Creating nutrient sustainability indicators for dairies nationwide

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Towards Sustainable Agriculture

- Sustainability issues are increasingly featured on agricultural agendas
- Growing world population and increasing frequency of weather extremes
- Resource scarcity and environmental issues

Resource Protection and Environmental Issues

- Land and soil
- Air
- Water

Recently in the (Local) Popular Press

Toxic algae is invading our lakes and lack of transparency makes it difficult to track

This photo of manure was photographed from the shore of Cayuga Lake on July 22, 2014, one day after a large CAFO in Reposa had applied manure to a frozen field. The NYDEC later fined the farm $10,000 for that and other manure runoff events that same year. As toxic algae blooms feed manure pollution present on Cayuga, towns that draw their public drinking water from the lake are urging the DEC to adopt tougher permitting rules for manure spreading.

Large Dairies Heeded to Permitting Loophole as Toxic Algae Blooms Threaten Finger Lakes Drinking Water

September 14, 2018

October 15, 2018
Our Responsibility

Harmful Algal Blooms: Together we can protect our lakes, divided we all lose.

On Monday, October 1, Quinn Delaplane, Tom Osborn and others wrote in the editor to three newspapers in the region that addressed issues in a responsible way that they had considered harmful to local organizations. Among other things, the article suggested that a single measure in the water of Lake Michigan in Omena is the following survey. In its response, the letter included the following point: “Our responsibility is not to point fingers at others, but to work together to address the issue.”

Kari Czaplewski

Letter to the editor:

The article “Harmful Algal Blooms: Together we can protect our lakes, divided we all lose.” is a call for action and a reminder that harmful algal blooms (HABs) are a global issue. In Michigan, HABs can occur in any lake, river, or stream, and are caused by an overgrowth of algae that can cause harm to human and animal health. The article calls for responsible action from local organizations and individuals to address the issue.

Not Sufficient!

Reactionary...

The Need for Sustainability Definitions and Goals

- Many institutions/companies/organizations have adopted sustainability in their programs.

"Sustainable agriculture" was addressed by Congress in the 1990 “Farm Bill” [Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), Public Law 101-624, Title XVI, subtitle A, Section 1601 (Government Printing Office, Washington, DC, 1990)] and L. Call e K1682, A31 1990]. Under that law, “the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs;
- enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- make the ecosystem service of non-renewable resources on and off-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations; and
- enhance the quality of life for farmers and society as a whole."
Sustainability Definitions and Goals

- Definitions used by companies are often very broad and/or vague, without clear targets.
- Animal agriculture benefits from developing sustainability statements, commitments, and develop benchmarks.
- This will help improve sustainability over time but also monitor and signal progress made (and targets reached).
- Can give farmers insight in their nutrient use and how to improve.
- Can be used by companies as incentive to reward producers.

Dairy Nutrient Sustainability Indicators

- Several nutrient sustainability indicators exist:
  - Milk Urea Nitrogen (MUN)
  - Dairy P content in ration
  - Feed use efficiency
  - Corn Stalk Nitrate Test (CSNT)
  - Soil tests
  - Etc.
- An integrator is needed to address sustainability challenges at the whole farm level.

Whole-Farm Nutrient Sustainability Indicator

Criteria for a successful indicator:
- Easy to interpret
- Gives a measure of sustainability across management units within the farm (cows, storage, crops, soil, etc.)
- Sets feasible targets to strive for
- Is responsive to management changes
- Takes little time to calculate

Whole-Farm Nutrient Mass Balances (NMBs)

[Diagram showing nutrient balances with imports and exports highlighted, including per tillable acre and per cwt of milk.]
Feasible Nutrient Mass Balances

<table>
<thead>
<tr>
<th>Mass balance</th>
<th>Time period</th>
<th>Desirable/Undesirable</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>Short term</td>
<td>Desirable</td>
<td>If soil test P and K are high</td>
</tr>
<tr>
<td>(Imp. &lt; Exp.)</td>
<td>Long term</td>
<td>Undesirable</td>
<td>Soil P and K mining → yield losses</td>
</tr>
<tr>
<td>Surplus</td>
<td>Short term</td>
<td>Undesirable</td>
<td>Inefficiencies in plant and animal production</td>
</tr>
<tr>
<td>(Imp. &gt; Exp.)</td>
<td>Long term</td>
<td>Desirable</td>
<td></td>
</tr>
<tr>
<td>Large Surplus</td>
<td>Short term</td>
<td>Undesirable</td>
<td>High risk of nutrient losses to the environment. Soil P and K buildup.</td>
</tr>
<tr>
<td>(Imp. &gt;&gt;&gt; Exp.)</td>
<td>Long term</td>
<td>Undesirable</td>
<td>Low nutrient use efficiency Maybe economic losses</td>
</tr>
</tbody>
</table>

- A feasible mass balance should allow farms to be:
  - Economically viable and environmentally sustainable
  - Feasible limits were set based on balances from commercial dairy farms in New York

<table>
<thead>
<tr>
<th>Mass Balances</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>(lbs/acre)</td>
<td>0-105</td>
<td>0-12</td>
<td>0-37</td>
</tr>
<tr>
<td>(lbs/cwt)</td>
<td>0-0.88</td>
<td>0-0.11</td>
<td>0-0.30</td>
</tr>
</tbody>
</table>

"Optimal operational zone" (green box)
Low NMB/acre (blue) and low NMB/cwt (yellow)

High NUE and can recycle nutrients in the land base

Whole-Farm Feasible Nutrient Balances

Nitrogen | Phosphorus | Potassium
Whole-Farm Feasible Nutrient Balances

Opportunities Table with Indicators

<table>
<thead>
<tr>
<th>Indicator to predict likelihood of exceeding feasible balances</th>
<th>Example 2015</th>
<th>High risk of exceeding the feasible balances if</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Balance per head (lbs/head)</td>
<td>13.9 - 14.9</td>
<td>&gt; 15.5 &gt; 16.1 &gt; 16.6 &gt; 17.2 &gt; 17.7 &gt; 18.2</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>2. Balance per cwt milk (lbs/cwt milk)</td>
<td>22.0 - 22.6</td>
<td>&gt; 24.0 &gt; 25.0 &gt; 26.0 &gt; 27.0 &gt; 28.0 &gt; 29.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>3. Feed consumption (lbs/day head)</td>
<td>23.0 - 24.0</td>
<td>&gt; 25.0 &gt; 26.0 &gt; 27.0 &gt; 28.0 &gt; 29.0 &gt; 30.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>4. Whole farm nutrient use efficiency (%)</td>
<td>9.0 - 9.9</td>
<td>&gt; 10.0 &gt; 11.0 &gt; 12.0 &gt; 13.0 &gt; 14.0 &gt; 15.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>5. Purchased feed (lbs/head)</td>
<td>22.0 - 22.6</td>
<td>&gt; 24.0 &gt; 25.0 &gt; 26.0 &gt; 27.0 &gt; 28.0 &gt; 29.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>6. Total N in purchased feed (%)</td>
<td>26.0 - 27.0</td>
<td>&gt; 28.0 &gt; 29.0 &gt; 30.0 &gt; 31.0 &gt; 32.0 &gt; 33.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>7. Nitrogen balance (lbs/acre)</td>
<td>10.0 - 15.0</td>
<td>&gt; 16.0 &gt; 17.0 &gt; 18.0 &gt; 19.0 &gt; 20.0 &gt; 21.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>8. Homegrown forage (%)</td>
<td>6.0 - 7.0</td>
<td>&gt; 8.0 &gt; 9.0 &gt; 10.0 &gt; 11.0 &gt; 12.0 &gt; 13.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>9. Homegrown grain (%)</td>
<td>0.0 - 1.0</td>
<td>&gt; 2.0 &gt; 3.0 &gt; 4.0 &gt; 5.0 &gt; 6.0 &gt; 7.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>10. Homegrown nutrients (%)</td>
<td>50.0 - 60.0</td>
<td>&gt; 70.0 &gt; 90.0 &gt; 110.0 &gt; 130.0 &gt; 150.0 &gt; 170.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>11. Crop imports (%)</td>
<td>26.0 - 27.0</td>
<td>&gt; 28.0 &gt; 29.0 &gt; 30.0 &gt; 31.0 &gt; 32.0 &gt; 33.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>12. Feed imports (%)</td>
<td>26.0 - 27.0</td>
<td>&gt; 28.0 &gt; 29.0 &gt; 30.0 &gt; 31.0 &gt; 32.0 &gt; 33.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>13. Feed N density (%)</td>
<td>10.0 - 15.0</td>
<td>&gt; 16.0 &gt; 17.0 &gt; 18.0 &gt; 19.0 &gt; 20.0 &gt; 21.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>14. Feed N density (%)</td>
<td>10.0 - 15.0</td>
<td>&gt; 16.0 &gt; 17.0 &gt; 18.0 &gt; 19.0 &gt; 20.0 &gt; 21.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
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<td>15. Feed N density (%)</td>
<td>10.0 - 15.0</td>
<td>&gt; 16.0 &gt; 17.0 &gt; 18.0 &gt; 19.0 &gt; 20.0 &gt; 21.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>16. Crop exports (%)</td>
<td>26.0 - 27.0</td>
<td>&gt; 28.0 &gt; 29.0 &gt; 30.0 &gt; 31.0 &gt; 32.0 &gt; 33.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>17. Manure exports (%)</td>
<td>26.0 - 27.0</td>
<td>&gt; 28.0 &gt; 29.0 &gt; 30.0 &gt; 31.0 &gt; 32.0 &gt; 33.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>18. Overall crop yield (tons dry matter/acre)</td>
<td>4.6 - 5.0</td>
<td>&gt; 5.5 &gt; 6.0 &gt; 6.5 &gt; 7.0 &gt; 7.5 &gt; 8.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>19. Acres receiving manure (%)</td>
<td>74.0 - 90.0</td>
<td>&gt; 95.0 &gt; 105.0 &gt; 115.0 &gt; 125.0 &gt; 135.0 &gt; 145.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
<tr>
<td>20. Land in legumes (%)</td>
<td>37.0 - 50.0</td>
<td>&gt; 55.0 &gt; 65.0 &gt; 75.0 &gt; 85.0 &gt; 95.0 &gt; 105.0</td>
<td>W High risk of exceeding the feasible balances if</td>
</tr>
</tbody>
</table>

Main Drivers and Opportunities

- High animal density (> 1.0 AU/acre)
- Low home-grown feed (< 65%)
- High imports of nutrients in feed and fertilizer sources

Main Drivers and Opportunities

- Changes in nutrient mass balances over time and related drivers for 54 New York State dairy farms
- Long-term trends of nitrogen and phosphorus mass balances on New York State dairy farms

y = 0.7446x - 18.492
R² = 0.9286

y = 0.8566x - 6.6578
R² = 0.8682
Main Drivers and Opportunities

In general, farms:
- Reduced imports of soybean, cotton, canola
- Increased imports of blends with lower CP% and P%
- Reduced CP and P (%) in purchased feed
- Evaluated their fertilizer program and increased home-grown forages

NMSP website (nmsp.cals.cornell.edu)

http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html

Page One Input Sheet
- Farm contact information
- Acres
- Miscellaneous characteristics
- Animal types, numbers, weights

Page Two Input Sheet
- Farm crop production
  - Farm crop production will not impact the balance calculation (inside the farm boundaries) but accurate data will help with identification of “issues” or “opportunities to improve”
- Feed imports
Page Three Input Sheet

- Fertilizer purchases
- Animal purchases
- Bedding and miscellaneous imports
- Milk sold and crude protein level
- Animals sold or exported off the farm

Page Four Input Sheet

- Crops exported
- Manure, compost or other exports

Sustainability Definitions and Goals

- Definitions used by companies are often very broad and/or vague, without clear targets
- Animal agriculture benefits from developing sustainability statements, commitments, and develop benchmarks
  - This will help improve sustainability over time but also monitor and signal progress made (and targets reached)
    - Can give farmers insight in their nutrient use and how to improve
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Four NY Case-Study Farms

- N balance (lbs/acre)
- P balance (lbs/acre)
- Milk per cow (lbs/cow/yr)
NMBs as Monitoring Tool

• Changes between 2004 and 2013
  • New York: 189 farms
  • Upper Susquehanna Watershed: 91 farms
  570 nutrient mass balances
  293 nutrient mass balances

Percentage of farms in the Green Box

NMBs as Monitoring Tool

• Nutrient import reductions over a decade:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>New York State</th>
<th>Upper Susquehanna Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>66.0 (26%)</td>
<td>9.5 (30%)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>6.6 (19%)</td>
<td>0.9 (20%)</td>
</tr>
</tbody>
</table>

Feedback from farmers

“When you fill your car’s gas tank, you can’t expect 100% efficiency. The same holds true for nutrients applied on the farm, but until the NMB we didn’t have a tool to show us what’s possible.”

–Willard DeGolyer, Table Rock Farm

Crazy New York Idea?

OVERSEER® Nutrient Budgets

A farm-level Decision Support System used to advise on management of nutrients and greenhouse gas emissions. It is widely used throughout New Zealand by farmers and their advisors and is also used for policy support.

Login here
Feedback from farmers

“It took a few years to see trends in the NMB numbers. Then we began to delve into what’s behind them. They reflect our progress with the goals we set for feed and crop management. The NMB is part of our annual planning, and we look forward to seeing how our NMB trends reflect the efficiency we aim to achieve.”

–Edie McMahon, McMahon’s EZ Acres

In Summary

• Animal agriculture can benefit from development of whole-farm sustainability indicators
• The whole-farm nutrient mass balance is a tangible nutrient indicator
• It can be used to track management, set and track goals, and possibly to evaluate management scenarios
• Industry-driven initiatives are essential to the development of this tool

Next Steps

• Expand adoption of the nutrient mass balance approach (individual farms, cooperatives, etc.)
• Work to integrate management tools already in use by farms to determine additional key performance indicators and facilitate scenario evaluations

Continued Proposal Development:

The objectives are to: (1) create an integrated systems model for the analysis of dairy farms based on integrating existing models developed by Cornell University; (2) evaluate and validate the model for a FarmBeats enabled dairy farm; and (3) utilize the model to develop and analyze key performance indicators for food, energy and water as qualitative and quantitative outcomes, to identify mutually beneficial strategies and important trade-offs.

Mike van Amburgh, Curt Gooch, Pete Wright, Hakim Witherspoon, Quirine Ketterings

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Thanks for your attention. For more information, send us an email:
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