Adaptive Nitrogen Management for Field Crops in New York

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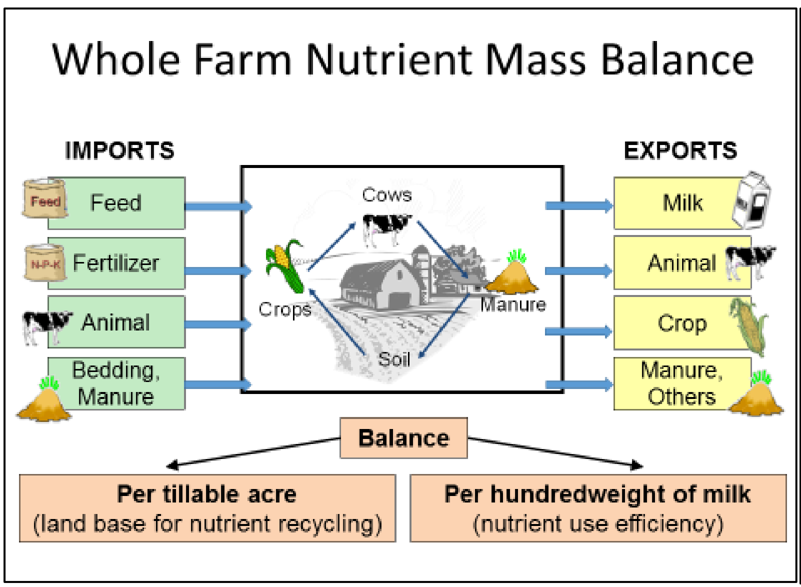

In conjunction with the **Cornell NMSP Advisory Committees**

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Executive Summary

- Management and weather can impact nitrogen (N) supply and N demand by crops. The best decisions are often taken when farmers can experiment with N application decisions for manure or fertilizer. Thus, in 2013, a partnership of the Nutrient Management Spear Program (NMSP) at Cornell University, New York Natural Resources Conservation Service (NY-NRCS), Department of Agriculture and Markets (NYSAGM) and Department of Environmental Conservation (NYSDEC), with input from farmers and farm advisors, developed and implemented an "Adaptive Management for Nitrogen Management of Field Crops" approach.

- Adaptive management is field specific and requires an end-of-season evaluation. The initial approach required farmers who opt to apply N at rates that exceed the foundational Cornell guidelines to measure yield, take corn stalk nitrate test (CSNT) samples, and manage CSNT levels to be below 3000 ppm over time. In consultation with members of the NMSP Advisory Committees, additional evaluation options were added in 2018 and 2023, including evaluation of yield results of test strips where crop response to a higher N rate is compared to the foundational guidelines for the field. This document expands the evaluation options to include conducting field specific available N balances for corn silage.

- This document summarizes under which conditions field-specific adaptive management applies and lists five environmental assessment options, in addition to measuring yield, to be selected from once the adaptive management approach is chosen. This document replaces "Adaptive Nitrogen Management for Field Crops in New York" published in 2023.

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Acronyms

- AEM: Agricultural Environmental Management Program
- BMP: Beneficial Management Practice
- CAFO: Concentrated Animal Feeding Operation
- CCE: Cornell Cooperative Extension
- CNMP: Comprehensive Nutrient Management Plan
- CPS: Conservation Practice Standard
- CSNT: Corn Stalk Nitrate Test
- FOTG: NRCS Field Office Technical Guide
- NMP: Nutrient Management Plan
- NRCS: Natural Resources Conservation Service
- NYSAGM: New York State Department of Agriculture and Markets
- NYSDEC: New York State Department of Environmental Conservation
- SWCD: Soil and Water Conservation District

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1. Introduction

The Natural Resources Conservation Service (NRCS) 590 Nutrient Management Conservation Practice Standard (CPS) is a core component of compliance with the New York Concentrated Animal Feeding Operation (CAFO) Permit and the development and operation of comprehensive nutrient management plans (CNMPs) in general. The NRCS 590 standard requires the use of Cornell University guidelines for nutrient applications.

Cornell University guidelines for nitrogen (N) management of field crops like corn silage or grain are developed taking into account realistic yield potentials (hereafter referred to as yield indices) as well as N sources already on the farm. These guidelines are hereafter referred to as "foundational guidelines". Because the true optimum N rate for any field can only be confirmed at harvest, producers and planners must work within ranges to ensure adequate N is supplied to crops, while striving to avoid excess applications. From crop production and environmental management points of view, limiting yields due to nutrient shortage and excess nutrient application beyond what crops can use are both undesirable.

Since 2000, farm field-specific yields can be used instead of soil type specific yield index values listed in the Cornell yield index database so long as a farm had at least three years of yield data to justify the use of a higher yield index for a specific field.

In 2013, a partnership of state and federal agency staff and Cornell University nutrient management specialists framed an adaptive management process based on guidance from USDA-NRCS at the federal level (USDA-NRCS, 2013). The goal of adaptive management is to create guidance for and incentivize on-farm evaluation of practices that improve nutrient management over time so that farming can become more site-specific. This can be especially important in field crop systems with regular manure applications and sod in rotation where producers are looking to better gauge and use the soil's N supply and N buffering capacity. The implementation of a flexible management system that sets baseline rates (foundational guidelines) with the option to adapt and supplement as needed using in-season tools (models, crop sensors, soil and/or plant tests, etc.) is consistent with the adaptive management process outlined by USDA-NRCS and Cornell University guidance for N management of field crops.

Two fundamental components of the field-specific adaptive management process as described by USDA-NRCS are (1) measuring yield, and (2) conducting an end-of-season evaluation step to determine if the crop was in fact responsive to N added beyond the foundational guidelines in that field. The partnership of Cornell University, NRCS, NYSAGM, NYSDEC released two Agronomy Fact Sheets in 2013 (Agronomy Fact Sheets #77: Nitrogen for Corn; Management Options and Agronomy Fact Sheet #78: Adaptive Management of Nitrogen for Corn) to guide corn N management decisions under the adaptive management process. Maintaining yield records and assessing crop N status through the corn stalk nitrate test (CSNT) (Agronomy Fact Sheet #31: Corn Stalk Nitrate Test and Fact Sheet #72: Taking a Corn Stalk Nitrate Test Sample after Corn Silage Harvest) were identified as the evaluation steps for N management of corn at that time. The process called for managing CSNTs below 3000 ppm over the intermediate to long term.

In 2018 and in 2023, based on producer and planner feedback, a wider list of options to implement the end-of-season evaluation was developed. This included implementation and evaluation of results of test strips. Following the completion of a statewide study on field N balances for corn in 2024, the adaptive management evaluation options are now expanded to also include field N balances for corn silage. The process calls for managing the available N balance below 142 lbs N/acre over the intermediate to long term.

This document updates the guidance from 2023. We describe how to set field specific yield indices for fields with at least three years of yield data, explain the adaptive management process, and list updated evaluation options currently approved for adaptive nutrient management for field crops for farms that are required to follow the NRCS 590 Standard in New York.

It should be clear that under the adaptive management process, farmers and planners may use any in-season adaptive management tool at their disposal and may batch fields as necessary using realistic yield expectations and written justification for purposes of determining which ones will receive N beyond the foundational guidelines outlined in Nitrogen Guidelines for Field Crops in New York. However, consistent with the USDA-NRCS adaptive management guidance, the end-of-season evaluation step will need to be performed on a ***field-by-field basis*.**

2. Setting Field-Specific Yield Indices

For farms that have at least three years of corn yield data for a specific field, average yield for the field (whole-field basis) can be used to substitute for the yield index values from the Nitrogen Guidelines for Field Crops in New York. For more information on ways to record corn yield, see Agronomy Fact Sheet #71: Measuring Corn Silage Yield. With only three years of yield data, the lowest yielding year can be dropped from the average while yield tracking continues. With four years of data, the lowest yielding year can be dropped from the average to obtain a 3-year average while tracking continues. With five years of data, up to two low years can be dropped to determine the 3-year average. Once five years of data are obtained, maintain a rolling average of the most recent five years with the option to drop the two lowest yielding years from the average. The adjusted yield index can be used in the N equations to derive N application rates for silage or grain; yield for grain is entered in bu/acre at 85% dry matter (DM) and yield for silage is entered in ton/acre at 35% DM. No further action is needed if actual applications do not exceed the rate calculated based on field average yields determined from actual yield records as outlined above. However, if the farm has documented evidence that a realistic yield above the actual yield-based index can be achieved, adaptive management using the applicable scenarios below can be pursued.

3. Where Adaptive Management Steps Apply

Additional N beyond the foundational guidelines derived using the Nitrogen Guidelines for Field Crops in New York, needs to be based on evidence of realistic yield expectations for rate selection. A realistic yield expectation for a field should be derived using whole farm historic yield records, soil characteristics, hybrid/plot data, etc. and be justified in the CNMP or NMP. Method of rate selection and application rate need to be documented (e.g. records from a model or sensor, N application maps).

The adaptive management process is field-specific. It can be used under one of two scenarios:

1) *Pre-season planning*: When a farm opts to use a yield index above the book value for the soil type but does not have three years of yield data. In this case, a higher yield index based on the documented realistic yield goal determination is used to derive an N rate that is higher than the foundational guideline.
2) *In-season adjustments*: When the CNMP or NMP has used either the yield index values or field specific yield records to calculate manure and fertilizer rates, rates have been applied to meet the guideline, and evidence is documented that suggests additional N is needed at sidedress time (e.g. PSNT, records from a model or sensor).

4. Adaptive Management Field-Scale Evaluation

Farms that opt for the adaptive management process for specific fields need to **collect and maintain yield records** for each field to which this applies, *and* select one of the following:

1. Conduct a four-time replicated **N rate study** to determine N needed.
2. Collect a composite Corn Stalk Nitrate Test (CSNT) sample from a representative area and manage results to be below 3000 ppm over time.
3. Implement an **N-rich strip** at planting, with an N rate above recommended, and collect yield for the strip(s) and the surrounding area to evaluate crop yield response to the extra N.
4. Implement one or more **control strips** treated in accordance with the foundational guidelines; collect yield data for the strip(s) and the surrounding areas where additional N was applied.
5. Determine total and available N **field balances** (N applied plus N supply by soil and crop rotation credits as defined in Nitrogen Guidelines for Field Crops in New York minus N removed with harvest).

Fields that show efficient N utilization above foundational guidelines using applicable adaptive strategies can continue the adaptive process until a new yield index can be documented and maintained according to guidance for setting field-specific yield indices in section 2. As realistic yield goals are updated and documented, new adaptive management opportunities may become available. Fields that cannot be documented with efficient N utilization above foundational N guidelines over time (2-3 years) should revert to the foundational guidelines (either book soil yield index values or actual yield index values). Fields with significant management changes beyond this timeframe (tile drainage, organic matter buildup, etc.) can be re-engaged in the adaptive management process. In sections 4.1 through 4.5, each of these N management evaluation options will be described in more detail.

4.1 Nitrogen Rate Studies

On-farm research is an excellent approach to gaining confidence in current management practices or to help identify the need for a change. Findings of 2-3 years of on-farm replicated trials with a minimum of four replications and five N rates including a zero-N control treatment can be used to determine if adjustments in optimum N rates for a field are warranted. Of the five N rates, two should exceed the expected optimum N rate, one should be at the expected optimum N rate, and two are below the optimum N rate, including a zero N control. Thus, where research trials are conducted, some treatments will exceed the optimum N rate by design. See Agronomy Fact Sheet #99: Nitrogen Rate Trials in Corn, for more information. It should be clear that including elevated N rates in on-farm trials is an acceptable practice per NRCS CPS 590.

4.2 Corn Stalk Nitrate Test

Collect a CSNT sample from a representative area to assess whether additional N beyond the foundational guidelines was utilized that year. A CSNT sample for this purpose should consist of 10-20 stalk as a representative sample of the higher yielding portions of the field (see Agronomy Fact Sheet #31: Corn Stalk Nitrate Test and Fact Sheet #72: Taking a Corn Stalk Nitrate Test Sample after Corn Silage Harvest). Excluding 1st year corn after sod where CSNT levels may be low, and severe drought years where CSNT levels may be high due to low crop yield, if results exceed 3000 ppm for 2 years, N rates need to be reduced with continued yield and CSNT monitoring until CSNTs are routinely below 3000 ppm. In situations when more than three true leaves above the soil are yellowing, there is an option to collect three georeferenced photos of an area representative of the general condition of leaf N status within the highest yielding areas in the field instead of CSNT sampling as stalks are unlikely to exceed 3000 ppm CSNT (note, optimal yielding corn crops will often exhibit 3-5 N deficient leaves and CSNT values between 750 – 2000 ppm).

4.3 Nitrogen Rich Strip

Nitrogen rich strips are strips in a field that receive an application of fertilizer N that exceeds what is anticipated to be the N needs of the crop, creating an area where an N limitation is highly unlikely. In annual row crops, like corn, such a strip should be implemented before or shortly after planting (before seed germination). This approach can be applied to corn fields in all years of rotation, including 1st year corn fields after sod.

If the N-strip is applied at planting and plants in the strip are indistinguishable from plants in the surrounding area at V8-10 or later, extra N may not be needed. When the plants in the strip are more vigorous and darker in color (i.e. the strip is clearly distinguishable), additional N may benefit the crop, and N may be side-dressed across the field at 50-75 lbs. N/acre beyond the foundational guidelines. If at the end of the season corn in the N-rich strip did not yield higher, the extra N was not needed. The N application in the N rich strip should not exceed 50-75 lbs N/acre additional fertilizer beyond the foundational guidelines. Depending on N source and application method and timing, a urease inhibitor should be used when surface applying urea while a nitrification inhibitor could be considered for the N-rich strip established at planting.

Check strips need to be field length and at least two full chopper or combine head widths wide**.** When N rich strips are implemented for this purpose, it should be clear that the fertilizer N added to the strip is an acceptable practice in a CNMP or NMP, per NRCS 590. For both types of N-rich strip, collect yield for the surrounding field as well as the strip(s). If yield differences are less than 2.0 wet tons corn silage/acre or 13 bu/acre for 2-3 years, this signals that the extra N is not likely needed, and field N management needs to be adjusted accordingly in subsequent years.

Alternatively, producers who have yield monitor systems and yield stability zone maps, can use the strip approach to evaluate the actual benefit of the additional N, or lack thereof, using the Single-strip Spatial Evaluation Approach or SSEA (see Agronomy Fact Sheet # 124: Single-Strip Spatial Evaluation Approach). Confidence of 80% or higher can be used to identify a minimum significant yield increase. Based on these results, the yield index of the field or zone within a field in case of zone-based management, can be increased by this minimum yield increase to set a new yield index for the field (or zone), while yield determination and testing continues.

4.4 Control Strips

Farms are encouraged to consider implementing a control check strip at side-dress time to help inform future N management decisions. This approach can be applied to corn field in all years of rotation, including 1st year corn fields after sod. Under adaptive management, the strip receives what is derived using the foundational guidelines, and the rest of the field can receive up to 50-75 lb N/acre additional fertilizer N. An alternative is that the strip receives the additional N and the rest of the field is side-dressed per foundational guidelines.

If yield differences are greater than 2.0 wet tons/acre corn silage or 13 bu/acre corn grain for 2-3 years, the extra N was needed, and field N management can be adjusted accordingly in subsequent years. Check strips need to be field length and at least two full chopper or combine head widths wide.

Alternatively, producers who have yield monitor systems and yield stability zone maps (see Agronomy Fact Sheet #123: Yield Stability Zones), can use the single strip approach to determine confidence in a yield benefit to additional N beyond the foundational guidelines, or lack thereof, using the Single-strip Spatial Evaluation Approach (see Agronomy Fact Sheet #124: Single-Strip Spatial Evaluation Approach). Confidence of 80% or higher can be used to identify a minimum significant yield increase. Based on these results, the yield index of the field or zone within a field in case of zone-based management, can be increased by this minimum yield increase to set a new yield index for the field (or zone), while yield determination and testing continues.

4.5 Field Balances

Field balances can be determined as an end-of-season assessment tool. A field N balance is the difference between the N accumulated in the crop over a growing season (N uptake determined by multiplying yield by %N in the harvest) and the amount of N made available to the crop (N supply). The balance is the amount of N applied that is not taken up by the plant. The bigger the balance, the greater the potential for N loss to the environment.

Field balances can be derived for any field for which one has accurate yield data and records on crop rotations, past and current manure applications (rate, timing, method, inorganic and organic N content), and fertilizer additions. Once soil type and drainage status are identified, book values can be used for soil N supply to complete the balance calculations. Two balances should be derived: (1) available N and (2) total N (Figure 1).

For the available N balance, manure N applied in the current crop year is adjusted based on estimates of availability of the organic and inorganic N in the manure. See Nitrogen Guidelines for Field Crops in New York or Agronomy Fact Sheet #4: Nitrogen Credits from Manure for guidance on how to credit current year N values for manure. The total N balance does not adjust manure N availability for the application during the current crop year, but rather calculates N supply based using the total amount of N in the manure (organic + inorganic N). The total balance reflects the full pool of N from manure, some of which will be available for future crops and some of which will be lost from the root zone. The available N balance reflects that not all manure N can be captured. When manure is surface applied (not incorporated or injected) outside of the growing season, the difference between total N and available N balance for a field will be larger than when manure is incorporated or injected closer to planting and crop uptake (more efficient use of the N in the manure as long as rates match crop N needs). For more information on field N balances for corn silage, see Agronomy Fact Sheet #125: Field Nitrogen Balance for Corn Silage.

(1) Available N balance:

fertilizer N applied during the current crop year
+ available organic N from manure applied during current crop year
+ available inorganic N from manure applied during current crop year
+ organic N manure credits from applications in the past two years
+ soil N credits
+ crop rotation N credits (sods, cover crop)
− N removed with harvest (total DM multiplied by N content)

= available N balance

(2) Total N balance:

fertilizer N applied during current crop year
+ total organic and inorganic N from manure applied during current crop year
+ organic N manure credits from applications in the past two years
+ soil N credits
+ crop rotation N credits (sods, cover crop)
− N removed with harvest (total DM multiplied by N content)

= total N balance

Figure 1: Two field balances: (1) available N, and (2) total N.

For most effective use of N balances, derive balances for each field for a specific crop and rank them from left to right based on the balance itself (i.e. the difference between N supply and uptake). This should be done for the available N balances and, separately, for the total N balances. Fields with the largest N balances will likely indicate opportunities for improvements in nutrient allocation, especially when a large portion of the balance is due to fertilizer application. Research so far has shown that fields with the highest balances tend to be lowest yielding showing: (1) something else than N availability (e.g. compaction, shallow soil, etc.) is limiting yield in those fields; and (2) that additional fertility will not increase production if other factors are limiting yield, both of which result in N losses.

Based on a statewide research project, completed in 2024, field available N balances for corn silage, under the adaptive management policy, should be managed at or above a 50% uptake efficiency (N removal/N supply ≥ 0.50) and at or below 142 lbs N/acre available N balance. Fields that meet these feasible limits are in the Green Operational Outcomes Domain (GOOD; green box in Figure 2). Fields that do not meet these upper limits over time (2-3 years) should revert to the foundational guidelines.

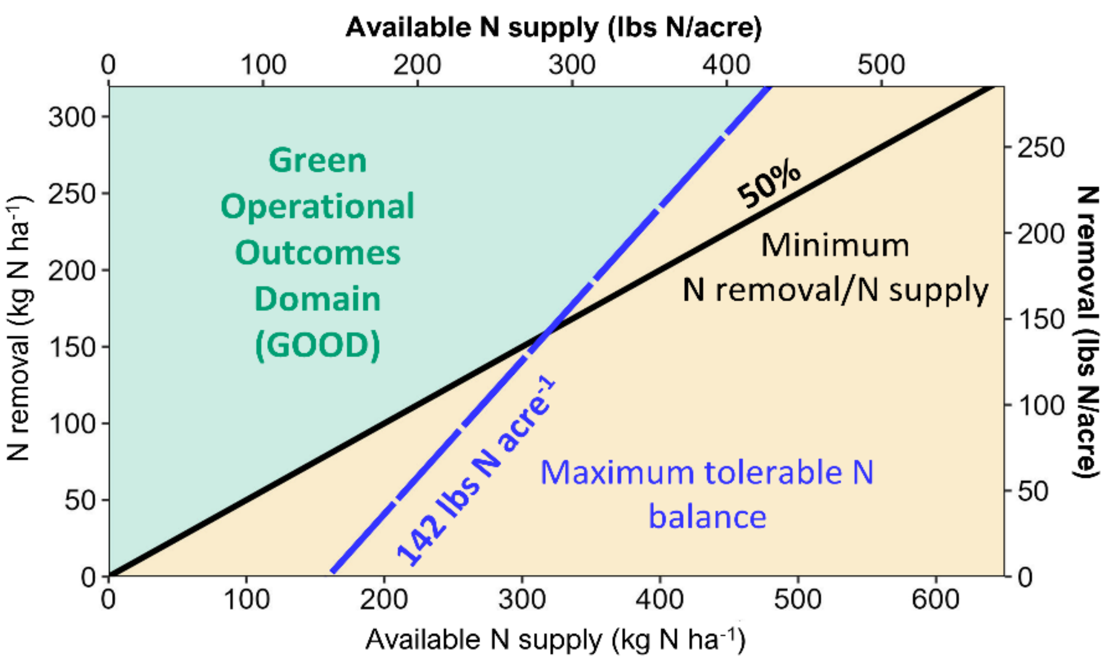

Figure 2: Feasible outcome values for maximum tolerable available nitrogen (N) balance and minimum N removal/N supply that define the GOOD framework (from Olivo et al., 2024a).

5. Adaptive Management Whole Farm Balance Option

Farms that maintain a 3-year running average whole farm N balance at or below 105 lb/acre meet the adaptive management guidelines and do not require additional field-specific evaluations beyond recording yield (Figure 3). For more detail on whole farm mass balance (NMB) assessments and software use, see Agronomy Fact Sheet #25: Nutrient Mass Balance Software and Agronomy Fact Sheet #85: Feasible Whole Farm Nutrient Mass Balances.

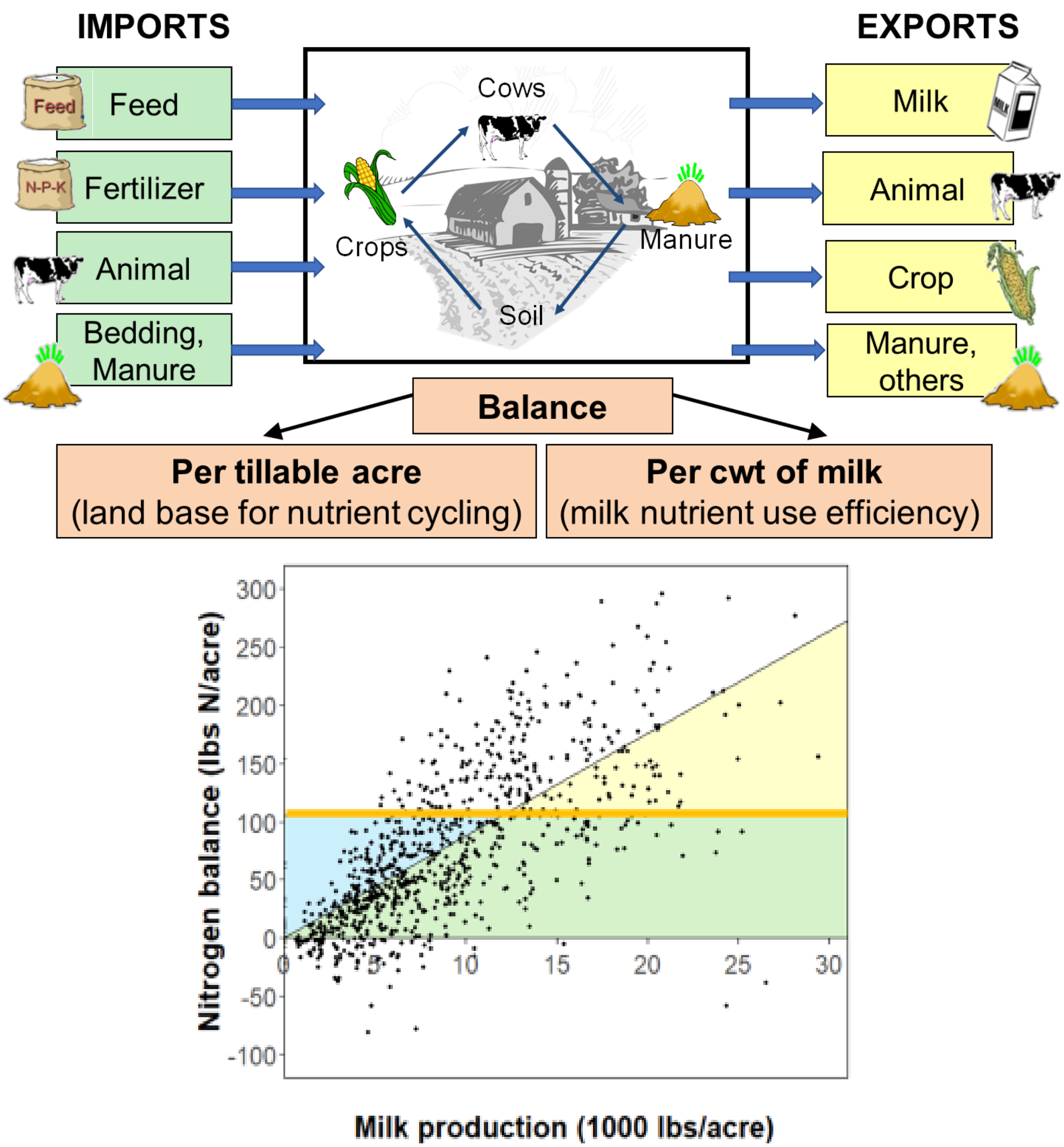

Figure 3: Farms with a 3-year running average whole farm nutrient mass balance at or below 105 lbs N/acre (yellow line), meet the adaptive management guidelines and do not require additional field-specific evaluations beyond recording yield.

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