The Role of Livestock in Circular Agricultural Systems

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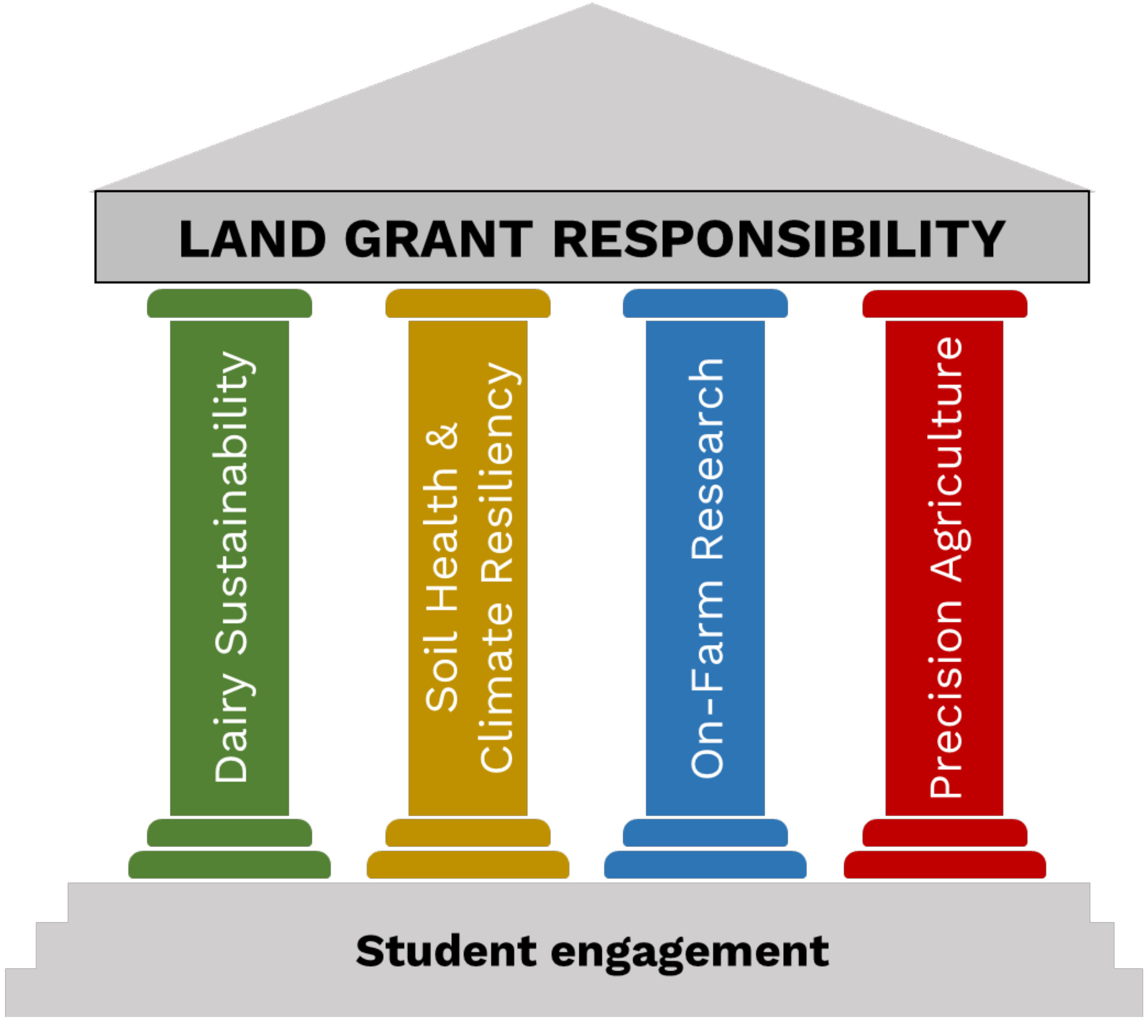
Outline

- Who is NMSP and what do we do?
- What is Circular Agriculture?
- How circular is NY agriculture?
- The need for sustainability tools
    - State level
    - Farm level
- Whole-farm nutrient mass balance: example of a successful tool
- How to participate in the whole-farm nutrient mass balance

Nutrient Management Spear Program



Nutrient Management Spear Program

Our approach in the Dairy Sustainability project

The NMSP works **directly** with farmers across New York (NY) to determine sustainability Key Performance Indicators (KPIs) that allow farms to **compare to others** and to **monitor performance over time**.

Whole-farm scale analysis

- **NUTRIENT BALANCES (N, P, K)**
- **GHG EMISSIONS**
- **BIODIVERSITY**
- **ECONOMICS**

Environmental & economic impact

Ultimately, we want to identify KPIs that help farmers minimize nutrient loss and GHG emissions, enhance biodiversity, and **ensure economic success**.

The circular economy

Three principles:

1. Eliminating waste and pollution
2. Circulating products and materials
3. Regenerating nature

NY dairy industry: 2022

Other industries:

- Forage (for dairy)
- Cash grain
- Fruit
- Vegetables
- Ranked in top 5 states for snap beans, apples, cabbage, grapes, squash, cherries, blueberries

5th for milk production in the US

> 3,500 dairy farms

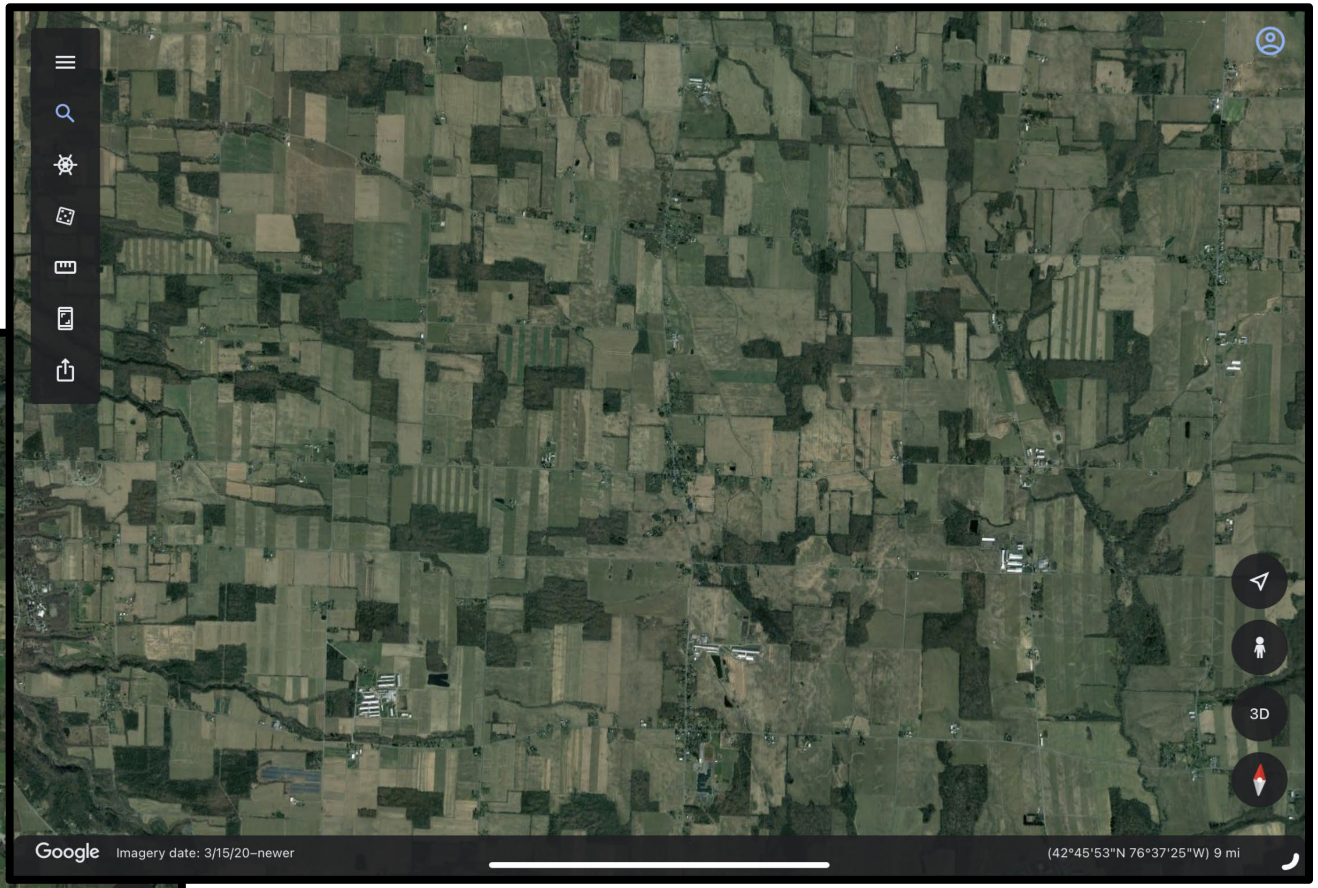
> 0.6 million milk cows (6.7% of US total)

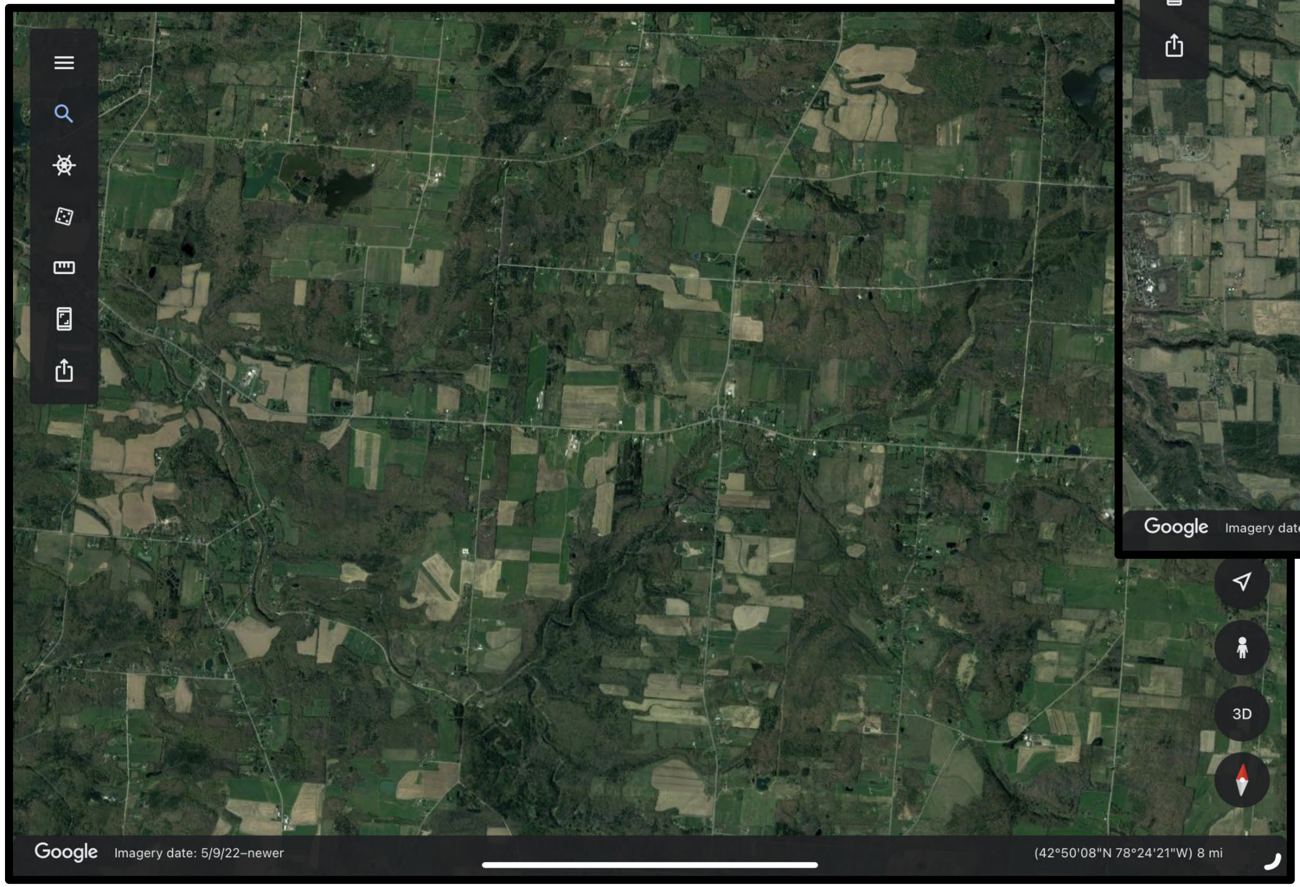
15.7 billion lb milk (6.9% of US total)

> $4 billion

Source: USDA National Agricultural Statistics Service

New York has an integrated crop- livestock system





>70% of feed is homegrown on NY dairy farms (forage)

Source: Ros et al. (2023)

The circular economy

Three principles:

1. Eliminating waste and pollution
2. Circulating products and materials
3. Regenerating nature

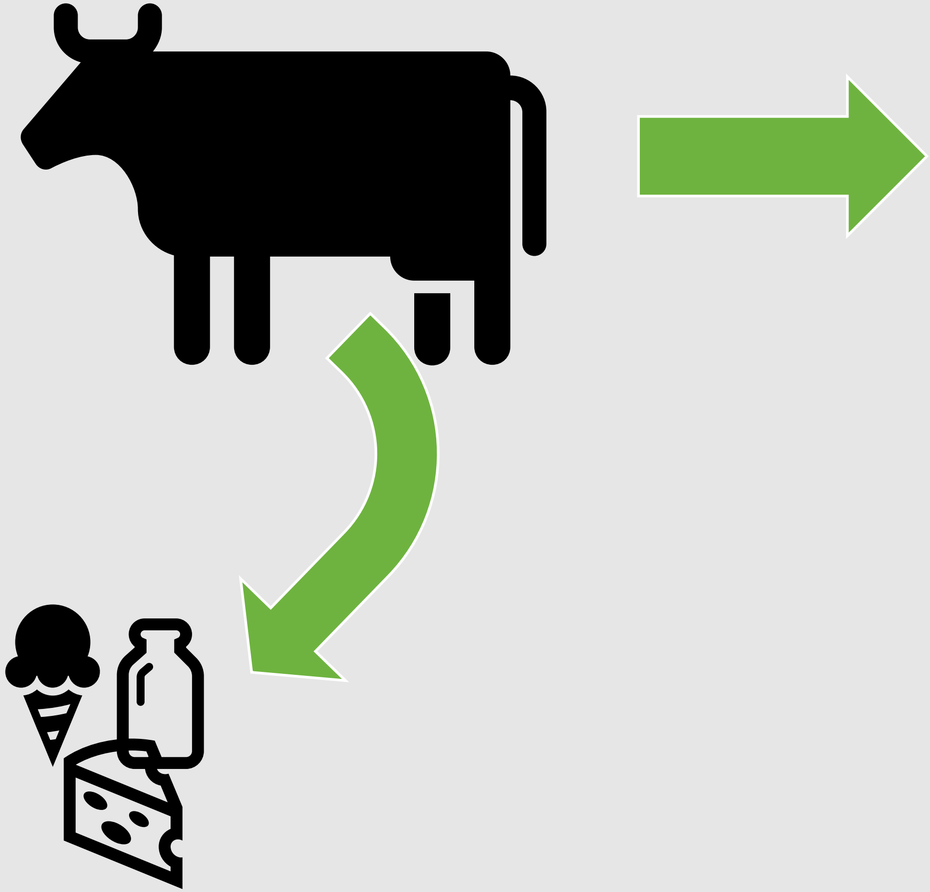
Circular economy for New York agriculture

- New York has an integrated crop-livestock system
- Large land base means relatively low animal densities
  - 0.49 AU per acre at the state level
- Ability to responsibly recycle nutrients in manure
- Low reliance on synthetic fertilizer:
  - 4.0 lb P / acre
  - 60 lb N / acre

Source: USDA National Agricultural Statistics Service; Ros et al. (2023)

Implications of dairy

Watersheds:
- Upper Susquehanna and Chesapeake Bay
- Lake Erie
- Lake Ontario
- Lake Champlain



Manure:

Benefits, **opportunities** and **challenges** for attaining a climate resilient, environmentally and economically sustainable agriculture

Essential nutrients
Organic matter

Nutrient balances

- Allow us to monitor nutrient use and assess the efficiency of agricultural nutrient management:
  - Summarize nutrient flows
  - Identify imbalances at various scales
  - Identify areas of opportunity for improvement
  - Indicate impact of nutrient management policy, guidelines, and extension education

Nutrient balances

- Optimize cycling of nutrients for economic crop production, and environmental protection – focus on **nitrogen (N)** and **phosphorus (P)**
  - Excess N can impact air and water quality, ecosystem stability and contributes to greenhouse gas emissions
  - Excess P can contribute to impairment and degradation of rivers and lakes

Why state-level assessments?

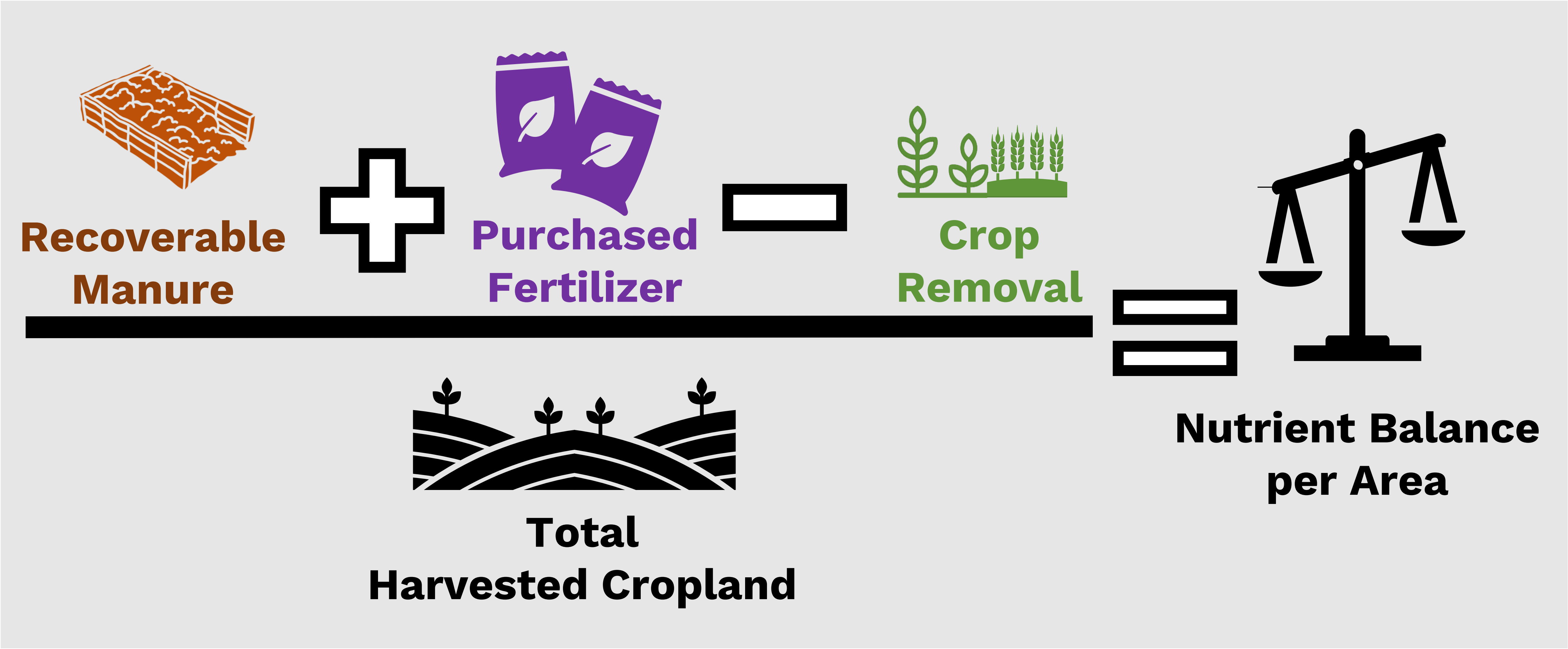
States need to measure, monitor and report nutrient status:

1. Chesapeake Bay model
2. Regional and local authorities

Other additional benefits:

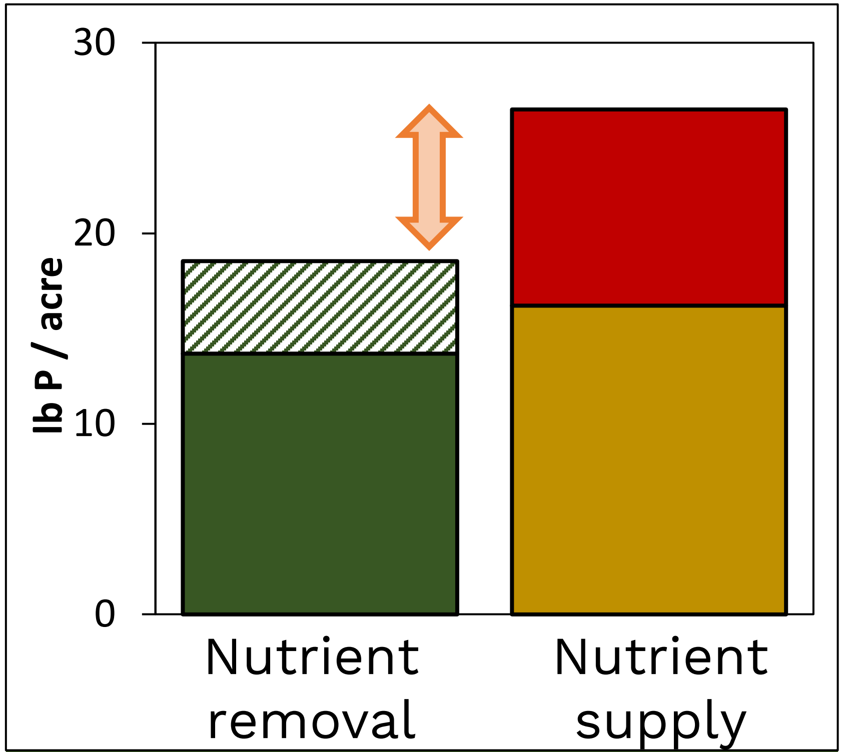
1. Have a tool to guide improvements
2. Demonstrate good practice

State balances for circularity in New York

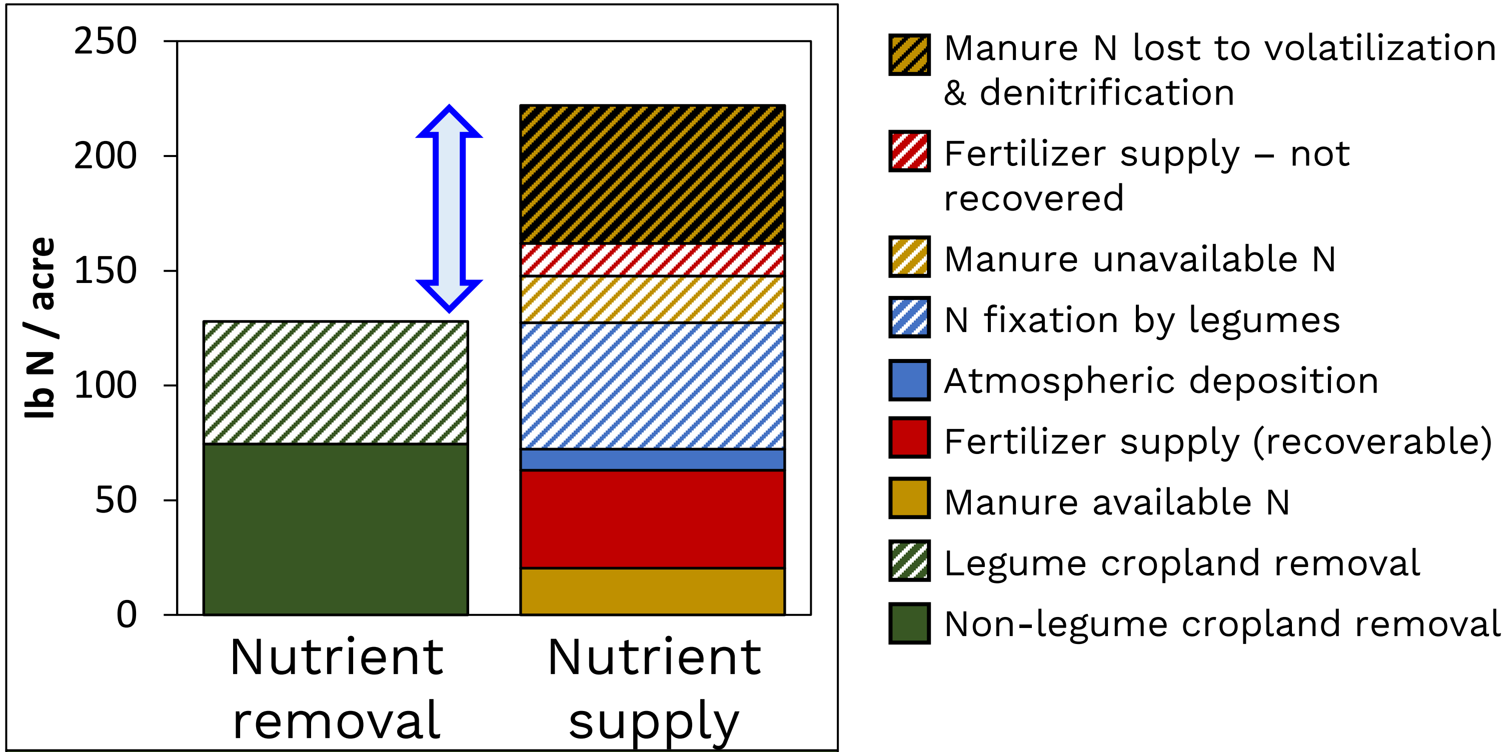


New York state N and P balances

New York has a manure deficit at the state level



NY state P balance = 9 lb P / acre



NY state N balance = 33 – 80 lb N / acre

Why farm level sustainability tools?

Farms need to be able to measure, monitor and report:

1. Know their status
2. Have a tool to guide improvements
3. Increase farm efficiency
4. Demonstrate good practices on their farm

Increasing pressure from stakeholders to report sustainability metrics and meet targets:

Policy, processors, retailers,

consumers...

Market competition!

Why are whole-farm tools important?

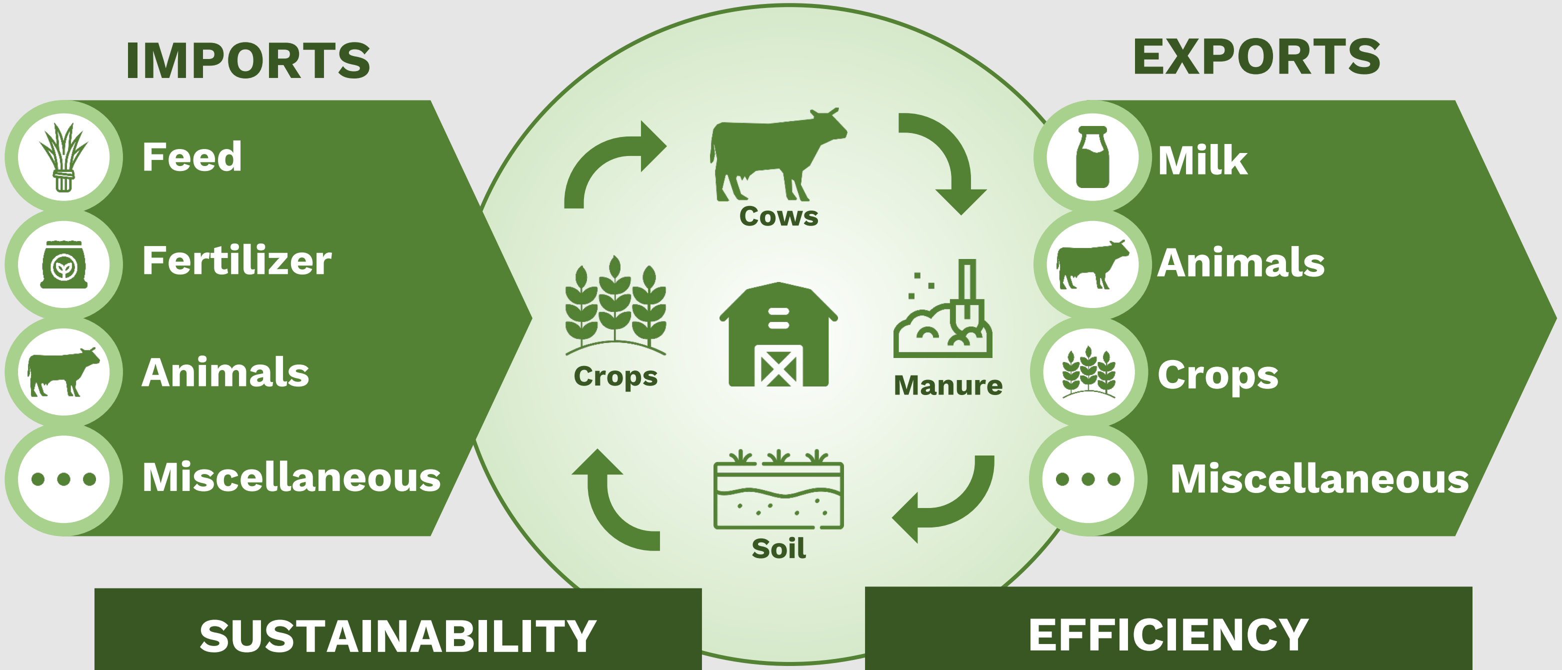
- We need a tool that looks at the big picture but has the ability to identify areas to focus on for individual farms
- Farms can then use more specific tools or process-based models ***if*** more detail is required
- New York dairy farms are integrated crop-livestock systems
    - 70% of feed is homegrown
    - We should not consider one area without the other

Criteria for successful sustainability tools

- Minimum input with maximum output
- Gives a measure of sustainability across management units:
  E.g. cows, storage, crops, soil
- Transparent calculations and easy to interpret results
- Sets feasible targets to strive for
- Responsive to management change
- Can be used to document improvement over time
- Takes little time to calculate
- Can be easily updated as new information becomes available
- Trusted among dairy stakeholders – farmers, processors, retailers, consumers, policy makers

Whole-farm nutrient mass balance (NMB) as an example tool

The NMB is the difference between the amounts of nitrogen (N), phosphorus (P), and potassium (K) exported versus imported, at the **whole-farm** level



SUSTAINABILITY

Balance per acre =

$$\frac{Imports - Exports}{total\ tillable\ acre}$$

EFFICIENCY

Balance per cwt milk =

$$\frac{Imports - Exports}{total\ cwt\ milk}$$

Whole-farm NMB development over time

- **Step 1**: Basic accounting approach
- **Step 2**: Set the feasible balances
- **Step 3**: Development of the Green Box
- **Step 4**: Development of the Opportunity table
- **Step 5**: Reassess feasible balances and thresholds
- **Step 6**: Replicate for other sustainability metrics *(ongoing)*
- **Step 7**: Link sustainability metrics *(ongoing)*

Whole-farm NMB development over time
Step 1: Basic accounting approach

Allowed farms to know their N, P and K balances

But:

- Initial participants (before 2014) received a page with numbers
- Results could not be put into context
- Drivers of balances were not easily detectable
- Difficult to know if balances needed to be improved, and how to identify what needed improvement
- *But thanks to sharing of data…we could go a step further*

Whole-farm NMB development over time

Step 2: Set the feasible balances

	Lbs nutrient per acre	Lbs of nutrient per cwt milk
Nitrogen	> 0 and ≤ 105	> 0 and ≤ 0.88
Phosphorus	> 0 and ≤ 12	> 0 and ≤ 0.11
Potassium	> 0 and ≤ 37	> 0 and ≤ 0.30

- Based on:
  - Data from 102 dairy farms
  - Long-term records from farms
  - Carrying capacity calculations
  - Farmer agreement on feasibility

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Characterization of nitrogen, phosphorus, and potassium mass balances of dairy farms in New York State

Sebastian Cela, Quirine M. Ketterings,[1] Karl Czymmek, Melanie Soberon, and Caroline Rasmussen
Department of Animal Science, Cornell University, Ithaca, NY 14853

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Long-term trends of nitrogen and phosphorus mass balances on New York State dairy farms

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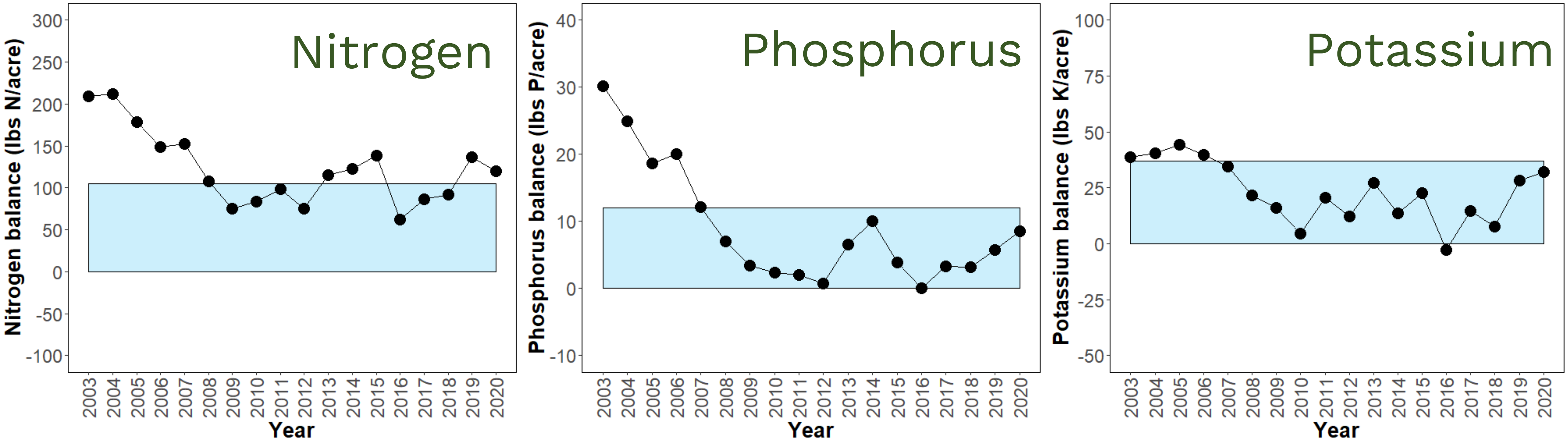
Department of Animal Science, Cornell University, Ithaca, NY 14853

Farms could put their results into context and track progress

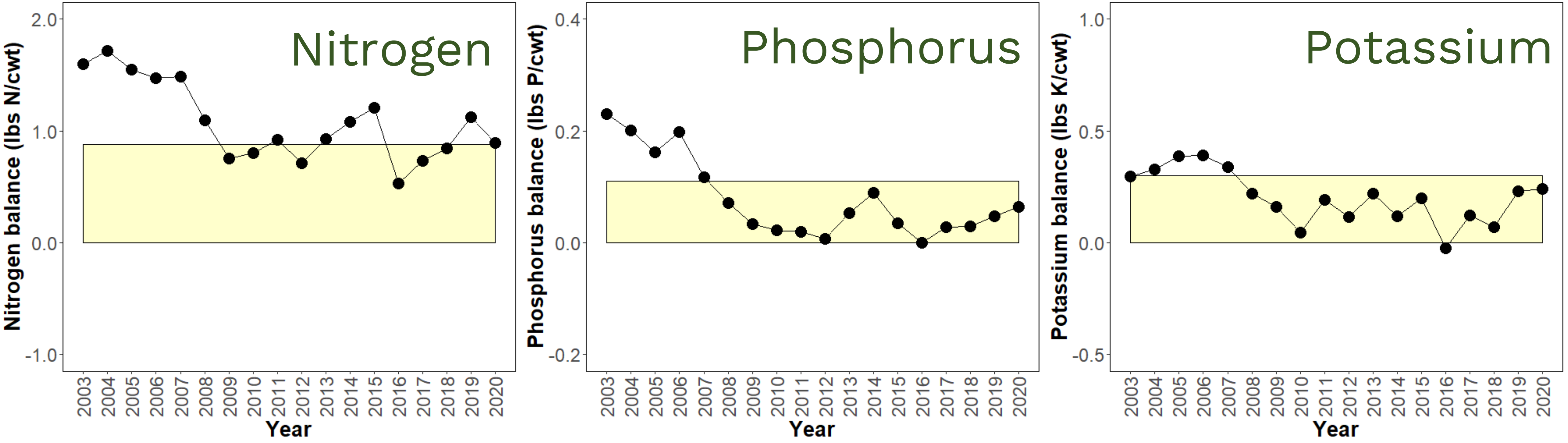
Whole-farm NMB development over time
Step 2: Set the feasible balances

Track trends and progress over time on a per acre basis



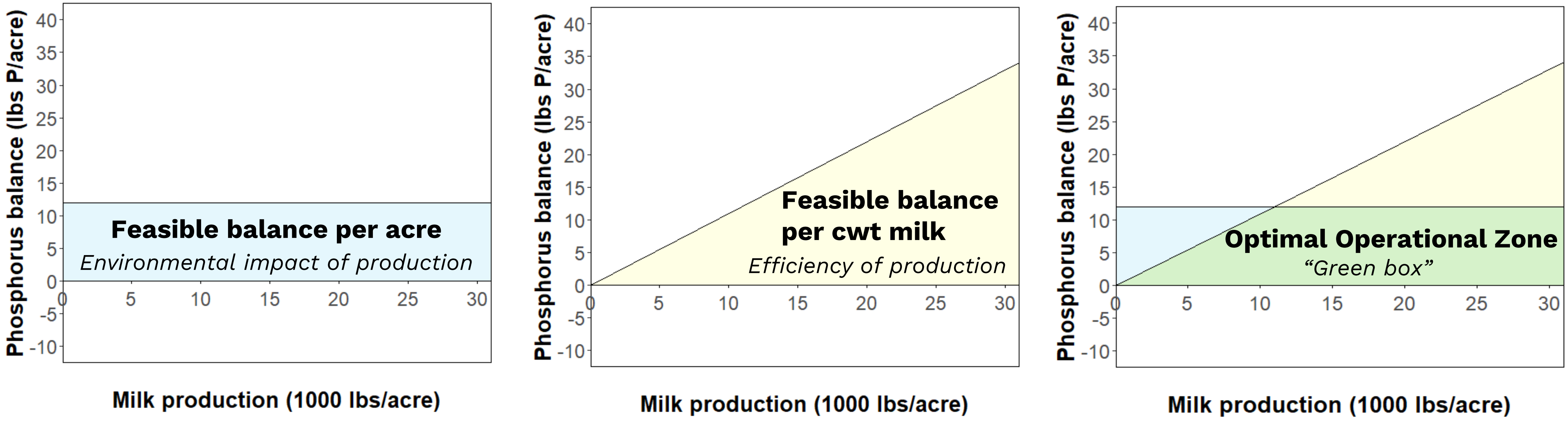
Whole-farm NMB development over time
Step 2: Set the feasible balances

Track trends and progress over time on a per cwt milk basis



Whole-farm NMB development over time
Step 3: Development of the "Green Box"

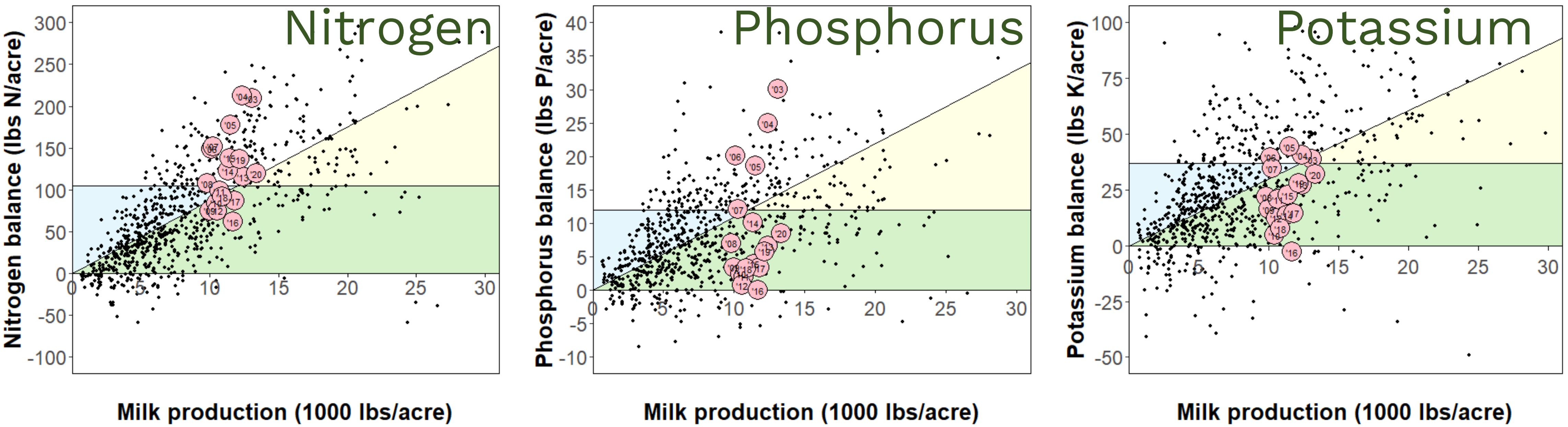
Easier way to communicate results



Whole-farm NMB development over time

Step 3: Development of the "Green Box"

Allowed farms to compare themselves to peers



Whole-farm NMB development over time
Step 4: The opportunity table

Provides farm specific indicators to predict high risk of exceeding feasible balances

	Indicator to predict likelihood of exceeding feasible balances	Example Farm 2022			High risk of exceeding the feasible balances if		
		N	P	K	N	P	K
1	Balance per ha (lb/ac)	192	17	81	> 105	> 12	> 37
2	Balance per Mg milk (lb/cwt milk)	0.74	0.08	0.34	> 0.88	> 0.11	> 0.30
3	Milk per cow (lb/cow/year)		26,815		-	< 20,000*	-
4	Animal density (animal units/ac)		1.29		-	> 1.00	-
5	Whole-farm nutrient use efficiency (%)	60	78	66	< 44	< 51	< 39
6	Purchased feed (lb/ac)	286	40	77	> 121	> 20	> 38
7	Feed (Ton dry matter/animal unit)		6.5		-	3.5 to 7.5	-
8	Feed use efficiency (milk, %)	26	31	15	< 20	< 25	< 11
9	Homegrown feed (% dry matter)		62		-	< 65	-
10	Homegrown forage (%)		62		-	-	-
11	Homegrown grain (%)	0	0	0	-	-	-
12	Homegrown nutrients (% dry matter)	43	45	71	< 50	< 50	-
13	Crude protein (CP) and P in all feed (%)	16	0.36	1.30	> 17	> 0.40	-
14	CP and P in purchased feed (%)	23	0.52	1.01	> 30	> 0.60	-
15	CP in homegrown feed (%)	10.7			< 11.8	-	-
16	Fertilizer (lb/ac)	81	9	67	> 39	> 6	> 38
17	Crop exports (lb/ac)	3	0	3	-	-	-
18	Manure exports (lb/ac)	29	6	17	-	-	-
19	Overall crop yield (Ton dry matter/ac)		4.6		-	-	-
20	Acres receiving manure (%)		62		-	-	-

* Based on Holstein cows

Key Sustainability Indicators (KPIs):

- **Feed** & **fertilizer** imports are the biggest drivers of NMBs
- **Animal density** is a key driver

Whole-farm NMB development over time
Step 5: Reassess feasible balances

Continue tool development as the dairy industry progresses

- What is the current status of New York dairy NMBs?
- Are feasible thresholds still applicable?
- Can new KPIs be identified for inclusion in the opportunity table?
- How are new management practices impacting NMBs?
  - Higher animal densities
  - New manure management practices
  - Improvements to dairy diet formulation

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Key nitrogen and phosphorus performance indicators derived from farm-gate mass balances on dairies

Mart B. H. Ros,* Olivia F. Godber, Agustin J. Olivo, Kristan F. Reed, and Quirine M. Ketterings†
Department of Animal Science, Cornell University, Ithaca, NY 14853

Whole-farm NMB development over time

- **Step 1**: Basic accounting approach ☑
- **Step 2**: Set the feasible balances ☑
- **Step 3**: Development of Green Box ☑
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- **Step 7**: Link sustainability metrics *(ongoing)*

Whole-farm NMB development over time
Step 6: replicate for other metrics

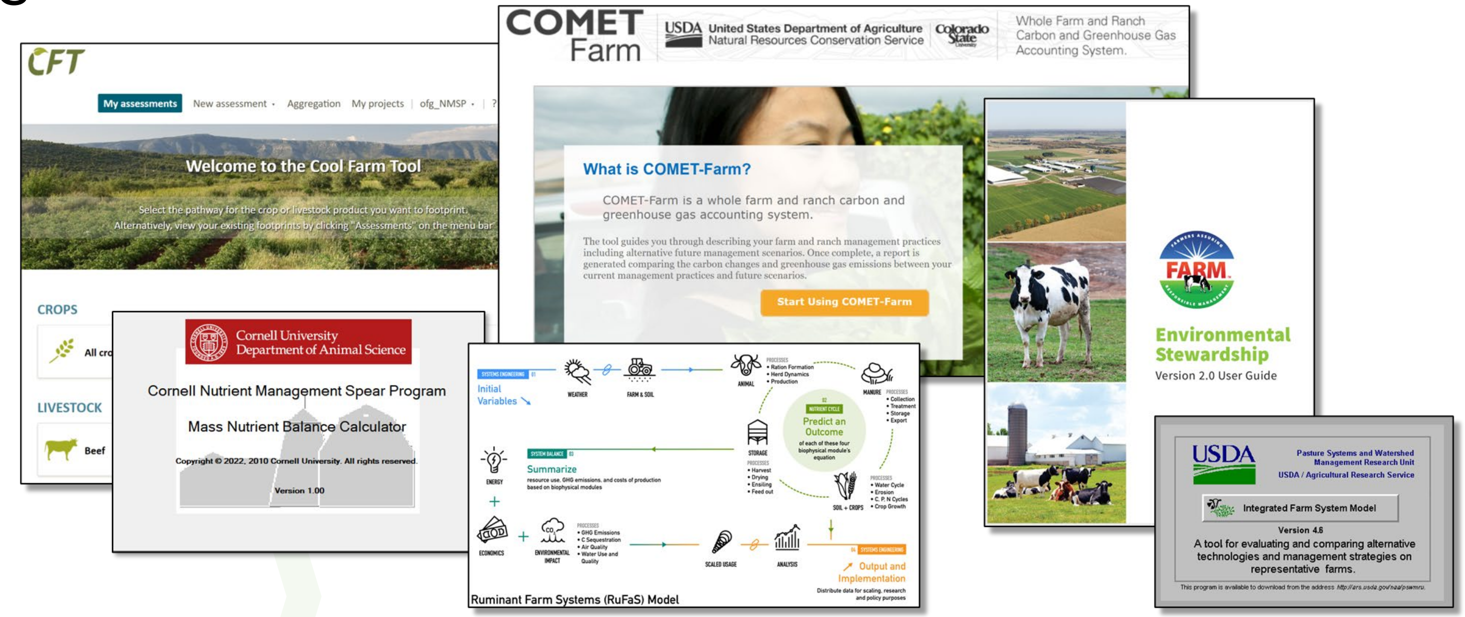
More tools needed

Focus:

- Greenhouse gas emissions
- Biodiversity

Questions:

- Can we streamline data collection?
- Can we identify common KPIs?



Sustainability tools as a marketing tool

Marketing data to
promote, drive and support sustainability

Sustainability tools can help farmers to measure, monitor and market their sustainability if they are carefully designed

Known benefits:

- Environmental protection and enhancement
- On-farm efficiency
- Decision support

Additional benefits?

- Market advantage?
- Informing consumers?
- Guiding policy?

To achieve this, tools need to be trusted among dairy stakeholders: farmers, processors, retailers, consumers, regulators

Do you want to know your farm's NMB?

Submit your data!

Submit your data to us on the data entry sheet available at https://www.nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/massbalance/NMBinputform2022.pdf

You will receive:

- An individual report for your farm's N, P and K mass balance
- A comparison to other NY dairy farms
- An opportunity table to identify areas for potential improvement

Help grow the database and show the true performance of your farm!

Thank you!

This work is not possible without the invaluable data and feedback provided by NY dairy farms and the support of their nutrient management planners and nutritionists.

We want to grow this initiative!

Let's find a way to make it beneficial for all of us!

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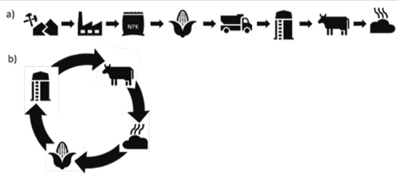
Northeast dairy and the circular economy

Olivia Godber, Kirsten Workman, and Quirine Ketterings

It is well-established that the dairy sector provides essential livelihoods and vital nutrition to billions of people, and that the dairy sector is dedicated to addressing sustainability challenges. Current conversations about dairy sustainability include terms like circularity, regenerative agriculture, and carbon footprint. What is that all about?

FIGURE 1
An example of a linear economy (a) versus a circular economy (b) within an agricultural system.



WHAT IS A CIRCULAR ECONOMY?

Traditionally economies are linear, starting with raw materials that are made into products that are used and eventually become part of a waste stream. In a circular economy, one looks at the bigger picture, takes into account the whole system, and tries to form a closed loop, keeping materials, products, and services in circulation for as long possible. A circular economy is based on three main principles: to eliminate waste and pollution, to circulate products and materials, and to regenerate nature. This concept strives to reduce environmental impact, while improving financial and social aspects of production, including agricultural production.

One illustration of a linear versus circular economy within an agricultural system is the application of nutrients. A linear example is applying fertilizers mined from the earth or manufactured through industrial processes to crops that feed animals and produce manure that is not recycled back onto the cropland. In comparison, use of livestock manure to fertilize crops that are fed to livestock and produce more manure to apply to cropland and continue the cycle are a circular economy. **(FIGURE 1)**

Dairy farms can have various degrees of circularity, often influenced by their location and availability of local resources, including manure, land for feed production, climate, water availability, contractors, and equipment. Farm management and decisions on how to use these resources can also greatly influence the degree of circularity on a dairy farm.

SUSTAINABILITY BENEFITS OF A CIRCULAR ECONOMY

Circular economies are strongly encouraged in all industries because of their sustainability benefits. A circular economy can help lower greenhouse gas (GHG) emissions through shorter supply chains, reduced transport needs for inputs and waste materials, reduced processing needs and use of energy, fuel and other raw material, and reduced use of end-life of products.

In dairy systems, many of the beneficial and protective management practices adopted by farmers already reflect principles of a circular economy and improved sustainability. This includes practices such as use of cover crops and subsequent reductions in nitrogen fertilizer use, injection of manure to capture more of its nutrients, and reducing tillage intensity to protect soil and soil carbon. Positive results of these efforts are seen in water quality, soil carbon sequestration, and overall resilience of the agriculture system and nature. Further, good management of feed storage on farm to avoid waste through spoilage and feed refusals, and animal husbandry practices that promote good animal health and welfare to reduce the need for veterinary inputs, milk disposal and animal culls, all follow the principles of a circular economy.

Continued on back

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