Process-Based Nutrient Modeling Of Integrated Beef Cattle Finishing and Crop Production Systems in the Northern Great Plains

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Need

• Increase in feeding capacity under roof
• Variations in bedding and management styles
• Integrated with crop production in time, money and nutrients

What are the systematic effects of crop or cattle production changes in the Northern Great Plains on nitrogen and phosphorus cycling efficiency?

Objectives

1. Adapt and evaluate a process-based model that estimates the fate of N and P for confined beef cattle housing/manure management methods, including bedded manure pack and deep pit manure storage in mono-slope or hoop-style buildings
2. Adapt and evaluate a process-based model that estimates the N and P availability and losses from land applied solid beef cattle manure (with and without bedding)
3. Evaluate housing, manure management and crop production scenarios for N and P fate and farm profitability under variable climatic conditions
Project Overview

- Two year plot-scale land application study replicated in ND, SD and NE
- Two year farm-scale barn manure storage emission study
- Collected and existing data are used to adapt and evaluate the *Integrated Farm System Model*
- Generate predictions for various farm system scenarios under variable climatic conditions

Land Application Study

- Treatments
  - Bedded beef cattle manure
  - Beef cattle manure
  - Urea
  - No fertilizer
- 4 replicate plots per site; 3 sites
- Weather, soil, plant, soil water, GHG gas, NH3 flux measurements
## Land Application Sites

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil Parent Material (Soil Family)</th>
<th>Soil Texture, Drainage</th>
<th>Temperature[^A], °C (°F)</th>
<th>Prec[^A], cm (inch)</th>
<th>Irr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fargo, ND</td>
<td>Lucustrine deposits (Typic Epiaquert)</td>
<td>Silty clay, Poor</td>
<td>-35 (-32) 6 (44) 39 (102)</td>
<td>61 (24)</td>
<td>No</td>
</tr>
<tr>
<td>Beresford, SD</td>
<td>Glacial till (Udic Haplustoll)</td>
<td>Silty clay loam, well</td>
<td>-38 (-36) 9 (48) 40 (105)</td>
<td>56 (22)</td>
<td>No</td>
</tr>
<tr>
<td>Clay Center, NE</td>
<td>Loess (Udic Argiustoll)</td>
<td>Silt loam, well</td>
<td>-26 (-15) 11 (52) 41 (106)</td>
<td>66 (26)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

[^A]: Minimum (Min), average (Ave) and maximum (Max) temperature and precipitation (Prec) are based on ten years data (May 2003 – December 2012) (HPRCC, 2013).

## Barn Study

- Deep-pit gable roof
  - 3 cooperators identified
- Bedded-pack hoop barn
- Year 1 – environmental measurements
- Year 2 and 3 – Nitrogen and phosphorus movement
Airflow through Barn Openings

Concept of the type of data currently being collected.

Average of N_Wall_Flow_m3/s
Average of N_Eave_Flow_m3/s
Average of Ridge_Flow_m3/s
Average of S_Eave_Flow_m3/s
Average of S_Wall_Flow_m3/s

Integrated Farm System Model
Modelling

<table>
<thead>
<tr>
<th>Model Component</th>
<th>Integrated Farm System Model (Rotz et al., 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Types</strong></td>
<td>• Farm parameters</td>
</tr>
<tr>
<td></td>
<td>• Machinery parameters</td>
</tr>
<tr>
<td></td>
<td>• Weather data</td>
</tr>
<tr>
<td><strong>Farm System Components</strong></td>
<td>• Crop and Soil</td>
</tr>
<tr>
<td></td>
<td>• Grazing</td>
</tr>
<tr>
<td></td>
<td>• Machinery</td>
</tr>
<tr>
<td></td>
<td>• Tillage and Planting</td>
</tr>
<tr>
<td></td>
<td>• Economic Analysis</td>
</tr>
<tr>
<td><strong>Output Types</strong></td>
<td>• Crop Storage</td>
</tr>
<tr>
<td></td>
<td>• Herd and Feeding</td>
</tr>
<tr>
<td></td>
<td>• Manure Handling</td>
</tr>
<tr>
<td></td>
<td>• Crop Yields, Feeds Produced/Bought/Sold, Manure Produced, Feed Production, Manure Handling and Other Farm Costs, Net Return or Profitability</td>
</tr>
<tr>
<td></td>
<td>• N and P losses</td>
</tr>
<tr>
<td></td>
<td>• Whole farm balance of N, P and K</td>
</tr>
</tbody>
</table>

Expected Outcomes

• Emission estimating datasets specific to manure storage systems and land applied manure in the Northern Great Plains Region
• Strengthened model for scenario testing
• Informed decision making considering whole farm nutrient cycling