N$_2$O Emissions from Application of Fertilizers in Agricultural Soils

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Need to quantify and reduce amount of N$_2$O emissions and uncertainty around estimates of agricultural N$_2$O emissions at multiple spatial and temporal scales.

Accurate assessments of annual N$_2$O budgets need detailed, event-related N$_2$O flux measurements to calibrate and validate biogeochemical models for prediction of daily, seasonal, and annual N$_2$O emissions from agriculture.
Objectives

*To combine event-related N$_2$O measurements at multiple spatial and temporal scales with field information and soil measurements to develop a database ideal for calibration and validation of biogeochemical models used to estimate GHG budgets of current and future conventional and alternative CA cropping systems.*

**Tasks**

1) determine detailed time series of N$_2$O fluxes and underlying factors at crucial management events (irrigation, fertilization, etc.) in representative agroecosystems in California.

2) assess N$_2$O emissions at the spatial scale of farmer management

3) use the intensive and extensive data on N$_2$O fluxes to initialize the calibration and validation of DNDC.
N$_2$O emissions: highly variable

N$_2$O emissions (g N$_2$O-N ha$^{-1}$ day$^{-1}$)
# Ranking of California crops

Table 2: California’s 10 most important crops, area wise, and their economic value (California Department of Food and Agriculture)

<table>
<thead>
<tr>
<th>area rank</th>
<th>crop</th>
<th>area (1000 acres)</th>
<th>economic value ($million)</th>
<th>economic rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>hay (mainly alfalfa)</td>
<td>1550</td>
<td>1141</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>nuts (almonds, walnuts and pistachios)</td>
<td>900</td>
<td>3454</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>grapes</td>
<td>800</td>
<td>3166</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>cotton</td>
<td>657</td>
<td>625</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>rice</td>
<td>526</td>
<td>408</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>intensely cropped vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(lettuce, broccoli, carrots, celery, and peppers)</td>
<td>496</td>
<td>2920</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>wheat</td>
<td>389</td>
<td>104</td>
<td>&gt;15</td>
</tr>
<tr>
<td>8</td>
<td>fruit trees (oranges, plums, lemon, peaches)</td>
<td>350</td>
<td>1292</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>tomatoes</td>
<td>307</td>
<td>942</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>corn</td>
<td>110</td>
<td>52</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>
Status of $\text{N}_2\text{O}$ budgets

<table>
<thead>
<tr>
<th>cropping system</th>
<th>nr observations in literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>alfalfa</td>
<td>4</td>
</tr>
<tr>
<td>nut orchards</td>
<td>0</td>
</tr>
<tr>
<td>vineyards</td>
<td>0</td>
</tr>
<tr>
<td>cotton</td>
<td>5</td>
</tr>
<tr>
<td>rice</td>
<td>78</td>
</tr>
<tr>
<td>intensely cropped</td>
<td></td>
</tr>
<tr>
<td>vegetables</td>
<td>29</td>
</tr>
<tr>
<td>wheat</td>
<td>77</td>
</tr>
<tr>
<td>fruit orchards</td>
<td>0</td>
</tr>
<tr>
<td>tomato</td>
<td>6</td>
</tr>
<tr>
<td>corn</td>
<td>157</td>
</tr>
</tbody>
</table>

Field sites

Russell Ranch--University of California research farm for controlled field experiments in tomato/wheat systems (5 fertilizer rates)

Farmers fields--alfalfa (2X), orchards (2X), vineyards (2X), corn (1X) and vegetables (1)

Sampling for gas fluxes will be:
- event-related: continuous measurements (1 wk) after critical events such as irrigation, fertilization
- non event-related: 10 manual measurements
N₂O monitoring requires targeted measurements

The graph shows the emission of N₂O (g N₂O-N ha⁻¹ day⁻¹) over time, with peaks during certain seasons and times. Key points include:

- **Winter**
- **Tomato growing season**
- **Fall**
- **Dry post-harvest**
- **Spring tillage**
- **Post spring tillage**
- **N applications**
- **Fall tillages**

The graph also indicates rainfall (mm day⁻¹) on the right axis, with significant rainfall events shown.
Chamber measurements

Continuous measurements for event sampling with 3 reps

Manual measurements for non-events with 6 reps

Figure 6: Drawing of the proposed mobile gas autosampler for continuous measurements in the field
Eddy covariance (TDL / QCL)

N$_2$O flux footprint

100 to 10,000 m$^2$
resolution
30 min sampling freq
Yr 1: 2 fields
Yr 2: 4 fields combined with chambers

Mark Fisher
LBL
Modeling

DNDC model includes:
- soil climate, plant growth and decomposition sub-models
- biogeochemical process sub-models

Calibration and validation of the soil water and N cycle module

Model will then be used for scenario and trade-off analyses of potential ag practices to minimize GHG emissions
Collaborations and cost-sharing

- **Evaluating the Potential for California Almond Orchards to Sequester Carbon and Mitigate Greenhouse Gas Emissions and Conservation Tillage of Cover Crops as a Means of Improving Carbon Storage in California Vineyard Soils and Mitigating GHG Emissions**: The Almond Board of California (ABC), the American Vineyard Foundation (AVF), the California Competitive Grants Program for Research in Viticulture & Enology (CCGPRVE) and the USDA Viticulture Consortium (USDA VC) funds for preliminary N$_2$O emissions assessments to D.R. Smart.

- **Field carbon data collection for vineyard and orchard crops** funded by Natural Resources Conservation Service, to set up monitoring sites in orchards and vineyards to collect time series of soil C and production, with the immediate purpose of calibrating and validating the model for orchards and vineyards.

- **Assessing the Carbon Budget of Almond Trees and Developing a 3-D Computer Simulation Model of Almond Tree Architectural Growth and Dry Matter Partitioning**: Dr. T. De Jong and Dr. J. Six funded by Almond Board.

- Additional matching funds will be sought through the California State University (CSU) Agricultural Research Initiative (ARI). External grants can be matched up to $150,000 per year for up to 3 years.

- The N$_2$O eddy covariance measurements are made possible for a minimal cost because the Lawrence Berkeley National Laboratory supported development of the instrument ($115,000 for instrumentation and $200,000 labor effort) for ammonia flux measurements. This proposal is hence leveraged by an approximately $300,000 investment in instrumentation and intellectual capability.

- **Establish Baseline N$_2$O Emissions from Nitrogen Fertilizer use Based on Field-Derived California Specific N$_2$O Emission Factors** project, submitted to the California Air Resource Board (CARB) and California Department of Food and Agriculture (CDFA).

- Kearney Foundation of Soil Science

- Agricultural Sustainability Institute (ASI) Russell Ranch experimental farm