Budget Approach Provides Insights into Transformations and Fate of Nitrogen Applied to Eastern Washington Agroecosystem

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Nitrogen in the Environment

- Nitrogen losses from agroecosystems to the atmosphere and waterways have been linked to adverse environmental and human health impacts, including greenhouse gas accumulation in the atmosphere, algal blooms, and polluted drinking water.
- However, N fertilizer additions are required to achieve crop productivity necessary to feed the growing world population.
- A comprehensive analysis of N transformations and fate has never been conducted in our study region. An interdisciplinary approach is required to do this analysis, looking at movement between the soil, atmosphere, and aquatic continuum.

Overall Objectives of Collaboration

- Use novel interdisciplinary approach to understand the transformations and fate of N inputs to a semi-arid agroecosystem.
- Determine the relative importance and controls of input and loss fluxes.
- Inform future research and agricultural management and policy for the region.

Approach

We are synthesizing 12 years of soil, crop, hydrologic, biogeochemical, and atmospheric research conducted at the Cook Agronomy Farm to develop a long-term N budget for the farm, including the sources (inputs), losses (outputs), and change in soil storage.

Cook Agronomy Research Farm

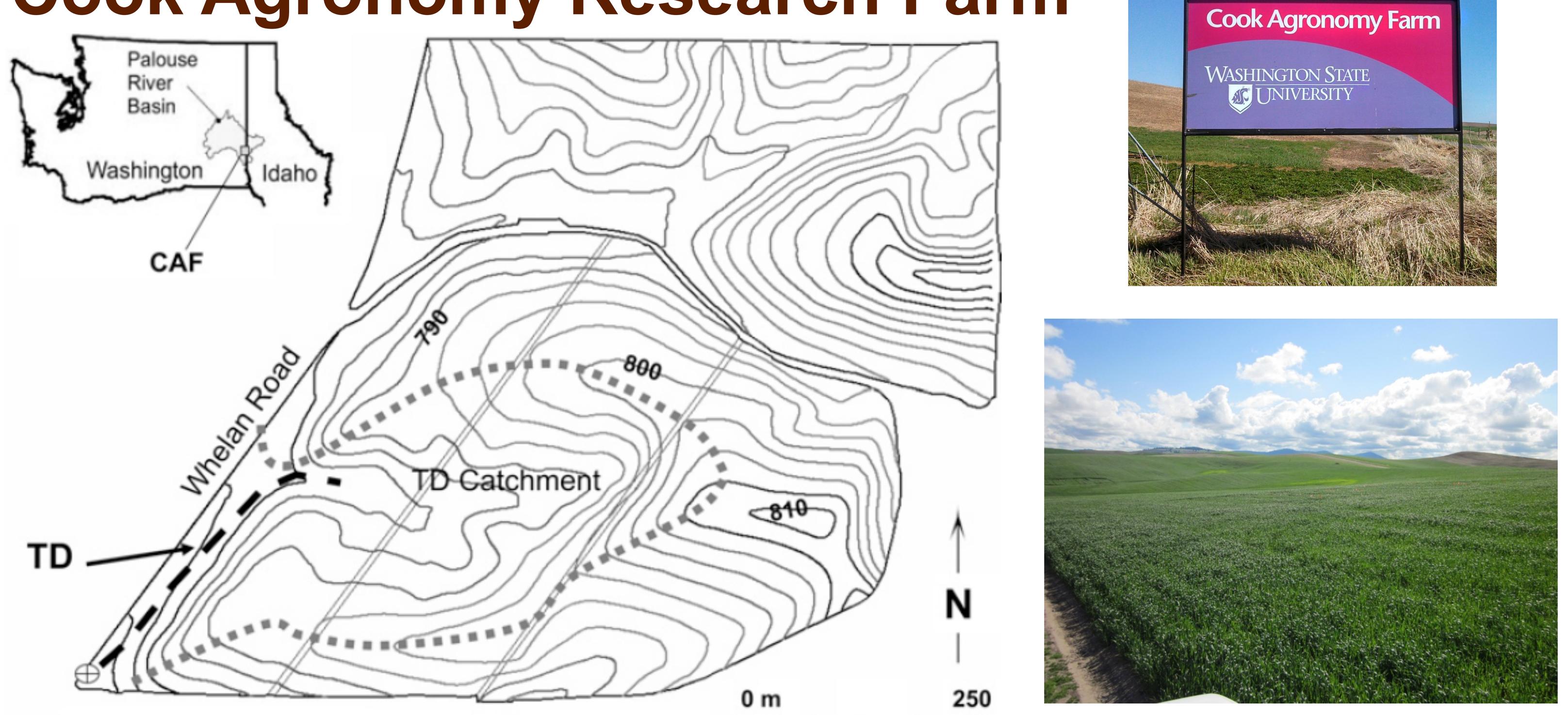

Figure 1. Cook Agronomy Farm (37 ha), located in eastern Washington, is managed under a three year cereal rotation (wheat, barley, legume). The Palouse region is characterized by steep, complex topography and a semi-arid climate with average annual precipitation 560 mm, most of which occurs from November to March, outside the growing season. Soils are deep, highly productive silt loams of the Mollisol Order. The SW ~12 ha are tile drained (shown above by dotted line). Map from Keller et al. (2008).

Preliminary Findings

- Fertilizer is the largest input and harvest the largest output.
- Approximately 14% of inputs are exported through leaching.
- Currently, 17% of N inputs have not been accounted for.
- N can be transformed, recycled, and transported via many pathways, making it difficult to account for all N inputs and outputs in ecosystems.
- Factors contributing to the “missing” nitrogen include:
  - Underestimation of leaching and/or atmospheric emissions due to under-sampling during “peak” loss events
  - Lack of available data on other losses, including leaching to groundwater, erosion, and volatilization from plants

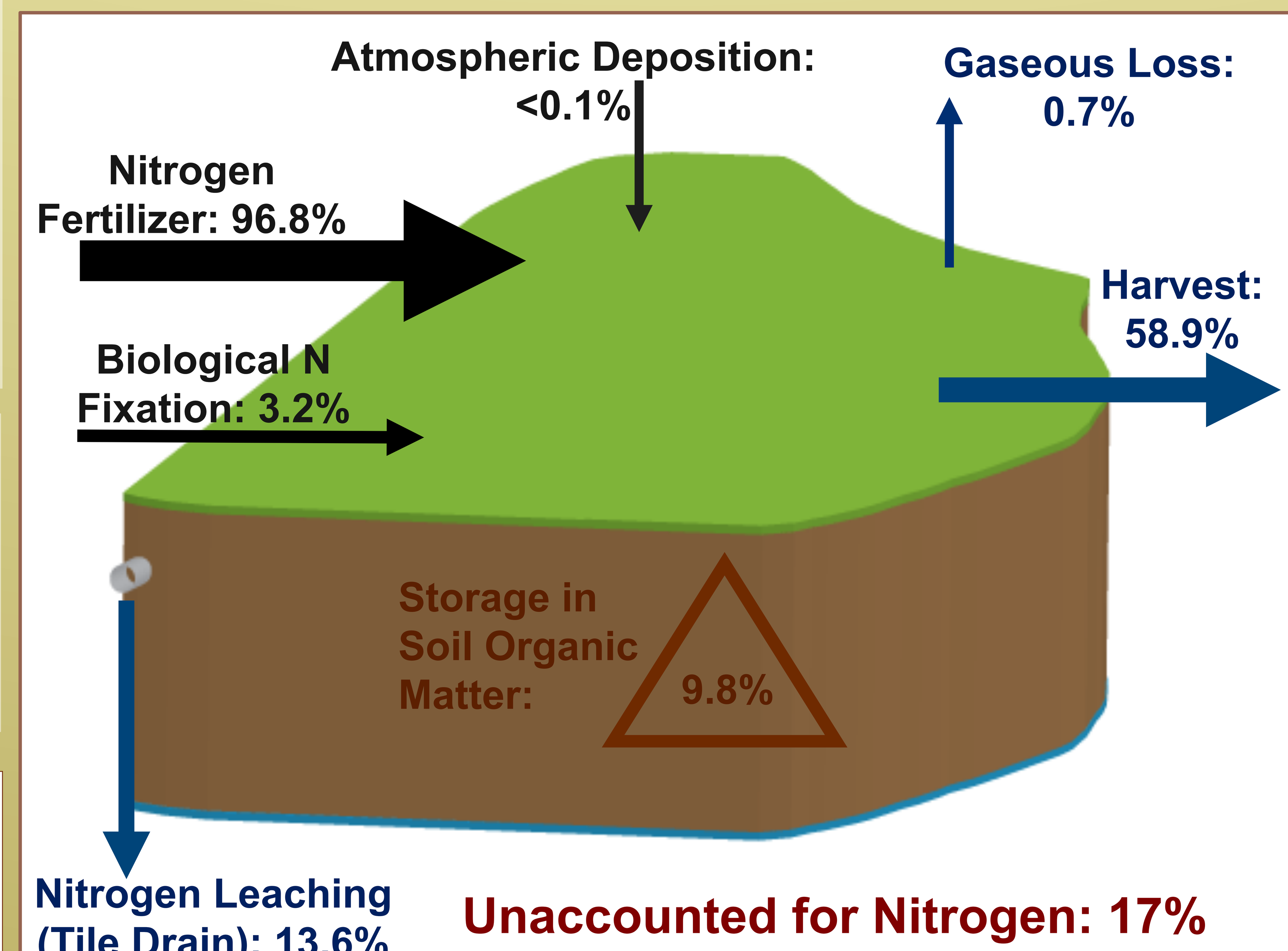

Table 1. Nitrogen budget for Cook Agronomy Farm (2000 to 2010) with assessment of relative proportion of inputs, measurement certainties, and natural variability of fluxes and pools of N.

Nitrogen Fluxes and Pools	Total N (kg)	Proportion of Inputs (%)	Estimated Certainty†	Natural Variability†
Inputs				
Deposition	10	<0.1	medium	medium
Fertilizer	54,000	96.8	high	low
Biological N_2 Fixation	1,800	3.2	low	high
Total Inputs	**56,000**			
Outputs				
Gaseous Loss	400	0.7	low	high
Harvest (Crop N)	33,000	58.9	high	medium
Leaching	7,600	13.6	low	low
Total Outputs	**41,000**	**73.2**		
N Storage				
Soil Organic Matter	5,500	9.8	low	low
Unaccounted for N‡	**9,500**	**17.0**		

† Preliminary estimate
‡ Unaccounted for N calculated from: Inputs – (Outputs + Storage)

Implications

Greenhouse Gas Emissions

Agricultural nitrous oxide emissions to the atmosphere in this region may be lower than IPCC estimate, which is 1% of applied fertilizer. More research is needed to understand how fertilizer management influences greenhouse gas emissions.

Drinking Water Quality

EPA drinking water standards for nitrate are regularly exceeded during the winter and spring in this region, when crops are not growing. The timing and amount of fertilizer application could be targeted as a management strategy to reduce this loss.

Efficient Use of Nitrogen

Currently only half of fertilizer applied is harvested. Improving crop uptake and utilization of N and fertilizer application techniques could reduce growers’ costs as well as mitigate the negative consequences for the environment.

Synthesis of soil-crop-aquatic-atmospheric sciences to quantify the fate of N is novel for these semi-arid agroecosystems.

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