Nitrous Oxide and Nebraska Crop Production

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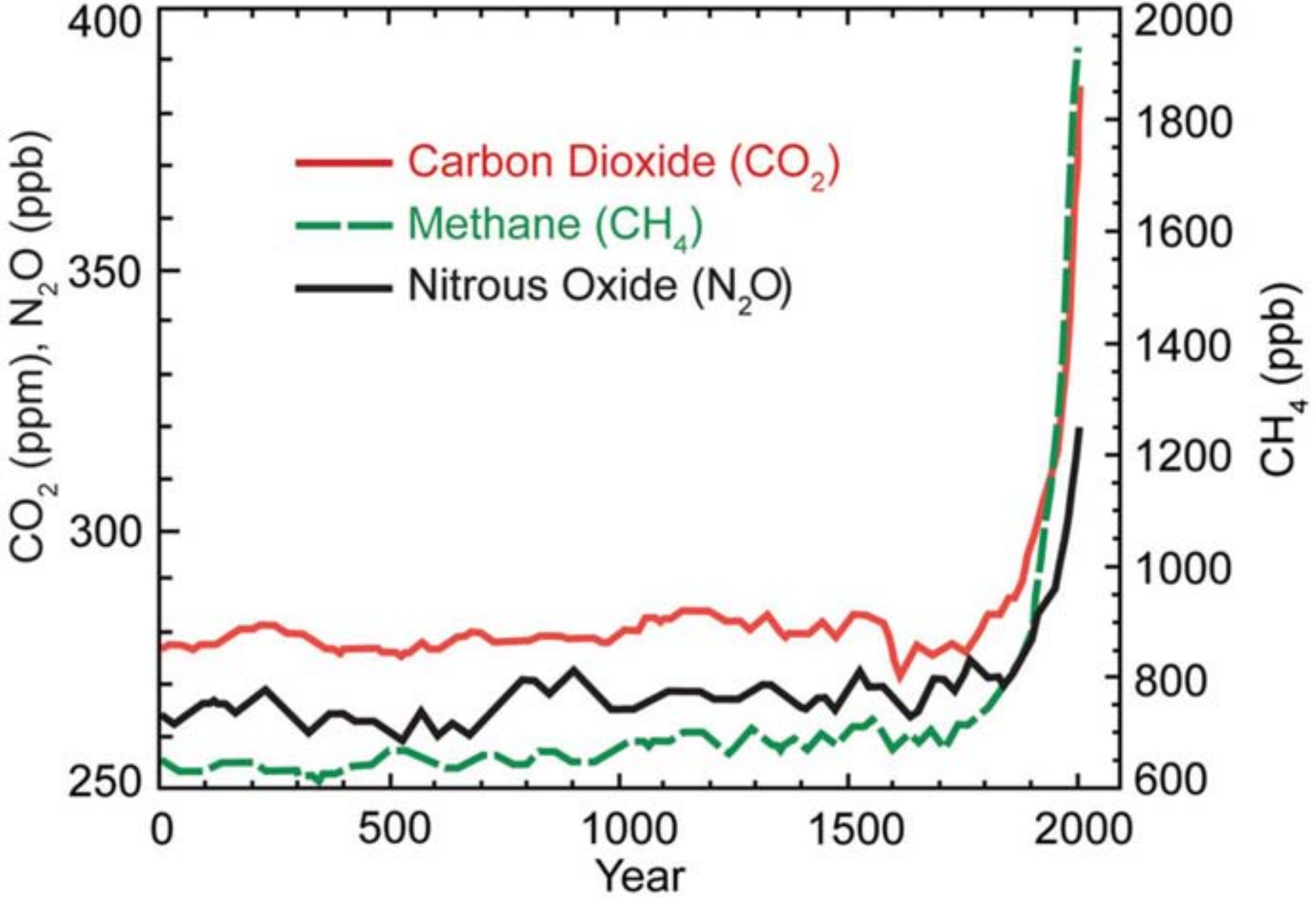
Climate Change (global warming; climate weirdness)

- Is there a human factor?
- We will probably have to act on this even if we don't believe that there is human influence
  - need to be informed
  - better to be proactive

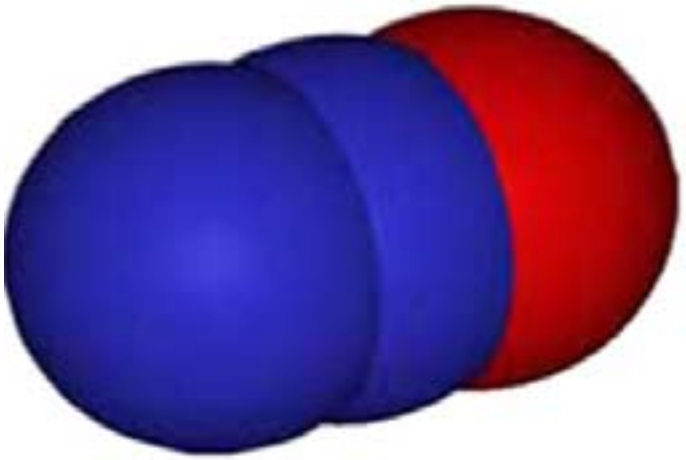
The greenhouse gases

- Nitrous oxide (N_2O), water vapor, carbon dioxide (CO_2), and methane are gases in the atmosphere that absorb and emit heat (Infrared radiation) back to earth
- A 'greenhouse effect'
- Water vapor is the most important of these
  - not affected globally by human activity
  - Increases with higher temperatures



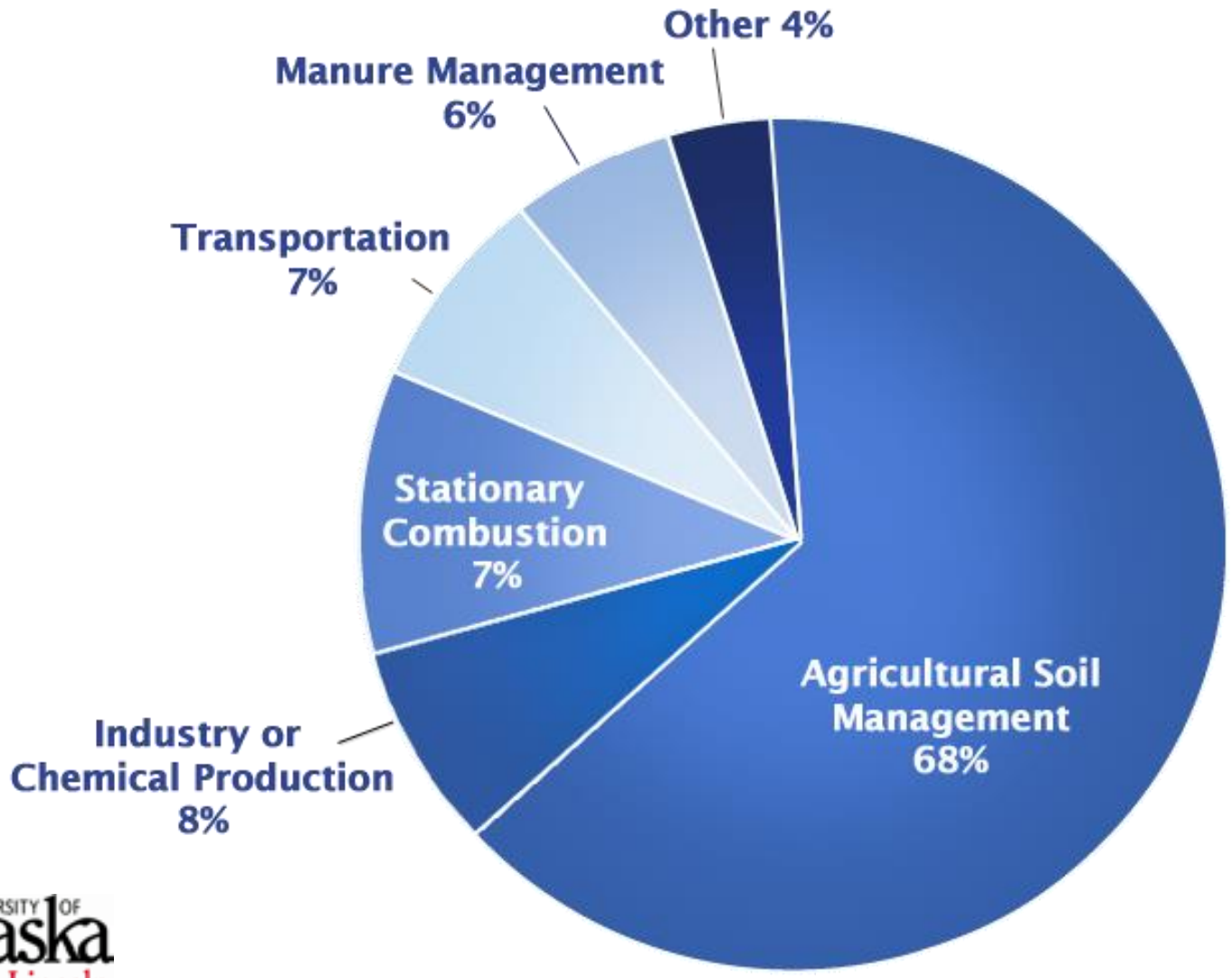
Forster *et al.*[3];Blasing[7]

Nitrous oxide



- The CO_{2e} of N_2O is 298 to 310. One ton of N_2O in the atmosphere = ~300 t CO_2

US N_2O Emissions



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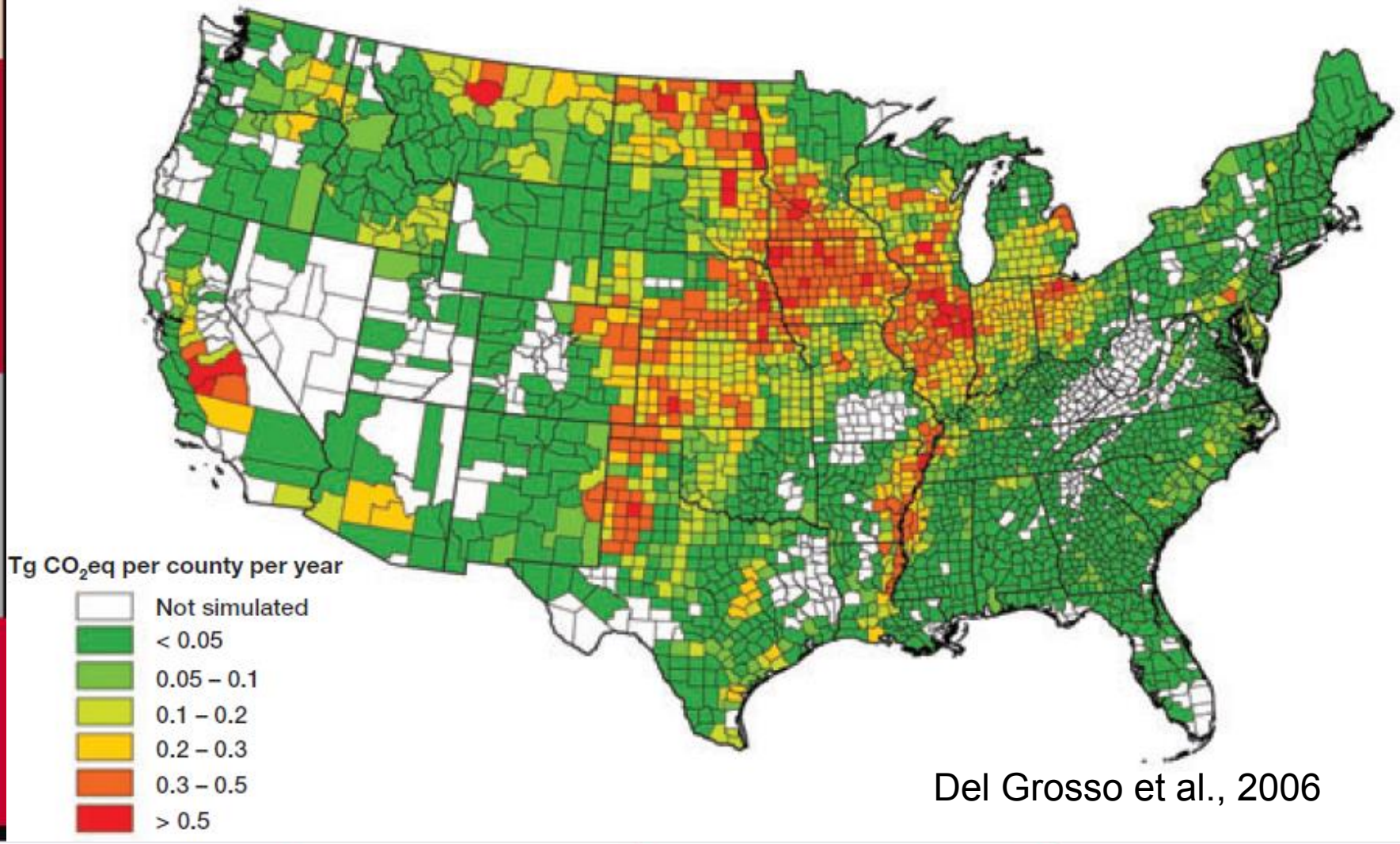
N_2O coupled to nitrogen application



Del Grosso et al., 2006

Nitrous oxide

- Agriculture
  - Main source of N_2O emission in US
  - Soil processes
    - denitrification
    - incomplete nitrification
  - animal manure
- 40-50% of N2O emission globally is from natural sources

Denitrification

- Reduces nitrate (NO_3^-) primarily to N_2, but with some N_2O emission
- Associated with
  - poor soil aeration
  - abundant decomposable organic material, e.g. fresh crop residues
  - Temperature sensitive
- Therefore, less with well-drained compared with poorly drained soil

Incomplete nitrification

- ammonium (NH_4^+) is converted to nitrite but not all nitrite (NO_2^-) is converted to nitrate (NO_3^-) with some N_2O emission
  - probably the main source of N_2O emission Nebraska crop production
  - Increased with
    - more soil NH_4^+ that undergoes nitrification
    - low soil aeration
    - warm temperature

Animal manure

- <10% of agricultural N_2O emission
- much from urine-N with high protein diets

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Emission from Nebraska Cropland

- N_2O emissions in eastern Nebraska were found to be 4 - 5.5 lb N_2O/ac/yr
  - Less for rainfed
  - More for continuous corn
- 5 lb N_2O/ac = ~1500 lb/ac CO_2 = CO_2 from ~75 gal gasoline

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Do we have some no cost or low cost opportunities?

- Potential for win-win-win solutions

Rotation vs monoculture

Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
Variable	↓	↓

N erosion/ runoff	N_2O emission	Denitrification
Var/ ↓	↓ Var	↓

Results of N_2O research

- Less with corn-soybean rotation compared with continuous corn in NE and IA studies
- Variable in others
- 3-6 wins; possibly no cost!!

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No till vs tillage

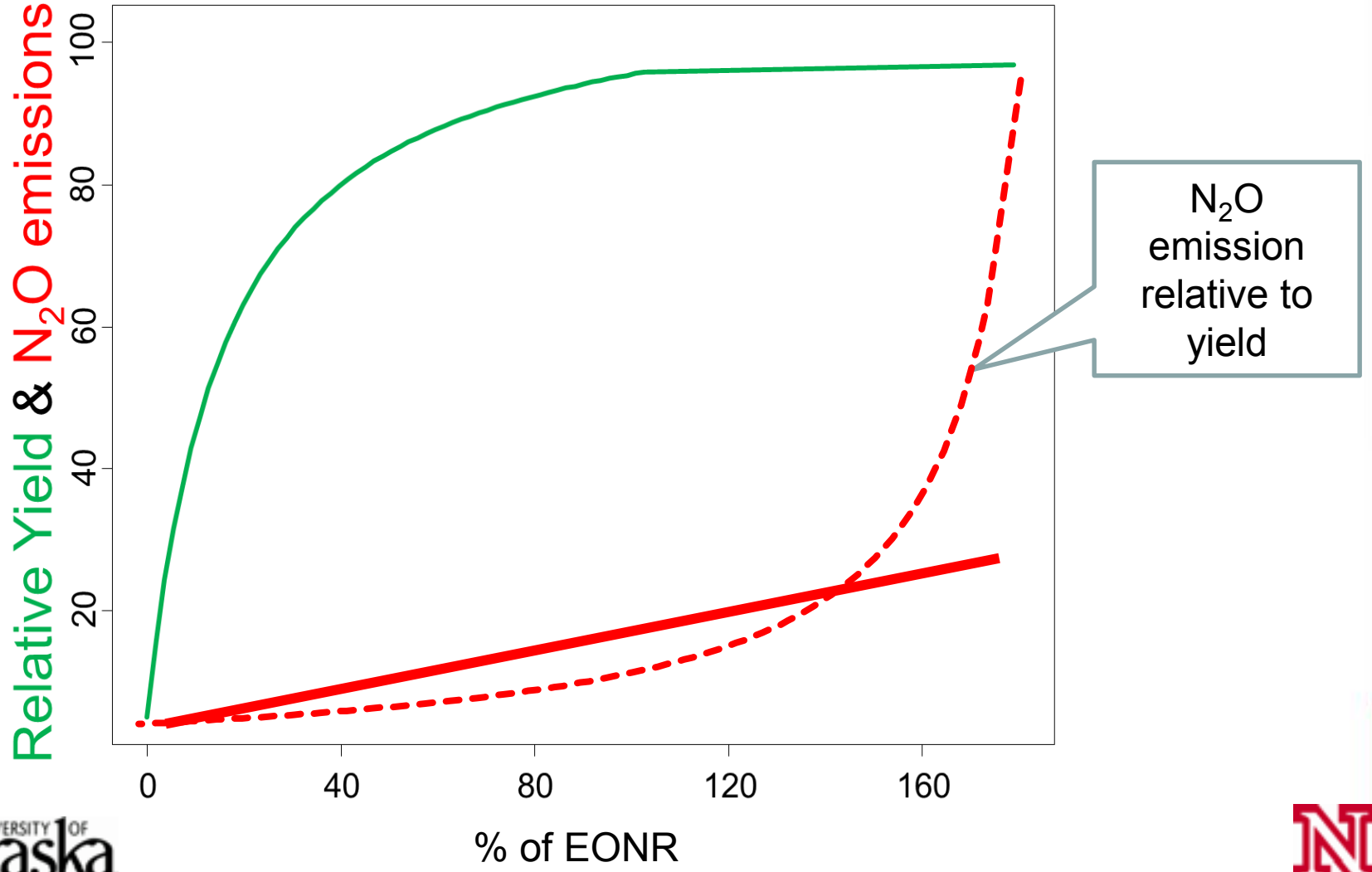
Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
Var	Var§	⇧

N erosion/ runoff	N_2O emission	Denitrification
⇩/Var	Var	Var

Results of N_2O research

- §Var: often benefits depend on the level of risk of N loss to a process!!!
- less emission with no-till in Colorado, but more in Canada
- tillage effect varies
- 1-5 wins; often with no cost

Economic Optimal N Rate



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EONR

Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
↑	↓	↓

N erosion/ runoff	N_2O emission	Denitrification
↓	↓	↓

Results of N_2O research

- N rate is the best predictor of emissions
- 1-4% of applied N equivalent found to be emitted across Corn Belt
- Under study by UNL
- 6 wins; no cost!!!

Anhydrous NH_3 vs other N fertilizers

Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
↑	Var	↓

N erosion/ runoff	N_2O emission	Denitrification
Var	↑	Var

Results of N_2O research

- MN studies:
  - 50% more emission with AA injected compared with urea broadcast and incorporated
  - more with AA compared with $CaNO_3$
- more with urea than with UAN
- Switch from AA; some other negative effects

Injected vs surface

Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
Var	Var	⇩

N erosion/ runoff	N_2O emission	Denitrification
Var	Var	Var

Results of N_2O research

- Mixed results: reduced emission with injection in MO, but increased in CO
- Inconclusive; under study by UNL

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In-season N application

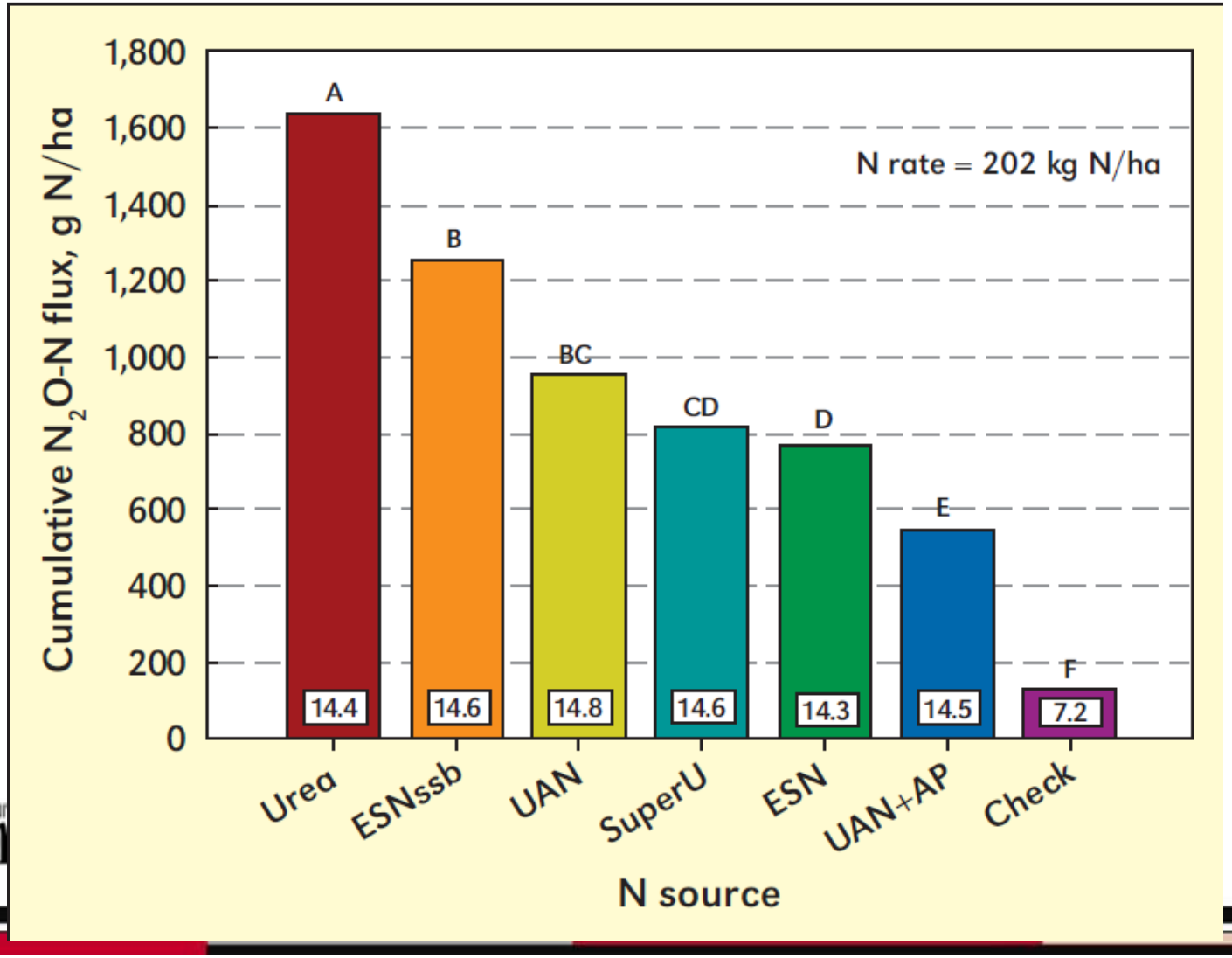
Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
Var	↓	Var

N erosion/ runoff	N_2O emission	Denitrification
↓	↓	↓

Results of N_2O research

- Less emission expected with sidedress application and fertigation
- Under study by UNL
- Decreased emission with 4 to 6 wins, probably no loss of profit for situations of high risk of leaching or denitrification loss

Inhibitors, controlled release: also placement and type; continuous corn, CO



Halvorson and Delgrosso, ARS

Nitrification inhibitors

Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
Var	↓	----

N erosion/ runoff	N_2O emission	Denitrification
----	↓	↓

Results of N_2O research

- Use of a nitrification plus urease inhibitor reduced emission by 40% in CO
- Under study by UNL
- 3-4 wins; probably no loss of profit for situations of high risk of leaching or denitrification loss

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Controlled released N fertilizer

Profit	NO_3^--N leaching	NH_3^+-N volatiliz.
Var	⇩	⇩

N erosion/ runoff	N_2O emission	Denitrification
Var	⇩	⇩

Results of N_2O research

- Reduction in emission varied across four studies with decreases up to 50%
- Under study by UNL
- 4 to 6 wins; effect on net profit will depend on
  - risk of N loss to one or more processes
  - the cost of controlled release N

Other practices

- Other practices have been found to have little or inconsistent effect on N_2O emission
  - Spring compared with fall application
  - Cover crops

Best no- or low-cost win-win-win N_2O opportunities

- Rotation
- EONR
- In-season N application
- Inhibitors where leaching or denitrification risk is high
- Controlled release fertilizer: depends on cost and potential for other losses

Variability in effectiveness and net cost

- Risk of N_2O emission as well as N loss to different processes varies with field and management conditions
- We are developing an easy to use N management tool
  - assessment of N loss risk to different processes
  - evaluate effects of alternative practices
  - Using ‘saved’ money; need more money to complete

Opportunities

- Some N_2O reduction practices have multiple benefits, often with little or no loss in profit
- Good N loss risk assessments can greatly improve decisions on alternative practices