Sustainability in a Global Environment:
Have You Considered Your Nitrogen Footprint?

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With contributions from:
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Have You Considered Your Nitrogen Footprint?

Water, water everywhere,
And how the boards did shrink.
Water, water everywhere,
Nor any drop to drink.

Rime of the Ancient Mariner
Samuel Taylor Coleridge

The Main Topics

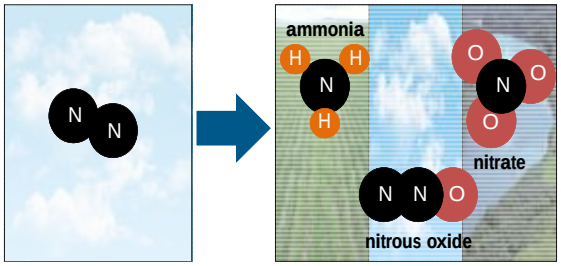
- **Why nitrogen?**
  - **What is reactive N (Nr)? How is it created?**
- **Nr as a resource**
  - **How is it used?**
    - **Easier to lose it than to eat it.**
  - **What happens to it?**
    - **Cascading consequences**
- **The Nitrogen Dilemma**
  - **Food vs. Environment?**
- **N footprint models as management tools**
  - **From education to action**
    - **Personal (lunch anyone?)**
    - **Institutional**

Nitrogen: Setting the Stage

- Earth has >10,000,000 biological species
  - ***They all need nitrogen to survive***
  - ***N is the limiting nutrient for many ecosystems***
- ***Good news****: 78% of the atmosphere is N_2*
- ***Bad News****: Only 1,000 species (0.01%) can convert N_2 to a useable form*
- **Questions:**
  - *How do organisms get reactive N?*
  - *What is reactive N?*

What is REACTIVE NITROGEN?

Unreactive Nitrogen | **Reactive Nitrogen**



N_2 | *All types of nitrogen except N_2*

How is Reactive Nitrogen (Nr) Created?

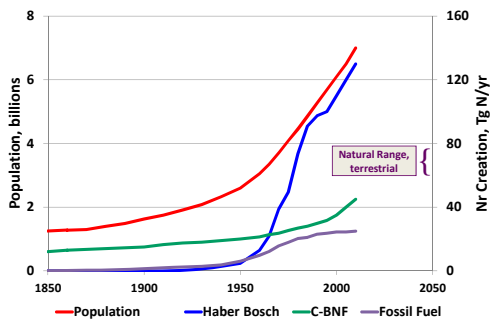
Natural processes:

- Biological nitrogen fixation by microbes (e.g., naturally occurring clover)
- Lightning

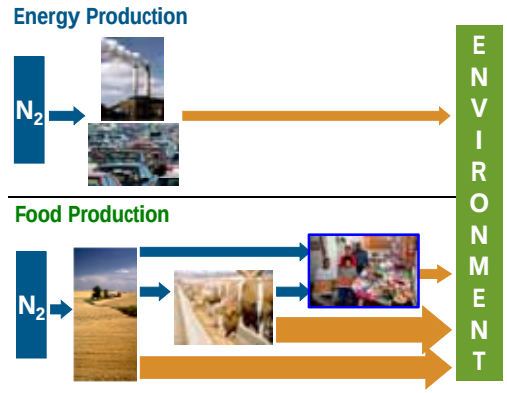
Anthropogenic processes:

- Fossil fuel combustion
- Haber Bosch process
- Planting legumes

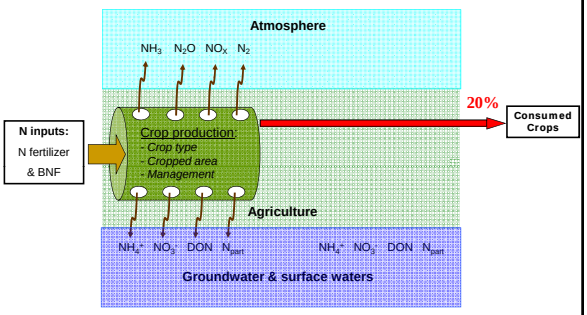
Global Rates of Nr Creation by *Humans*



What happens to Nr after it is Created?



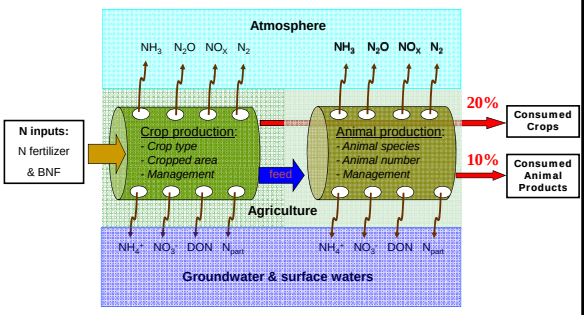
Nitrogen: A Very Leaky Element



Oenema, 2009

And What About Meat?

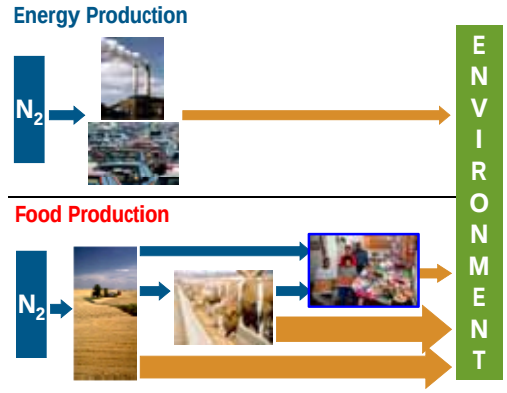
Nitrogen: A Very Leaky Element



Most of Nr used to produced food is lost to the environment either before or after consumption

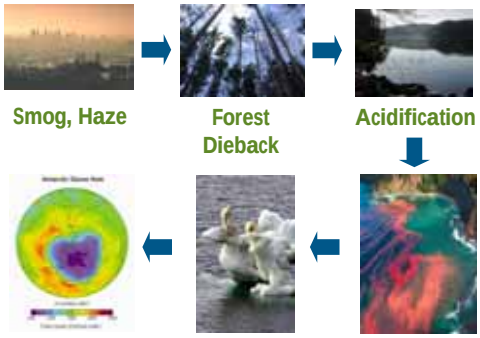
Oenema, 2009

What are the Impacts of Nr?



Too Much Nitrogen: In a Cascade

ENVIRONMENT



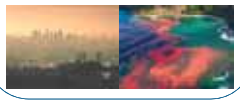
The Nitrogen Dilemma

Benefits:

- Necessary for life
- Synthetic nitrogen fertilizer provides unlimited food supply

Drawbacks:

- Excess reactive nitrogen negatively affects environmental and human health



Challenge:
Optimizing the use of nitrogen,
while minimizing the negative impacts

How can we address the N dilemma?

Nitrogen Footprint Model

Jim Galloway, UVA (USA) | Allison Leach, UVA (USA) | Albert Bleeker, ECN (NL) | Jan Willem Erisman, Louis Bolk (NL) | Rick Kohn, UMD (USA)

N-PRINT Projects

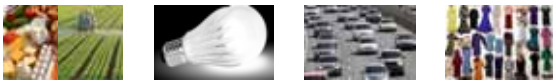
1. **N-Calculator**: Informs the **consumer** about how their food and energy use contributes to nitrogen losses to the environment.
   - For a year or for a meal
2. **N-Institution**: Calculates an **institution's** contribution to N losses, through resource consumption
   - Provides environmental managers with a tool to
     - Calculate the institution's nitrogen footprint
     - Test scenarios on how to decrease the footprint
     - Set a goal for footprint reduction
     - Track how actions result in N footprint decreases

N-Calculator

N footprint = Amount of reactive N released to the environment as a result of an entity's resource consumption

Individuals answer questions about 4 areas of resource consumption:

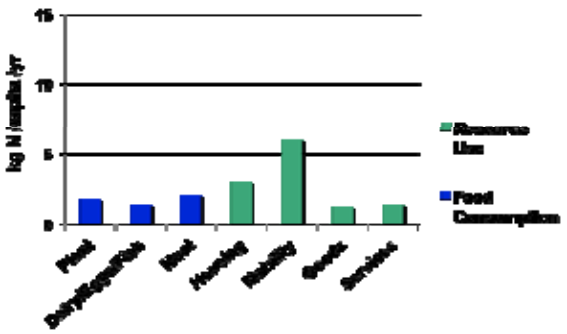
Food | **Housing** | **Transport** | **Goods & services**



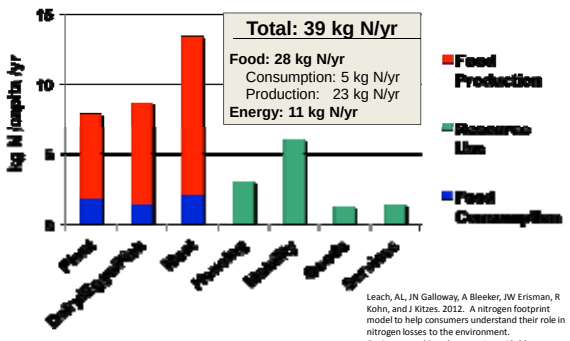
- **Completed**: US, Netherlands, Germany, UK
- **In progress**: Tanzania, China, Austria, Japan, and more!

www.N-Print.org

Average USA per capita N Footprint



Average USA per capita N Footprint



Leach, AL, JN Galloway, A Bleeker, JW Erisman, R Kohn, and J Kitzes. 2012. A nitrogen footprint model to help consumers understand their role in nitrogen losses to the environment. *Environmental Development* 1 pp. 40-66.

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Let's talk about Lunch!

Vegetable soup

Potato salad

Turkey sandwich

Ham & cheese sandwich

Roast beef sandwich

What is the N footprint of today's menu?

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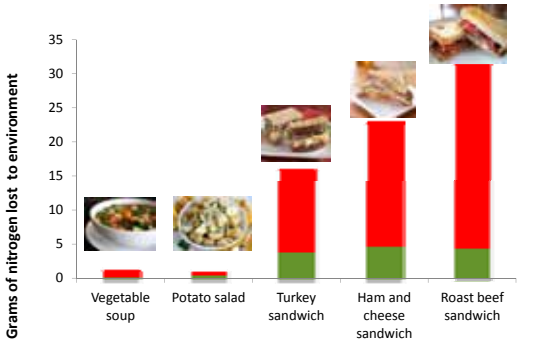
What is the N footprint of today's menu?



With thanks to Allison Leach for the calculations!

What can you do in your daily life?

Calculate your N footprint: **www.N-PRINT.org**

Energy:

- Reduce utility usage
- Public transit
- Reduce, reuse, recycle!

Food:

- Recommended amount of protein
- Less animal protein
- Less N-intensive meat
- Food from sustainable farms
- Reduce food waste

N-Institution
UVA Nitrogen Footprint Reduction Project

A Joint Project with the Office of the Architect, Facilities Management and Student Dining Services

Leach et al., 2013; A. Geene, Image

NITROGEN Part 2 of the Environmental Footprint Reduction Plan

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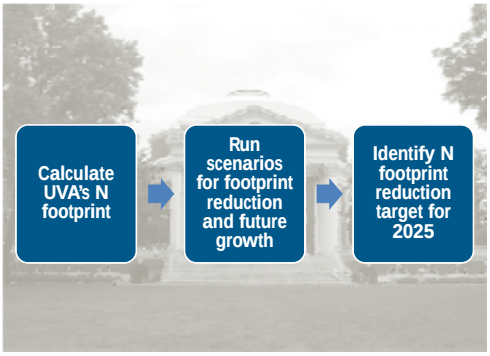
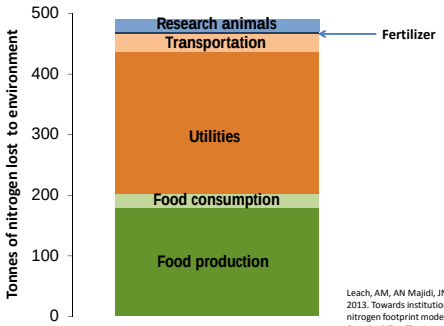
Introduction: Nitrogen footprint of UVA

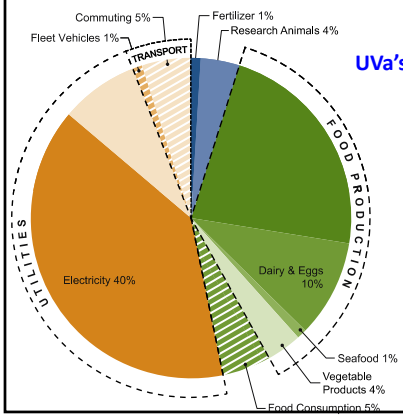
PROJECT GOALS



Total Annual N Footprint of UVA in 2010:
492 metric tons N

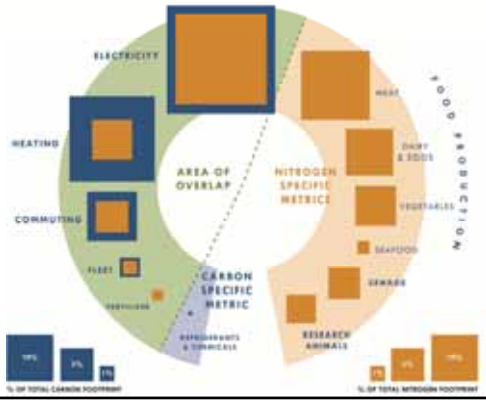


Leach, AM, AN Majidi, JN Galloway, A Greene. 2013. Towards institutional sustainability: A nitrogen footprint model for a university. *Sustainability: The Journal of Record* 6: 211-219.



UVa's Nitrogen Footprint
2010
492 tonnes N

Relationship to Carbon Footprint



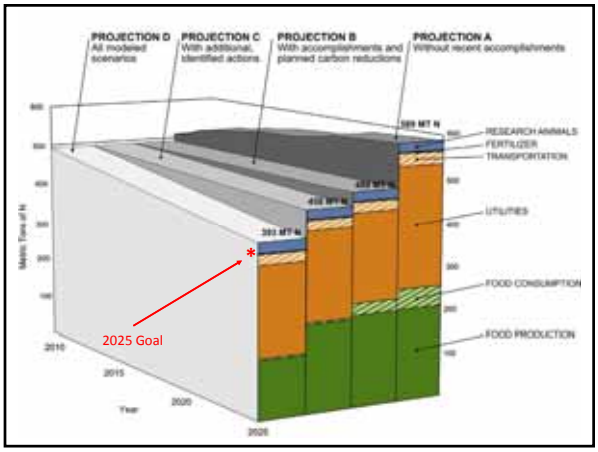
NEXT STEPS: Nitrogen footprint of UVA

PROJECT GOALS

- Board of Visitors Approval of Target {25% decrease by 2025} — DONE
- Run scenarios for footprint reduction and future growth — DONE
- Develop strategies for footprint reduction and track outcomes — IN PROGRESS

Opportunities to reduce UVA's N footprint

- Improve sewage treatment
- Expand composting & food recycling
- Reduce energy consumption
- Offer more sustainable food options
- Reduce or share transportation
- Reduce food waste



Summary

1. **Nitrogen challenge**: To optimize nitrogen's benefits while minimizing its negative consequences

2. **Personal N footprint:** Personal nitrogen footprint model educates consumers about how their choices impact nitrogen losses and the environment

www.N-Print.org

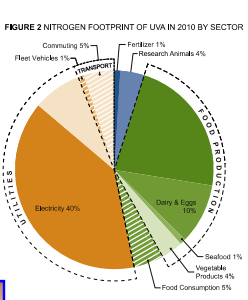
3. **UVA N footprint:** UVa has developed the first institution-level nitrogen footprint model

SUSTAINABILITY · UVA

Concluding Thoughts

- Humans now dominate Nr introduction into environment.
- There is a rapid rate of environmental change that is magnified by the N cascade.
- Institutions can decrease their contributions to N-related problems.
- Many of the actions also will result in a decrease to the Greenhouse Gas footprint
- A key challenge is to communicate the issues of N to the stakeholders:
  - consumers, producers
  - students, staff
  - administrators

Questions?



www.n-print.org