Nitrous Oxide Emissions in Response to Nitrogen Fertilization

Research Proposal

Prepared for California Air Resources Board

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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

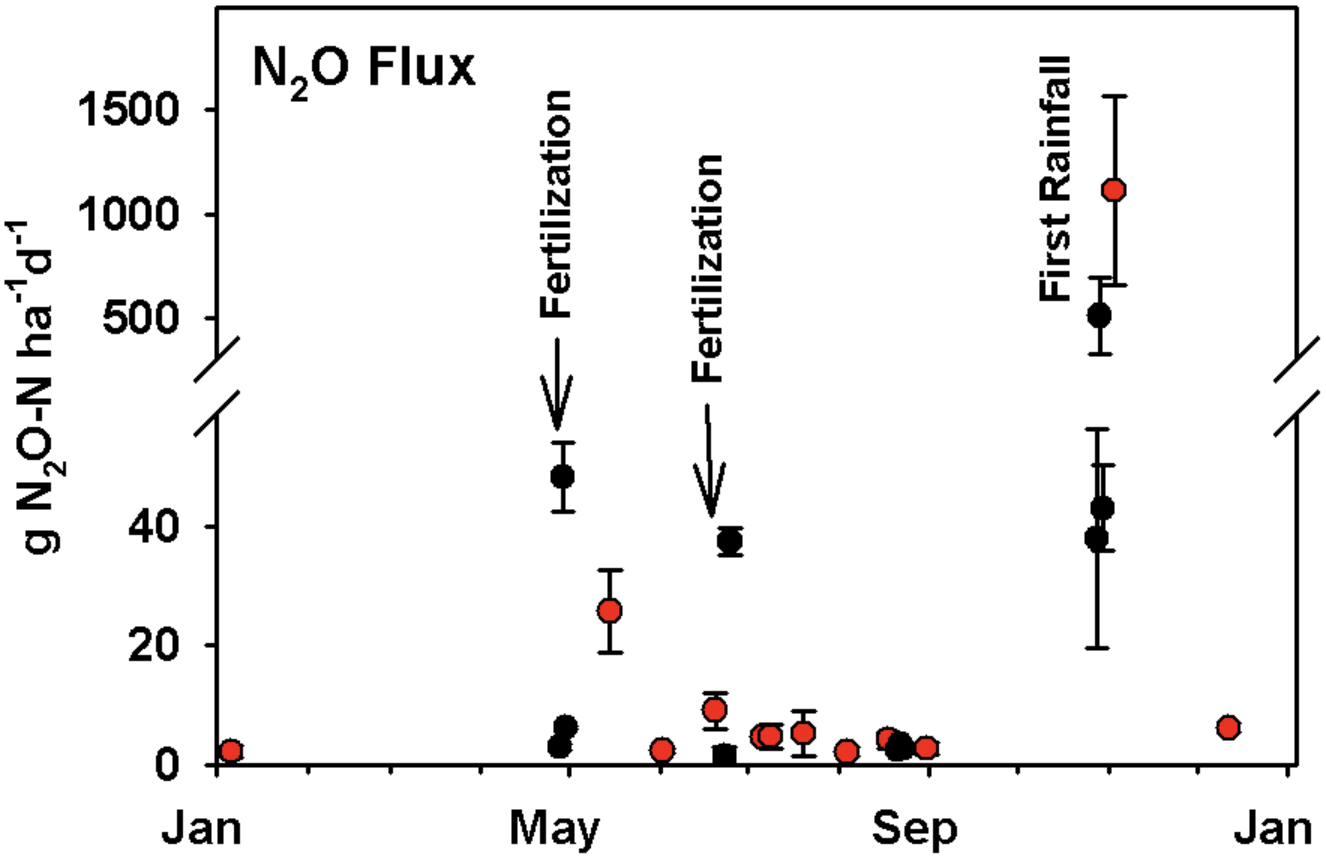
California Crops

	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	

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

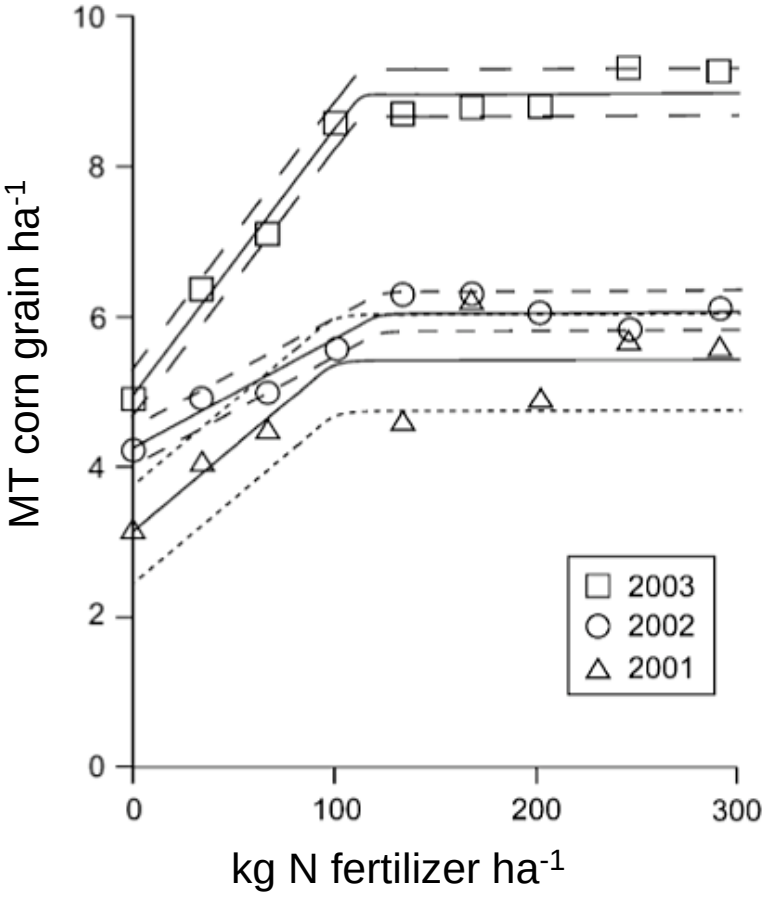
N_2O emissions tend to be event based



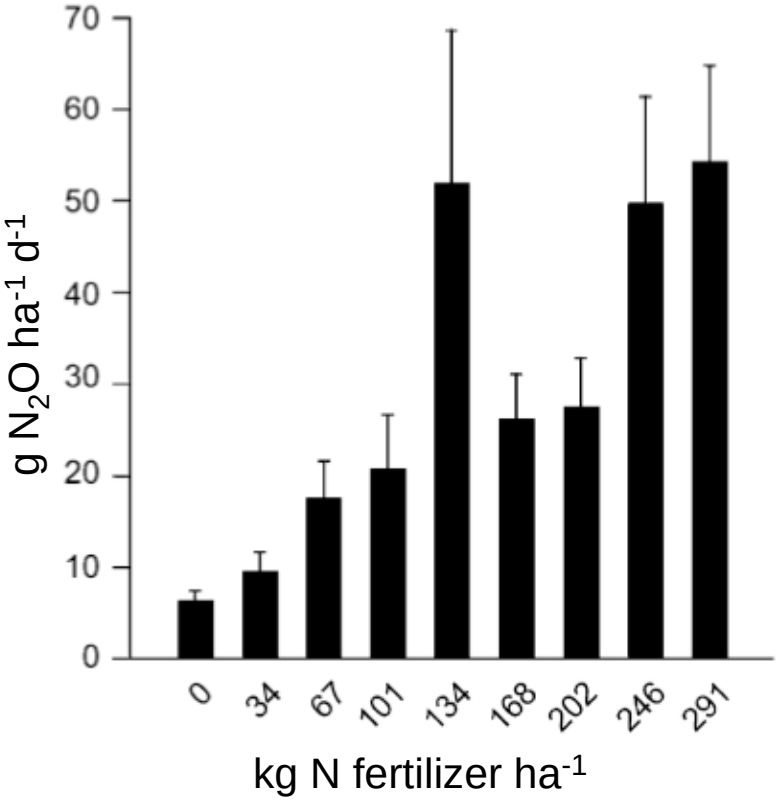
N_2O flux in response to N inputs and increased soil moisture in tomato systems in Yolo county.

N_2O emissions, Yield and Fertilizer N

Economic N Yield



N Fertilizer Rate *vs*. N_2O Emission



N_2O emissions increase non-linearly with N inputs exceeding those required to obtain maximum yield

McSwiney & Robertson, 2005

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

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

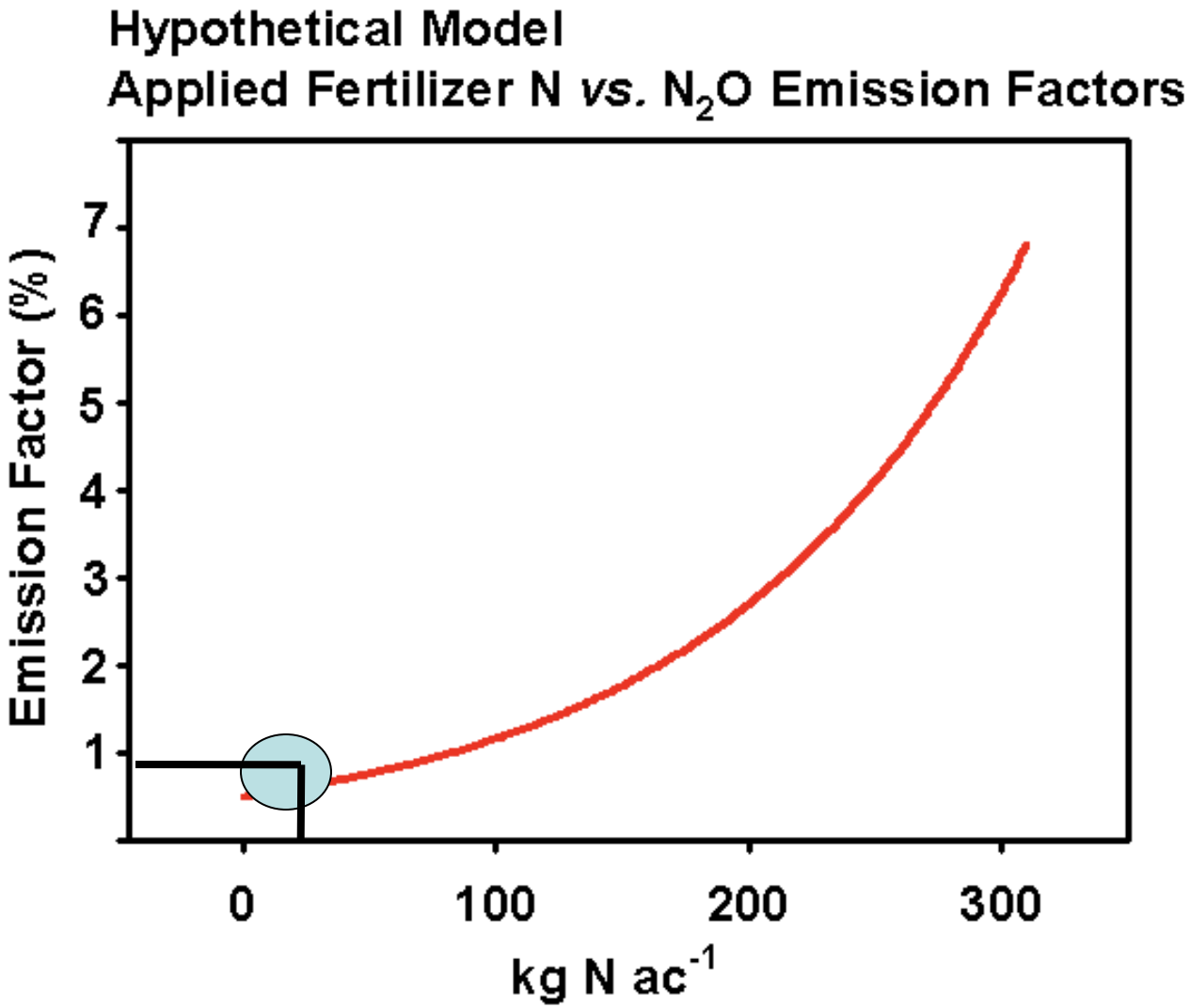
- Emission factors = Annual N_2O-N emissions / Applied N

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

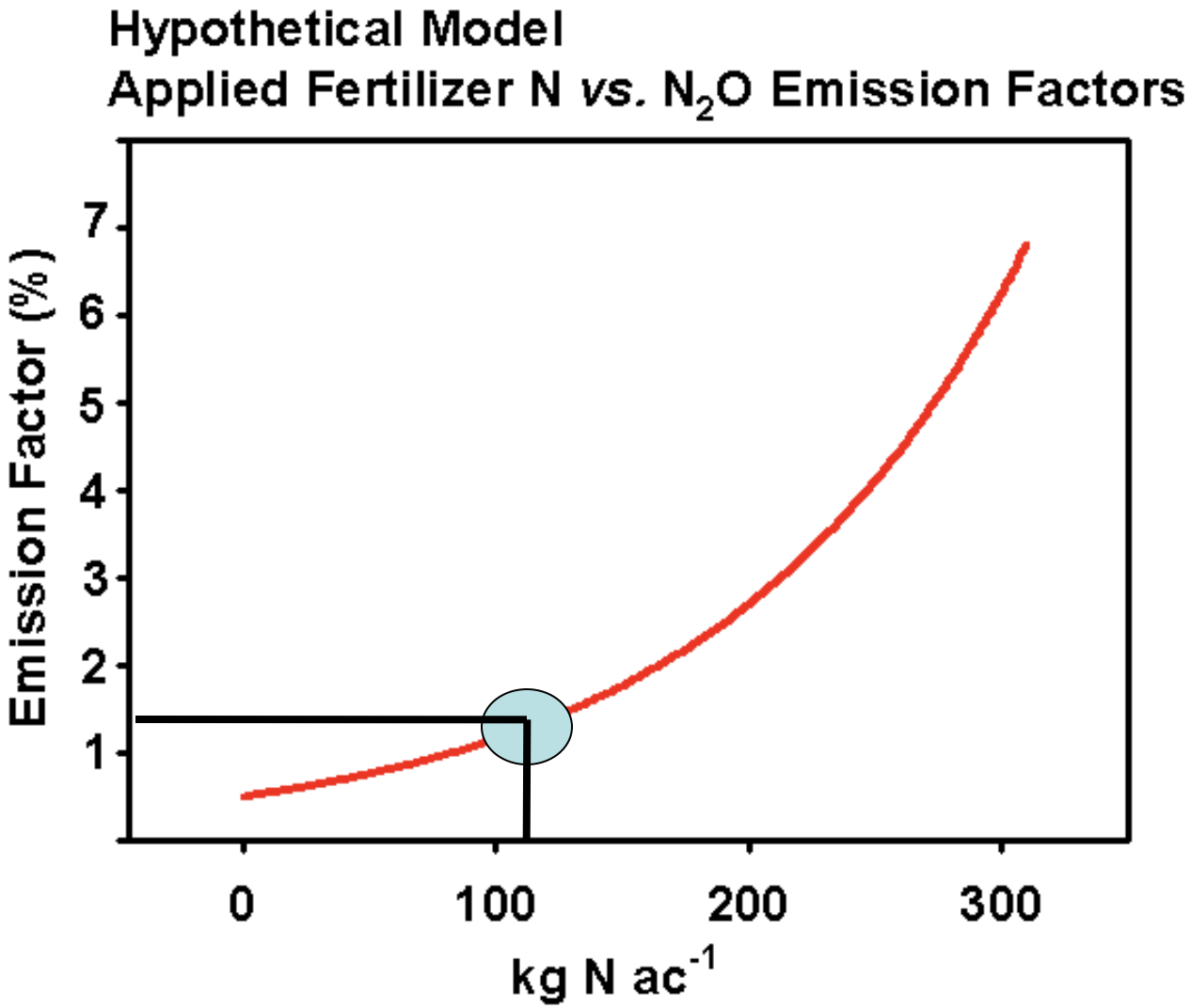
Environmental Variables

- 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

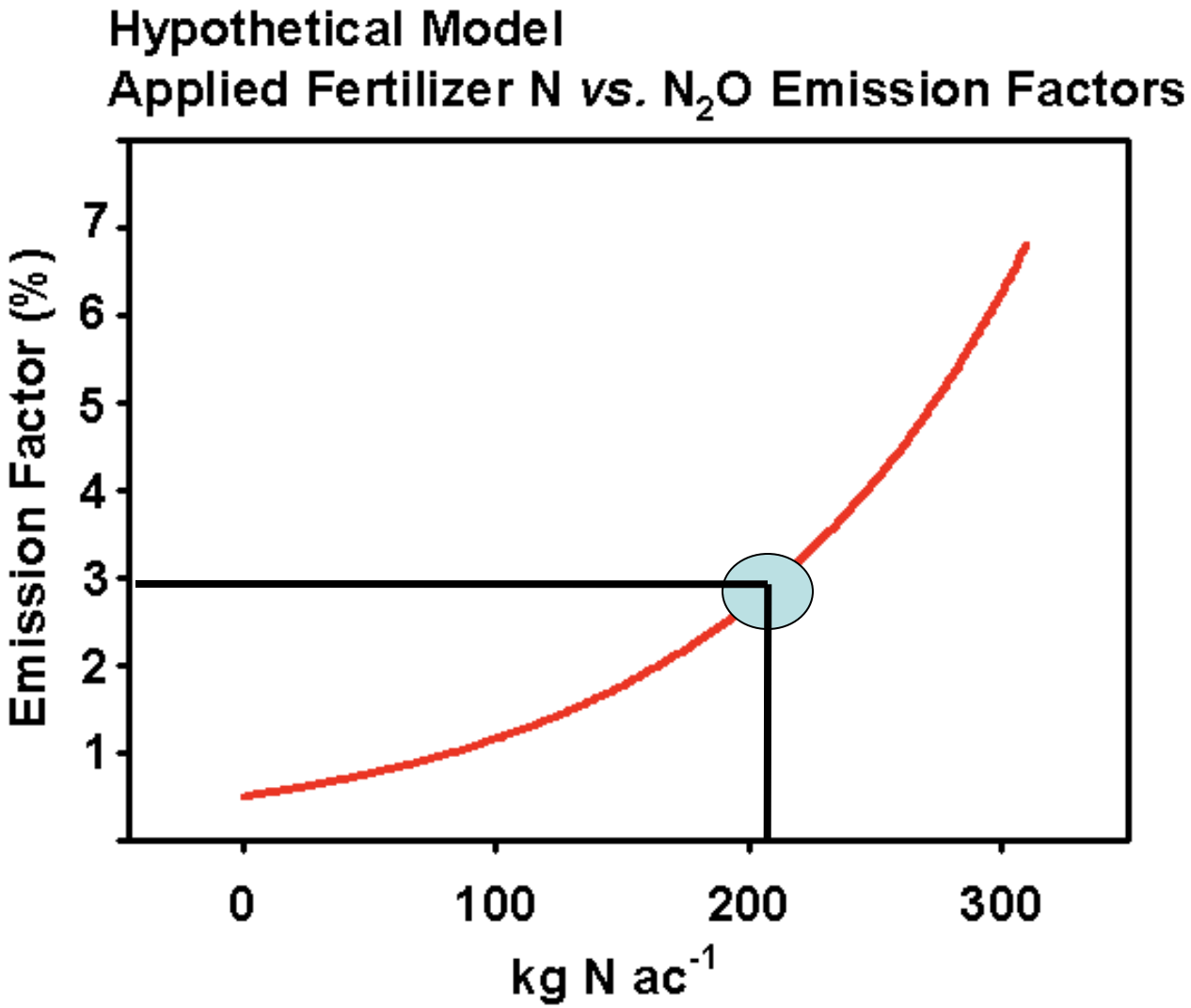
Sliding emission factor



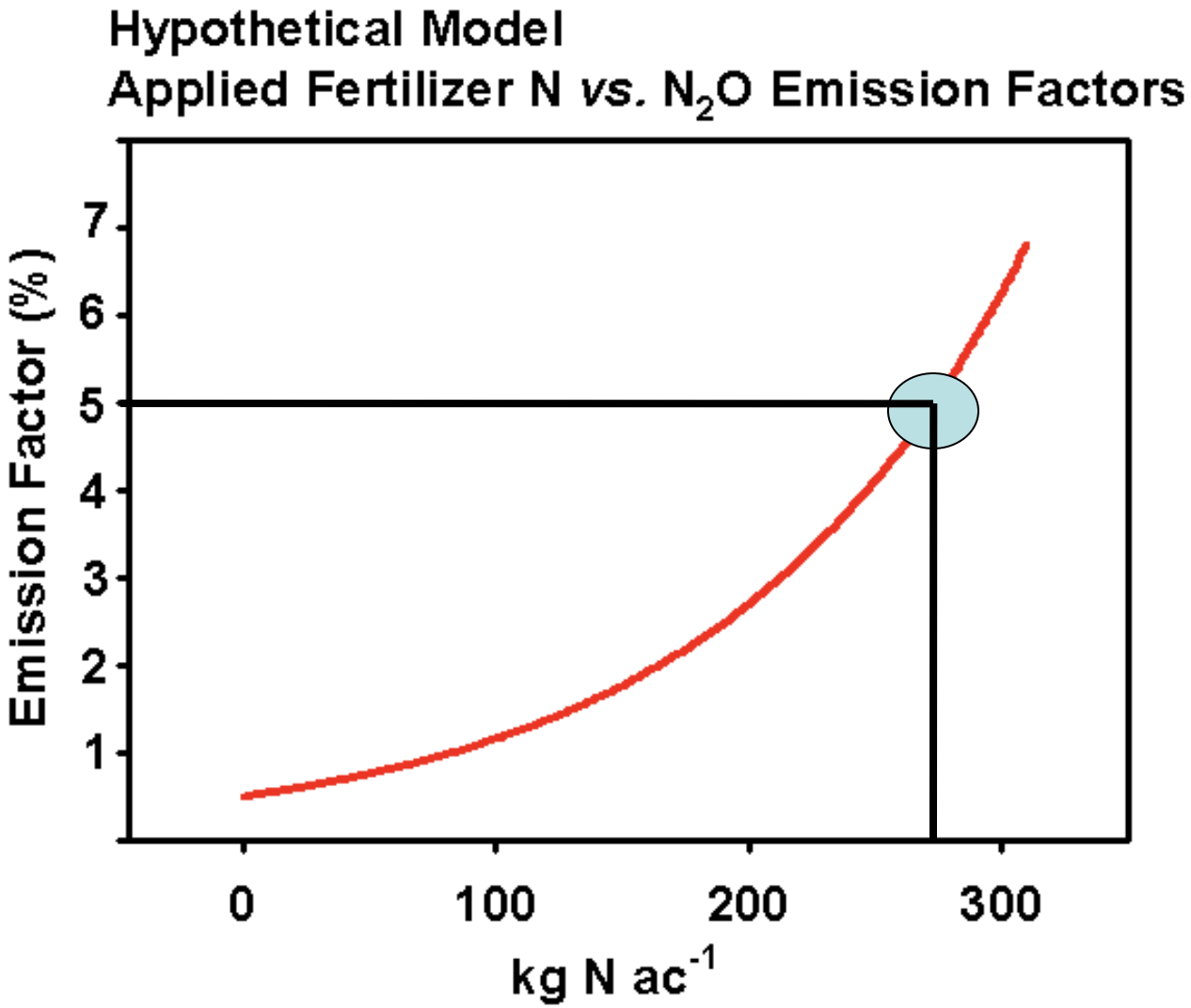
Sliding emission factor



Sliding emission factor



Sliding emission factor



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