

NRCS CONSERVATION INNOVATION GRANT
Final Report (Submitted 12-7-2022)

Grantee Name: Quirine Ketterings
Revising and implementing phosphorus indices to protect water quality in the northeastern US.
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1. Project Summary (1/2 page):

The Phosphorus Index (PI) is one of the principal nutrient planning and risk assessment tools addressing P related water resource concerns under the NRCS 590 Nutrient Management Conservation Practice Standard. The goal of this USDA-NRCS CIG project to was evaluate a new PI approach for adoption in the Northeastern United States. The improved PI approach included as a first step the identification of inherent landscape risk of P transport if P is applied (“transport”), to reach a field-specific raw PI score that is then modified by credits for implementation of beneficial management practices (“BMPs”) to reduce P loss risk. This transport x BMP approach allows farmers and farm planners to identify fields with the greatest risk of P loss from manure or fertilizer *if applied*, and then better incentivize BMPs such as incorporation or injection of manure, manure spreading setbacks, application to ground with cover (crop residue, cover crops, planting green) and timing of application closer to crop nutrient uptake, for reduced P loss from agricultural fields. We worked with dairy farms and nutrient management planners across the region to design, set coefficients, and evaluate suitability of the new approach across the Northeast region. We combined stakeholder input (data sharing and feedback sessions), modeling-based evaluations of the most relevant BMPs, and assessment of whole farm P balances and manure spreading options for commercial dairy farms, to develop the first Northeast Region PI, now adopted for use by NRCS in NY, CT, MA, ME, NH, and RI, (<http://nmsp.cals.cornell.edu/publications/extension/NortheastPIIndexUserGuide.pdf>) and also incorporated into state permits for concentrated animal feeding operations. In addition to creating the first regional P loss risk assessment tool, this project produced the following outputs:

- 7 published journal articles
- 2 User Manuals (New York and Northeast Regional)
- 3 Software tools
- 5 Agronomy Fact Sheets
- 8 oral presentations at scientific meetings
- 13 extension workshops/trainings on how to use the tool
- 7 extension publications

2. Project Goal and Objectives (1/2 page):

The project involved three organizing objectives designed to ensure that development of the new Northeast Region PI was grounded in the best available science, reflected local conditions and

concerns, and anticipates impacts to water quality and farm management.

1. Revise state P Indices, improving their ability to identify fields with high risk of P loss if manure or P fertilizer is applied, and their ability to incentivize implementation of beneficial management practice for manure and/or fertilizer P application, promoting a consistent approach across state boundaries and effective recommendations for P management.
2. Predict the management impact of P Indices (existing and refined) on nutrient management practices and water quality.
3. Coordinate efforts with SERA-17, other USDA-CIGs, and NRCS.

3. Project Background (1/2 page):

Our primary objective was evaluation and implementation of a revised PI approach to protect water quality in the Northeast region. The P Index is one of the principal nutrient planning and risk assessment tools under NRCS's 590 Nutrient Management and almost all states have adopted a PI approach to assess field vulnerability to P loss and target nutrient management practices that reduce P loss. Despite widespread adoption of the P Index and progress made, concerns remained about the effectiveness of several PIs in (1) ranking fields for relative risk of P runoff, and (2) steering farmers and planners to implement BMPs that reduce P loss risk across diverse landscapes. In addition to the need to re-evaluate approaches, there was also a clearly voiced desire by planners and farmers to evaluate P indices across state boundaries and to evaluate the development and implementation of a more regional approach. Scientists within the Southern Extension-Research Activity Group 17 (SERA-17) have worked closely with NRCS to revise the 590 Nutrient Management Standard (Sharpley et al., 2011; 2012) and to promote evaluation, coordination and revision of P Indices across much of the USA. In 2012, three regional consortia were formed, each preparing USDA-CIG proposals to evaluate, assess, validate, and, where appropriate, refine P Indices in the Heartland, Chesapeake Bay, and Southern Regions. One outcome of the 2012 grant for the Chesapeake Bay Watershed included a new approach to P loss assessment proposed by NY, where "source x transport" (the original P index approach) is replaced by a landscape-based assessment of transport risk under worst-case scenarios (surface application to bare ground) multiplied by a BMP reduction, incentivizing implementation of BMPs that are effective in reducing risk of P loss for the most risky fields on the farms. This approach, hereafter referred to as "transport x BMP", was shared with partners at regional meetings and the annual SERA17 meeting in 2015. Transport x BMP offers a potential path toward a regional overall P index approach across the Northeastern regions. It allows for identification of local, landscape specific, factors to describe inherent transport risk in each of the states, watersheds, and physiographic regions, and incentivizes regionally relevant BMPs. Here we proposed to combine a stakeholder-engagement based approach to evaluation of P management approaches and whole farm and farm-level assessments with watershed modeling to explore the development of a Northeast Region PI.

4. Project Methods (1/2 page):

The initially proposed revised P index structure was evaluated with (1) a database of 33,000+ individual farm fields with P index information from NY; and (2) a database including 18 farms with 2 years of whole farm P balance and P index information from NY, three farms from VT, and two from ME. The first database was used to identify appropriate factors and settings for the

proposed new landscape x BMP approach. For each case study farm in NY in the second dataset, the impact of implementation of the revised approach was assessed. These evaluations resulted in some changes in both landscape factors and coefficients of the new PI, as well as soil test cutoffs for manure application applicable across the region. Results were presented to the farms and discussed with farmers and farm consultants, through stakeholder meetings, resulting in a revised P index for NY that was presented and released for use for nutrient management planning in December of 2019 at the Northeast Region Certified Crop Advisor Training.

We worked with the modelers on the team in Virginia Tech and the University of Maryland Eastern Shore to complete modeling runs of BMPs for three watersheds (PA, NY, and VT). Prior to the first modeling runs, the team had monthly meetings to define the list of BMPs to model and set location specific parameters. This assessment was done to identify common trends in impact of BMPs across the region and ensure directional correctness of BMPs incentivized in the new Northeast Region PI.

From start to finish, the project included numerous team Co-PI meetings, stakeholder meetings to share initial finding, receive feedback, and evaluate potential areas for confusion or contradiction, and individual nutrient management planning firms and farms. The new PI was officially released for use by planners in New York in fall of 2019, and the focus after this release was on evaluation of the same approach across New England states. Two consulting firms were involved in evaluation of the impact of the new PI across farms in the region.

Progress on the project and development of the Northeast Region PI was reported annually in regional and national meetings including the Northeast Region Certified Crop Advisor Annual Conference, SERA17 meetings, ASA/SSSA/CSSA annual meetings, and the USDA Showcase event of the Soil and Water Conservation Society Annual Conference in 2021. These presentations facilitated discussion among peers beyond the Northeastern region.

5. Project Results (5-7 pages):

This project has two main results of practical and regional importance, currently implemented:

- (1) In fall of 2019, the NY-PI 2.0 was released for use in New York, replacing the first, source x transport-based PI 1.0 that had been in place in NY since 2001. For the manual, see http://nmsp.cals.cornell.edu/publications/extension/NYPI_2_User_Manual.pdf. Under state regulations for concentrated animal feeding operations, planners have three years to fully implement the new PI 2.0 by September 2025. Additionally, New York NRCS updated their guidance the plans funded under cost-share incentive programs like EQIP should use the new PI 2.0 starting in 2023.
- (2) In September of 2022, NRCS and partners in CT, ME, MA, CT, NH and RI agreed to implement the first ever Northeast Region PI, based on the same approach as had been implemented in NY, but with adjustments where needed to accommodate differences in soil test P methods across the states. Each of the states also formulated a state-specific drawdown strategy for farms that have maximized their spreading base and exhausted feasible export options. For the User's Guide of the Northeast Region PI, see: <http://nmsp.cals.cornell.edu/publications/extension/NortheastPIIndexUserGuide.pdf>

Both documents reflect many years of research with findings documented in a series of journal articles and extension documents, including fact sheets (see outputs below), and a large number of meetings with stakeholders, and training sessions for nutrient management planners.

The research showed the importance of ranking and selecting the right fields (high risk fields) and incentivizing implementation of BMPs that can significantly reduce P loss risk from agricultural land. The Northeast Region PI reflects this recognition by utilizing a transport x BMP approach. The new PI also incentivizes checks on soil test P levels, where options for manure applications are reduced or eliminated once soil test P levels reach threshold values. For a schematic of the structure of the PI, see Figure 1.

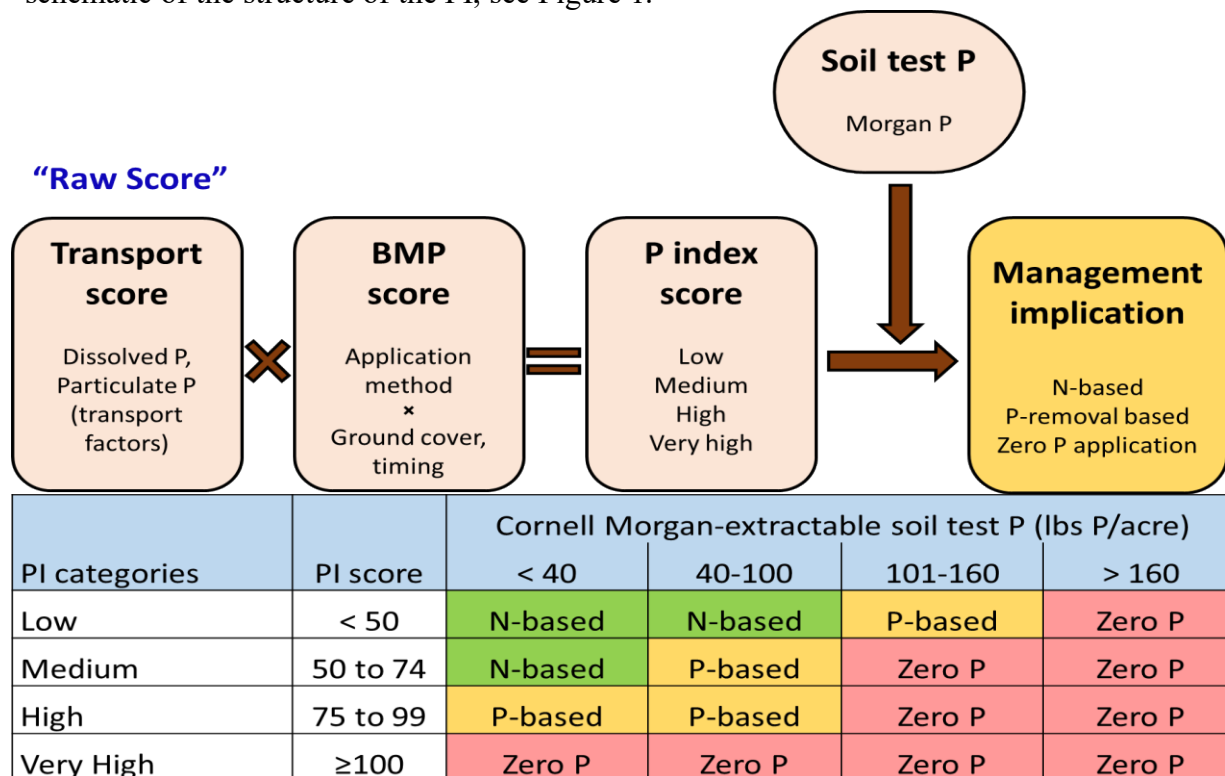


Figure 1: The transport x beneficial management practice (BMP) approach first introduced in the NY-PI 2.0 and now adopted for use in the Northeast Region PI, ensures identification of high-risk fields, incentivizing of manure and fertilizer P related BMPs, and limits applications to soils that exceed a threshold soil test P.

The transport score of a field is determined by taking into account flow distance from the edge of the field to a stream, vegetation in that flow path, flooding frequency, hydrologic soil group, annual erosion and presence or absence of concentrated flows (Figure 2). The BMP list includes options for method of application (manure spreading setbacks, incorporation or injection of manure) and ground cover and timing (applying close to crop nutrient needs, planting cover crops, application to crop residues, on sod after last cutting or on growing sods or growing row crops, including planting green). The obtain credits for BMPs, the score for method of application is multiplies times the score for ground cover and timing (Figure 3).

Determination of a Field PI Score

Transport score
Dissolved P, Particulate P (transport factors)

Dissolved P (DP score)=
 $10 * [FD + VFD_{DP} + FF + HSG_{DP} + CF]$

Particulate P (PP score)=
 $10 * [FD + VFD_{PP} + FF + HSG_{PP} + E + CF]$

Factor	Option	Coefficient	
Flow distance (FD) to stream in ft	> 500	0	
	301-500	4	
	101-300	6	
	≤ 100	8	
Vegetated flow distance (VFD) ¹	<35 ft	0	
	≥35 ft	DP: -2	PP: -4
Flooding frequency (FF)	Never	0	
	Occasionally	2	
	Frequent	5	
Hydrologic soil group (HSG)	A	DP: 0	PP: 0
	B	DP: 4	PP: 1
	C	DP: 6	PP: 3
	D	DP: 8	PP: 5
Erosion (E) in ton/acre ²	≤ 1.0	0	
	1.1-3.0	1	
	3.1-5.0	3	
	> 5.0	5	
Concentrated flow (CF)	None/treated	0	
	Present	4	

¹Only for fields with FD ≤ 500 ft; RUSLE2 A-value (yearly).

Figure 2: Determination of the raw (pre-BMP) transport score for dissolved P and particulate P.

BMPs – Select One from Each List and Multiply

BMP score
Application method × Ground cover, timing

Method of application	
Surface spread without setback	1.0
Surface spread with ≥100-ft setback from the field boundary (start of the predominant flow path) ¹	0.8
Surface spread with ≥35-ft managed vegetated (sod/harvested) setback from the field boundary (start of the predominant flow path) ¹	0.7
Incorporation within 24 h 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 crop residue (~80% or more ground cover, e.g. corn grain)	0.7
Sod after last cutting (fall/winter)	0.6
Growing sod or row crop/planting green	0.5

¹Only for fields with FD ≤ 500 ft.

Figure 3: The beneficial management practices (BMP) score is derived by multiplying a score for method of application times a score for ground cover and timing.

There are two areas where state specific adjustments needed to be made. This include cutoffs for soil test P levels for NH where the Mehlich-3 test is the main test versus Morgan in NY and Modified Morgan in the other states. The states that use the Modified Morgan Test opted to retain the same soil test P cutoffs as used in NY (Morgan test), while NH opted to use P saturation based on P and Al+Fe, with 11, 23 and 35% as the cutoffs.

The second area of state specificity in the Northeast Region PI was for incidental manure application. All states that this should only apply when the farm has maximized their spreading base and exhausted feasible export options (Figure 4).

When a farm has maximized their spreading base and exhausted feasible export options, i.e. adding hay land or more distant crop fields that were not previously spread, land application of manure to fields with STP over 100 lbs P/acre Morgan (NY) or Modified Morgan (ME, MA, RI and CT), and 23% Psat (NH) is permitted given the NE-PI score for the field is <100; crops are harvested from the field; and the following conditions apply:

For NY:

- The farm does not import any manure from off-farm sources.
- The manure source is treated effluent (P₂O₅ equivalent is less than 1 pound per thousand gallons) or a very dilute source (full collection of high flow bunk runoff).
- Applied material must have attributes that provide other benefits to crop yield and therefore increase P removal, such as supplying irrigation water and/or N.
- A P drawdown plan is implemented by farm management and their AEM certified planner in accordance with the following:
 - Phosphorus application rates are limited to the lesser of 20 lbs P₂O₅/acre or 25% of crop removal.
 - This plan includes annual soil testing to monitor P levels and, over time, demonstrate a decreasing trend in soil test P
 - Track the whole-farm nutrient mass balance (NMB) to ensure that P is being managed optimally across the farm (at or below 12 lbs P/acre).

For ME, MA, and NH:

- The farm does not import any manure from off-farm sources.
- Applied material must have attributes that provide other benefits to crop yield and therefore increase P removal, such as supplying irrigation water and/or N.
- A P drawdown plan is implemented by farm management in accordance with the following:
 - Phosphorus application rates are limited to:
 - < 50% of crop removal for STP >160 lbs/acre (35% Psat for NH).
 - < 75% of crop removal for STP 101-160 lbs/acre (23-35% Psat for NH).
 - The plan includes soil testing every other year to monitor P levels and, over time, demonstrate that P levels are decreasing over time.

For CT:

- The farm does not import manure or other P containing materials such as biosolids or compost from off-farm, sources and does not apply P fertilizer
- Applied material must have attributes that provide other benefits to crop yield and therefore increase P removal, such as supplying irrigation water and/or N.
- A P drawdown plan is implemented by farm management in accordance with the following:
 - < 50% of crop removal for STP >160 lbs/acre.
 - < 75% of crop removal for STP 101-160 lbs/acre.
 - < 90% of crop removal for up to three years if 50 or 75% of crop removal does not allow the farm to allocate all on-farm generated manure, while other options are implemented including one or more of the following:
 - Reduce animal numbers on the farm.
 - Increase exports of manure or nutrient products off the farm.
 - Use Cornell's NMB software and manage the farm's annual P balance (3-year average) at or below 12 lbs P/acre.
 - The plan includes soil sampling every 3 growing seasons or less and keeping at least three consecutive results (3-9 years) at all times to show STP trend over time. If STP results for fields under incidental P application are static or increase over time, a nutrient management planner should be contacted to justify or adjust the drawdown plan.

For RI:

- Seek guidance from the NRCS-RI Nutrient Management Specialist.

Figure 4: Incidental P application for six states that adopted the Northeast Region P Index.

6. Project Outputs (1 page):

This project contributed to the scientific literature, generated extension articles including fact sheets, workshops and software tools:

Published journal articles:

1. Ros, M., O. Godber, A. Olivo, K. Reed, and Q.M. Ketterings (2022). Key nitrogen and phosphorus performance indicators derived from farm-gate mass balances on dairies. *Journal of Dairy Science* (*in press*).
2. Battaglia, M.L., Q.M. Ketterings, G. Godwin, and K.J. Czymmek (2021). Conservation tillage is compatible with manure injection in corn silage systems. *Agronomy Journal* 113: 2900-2012. <https://doi.org/10.1002/agj2.20604>
3. Ros, M.B.H., K.J. Czymmek, and Q.M. Ketterings (2020). Combining field phosphorus (P) runoff risk assessments with whole-farm P balances to guide manure management decisions. *Journal of Environmental Quality* 49:496–508. <https://doi.org/10.1002/jeq2.20043>.
4. Ros, M.B.H., Q.M. Ketterings, S. Cela, and K.J. Czymmek (2019). Evaluating management implications of the New York Phosphorus Index with farm field information. *Journal of Environmental Quality* 48:1082–1090. doi:10.2134/jeq2019.01.0010
5. Ketterings, Q.M., S. Cela, A. Collick, S. Crittenden, and K.J. Czymmek (2017). Restructuring the P index to better address P management in New York. *Journal of Environmental Quality* 46:1372–1379. doi:10.2134/jeq2016.05.0185.
6. Crittenden, S., Q.M. Ketterings, and K.J. Czymmek (2017). Soil phosphorus saturation ratio sets comparable manure application cutoffs across states differing in agronomic soil test. *Soil Science* 182: 36-44. doi: 10.1097/SS.0000000000000192.
7. Cela, S., Q.M. Ketterings, M., Soberon, C. Rasmussen, and K.J. Czymmek (2017). Upper Susquehanna watershed and New York State improvements in nitrogen and phosphorus mass balances of dairy farms. *Journal of Soil and Water Conservation* 27:1-11. doi: 10.2489/jswc.72.1.1.

Articles submitted but not yet accepted for publication:

1. Janata, B., S. Gami*, and Q.M. Ketterings (submitted). Assessing the impact of mixing acid whey with dairy manure on pH and nitrogen dynamics during manure handling. *Journal of Soil Science and Plant Nutrition* (*in review*).
2. Battaglia, M., M. Ros, Z. Easton, A. Collick, J. Faulkner, M. Berbero, C. Twombly, D. Fuka, K.J. Czymmek and Q.M. Ketterings (submitted). *Agrosystems, Geosciences & Environment* (*in review*).

Posters at scientific meetings:

1. Ketterings, Q.M., K.J. Czymmek, M. Ros, M. Battaglia, D. Beegle, P. Kleinman, J. Faulkner, J. Carter, A. Collick, Z. Easton, M. Hashemi and T. Morris (2021). Revising and Implementing Phosphorus Indices to Protect Water Quality in the Northeastern US. USDA-CIG Showcase Poster. Soil and Water Conservation Society 2021 Annual Conference. Virtual July 26-28, 2021.
2. Ros, M.B.H., K.J. Czymmek and Q.M. Ketterings (2018). [Linking the New York Phosphorus Index with Whole-Farm Phosphorus Balances](#). ASA/SSSA/CSSA Annual Meeting, November 4-7, 2018. Baltimore, Maryland. Abstract and Poster.

3. Ros, M.B.G., S.J. Crittenden, S. Cela, K.J. Czymmek and Q.M. Ketterings (2018). Setting targets for the phosphorus index using whole-farm phosphorus balances. Sustainable Dairy Systems 2018, 3rd Annual Cornell Dairy Center of Excellence Symposium presented in partnership with The David R. Atkinson Center for a Sustainable Future. Ithaca NY. February 22, 2018. Short presentation and poster.
4. Ros, M.B.G., S.J. Crittenden, S. Cela, K.J. Czymmek and Q.M. Ketterings (2017). [Setting Targets for the Phosphorus Index Using Whole-Farm Phosphorus Balances](#). ASA/SSSA/CSSA Annual Meeting, October 25, 2017. Tampa, Florida. Poster and abstract.

Cornell Agronomy Fact Sheets (<http://nmsp.cals.cornell.edu/guidelines/factsheets.html>):

1. # 28: Phosphorus Removal by Field Crops (7/21/2007; updated 2/3/2020)
2. #106: Determining an Average Soil Test P or pH value from Grid Samples for Nutrient Management Planning (6/25/2019)
3. #110: The New York Phosphorus Index 2.0 (2/5/2020; updated 10/30/2021)
4. #115: Hydrologic Soil Group (12/8/2021)
5. #117: How to Use Grid Soil Sample Results for the NY-PI 2.0 (1/7/2022)

Extension documents and software:

1. Northeast Region PI User's guide: <http://nmsp.cals.cornell.edu/publications/extension/NortheastPIIndexUserGuide.pdf>
2. Zoom-based Training Session for NY: [NY-PI 2.0 Training Session](#)
3. Educational Tool: [Downloadable P-Index Calculator for NY-PI 2.0](#).
4. NY-PI 2.0 User manual: [The New York Phosphorus Runoff Index 2.0 User's Manual and Documentation](#) (2020 with updates in 2021 and 2022)
5. Extension article: [Manure Injection for Corn Silage in Conservation Till, Strip Till and No-Till Conditions](#). What's Cropping Up? (2021)
6. Extension article: [The New York Phosphorus Runoff 2.0 Index. What's Cropping Up? Article](#) (2020)
7. A software tool accessible at: <http://nmsp.cals.cornell.edu/software/pindex.html>
8. Two e-Leader Announcements: [A New York Phosphorus Index for NY: Part 2: How the P Index Works](#), and [A New York Phosphorus Index for NY: Part 1: What Farmers Need to Know](#).
9. Popular press article: [Northern NY farms add data to NY Phosphorus Index 2.0 | Morning Ag Clips](#).

Oral presentations at scientific meetings:

1. Ketterings, Q. M. (2022) Engaging Stakeholders for Development of a Regional Phosphorus Index in the Northeast. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD. <https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/144179>. 15 min, ~25 people.
2. Ketterings, Q.M., M. Battaglia, M. Contessa, and K.J. Czymmek (2021). Field Identification and BMP Selection for Determination of Rates of Manure Application Based on the NY-PI 2.0. 2021 ASA/SSSA/CSSA Annual Meeting. Salt Lake City, UT. November 7-10, 2021. 15 min. ~20 participants.

3. Ketterings, Q.M., K.J. Czymmek, M. Ros, M. Battaglia, D. Beegle, P. Kleinman, J. Faulkner, J. Carter, A. Collick, Z. Easton, M. Hashemi and T. Morris (2021). A New Transport x BMP-Based Phosphorus Index Approach for Identifying Fields with a High Risk of P Loss and Selection of BMPs for Manure Management Across the Northeastern US. USDA-CIG Showcase Oral Presentation. Soil and Water Conservation Society 2021 Annual Conference. Virtual July 26-28, 2021. ~50 people.
4. Ros, M.B.H., K.J. Czymmek and Q.M. Ketterings (2020). Using Nitrogen and Phosphorus Mass Balances to Set Sustainability Key Performance Indicators for Dairy Farms. ASA/SSSA/CSSA Annual Meeting, November 9-13, 2020. Virtual. Abstract and Oral Presentation. 15 min. Attendance unknown.
5. Battaglia, M., Q.M. Ketterings, G. Godwin and K.J. Czymmek (2020). Conservation Tillage Is Compatible with Manure Injection in Corn Silage Systems. ASA/SSSA/CSSA Annual Meeting, November 9-13, 2020. Virtual. Abstract and Oral Presentation. 15 min. Attendance unknown.
6. Battaglia, M., M.B.H. Ros, Z. Easton, A.S. Collick, J. Faulkner, K.J. Czymmek, and Q.M. Ketterings (2020). Watershed Modeling of Best Management Practices for Regional P Index Evaluation. ASA/SSSA/CSSA Annual Meeting, November 9-13, 2020. Virtual. Abstract and Oral Presentation. 15 min. Attendance unknown.
7. Ketterings, Q.M., M.B.H. Ros, and K.J. Czymmek (2019). Combining Field Phosphorus (P) Runoff Risk Assessments with Whole-Farm P Balances to Guide Manure Management Decisions. ASA/SSSA/CSSA Annual Meeting, November 10-13, 2019. San Antonio, Texas. Abstract and Presentation. 140-2. 15 min, ~30 people.
8. Crittenden, S.J., Q.M. Ketterings and K. Dietzel (2017). Impact of Phosphorus Source on Soil Test Phosphorus Increase. ASA/SSSA/CSSA Annual Meeting, October 23, 2017. Tampa, Florida. 15 min. Abstract and Presentation. Delivered by Q.M. Ketterings. 15 min, ~30 people.

Extension presentations and workshops (excludes farm visits and project meetings with farmer and consultant groups as the new PIs were being developed):

1. Ketterings, Q.M. (2022). Northeast Region Phosphorus Index. NEC1812 Annual Meeting. Milford, PA. October 7, 2022. 15 min. 12 people.
2. Ketterings, Q.M., and K. Workman (2022). CNMP training – Nutrient management. Ithaca NY. April 6, 2022. 4 hrs. ~70 people.
3. Ketterings, Q.M., K. Workman, and M. Contessa (2022). Regional Phosphorus Index meeting. April 1, Virtual. ~20 people. 75 min.
4. Ketterings, Q.M. and K. Workman (2022). Value of manure told in five stories. South Central NY Dairy and Field Crops Program. Virtual Winter Crop Meeting 2022. 1 hr. January 28, 2022. Virtual. 26 people
5. Ketterings, Q.M. (2021). Nutrient Management Spear Program External Advisory Committee Meeting. December 21, 2021. Virtual. ~25 people. 150 min.
6. Ketterings, Q.M., G. Albrecht, and D. Gates (2021). NY-PI 2.0 Training. November 18, 2021. Virtual. 2 hr. 86 participants.
7. Ketterings, Q.M. (2021). New York Phosphorus Index 2.0 for New England States. Virtual. August 31. 2 hr. 10 participants.
8. Czymmek, K.J., M. Ros, and Q.M. Ketterings (2019). The new NY Phosphorus Index. Northeast Region Certified Crop Advisor annual meeting. December 3, 2019. 2 x 50 min. ~100 people total.

9. Ketterings, Q.M., K.J. Czymmek, and M. Ros (2017). Phosphorus index project update. Northeast Region Certified Crop Advisor Annual Training. East Syracuse. November 28, 2017. 50 min. 53 people.
10. Ketterings, Q.M., K.J. Czymmek, and M. Ros (2017). Phosphorus index project update. Northeast Region Certified Crop Advisor Annual Training. East Syracuse. November 30, 2017. 50 min. 27 people.
11. Ketterings, Q.M. and K.J. Czymmek (2017). Whole Farm Mass Nutrient Balances and P Index Assessment. Vermont. April 3, 2017. Webinar. 1 hour. 5 people.
12. Ketterings, Q.M. and K.J. Czymmek (2017). Whole Farm Mass Nutrient Balances and P Index Assessment. Champlain Valley Ag and Miner Institute Meeting. Chazy, NY. March 31, 2017. 3 hours. 6 people.
13. Ketterings, Q.M., K.J. Czymmek, and S. Crittenden (2016). Phosphorus Index project update. Northeast Region Certified Crop Advisor Annual Training. East Syracuse. November 29-December 1, 2016. 2x50 min. 99 people.

7. Project Impacts (1/2 page):

The project resulted in the release of a new NY-PI 2.0 in fall of 2019, impacting *all farm acres* managed by concentrated animal feeding operations (roughly 500 of the state's largest farms) and farms in sensitive watersheds that are required to have a nutrient management plan in New York. The NY-PI 2.0 was included in the revised NRCS 590 standard and new CAFO permit and all farms that have to follow NRCS 590 also need to assess their farm fields for NY-PI 2.0. This one tool impacts all the highest priority nutrient managers in the state of NY and improves both the farm's ability to identify high risk fields and incentivizes BMPs that reduce P loss from agricultural fields. Through the adaptive management option in the PIs, better whole farm P balancing is incentivized as well.

The New England states CT, MA, ME, NH, and RI have adopted the Northeast Region PI, which impact all farms under 590 planning in each of these states as well. In VT, the Northeast Region PI was incorporated into the University's goCrop software for use by planners that work across state boundaries, while discussions are ongoing about a possible inclusion of VT in the Northeast Region PI.

As the revised NY and Northeast PI tools are currently being implemented under 590 and CAFO regulations, it is not possible yet to list acres where management practices have already changed (work in progress). However, feedback from planners so far is that this new approach clearly emphasizes BMPs and quantifies their benefits for farmers, thereby encouraging adoption of risk mitigating strategies for high-risk fields. New York CAFO regulations have given planners 3 years to fully switch to use of the NY-PI 2.0 and the New England states are transitioning now as well.

The success of this project, the delivery of a regional PI, means that farmers, planners, and advisers who work with farms across the region have one consistent tool to assess P-loss risk and incentivize implementation of BMPs (including restrictions on manure spreading on high-risk fields). This is a major advancement toward regional implementation of science-informed, responsible management of farm-applied P (manure and fertilizer) for protection of water quality.