The Vermont Dairy Farm Sustainability Project, Inc.
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A Collaboration to Improve Dairy Farm Nutrient Balance

- Bill Jokela, Univ. of Vermont, Interim Coordinator, 2003-2005
- Slide show created by Greg Weber; revised by Bill Jokela
- Photo credits: Bill Jokela
A Collaboration Involving:

- Ben & Jerry’s
- St. Alban’s Coop.
- Poulin Grain
- Bourdeau Bros. of Middlebury
- University of Vermont Extension
- 8 Dairy Farmers

Funding from: Ben & Jerry’s, NE SARE, The Ben & Jerry’s and Windham Foundations.
Issues in Dairy Farm Sustainability

- Environmental
  - Water quality impacts
    - Surface water – P in runoff, erosion
    - Groundwater – nitrate leaching

- Economic
  - Farm profitability
    - Milk price
    - Production level
    - Cost of production
Response

Ben & Jerry’s initiated an industry collaboration to investigate and document management practices that improve farm environmental and economic sustainability.
Unique Aspects of VDFSP

- Whole-farm nutrient approach
  - Cows and feed
  - Crops and soil

- Collaborative
  - Private industry/public (university, Extension)
  - Ag suppliers, consultants, processors
  - Farmers

- Environmental and Economic Goals
Technical Goals of VDFSP

- More precisely match feed supply to cow requirements.
  - Utilize CNCPS software to reduce overfeeding of N and P.
- More precisely match manure and fertilizer application to crop requirements.
  - Use of CropMD software to match application to requirements.
  - Use of Phosphorous Index to reduce risk of phosphorous run-off.
- More precisely match crops grown on farm to herd nutritional requirements and soil fertility.
Approach

- **Baseline**
  - One year period to document N and P status of whole farm, feed and crop enterprises on 8 farms

- **Nutrient Management Improvement Plan**
  - Opportunity identification, improvement plan development and implementation in collaboration with farmer, farm suppliers and advisors

- **Implementation**
  - One year period to document impact of improvement implementations

- **Educational Phase**
  - Dissemination of information to dairy industry concerning successful improvements for N and P efficiency and lessons learned
Feed Enterprise

- Periodic evaluation of diet N and P supply relative to requirement, by group
  (Use Cornell Net Carbohydrate and Protein System v4.0.31 (CNCPS) software)
  - Measured intake.
  - Production level.
  - Physiologic state.

- Work with feed suppliers, dairy nutritionists
Crop Enterprise

- Evaluation of N and P supply relative to crop requirement, by field
  
  (Use VT CropMD or proprietary (NNYCMA) software.)

- Soil sampling and testing
- Manure analysis and management
- Fertilizer application
- Expected crop yield/crop management
- Evaluate P runoff potential with P Index

- Work with fertilizer suppliers and crop consultants.
Project success depended on farmer-cooperators, ag suppliers/consultants, and project staff working together for a common goal. Here project coordinator Greg Weber discusses management issues with a farmer and his crop consultant.
Whole Farm

- **Imports**
  - Feed, Animals, Fertilizer, N Fixation.

- **Exports**
  - Milk, Feed, Manure, Animals

- **Whole-farm nutrient balance**
  - Refers to the proportion of imported nutrients that are converted to useable product or retained on the farm
  - More nutrient retained means increased potential for loss to the environment via runoff or leaching
Feed
Fertilizer
Fixed N

Conversion Efficiency
Accumulation
Milk and Animals

Farm Boundary
Where are the Opportunities?

- Look at Results for Baseline Year
- 8 Dairy Farms
  - 80-300 milkers (1 heifer operation)
  - Cropland: 130-900 acres
    - Most legume-grass and corn silage
    - One pasture-based
- 7 in VT, 1 in NY
Conversion Efficiency

Nutrient Allocation, Timing, Method, Crops Grown

Diet Parameters
CP, MP, NSC, Rumen N, P

Crop Nutrient Supply

Conversion Efficiency

Total Crop Nutrients

Soil Nutrients

Nutrient Accumulation

Manure Nutrients

Home Grown Ration Nutrients

Total Intake Ration Nutrients

Feed

Nutrient Export In Milk + Animals

Purchased Feed

Purchased Feed

N Fixation

Crops

Farm Boundary

Farm Boundary
Results

- Whole Farm Nutrient Conversion Efficiency
  - Exported N or P, as percent of imported nutrient

- Feed Nutrient Conversion Efficiency
  - Product (milk and tissue) as percent of intake.

- Crop Nutrient Status
  - Applied crop available nutrient amount minus recommended application rate.
Whole-farm Phosphorus Import Baseline Year

- On most farms purchased feed was the largest import of P; fertilizer was the largest on others.
Milk was the primary P export (except on heifer operation)
Conversion efficiencies ranged from 20 to 50% (50 to 80% retained), except for a grazing-based farm with a large land base, which had a 75% conversion efficiency.
Whole-farm Nitrogen Balance
Baseline Year

Nitrogen Mass Balance

Tons

Farm

% Retained
% Converted
How much N and P in feed?
### Feed Characteristics

<table>
<thead>
<tr>
<th>Farm</th>
<th>Lactating Averages - Baseline Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Dietary Crude Protein %</td>
<td>17.7</td>
</tr>
<tr>
<td>Ruminal N Supply (% of req.)</td>
<td>129.5</td>
</tr>
<tr>
<td>MP N Supply (% of req.)</td>
<td>107.1</td>
</tr>
<tr>
<td>P Intake (% of req.)</td>
<td>111.0</td>
</tr>
</tbody>
</table>

- Overfeeding of N and P lowers nutrient efficiency and increases manure nutrient content.
### Manure Application

<table>
<thead>
<tr>
<th>Farm</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure Rate, gal/Acre</td>
<td>6956</td>
<td>7526</td>
<td>5122</td>
<td>6968</td>
<td>5188</td>
<td>?</td>
<td>3646</td>
</tr>
<tr>
<td>% Acres Manured</td>
<td>63</td>
<td>94</td>
<td>81</td>
<td>94</td>
<td>83</td>
<td>77</td>
<td>62</td>
</tr>
</tbody>
</table>

Percent of Acreage Manured by Crop

- Corn silage: 82%
- Legume-grass: 68%
- Grass: 76%

Manure sampled and analyzed 1-3 x per farm
Phosphorus in manure...

...can result in phosphorus in runoff.
Most P fertilizer was applied to corn land, mainly as starter fertilizer.
Soil test P distribution varied by farm.

Most farms had large acreage with low and/or high/excessive soil test P, showing need for improved manure and fertilizer allocation.
Soil Test P and Animal Density

With 2 exceptions, % of fields testing high or excessive increased with animal density.
Other research in VT showed that dissolved P in runoff increases with increasing soil test P (Tilley et al.).
Determination of P Index on 3 farms showed a wide range, most low to medium, some high, and only 2 very high (apply no P).
PSNT for Corn on 6 Farms

PSNT results showed many fields above the 25 ppm threshold (no more N needed) and many below (N recommended).
Averaged across fields, most farms were applying more N and P than recommended in the baseline year, showing an opportunity for reduced nutrient loading and potential cost savings.
Demonstration trials on one of the cooperating farms showed an opportunity for decreased starter fertilizer rate with no effect on corn yield. (Project coordinator shown.)
What were the Impacts?
Feed Comparisons (Yr 2-Baseline)

<table>
<thead>
<tr>
<th>Farm</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>Avg</th>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk lbs/hd/day</td>
<td>3.07</td>
<td>-5.29</td>
<td>2.65</td>
<td>5.70</td>
<td>2.05</td>
<td>0.25</td>
<td>1.00</td>
<td>1.35</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>MP supply (% of req.)</td>
<td>0.22</td>
<td>5.25</td>
<td>4.68</td>
<td>11.15</td>
<td>4.08</td>
<td>8.47</td>
<td>2.15</td>
<td>5.14</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Rumen N Balance g/hd/day</td>
<td>-14.11</td>
<td>-2.29</td>
<td>-34.32</td>
<td>-51.62</td>
<td>-3.34</td>
<td>-42.43</td>
<td>2.45</td>
<td>-20.81</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Feed N Efficiency %</td>
<td>0.81</td>
<td>-1.51</td>
<td>1.60</td>
<td>1.58</td>
<td>-0.78</td>
<td>1.41</td>
<td>-0.45</td>
<td>0.38</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Feed P Efficiency %</td>
<td>6.30</td>
<td>2.81</td>
<td>10.22</td>
<td>6.37</td>
<td>4.65</td>
<td>-0.85</td>
<td>7.39</td>
<td>5.27</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Diet P %</td>
<td>-0.06</td>
<td>-0.04</td>
<td>-0.11</td>
<td>-0.10</td>
<td>-0.06</td>
<td>-0.01</td>
<td>-0.09</td>
<td>-0.07</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

Most farms showed improvement in milk production and several feed parameters in the implementation year (Year 2) compared to the baseline year.
Change in Nutrients Applied – Recomm: Year 2-Baseline

<table>
<thead>
<tr>
<th>Farm</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>7</th>
<th>8</th>
<th>Avg</th>
<th># of Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, lbs/A</td>
<td>-10.0</td>
<td>-1.2</td>
<td>-12.0</td>
<td>-10.7</td>
<td>26.7</td>
<td>-34.7</td>
<td>27.1</td>
<td>-2.1</td>
<td>2/5</td>
</tr>
<tr>
<td>P2O5, lbs/A</td>
<td>21.0</td>
<td>-33.3</td>
<td>14.3</td>
<td>27.8</td>
<td>22.2</td>
<td>-19.7</td>
<td>33.5</td>
<td>-14.4</td>
<td>2/5</td>
</tr>
</tbody>
</table>

Five of seven farms reduced average N and P application rates to bring them closer to recommended rates.
<table>
<thead>
<tr>
<th>Farm 8</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2O5 lbs/acre</td>
<td>63.2</td>
<td>37.2</td>
<td>25.9</td>
</tr>
<tr>
<td>Cost/acre</td>
<td>$40.20</td>
<td>$26.27</td>
<td>$13.93</td>
</tr>
</tbody>
</table>

For 2002

| P2O5 Import Avoided (tons) | 3.9 |
| Savings                  | $4,197 |

<table>
<thead>
<tr>
<th>Farm 7</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2O5 lbs/acre</td>
<td>106.4</td>
<td>59.6</td>
<td>46.8</td>
</tr>
<tr>
<td>Cost/acre</td>
<td>$40.76</td>
<td>$28.83</td>
<td>$11.94</td>
</tr>
</tbody>
</table>

For 2002

| P2O5 Import Avoided (tons) | 9.3 |
| Savings                  | $4,765 |

<table>
<thead>
<tr>
<th>Farm 2</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2O5 lbs/acre</td>
<td>35.9</td>
<td>23.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Cost/acre</td>
<td>$20.64</td>
<td>$13.69</td>
<td>$6.96</td>
</tr>
</tbody>
</table>

For 2002

| P2O5 Import Avoided (tons) | 1.0 |
| Savings                  | $1,151 |

Prices used

- 10-20-20 $230/ton
- 7-27-27 $261/ton
- 10-40-10 $283/ton
- 21-17-0 $240/ton
- 19-19-0 $240/ton
Whole-farm Phosphorus Balance Change: Baseline to Year 2

Phosphorus Mass Balance

Phosphorus Mass Balance - Year 2
Whole-farm conversion efficiency improved on most farms for phosphorus (7 of 8) and nitrogen (5 of 8).
Opportunities

**Successes**
- Corn Starter P
- Feed P
- Feed N

**Potentials**
- Fertilizer N
  - PSNT
- Cropping Strategy
Implemented practices reduced:

- Fertilizer P rate and cost (3 of 7).
- Feed (rumen) N excess (6 of 7)
- Diet P excess (6 of 7).

Impacts

- Excess crop N and P reduced (5 of 7).
- Lactating Feed Efficiency improved for N (4 of 7) and P (6 of 7).
- Whole Farm Efficiency improved for N (5 of 8) and P (7 of 8).
Management tools that decrease excess nutrient supply improve net farm nutrient balance and profitability.

Nutrient Conversion Efficiency and Balance are constrained by efficiency of biological processes and economics.

Considerations in improving farm nutrient balance are farm information systems, quality control procedures and farm and supplier risk approach.

Excess reduction requires accurate information, consistency and farm-supplier relationships capable of honestly assessing risk vs. gain.

Farm P balances are more easily improved than N balances, partly due to increased risk of reduced performance with N.

Nutrient accumulation depends more on management than on AU/acre.