Nitrogen

and its role in agricultural resilience to climate change

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Resilient Agriculture 2014

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Cropping Systems Coordinated Agricultural Project: Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems

Ammonia synthesis has changed the world

Nitrogen fertilizer responsible for feeding 48% of the world's population in 2008

Erisman et al. 2008

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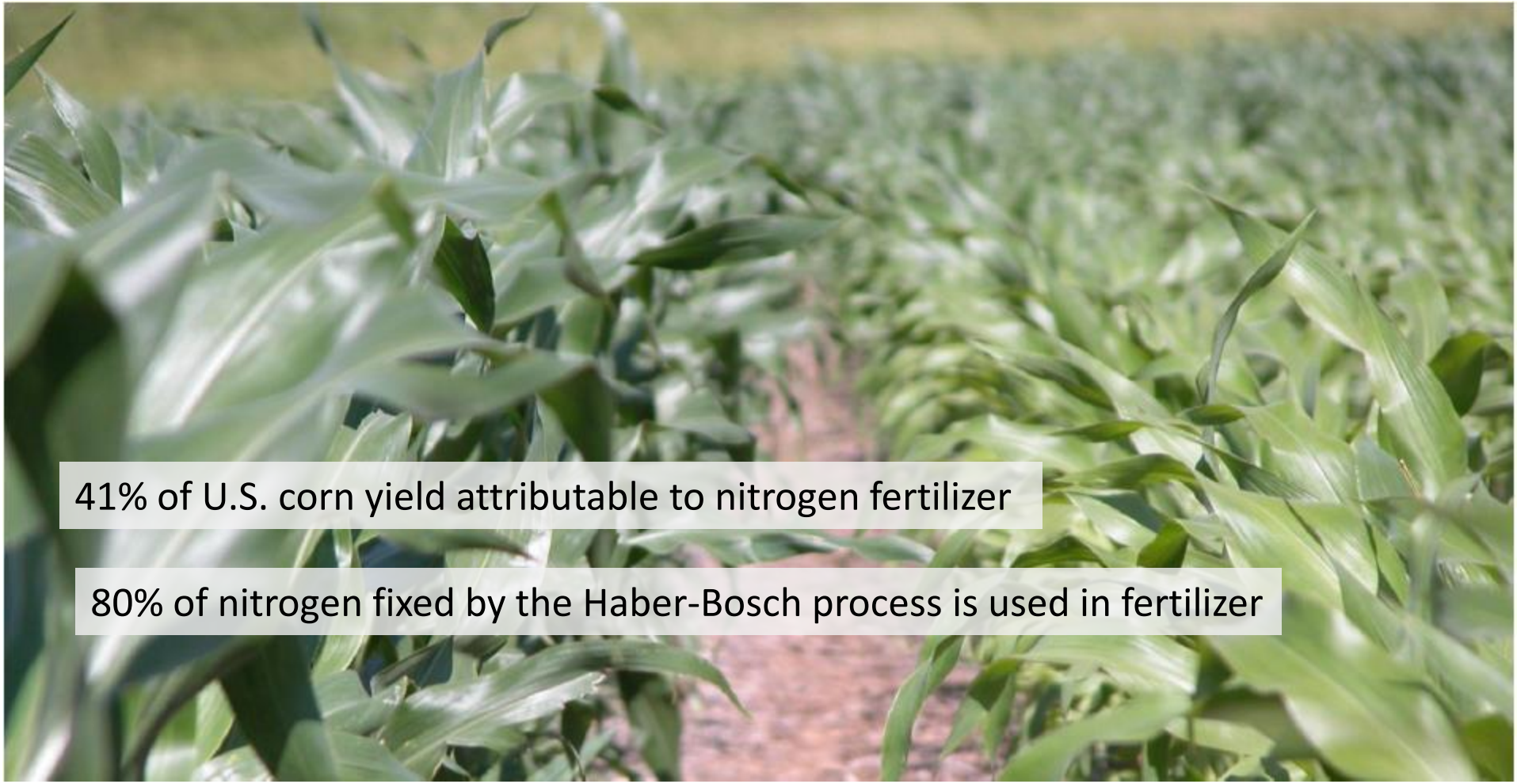
Ammonia synthesis has changed farming



Stewart *et al.* 2005 Erisman et al. 2008

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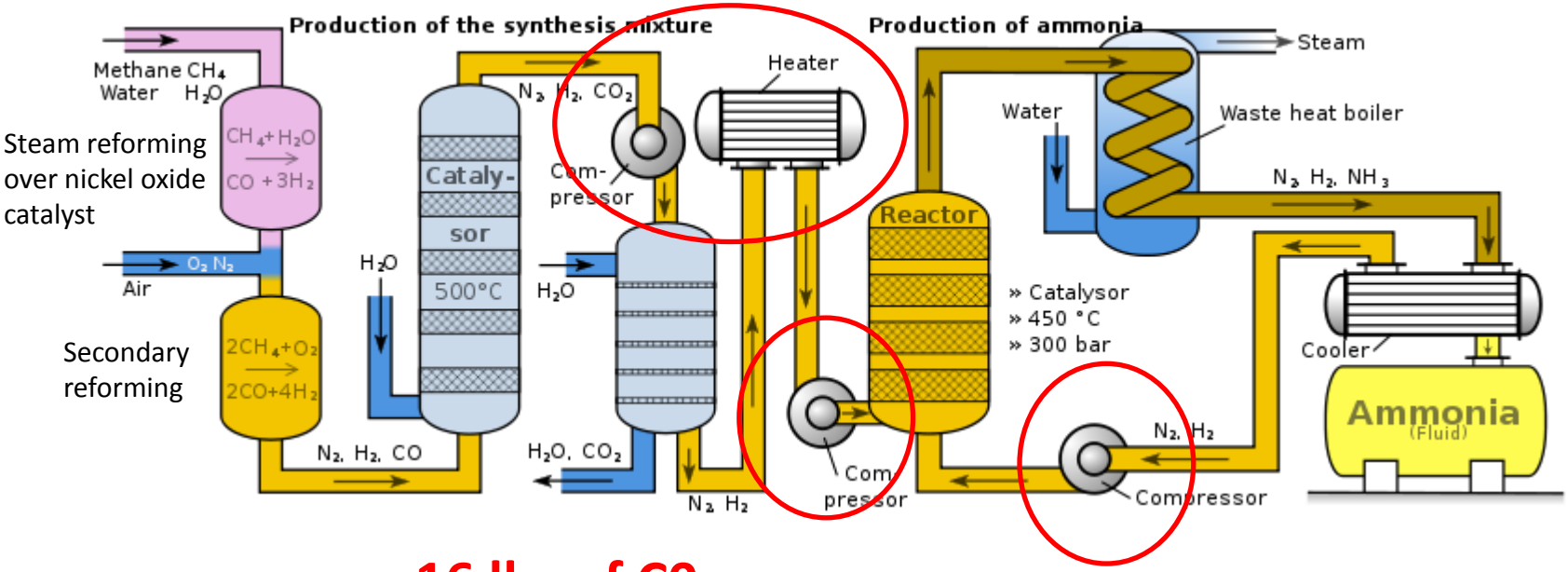
Ammonia Synthesis by Haber-Bosch

8 lbs of Methane (CH_4)



16 lbs of $C0_2$

10 lbs of Ammonia (NH_3)

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Making the N fertilizer used on U.S. corn in 2011 emitted GHGs equal to…

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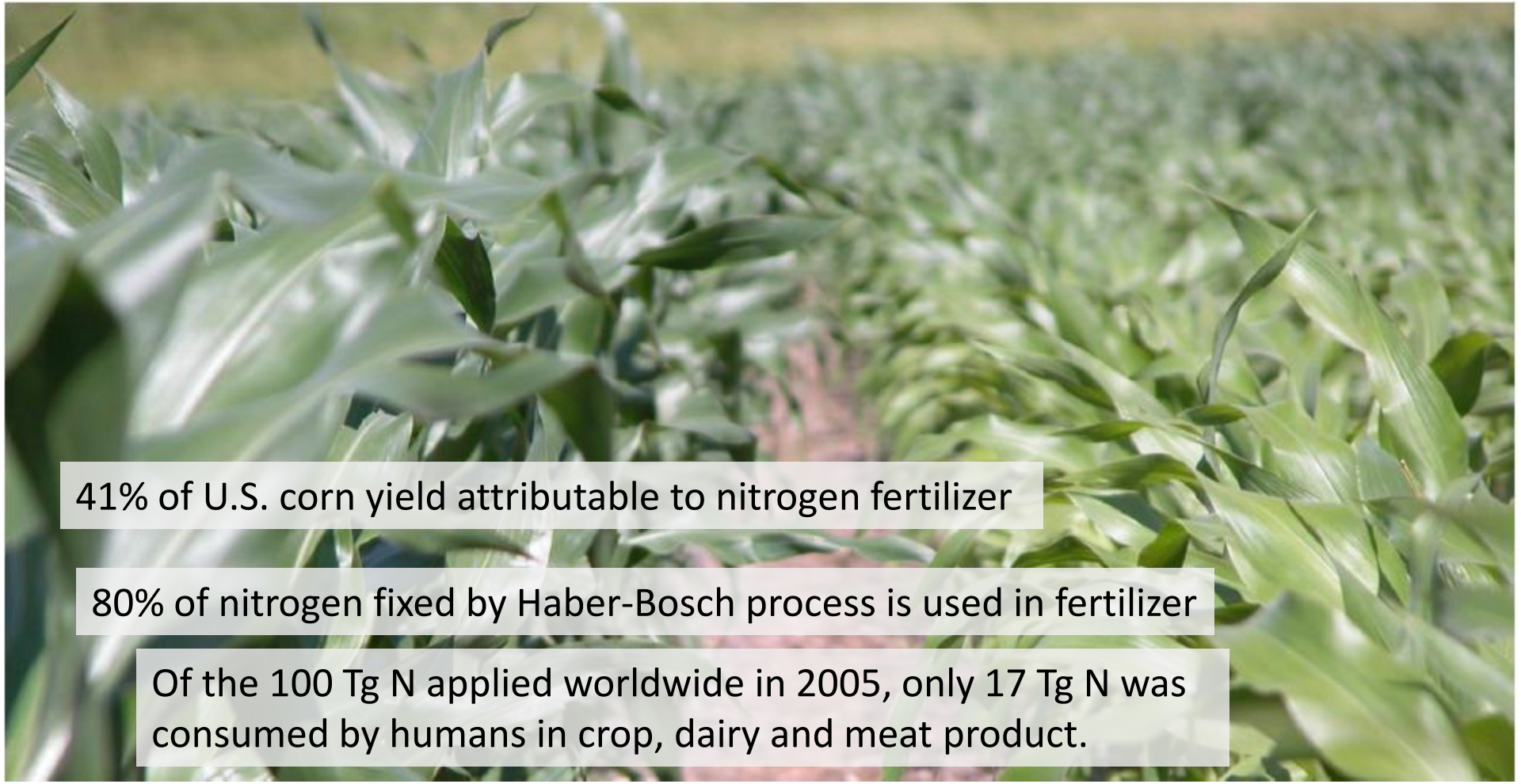
Upstream effects of N-production

- 45% of life cycle energy use in corn production is in N fertilizer production
- 40% of life cycle GHG emissions are associated with N fertilizer production

The only way to reduce upstream effects is to reduce N use

Ammonia synthesis has changed farming



41% of U.S. corn yield attributable to nitrogen fertilizer

80% of nitrogen fixed by Haber-Bosch process is used in fertilizer

Of the 100 Tg N applied worldwide in 2005, only 17 Tg N was consumed by humans in crop, dairy and meat product.

Up to 70% of nitrogen applied to corn is harvested in grain

Stewart *et al.* 2005 Erisman et al. 2008

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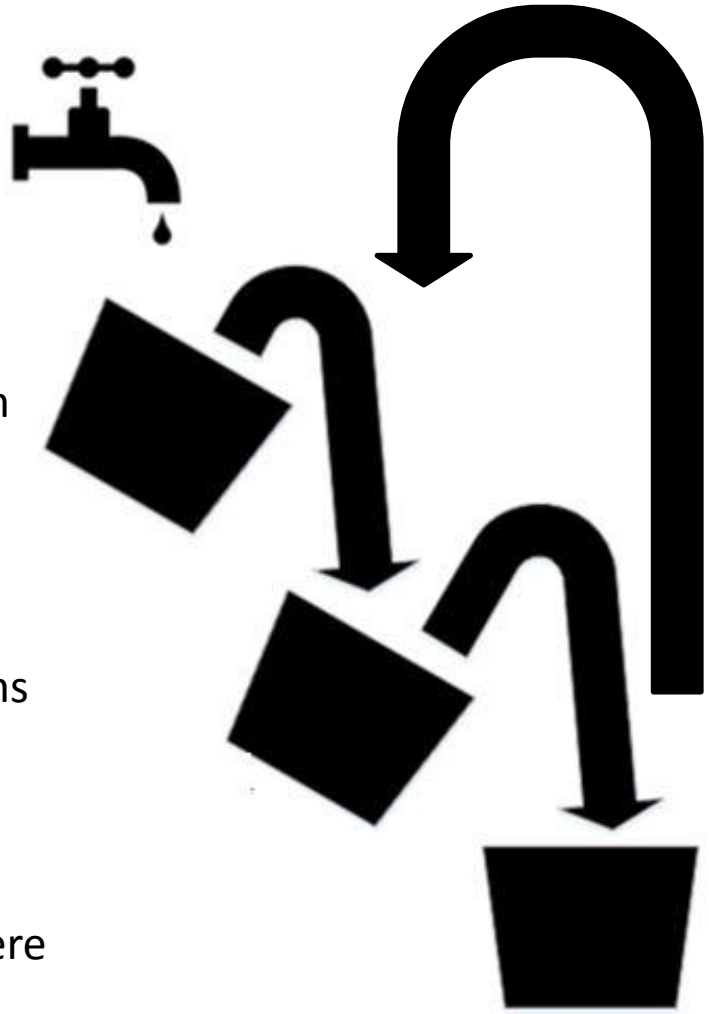
Nitrogen Cascade of Effects

Reactive Nitrogen Fertilizer



atmospheric deposition

Terrestrial Ecosystem

- Soil acidification
- Biodiversity loss

Aquatic Ecosystems

- Surface & groundwater quality
- Eutrophication
- Biodiversity loss

Atmosphere

- Particulate matter & visibility
- Tropospheric ozone increase
- Stratospheric ozone loss
- Greenhouse effects

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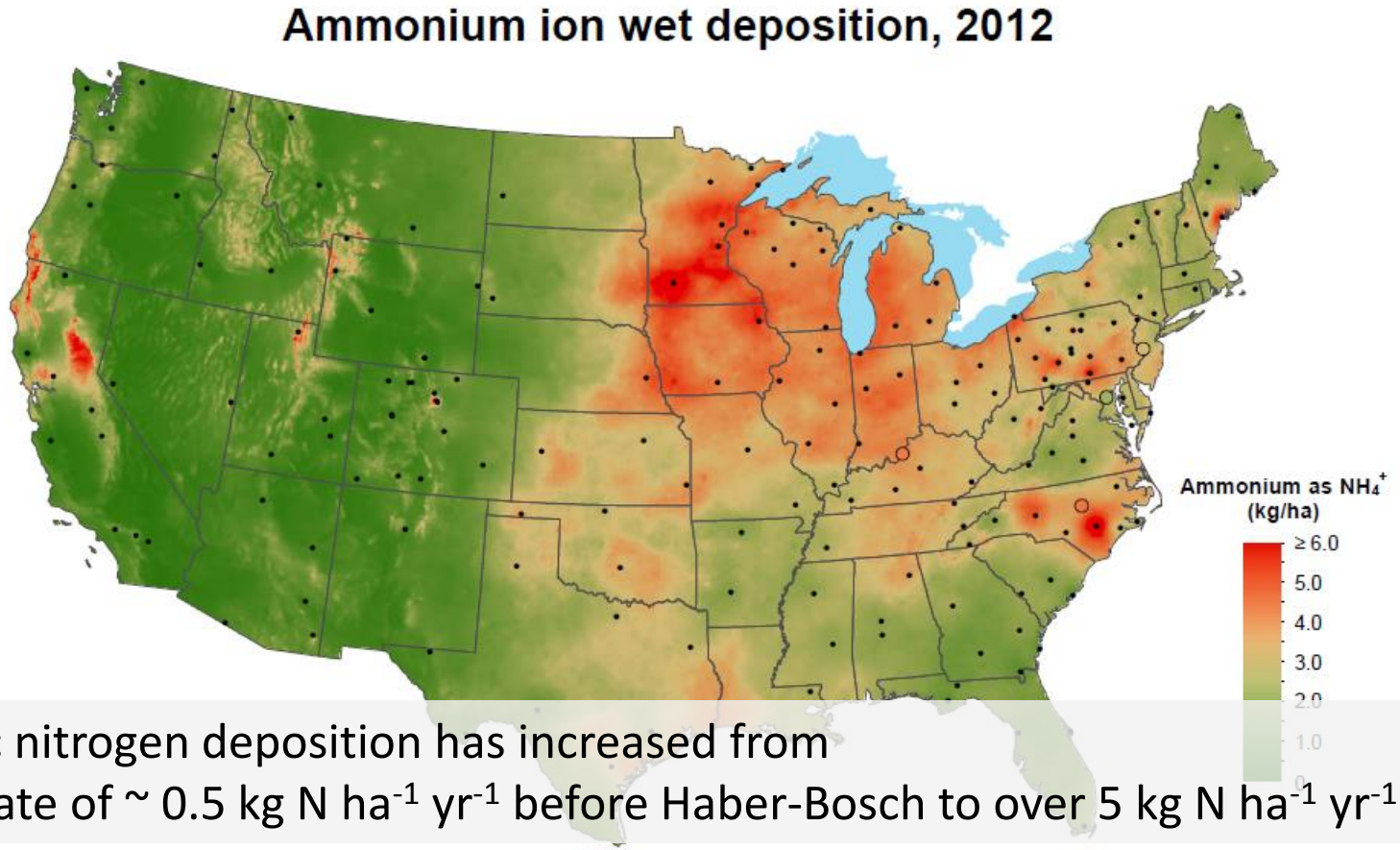
N Fertilization is (BIG) Global Change



Atmospheric nitrogen deposition has increased from
an average rate of ~ 0.5 kg N ha^{-1} yr^{-1} before Haber-Bosch to over 5 kg N ha^{-1} yr^{-1}

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

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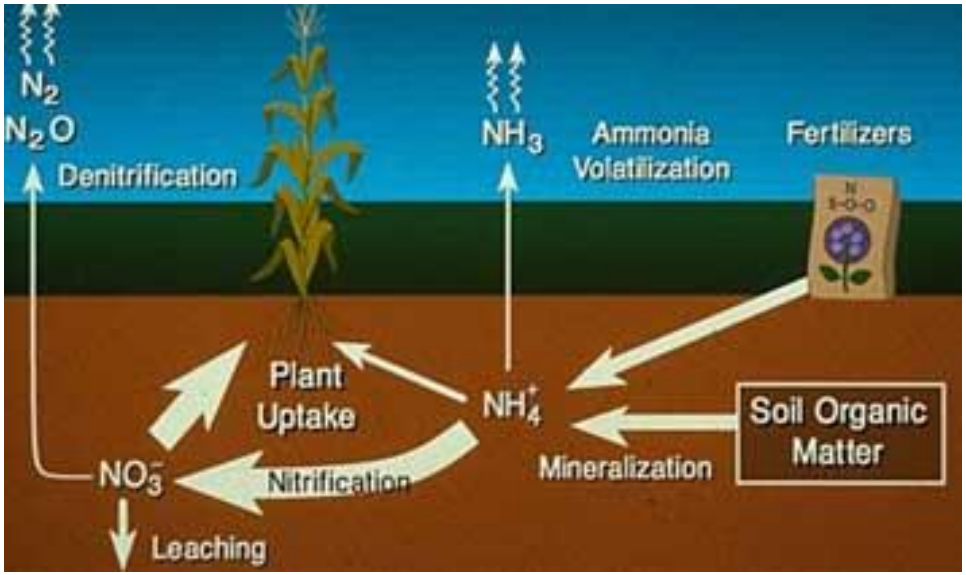
How is nitrogen lost from the field?



- leaching
- denitrification
- ammonia volatilization

Mathesius and Luce, Pioneer. *Assessing and Managing Nitrogen Losses in Corn*

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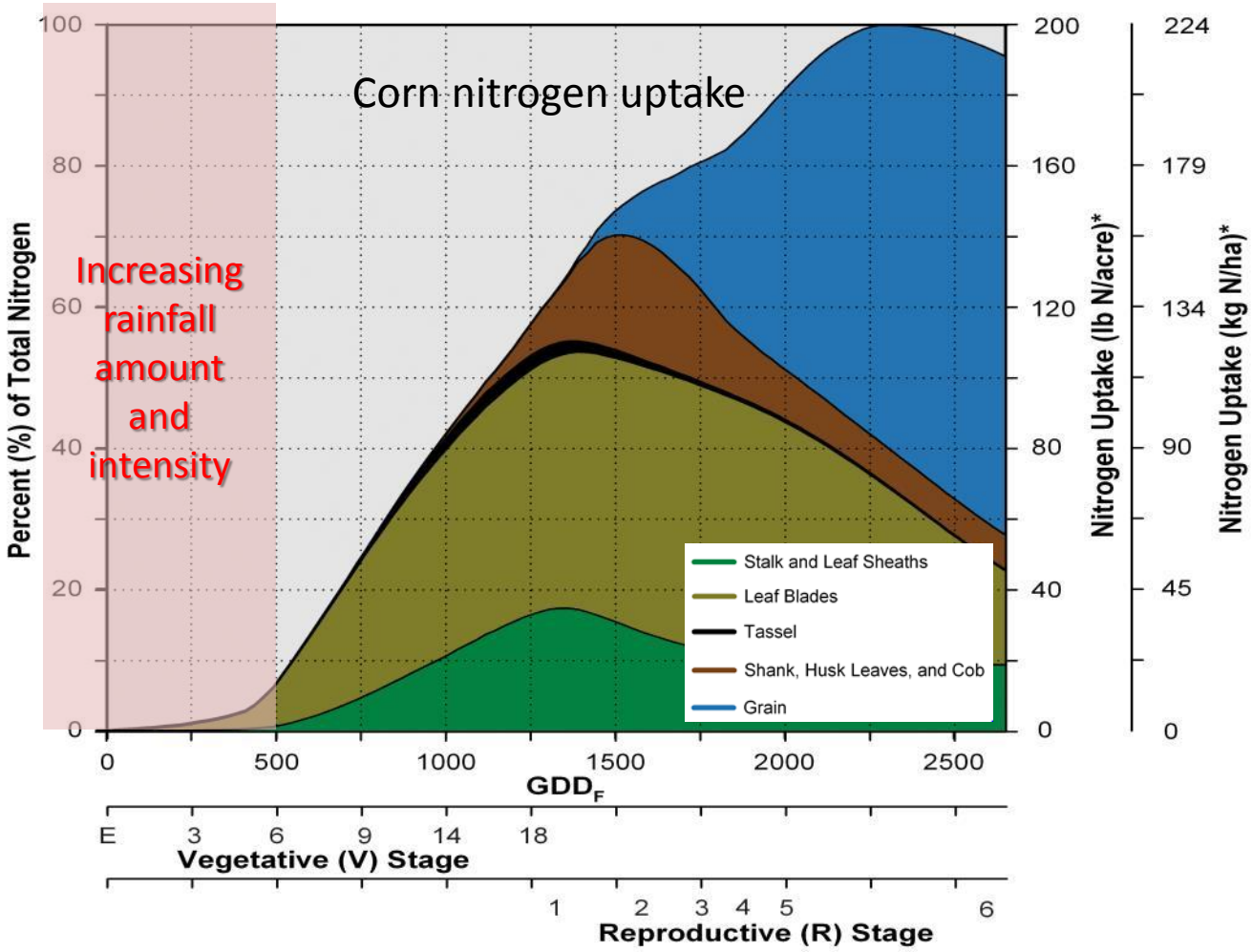
Changing Climate in Midwest

- Increase in atmospheric CO_2
- Increased atmospheric & soil temperatures

- Precipitation:
  - More in spring
  - More intense storms

Increasing rainfall when risk of nitrate loss is greatest



Iowa State University Extension PMR 1009 (2011).

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Resilience through Nitrogen Management

- Side-dress
  - planned side-dress
  - reactive side-dress/top-dress

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Resilience through Nitrogen Management

- Side-dress
  - planned side-dress
  - reactive side-dress/top-dress
- Nitrification inhibitors, urease inhibitors, coated urea

Other Management Practices

- Side-dress
  - planned side-dress
  - reactive side-dress/top-dress
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- Cover crops

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- Drainage water management

Goal: Resilience & Nutrient Reduction

	Practice	Comments	% Nitrate-N Reduction[+]	% Corn Yield Change[++]
			Average (SD*)	Average (SD*)
Nitrogen Management	Timing	Moving from fall to spring pre-plant application	6 (25)	4 (16)
		Spring pre-plant/sidedress 40-60 split Compared to fall-applied	5 (28)	10 (7)
		Sidedress – Compared to pre-plant application	7 (37)	0 (3)
		Sidedress – Soil test based compared to pre-plant	4 (20)	13 (22)**
	Source	Liquid swine manure compared to spring-applied fertilizer	4 (11)	0 (13)
		Poultry manure compared to spring-applied fertilizer	-3 (20)	-2 (14)
	Nitrogen Application Rate	Nitrogen rate at the MRTN (0.10 N:corn price ratio) compared to current estimated application rate. (ISU Corn Nitrogen Rate Calculator – http://extension.agron.iastate.edu/soilfertility/nrate.aspx can be used to estimate MRTN but this would change Nitrate-N concentration reduction)	10	-1
	Nitrification Inhibitor	Nitrapyrin in fall – Compared to fall-applied without Nitrapyrin	9 (19)	6 (22)
	Cover Crops	Rye	31 (29)	-6 (7)
		Oat	28 (2)	-5 (1)
	Living Mulches	e.g. Kura clover – Nitrate-N reduction from one site	41 (16)	-9 (32)
Other	Extended Rotations	At least 2 years of alfalfa in a 4 or 5 year rotation	42 (12)	7 (7)
	Drainage Water Mgmt.	No impact on concentration	33 (32)	

Lawrence (2013). *Reducing Nutrient Loss*. SP 0435

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Nitrogen Resilience to Climate Change means:

- Maintaining flexibility in N fertilization so rate can be adjusted to match year (side-dress, top-dress, inhibitors in some places).
- Minimizing N release from field (cover crop, extended rotations, buffers and drainage water management).

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