

# Northern New York Agricultural Development Program 2021 Project Report

# Whole Farm Sustainability Assessments: Protecting the Environment and Saving Dollars!

#### Project Leader:

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# **Collaborators:**

- Crop Consultants and Nutrient Management Planners: Mike Contessa and Eric Beaver, Champlain Valley Agronomics, Peru, NY
- Cornell Cooperative Extension: NNY Regional Field Crops Specialists Kitty O'Neil, Ph.D., Mike Hunter
- Miner Institute: President Rick Grant, Research Scientist Laura Klaiber, Forage Agronomist Allen Wilder
- Cornell University Campus: Post-doctoral Research Associate Olivia Godber, Graduate Research Assistant Agustin Olivo, PRO-DAIRY Nutrient Management and Environmental Sustainability Specialist Kirsten Workman
- Northern New York dairy farms (3)

# Background:

Since 2015, dairy farmers who participate in the annual whole farm nutrient mass balance (NMB) assessment for nitrogen (N), phosphorus (P), and potassium (K) receive a farm-specific annual report that shows their farm NMBs per acre and per hundredweight (cwt) of milk produced. In the report, the numbers are compared to all other dairy farms in the assessment (anonymously) and to feasible limits (benchmarks aka "the green box") derived from data supplied by dairy farms across New York (NY), including farms in Northern New York (NNY). Additionally, the report shows trends in N, P and K balances over time for farms that participate for multiple years, and an "opportunity table" that lists key performance indicators (KPIs) for the farm. The information in the report can be used to help idenfity dairy farm management changes to maximize productivity while minimizing the farm's environmental footprint.

A farm's NMB can be derived with information on farm imports and exports, total acres and total milk production. With additional information on crop production (yield per acre and total

acres of crops), we also derive KPIs such as %CP and %P in the diet, feed use efficiency, fertilizer use per acre, percent homegrown forage in the diet, etc. While these KPIs aim to help a farmer identify if opportunities for improvement may be feasible, based on comparisons with peers, it is not always clear where the most profitable and practical opportunities are. In addition, our approach so far only evaluates N, P, and K nutrient use efficiency, while the dairy industry is increasingly being asked to report additional sustainability indicators, including greenhouse gas (GHG) emissions, water use, water quality impacts, animal and plant production efficiencies, animal welfare, and biodiversity on farms. Thus, other KPIs need to be evaluated and user-friendly and effective tools need to be made available.

Currently, multiple tools and software programs are available to carry out sustainability assessments beyond the NMB. There is much overlap between what the available tools can report, but there is no single tool that can be easily and reliably used to report on all aspects of sustainability. Furthermore, several studies have shown that results can differ between tools reporting on the same aspect of sustainability for an individual farm due to differences in the data input requirements and the calculation methods used among tools. This inconsistency is not useful when we search for better ways to identify practical solutions and to report progress made. To evaluate what is useful and what is not, case study analyses with commercial dairy operations in the state are essential.

Our goal with this project was to evaluate a suite of whole farm assessment tools using real farm data and compare outputs in collaboration with three working dairy farms in Northern NY.

# Methods:

Three NNY dairy farms shared farm data needed to run the most relevant/promising sustainability tools, including the NMB, Cool Farm Tool GHG module, COMET-farm, FARM-ES, and the biodiversity modules of Field to Market and Cool Farm Tool. Each farm supplied data. We evaluated what sustainability credentials the tool can report (how comprehensive the tool is), the data input needs (amount and complexity of data as well as possible overlap among tool inputs), and how comparable results are on both an absolute basis (the specific result obtained), and a relative basis (the ranking of farms by the tools). Through what-if scenarios, we identified key drivers of the results from each tool (i.e., crop yields, fertilizer use, feed purchases, herd replacement rate) to help focus on identification of management changes that have a positive impact on the widest range of dairy farm sustainability credentials as possible.

# Results:

# Data Needed and Ease of Use of Software Tools

The NMB assessment is unique as it is the only tool that evaluates whole farm nutrient use efficiency (Table 1). It is a farm-scale, decision support and research assessment tool that is easy to use. It reports based on real farm inputs (accounting system). The two biodiversity modules were very similar in terms of scale (farm), ease of data collection (moderate), application use (decision support/education), and method (index based). The three tools that report GHG emissions vary in scale of assessment, ease of data collection, application and use. All three tools use emission factors but COMET-farm is a more process-based approach. This particular tool is more difficult to use, requiring a large amount of data (individual fields, 20 years of records), and therefore not a tool that farms can implement and run routinely.

	Nutrient Mass Balance (NMB)	Cool Farm Tool Greenhouse Gas module	COMET- Farm	FARM-ES	Field to Market Biodiversity module	Cool Farm Tool Biodiversity module			
Greenhouse gases		1	1	1					
Energy use		1		1					
Nutrient use efficiency									
Economics		1							
Soil carbon		1							
Biodiversity					1	✓			
Scale of assessment	Farm	Farm, Product	Farm	Farm	Farm	Farm			
Ease of data collection	Easy	Easy	Difficult	Easy	Moderate	Moderate			
Application/use	Decision support/ Research	Decision support/ Education	Decision support/ Research	Decision support	Decision support/ Research	Decision support/ Education			
Method	Mathematical calculation	Emission factors	Emission factors/ Process based	Emission factors	Index based	Index based			

Table 1: Characteristics of six tools currently being assessed for their relevance to dairy farm sustainability in the United States.

# Table 2: Whole farm nutrient mass balances for northern New York and other New York farms in 2019, compared to feasible balances set for New York.

		NNY	Other NY	Feasible	
		farms $(n = 36)$	farms $(n = 63)$	balances	
			Balance per acre		
Nitrogen	Median balance (lbs/acre)	132	104	$> 0$ and $\le 105$	
	% of farms meeting feasible limits	31%	49%		
Phosphorus	Median balance (lbs/acre)	10	8	$> 0$ and $\leq 12$	
	% of farms meeting feasible limits	44%	59%		
Potassium	Median balance (lbs/acre)	36	29	$> 0$ and $\leq 37$	
	% of farms meeting feasible limits	24%	44%		
Balance per cwt milk			k		
Nitrogen	Median balance (lbs/cwt milk)	0.92	0.91	$> 0 \text{ and } \le 0.88$	
	% of farms meeting feasible limits	36%	43%		
Phosphorus	Median balance (lbs/cwt milk)	0.08	0.07	$> 0 \text{ and } \le 0.11$	
	% of farms meeting feasible limits	56%	67%		
Potassium	Median balance (lbs/cwt milk)	0.27	0.24	$> 0 \text{ and } \le 0.30$	
	% of farms meeting feasible limits	50%	56%		
Optimal Operational Zone "Green Box"					
Nitrogen	% of farms meeting feasible limits	22%	32%		
Phosphorus	% of farms meeting feasible limits	39%	51%		
Potassium	% of farms meeting feasible limits	31%	40%		

# Whole Farm Evaluations for Participating NNY Farms

In 2019, the median P and K balances per acre and per cwt for the participating farms in NNY were both within the feasible range, while the N balance per acre and per cwt milk exceeded the feasible range by 27 lbs/acre, on average. The red dots in Figure 1 show where the NNY farms operated for each nutrient, compared to the other NY farms in 2019.



Milk production (1000 lbs/acre)

**Figure 1.** Whole farm nutrient mass balances (NMBs) for NNY farms participating in the 2019 assessment for nitrogen (a), phosphorus (b), and potassium (c) are represented by the red dots, compared to all other NY dairy farms participating in 2019 (black dots). The red diamond shows the average (median) balance for the NNY farms in 2019, and the black diamond shows the average balance for all other NY dairy farms participating in 2019. The blue and yellow zones represent the feasible balance zones *per acre* and *per cwt*, respectively. The green area where they overlap is the *optimal operational zone* for NY dairy farms.

Table 3 presents indicators that contribute to the NMB and help predict the risk of exceeding feasible nutrient mass balances. The indicators in Table 3 do not show any major differences between the NNY farms and the other NY farms. For both groups of farms, the average amount of nutrients imported in feed, and N fertilizer imports, exceed the thresholds set to indicate a high risk of exceeding the feasible balances.

indicators to predict high risk of exceeding feasible balances							
		Median NNY	Median other	High risk of			
		farms	NY farms	exceeding the			
Indicator		(n = 36)	(n = 63)	feasible balances if			
Animal density	AU/acre	1.09	0.97	>1.00			
Milk per cow	lbs/cow/acre	23,365	24,940	20,000			
Homegrown feed	% of total feed DM	70 %	71 %	< 65%			
Homegrown forage	% of total feed DM	67 %	69 %	-			
N in purchased feed	lbs N/acre	162	145	> 121			
P in purchased feed	lbs P/acre	21	22	> 20			
K in purchased feed	lbs K/acre	42	37	> 11			
CP in all feed	%	15.6 %	15.1 %	> 17			
P in all feed	%	0.36 %	0.35 %	> 0.40			
Feed use	Tons DM / AU	6.3	6.5	3.5 to 7.5			
N fertilizer imports	lbs N/acre	53	51	> 39			
P fertilizer imports	lbs P/acre	3.6	2.2	> 6			
K fertilizer imports	lbs K/acre	15	14	> 38			
CP in homegrown feed	%	12.0 %	11.8 %	< 11.8			
Overall crop yield	Tons DM/acre	4.7	4.6	-			
% legume acres	%	42 %	39 %	-			
Acres receiving manure	%	85 %	78 %				

# Table 3. Indicators to predict high risk of exceeding feasible nutrient balances.

Work is ongoing to derive the GHG and carbon footprints and biodiversity scores for each of the farms. All farms were visited to share their whole farm NMB results and discuss the GHG emission and biodiversity tools.

In addition to the research, placement of a summer intern, Megan Lamb, with Laura Klaiber and the Miner Agricultural Research Institute this summer, enhanced the student's understanding of dairy sustainability and environmental footprinting. Her experience as an intern was featured by the College of Agriculture: <u>https://cals.cornell.edu/news/2021/12/megan-lamb-22-reflections-next-generation-ag-educators</u>.

#### Conclusions/Outcomes/Impacts:

Farms engaged in the project contributed relevant scenarios for "what-if" evaluations of six evaluation tools. Analysis of the use of these tools to produce farm-level NMBs show drivers for balances for N and P and possible opportunities to reallocate nutrients for greater nutrient use efficiency. Assessments of GHG footprints and biodiversity indices is ongoing.

#### Outreach:

#### New agronomy factsheet:

 Fact Sheet #120: Farm Greenhouse Gas (GHG) Inventory has been developed to describe the main sources of GHGs from a dairy farm's activities, what carbon sequestration is, and tools being developed to measure GHG footprints for dairy so farms can work to reduce GHGs in the atmosphere. Once final review is completed, this factsheet will post to the NMSP Dairy Sustainability Key Performance Indicators project website: <u>http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/DairySustainabilityIndicators.</u> <u>html</u> and Agronomy Factsheet page: <u>http://nmsp.cals.cornell.edu/guidelines/factsheets.html</u>.

#### Student Impact Story:

<u>https://cals.cornell.edu/news/2021/12/megan-lamb-22-reflections-next-generation-ag-educators</u>

#### **Extension** Article:

• Godber, O.F., Czymmek, K.J. (2021). <u>Greenhouse Gas Footprint Tools On Farms</u>. Progressive Dairy. PRO-DAIRY's The Manager.

#### Software Tools Being Evaluated:

- Whole-farm nutrient mass balance (NMB) http://nmsp.cals.cornell.edu/software/Cornell\_NMB\_1.0.exe)
- Cool Farm Tool (<u>https://app.coolfarmtool.org/</u>)
- COMET-Farm (<u>http://comet-farm.com/</u>)
- FARM-ES (<u>https://nationaldairyfarm.com/dairy-farm-standards/environmental-stewardship/</u>)

# • Field to Market (<u>https://calculator.fieldtomarket.org/</u>)

#### Extension Talks to Date (Virtual/Hybrid; Statewide)

- Ketterings, Q.M. and O.F. Godber (2021). Managing Dairy Footprints: Whole Farm Nutrient and Carbon Balances in Action. Cornell Nutrition Conference 2021. East Syracuse, NY. October 20, 2021.
- Czymmek, K.J, and Q.M. Ketterings (2021). Environmental Update: Where Are We Heading? NEDPA Operations Manager Conference 2021. Virtual. February 4, 2021.

#### Next Steps:

We continue the work with the three NNY dairy farms, their staff and advisors to assess the tools in Table 1 for both the 2020 and 2021 calendar year. We aim to identify the key drivers of the results from each tool (i.e., crop yields, fertilizer use, feed purchases, herd replacement rate) and develop recommendations for use of tools or specific KPIs that can be utilized by farmers to obtain a most robust and comprehensive sustainability assessment with data readily available to them, and to accurately monitor impact of management changes on progress over time.

#### Acknowledgments:

We thank the Northern New York farmers participating in the project for sharing data and providing valuable feedback on findings and scenarios to evaluate.

#### For More Information:

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#### Photos:

Photo 1: Dairy sustainability indicators resulting from data collection with NNY dairy farms for the NNYADP-funded Whole Farm Sustainability Assessments 2021 project were presented and discussed with project collaborators Mike Contessa of Champlain Valley Agronomics and Laura Klaiber of the Miner Institute at Chazy, NY. Photo: Quirine Ketterings.



Photo 2: Summer interns and NMSP staff members visited Miner Institute to learn about dairy farm sustainability, hosted by Miner Institute President Rick Grant (3<sup>rd</sup> from right), Research Scientist Laura Klaiber, Forage Agronomist Allen Wilder and the project's summer intern Megan Lamb, as part of the NNYADP-funded Whole Farm Sustainability Assessments 2021 project. Photo: Quirine Ketterings.



Photo 3: Megan Lamb, a Cornell University Agricultural Sciences major, participated in the NNYADP-funded Whole Farm Sustainability Assessments 2021 project as a summer intern with Miner Institute and the Cornell Nutrient Management Spear Program. Above, she presents on her work on dairy sustainability and water quality at the Miner Institute in summer 2021. Photo: Quirine Ketterings.