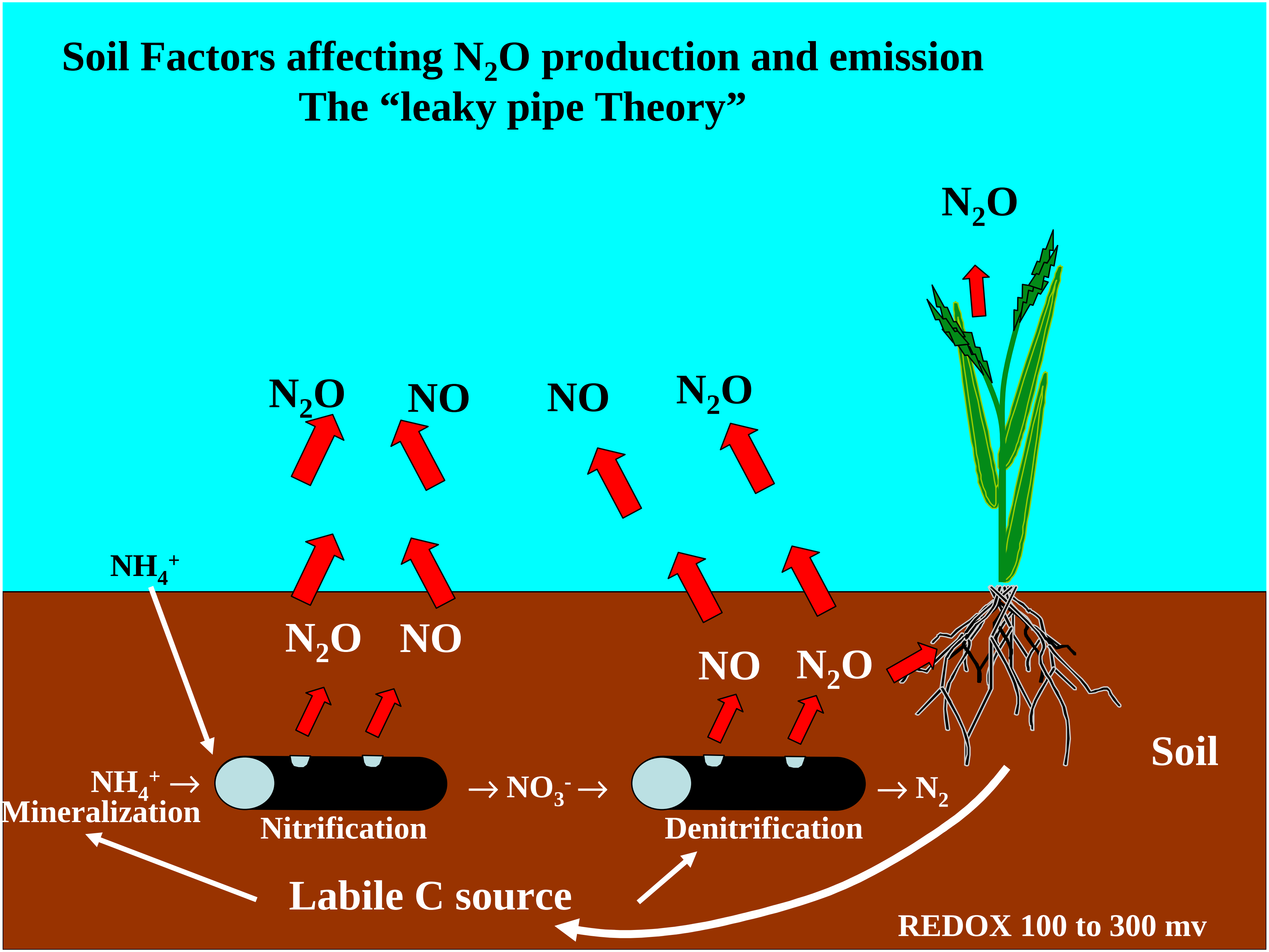
N_2O Emissions in Response to Nitrogen Fertilization

W. R. Horwath and M. Burger

Univ. California Davis

Dept. Land, Air and Water Resources

Fund by the California Air Resources Board



Soil Factors affecting N2O production and emission
The "leaky pipe Theory"
N2O
N2O
NO
NO
N2O
NH4+
N2O
NO
NO
N2O
NH4+ →
Mineralization
Nitrification
→ NO3- →
Denitrification
→ N2
Soil
Labile C source
REDOX 100 to 300 mv

Controls on N_2O Emissions

- **Soil water content (WFPS = water-filled pore space)**
  - Soil water content regulates diffusion of gases into the soil (O_2, CH_4) and out of the soil (N_2O, N_2, CO_2), as well as microbial activity
  - Irrigation
  - Winter rainfall
  - Tillage and traffic effects such compaction
- **Carbon inputs:**
  - Residue incorporation
- **Temperature**
- **Inorganic N concentration:**
  - N fertilization: Ammonium, nitrate, organic matter mineralization
  - Residual nitrate after crop season

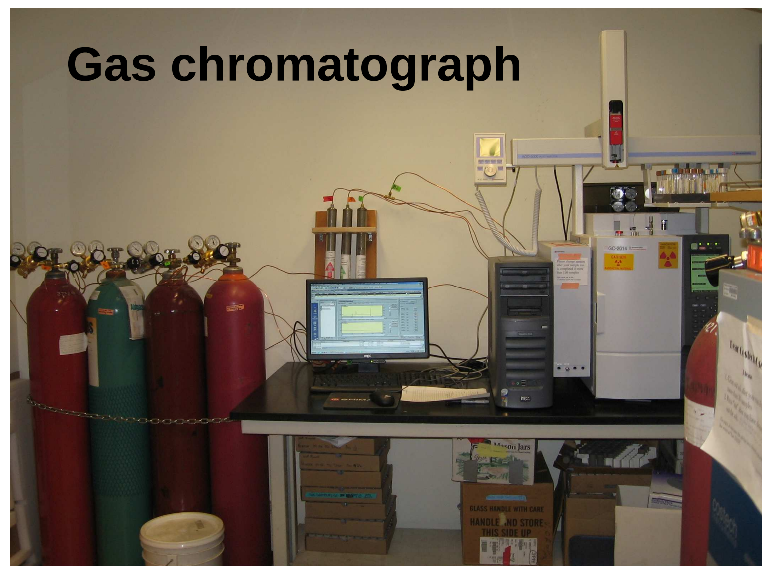
Research Objectives

- Estimate annual baseline N_2O emissions in representative cropping systems under typical management practices
- Determine N_2O emission factors in response to a range of N fertilizer inputs
- Estimate potential reductions in N_2O emissions through lower N inputs, but without yield penalty
- Identify key environmental (magnitude of influence) conditions affecting N_2O flux
- Provide data for modeling by collaborators

California Crops

	Acreage	kg N inputs/ac	County
This project			
Alfalfa	1050,000	0-25	Yolo
Wheat, oats, barley	730,000	0-90	Yolo
Rice	526,000	0-200	Colusa, Butte
Lettuce, broccoli, celery	360,000	50-150	Monterey
Tomato	324,000	50-120	Yolo
Collaborators' projects			
Almonds, walnuts	800,000	20-160	
Vineyards	790,000	0-50	
Cotton	560,000	30-120	
Corn	520,000	0-140	

Chambers used for static N_2O flux measurements in the field



Gas chromatograph

Annual N_2O Emission Measurements

- Year-round N_2O flux measurements
  - Required to fine-tune crop (system) emission factors

- Frequent event-based N_2O flux measurements until fluxes recede to background level
  - after N fertilization
  - following irrigation and rainfall events
  - incorporation of residue

- Less intensive measurement when N_2O flux is low & soils relatively dry

- Integrate flux measurements to estimate yearly N_2O emissions

Suggested sites for CEC, ARB and FREP projects

Crop	Site	Monitoring Period	PROJECT			
			CEC	ARB	FREP	HP
Corn		Summer/Winter	x		x	
Cotton		Summer/Winter			x	
Alfalfa	Turkovich Farm – Yolo County	Summer/Winter	x	x		
Alfalfa	UCD Farm	Summer/Winter	x			
Rice	Cooperative Rice Experiment Station - Biggs.	Summer/Winter		x		
Wheat		Summer/Winter		x		
Lettuce	Hatnell College East Campus Farm - Salinas	Summer/Winter	x	x		
Vineyard	Triple T Vineyards/Sutter Homes - Arbuckle, Colusa County	Summer/Winter	x			
Vineyard	Triple T Vineyards/Sutter Homes - Coastal Napa Region	Summer/Winter	x			
Almond Orchard	Nickels Soil Laboratory – Arbuckle, Colusa County	Summer/Winter	x			
Walnut Orchard	Dixon Ridge Farms, Winters, Solano County	Summer/Winter	x			
Tomatoes	UCD Russell Ranch, Yolo County	Summer/Winter	x	x		
Tomatoes	Turkovich Farm – Yolo County	Summer/Winter				x

Emission Factors in Relation to Yield and N Fertilizer Levels

- Replicated microplots with a range of N fertilizer inputs (e.g. 0, 30, 60, 90, 120 kg N ac^{-1})

- Measure yield and annual N_2O emissions at each N fertilization level

  Hypothesis: N_2O emissions increase mainly when N is applied in excess of the amount required to achieve optimal yields

- Emission factors = Annual N_2O-N emissions / Applied N

- Estimate N_2O mitigation potential under various N fertilization scenarios based on emission factors

Environmental Variables

- Measurements of ancillary variables (e.g. inorganic N, soil moisture, soil & air temperature)
  - Needed to calculate N_2O flux
  - Understand effects of typical management practices (e.g. irrigation or fertilizer type)
  - Modeling by collaborators

Benefits

- Baseline N_2O emissions for five types of cropping systems occupying 3 million acres of CA agricultural land
- N_2O emission factors at multiple N fertilizer levels to estimate potential N_2O emission offsets at reduced N fertilizer levels (Sliding emission factor)
- Results will provide basis for developing N fertilizer guidelines to growers
- Rich data set to calibrate and validate models
- Use results to evaluate effects of alternative management practices and future changes in California's cropping systems on N_2O emissions

PROJECT SCHEDULE
CARB PROJECT

- **Task 1:** Select sites, build flux chambers **SEPT 2009**
- **Task 2:** Set up N fertilization plots **Seasonally Year 1 & 2**
- **Task 3:** Measure N_2O flux **Years 1, 2 & 3**
- **Task 4:** Calculate annual N_2O emissions, emission factor **Ongoing**
- **Task 5:** Measure factors that control N_2O emissions **Ongoing**
- **Task 6:** Measure economic N yield **End of season years 1, 2 &3**
- **Task 7:** Prepare final report **June 2011**

CARB Project Start Date Sept. 2009

Proposed future Work

- *Determining Nitric Oxide Emissions from Soil in California Cropping Systems to Improve Ozone Modeling*
- *Assessment of Baseline Nitrous Oxide Emissions in California's Dairy Systems*