Whole-Farm Nutrient Mass Balances

In Summary

Nutrient Management Spear Program

http://nmsp.cals.cornell.edu

Department of Animal Science
Cornell University
What is a nutrient mass balance?

• Balance = Imports – Exports (just farm boundaries).
• We only measure what is reasonably feasible to measure.
<table>
<thead>
<tr>
<th>Mass balance</th>
<th>Time period</th>
<th>Desirable/Undesirable</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Negative</strong></td>
<td>Short term</td>
<td>Desirable</td>
<td>If soil test P and K are high</td>
</tr>
<tr>
<td>(Imports &lt; Exports)</td>
<td>Long term</td>
<td>Undesirable</td>
<td>Soil P and K mining → yield losses</td>
</tr>
<tr>
<td><strong>Surplus</strong></td>
<td>Short and Long term</td>
<td>Desirable</td>
<td>Inefficiencies in plant and animal production</td>
</tr>
<tr>
<td>(Imports &gt; Exports)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Large Surplus</strong></td>
<td>Short and Long term</td>
<td>Undesirable</td>
<td>Nutrient losses to the environ. Soil P and K buildup. Low nutrient use efficiency Maybe economic losses</td>
</tr>
</tbody>
</table>
New York dairy farms operate with a wide range of mass balances per acre and per cwt, regardless of their size.

<table>
<thead>
<tr>
<th>Distribution Across NY dairies*</th>
<th>NMB (lbs/acre)</th>
<th>NMB (lbs/cwt milk)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Minimum</td>
<td>-35</td>
<td>-7</td>
</tr>
<tr>
<td>Maximum</td>
<td>211</td>
<td>45</td>
</tr>
<tr>
<td>&quot;Feasible&quot;</td>
<td>0 to 105</td>
<td>0 to 12</td>
</tr>
</tbody>
</table>

*Based on 102 dairy farms in 2006

Farms with “feasible” mass balances have:
- low risk of losing nutrients to the environment (per acre)
- high nutrient use efficiencies (per cwt).
EXAMPLE 1  

and produce the same amount of milk per acre (6,000 lbs/acre), but has lower NMB, and hence a lower risk of losing nutrients to the environment.

EXAMPLE 2  

and have the same NMB per acre (80 lbs/acre), but produces twice more milk, and hence has a higher nutrient use efficiency. Indeed, works in the Optimal Operational Zone.
What causes excessive NMBs?

**Mass balance**
- **Per acre**
  - High if N > 105 lbs/ac
  - P > 12 lbs/ac
  - K > 37 lbs/ac
- **Animal density (AU/ac)**
  - High if >1.0 AU/ac
- **Homegrown feed (%)**
  - High risk if <62-65%
- **Overall crop yields**
  - Could be increased if <4.7 tons/ac

**Feed**
- **Purchased feed (lbs/ac)**
  - High risk if >121 lbs N/ac
  - > 20 lbs P/ac
  - > 38 lbs K/ac
- **CP and P (%) in purchased feed**
  - Can be reduced if > 27-30% CP
  - > 0.60% P

**Feed use efficiency (%)**
- Can be improved if
  - N < 20%
  - P < 25%
  - K < 11%
- **CP and P (%) in all feed**
  - Can be reduced if
  - > 17% CP
  - > 0.40% P

**Total imports**
- **Per cwt of milk**
  - High if N > 0.88 lbs/cwt
  - P > 0.11 lbs/cwt
  - K > 0.30 lbs/cwt
- **Fertilizer**
  - Could be reduced if
  - >39 lbs N/ac
  - > 7 lbs P/ac
  - > 38 lbs K/ac

**Other indicators**
- **Milk/cow**
  - Could be increased if <20,000 lbs/cow per yr
- **Exports**
- **Crops**
- **Manure**
QUESTION 1: WHAT IS A NUTRIENT MASS BALANCE?

- Lbs N, P or K/acre
- Lbs N, P or K/cwt

QUESTION 2: WHY DO WE CARE?

- Economic and environmental gains
- Balances can be reduced while maintaining or increasing milk production

QUESTION 3: WHAT DO THEY MEAN?

- N balance = annual N losses
- P & K balances = soil buildup or mining
- **Negative** and **very positive** balances are undesirable

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Lbs per acre</th>
<th>Lbs per cwt</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>≤105</td>
<td>≤0.88</td>
</tr>
<tr>
<td>P</td>
<td>≤12</td>
<td>≤0.11</td>
</tr>
<tr>
<td>K</td>
<td>≤37</td>
<td>≤0.30</td>
</tr>
</tbody>
</table>

QUESTION 4: WHAT IS FEASIBLE FOR NY DAIRY FARMS?

- Animal density >1 AU/acre
- Farm produced feed <65% DM
- Feed use efficiencies <20% for N, <25% for P, <11% for K

OPPORTUNITIES TO IMPROVE MASS BALANCES:

- Fine-tuning %CP and %P in purchased feed. Feasible: <27%CP and <0.60%P
- Fine-tuning fertilizer use. Feasible: <39 lbs N/ac, <7 lbs P/ac, <38 lbs K/ac
- Increase percent homegrown forage
- Export of crops
- Exports of manure

QUESTION 5: WHAT CAUSES EXCESSIVE BALANCES?

- Animal density >1 AU/acre
- Farm produced feed <65% DM
- Feed use efficiencies <20% for N, <25% for P, <11% for K

QUESTION 6: WHAT DO FARMERS SAY?

- For farmer impact stories in both small and large dairies, see:
  - [http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html](http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html)
• **Nutrient mass balance website:**
  with the NMB software, data input sheets, user manual, impact stories, fact sheets and articles

  [http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html](http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html)

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