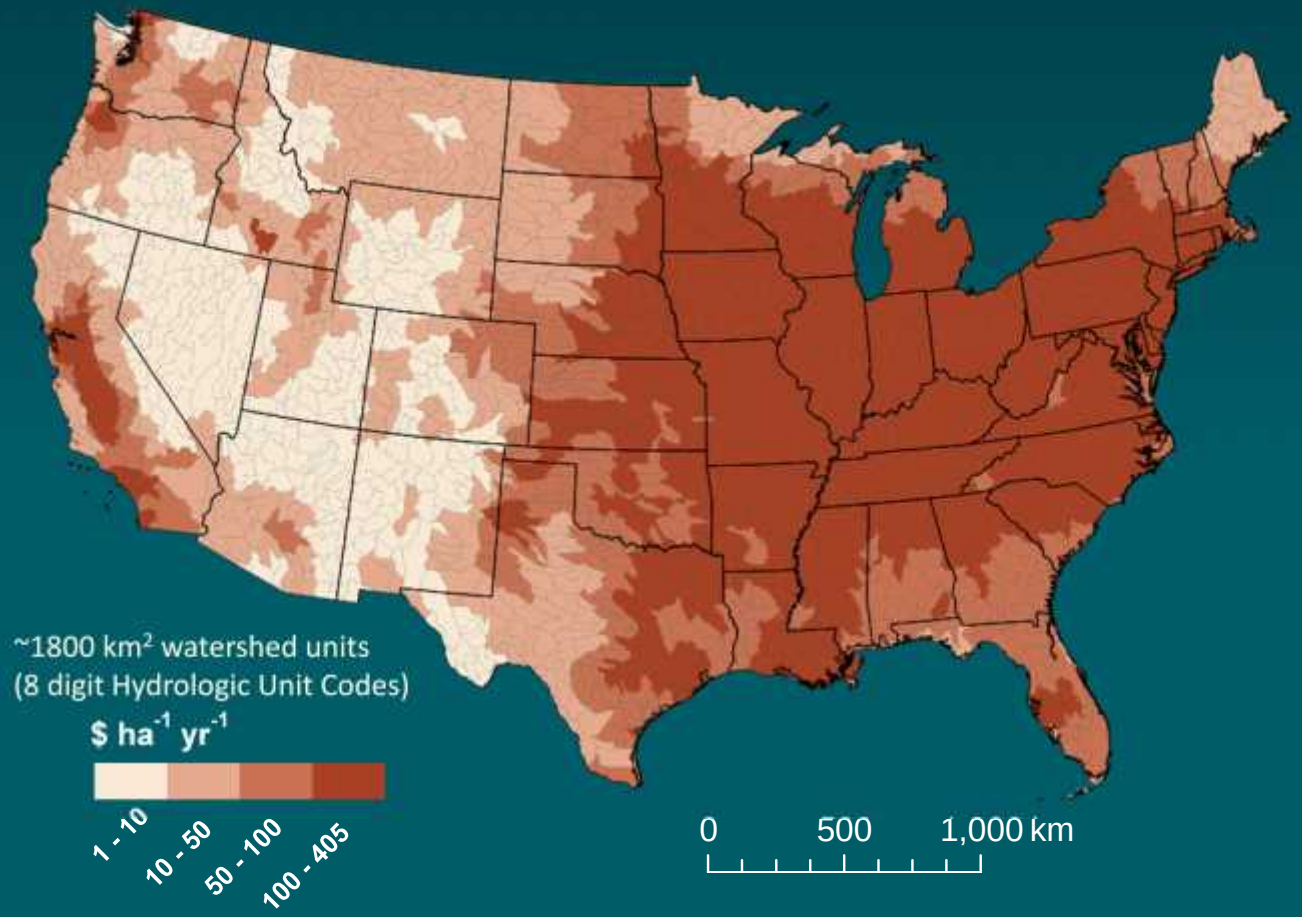
Sobota et al. 2015

Coastal damage costs, US circa 2000



Sobota et al. 2015

Human health costs, US circa 2000



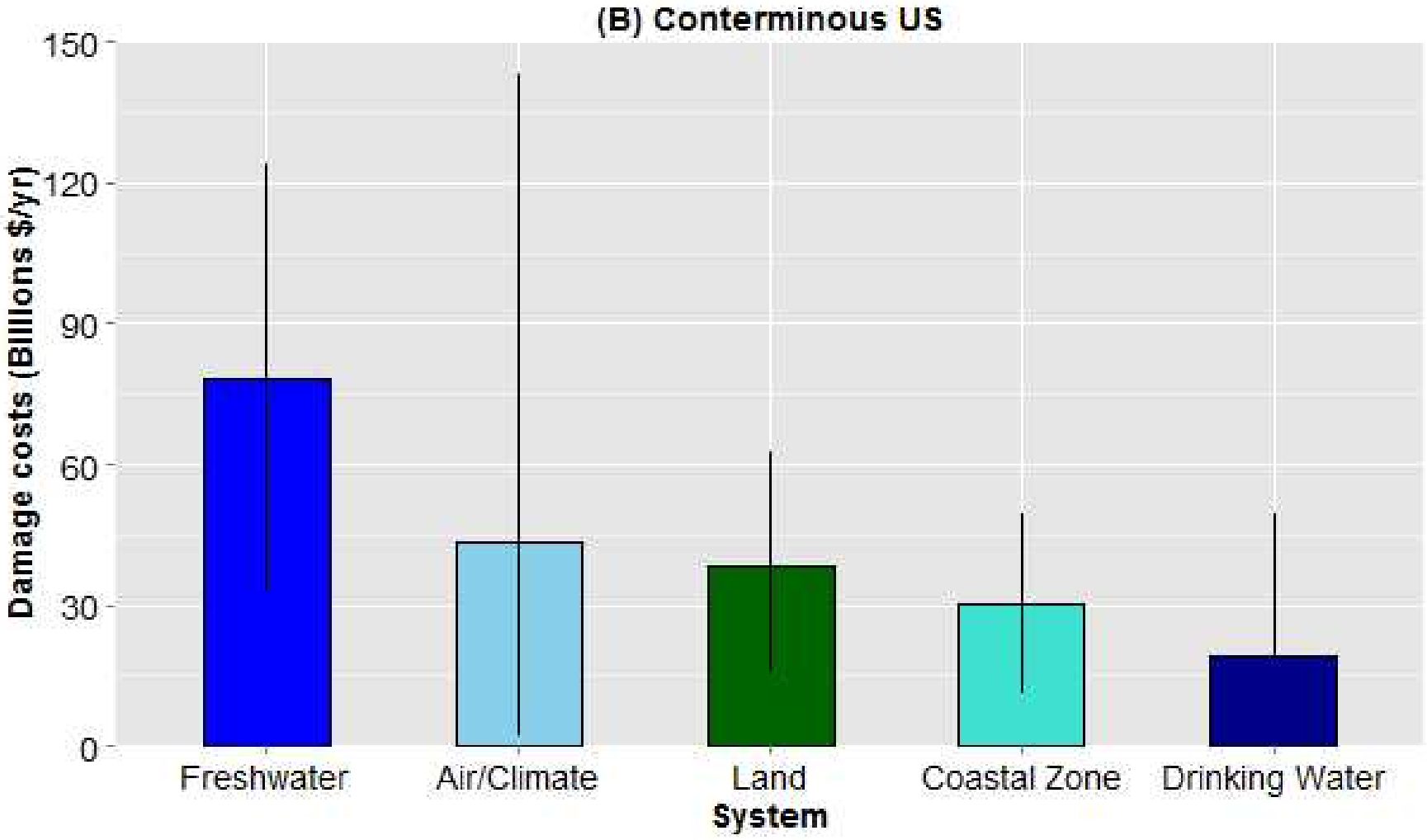
Sobota et al. 2015

Damages from source

Source/Sector	Damage cost (billion USD)
Agriculture	$157.1
Fossil fuel	$50.2
Sewage	$2.3
Total damages from N	**$209.6**
Range	***$81-441***

Sobota et al. 2015

Damages to endpoints

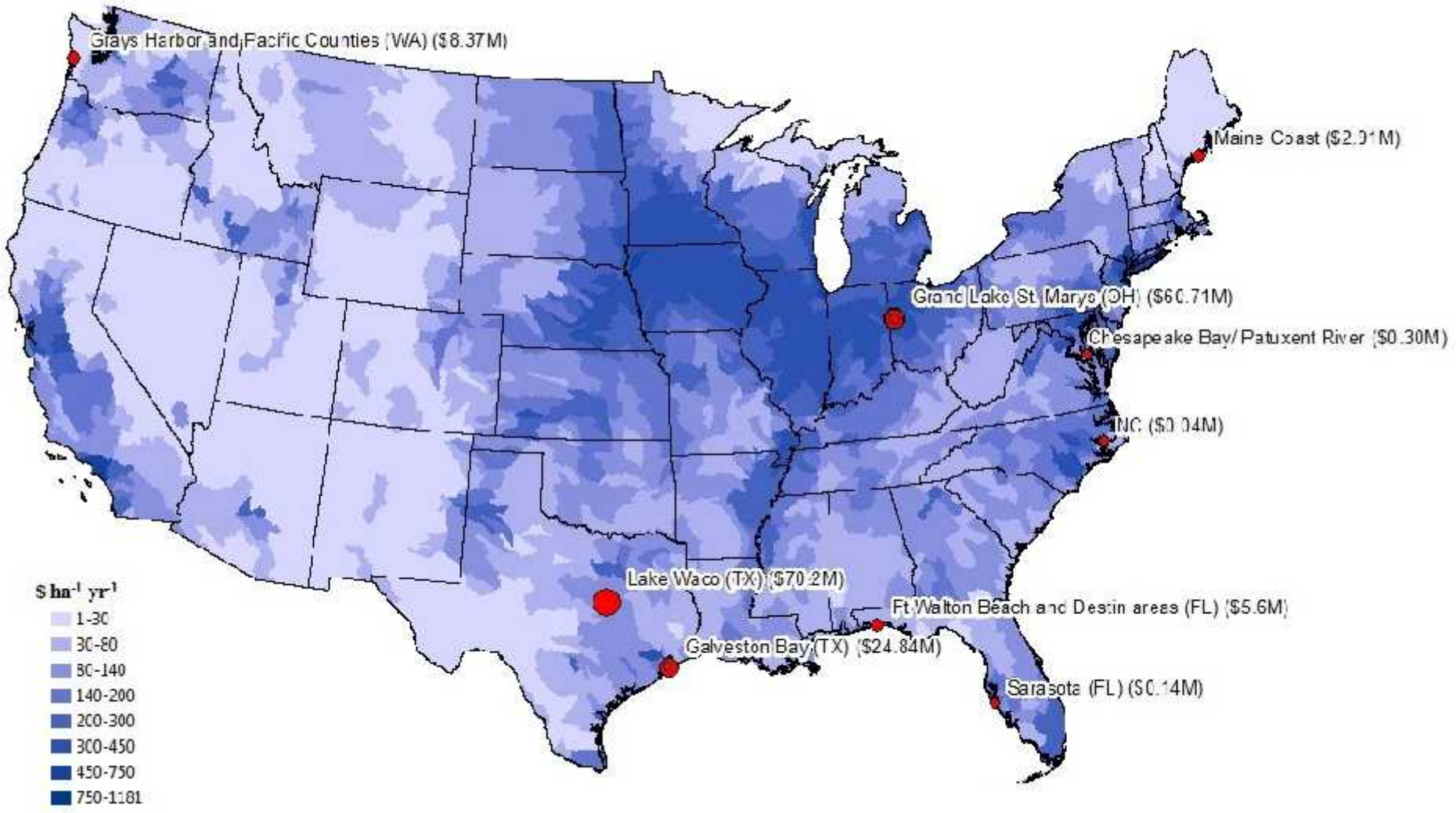


Sobota et al. 2015

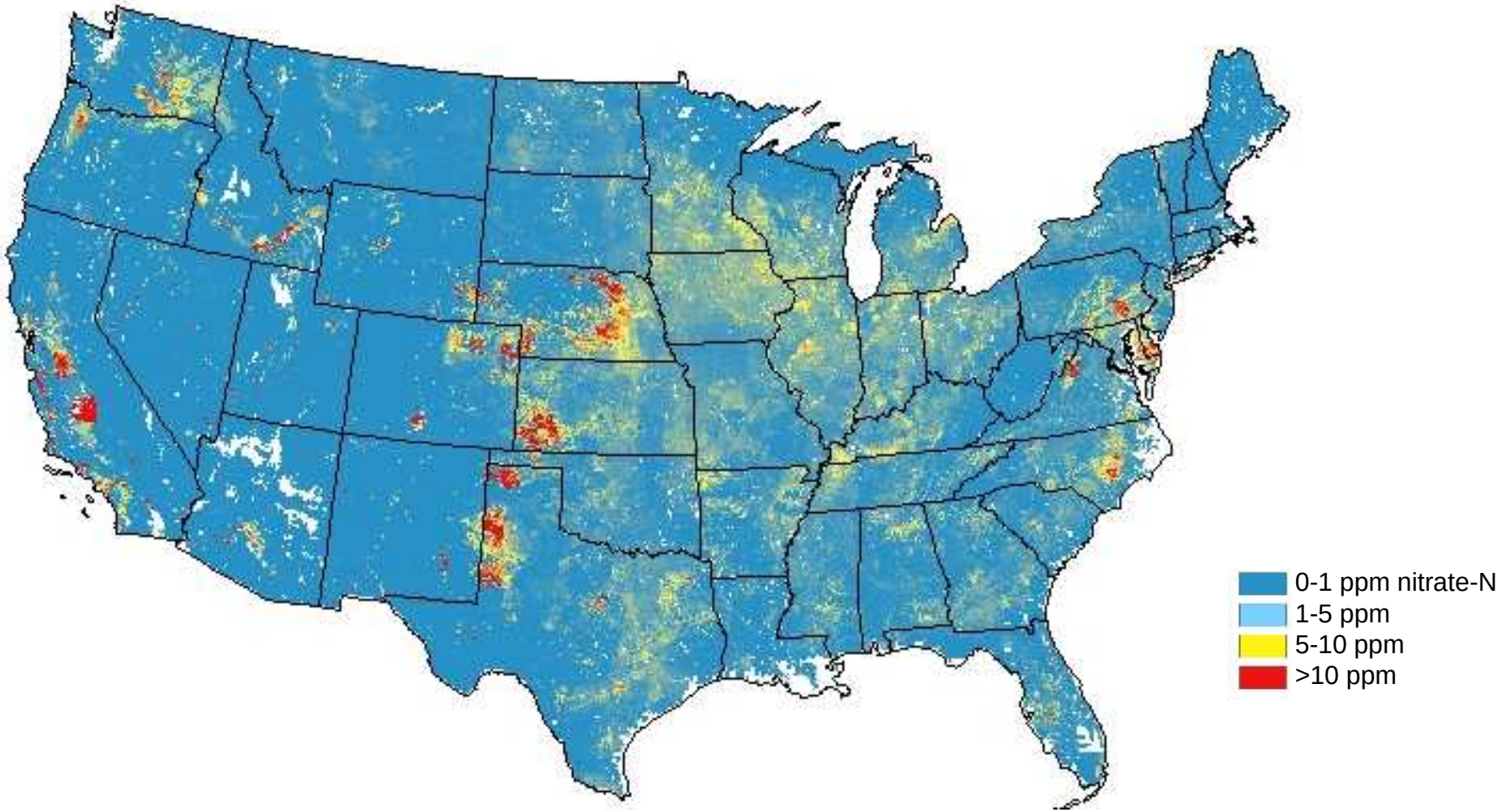
Other damage estimates

- **Cost of N impacts in the EU27, 2008**
  - $97-625 billion USD (Van Grinsven et al. 2013)
- **Gross annual damages from NO_x and NH_3, 2002**
  - $16 billion USD (Muller and Mendelsohn 2007)
- **Increased mortality associated with NH_3-derived $PM_{2.5}$ from food export, 2006**
  - $36 billion USD (Paulot & Jacob 2013 ES&T)

Comparison of potential freshwater costs with existing site-specific damages



Groundwater nitrate concentrations

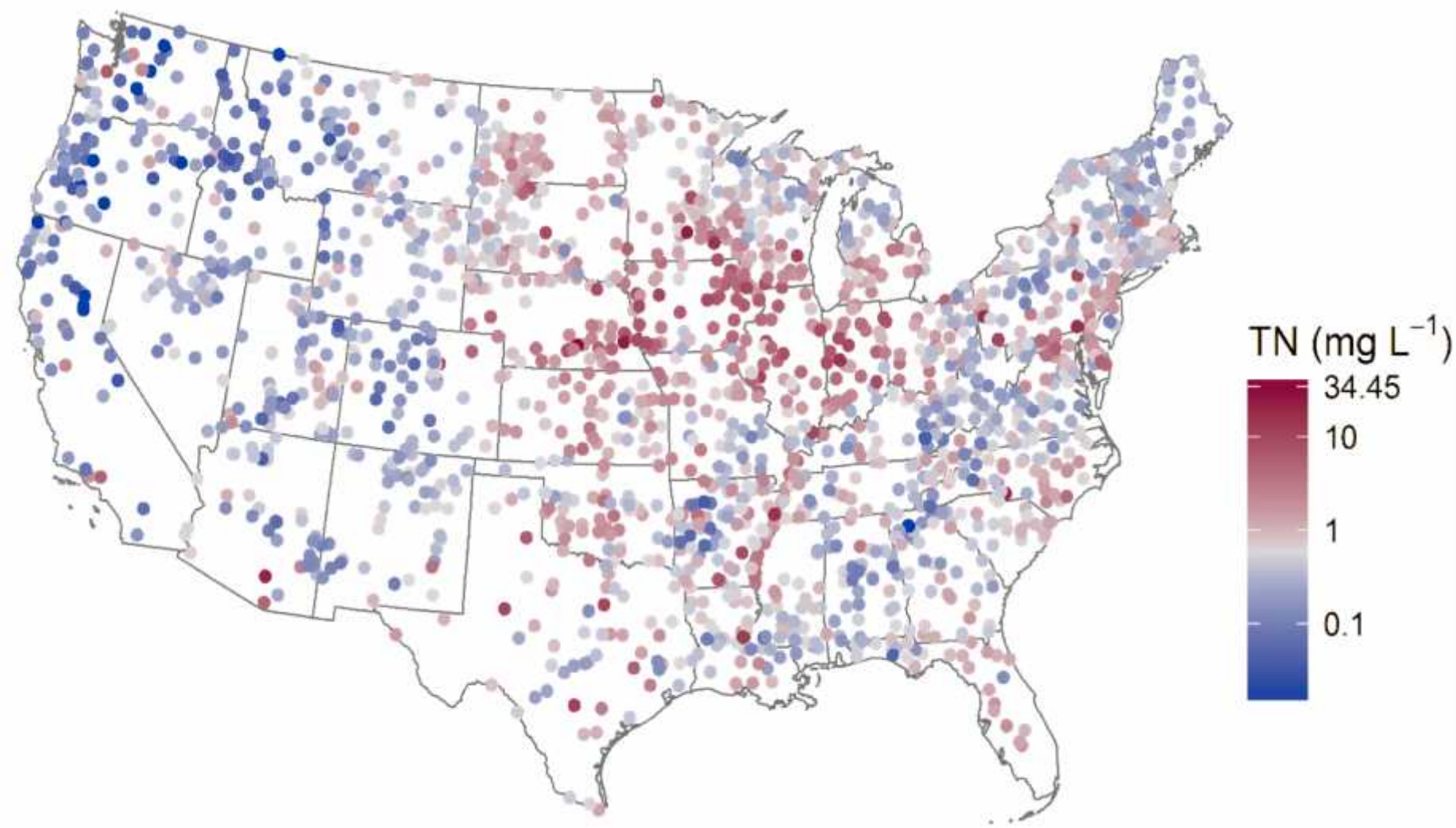


GWAVA-DW Model Results (Nolan & Hitt 2006)

Model based on 1991-2003 data, Map generated by Michael Pennino, EPA

Stream N concentrations

2008-2009 US National Rivers & Streams Assessment



R. Bellmore et al. In review

Summary

- **Human activities have increased N fixation by 5-fold in the US. 65% of N fixation is for agriculture.**
- **71% of N leaked ends up in water resources.**
- **Nitrogen damage costs are substantial - highest costs were in freshwater and coast.**

Caveats and Research Needs

- **Many missing costs in our assessment, particularly for algal blooms.**
- **Linear scaling of effects of a kilogram of N.**
- **Estimates represent potential damages for a particular location.**
- **Starting point for research connecting nutrients and damages to ecosystem goods and services.**

For more information →
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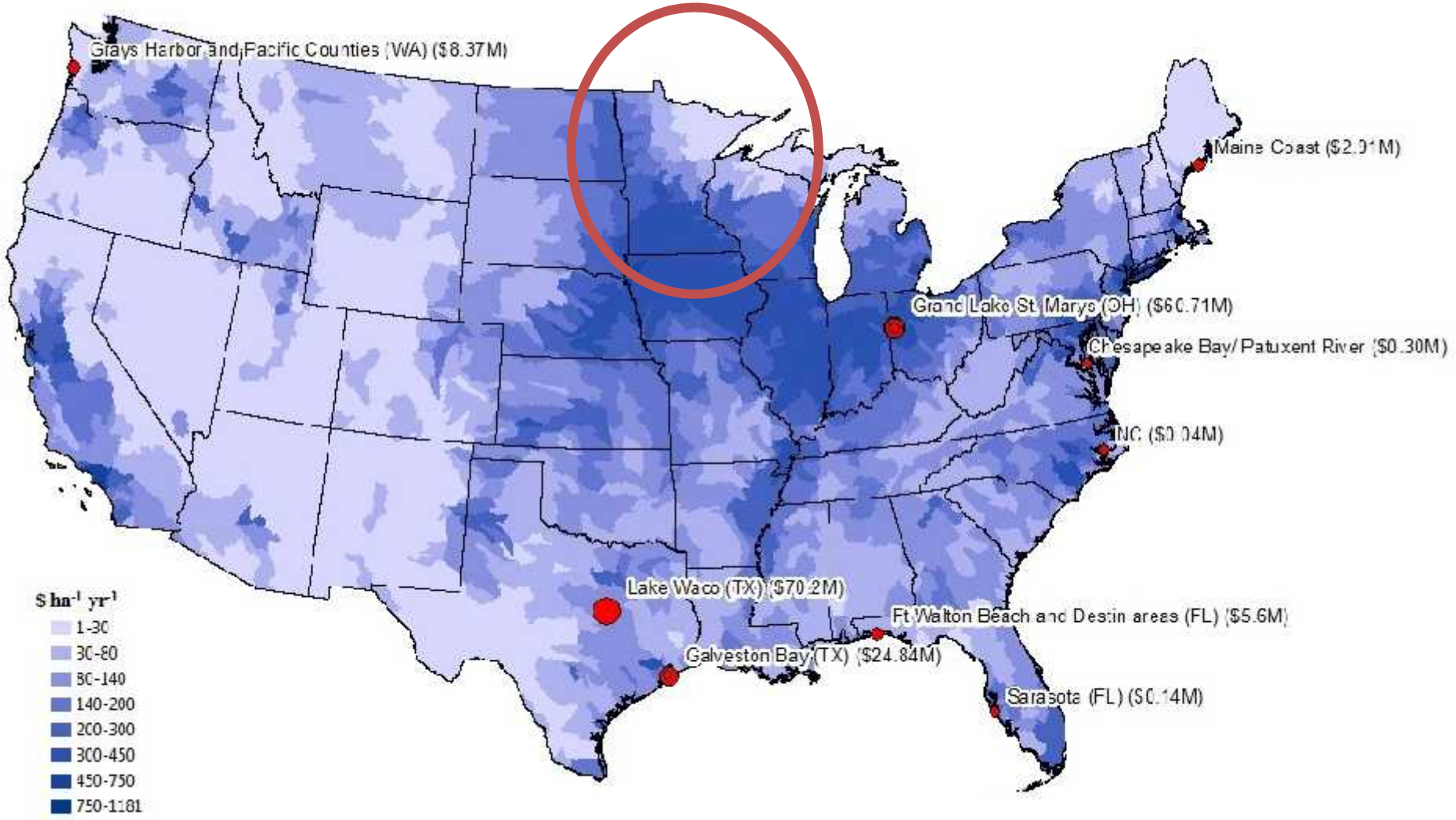
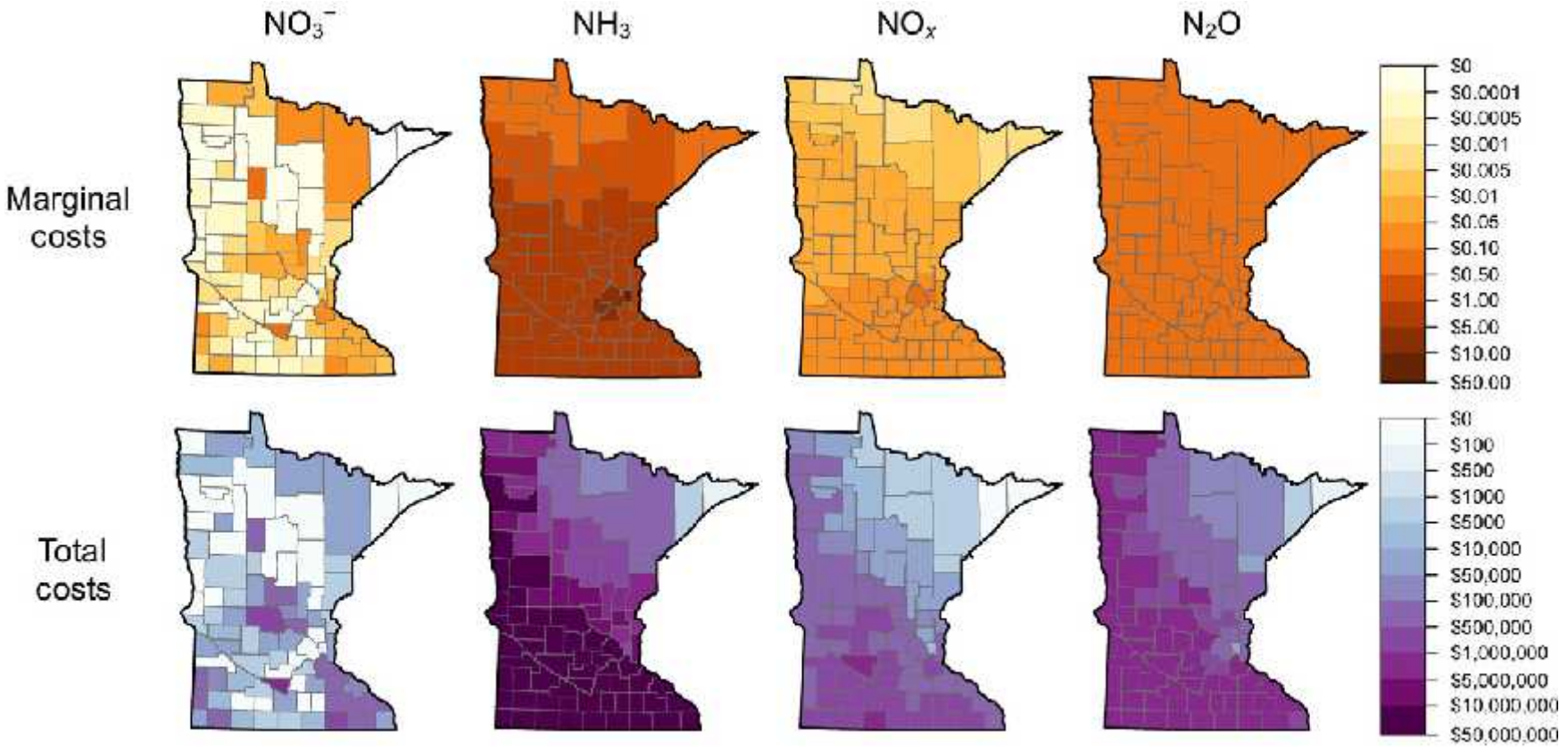
Also see: EPA SAB Integrated nitrogen committee report 2011
EU Nitrogen Assessment 2011
International Nitrogen Initiative website

Comparison of potential freshwater costs with existing site-specific damages



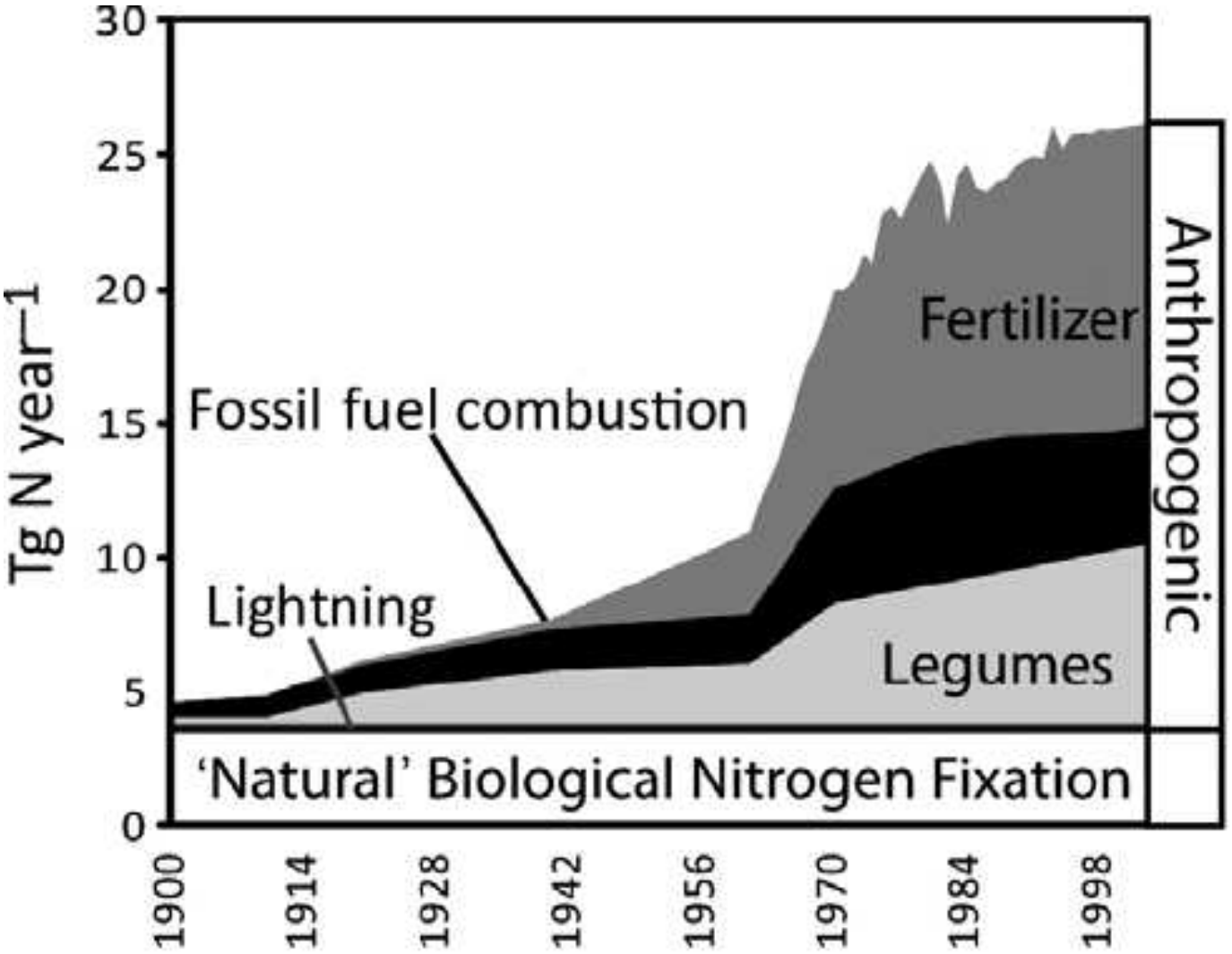
Next steps – including non-linear effects



Keeler et al. 2016

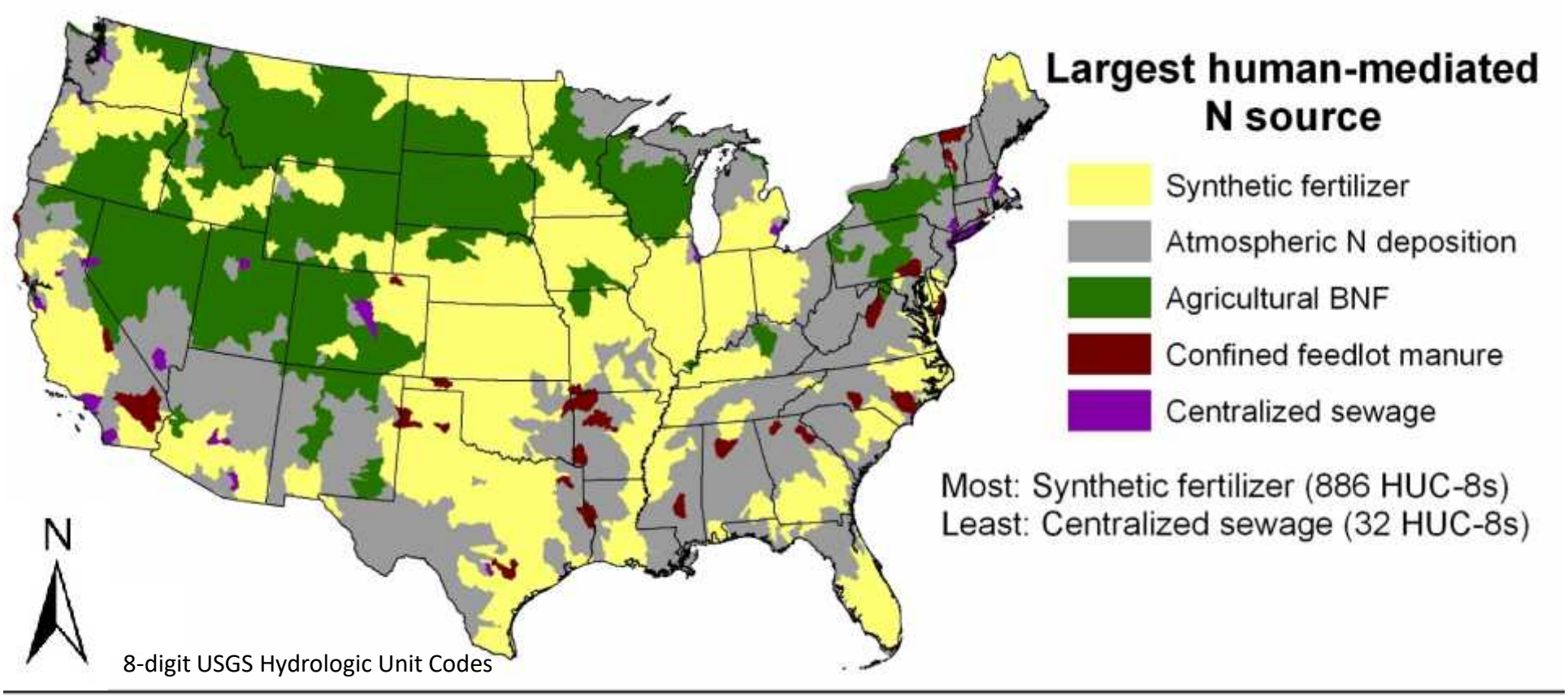
Nitrogen (N) inputs to US

increased 5-fold since 1900



Compton et al. 2011 Ecology Letters

Dominant Human N Source



Sobota et al., 2013, Frontiers in Ecology and the Environment