Mitigating N_2O Emissions from Agricultural Soils: Scientific Basis and Modeling Approach

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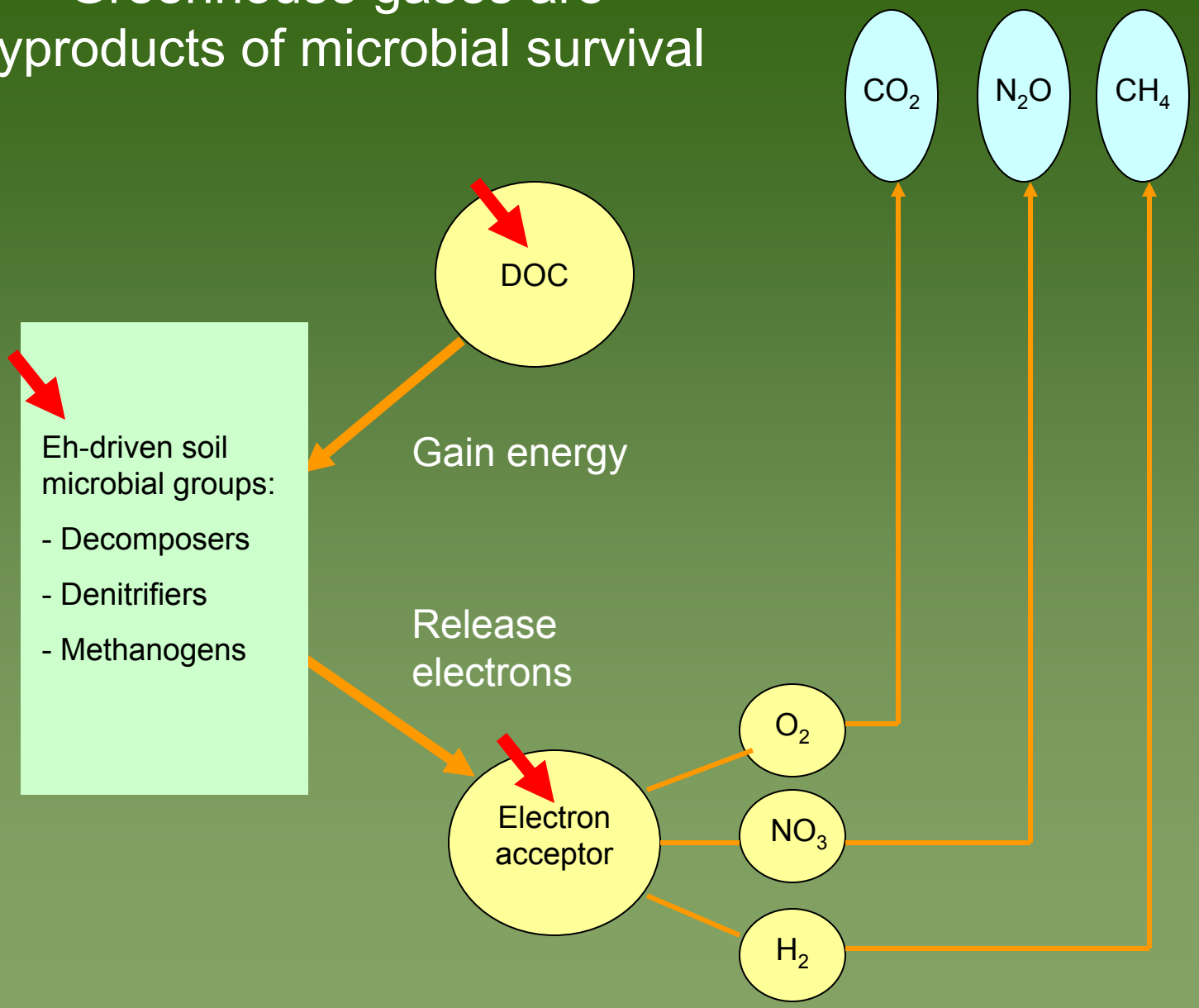
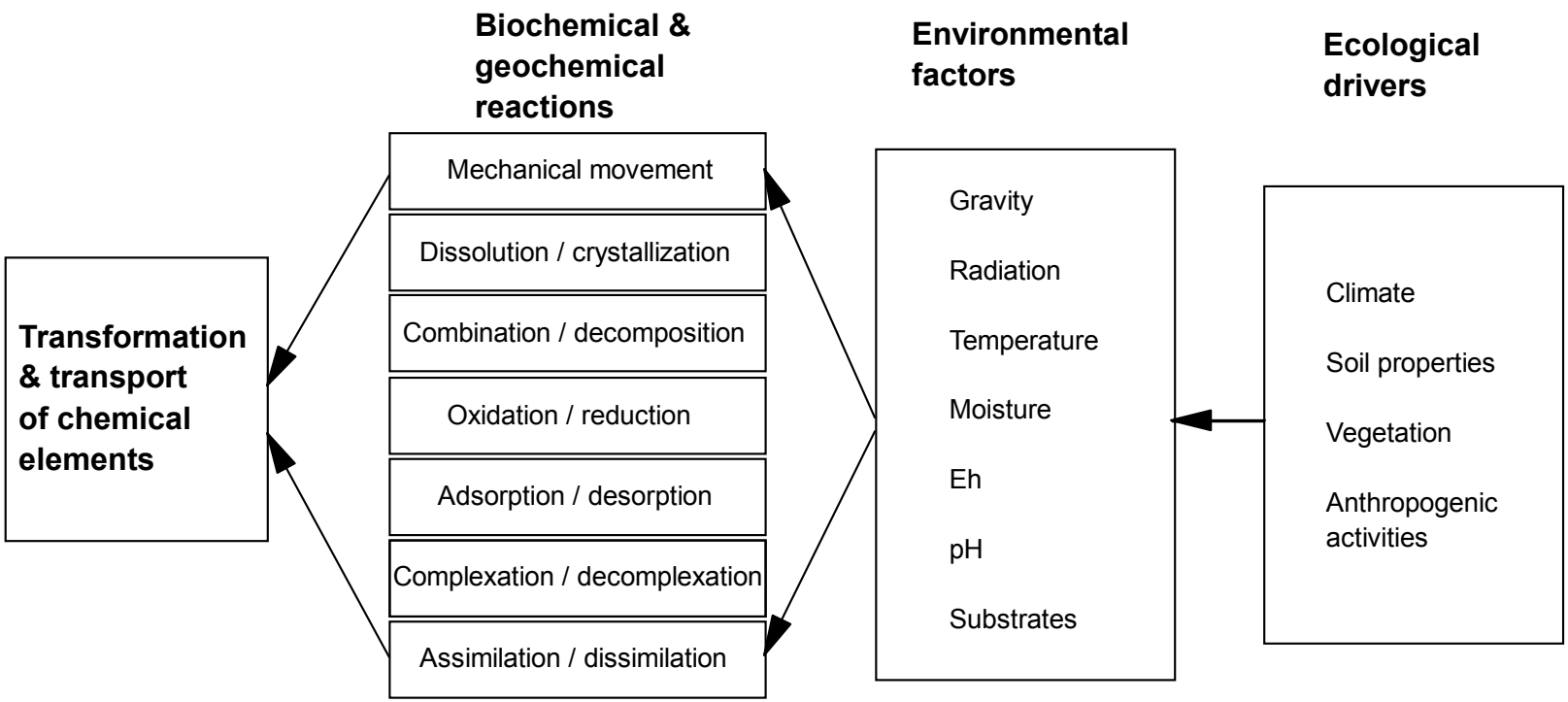
1. Quantifying impact of farming practices on N_2O emissions

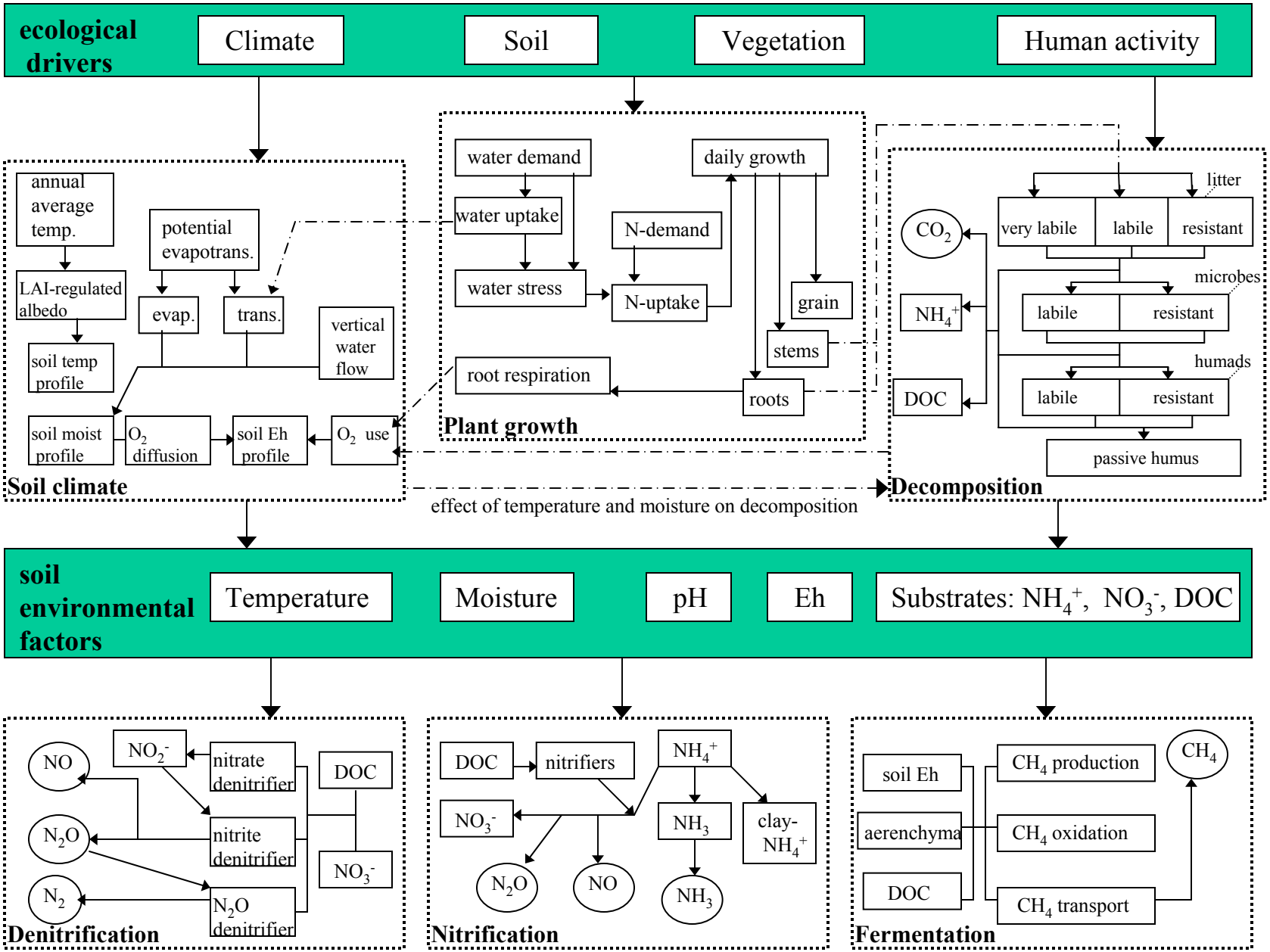
Greenhouse gases are byproducts of microbial survival



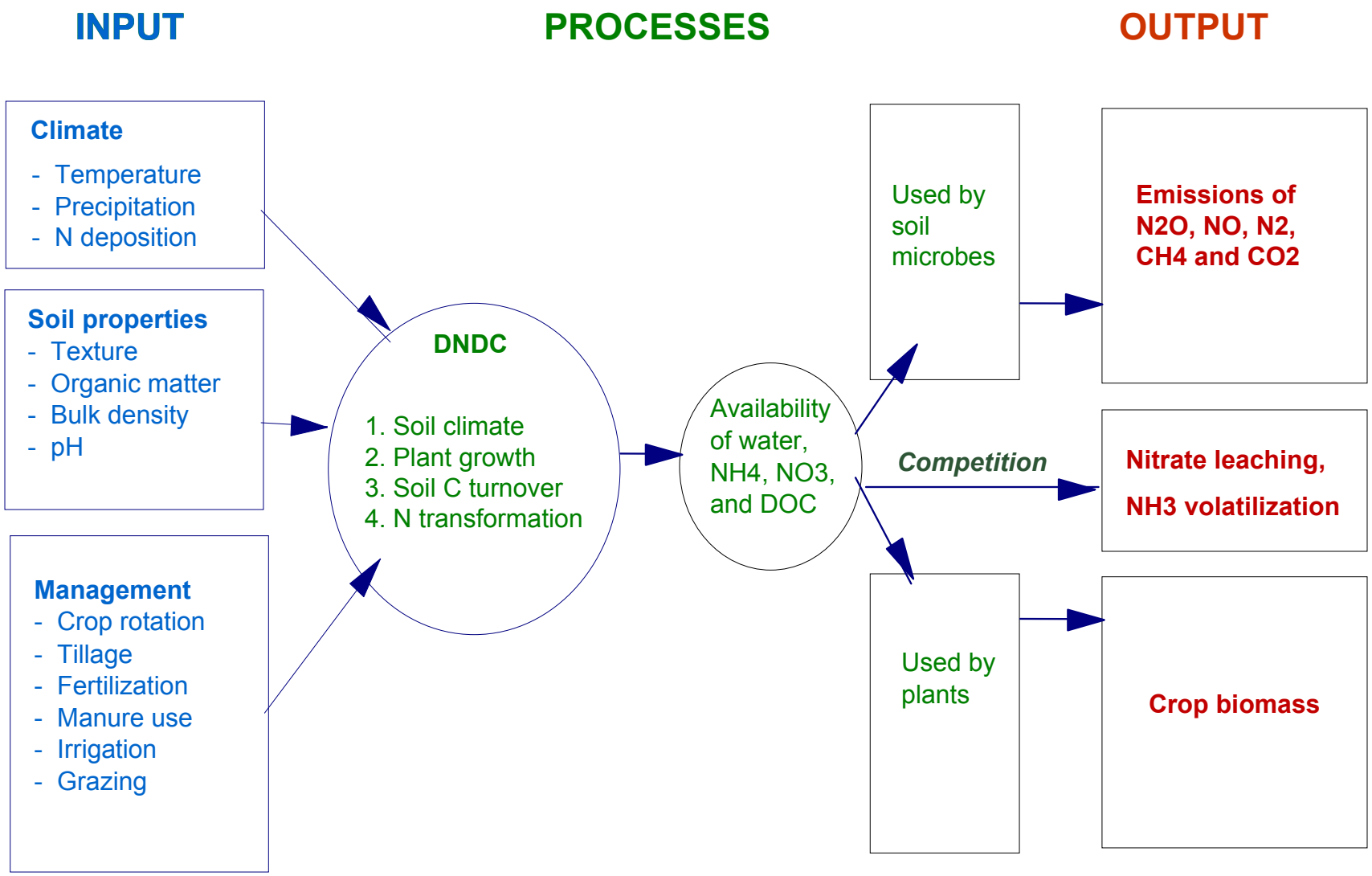
Integrating the Drivers and Processes Controlling GHG Production into a Modeling Framework



The DNDC Model

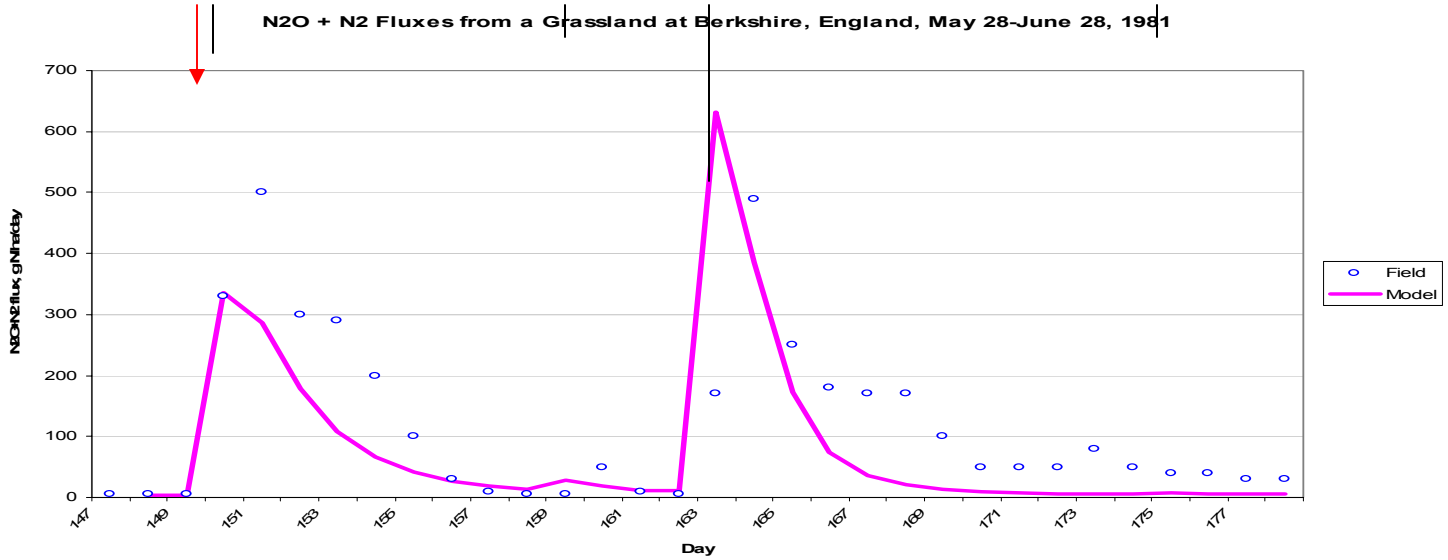


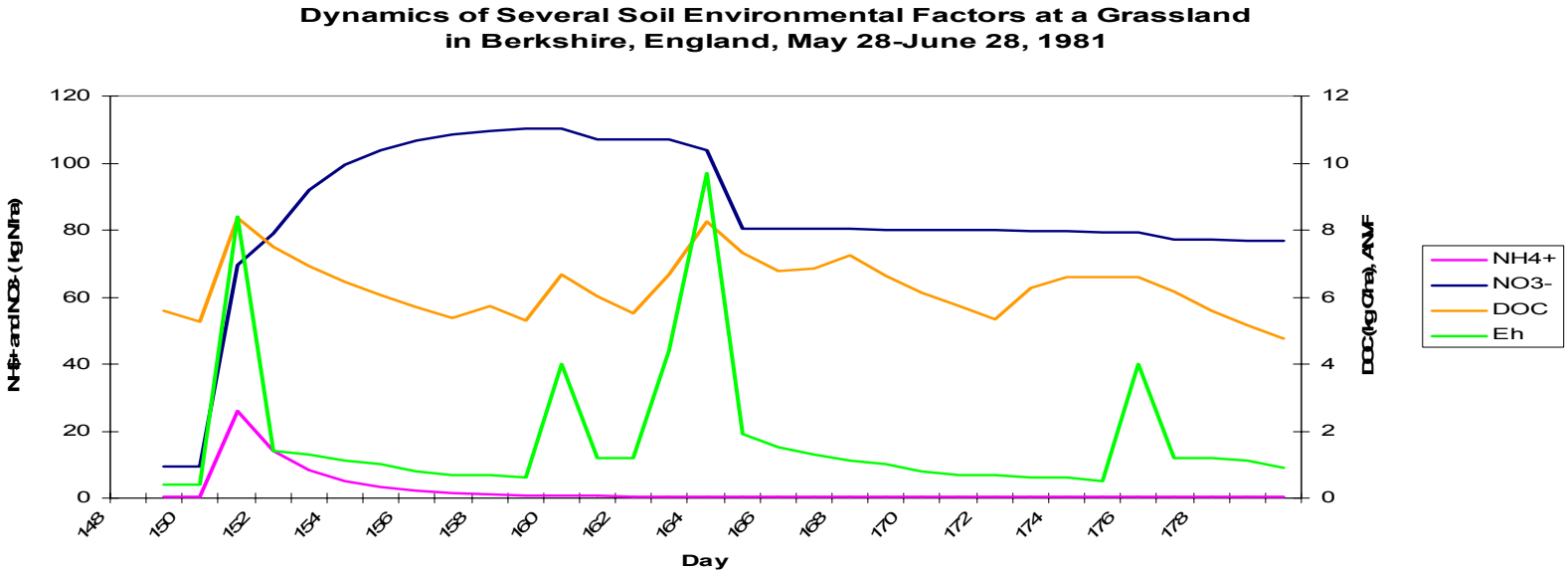
DNDC predicts crop growth, SOC dynamics, N leaching and trace gas emissions driven by climate, soil and management



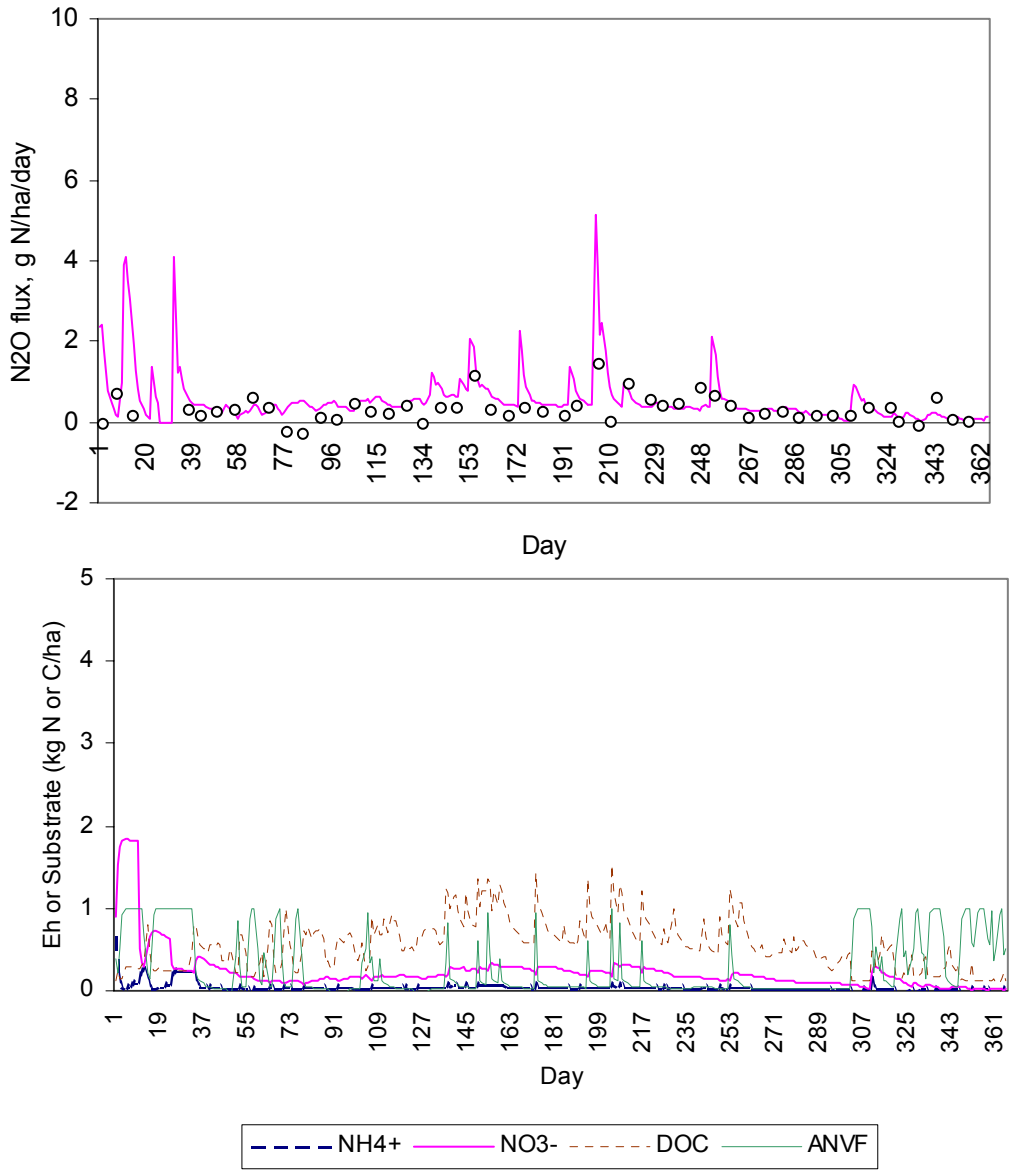
N2O from a fertilized grassland in UK

(Field data from Ryden 1983)





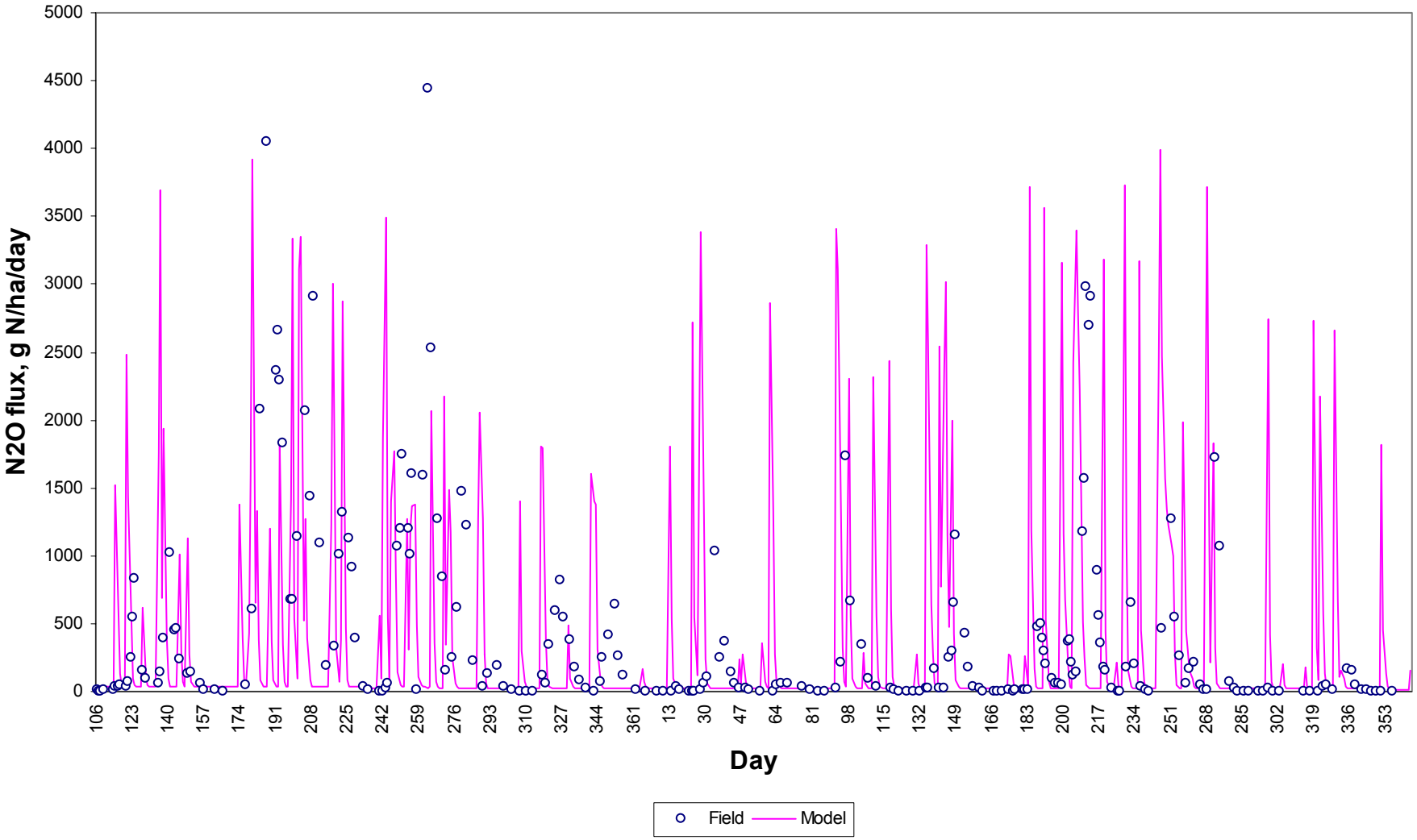
N2O from a grassland in Colorado



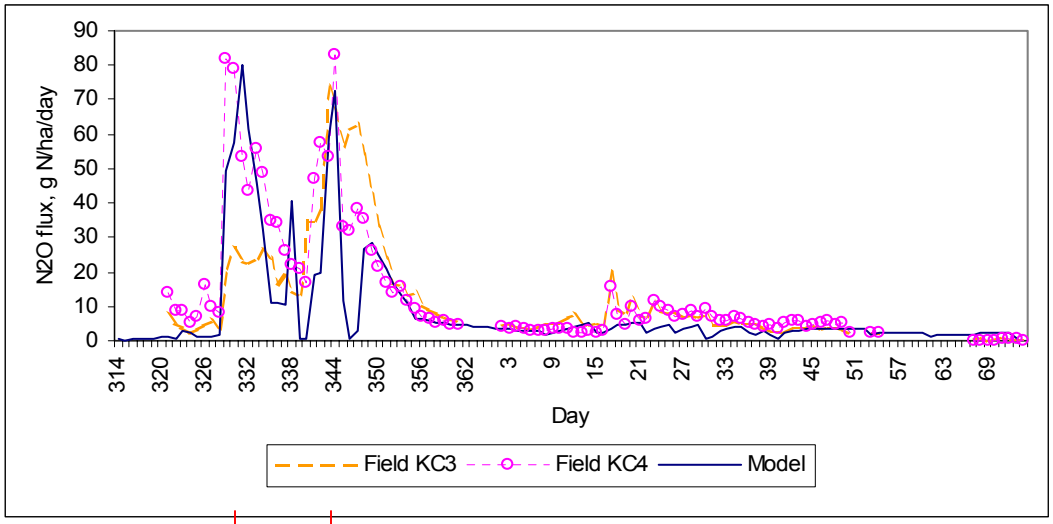
Low N2O fluxes were measured at a grassland in Colorado. Both nitrate and DOC were limiting factors.

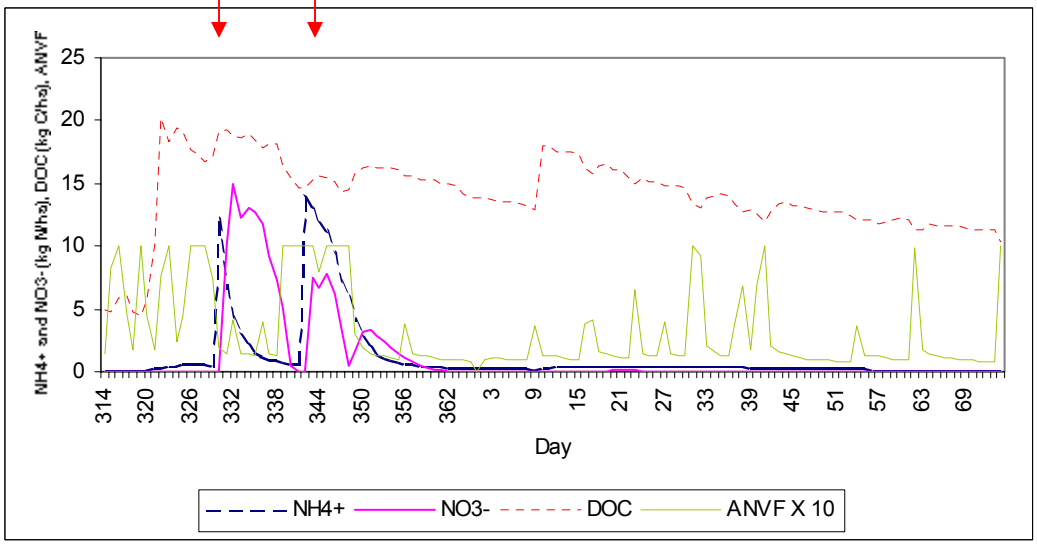
(Field data from Mosier et al., 1996)

N2O from an organic soil in Florida



N2O from a corn field in Costa Rica

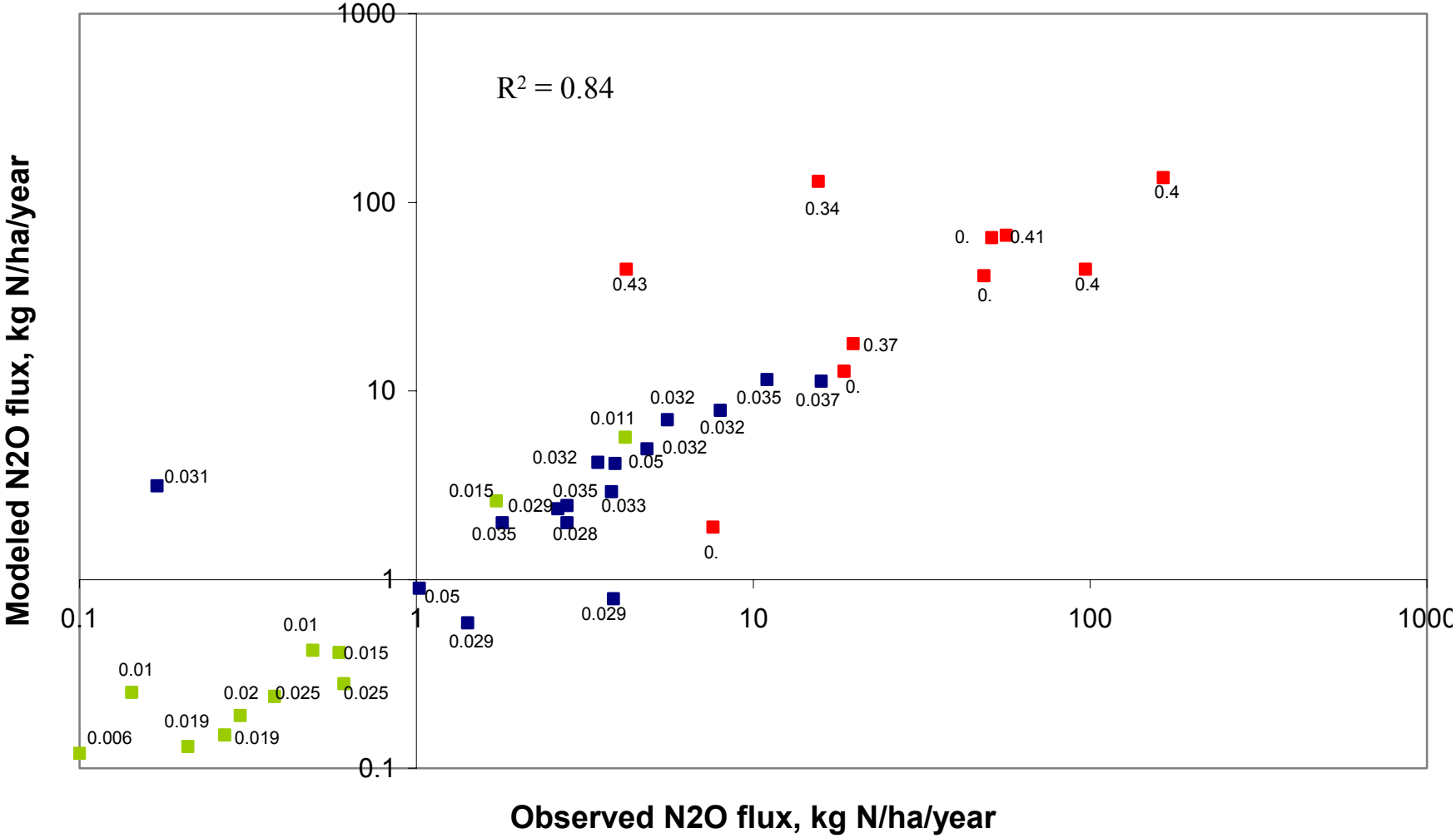




Two high peaks of N2O flux were caused by fertilization at a corn field in Costa Rica, 1994.

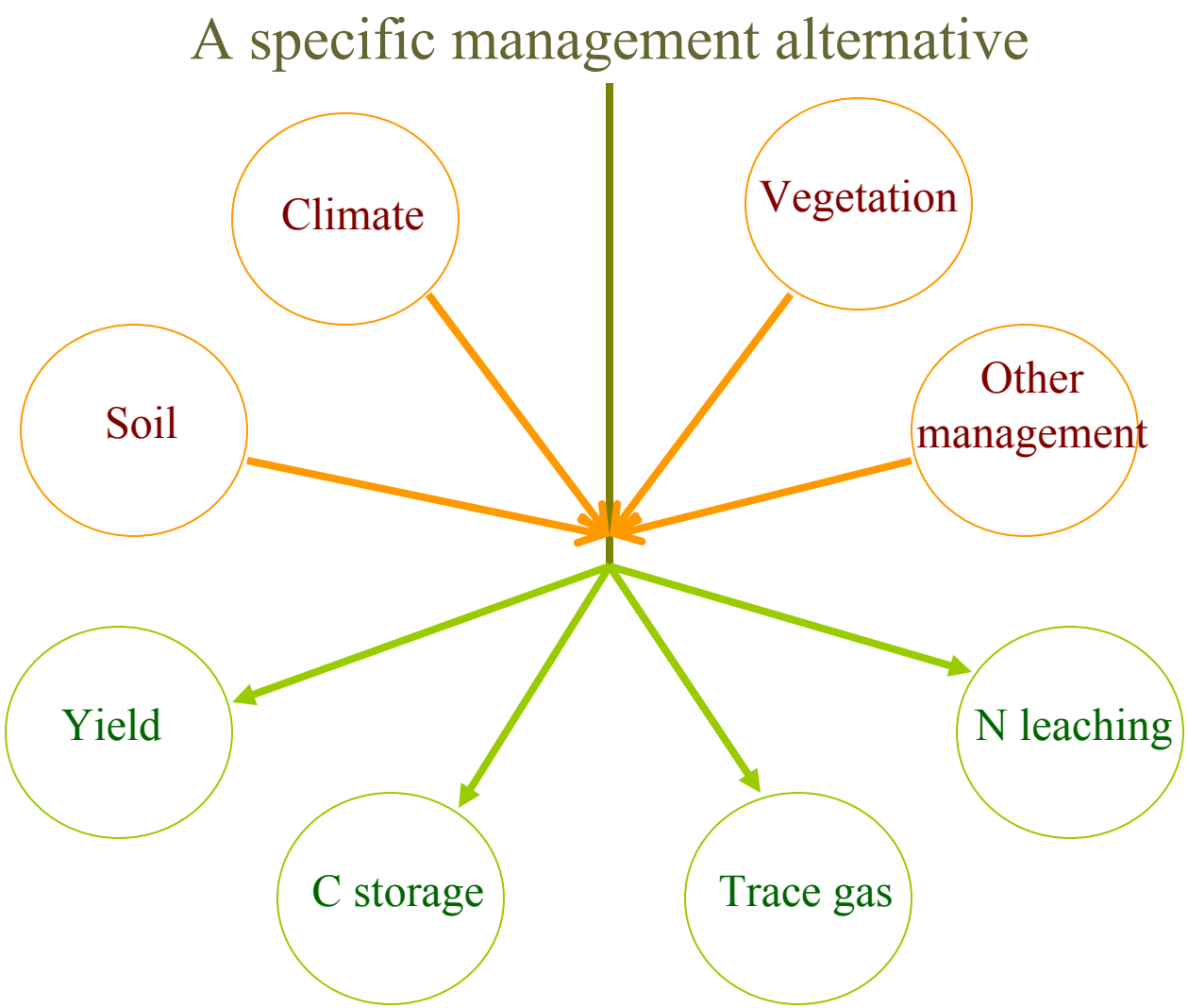
(Field data from Crill et al., 1999)

DNDC has been utilized for quantifying N_2O emissions in the U.S., Canada, EU nations, Australia, New Zealand, Russia, China and India



2. Searching management alternatives for mitigation of N_2O emissions with DNDC

Biogeochemical models serve Best Management Practices



10-Year Simulations for a Crop Field in CA

Site: A tomato field at SAFS site in Davis, California

Simulated period: 1991-2000

Climate: Temperature 16°C, precipitation 210-630 mm

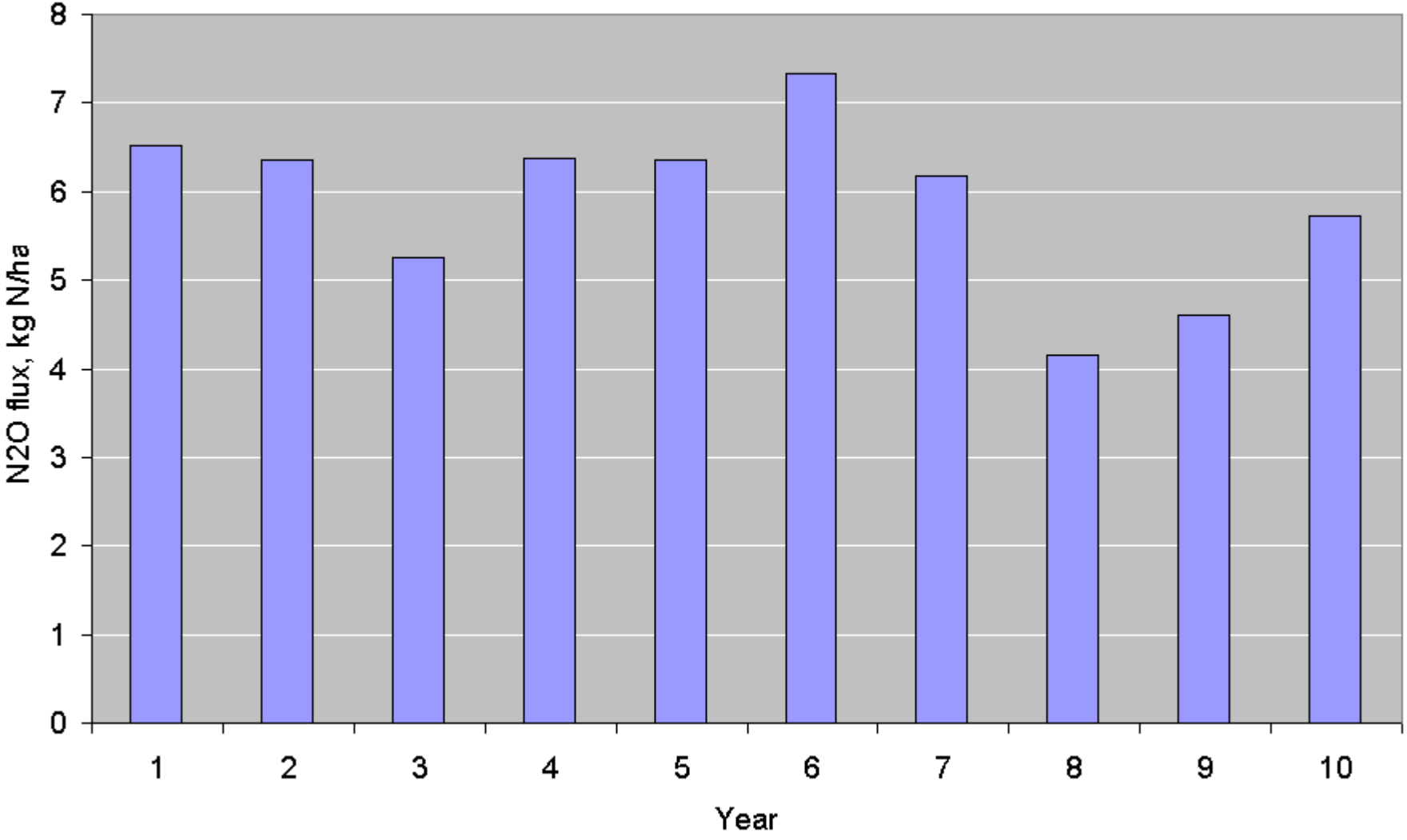
Soil: Silt loam, SOC 0.011 kg C/kg, pH 7.0

Tillage: Conventional

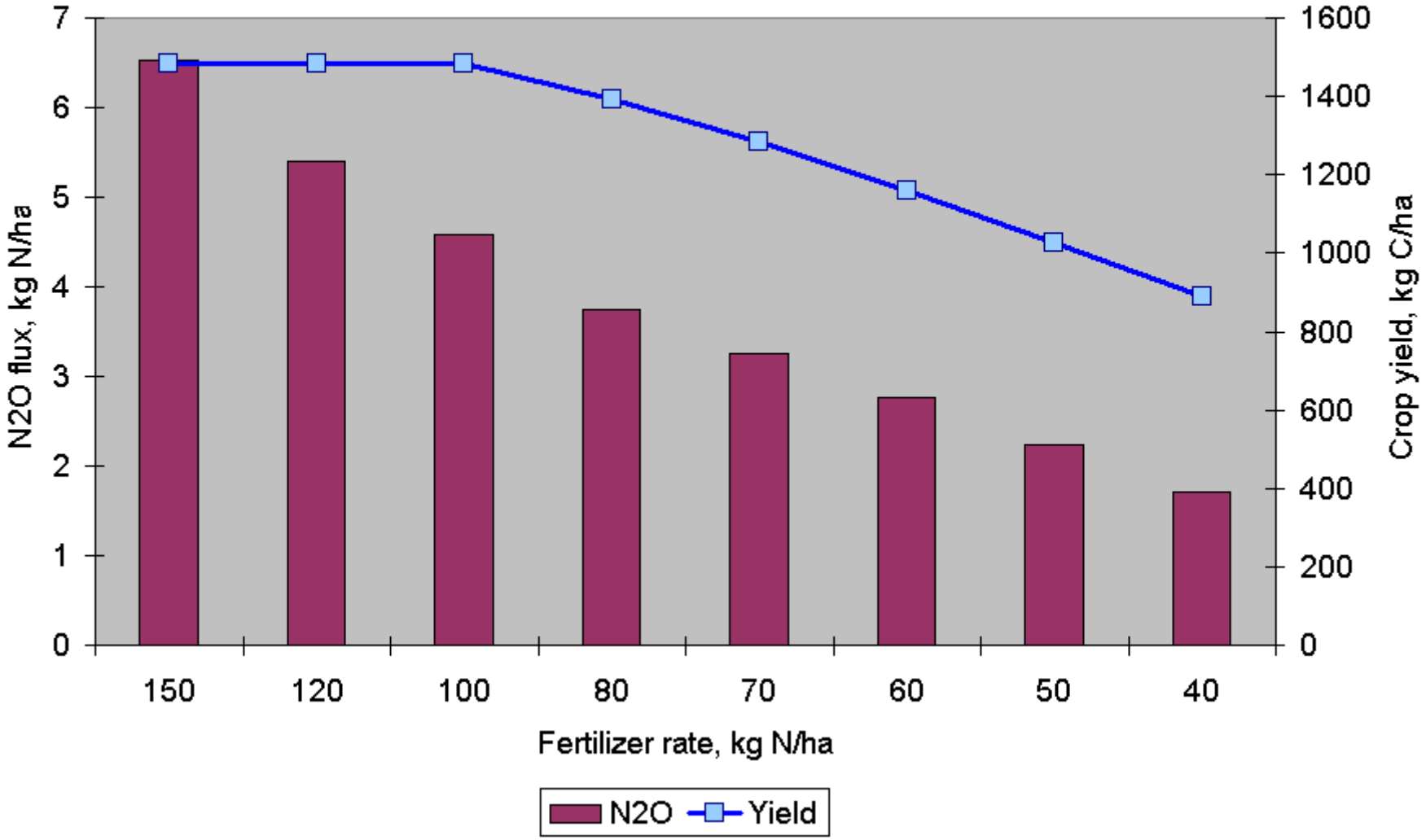
Fertilization: 150 kg urea-N/ha

Irrigation: Precision with drip or better spray method

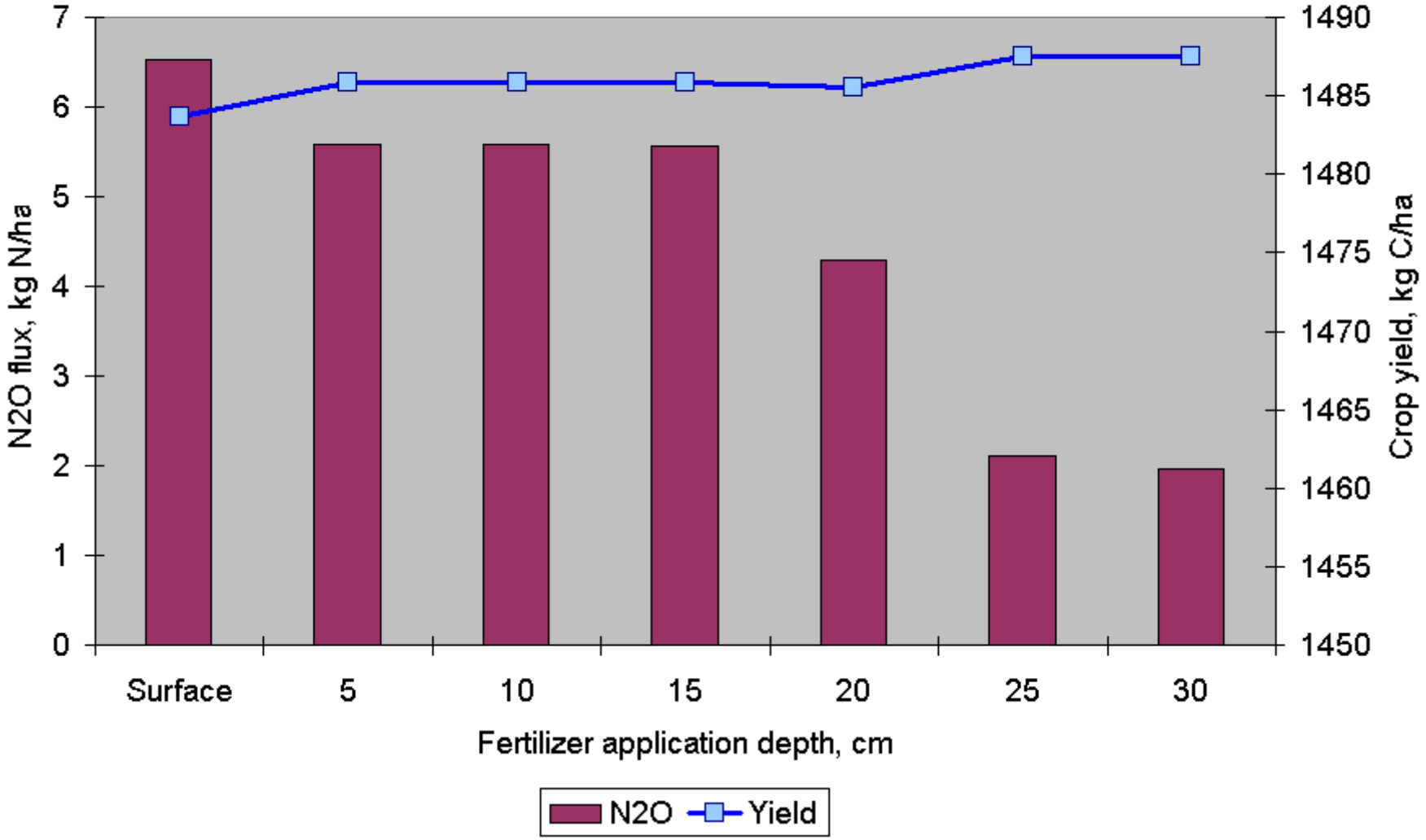
Modeled annual N2O fluxes from a tomato field in Davis, CA in 1991-2000



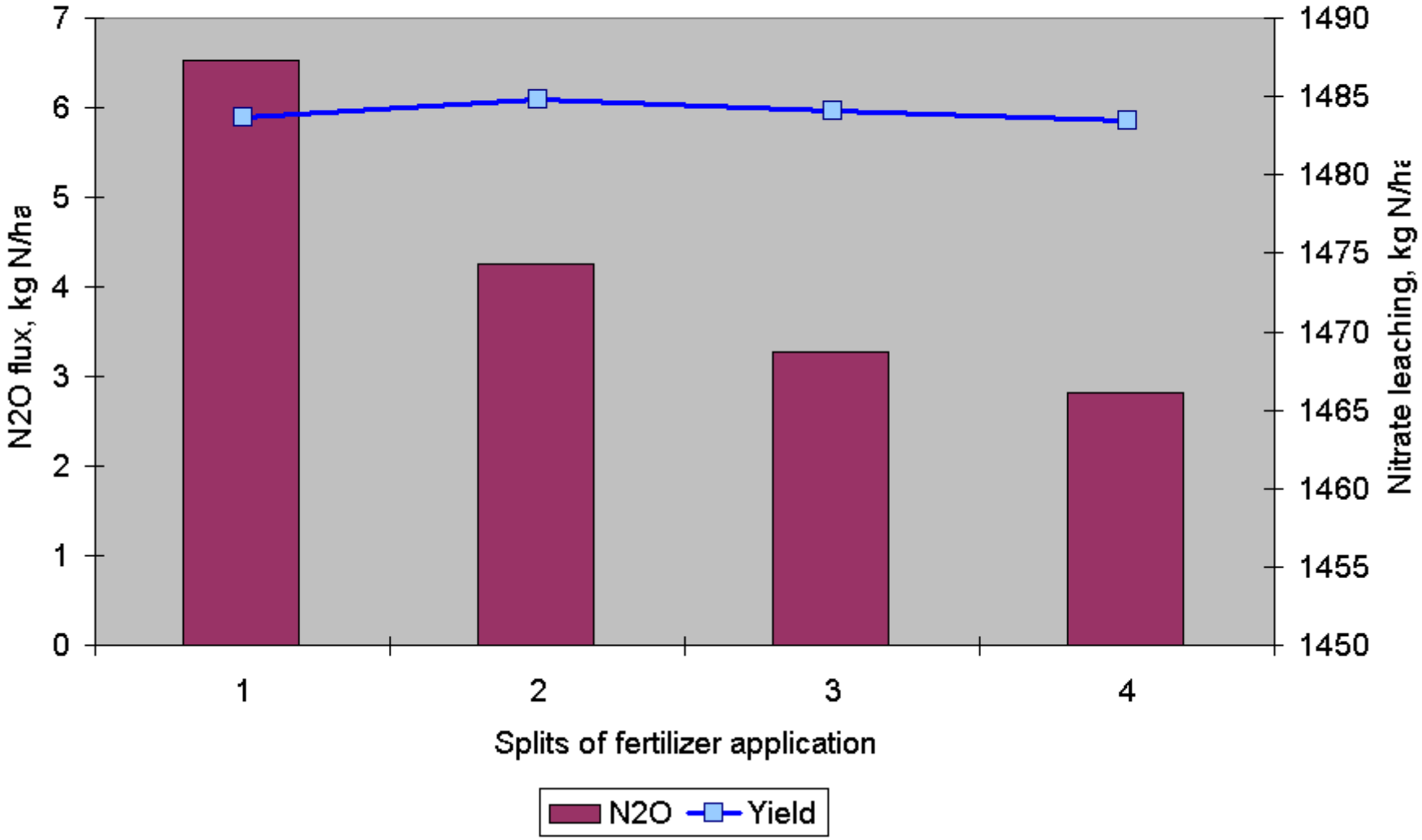
Alternative 1: Change in fertilizer rate



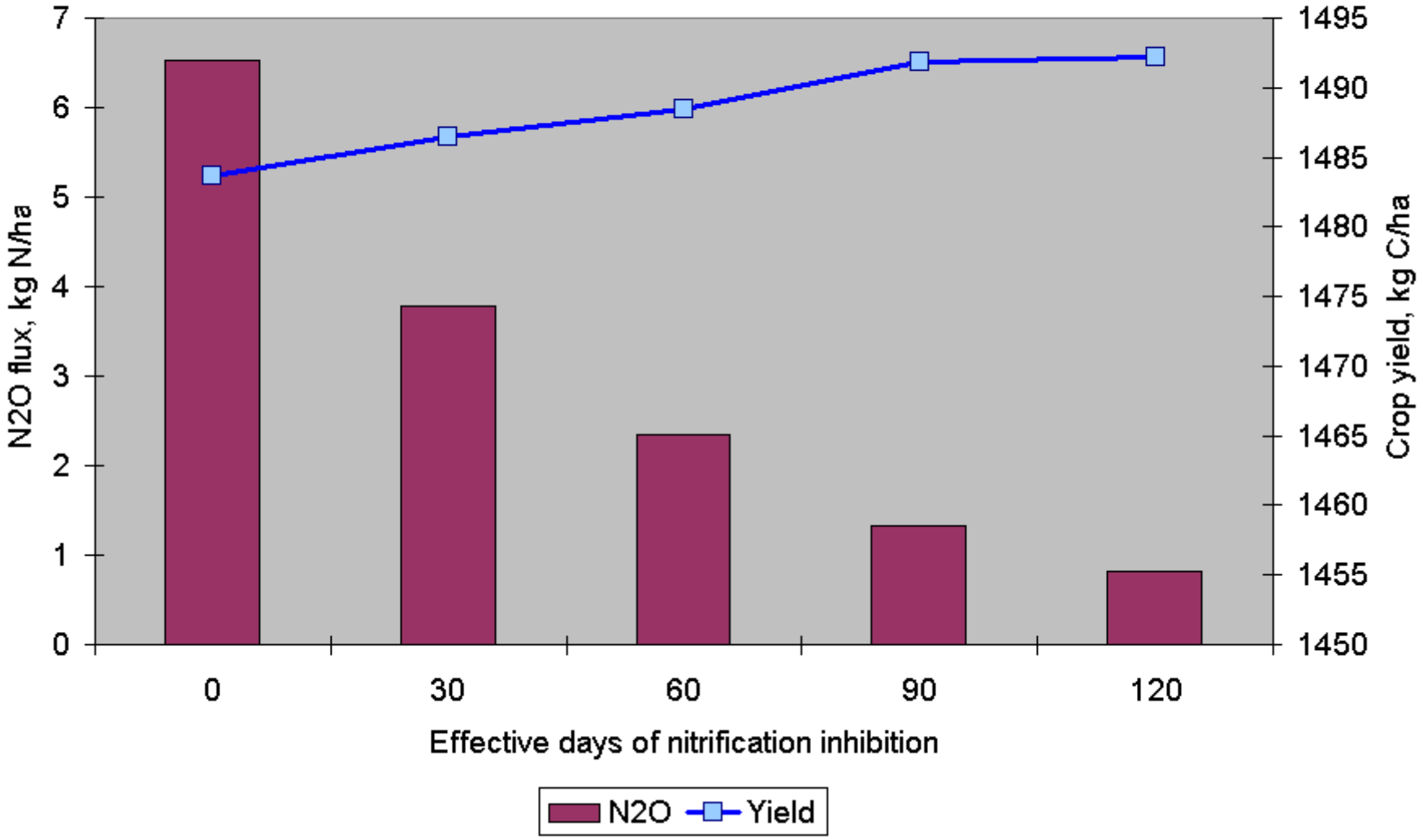
Alternative 2: Change in fertilizer application depth



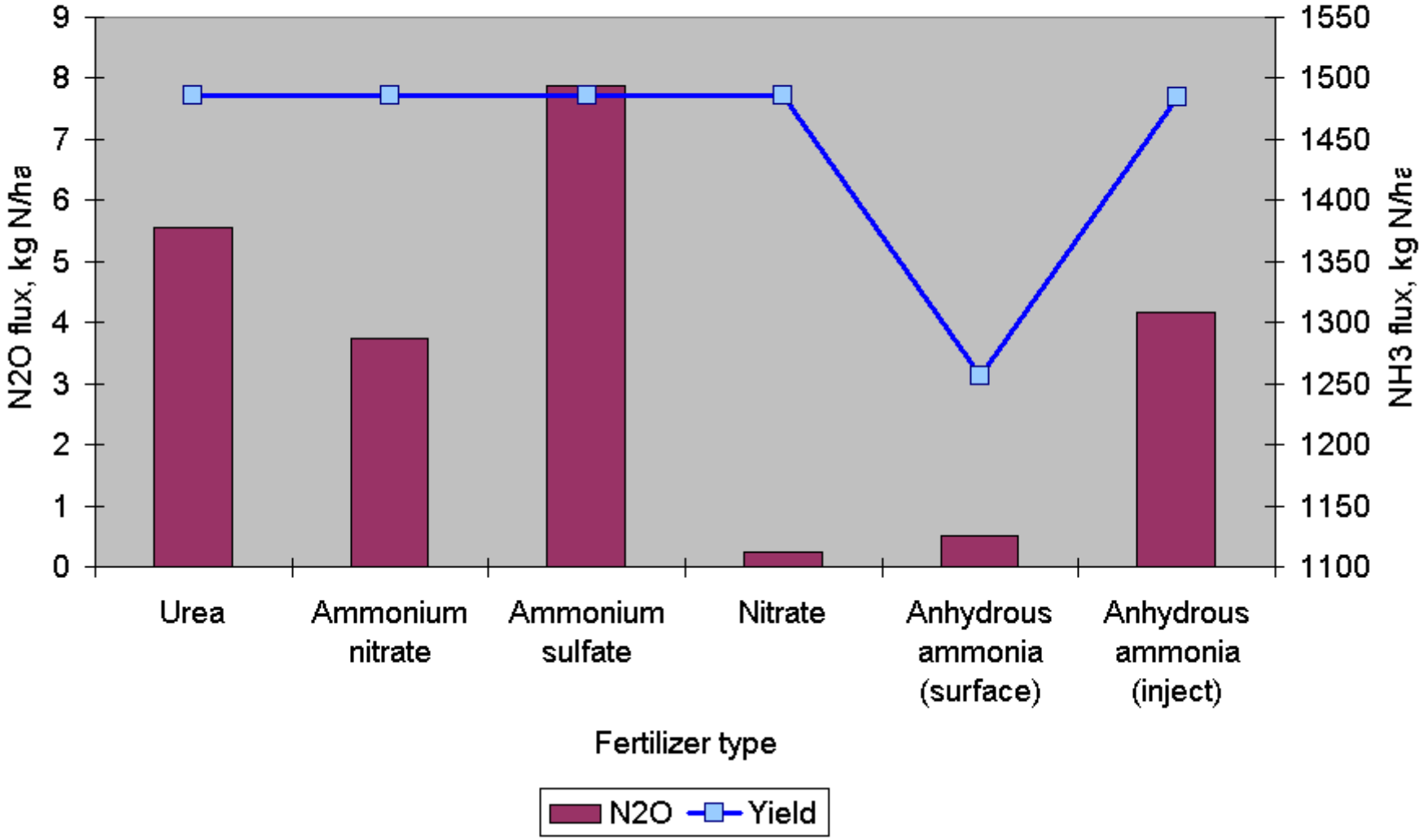
Alternative 3: Change in fertilizer splits



Alternative 4: Use of nitrification inhibitor



Alternative 5: Change in fertilizer type



Composing a best management practice (BMP) with alternative fertilization methods:

-Rate: 100 kg N/ha

-Depth: 15 cm

- 3 splits

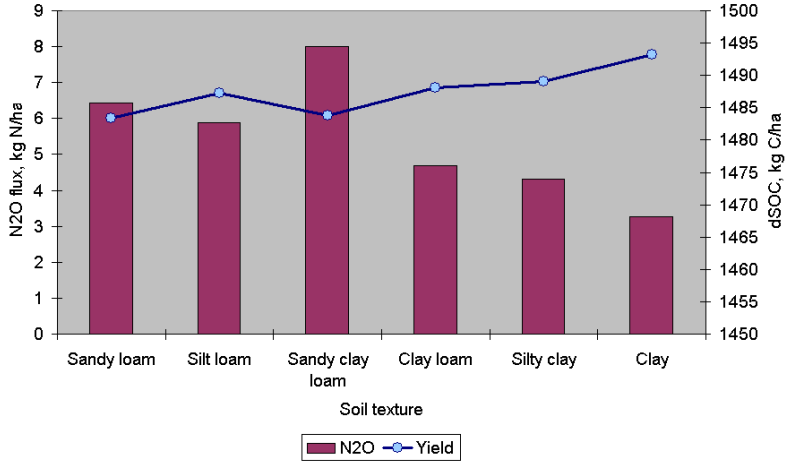
- Nitrification inhibition: 90 days

Impacts of Baseline vs. BMP Scenarios on N_2O Emission and Other C and N Fluxes from a Tomato Field in Davis, CA

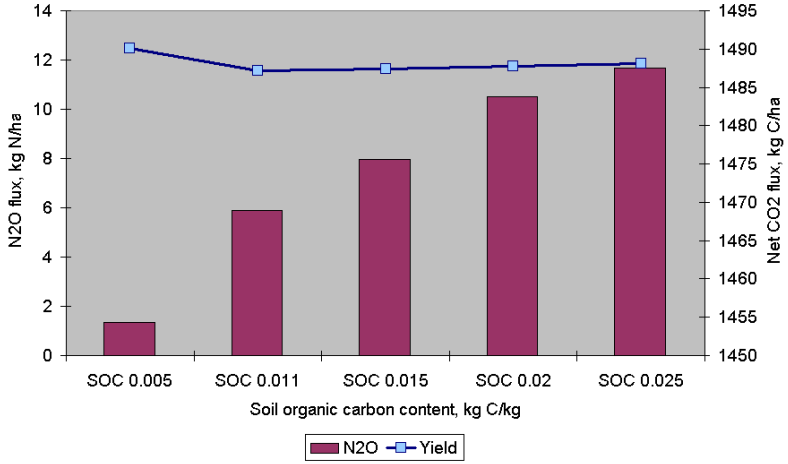
	Baseline	BMP	Change rate
N_2O (kg N/ha)	5.9	2.7	-54%
NH_3 (kg N/ha)	4.4	2.1	-52%
N leaching (kg N/ha)	56	21	-63%
Crop yield (kg DM/ha)	3718	3710	-0.2%
dSOC (kg C/ha)	-1470	-1472	+0.1%

Impacts of farming practice on N_2O vary according to soil or climate conditions

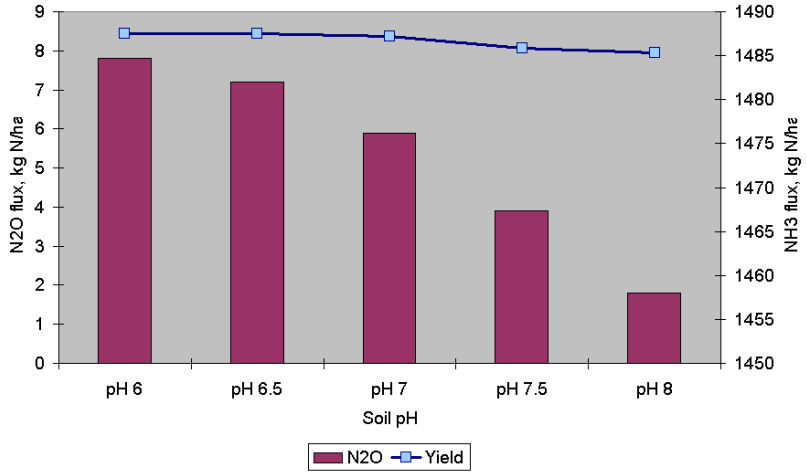
Soil texture



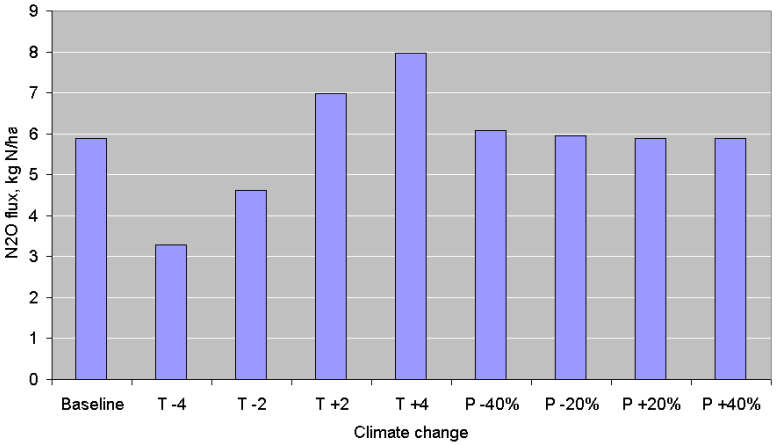
SOC content



Soil pH



Temperature and precipitation



Discussions

1. N_2O emissions from agricultural soils can be reduced by up to 50% (~7 MMT CO_2 eq. for CA) by adopting alternative fertilizing approaches;
2. Effectiveness of the alternatives varies with climate, soil and other management conditions;
3. Integrated model-database tools could serve up the spatially differentiated BMPs across CA;
4. Economic cost for each BMP scenario will need to be estimated with economists.

Work in California

- **Development of Manure-DNDC:**
  - Modify DNDC for quantifying GHG emissions from California dairies (supported by CEC PIER and USDA NRI);
- **Model validation:**
  - Validate DNDC for California cropping systems (supported by CEC PIER and Kearney Foundation, in collaboration with UC Davis);
- **Net GHG from afforestation of rangelands:**
  - Apply Forest-DNDC for California rangelands (supported by CEC PIER, collaboration with Winrock)