

Whole-Farm Nutrient Mass Balances for Outcome-Based Adaptive Nutrient Management on Dairy Farms



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1. Introduction and Project (ENE16-143)

- Sustainable solutions for agriculture and environmental management on dairy farms require improved nutrient use efficiencies across the entire farm (animals and cropland).
- In an adaptive approach for whole-farm nutrient management, the nutrient status of the whole farm is assessed, pinpointing areas where improvements can be made, and tracking progress from year to year. A whole-farm nutrient mass balance (NMB) assessment is a tool that can help farmers and advisors do this effectively and efficiently.
- A NMB is the difference between the amounts of N, P, and K imported onto dairy farms as feed, fertilizer, animals, and bedding, and exported via milk, animals, crops, and manure. We express a NMB per tillable acre to indicate the potential for recycling nutrients in the land base (environmental indicator) and per cwt milk (milk production efficiency indicator).
- Large positive NMBs per acre suggest high risk of nutrient losses to the environment, while large positive NMBs per cwt reflect low nutrient use efficiencies, and potential economic loss for the farm as well. Negative NMBs (resulting from exports exceeding imports) reflect mining of soil P and K resources, and will eventually reduce crop yields.
- Farms that manage nutrients in the optimum operational zone (**Green Box**) recycle nutrients on their land base and produce milk efficiently.
- With NESARE ENE16-143, we developed curriculum and teach farm advisors (crop consultants, nutritionists, extension) the ins and outs of the NMB assessment.
- Performance target: 20 farm advisors will learn to conduct NMBs for dairy farms and 8 will adopt use of NMB assessments, conduct balances, and discuss results with two dairy farmers each. Ten farmers will conduct the NMB a second year and show intent to continue beyond the project.

2. Whole-Farm Nutrient Mass Balances - Concept

The NMB (Figure 1) is a tool to assess farm nutrient sustainability and efficiency. A **farm balance** for N, P, and K is calculated by **subtracting nutrients in farm exports** (milk/crop sales/manure exports), **from those in imports** (fertilizer/feed purchases). The balances are then expressed per tillable acre and per cwt of milk sold, to allow for comparison among farms in New York.

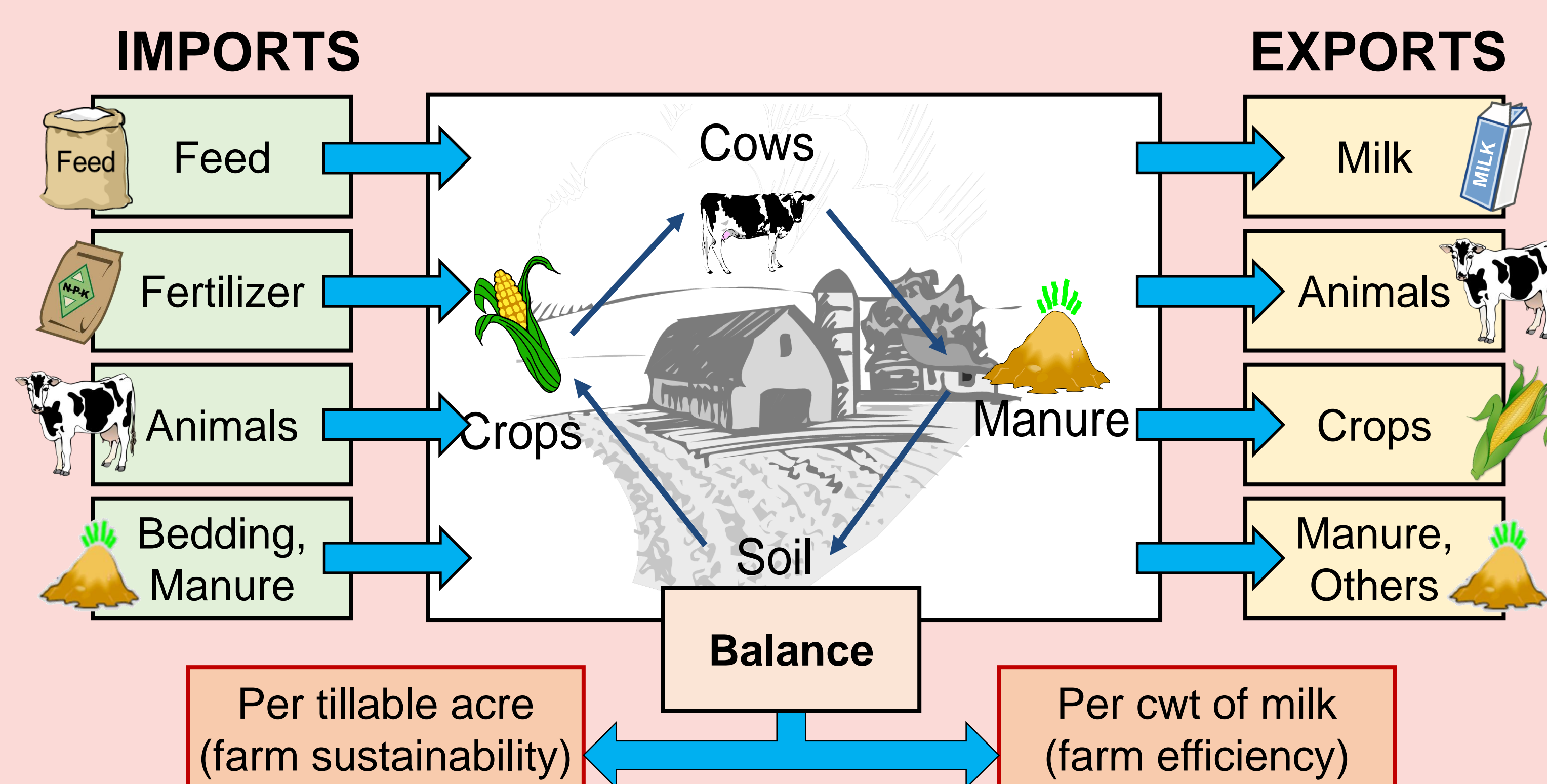


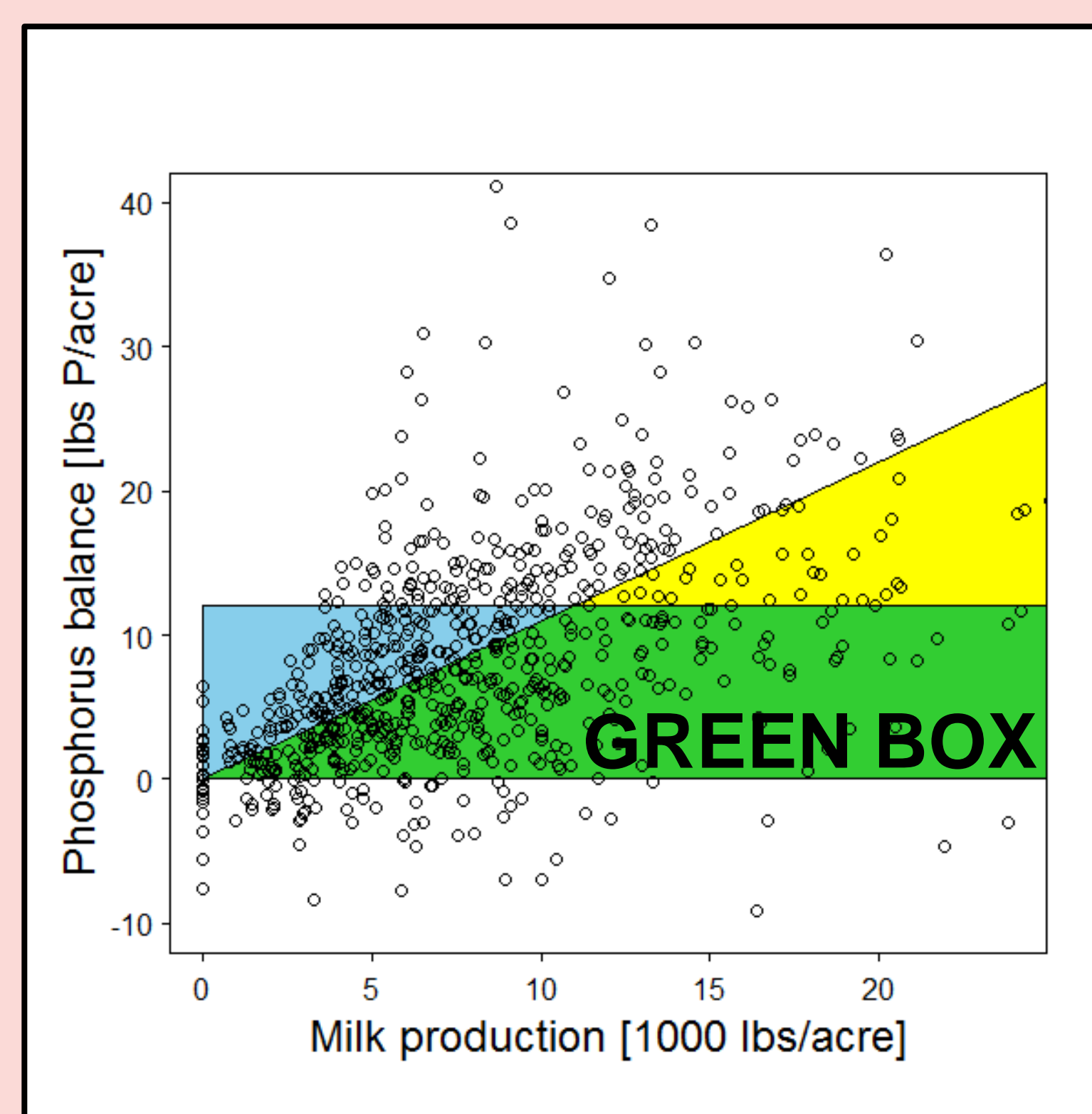
Figure 1. Overview of farm imports and exports included in the NMB. Only easily measurable components are considered. The nutrients in the resulting balance either remain on the farm system, or are lost to the environment.

Based on 102 dairy farms, we created the **Green Box** for New York (Figure 2, Table 1). For P (Figure 2), this optimal operation zone was defined as a balance per tillable acre of 0-12 lbs/acre, and a balance per milk of 0-0.11 lbs/cwt.

Table 1. Feasible balances for dairy farms in New York.

Nutrient	Lbs per acre	Lbs per cwt milk
N	0 ≤ 105	0 ≤ 0.88
P	0 ≤ 12	0 ≤ 0.11
K	0 ≤ 37	0 ≤ 0.30

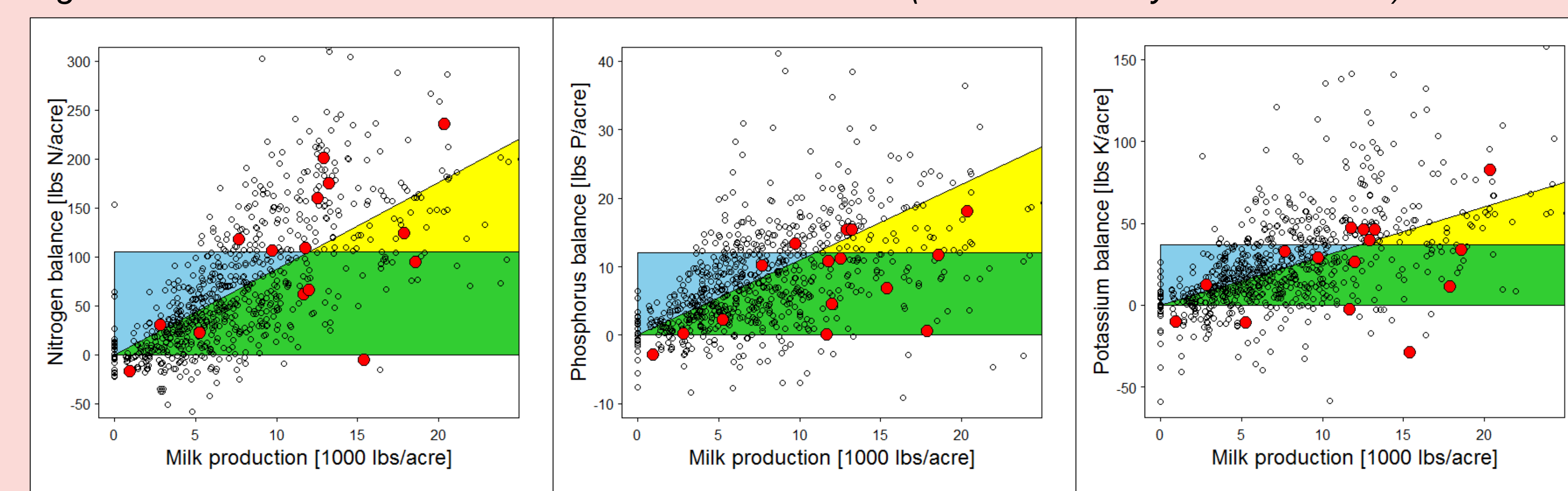
Figure 2. Current Cornell database for P balances of over 750 farms. Circles represent individual farms. The blue rectangle indicates the range of feasible balances per acre (0-11 lbs/acre), and the yellow triangle depicts the range of feasible balances per milk (0-0.11 lbs/cwt). The Green Box where these areas overlap is the optimal operation zone for P.



3. Accomplishments ENE16-143 to Date

- We developed two 45 min training sessions, in addition to factsheets that were made available on NMB assessment and feasible balances.
- Training sessions were held with farmers in the Caring Dairy program of Ben & Jerry's (two events; web-based) and in-class training sessions were held with all collaborating crop consulting firms, extension offices and Soil and Water Conservation districts in New York (across the state).
- In New York itself, we were able to complete 18 NMBs in 2017 (Figure 3), plus 40 balances in collaboration with Ben & Jerry's. This year, we expect another 15-20 NMBs in New York, plus ~80 balances for the Ben and Jerry's Caring Dairy Program.
- In collaboration with Agricultural Consulting Service (ACS), we evaluated integration of mass balance assessment with record keeping, which resulted in the NMB being build into their fields and crops record keeping system.
- We collaborate with partners in the Pennsylvania, the New England states and Virginia where NMB assessments are now ongoing as well.

Figure 3. Whole-farm mass balances for New York farms (2016 calendar year data in red).



3. Statewide Trends

- Measuring = improving (Table 2).
- Reduced imports = reduced risk of nutrients loss/accumulation
- Often: reduced imports = increased profit

Table 2: Reductions in total nitrogen and phosphorus imports when comparing 2013 vs 2004.

Nutrient	New York State		Upper Susquehanna Watershed	
	Million lbs	(%)	Million lbs	(%)
Nitrogen	66.0	26	9.5	30
Phosphorus	6.6	19	0.9	20

4. Farmer Feedback

- Farmer and farm advisor impact stories:
 - [Impacts of Cornell's Nutrient Mass Balance Diagnostic Tool: An Industry Perspective.](#)
 - [Nutrient Mass Balance Tool Helps Table Rock Farm Achieve Their Goals.](#)
 - [Table Rock Farm Reaps Many Benefits Through On-Farm Research Partnership.](#)
 - [Spruce Haven Dairy's Managing Member Applies Whole Farm Nutrient Balance Beyond the Farm.](#)
 - [Managing Farm Nutrient Efficiencies: EZ Acres Journey.](#)
 - [Howland Dairy Benefits from Whole Farm Analysis Project.](#)
 - [Cornell's Mass Nutrient Balance is a Valued Monitoring Tool for the Hardie Farm.](#)
 - [Mass Nutrient Balance Project for Small Dairies.](#)

"We included the whole-farm nutrient mass balance in the Caring Dairy program so farmers take a look at their current management. With the results, farmers are more able to determine if they can and should reduce their nutrient balance for improved profitability and stewardship." Caring Dairy Program of Ben & Jerry's

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

Contact Information

Want to know more or conduct a whole farm NMB, shoot us an email!
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