# Setting targets for the phosphorus index using whole-farm phosphorus balances

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## 1. Introduction

- The New York phosphorus index (NY-PI) is a tool used by farmers and planners to **identify fields with a high risk of phosphorus (P) loss**, and determine how much manure/fertilizer can be used per field. The overall aim is to prevent eutrophication of surface water.

- Due to resurgent algal blooms over recent years, there has been impetus to revise and improve the NY-PI. With feedback from nutrient management planners and other experts, **a new structure has been proposed** (Fig. 1). This approach aims to stimulate the use of best management practices (BMPs) to reduce the risk of P loss.

- In parallel, nutrient mass balance (NMB) assessments were developed for dairy farms in New York. Farms that operate with feasible balances are said to operate in the **Green Box** (Fig. 3). This tool allows farmers to assess the nutrient flows to and from their farms, and can be an **indicator for areas to improve nutrient use efficiency**.

- Integrating both assessment tools allows for **adaptive management** that addresses both P runoff risk and strategies to increase whole-farm P use efficiency.

## 2. New York phosphorus index

In the new NY-PI setup (Fig. 1), we try to classify fields by their risk of P loss in three steps[1]:

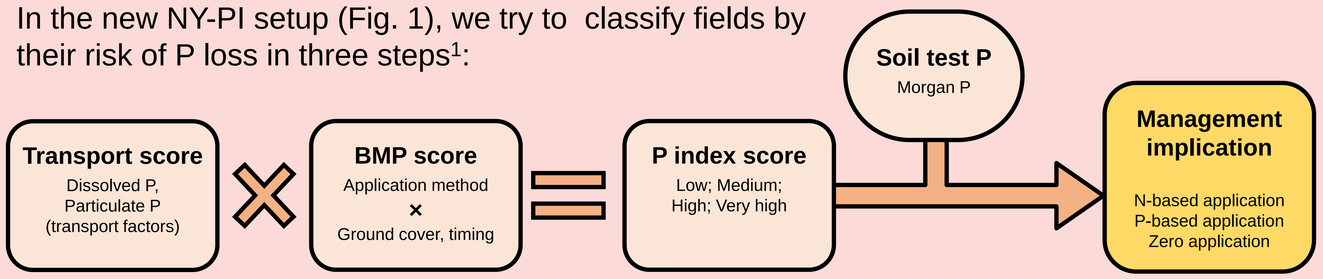


*Figure 1. Proposed (transport × BMP) structure for a new NY-PI.*

**Step 1.** A field-inherent potential P loss risk is calculated (transport score). The higher the score, the greater the risk. This score depends on transport factors like drainage, erosion risk, and flooding frequency of the field.

**Step 2.** This transport score is multiplied by a BMP score (between 0 and 1) reflecting a reduced risk. The BMPs included in the NY-PI relate to application methods (such as incorporation or injection) and timing of manure and fertilizer.

**Step 3.** The resulting NY-PI score is used, together with soil test P, to arrive at a management implication (Table 1). This combination determines whether P application should be based on crop needs (N-based), based on crop P removal (P-based), or completely shunned (Zero).

*Table 1. Management implications for the NY-PI are based on an inherent P loss risk, with soil test P as a cutoff.*

| | | Morgan soil test P [lbs P/acre][a] | | | |
|---|---|---|---|---|---|
| **P loss risk** | **NY-PI score** | < 40[b,c] | 40-100 | 101-160 | > 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 |

[a] Concentrated Animal Feeding Operation (CAFO) permit and other guidelines will regulate manure applications to frozen, snow covered, and saturated fields.
[b] Cornell guidelines for P addition to corn becomes zero when soil test P is 40 lbs P/acre or higher.
[c] Morgan soil test P values of 40, 100, and 160 lbs P acre$^{-1}$ correspond with P saturation [$P_{M3}$] / ([$Al_{M3}$]+[$Fe_{M3}$]) rates of roughly 10%, 20%, and 35% respectively.[2]

## 3. Whole-farm nutrient mass balances

The NMB (Fig. 2) is a tool to assess farm nutrient sustainability and efficiency. A **farm balance** for N, P, and K is calculated by **subtracting nutrients in farm exports** (milk/crop sales/manure exports), **from those in imports** (fertilizer/feed purchases). The balances are then expressed per tillable acre and per cwt of milk sold, to allow for comparison among farms in New York.

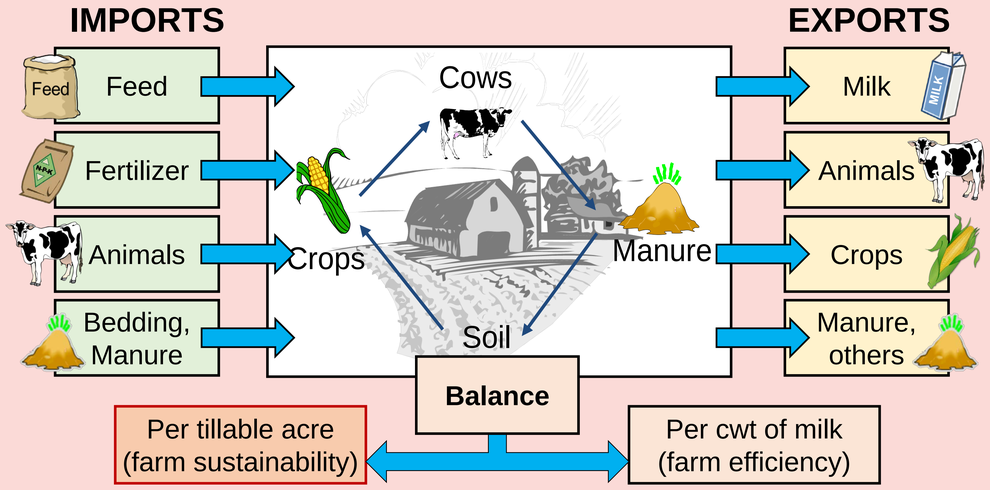


*Figure 2. Overview of farm imports and exports included in the NMB. Only easily measurable components are considered. The nutrients in the resulting balance either remain on the farm system, or are lost to the environment.*

Based on a 102 farm database, we created the **Green Box** for New York[3]. For P (Fig. 3), this optimal operation zone was defined as a balance per tillable acre of **0-12 lbs/acre** (13.5 kg P/ha), and a balance per milk of **0-0.11 lbs/cwt** (0-2.53 kg/kg milk).

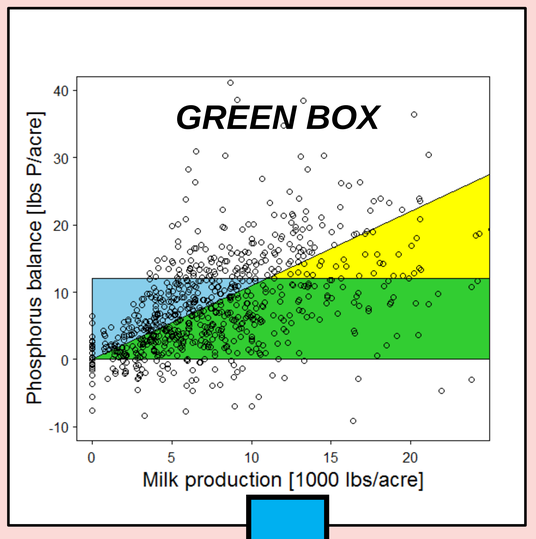


*Figure 3. Current Cornell database for P balances of over 750 farms. Circles represent individual farms. The blue rectangle indicates the range of feasible balances per acre (0-11 lbs/acre), and the yellow triangle depicts the range of feasible balances per milk (0-0.11 lbs/cwt). The Green Box where these areas overlap is the optimal operation zone for P .*

## 4. Combining the NY-PI and NMB

We aim to integrate the farm P balance per tillable acre into the NY-PI. Several options are currently under evaluation:

- **Including the NMB assessment as an extra BMP factor** (depending on the size of the P balance, the NY-PI score gets multiplied by an additional factor, ranging from a slight score reduction for a NMB assessment by itself, and a stronger reduction for feasible P balances).
- **Reducing the P loss risk category for farms operating in the Green Box** (farms that have a P balance under 12 lbs/acre are moved to a lower category, for example from High to Medium).
- **Creating separate implication assessments for farms operating in the Green Box** (this would involve different versions of Table 1, depending on the size of the farm P balance)

We continue to develop the NY-PI and assess these options.

## References

[1] Ketterings, Q.M., Cela, S., Collick, A.S., Crittenden, S.J., Czymmek, K.J., 2017. Restructuring the P Index to better address P management in New York. *Journal of Environmental Quality*.
[2] Crittenden, S.J., Ketterings, Q.M., Knight, J., Czymmek, K.J., 2017. Soil phosphorus saturation ratio sets comparable manure application cutoffs across states differing in agronomic soil test. *Soil Science* **182**, 36-44.
[3] Cela, S., Ketterings, Q.M., Czymmek, K., Soberon, M., Rasmussen, C., 2014. Characterization of nitrogen, phosphorus, and potassium mass balances of dairy farms in New York State. *Journal of Dairy Science* **97**, 7614-7632.

## Contact information

Want to know more? Shoot us an email!

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