Northern NY Agricultural Development Program
2012-2014 Project Report

Implementing the Adapt-N Took in Northern New York: Reducing Cost, Mitigating Losses, and Adapting to Climate Change

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Collaborators.
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Cooperating Producers.
. Clinton County: Bruce Dimock, Brian Sipley, Ed Carter
. Essex County: Lee Garvey, George Sayward
. Franklin County: Steve Gokey
. Lewis County: Bernie Gohlert
. Other growers involved in running simulations through their ag service providers, particularly through Champlain Valley Agronomics and Cook's Consulting.

A total of 22 NNY-based users have run simulations for over 350 locations as of 2013.

Background.
Nitrogen management on Northern NY corn silage and grain acres is costly and risk-filled for producers, and inefficient and variable crop N use results in high environmental impacts. Excessive nitrate levels in surface and groundwater are persistent concerns, and greenhouse gas impacts from agricultural soil N_2O losses are large. Yet, corn yields can be severely limited by nitrogen in wet years when heavy rains cause excessive losses.

Farmers therefore tend to over-apply N fertilizer and/or manure to maximize their returns to N applications in the presence of high uncertainty around the optimum N rate. This uncertainty is mostly associated with early-season weather-impacts on N availability. For example, a manured field may need no N inputs after a relatively dry spring, but 100 lbs/ac after wetter spring weather. Without knowing what kind of year it will be, the farmer will generally apply at a high rate. This is especially pertinent for dairy farmers who often have great difficulty estimating the manure N contribution under variable weather conditions, and are concerned about yield losses from wet conditions.

To effectively account for the variability, we have developed, and are testing, a dynamic N recommendation system, the Adapt-N web-based computational tool (http://adapt-n.cals.cornell.edu), which is data-driven and accounts for field-specific sources of variability (weather, soil type, organic N sources, soil and crop management, etc.).

When using the tool to inform in-season N application, early season weather effects can be incorporated into the recommendation, so that N management precision is significantly improved. This reduces overall inputs and environmental losses, and improves farmer profits.

Adapt-N is made up of three key components:

1) a well-calibrated simulation model (Melkonian *et al.*, 2005) that simulates key C and N transformations, water dynamics, and corn growth,
2) daily high resolution rainfall and temperature data on a 3 x 3 mile grid (DeGaetano and Belcher, 2007; DeGaetano and Wilks, 2009), and
3) field-specific inputs provided by the user through a cloud-based interface that can be accessed from any device with internet access.

The tool accounts for soil characteristics (organic matter, type, rooting depth, etc.), crop management (date of planting, maturity class, population, expected yield, rotation, tillage, and cover crops in 2015), and past fertilizer and manure applications.

Adapt-N simulates location-specific crop and soil N dynamics and provides a real-time recommendation and graphs of field specific dynamics such as mineralization of N from OM, soil nitrate content, denitrification (in 2015) and leaching losses, etc.

Generating a nitrogen recommendation requires only several minutes once the information has been gathered, and the recommendation is updated daily, based on weather. Soil testing, in contrast, is much more expensive and time-consuming, and offers lower precision and information quality.

A daily email/text alert feature is available, and batch uploads of data are supported, allowing for more rapid inputting of numerous fields, and easy continuous monitoring of N availability during the growing season.

Methods.

This project has focused on three important objectives:

1) to beta-test the Adapt-N tool's recommendations against current grower practices on NNY farms to assess whether the tool's recommendations can

increase grower profits and decrease unnecessary N inputs, and to expand education and on-farm implementation of the Adapt-N tool in NNY;

2) to obtain nitrate leaching data from the Willsboro farm lysimeter plots to document the water quality benefits of using Adapt-N; and

3) to enhance the precision of Adapt-N recommendations by incorporating further soil test information inputs related to soil health, particularly N mineralization and water dynamics, as well as information gained from on-farm use, into future versions of the tool.

1) On-farm testing and implementation.

More than 20 NNY growers have been involved, 9 in trial implementation, and additional growers in simulating fields on their farms. Growers who hosted trials worked with the project team to establish strip trials with at least two rates (Adapt-N recommendation vs. their current N management practice) and 3-4 replications in most cases. In a few cases intermediate or low rates were also included. Soil health, soil nitrate, and corn stalk nitrate were assessed, and yields were measured at harvest. Partial grower profit differences (Adapt-N rates minus Grower-N rates) were calculated. Results were added to the growing national dataset which allows us to assess Adapt-N performance and needs for model adjustments.

2) Willsboro lysimeter study.

Adapt-N vs. "Grower-N" treatments were implemented at the Willsboro Research Farm lysimeter sites over several years: 16 plots each on sand and clay soils, in continuous corn, under no-till and plow-till. Drainage water samples were collected from the lysimeters at key time points in the fall and spring following treatments, and N content was quantified, to allow us to assess differences in water quality in Adapt-N vs Grower-N plots.

3) Model and Interface Improvements.

Soil samples from research and commercial farms were analyzed using protocols for soil proteins (an indicator of the highest N-containing component of organic matter) and respiration (an indicator of microbial activity). These indicators are now included in the Cornell Soil Health Test, and are being assessed for their potential contribution to improved N recommendations in Adapt-N by various methods, including a greenhouse study to quantify N mineralization potential of soils representing a range in these characteristics.

Results:

1) On-farm testing and implementation.

Testing of the tool in Northern NY has been challenging over the last 4 years due to extreme weather conditions across the region, from drought to excessive rainfall, and associated issues, such as early crop stunting, disease pressure, pests, and weeds, as well as some establishment errors or logistical barriers (trial layout, lack of ability to sidedress less than 50lb N/ac). At times, extension collaborators had difficulty getting farmer collaborators to individually harvest and take yield measures on the trials. This was often the case with small farms with small fields where they didn't have yield monitors or scales to weigh their trucks.

Overall, such conditions have prevented planting, sampling, sidedressing, and/or harvesting in some trial fields. The wet spring of 2013 was particularly challenging as growers were prevented from successful establishment of the majority of the trials and data from others, though completed, was unusable for model improvements. In addition, two of our early collaborators (Kitty O'Neil and Mike Hunter) were unable to produce results for us in 2014 due to workload and an illness in the family.

Despite challenges, between all four years the NNY data look promising, and, particularly in the context of state-wide on-farm data (76 trials from 4 yrs) suggest NNY growers can improve profits and N use efficiency.

NNY results (2011-2014):

Table 1 in Appendix A shows results by trial for the successfully completed NNY trials. Table 2 summarizes results from 2011-2013. Out of 12 successfully completed trials 9 met both of the following criteria: a) an Adapt-N rate *and* Grower-N rate treatment were in place, and b) N rate comparisons differed by more than 15lb N/ac (N rate differences of only 3, 10, and 11lb N/ac were not considered useful comparisons). The results from these 9 trials can be summarized as follows:

- 7 out of 9 trials had increased profit with the Adapt-N treatment (78%)
- Average profit was $23/ac
- In 8 out of 9 cases, the N input was decreased, by an average of 37 lb/ac.

For context, Appendix B summarizes results from all 2011-2013 trials. Table 4 summarizes Adapt-N performance for New York and Iowa and Table 5 gives preliminary results from trials in Northern New York for 2014.

In short: in drier years (2011-2012) Adapt-N decreased N applications in NY by 66lb/ac, increasing grower profits in 80% of cases (more with proper use of the updated tool) by $31/ac on average, with minimal yield reductions. In 2013 with very wet spring conditions, Adapt-N increased N inputs by 28lb/ac on average over grower rates, for a yield gain of 24 bu/ac on average, and a profit increase in 90% of trials, by $106/ac on average. 2014 seems to be in line with 2011-12, results as it was more or less a "normal" year. More data and analysis pending for 2014.

2) Willsboro lysimeter study. Adapt-N vs. "Grower-N" treatments were implemented at the Willsboro Research Farm lysimeter sites. The Adapt-N rates were 20 to 35 lbs per acre lower on average in 2011-2012, but 20 lb higher in the clay loam in 2013 due to the wet spring (Table 1). Yield and profit analyses for these sites are included in the analysis above. Drainage water samples collected from lysimeters indicated lower water quality impacts under Adapt-N management (Appendix A, Table 3). More lysimeter samples were taken in 2014 but data gathering and analysis are still pending.

Yields did not differ significantly from N reductions in 2011-2012, nor did they differ significantly from moderately increased N inputs in D1 in 2013 (based on only 14 plots, as two were replanted; plots were highly variable due to early weather stress). In-field variability often makes it difficult to assess whether treatments have an effect, especially when the difference in rates is low. However, the evidence we do have suggests that the model did reasonably well. 2011 Adapt-N plots measured yield values higher on average

and additionally, we can see that leachate concentration after the 2011 growing season was significantly higher in D1 Grower-N plots ($p=0.008$), and trended toward higher values ($p=0.15$) in D5 Grower-N plots (Table 3), suggesting excess N was applied.

2012 Adapt-N plots were noted to have an appearance of slight N stress, and when the model was rerun for a retrospective recommendation in the winter following that season, high resolution data appeared to have been error-corrected, resulting in somewhat higher recommendations, that would have possibly been more appropriate. Spring leachate samples only were taken following the 2012 growing season, due to droughty weather and lack of tile flow. These trended toward higher concentrations under Grower-N ($p=0.15$) in D5, and did not differ in D1, corroborating small differences in excess N remaining after uptake.

In 2013, Grower-N plots in the Drainage 1 field appeared to be nitrogen deficient. In 2014 yields in D1 and D5 were not different yet N inputs were significantly lower from Adapt-N treatment ($p<.0001$).

3) Model and Interface Improvements.

On-farm trial results have been used to adjust the model underlying Adapt-N annually. Improvements have been made to soil type representation and availability in the tool, simulation of denitrification transformations (including estimation of nitrous oxide coming in 2015), and to the calculation of the recommended rate that incorporates price-ratio and risk related factors. Based on greater variability seen in trials that have received manure (both in NNY and other Northeast trials), we adjusted this risk factor for manured locations in the 2014 version.

The model's ability to represent drainage (or lack thereof) was enhanced in 2014. Development of two new service-lab protocols related to organic matter quality and microbial activity (soil protein content and respiration) was completed. These protocols have been moved into Cornell's Nutrient Analysis Laboratory. All Adapt-N trial samples have been analyzed for these indicators.

A beta soil health module for Adapt-N will be developed for testing in 2015. This activity was delayed in 2014 because Adapt-N was moved to the commercial version and work was done to develop the website interface and transitioning to commercial use. Module improvements within Adapt-N will be a priority in 2015.

Conclusions/Outcomes/Impacts.

Growers will benefit economically from using Adapt-N for in-season N applications, and society will benefit from the environmental improvements, especially in years with extreme weather. Every field being planted to corn should be carefully entered into Adapt-N (making sure that all inputs are representative of field realities), sampled for organic matter content, and any compaction/root zone depth issues should be assessed. A representative analysis of any manure applied to the field is essential. Preplant/starter applications of N fertilizer should be minimized, so that precise adjustments in a given year's N rate can be made in-season when weather effects on N availability, yield potential, and root zone can be made most appropriately. It will be very important for the farm to have accurate yield estimates of each field. This will require equipment and

training to monitor yield. Data to date suggest that, while not perfect, Adapt-N will improve NNY grower profits in 70-80% of locations, on average by $20-30/acre, more in wet years where the increased profits come from maintained yields, and with lower risks with appropriate tool use. So far farmer and service provider response has been positive, and we are receiving critically useful suggestions about interface improvements, and improvements in our on-farm testing design as we move forward. For example, as we have accumulated a large dataset on grower profits showing that the tool improves grower management, we can now turn our attention to zeroing in on whether Adapt-N is providing the best possible recommendation through trials with more than two N rates.

Outreach.

Weather impacts on N availability have come to the forefront of N managers minds over the last years as a number of extreme events (rain as well as drought) have shown these dynamics in the field during the conceptual learning process our team has promoted. Project outreach to the NNY region has included in-person visits for formal conferences and meetings, as well as informal visits and phone conversations with collaborators, multiple training webinars, and a number of publications (see links provided in Reports section). Our websites for both Adapt-N and Soil Health are now linked from the NNYCCE website, and the NNYADP website features several articles on Adapt-N. Presentations and publications are continuously updated on our website: adapt-n.cals.cornell.edu.

Awareness of and appreciation for the capabilities of the Adapt-N tool are increasing in the North Country, especially among agricultural service providers (consultants and extension educators) who tend to be more inclined toward new computer-based tool developments. A total of 22 NNY-based users have run simulations for over 350 locations as of 2013. While weather challenged implementation in 2013, the new tool features that were added, such as batch uploading of data and improved daily recommendation alerts are increasing excitement about the tool's capabilities.

Early in the project there was collaboration with Champlain Valley Agronomics (CVA), one of the largest consulting firms in the Eastern part of NNY. They implemented multiple trials on their clients' farms in 2012 and 2013 and educated their clients about weather impacts on N availability, and how Adapt-N can be used as a valuable N management tool.

Next steps.

In 2014, the Cornell Adapt-N research team established a public-private partnership with Agronomic Technology Corporation (ATC) to sustain Adapt-N availability to the public by covering increasing cost through annual license fees. ATC launched an improved commercial Adapt-N interface on April 1, 2014.

Adapt-N research and testing continues in the new interface, through no-cost accounts provided by ATC for the research team and collaborators. ATC has increased use by ag service providers and continues to provide the tool for free to collaborators who are contributing to research for tool improvement.

We are planning to continue our field trials, on a smaller scale and in collaboration with ATC and continue our outreach efforts. Studies in future years should continue to

monitor and quantify the economic and environmental benefits of the tool's use by region and by management. Calibration of the tool should be continued for use in new geographic areas, including internationally. Model capabilities should be expanded to handle a wider range of management practices, such as diverse cover cropping practices and their interactions with tillage practices; N stabilizer use; diverse rotations; additional crops. Detailed soil health data (aggregate stability, soil protein, etc.) should be incorporated in the model to refine recommendations, and highlight the impacts of diverse and divergent soil health status across farms on N dynamics. New advances in quantitative understanding of N dynamics should be incorporated into the model. Note that, because Adapt-N is based in the 'cloud,' any of the above enhancements will be instantaneously available to all users.

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Reports and/or articles.

Selected publications by project team: Please note that additional publications as well as recorded webinars are available on our Project Websites for Adapt-N and Soil Health:

What's Cropping Up? 10/2014: Adapt-N Boosts Profits and Cuts N Losses in Three Years of On-Farm Trials in New York and Iowa. By B. Moebius-Clune, M. Ball, H. van Es, and J. Melkonian

What's Cropping Up? 9/2014: Implementation of Soil Health Management Plan Resolves Pond Eutrophication at Tuckaway Farm, NH. By B. Moebius-Clune, D. Moebius-Clune, R. Schindelbeck, and H. van Es.

Adapt-N Training Manual by Bianca N. Moebius-Clune, M. Carlson, H.M. van Es, J.J. Melkonian, A.T. DeGaetano, and L. Joseph. 2014

Award-Winning Adapt-N Farm Tool Has Northern New York Roots. Northern New York Agricultural Development Program News. 2013

Adapt-N Uses Models and Weather Data to Improve Nitrogen Management for Corn by Bianca Moebius-Clune, H. van Es, and J. Melkonian. Better Crops. Vol 97:7-9. 2013.

What's Cropping Up? 5/2013: Adapt-N Proves Economic and Environmental Benefits in Two Years of Strip-Trial Testing in New York and Iowa by B. Moebius-Clune, M. Carlson, H. van Es, and J. Melkonian. Adapt-N Increased Grower Profits and Decreased Nitrogen Inputs in 2012 Strip Trials by B. Moebius-Clune, M. Carlson, Harold van Es, and Jeff Melkonian. Case Study – Part II: Central NY Farm Applies Adapt-N Rates on Whole Farm, Saves Money and Reduces Environmental Impact by B. Moebius-Clune, M. Carlson, D. Moebius-Clune, H.van Es, J. Melkonian and K. Severson.

Selected popular press articles:

The Packer, October 23, 2014. Wal-Mart adds detail to sustainability plans.

Communications of the ACM, October 14, 2014. Agriculture is Becoming a 'Model Citizen'.

Walmart Bog, October 13, 2014. Sustainable Farming with True Affordability in Mind.

Boston Globe, October 7, 2014. Walmart touts food initiative's green benefits.

Walmart Sustainability Milestone Meeting, October 6, 2014. Adapt-N mentioned in webcast of Walmart company leaders discussing their environmental sustainability efforts.

The Guardian, August 20, 2014. New technology helps farmer conserve fertilizer and protect their crops.

Prairie Farmer, April 1, 2014. Adapt-N gives real-time nitrogen answers.

Corn and Soybean Digest, July 26, 2013. Adapt-N tool calculates for weather extremes and soils.

Farm and Dairy, June 10, 2013 How much nitrogen does your field really need?

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