# Manure-DNDC: Building a Process-Based Biogeochemical Tool for Estimating Ammonia and GHG Emissions from California Dairies

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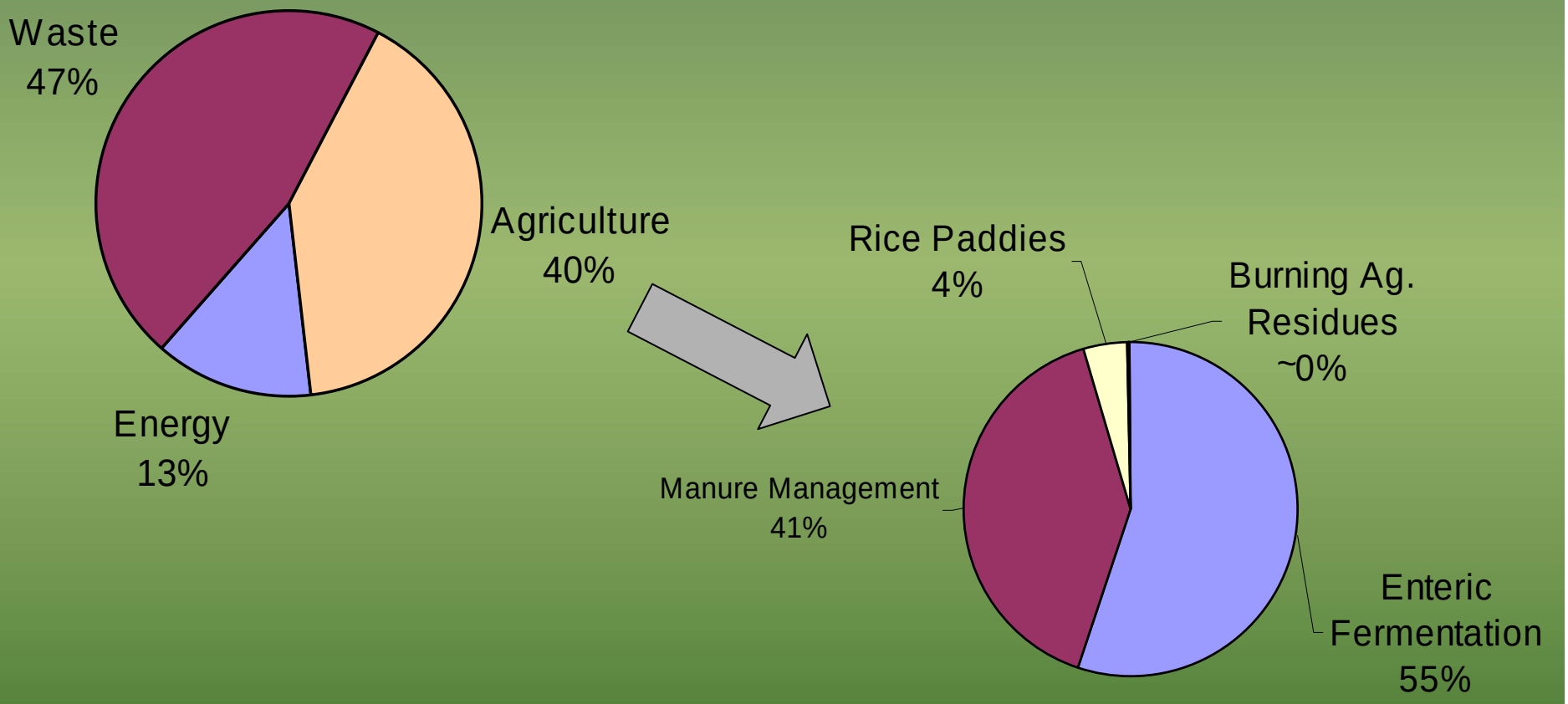
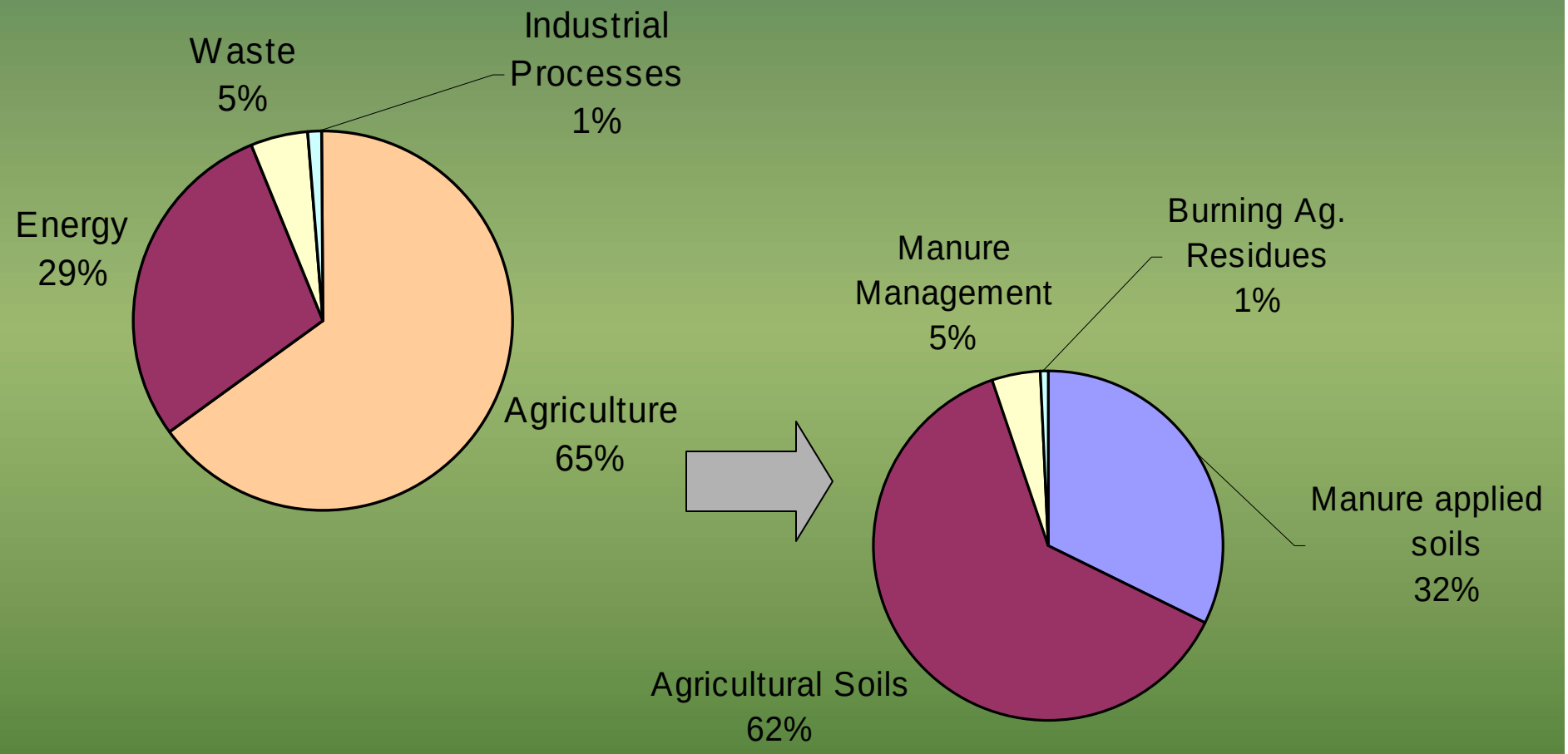
# 1999 California $CH_4$ Emissions
# 31.65 $MMTCO_2eq$




Source: CEC 2002 GHG Inventory

# 1999 California $N_2O$ Emissions
# 23.55 $MMTCO_2eq$




Source: CEC 2002 GHG Inventory

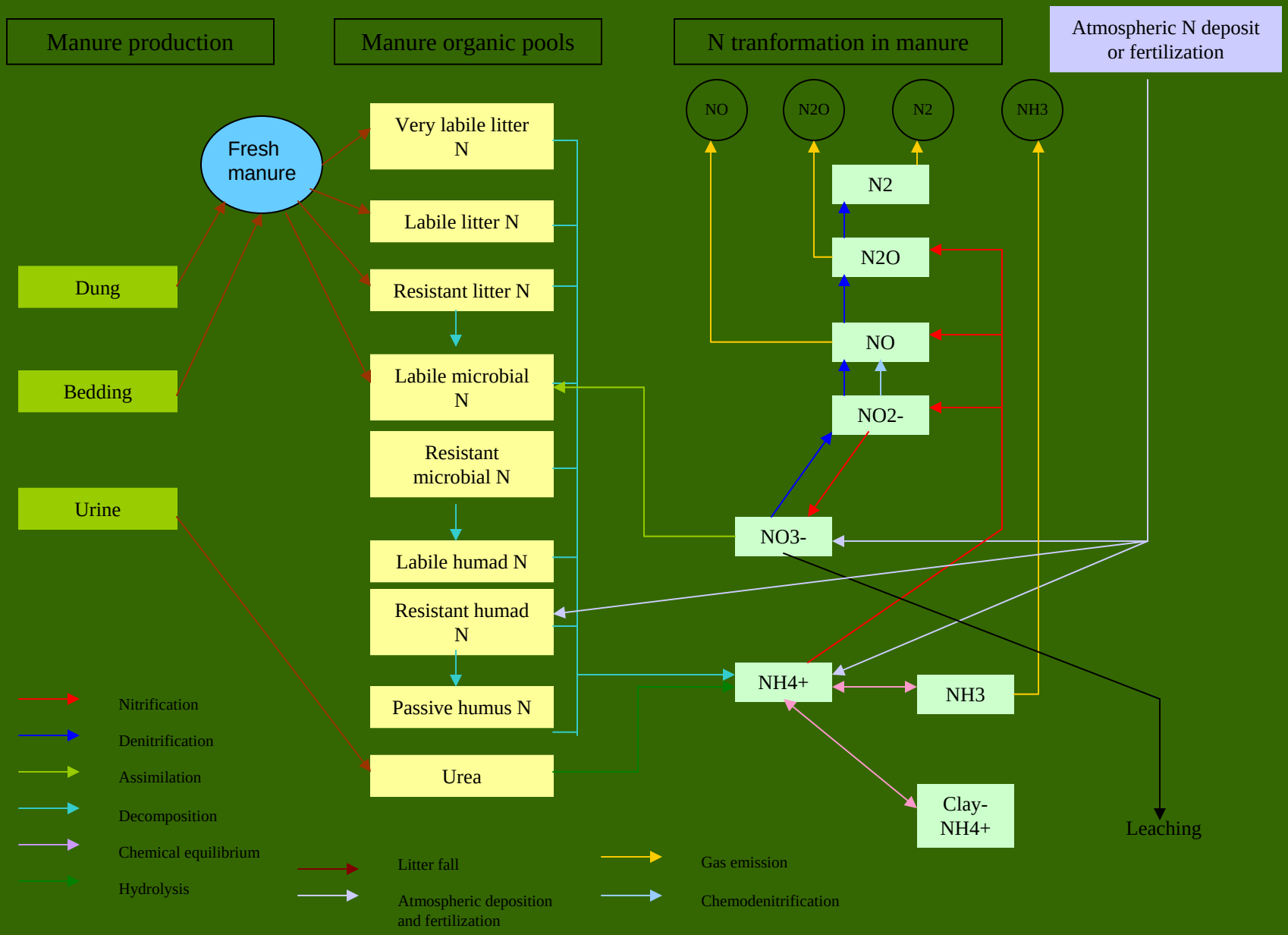
# Project Goals

- Modify an existing “process-based” biogeochemical model (DNDC) for estimating CH4, NH3, NO, N2O emissions from dairy systems in California.
- Collect field data to calibrate and validate this model
- Build GIS databases on soils, climate, dairy locations, and manure management.
- Apply the model to estimate emissions across California. Note: model is designed for both regional and single farm simulations.

# What are Process-based Models?

- Process-based modeling refers to biochemical and geochemical reactions or processes
  - Process modeling, in this case, does **not** refer to AFO practices or components (e.g. dairy drylots or manure lagoons) per se, but
- **Biogeochemical processes**… like decomposition, hydrolysis, nitrification, denitrification, etc…
- True process-based models **do not rely on constant emission factors**. They simulate and track the impact on emissions of varying conditions within components of the dairies (e.g., climate, flush lanes, storage facility, soils).

# Nitrogen Biogeochemistry of Manure

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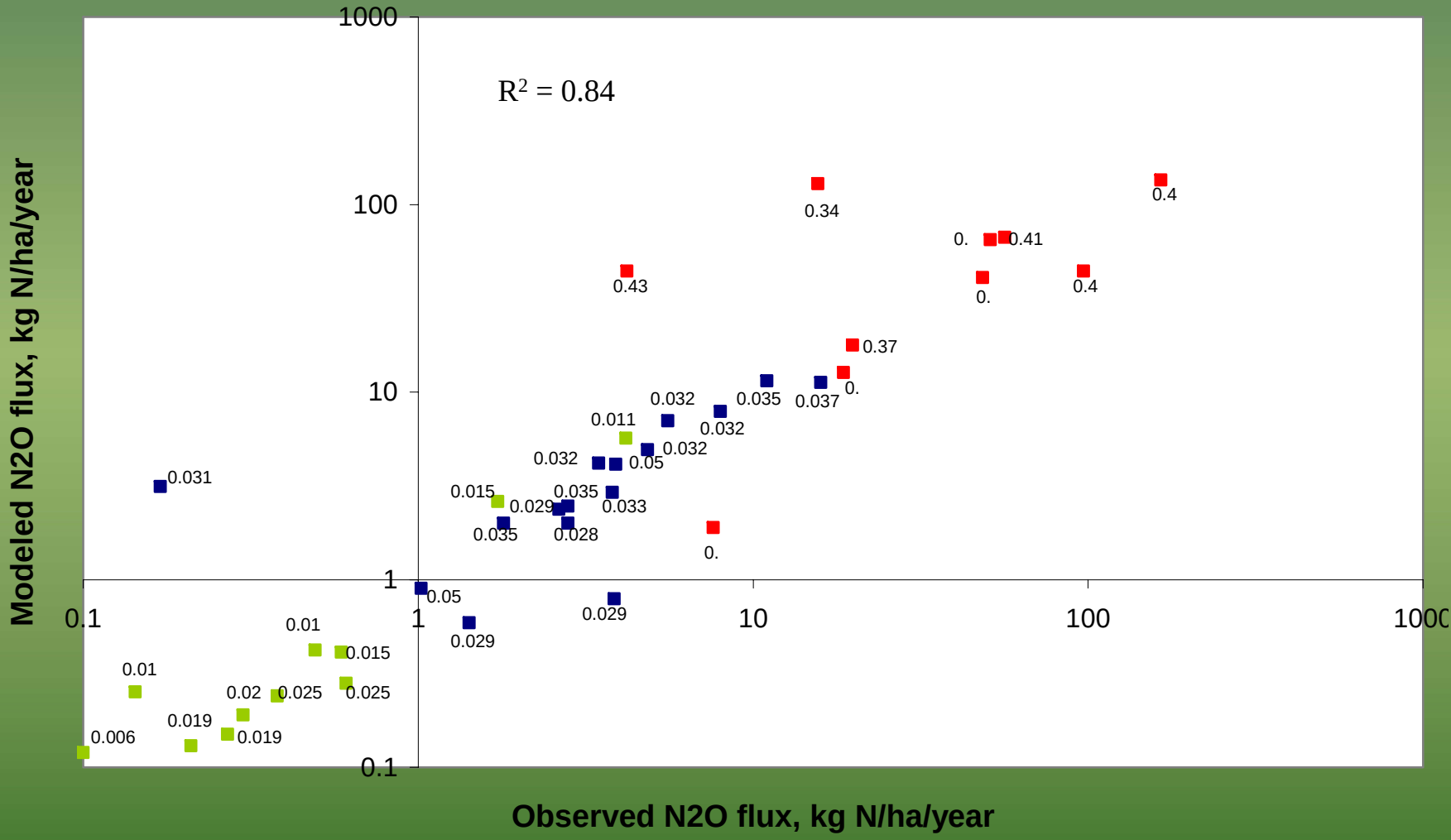
# Why DNDC Model?

- Contains algorithms for both anaerobic and aerobic soil environments
- Simulates full range of biogeochemical processes: decomposition, hydrolysis, nitrification, denitrification, ammonium adsorption, chemical equilibriums of ammonium/ammonia, fermentation, and gas diffusion
- Well validated across a wide range of agroecosystems and is currently being used for national GHG emission inventories and mitigation studies worldwide.

DNDC has been tested against a wide range of datasets of CO2, CH4, N2O, NO and NH3 emissions observed worldwide

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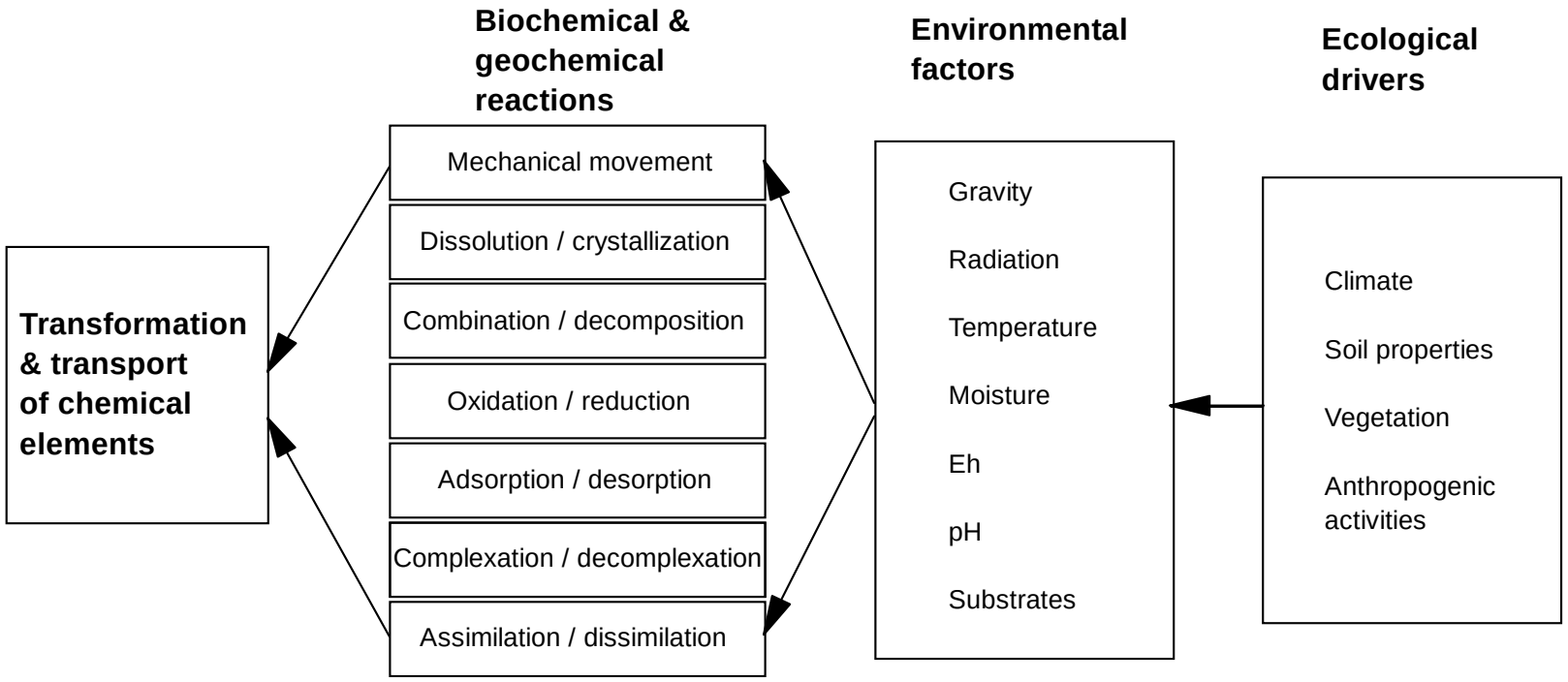
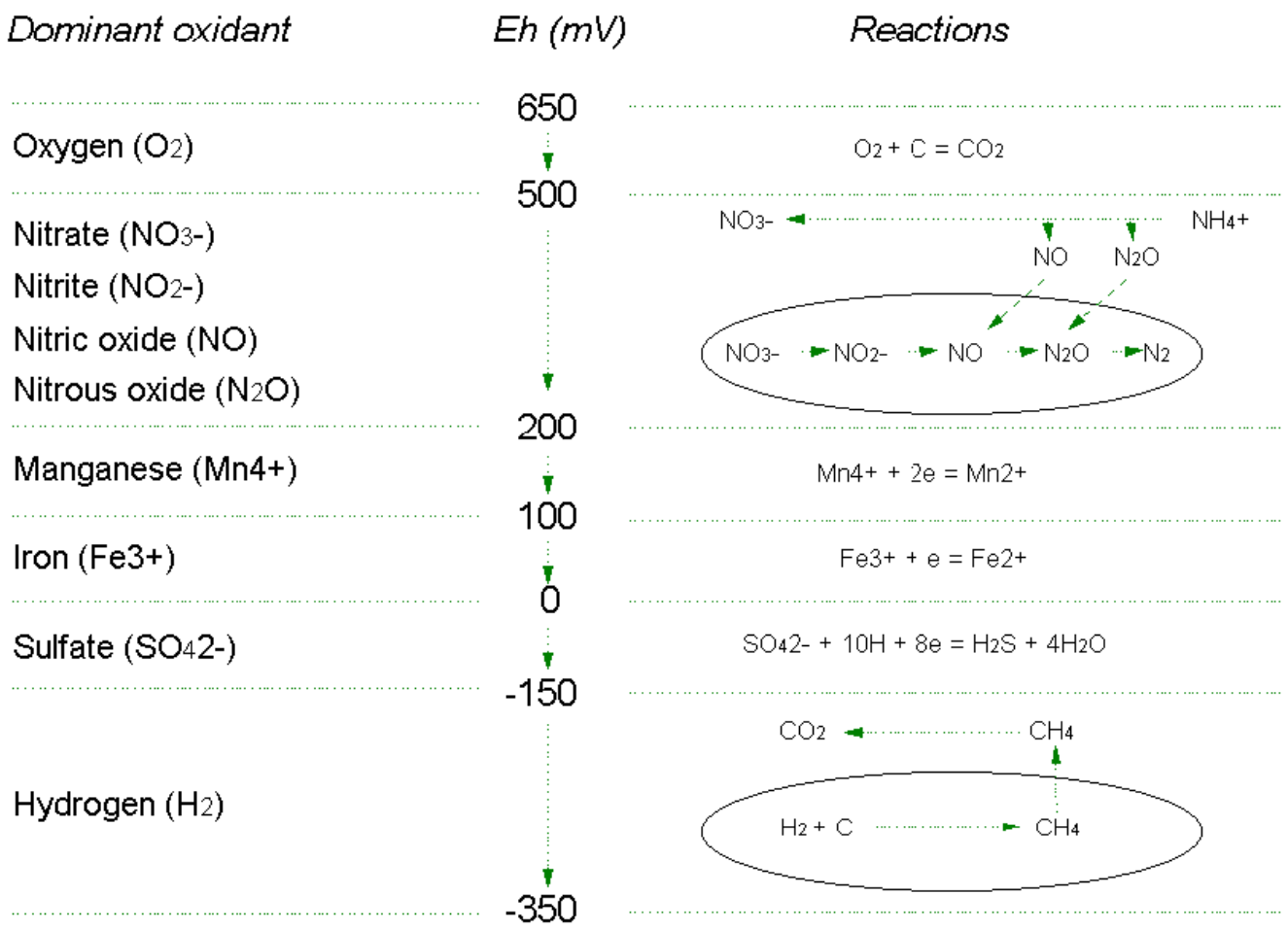
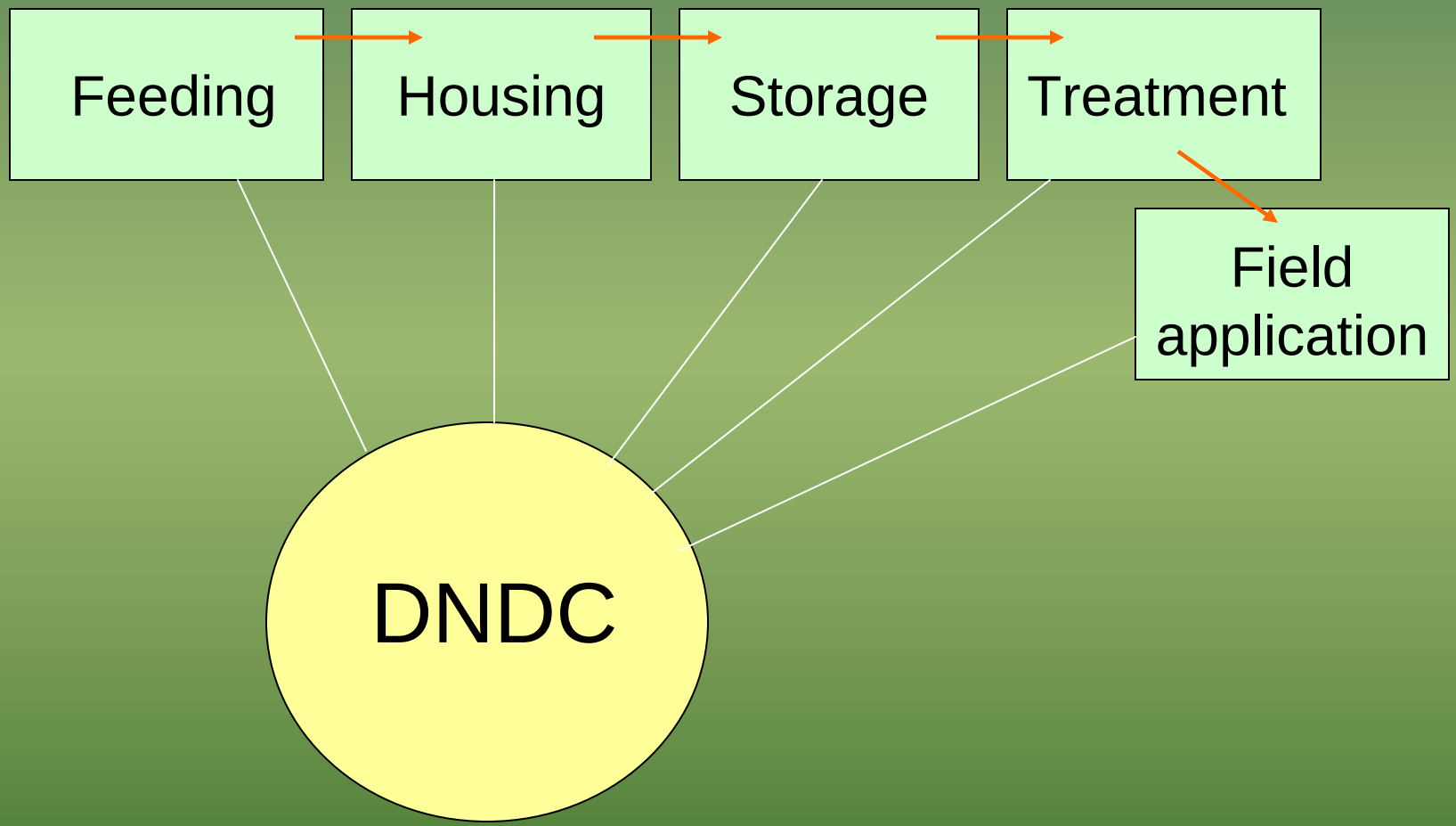
# Biogeochemical processes controlling C and N transformation in soil organic matter have been developed in DNDC



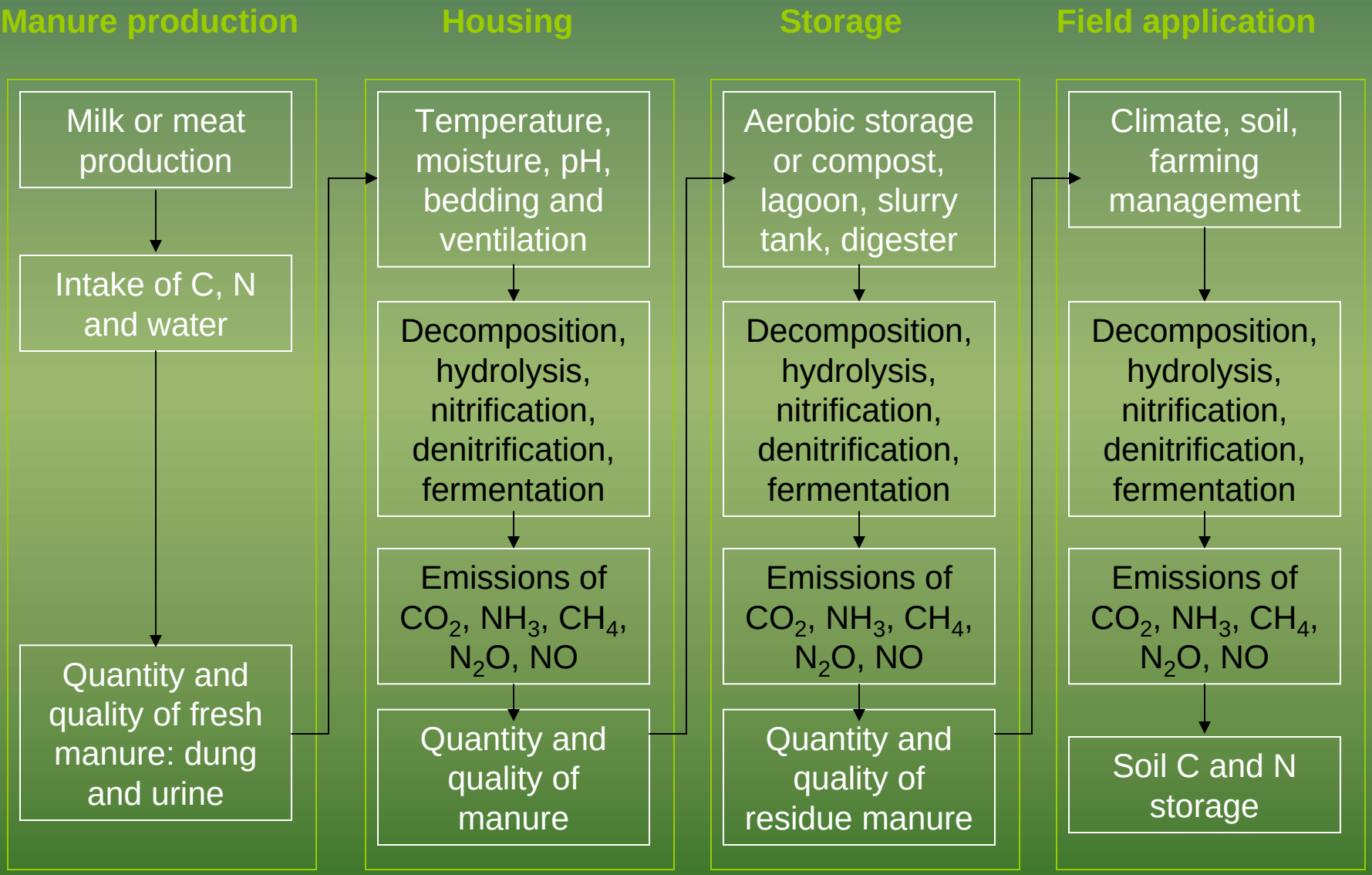
# DNDC quantifies trace gas emissions by tracking microbial activity in soil organic matter



# Create Manure-DNDC by linking farm components to DNDC



# Manure-DNDC utilizes the existing biogeochemical processes to track manure turnover in the farm components

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## Input parameters:

- Daily climate data;

- Animal type and population; milk/meat production; Intake protein and feed quality;

- Housing: ventilation; floor surface and bedding; cleaning method;

- Compost size, density, storage time, litter addition;

- Lagoon capacity, surface area, coverage, draining frequency;

- Slurry tank capacity, coverage, storage time;

- Anaerobic digester capacity, CH4 production;

- Manure field application: amount, C/N, timing, depth.

## Output parameters:

- Production of urine and feces;
- Enteric $CH_4$, $N_2O$ and $CO_2$;
- Emissions of $CH_4$, $N_2O$, $NH_3$, NO, $N_2$ and $CO_2$ from feeding lot, compost, lagoon, slurry tank and field;
- N leaching and uptake in field;
- Crop growth and yield;
- Soil C sequestration.

# Manure-DNDC will be validated with datasets observed in housing, storage, treatment and field application.

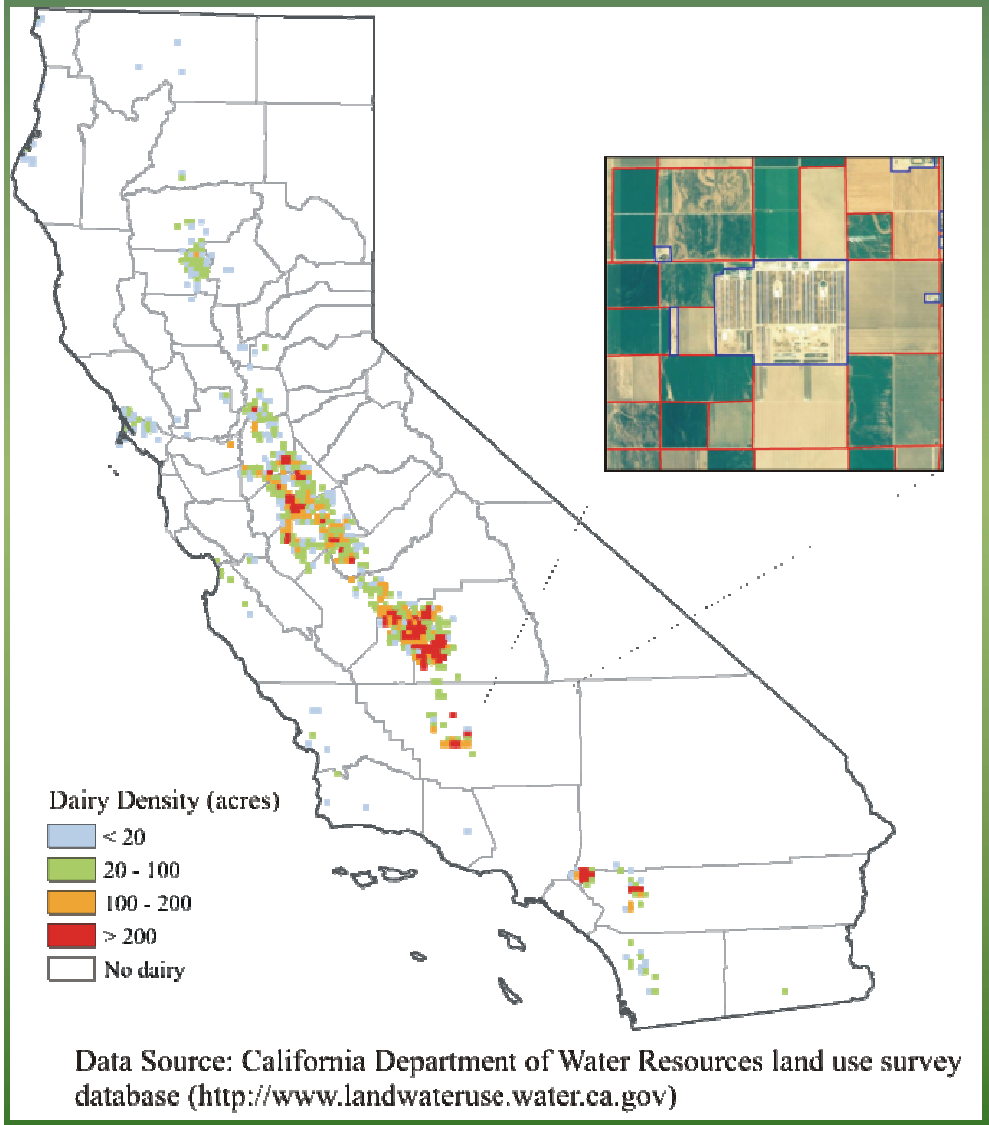
Sampling and measurement are conducted at feed-lot, housing, storage, lagoon and field in 6 dairy farms in CA in 2006-2008


Exercise corral receives 25% - 40% of the manure, depending on

Sampling ethanol, methanol, ammonia, $N_2O$ and ROG's from Total Mixed Ration (TMR) using flux chambers at Dairy A.

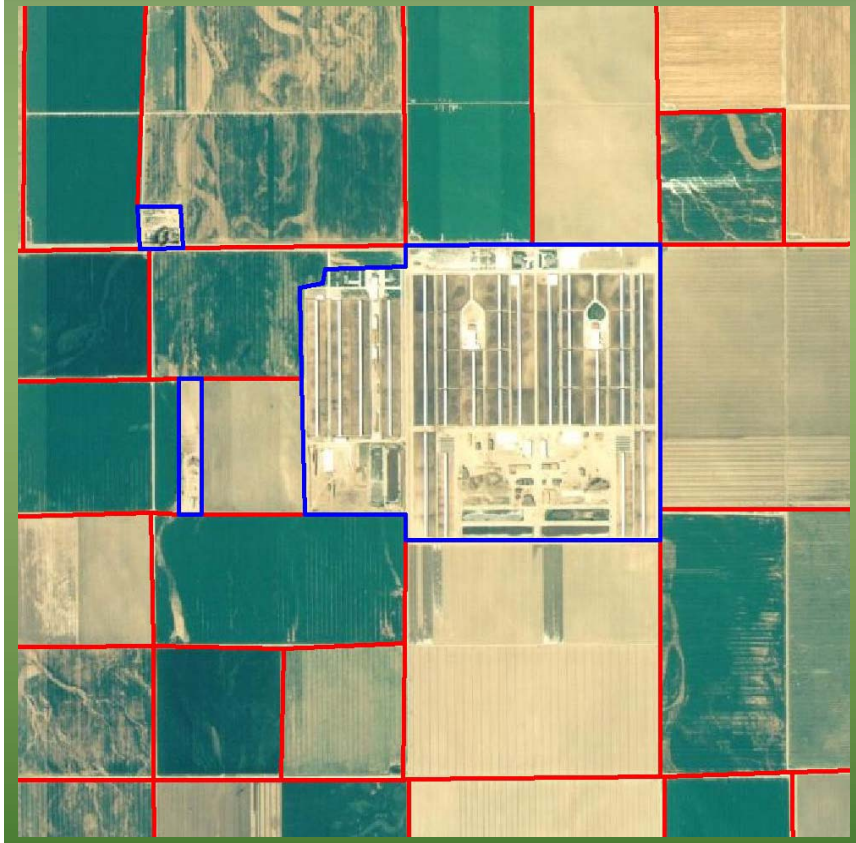
Flux Chamber monitoring of flush lane at Dairy B

# GIS databases have been constructed to support regional simulations for CA dairies




Data Source: California Department of Water Resources land use survey database (http://www.landwateruse.water.ca.gov)

Climate, soil, livestock and management information have been collected.



## **Example Results Manure-DNDC for a dairy farm**:

-500 cows with milk production 10 kg/head and weight gain 0.8 kg/head per day;

-Feeding rate 6.8 kg DM with protein 0.43 kg/head per day;

-Dung and urine separated for compost and lagoon, respectively;

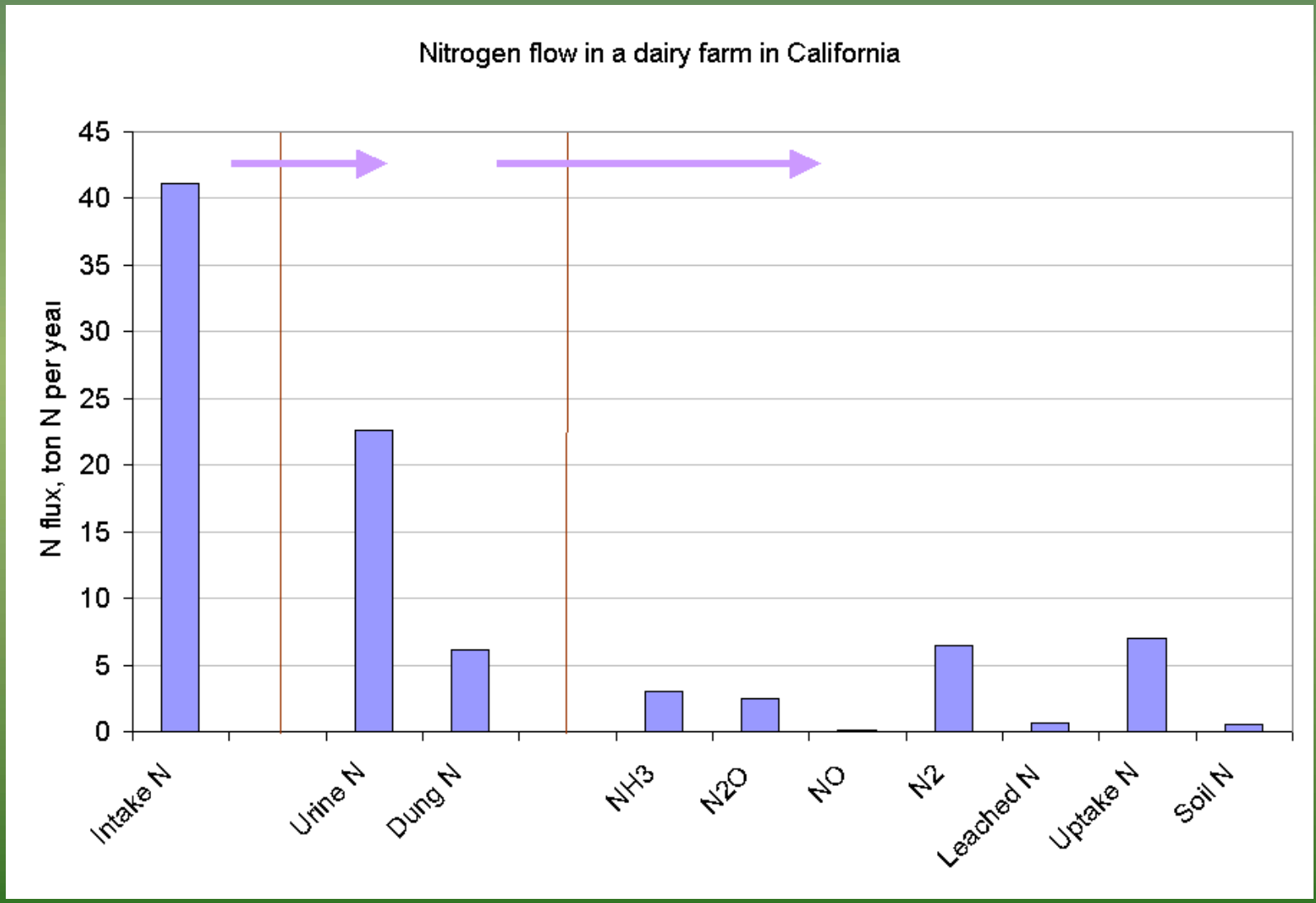
-Compost litter addition 2000 kg DM, C/N ratio 45;

-Lagoon capacity 2000 cubic meter, surface area 200 $m^2$;

-No slurry tank or anaerobic digester utilized;

-Lagoon manure application depth 20 cm.

# Manure-DNDC tracks N transport and transformation at farm scale

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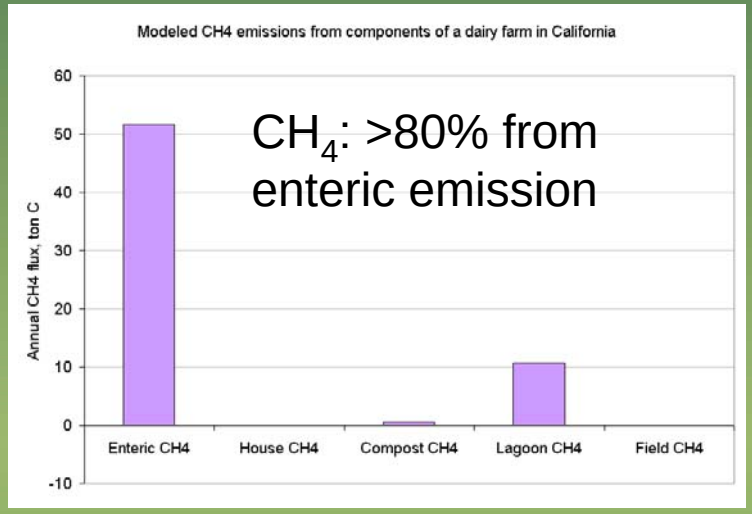
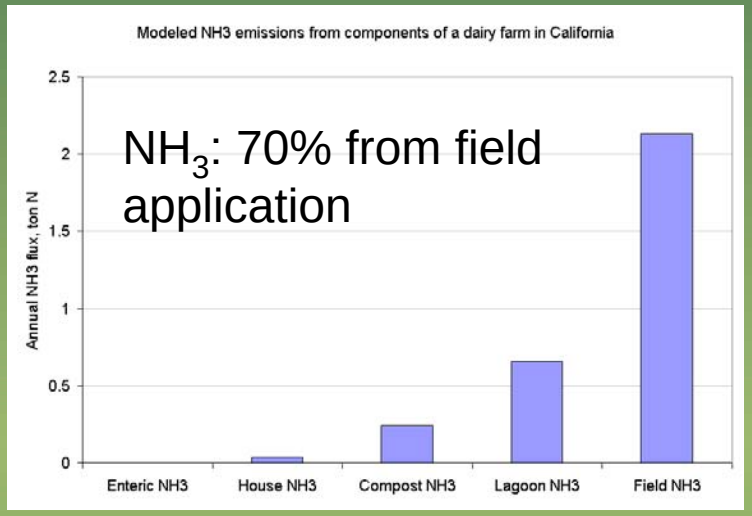
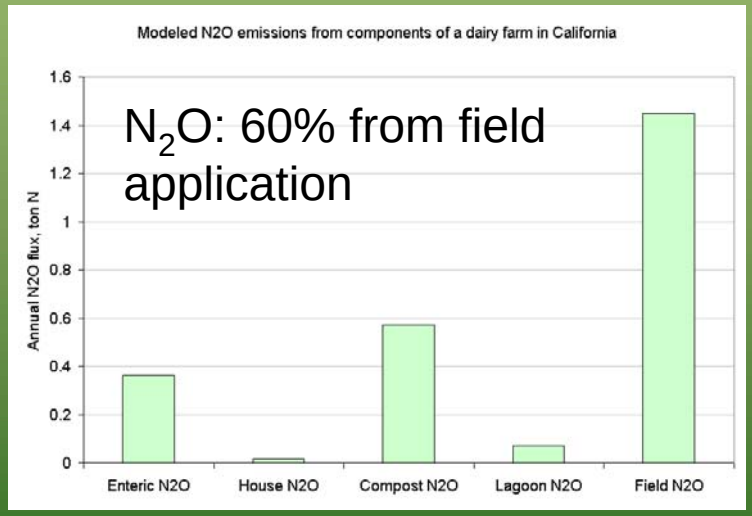
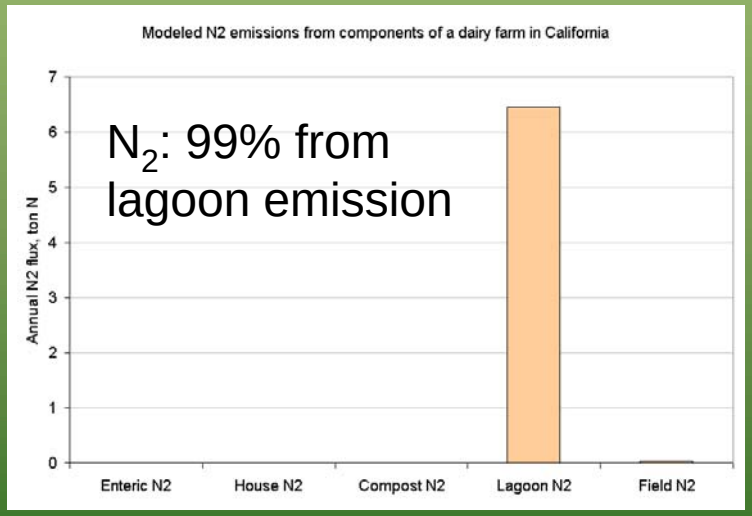
# Emissions of $CH_4$, $NH_3$, $N_2O$ and $N_2$ are dominated by different farm components

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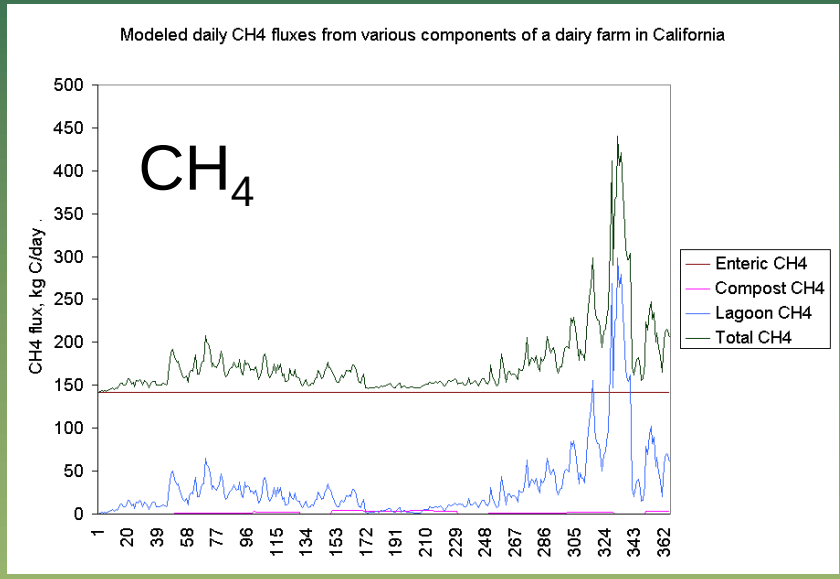
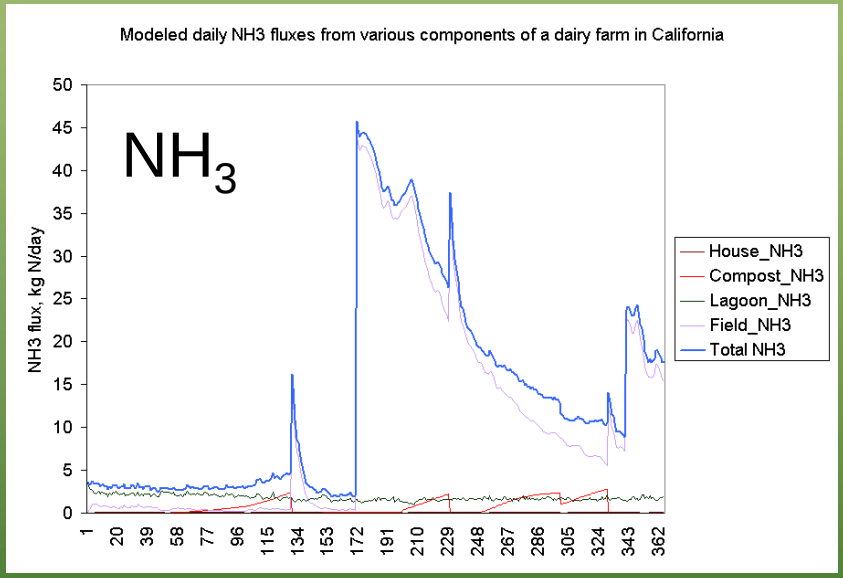
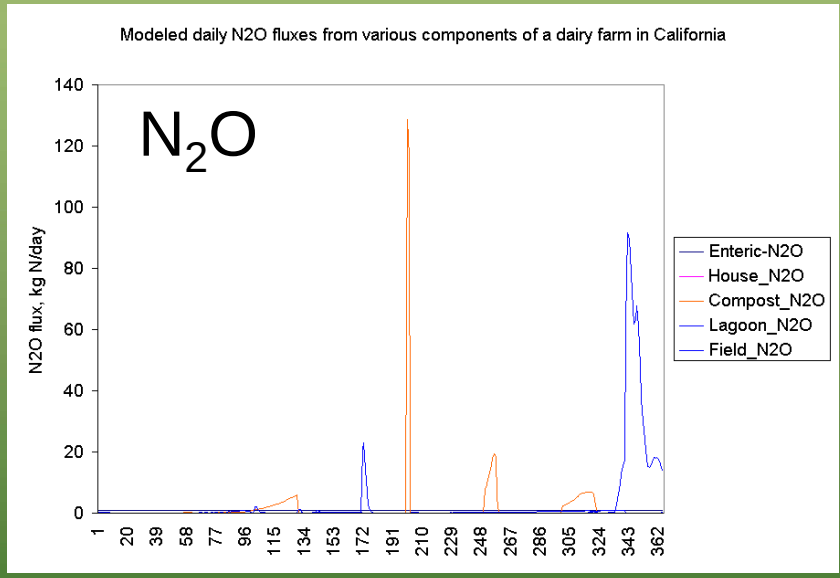
# Modeled daily $CH_4$, $NH_3$ and $N_2O$ emissions from a dairy.

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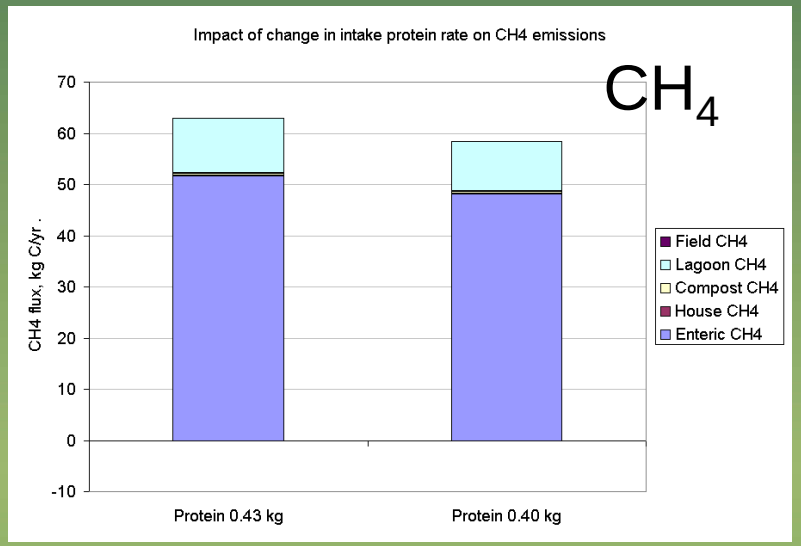
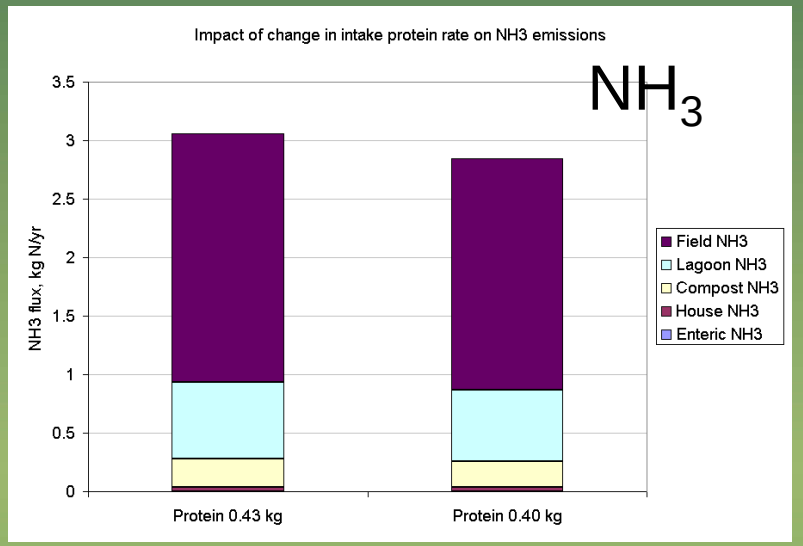
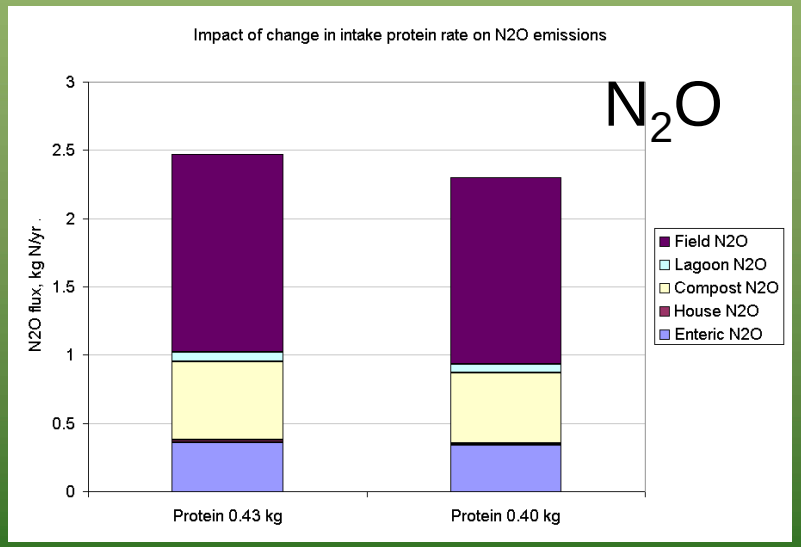
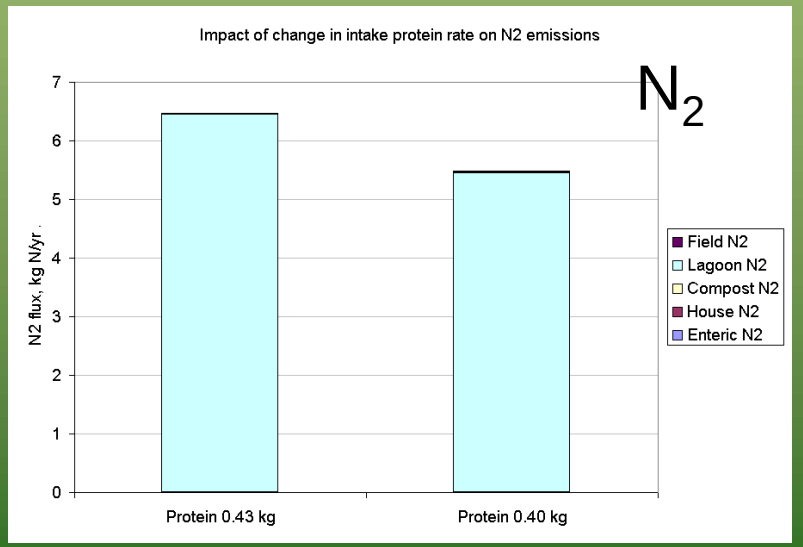
# Impact of change in diet (protein intake ) on gas emissions

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## Expected Project Outcomes:

- Biogeochemical process modeling tool for estimating air emissions ($CH_4$, $NH_3$, $N_2O$, NO) and N leaching from California dairies;
- GIS databases on dairies (location, types, herd sizes, manure management, local soils, climate, etc);
- Regional estimates of $NH_3$ and GHG emissions from California dairies;
- Emission inventory tool for emission inventories ranging from project or facility level up to air-district and state level

# Thank you!