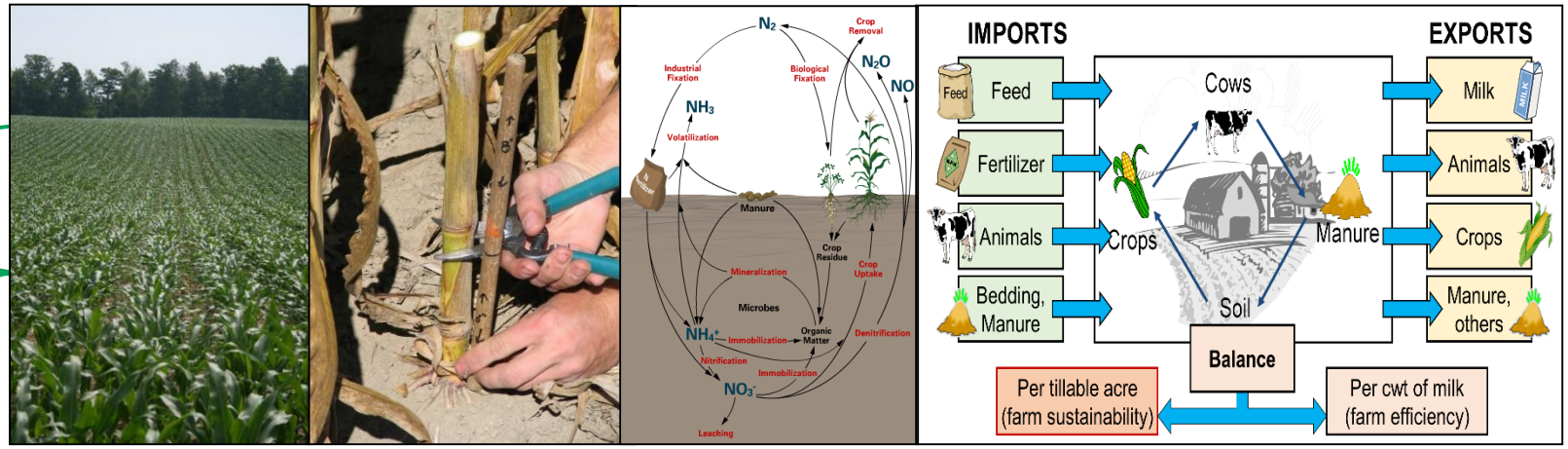
Nutrient Management Spear Program

Mission and Project Update



Quirine Ketterings and Karl Czymmek

Nutrient Management Spear Program and PRODAIRY

Department of Animal Science, Cornell University

Outline

- Nutrient Management Spear Program
  - Focus and mission
  - Advisory committees
- Adaptive Management
- Whole Farm Mass Balances
- New York Phosphorus Index 2.0

Nutrient Management Spear Program (NMSP)

Overall Goal

Enhance farm productivity while protecting the environment for long-term sustainability of agriculture in New York

(http://nmsp.cals.cornell.edu)

A collaboration among Animal Science, PRODAIRY, Cornell Cooperative Extension, many stakeholders

Cornell University
Cooperative Extension

Decision Agriculture **#4**

NMSP Yield Monitor Data Cleaning Project Improves Information for Farmers and Researchers

By Lisa Fields

In recent years, advances in yield monitor technology have increased the availability of crop yield data for both farm managers and researchers. An exciting project is improving the usefulness of these data by evaluation through a data cleaning process. Initiated in 2017, "Forage Yield Monitor Data Processing for Accurate Maps," is led by Professor Quirine Ketterings, Director of Cornell Nutrient Management Spear Program (NMSP). She elaborated, "We know that variations in field topography, drainage, and equipment operation can cause data errors that skew yield estimates from harvest equipment. To be able to use yield monitor data for crop and nutrient management on-farm research we needed a standardized protocol for cleaning raw yield monitor data. At the farm level, proper data cleaning is essential, as accuracy of yield data plays a big role in crop management decisions that can affect the farm's bottom line."

Rick Bair of Selden Stokoe and Sons Farm invested time into learning to use Yield Editor to improve yield data quality (photo credits: Kevin Keenan).

The Forage Yield Monitor Data Processing project is funded by the Northern New York Agricultural Development Program (NNYADP), Federal Formula Funds and a multi-state USDA-NIFA grant that aims to use advanced statistical methods to analyze data from on-farm strip trials. The project is in collaboration with counterparts at the University of Missouri and the Iowa Soybean Association. The cleaning protocol utilizes Yield Editor software to identify errors in yield monitor datasets so they can be removed from yield calculations. The software is available free of charge through the website of the USDA-ARS.

Ketterings noted, "In late 2016 we connected with Yield Editor's IT specialist, Scott Drummond of USDA-ARS to become familiar with the software and see if we could use it to standardize cleaning of corn silage data as well as corn grain data. We were successful in applying Yield Editor to corn silage data so we developed the standardized cleaning protocol based on the software."

The Yield Monitor Data processing project is integrated with another NNYADP funded initiative, "Re-Evaluating Yield Potential of Corn Grain and Silage in Northern NY." Its purpose is to update the database for corn grain yield potentials of soils, to develop an independent database for corn silage yield potentials, and to evaluate corn nitrogen management guidelines based on yield levels. It is really important that data that are shared are properly cleaned as trustworthy yield data from farmers' fields are essential for this project. Supporting farmers and farm consultants who wish to use Yield Editor is an important part of our work."

At the 2018 Corn Congress, Selden Stokoe and Sons Farm employee Rick Bair connected with the NMSP project. "We grow about 4,000 acres of commodity grain crops. Applying Yield Editor seemed to be a really good fit for my skills," he said. Bair's former career was Technical Sales and Business Development support in the corporate world of data management. He explained, "I was recruited to the farm because of my background. The speed at which data-generating technology was changing was beyond the time the guys could spend to keep up with it and make good use of the information. The desktop data

Ultimate Goal: Impact

- Development and implementation of beneficial management practices at field and farm levels
- Engage farmers in on-farm research
- Train students in multi-disciplinary projects including research, extension and teaching
- Contribute to agriculture and environmental management policy

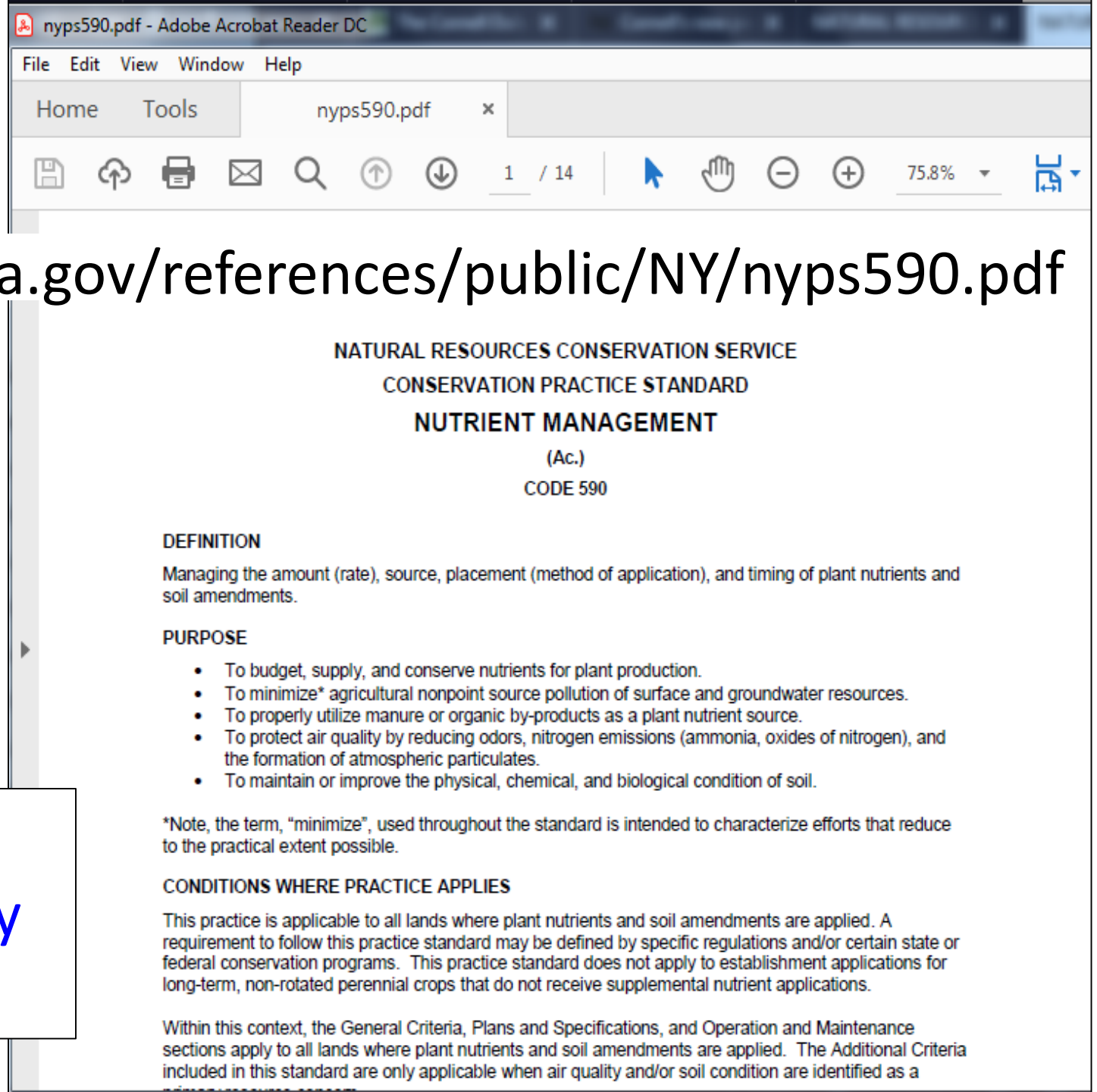
Little History…

- The NRCS 590 Nutrient Management Standard refers to Land Grant University guidelines (Cornell University)
  - Fertility management (N, P, K, soil pH)
  - Field-based risk assessment tools for nitrogen leaching and phosphorus runoff (NY-PI)
  - Manure management decisions (timing, rate, method)
  - Etc.

NRCS590 for NY

https://efotg.sc.egov.usda.gov/references/public/NY/nyps590.pdf

References
Cornell University
47 times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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT

(Ac.)

CODE 590

DEFINITION

Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments.

PURPOSE

- To budget, supply, and conserve nutrients for plant production.
- To minimize* agricultural nonpoint source pollution of surface and groundwater resources.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical, and biological condition of soil.

*Note, the term, "minimize", used throughout the standard is intended to characterize efforts that reduce to the practical extent possible.

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to all lands where plant nutrients and soil amendments are applied. A requirement to follow this practice standard may be defined by specific regulations and/or certain state or federal conservation programs. This practice standard does not apply to establishment applications for long-term, non-rotated perennial crops that do not receive supplemental nutrient applications.

Within this context, the General Criteria, Plans and Specifications, and Operation and Maintenance sections apply to all lands where plant nutrients and soil amendments are applied. The Additional Criteria included in this standard are only applicable when air quality and/or soil condition are identified as a

http://nmsp.cals.cornell.edu

Cornell University
Nutrient Management Spear Program

SEARCH: go
NMSP Cornell more options

Home | About Us | Research | Guidelines | Publications | Software | Events | Contacts | Links

The vision of the Cornell University's Nutrient Management Spear Program is to assess current knowledge, identify research and educational needs, conduct applied, field and laboratory-based research, facilitate technology and knowledge transfer, and aid in the on-farm implementation of beneficial strategies for field crop nutrient management, including timely application of organic and inorganic nutrient sources to improve profitability and competitiveness of New York State farms while protecting the environment. For more information about our program activities see our most recent NMSP Program Report.

News RSS

- 9/18/2919: New Journal Publication: Double-cropping with forage sorghum and forage triticale in New York. See Journal Article Page.
- 9/5/2919: New Journal Publication: In-field spatial variability of corn stalk nitrate test results. See Journal Article Page.
- 9/5/2919: New Journal Publication: Combining spatial and temporal corn silage yield variability for management zone development. See Journal Article Page.

Featured Links

- New York On-Farm Research Partnership
- Cornell Nutrient Guidelines for Field Crops
- Agronomy Factsheets
- Impact Statements
- Nutrient Management Tutorials

Featured Articles

- Processing/Cleaning Corn Silage and Grain Yield Monitor Data for Standardized Yield

Photo Gallery

Cornell University
Nutrient Management Spear Program

Home | About Us | Research | Guidelines | Publications | Software | Events | Contacts | Links

Guidelines
Agronomy Fact Sheets
Crop Nutrient Guidelines
Impact Statements

Cornell University Field Crops Nutrient Guidelines

Most of these articles are in pdf format and can be accessed using Adobe's Reader. Adobe Reader is free and is available for download.

Disclaimer

This is the official Cornell University College of Agriculture and Life Sciences website for fertility and nutrient management guidelines for field crops. The guidance presented in these documents reflects the current (and past) author's best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in these documents does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

Nutrient Guidelines for Vegetables
Guidelines for Nitrogen Management of 4-5 Cut Intensively Managed Grasses
Adaptive Management Guidelines for 2018
Guideline for Land Application of Acid Whey
Revised Winter and Wet Weather Manure Spreading Guidelines to Reduce Water Contamination Risk
Manure Management Guidelines for Limestone Bedrock/Karst Areas of Genesee County, New York: Practices for Risk Reduction
Manure Use for Alfalfa-Grass Production
Lime Guidelines for Field Crops in New York Ketterings, Q.M., W.S. Reid, and K.J. Czymmek (2006). Lime guidelines for field crops in New York. First Release. Department of Crop and Soil Sciences Extension Series E06-2. 35 pages.
Manure and Groundwater Protection Guidelines
Nitrogen Guidelines for Field Crops in New York Ketterings, Q.M., S.D. Klausner, and K.J. Czymmek (2003). Nitrogen guidelines for field crops in New York. CSS Extension Series E03-16. Cornell University, Department of Crop and Soil Sciences, Ithaca NY. 70 pp.
Phosphorus Guidelines for Field Crops in New York Ketterings, Q.M., K.J. Czymmek, and S.D. Klausner (2003). Phosphorus guidelines for field crops in New York. CSS Extension Series E03-15. Cornell University, Department of Crop and Soil Sciences, Ithaca NY. 35 pp.
Potassium Guidelines for Field Crops in New York Ketterings, Q.M., S.D. Klausner, and K.J. Czymmek (2003). Potassium guidelines for field crops in New York. CSS Extension Series E03-14. Cornell University, Department of Crop and Soil Sciences, Ithaca NY. 41 pp.
The New York Phosphorus Index User's Guide and Documentation Czymmek, K.J., Q.M. Ketterings, L.D. Geohring, and G.L. Albrecht (2003). The New York Phosphorus Index. User's guide and documentation. CSS Extension Bulletin E03-13. 64 pp.
The New York Nitrate Leaching Index Czymmek, K., Q.M. Ketterings, H. van Es and S. DeGloria (2003). The New York Nitrate Leaching Index. CSS Extension Publication E03-2. 34 pages.

For Further Information:

Information on field crops fertility guidelines can be obtained from Quirine Ketterings (qmk2@cornell.edu or 607-255-3061) or Karl Czymmek (kjc12@cornell.edu or 607-255-4890). You can also write to: Quirine Ketterings, Nutrient Management Spear Program, Department of Animal Science, Cornell University, 323 Morrison Hall, Ithaca NY 14853.

Advisory Committees

- Internal Advisory Committee
  - Cornell faculty, staff and Cornell Cooperative Extension

- External Advisory Committee
  - SWCD
  - SUNY
  - Farm Bureau
  - NEDPA
  - NRCS
  - NYSDAM
  - NYSDEC
  - Consulting and planner firms
  - Farmers

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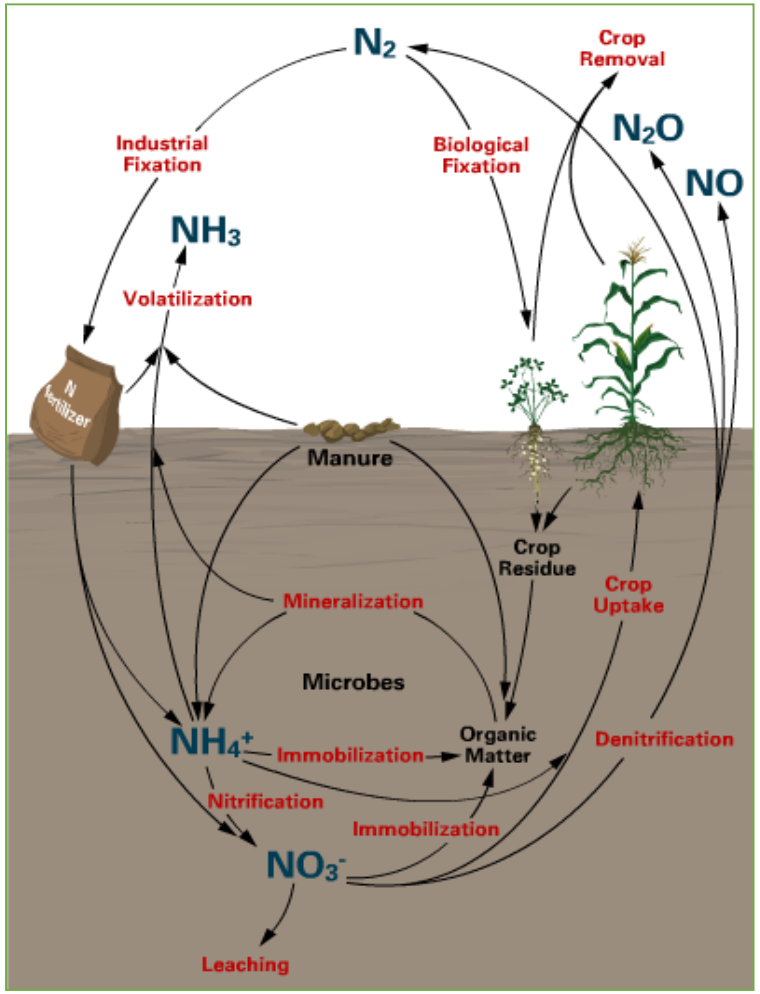
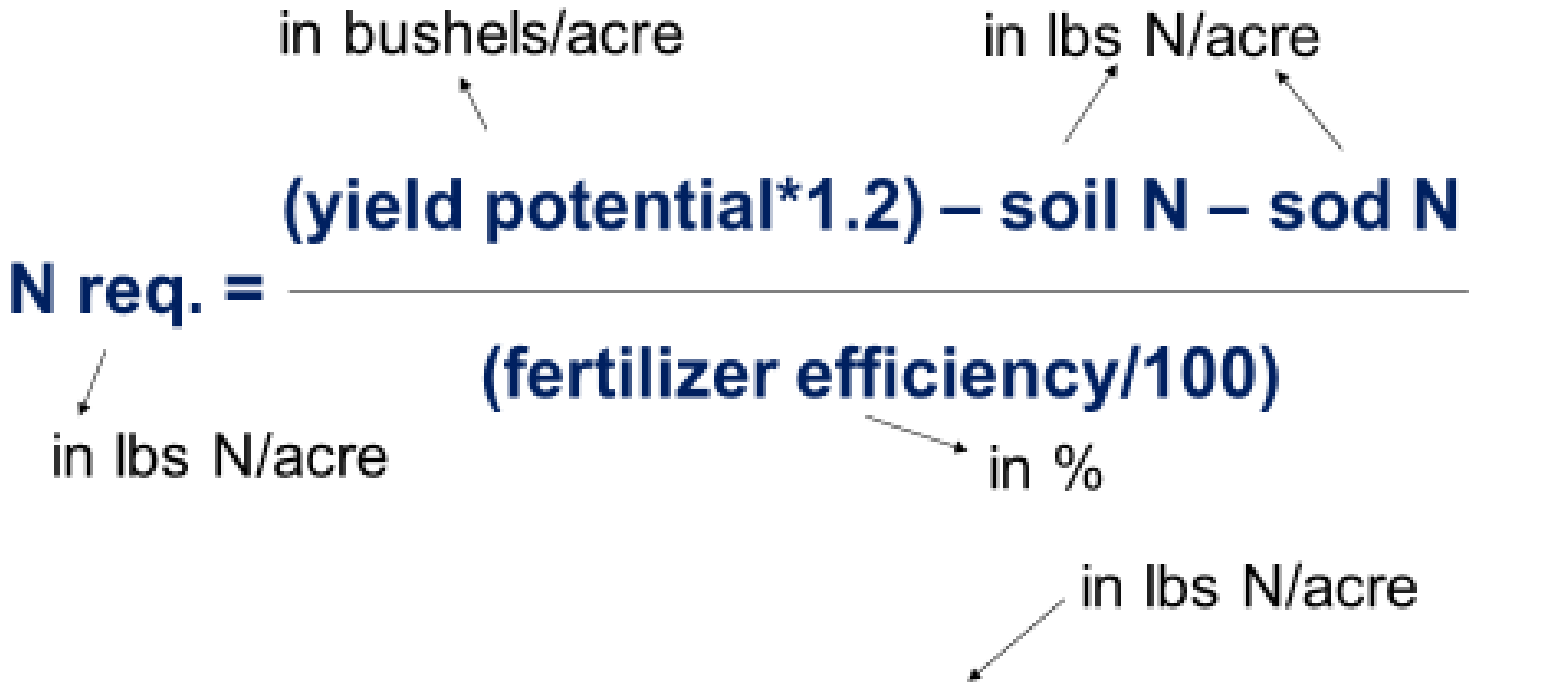
Land Grant University Guidelines are a Starting Point (Foundational Guidelines)

- Nitrogen management planning requires estimating N uptake *and* supply
- Nitrogen sources:
  - Nitrogen deposition
  - N fixation (legumes)
  - Soil organic matter
  - Crop residue and roots (rotation credits)
  - Manure applications (past and present)
  - Fertilizer N application



Cornell equation for corn N guidelines

Land Grant University Guidelines are a Starting Point (Foundational Guidelines)



Soils Database

Yield potential:

"Yield 3-4 years out of 5 under good management"

Soil Type	HC	D	Flooding Frequency	SMG	N uptake efficiency %		Soil N supply lbs N/acre		Yield Potential Corn bu/acre		Yield Potential Alfalfa tons/acre	
					UDr	Dr	UDr	Dr	UDr	Dr	UDr	Dr
Conesus	B	M	Rare/None	2	70	70	75	75	135	140	5.0	5.5
Conotton	A	W	Rare/None	3	75	75	70	70	125	125	5.5	5.5
Constable	A	W	Rare/None	5	70	70	50	50	75	75	4.5	4.5
Cook	D	V	Rare/None	5	50	60	70	80	70	90	2.5	3.5
Copake	B	W	Rare/None	4	75	75	65	65	135	135	6.0	6.0
Cornish	C	S	Occasional	3	60	65	65	75	95	110	3.5	4.5
Cosad	C	S	Rare/None	4	60	70	60	70	105	120	4.0	5.0
Cossayuna	C	W	Rare/None	4	75	75	65	65	135	135	5.5	5.5
Covert	A	M	Rare/None	4	70	70	60	60	115	120	5.0	5.5
Coveytown	C	S	Rare/None	4	65	70	65	75	90	110	3.0	4.5
Covington	D	P	Rare/None	1	55	60	70	75	75	95	2.5	3.5
Crary	C	M	Rare/None	4	65	70	60	70	110	120	4.0	4.5
Croghan	B	M	Rare/None	5	70	70	50	50	100	100	4.5	4.5
Culvers	C	M	Rare/None	3	70	70	75	75	115	125	4.5	5.0
Dalbo	C	M	Rare/None	3	70	70	75	75	95	115	4.5	4.5
Dalton	C	S	Rare/None	3	60	65	70	75	95	105	3.0	4.0
Danley	C	M	Rare/None	2	70	70	75	75	120	125	4.5	5.0
Dannemora	D	P	Rare/None	4	55	65	65	75	75	90	2.5	3.5
Darien	C	S	Rare/None	2	60	65	70	75	100	115	3.5	4.5
												3.5
												4.5
Deford	A	P	Rare/None	4	55	60	65	75	75	100	4.0	4.0
Dekalb	A	W	Rare/None	4	75	75	70	70	100	100	5.0	5.0

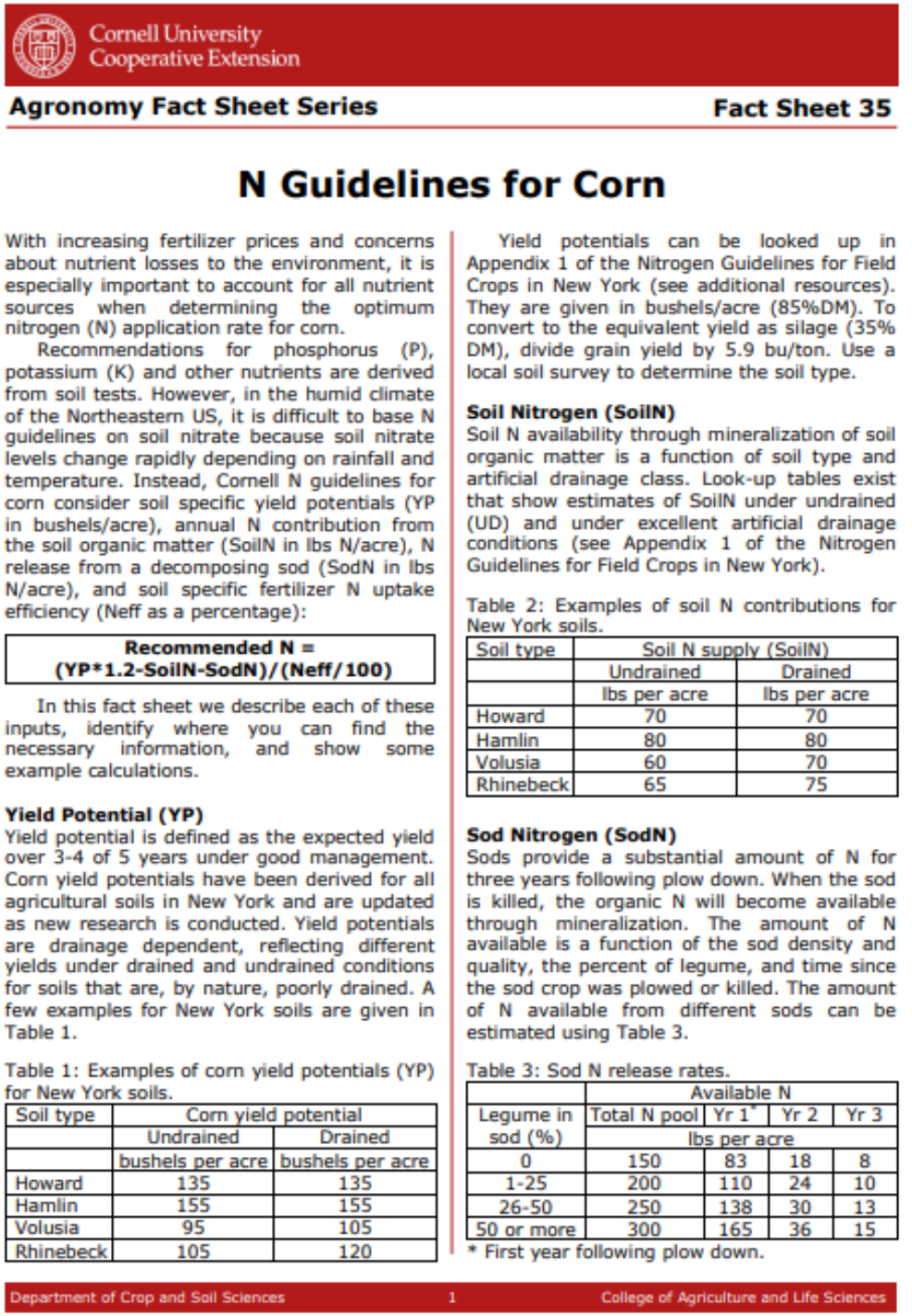
http://nmsp.cals.cornell.edu/publications/tables/soils_database.pdf

Cornell N Guidelines in 2000

Two options:

1. Corn yield potential for the soil type as per Cornell soil database and recommendations based on corn N equation (Agronomy Factsheet 35)
2. Actual corn yield measured (3 years of data) under current N guidelines (N management as in approach 1)

http://nmsp.cals.cornell.edu/guidelines/factsheets.html



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Agronomy Fact Sheet Series **Fact Sheet 35**

N Guidelines for Corn

With increasing fertilizer prices and concerns about nutrient losses to the environment, it is especially important to account for all nutrient sources when determining the optimum nitrogen (N) application rate for corn.

Recommendations for phosphorus (P), potassium (K) and other nutrients are derived from soil tests. However, in the humid climate of the Northeastern US, it is difficult to base N guidelines on soil nitrate because soil nitrate levels change rapidly depending on rainfall and temperature. Instead, Cornell N guidelines for corn consider soil specific yield potentials (YP in bushels/acre), annual N contribution from the soil organic matter (SoilN in lbs N/acre), N release from a decomposing sod (SodN in lbs N/acre), and soil specific fertilizer N uptake efficiency (Neff as a percentage):

Recommended N =
(YP*1.2-SoilN-SodN)/(Neff/100)

In this fact sheet we describe each of these inputs, identify where you can find the necessary information, and show some example calculations.

Yield Potential (YP)

Yield potential is defined as the expected yield over 3-4 of 5 years under good management. Corn yield potentials have been derived for all agricultural soils in New York and are updated as new research is conducted. Yield potentials are drainage dependent, reflecting different yields under drained and undrained conditions for soils that are, by nature, poorly drained. A few examples for New York soils are given in Table 1.

Table 1: Examples of corn yield potentials (YP) for New York soils.

Soil type	Corn yield potential	
	Undrained	Drained
	bushels per acre	bushels per acre
Howard	135	135
Hamlin	155	155
Volusia	95	105
Rhinebeck	105	120

Yield potentials can be looked up in Appendix 1 of the Nitrogen Guidelines for Field Crops in New York (see additional resources). They are given in bushels/acre (85%DM). To convert to the equivalent yield as silage (35% DM), divide grain yield by 5.9 bu/ton. Use a local soil survey to determine the soil type.

Soil Nitrogen (SoilN)

Soil N availability through mineralization of soil organic matter is a function of soil type and artificial drainage class. Look-up tables exist that show estimates of SoilN under undrained (UD) and under excellent artificial drainage conditions (see Appendix 1 of the Nitrogen Guidelines for Field Crops in New York).

Table 2: Examples of soil N contributions for New York soils.

Soil type	Soil N supply (SoilN)	
	Undrained	Drained
	lbs per acre	lbs per acre
Howard	70	70
Hamlin	80	80
Volusia	60	70
Rhinebeck	65	75

Sod Nitrogen (SodN)

Sods provide a substantial amount of N for three years following plow down. When the sod is killed, the organic N will become available through mineralization. The amount of N available is a function of the sod density and quality, the percent of legume, and time since the sod crop was plowed or killed. The amount of N available from different sods can be estimated using Table 3.

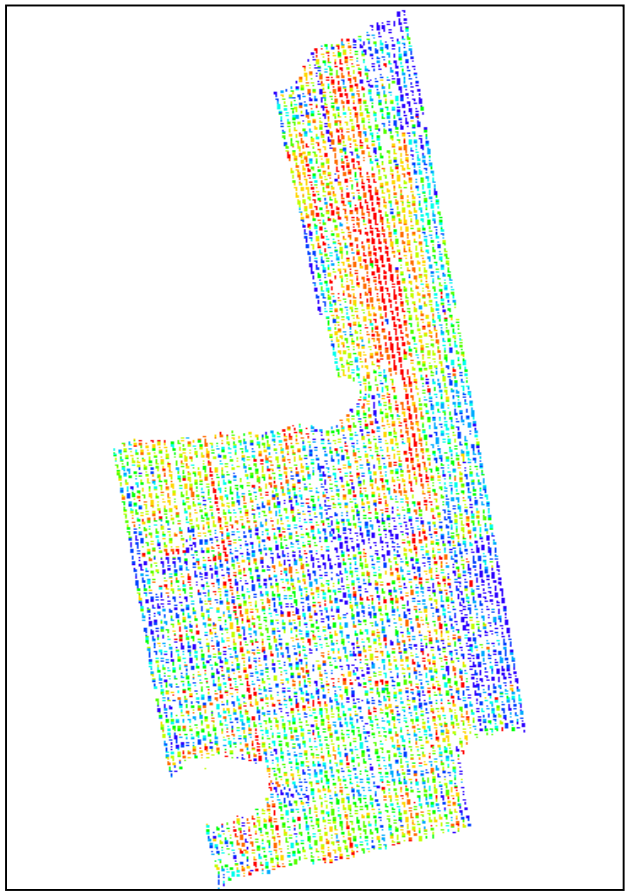
Table 3: Sod N release rates.

Legume in sod (%)	Available N			
	Total N pool	Yr 1*	Yr 2	Yr 3
	lbs per acre			
0	150	83	18	8
1-25	200	110	24	10
26-50	250	138	30	13
50 or more	300	165	36	15

* First year following plow down.

Context: Issues that Surfaced

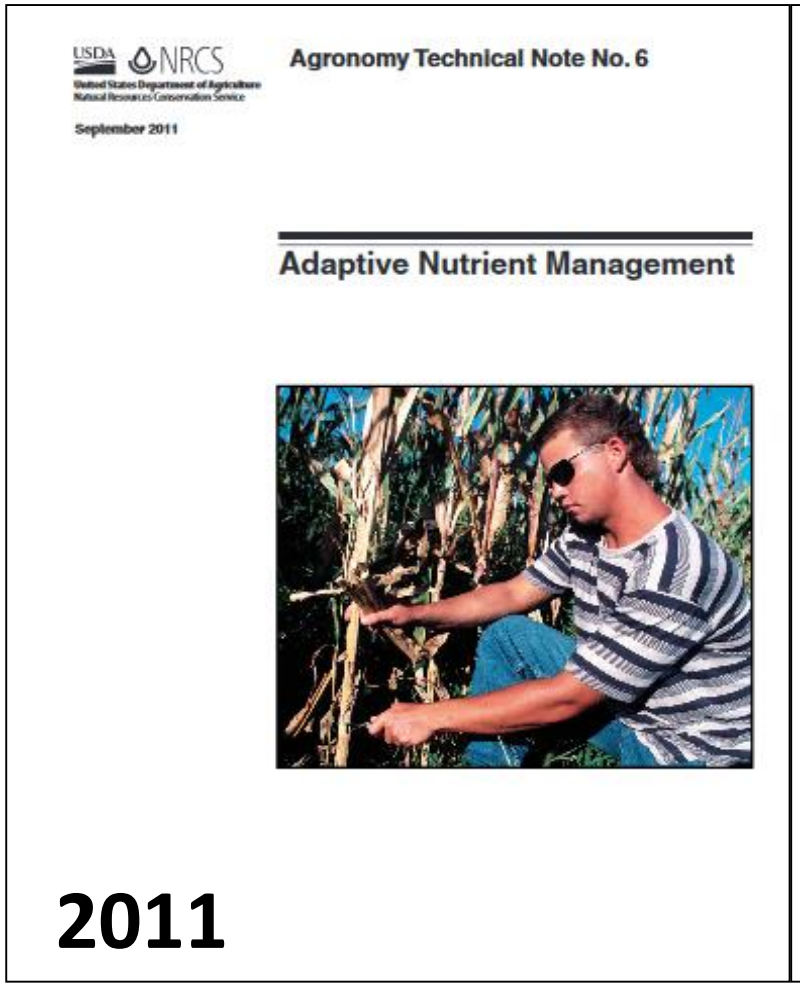
- Sometimes rates were increased with limited or no documentation
    - Risk to farmers and environment
- General belief: higher yield = more N needed
    - Not supported by data
- Limited funds to re-evaluate book values
- Yield potentials per soil type may not capture real variability; farm/field specific data better

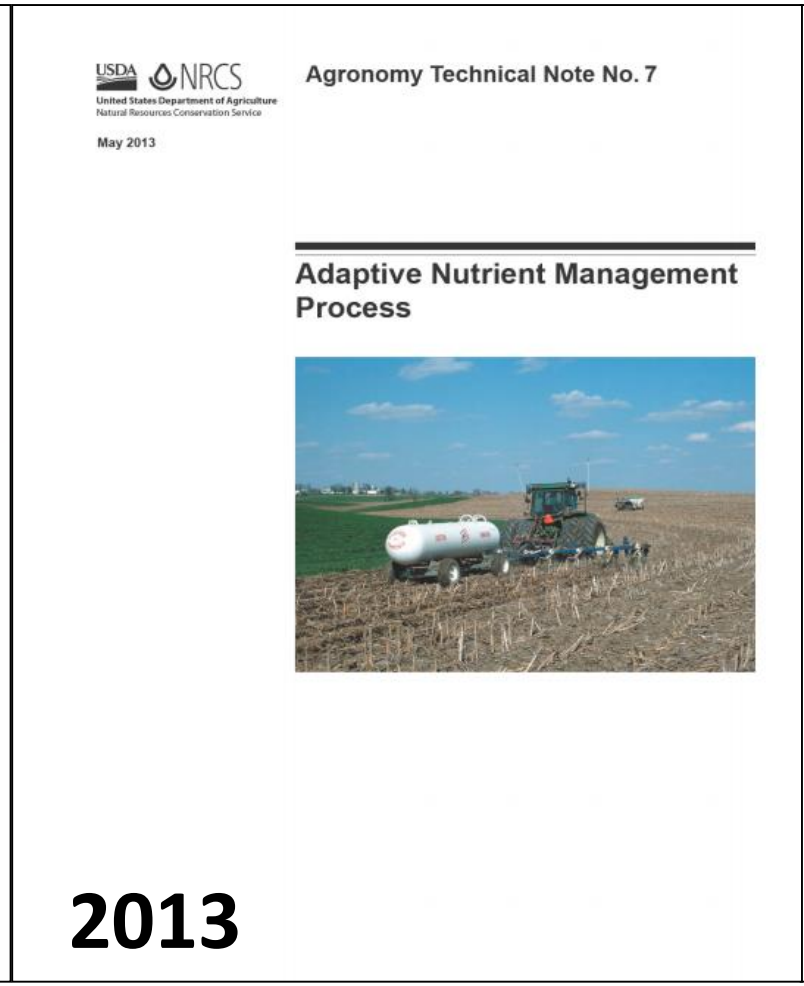


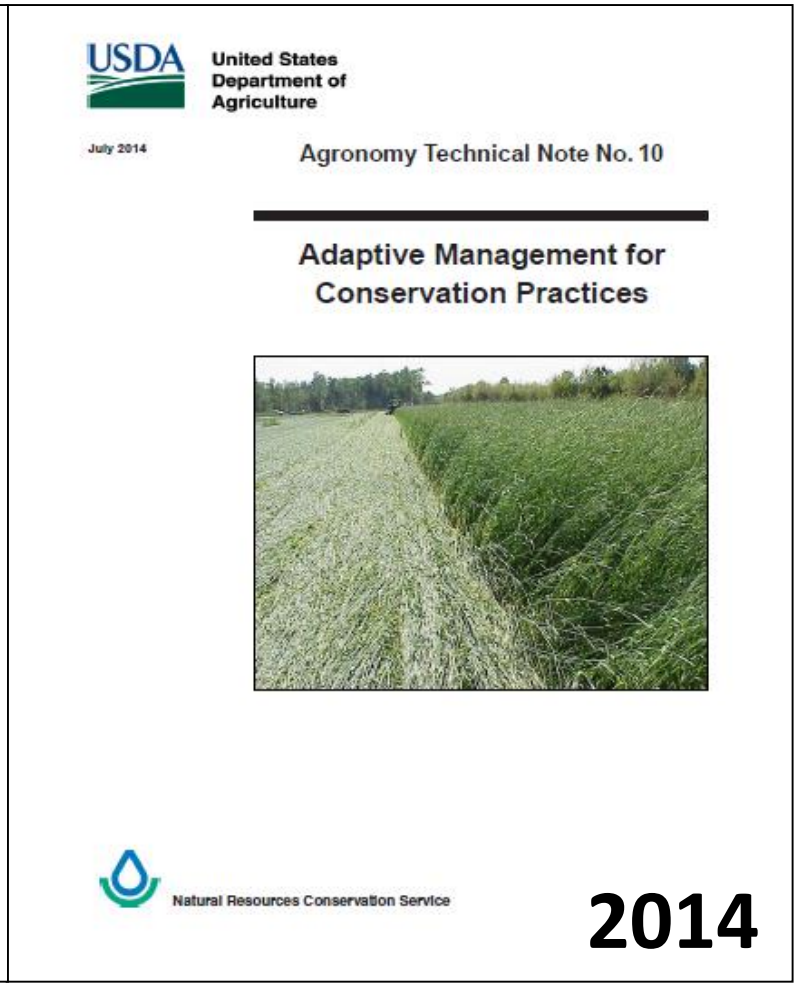
Opportunities

- We needed a means to move forward collectively with the industry; on-farm research partnerships
  - Make use of each other's expertise
- The opening to do so came when NRCS embraced an adaptive management process for nutrient management
- Technology advances (yield monitors and data cleaning protocols) helped greatly

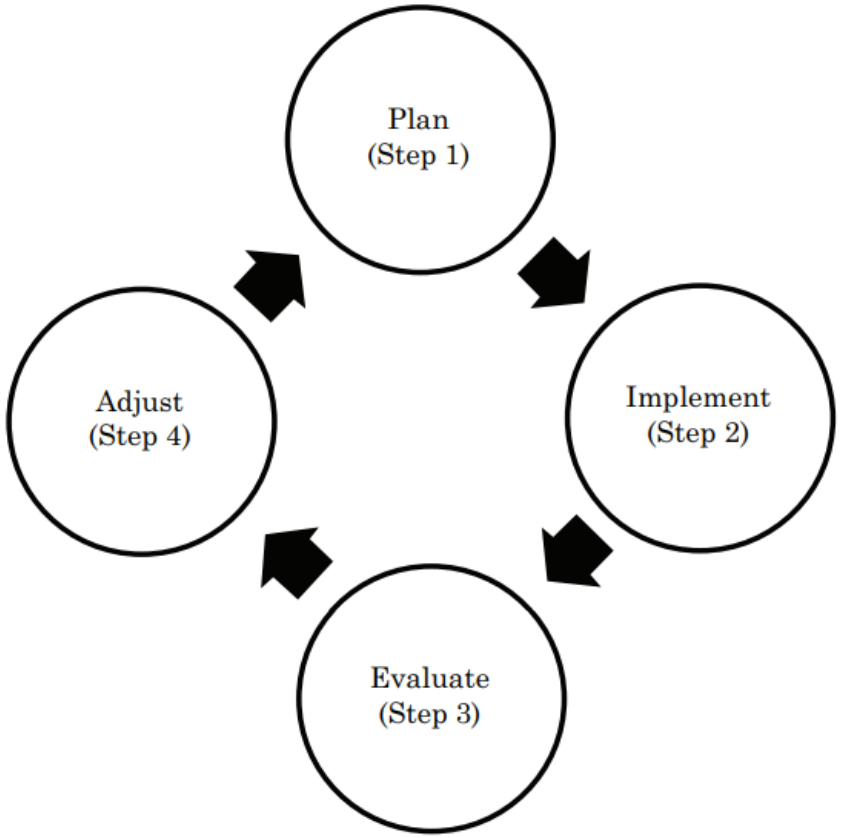
Adaptive Management NRCS







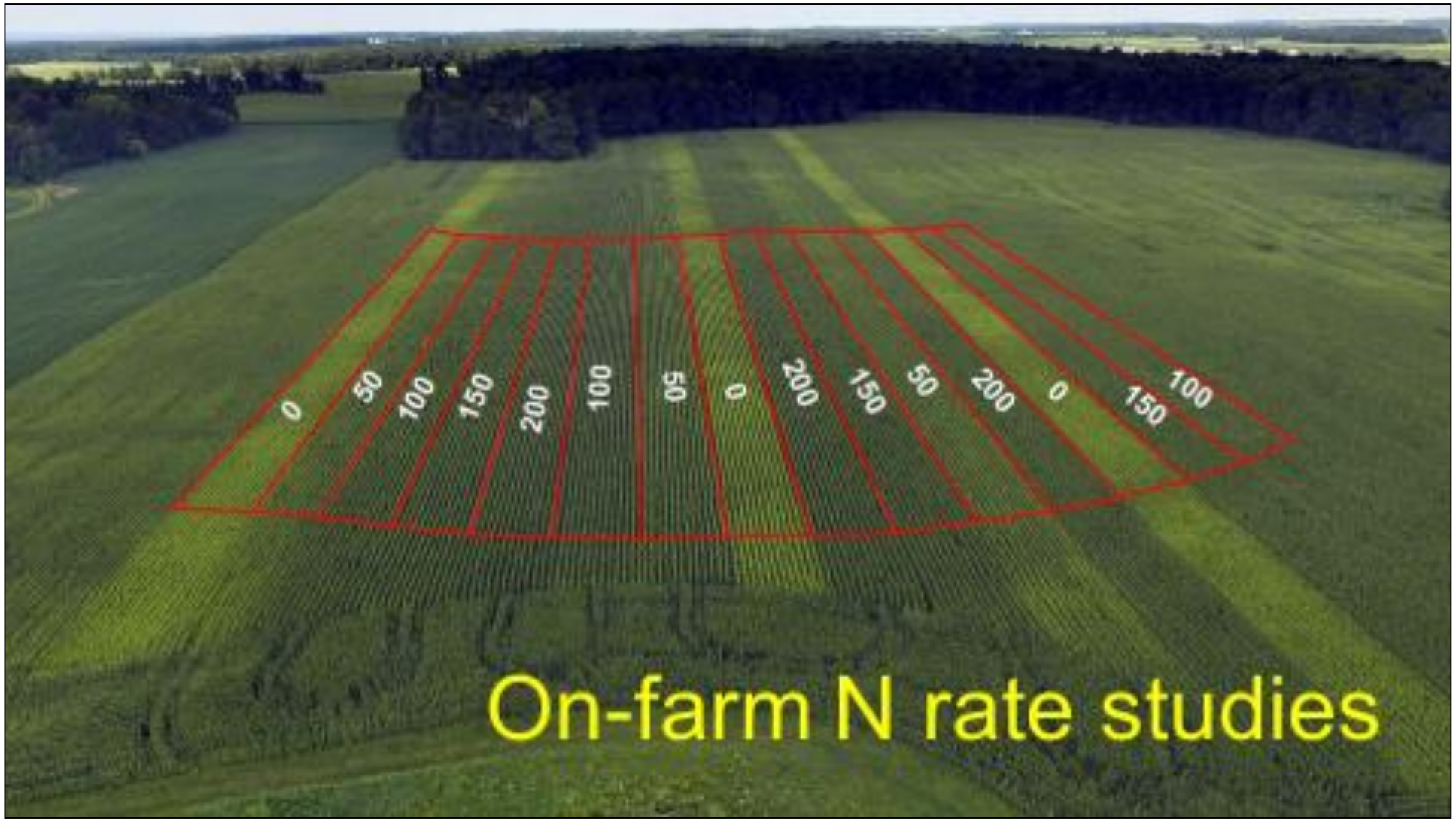
Adaptive Management NRCS



"Adaptive nutrient management is a process for evaluating and adjusting nutrient management based on **data collected at the field level** following a set of protocols."

"Adaptive nutrient management **requires evaluation** at least once a year when a crop is harvested. If in-season adaptive management tools are used, the evaluation occurs at least twice a year, when a soil or plant tissue test is completed and when a crop is harvested."

On-Farm Nitrogen Rate Trials



- Zero
- 50 lbs N/acre
- 100 lbs N/acre
- 150 lbs N/acre
- 200 lbs N/acre

+ Nrich

Replicated 3 or more times

Adaptive Management Factsheets

Cornell University
Cooperative Extension

Agronomy Fact Sheet Series **Fact Sheet 77**

Nitrogen for Corn; Management Options

Although fertility recommendations for corn can vary from state to state, most recognize that accurate yield records are essential to

yielding soils are often impacted by factors other than N supply (i.e. drainage, root restrictive soil layers, etc.) and tend to need

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Agronomy Fact Sheet Series **Fact Sheet 78**

Adaptive Management of Nitrogen for Corn

Accurate yield records and field management information are essential to guide N fertilization decisions for corn. The Cornell

In this equation, YP is the user-selected yield potential in bushels/acre. SoilN is the estimated annual N contribution from the soil

Adaptive Management in 2013

Two *additional* options in 2013:

3. Findings of two years of on-farm replicated trials with a minimum of four replications and five N rate including a zero-N control treatment.
4. ***Yield measurements and the results of the corn stalk nitrate test (CSNT), to be managed below 3000 ppm over time.***

http://nmsp.cals.cornell.edu/guidelines/factsheets.html

Adaptive Management Factsheets

Cornell University
Cooperative Extension

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Adaptive Management in 2013

Corn stalk nitrate test

- Assessment tool for N management
- End-of-season “report card”
- Fine-tuning over time / adaptive nutrient management

New York interpretations:

- Low: <250 ppm
- Marginal: 250-750 ppm
- Optimal: 750-2000 ppm
- Excess: >2000 ppm

Adaptive Management in New York since 2018

1. Targeted CSNT (t*op 25% yielding area)*
2. Comparison strip with control treatment (check strip)
3. 2-3 georeferenced photos (leaf N status) in top 25% yield area; +targeted CSNT when the 1-3 lowest true leaves are green
4. Determine and record individual field N balances (other crops)
   - [total N applied + N supply by soil and crop rotation credits per Cornell soils database] minus N removed in harvest

Adaptive Management in New York since 2018

- All adaptive management options ***require measuring yield***
- Farmers with yields can set farm-specific and field-specific yield potentials (3 or more years of data)
- Book values are still needed
  - For those without yield data
  - For those with insufficient amount of yield data
- Those with data can contribute to updating of book values
- Calibration and data cleaning are important

State Yield Histograms

The new database shows higher average yields than state reported average:

NY Ag Statistics averages (2014-2018):

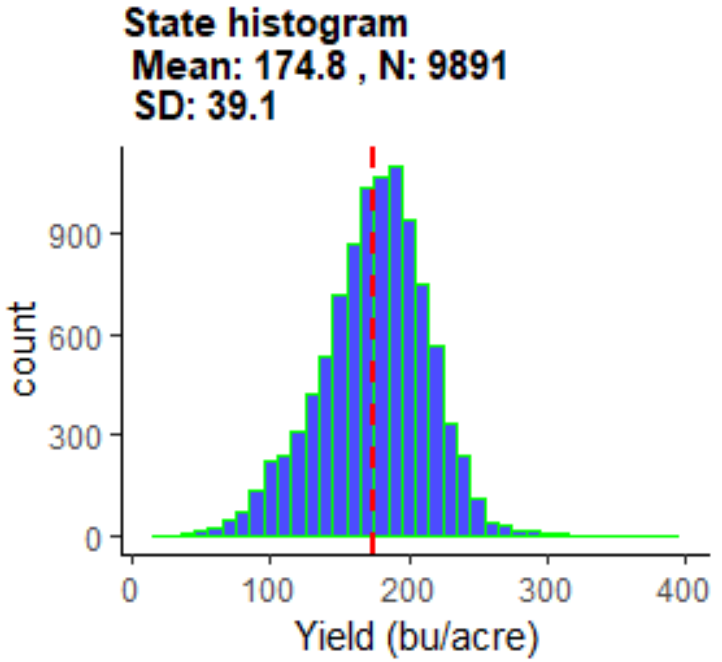
17.6 tons/acre and 148 bu/acre

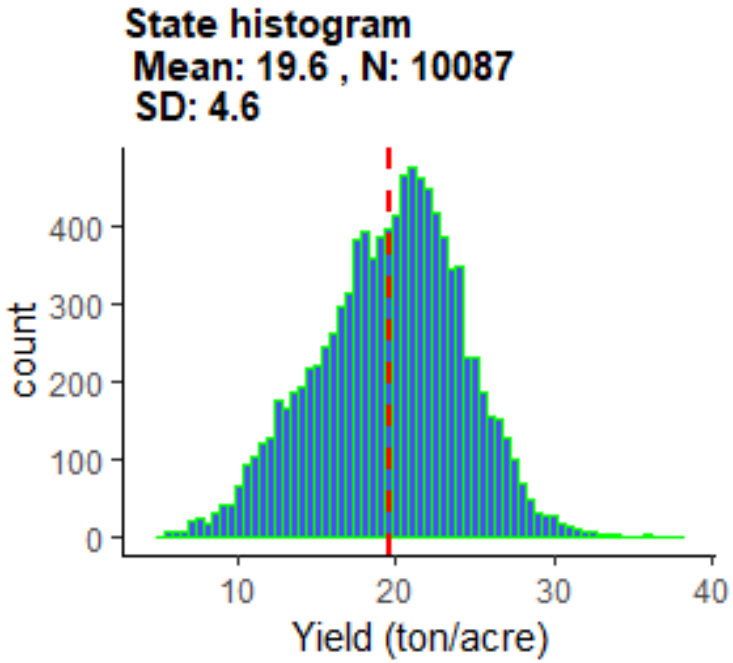
NY Ag Statistics averages (2017-2018):

18.5 tons/acre and 160 bu/acre

Yield monitor dataset (83% from 2014-2018):

19.6 tons/acre and 175 bu/acre

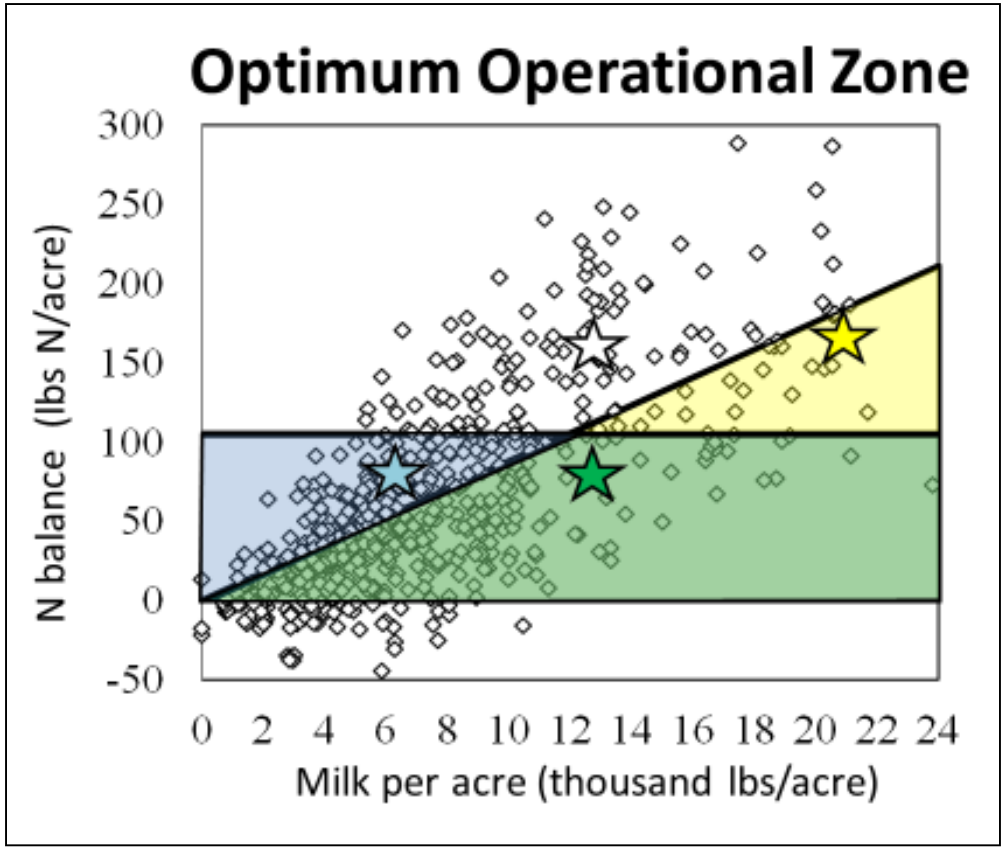




Adaptive Management in 2018

	Feasible mass balances	
	(lbs/acre)	(lbs/cwt)
Nitrogen	0 – 105	0 – 0.88
Phosphorus	0 – 12	0 – 0.11
Potassium	0 – 37	0 – 0.30

"Dairy farms that maintain a 3-year running average N balance at or below 105 lbs/acre, meet the adaptive management guidelines and do not require additional field-specific evaluations beyond recording yield."



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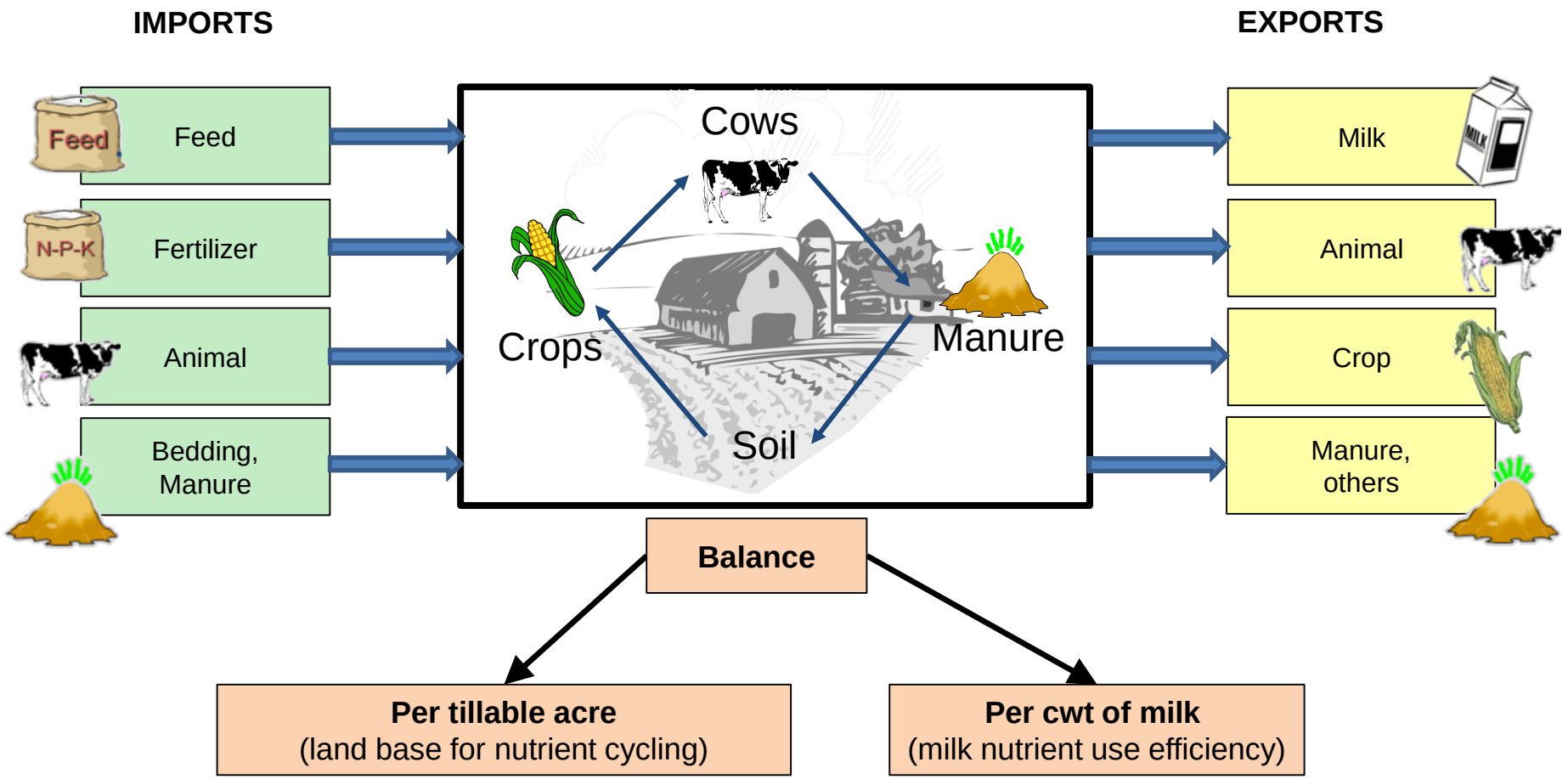
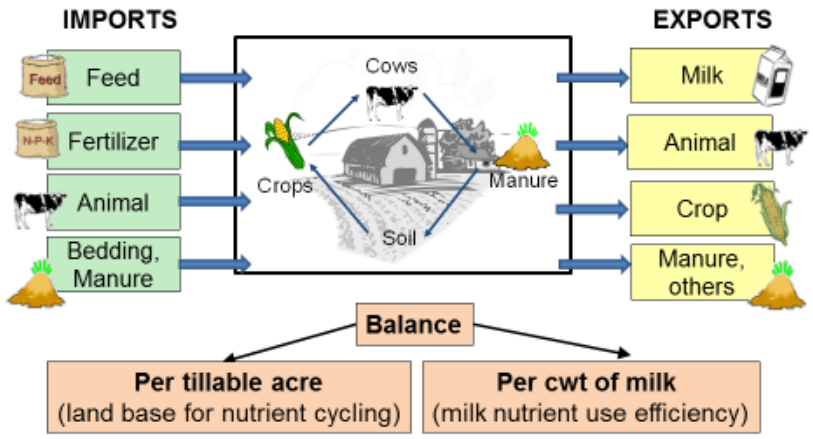
Whole-Farm Nutrient Mass Balances (NMBs)

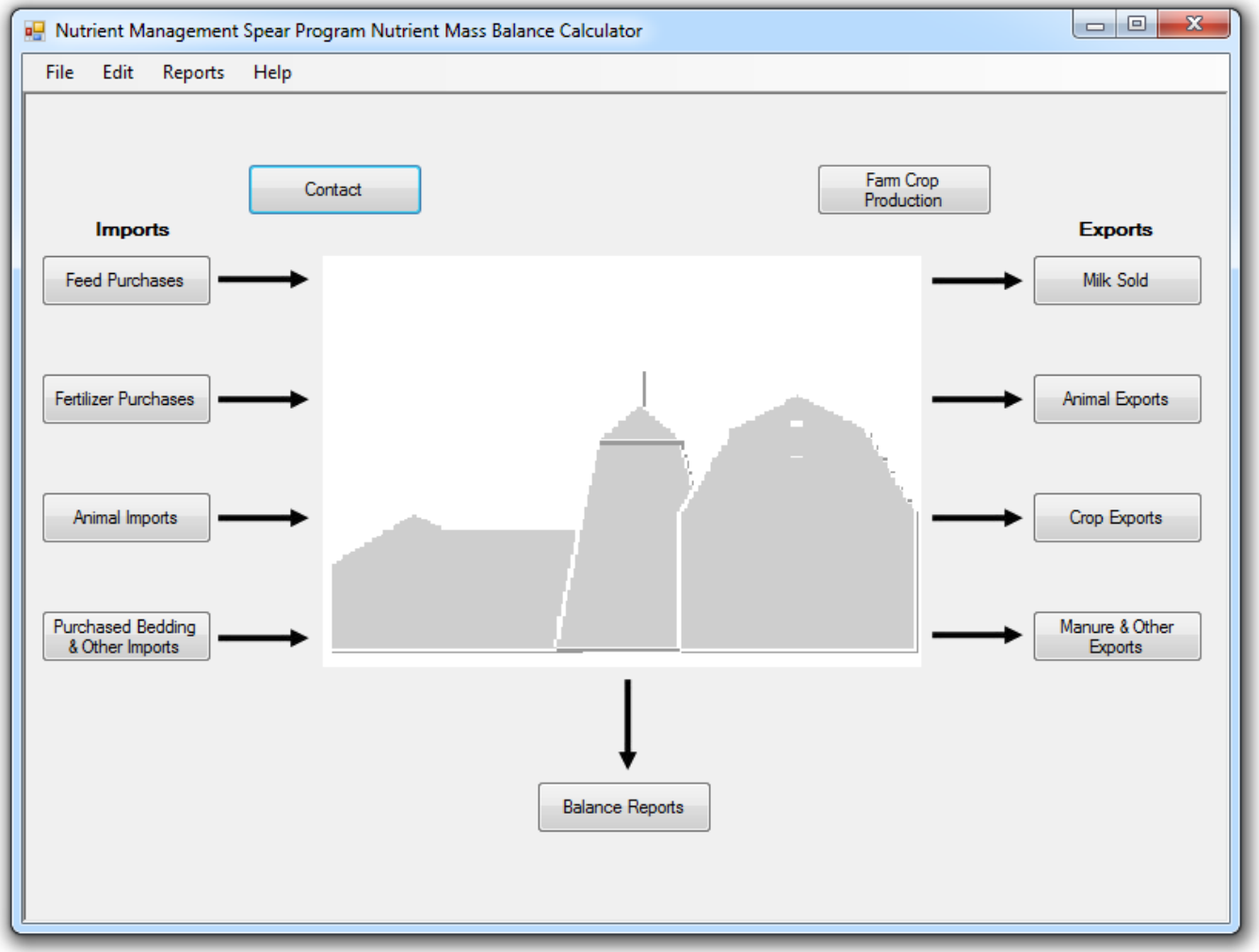


Tool = Cornell Nutrient Mass Balance Calculator

Balance = Imports – Exports (just farm boundaries)

We only measure what is **reasonably feasible** to measure

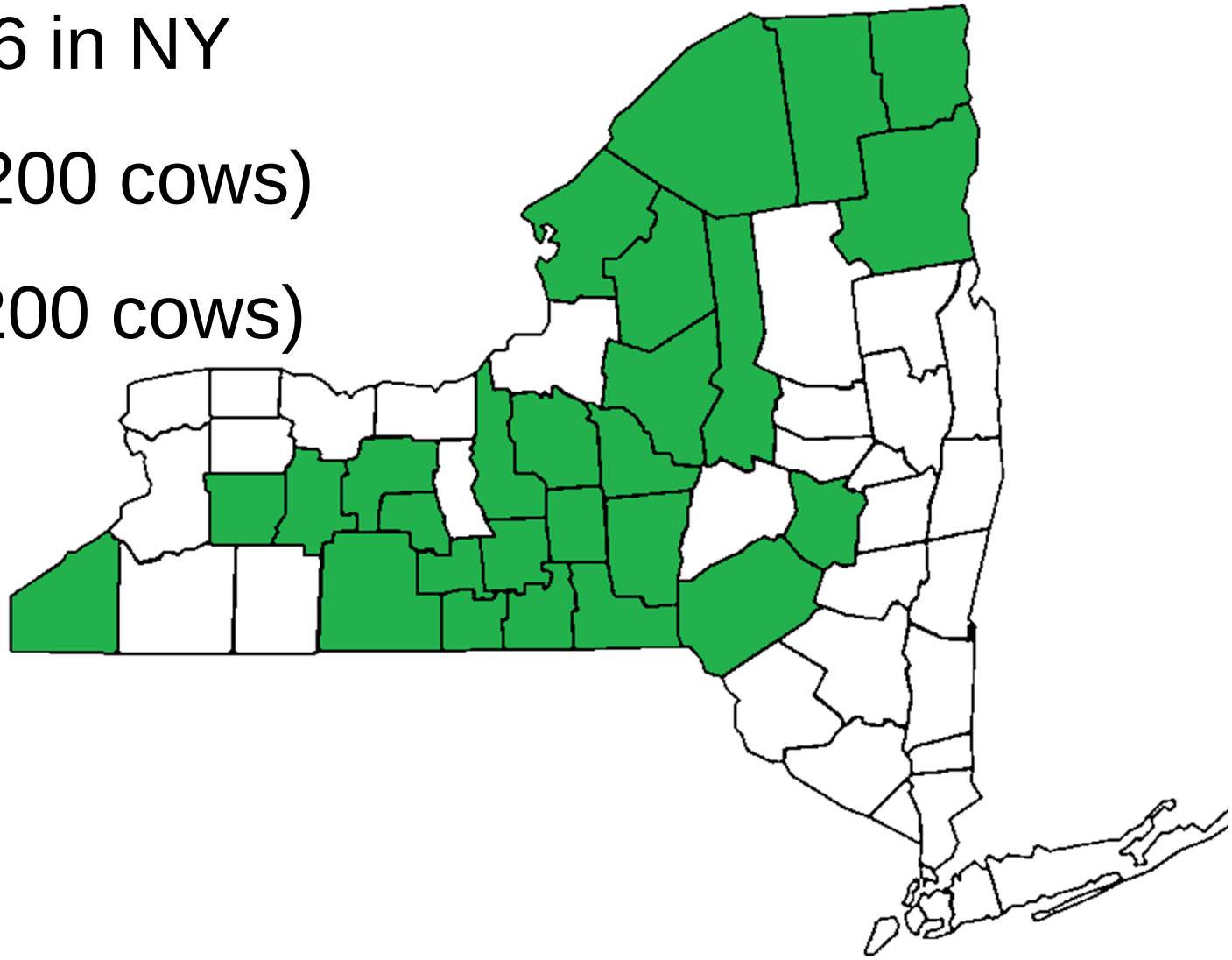




http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html

New York Statewide NMB Assessments in 2006

- 102 dairy farms in 2006 in NY
  - 73% small farms (<200 cows)
  - 27% large farms (>200 cows)



Feasible Mass Balances

A "feasible mass balance" should allow farms to be:

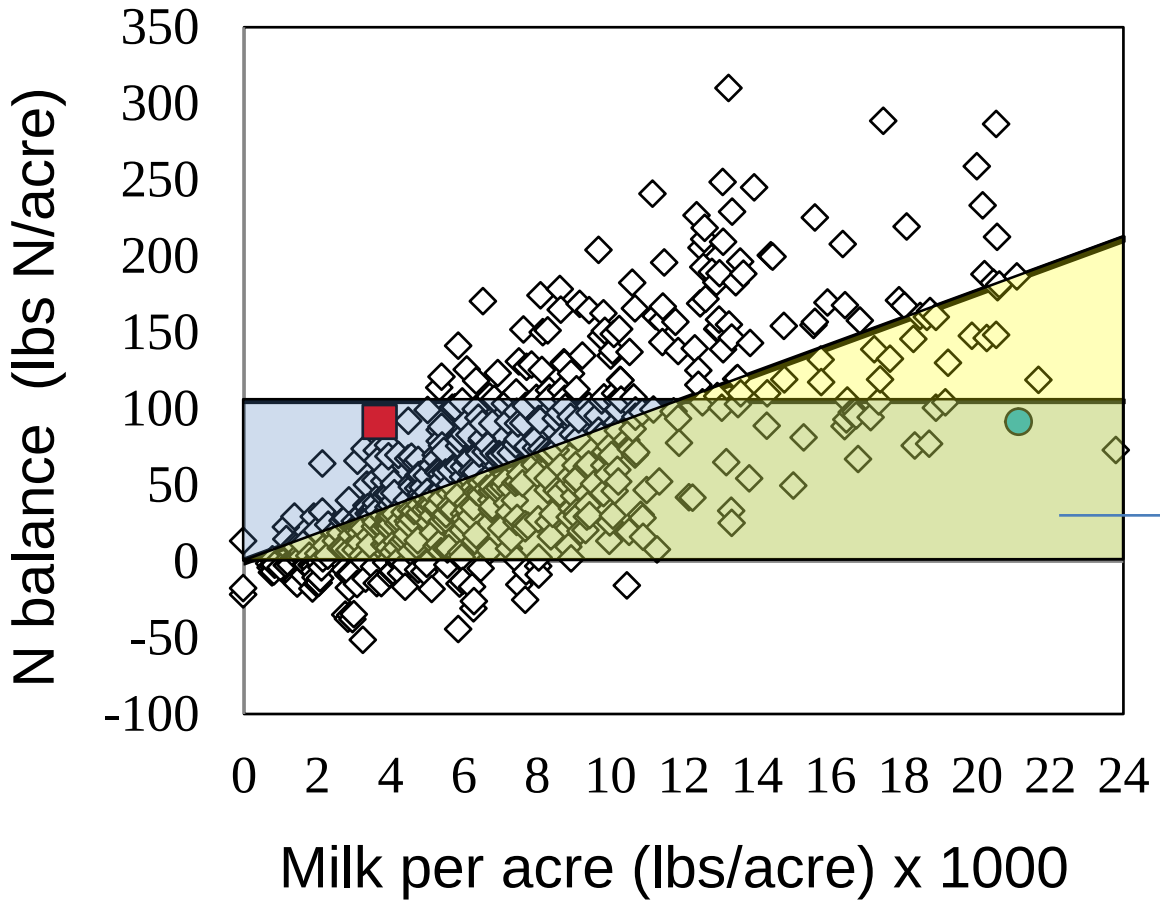
→Economically viable

→Environmentally sustainable

	Mass balances	
	(lbs/acre)	(lbs/cwt)
Nitrogen	0-105	0-0.88
Phosphorus	0-12	0-0.11
Potassium	0-37	0-0.30

“Optimal operational zone” (green box)

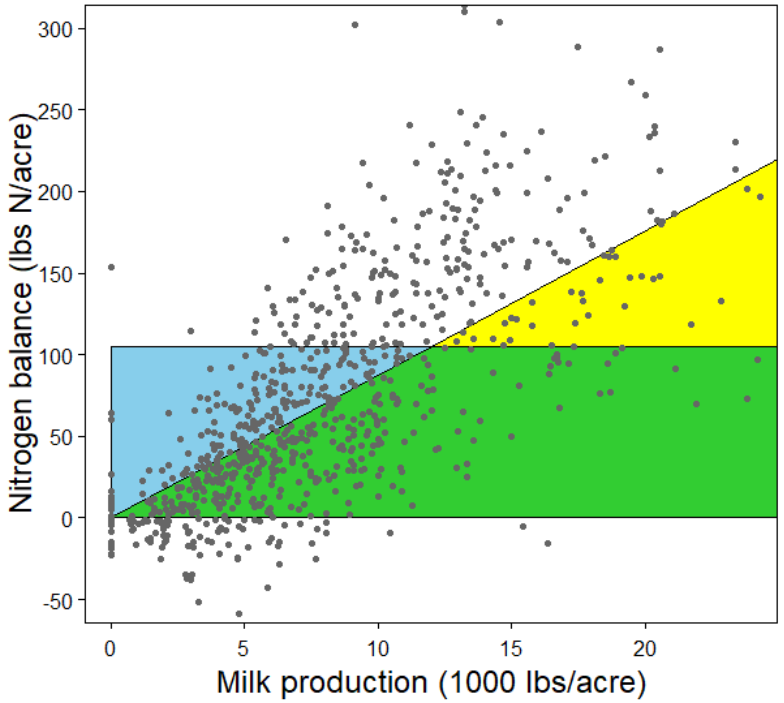
Overlap of low NMB/acre (blue) and low NMB/cwt (yellow)



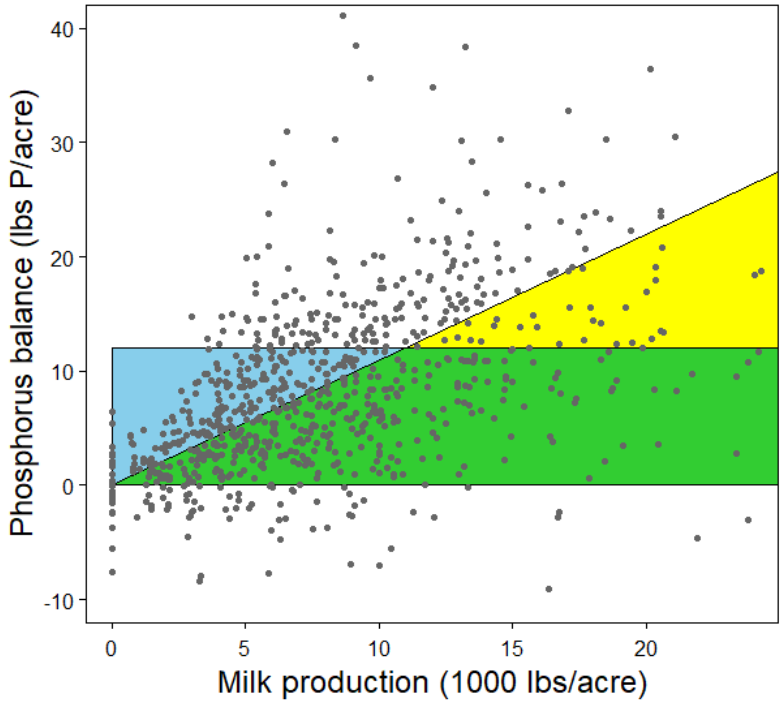
High NUE and can recycle nutrients in the land base

Whole-Farm Feasible Nutrient Balances

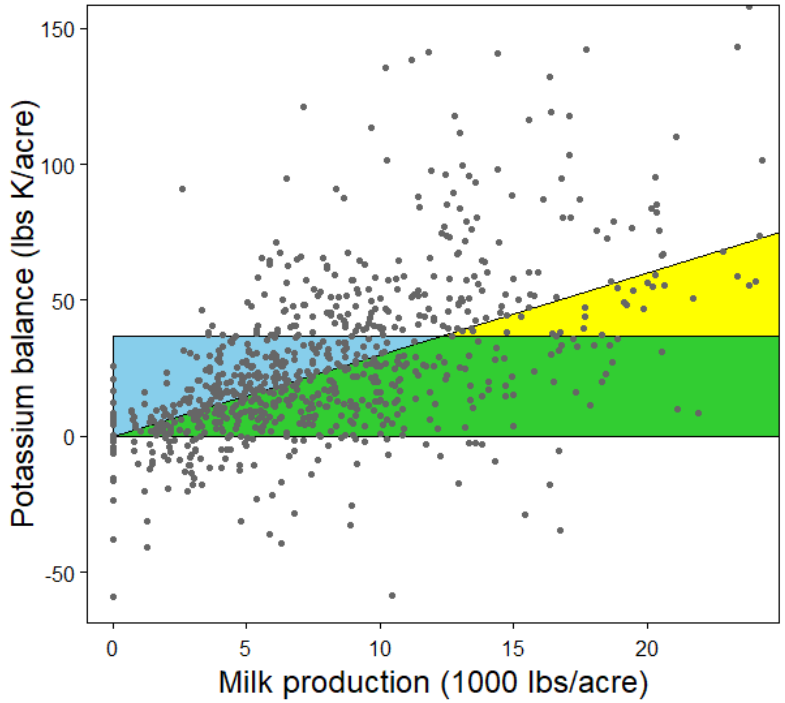
Nitrogen



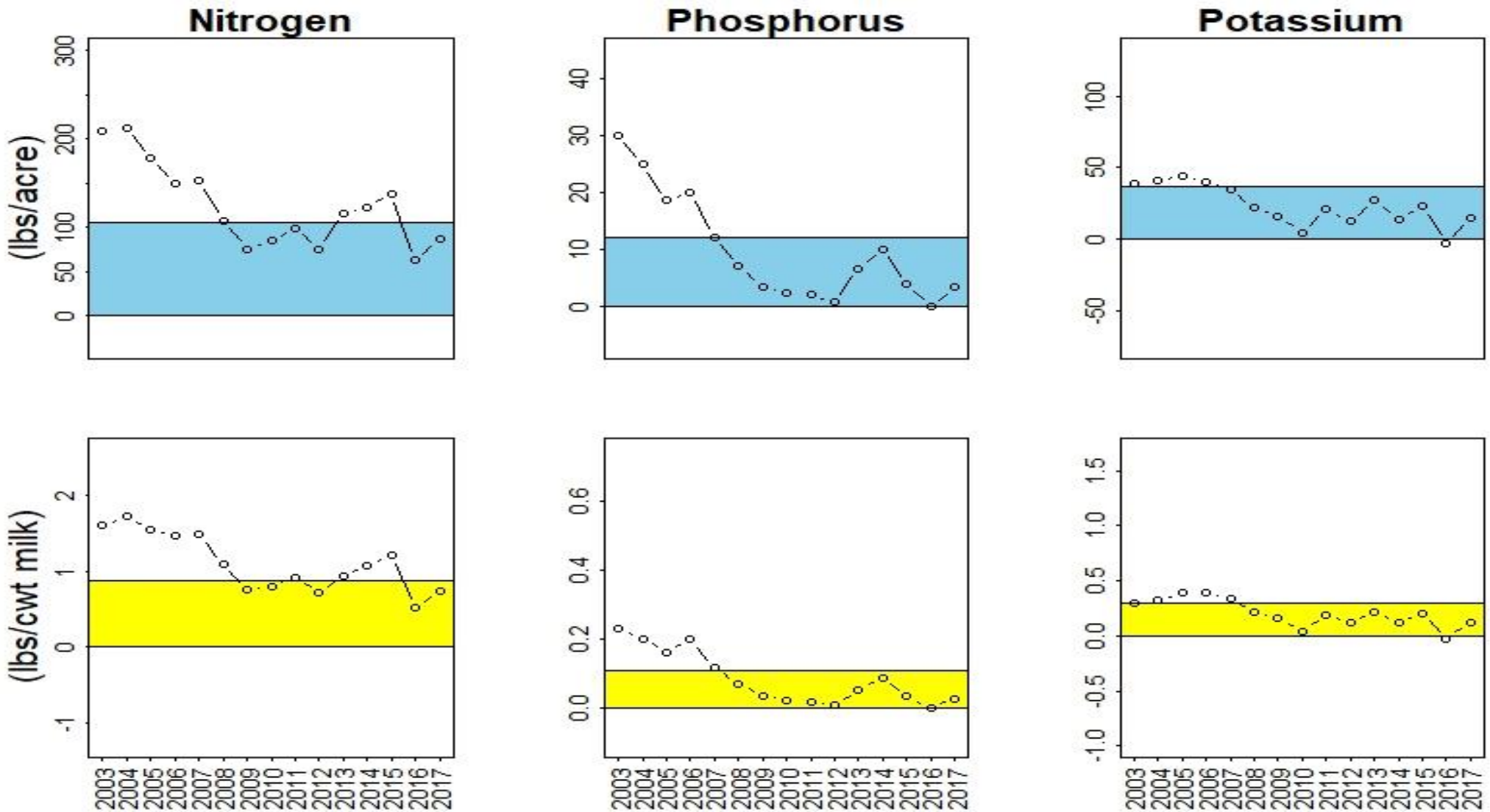
Phosphorus



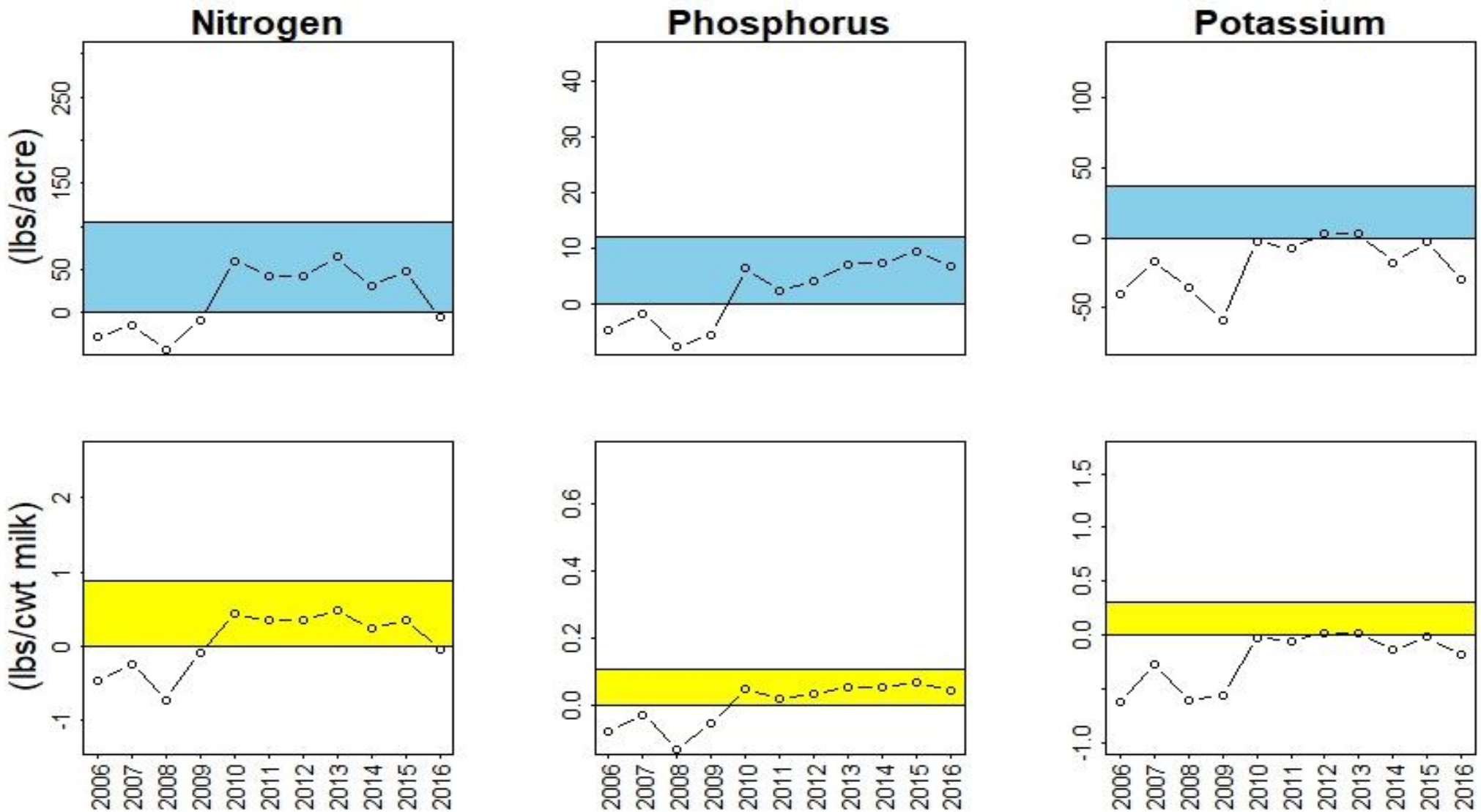
Potassium



Whole-Farm Feasible Nutrient Balances

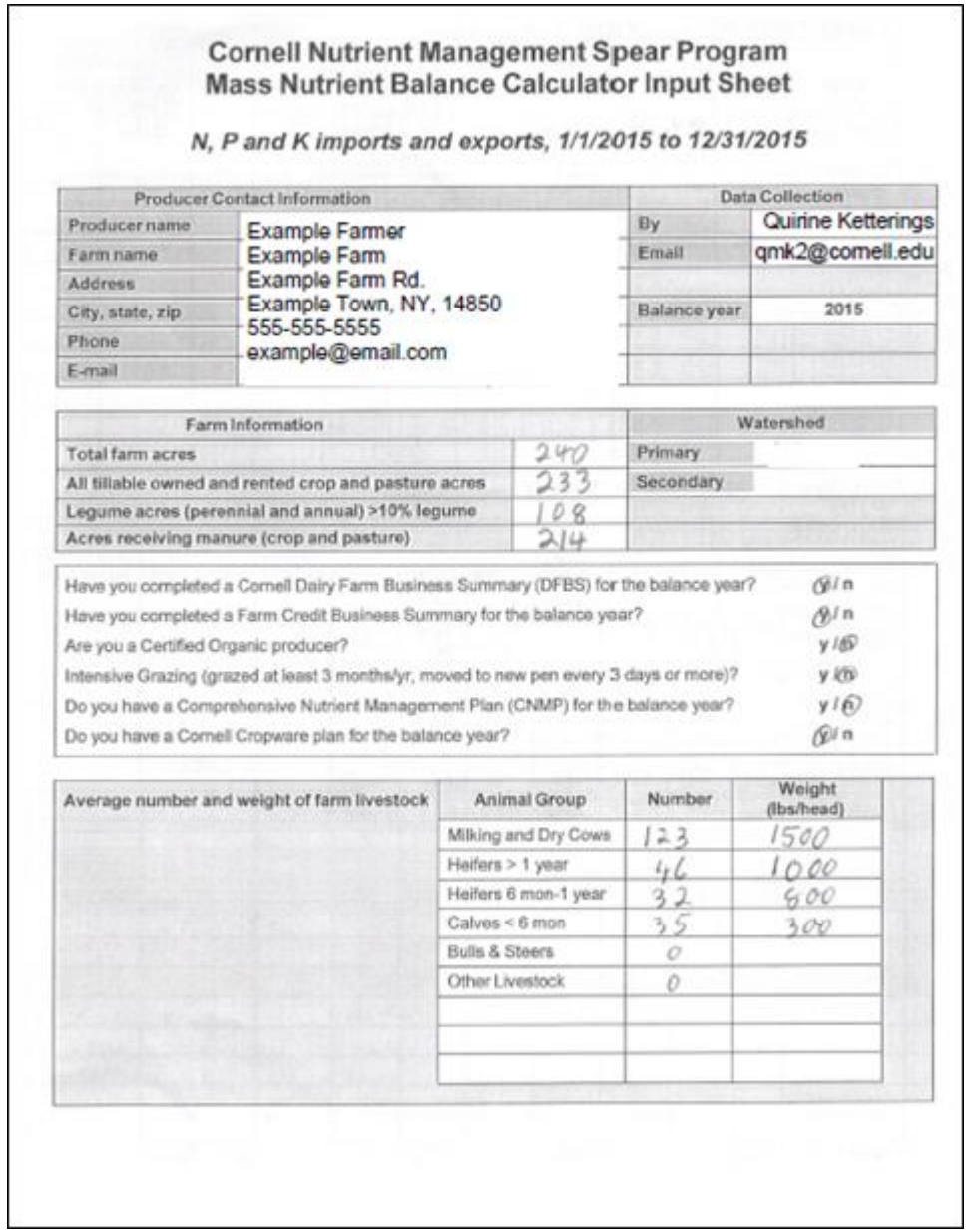


Whole-Farm Feasible Nutrient Balances



Opportunities Table with Indicators

	Indicator to predict likelihood of exceeding feasible balances	Example Farm			High risk of exceeding the feasible balances if			Comments
		N	P	K	N	P	K	
1	Balance per acre (lbs/acre)	178	19	44	> 105	> 12	> 37	
2	Balance per cwt milk (lbs/hundredweight milk)	1.55	0.16	0.39	> 0.88	> 0.11	> 0.30	
3	Milk per cow (lbs/cow/year)		22 927		-	< 20000	-	
4	Animal density (animal units/acre)		0.99		-	> 1.0	-	High animal density increases risk of high NMB per acre
5	Whole-farm nutrient use efficiency (%)	28	39	30	< 44	< 51	< 39	
6	Purchased feed (lbs/acre)	213	25	58	> 121	> 20	> 38	High feed purchases cause high NMB per acre
7	Feed (tons dry matter/animal unit)		6.8		-	3.5 to 7.5	-	
8	Feed use efficiency (milk, %)	18	22	10	< 20	< 25	< 11	
9	Homegrown feed (% dry matter)		62		-	< 62-65	-	Increasing homegrown feed can alleviate nutrient balances
10	Homegrown forage (%)		62		-	-	-	
11	Homegrown grain (%)		0		-	-	-	
12	Homegrown nutrients (% dry matter)	39	47	69	< 50	< 50	-	
13	Crude protein (CP) and P in all feed (%)	16	0.35	1.37	> 17	> 0.40	-	
14	CP and P in purchased feed (%)	26	0.48	1.12	> 30	> 0.60	-	
15	CP in homegrown feed (%)	10.4			< 11.8	-	-	Increasing CP in homegrown feed may help reduce N balances
16	Fertilizer (lbs/acre)	32	5	6	> 39	> 6	> 38	
17	Crop exports (lbs/acre)				< 1	< 1	< 1	Crop exports can reduce balances per acre
18	Manure exports (lbs/acre)				< 1	< 1	< 1	Manure exports can reduce balances per acre
19	Overall crop yield (tons dry matter/acre)		4.6					
20	Acres receiving manure (%)		74					
21	Land in legumes (%)							



Cornell Nutrient Management Spear Program
Mass Nutrient Balance Calculator Input Sheet

N, P and K imports and exports, 1/1/2015 to 12/31/2015

Producer Contact Information		Data Collection	
Producer name	Example Farmer	By	Quirine Ketterings
Farm name	Example Farm	Email	qmk2@cornell.edu
Address	Example Farm Rd.		
City, state, zip	Example Town, NY, 14850	Balance year	2015
Phone	555-555-5555		
E-mail	example@email.com		

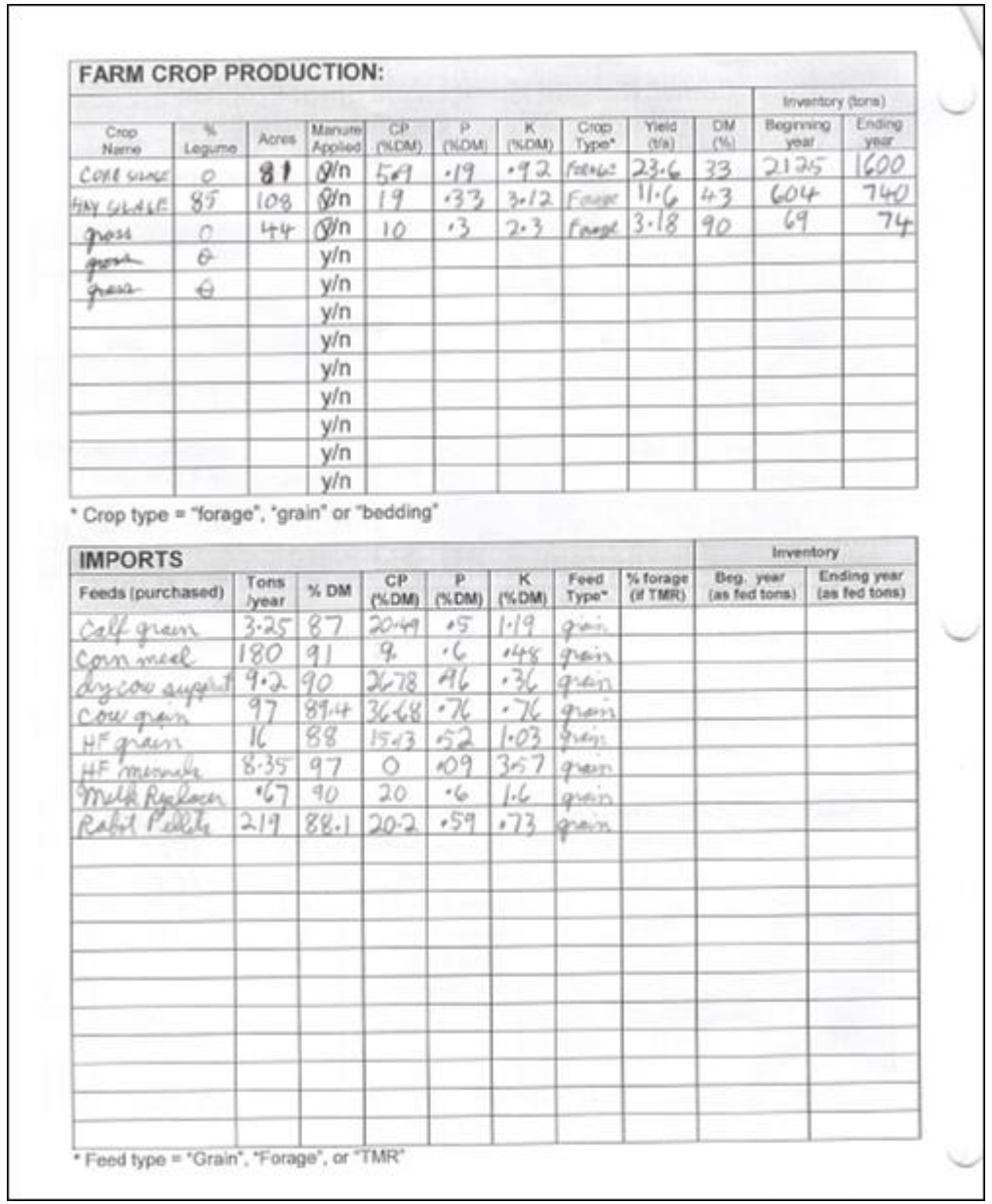
Farm Information		Watershed
Total farm acres	240	Primary
All tillable owned and rented crop and pasture acres	233	Secondary
Legume acres (perennial and annual) >10% legume	108	
Acres receiving manure (crop and pasture)	214	

Have you completed a Cornell Dairy Farm Business Summary (DFBS) for the balance year?	(y) / n
Have you completed a Farm Credit Business Summary for the balance year?	(y) / n
Are you a Certified Organic producer?	y / (n)
Intensive Grazing (grazed at least 3 months/yr, moved to new pen every 3 days or more)?	y (n)
Do you have a Comprehensive Nutrient Management Plan (CNMP) for the balance year?	y / (n)
Do you have a Cornell Cropware plan for the balance year?	(y) / n

Average number and weight of farm livestock	Animal Group	Number	Weight (lbs/head)
	Milking and Dry Cows	123	1500
	Heifers > 1 year	46	1000
	Heifers 6 mon-1 year	32	600
	Calves < 6 mon	35	300
	Bulls & Steers	0	
	Other Livestock	0	

Page One Input Sheet

- Farm contact information
- Acres
- Miscellaneous characteristics
- Animal types, numbers, weights



FARM CROP PRODUCTION:

Crop Name	% Legume	Acres	Manure Applied	CP (%DM)	P (%DM)	K (%DM)	Crop Type*	Yield (t/a)	DM (%)	Inventory (tons) Beginning year	Inventory (tons) Ending year
CORN SILAGE	0	81	Ø/n	5.9	.19	.92	Forage	23.6	33	2125	1600
HAY SILAGE	85	108	Ø/n	19	.33	3.12	Forage	11.6	43	604	740
grass	0	44	Ø/n	10	.3	2.3	Forage	3.18	90	69	74
grass	0		y/n								
grass	0		y/n								
			y/n								
			y/n								
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			y/n								
			y/n								
			y/n								

* Crop type = "forage", "grain" or "bedding"

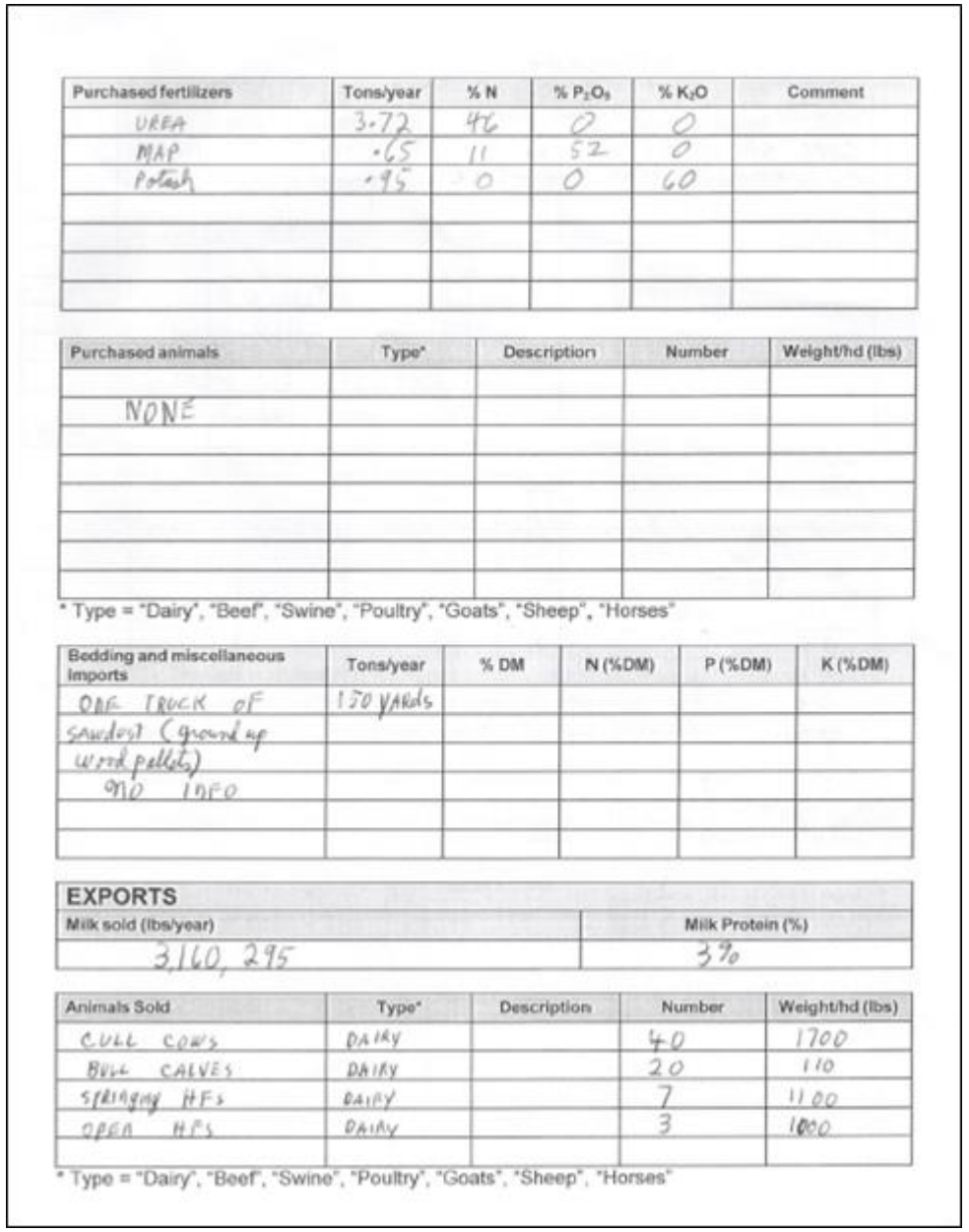
IMPORTS

Feeds (purchased)	Tons /year	% DM	CP (%DM)	P (%DM)	K (%DM)	Feed Type*	% forage (if TMR)	Inventory Beg. year (as fed tons)	Inventory Ending year (as fed tons)
Calf grain	3.25	87	20.49	.5	1.19	grain			
corn meal	180	91	9.	.6	.48	grain			
dry cow supp	9.2	90	26.78	1.96	.36	grain			
cow grain	97	89.4	36.68	.76	.76	grain			
HF grain	16	88	15.3	.52	1.03	grain			
HF mineral	8.35	97	0	.09	3.57	grain			
Milk Replacer	.67	90	20	.6	1.6	grain			
Rabbit Pellets	219	88.1	20.2	.59	.73	grain			

* Feed type = "Grain", "Forage", or "TMR"

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



Purchased fertilizers	Tons/year	% N	% P_2O_5	% K_2O	Comment
UREA	3.72	46	0	0	
MAP	.65	11	52	0	
Potash	.95	0	0	60	

Purchased animals	Type*	Description	Number	Weight/hd (lbs)
NONE				

* Type = "Dairy", "Beef", "Swine", "Poultry", "Goats", "Sheep", "Horses"

Bedding and miscellaneous imports	Tons/year	% DM	N (%DM)	P (%DM)	K (%DM)
ONE TRUCK OF	150 YARDS				
sawdust (ground up					
wood pellets)					
NO INFO					

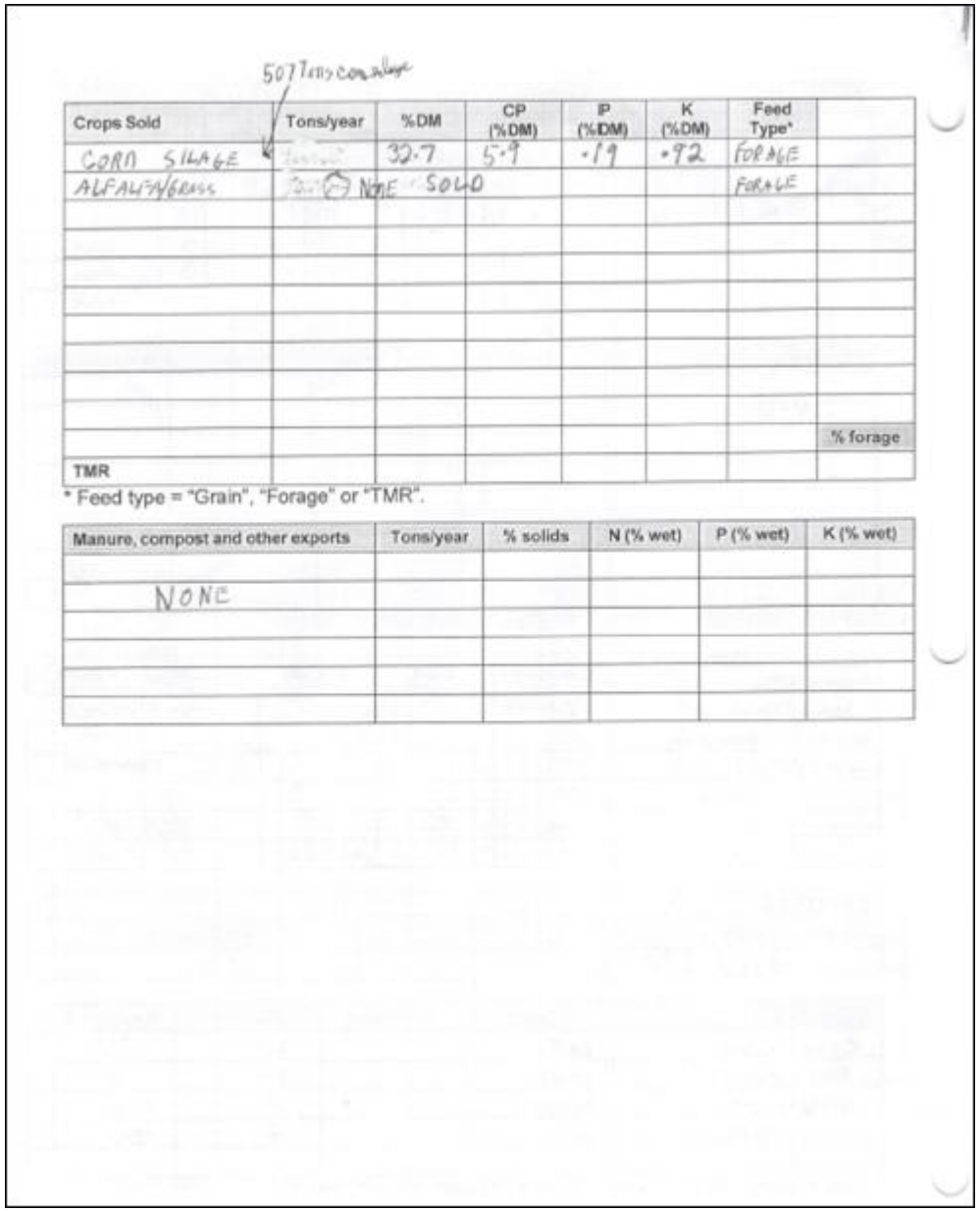
EXPORTS	
Milk sold (lbs/year)	Milk Protein (%)
3,160,295	3%

Animals Sold	Type*	Description	Number	Weight/hd (lbs)
CULL COWS	DAIRY		40	1700
BULL CALVES	DAIRY		20	110
SPRINGER HFs	DAIRY		7	1100
OPEN HFs	DAIRY		3	1000

* Type = "Dairy", "Beef", "Swine", "Poultry", "Goats", "Sheep", "Horses"

Page Three Input Sheet

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



507 Tons corn silage

Crops Sold	Tons/year	%DM	CP (%DM)	P (%DM)	K (%DM)	Feed Type*	
CORN SILAGE		32.7	5.9	.19	.92	FORAGE	
ALFALFA/GRASS		NONE SOLD				FORAGE	
							% forage
TMR							

* Feed type = "Grain", "Forage" or "TMR".

Manure, compost and other exports	Tons/year	% solids	N (% wet)	P (% wet)	K (% wet)
NONE					

Page Four Input Sheet

- Crops exported
- Manure, compost or other exports

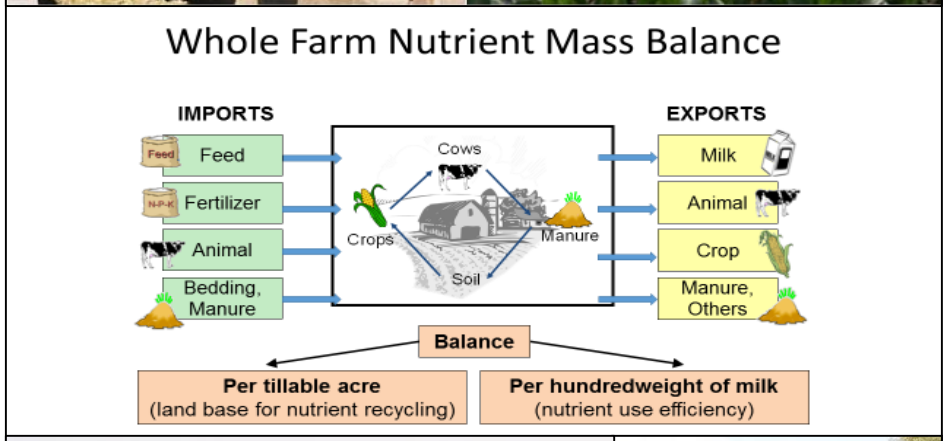
NMBs as Monitoring Tool

- Between 2004 and 2013, 570 NMBs were conducted for 189 New York dairy farms, including 91 farms (293 NMBs) in the Upper Susquehanna Watershed
- Nutrient import reductions over a decade:

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

In Summary

- The whole-farm NMB is a practical and effective nutrient indicator
- It can be used to track management, set and track goals, and to evaluate management scenarios
- Individual farms in the USW can benefit from knowing and managing their NMB
- Results make the case for improvements already implemented



Outline

- Nutrient Management Spear Program
  - Focus and mission
  - Advisory committees
- Adaptive Management
- Whole Farm Mass Balances
- New York Phosphorus Index 2.0

Background

- Early 90's: Lemunyon and Gilbert propose P index concept
- Late 90's: NRCS Nutrient Management 590 includes 3 options
  - Apply P to STP Land Grant guideline (= no P if STP > 40 lbs/acre Morgan)
  - Apply P to environmental threshold
  - Apply P based on PI
- NY accepted PI approach
- NY-PI 1.0 introduced in 2001
- User's manual published in 2003

The New York Phosphorus Runoff Index

User's Manual and Documentation

K. J. Czymmek[1], Q. M. Ketterings[2], L. D. Geohring[3], G. L. Albrecht[2]

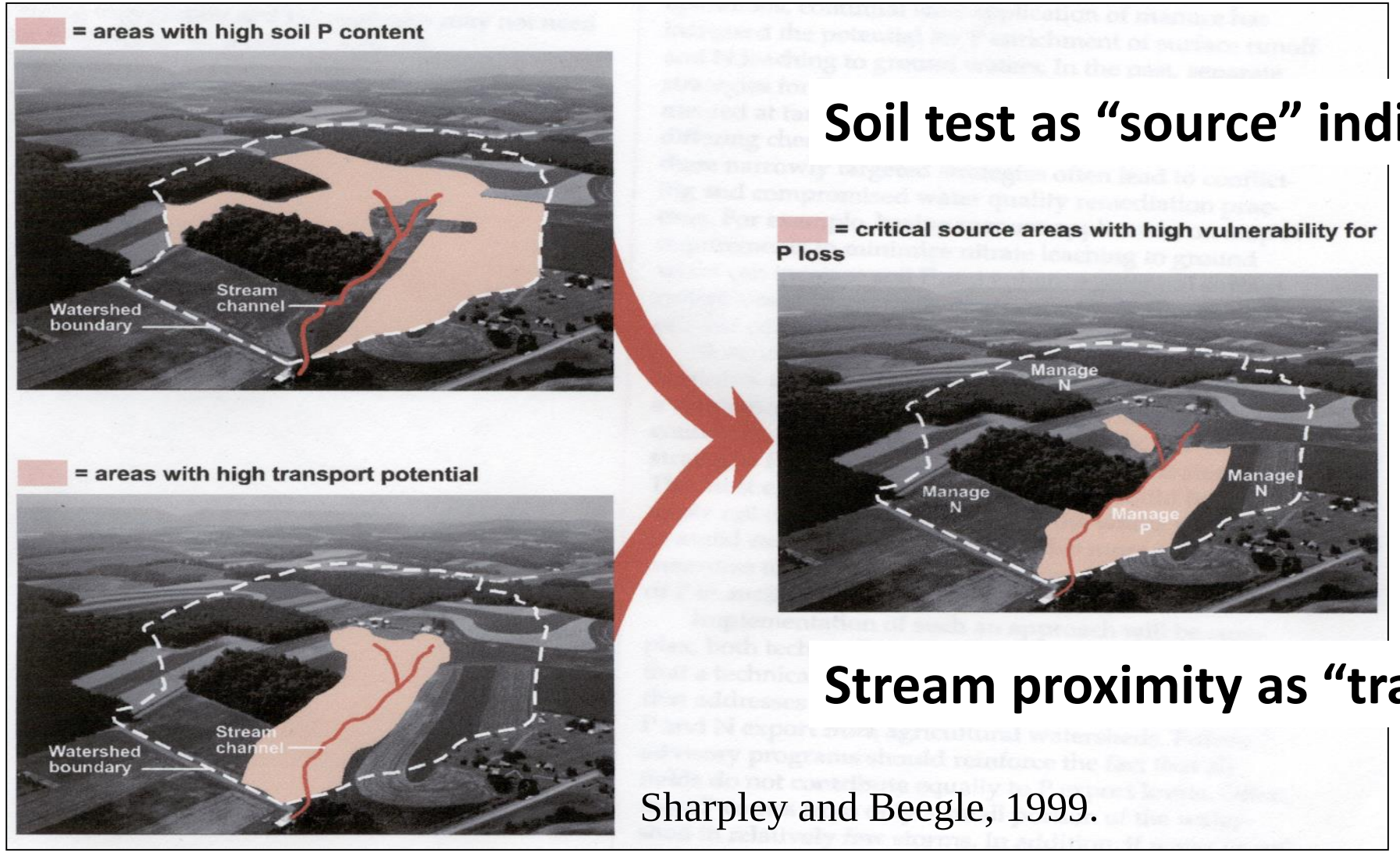
[1]ProDairy, [2]Department of Crop and Soil Sciences,
[3]Department of Biological and Environmental Engineering, Cornell University

Prepared for

New York State Department of Environmental Conservation
New York State Department of Agriculture and Markets

Cornell University, Ithaca, NY 14853, July 2003

Core Concept:



Sharpley and Beegle, 1999.

Soil test as "source" indicator.

Stream proximity as "transport" indicator.

New York P Index 1.0

Source

Soil test P (STP, Morgan test)
Manure P (Rate, Timing, Method)
Fertilizer P (Rate, Timing, Method)

Dissolved transport

- Soil drainage class
- Flow distance to stream
- Flooding frequency

Dissolved NY-PI

Particulate transport

- Erosion (RUSLE2)
- Flow distance to stream
- Flooding frequency
- Concentrated flow

Particulate NY-PI

New York P Index Introduced in 2001

Interpretation

Value	Rating	Management guidance
< 50	Low	N-based management
50 to 74	Medium	N-based management with BMPs
75 to 99	High	P applications to crop removal
> 100	Very High	No P can be applied

Issues/Opportunities Identified for v1.0

- Recognition of role of “manure/fertilizer P” versus STP
- Soil test P (STP) dominated final scores
- Allowed manure application near streams if STP was low
- Iterative process with multiple rounds of adjustments
- Implications partially hidden behind scores
- Advances in science since 2001
- Greater recognition of importance of legacy P (and the need to avoid P buildup)

NY-PI 2.0 approach

- Low, medium, high, very high
- Transport x BMP approach
- Addressed earlier STP dominance
- Incentivizes BMPs where transport risk is moderate-high
- Has a cutoff STP for land-applied P
- Includes adaptive management option

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Journal of Environmental Quality SPECIAL SECTION

THE EVOLVING SCIENCE OF PHOSPHORUS SITE ASSESSMENT

Restructuring the P Index to Better Address P Management in New York

Quirine M. Ketterings,* Sebastian Cela, Amy S. Collick, Stephen J. Crittenden, and Karl J. Czymmek

Abstract

The New York Phosphorus Index (NY-PI) was introduced in 2001 after the release of the state's first Concentrated Animal Feeding Operation (CAFO) Permit that required a nutrient management plan developed in accordance with NRCS standards. The stakeholder-based approach to development of the NY-PI, combined with a requirement for all regulated farms to determine a NY-PI score for all fields, ensured widespread adoption. While P management greatly improved over time, the initial NY-PI overemphasized soil-test P (STP), allowing for P addition if STP was low, even if the risk of P transport was high. Our goal was to develop a new PI approach that incentivizes implementation of best management practices (BMPs) where P-transport risk is high, building on feedback from certified planners (survey), analysis of a planner-supplied 33,000+ field database with NY-PI information, and modeling of the impacts of specific BMPs on P runoff using data from a central NY CAFO farm. We propose a new NY-PI structure that identifies landscape-driven P-transport risk if P is surface applied when crops are not actively growing to reach a raw PI score that is multiplied by credits (factors $\leq$ 1.0) for implementation of BMPs effective in reducing the risk of P transport. In this "Transport × BMP" approach, STP is used as P application cutoff. This approach could reduce barriers to regionalization of PIs, as states can identify landscape risk factors, soil-test cutoffs, and BMPs while maintaining the same management categories (no manure, P-removal-based rates, or N-based management).

Core Ideas

- Stakeholder engagement is essential to develop improved Phosphorus Indices (PIs).
- A "Transport × BMP"-based PI incentivizes BMP use where risk of P transport is high.
- In a "Transport × BMP"-based PI, soil-test P sets rate limits to enhance P balances.
- A "Transport × BMP"-based PI can reduce barriers to regionalization of PIs within watersheds.

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*Corresponding author (qmk2@cornell.edu).

THE first New York Phosphorus Index (NY-PI), released in 2001, aimed to reduce P runoff risk by scoring fields for relative risk of P runoff to meet the NRCS 590 standard and to incentivize best management practices (BMPs) that are effective in reducing P runoff across the farm (Czymmek et al., 2003). In New York, the Concentrated Animal Feeding Operation (CAFO) Permit requires regulated farms to have a comprehensive nutrient management plan (CNMP) addressing fertilizer and manure management, prepared in accordance with the NRCS 590 standard (USDA-NRCS, 2013). As a result, all CAFOs, as well as animal feeding operations receiving state or federal cost-share funds for a nutrient management plan (NMP), have been required to have a NY-PI score for all fields on the farm since 2001.

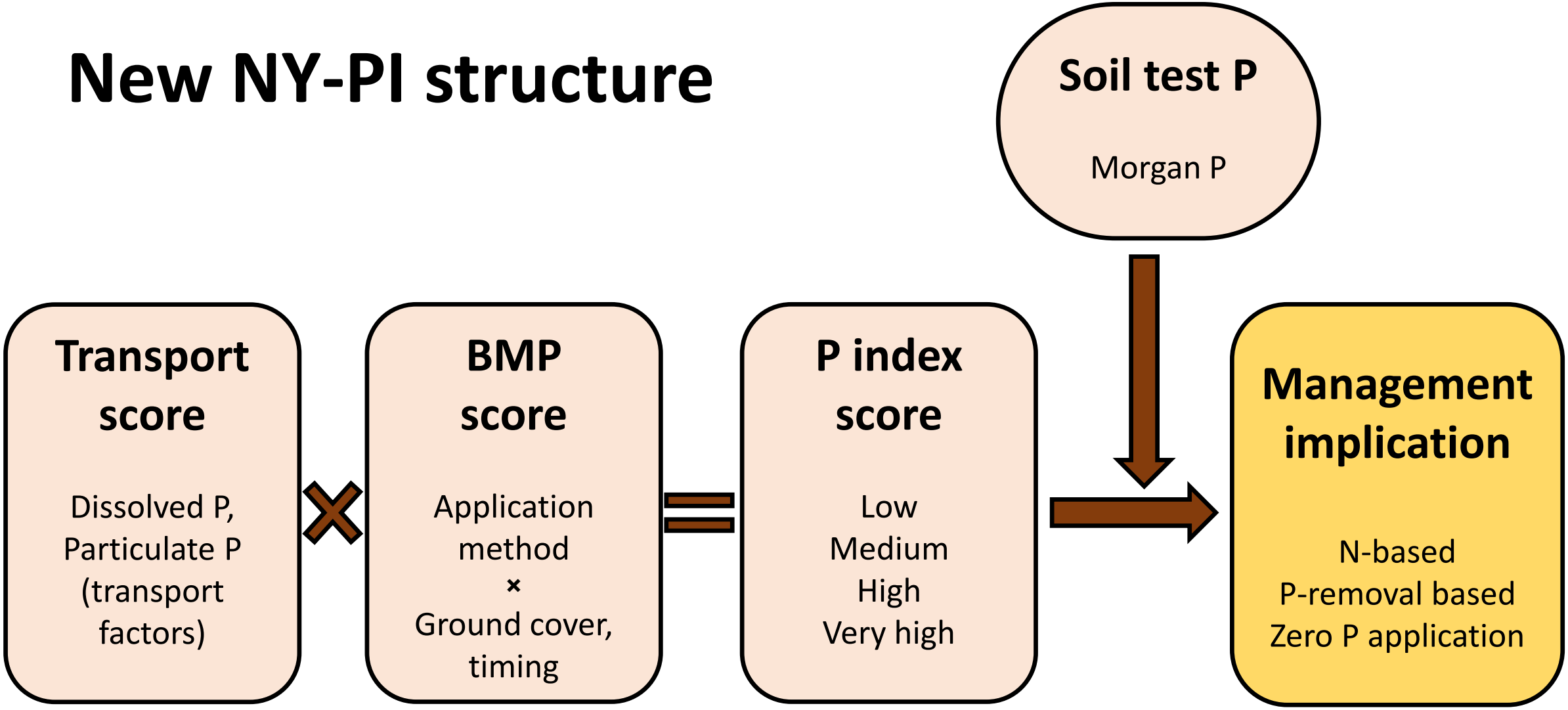
The original PI, devised by Lemunyon and Gilbert (1993), was an applied assessment tool used to identify agricultural fields most vulnerable to P loss by accounting for the major source and transport factors controlling P movement. The short-term objectives included (i) development of a procedure to assess the risk for P leaving "the landform site" and traveling toward a water body, (ii) development of a method that allows users to identify critical parameters that most strongly influence the PI, and (iii) to select management practices that could significantly reduce P loss (Lemunyon and Gilbert, 1993). Primary users were envisioned to be NRCS field staff and resource planners working with farmers. As such, the PI was designed to be used by planners to affect field-based manure and P fertilizer management.

The original PI assigned a weighing factor to eight "landform site characteristics," including soil erosion (1.5), irrigation erosion (1.5), runoff class (0.5), soil-test P (STP, 1.0), P fertilizer application rate (0.75), P fertilizer application method (0.5), organic P source application rate (1.0), and organic P source application method (1.0). Each site characteristic was described in terms of "level" using a rating system with a base of 2, with low = 1, medium = 2, high = 4, and very high = 8). The final PI score was obtained by selecting a level for each site characteristic, multiplying the score for that specific level by the weighing factor for the site characteristic, and then adding all scores. Site vulnerability ratings were low (<8), medium

Q.M. Ketterings, S. Cela, and S.J. Crittenden, Nutrient Management Spear Program, Dep. of Animal Science, Cornell Univ., Ithaca NY; A.S. Collick, Dep. of Agriculture, Food, and Resource Sciences, Univ. of Maryland Eastern Shore (UMES), Princess Anne, MD; K.J. Czymmek, PRO-DAIRY and Nutrient Management Spear Program, Dep. of Animal Science, Cornell Univ., Ithaca NY. Assigned to Associate Editor Andrew Sharpley.

Abbreviations: BMP, best management practice; CAFO, concentrated animal feeding operation; CBW, Chesapeake Bay Watershed; CNMP, comprehensive nutrient management plan; HRU, hydrologic response unit; NMP, nutrient management plan; NY-PI, New York Phosphorus Index; PI, phosphorus index; STP, soil-test phosphorus; SWAT, Soil and Water Assessment Tool; TI, topographic index; USW, Upper Susquehanna Watershed.

New NY-PI structure



New NY-PI Structure

P loss risk	PI score	Cornell Morgan-extractable soil test P (lbs P/acre)			
		< 40	40-100	100-160	> 160
Low	< 50	N-based	N-based	P-based	Zero P
Medium	50 to 74	N-based	P-based	Zero P	Zero P
High	75 to 99	P-based	P-based	Zero P	Zero P
Very High	> 100	Zero P	Zero P	Zero P	Zero P

NY-PI 2.0 Structure

Transport factors

- Flow distance to intermittent or perennial stream
- Flooding frequency
- Presence/absence of concentrated flow
- Soil hydrologic group
- Soil loss estimate
- Presence or absence of vegetated buffers ***outside of the field***

Beneficial management practices

Method of application

- Setbacks (100’ or 35’ grass)
- Incorporation or injection

Ground coverage/timing

- Bare ground within 2 weeks of planting
- Winter hardy cover crops
- Whole plant corn residue
- Sod after last cutting
- Growing sod or row crop/planting green

NY-PI 2.0 structure

Transport score

Dissolved P, Particulate P (transport factors)

Transport factors (DP score = FD + FF + CF + HG_{DP} + VB_{DP}; PP score = FD + FF + CF + HSG_{PP} + E + VB_{PP})					
Factor	Option	Coefficient	Factor	Option	Coefficient
Flow distance (FD) to first intermittent or perennial stream in ft	> 500	0	Hydrologic Soil Group (HSG)	A	DP: 0 PP: 0
	300-500	4		B	DP: 4 PP: 1
	100-300	6		C	DP: 6 PP: 3
	≤ 100	8		D	DP: 8 PP: 5
Flooding frequency (FF)	Never	0	Erosion $(E)^2$ in ton/acre	≤ 1	0
	Occasionally	2		1-3	1
	Frequent	5		3-5	3
Untreated concentrated flow (CF)	Absent	0		> 5	5
	Present	4	Vegetated buffer (VB)	Absent	0
				Present	DP: -2 PP: -4

Erosion determined by the RUSLE2 A-factor

NY-PI 2.0 structure

BMP score

Application method
×
Ground cover, timing

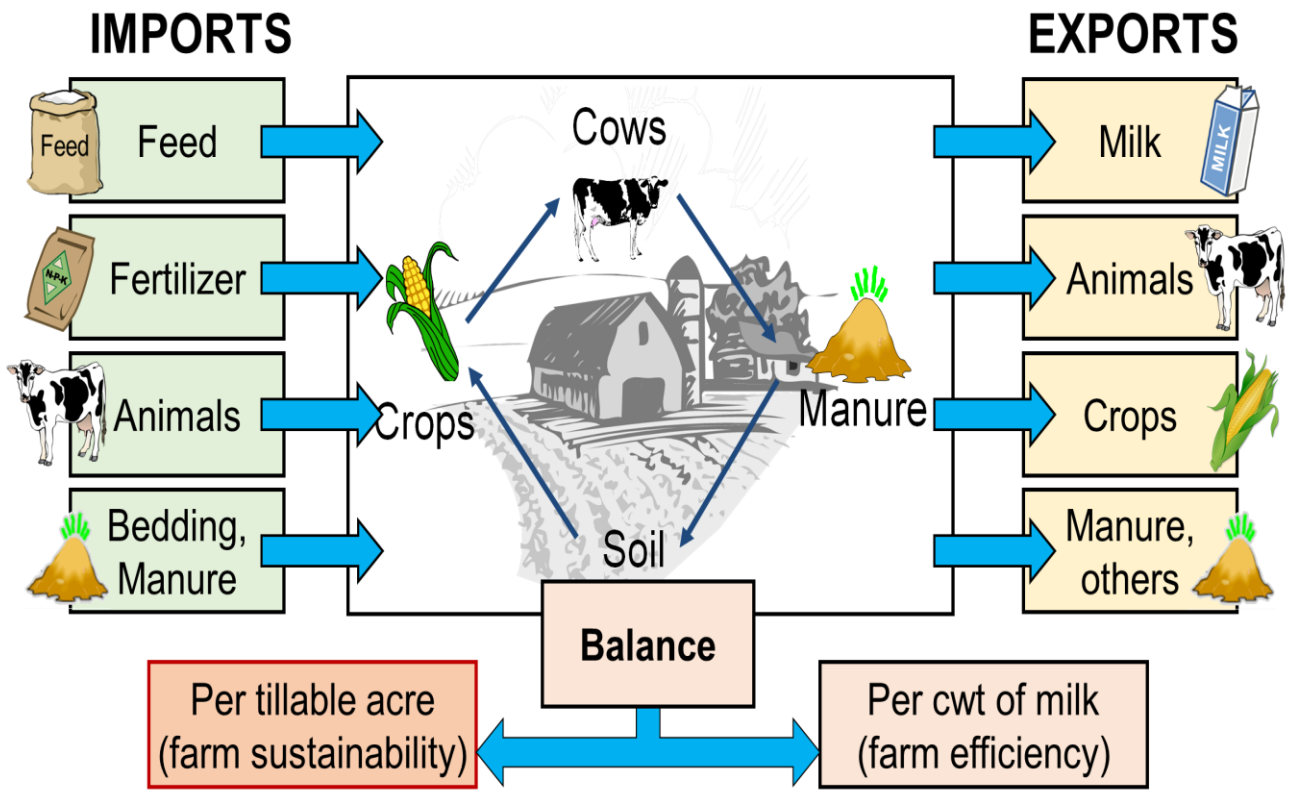
Table 3: Best/beneficial management practices of the NY-PI 2.0.

Best/beneficial management practices (BMP score = method × ground cover and timing score)	
Method of applications	Coefficient
Surface spread without setback	1.0
Surface spread with 100-ft setback from down-gradient surface waters†	0.8
Surface spread with 35-ft managed vegetative (sod/harvested) setback from down-gradient surface waters†	0.7
Incorporation (within 24 h and with 15-ft setback from down-gradient surface waters)	0.7
Injection (with 15-ft setback from down-gradient surface waters)	0.5
Ground cover and timing	
Bare ground and more than 2 weeks before planting	1.0
Bare ground and within 2 weeks of planting (in spring)	0.8
Winter-hardy cover crop (fall/winter)	0.8
Whole-plant corn residue (fall/winter)	0.7
Sod after last cutting (fall/winter)	0.6
Growing sod or row crop/planting green	0.5

† Only for fields with FD ≤ 500 ft.

Adaptive management option

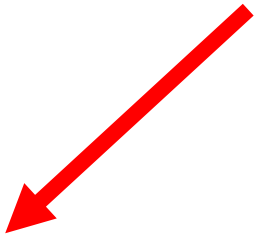
"Farms with a whole-farm P mass balance (3-yr running average) **at or below 12 lbs P/acre** can apply manure at N-based rates on fields with STP < 100 lbs P/acre, even if the initial NY-PI 2.0 score limits rates to P-based, as long as the selected BMPs to get to a P-based score are implemented."



Adaptive Management Option

- For farms with a feasible whole-farm P balance per acre (≤ 12 lbs/acre), additional room to spread manure:

P transport risk	PI score	Cornell Morgan-extractable soil test P (lbs P/acre)			
		<40	40-100	100-160	>160
Low	<50	N-based	N-based	P-based	Zero
Medium	50 to 74	N-based	P-based	Zero	Zero
High	75 to 99	P-based	P-based	Zero	Zero
Very High	>100	Zero	Zero	Zero	Zero



P transport risk	PI score	STP (lbs P/acre)			
		<40	40-99	100-160	> 160
Low	<50	N-based	N-based	P-based	Zero
Medium	50 to 74	N-based	N-based	Zero	Zero
High	75 to 99	N-based	N-based	Zero	Zero
Very High	>100	Zero	Zero	Zero	Zero

Conclusion

"The new transport × BMP approach, combined with the whole-farm P balance adaptive management option to reduce farm P surplus, effectively incentivizes use of BMPs in fields with high transport risk, while creating flexibility with manure application rates where transport risk is low and STP is less than 100 lbs P/acre (Morgan)"

What's Next?

- Further in-field evaluations this winter
- Working on extension materials (manual, articles, talks, training materials, field walks, etc.)
- Continued communication/ comparisons with other states
- Implementation based on CAFO permit/regulatory agency
- NYSDEC will decide when to implement NY-PI 2.0

Outline

- Nutrient Management Spear Program
  - Focus and mission
  - Advisory committees
- Adaptive Management
- Whole Farm Mass Balances
- New York Phosphorus Index 2.0

Feedback, Questions?