The North Carolina Approach to Phosphorus Loss Assessment

In 1999, the Phosphorus Loss Assessment committee was formed to respond to address the changes in the NRCS nutrient management policy and standard 590. This committee is composed of members of NRCS, the NC Division of Soil and Water Conservation, the NC Department of Agriculture and Consumer Services, and 11 faculty members of NC State University.

The NRCS policy offers three options for conducting a field specific phosphorus (P) loss assessment: an agronomic soil test threshold, an "environmental" soil-test threshold, or a "P Index" approach. Delivery of P to water requires source P accumulation and active transport processes in a field. Soil testing approaches, valuable as site-specific estimators of P accumulation, must be part of any P-Loss assessment method, but are inadequate predictors of potential phosphorus delivery from a landscape since they do not address the transport component. The North Carolina Phosphorus Loss Assessment Committee strongly endorsed the P-Loss Index concept. In order to avoid confusion with the agronomically based NCDA&CS "P-Index" reported on soil testing forms, North Carolina will use the term "P Loss Assessment Tool (PLAT)".

The committee examined the P Loss Index approaches proposed by NRCS national staff and those proposed in other states to see how well these approaches might work in North Carolina. These approaches commonly define a set of criteria such as erosion rate, soil P, and application amounts and methods. For each of the criteria, ranges of conditions are defined and rated from low to high, and numeric value are assigned that increase as P Loss potential increases. Since some criteria may be more important in delivering P than others, each is also weighted relative to the other criteria. In looking at existing examples, the committee found that most states either assumed loss occurred primarily through a single loss pathway such as erosion, or they focused on a single animal and cropping system such as poultry litter on pastures. In addition, enormous reliance was placed on best professional judgment in defining the loss criteria and numeric values, and in assigning the weighting factors for the criteria. Each of the proposed methods had serious limitations for use in North Carolina, where agricultural operations occur on over 480 soil series, (nearly 2000 mapping units) ranging across 7 soil orders, all drainage conditions, and nearly all particle size classes. Animal wastes applied to these sites come from dairy, beef, swine, layers, broilers and turkey operations, and each region of the state has important and often unique animal and cropping system traditions. In addition, North Carolina rules in effect in the Neuse and Tar Pamlico river basin could require nutrient management plans for fertilized fields to meet the new standard as well, a condition not experienced in other states. Because of the enormous diversity of situations encountered within the state, it became apparent NC needed to develop a new method that allowed analysis of each loss pathway separately for a given site based on the characteristics of each site. Using this generic approach and site-specific factors, only the appropriate source and transport factors are used to calculate loss potential. Each loss pathway is assigned a relative PLAT value for that site. The final results from each pathway are summed to obtain the overall P Loss Assessment for the site, as discussed below.

Loss Pathways

Phosphorus loss occurs through four major loss processes, any of which could be the dominant loss pathway for a situation common in some part of the state. One or more pathways may contribute to significant P loss for a site.

1. Runoff Carrying Soil-bound P

The largest pool of P in a field is the soil itself. The sorting of soil particles that naturally takes place during erosion results in the soil particles (clays) with the highest P concentration being carried with surface runoff.

Soils with higher soil test P levels will have higher P content in eroded particles. Site-specific factors that reduce sediment delivery to the stream, such as erosion control practices, redeposition in the field, and retention beyond the edge of the field by buffers or other best management practices (BMPs), reduce P loss.

2. Runoff Carrying Soluble P
For a given soil, the dissolved P concentrations in runoff increases proportionally as the soil test P level increases. The amount of P the soil releases to runoff at a given soil test level also varies with soil texture, organic matter content, and types of soil minerals. Very few BMPs are effective in reducing runoff P losses.

3. Subsurface Soluble P Losses Connected with Surface Water
Direct movement of P from soil to surface water is possible on sites with tile drains and ditches that enter surface waters. Soils with high P content and moderate or lower P retention capacity may also contribute to surface water through leaching and lateral flow from the field, since a high percentage of the near-surface groundwater feeds locally into surface water channels.

4. Runoff Carrying P From Nutrient Sources Applied to the Surface
There is a strong relationship between P application rate (as manure or fertilizer) and the concentration of P in runoff following applications. In manured or fertilized fields, the concentration of P in surface runoff increases with the application rate, the amount of applied P remaining on the soil surface, and the solubility of the applied P.

Factors Used by the P Loss Assessment Tool

TABLE 1. Factors affecting loss of soil-bound P through erosion (Particulate P).

FACTOR	COMMENTS
Soil erosion rate	Calculated using the Revised Universal Soil Loss Equation (RUSLE); affected by soil, slope, residue management, tillage, crop and in-field erosion control practices
Soil Test P (Mehlich 3) and estimated clay content	Used to estimate P Concentration associated with lost sediment
Receiving slope width	Used to estimate edge-of-field-delivery of detached soil particles
Fe-P fraction	Reducible-P component of sediment–bound P, specific to soil groups.
Enrichment factor	Estimates enhanced delivery of fine particles which are enriched with P relative to the whole soil
Buffer width	Retention of sediment-bound P
P-retaining practices and trapping efficiency	Sediment retention, ponds, etc.

TABLE 2. Factors affecting loss of soluble P from soil to surface runoff (Soluble P).

FACTOR	COMMENTS
Soil Test P (Mehlich 3) and Soil management group	P concentration supported in runoff (soil specific)
Estimated Runoff (inches per year)	
No artificial drainage	Improved curve number method (crop, residue level, and soil specific). Uses long-term (40+ years) county specific rainfall records, daily average runoff calculated, with antecedent moisture conditions accounted for.
Artificially drained	Based on drainage depth and distance between drains, and soil properties with depth, a Drainage Index (DI) is calculated. Runoff is calculated based on DI, crop, and average county rainfall. DRAIMMOD based.

TABLE 3. Factors affecting loss of soluble P in subsurface flow (Leachate P).

FACTOR	COMMENTS
Soil Test P (0-8 inches)	Initial estimate of P concentration supplied to subsoil layers.
Soil Test P – at 30 inch depth	Estimate of P concentration in subsurface flow
Very high P retention	Likelihood of P Movement from surface to beyond the 30 inch depth. Database value, soil specific.
Estimated subsurface flow (inches per year)	
No artificial drainage	Annual Rainfall – ET – Runoff (See Table 2). ET is based on Penman-Monteith equation, utilizing crop, soil, and local climatic data.
Artificially drained	Drainage Index (Table 2), crop and local rainfall specific. DRAINMOD based.

TABLE 4. Factors affecting loss of P from applied nutrient sources (Source P).

FACTOR	COMMENTS
Application rate	Amount of P applied
Application method	Surface exposed P remaining after application
Mobile P factor	Fraction of potentially released P remaining on the surface after application. Depends on source characteristics such as density, water content, total P, soluble P.
Runoff fraction	(See Table 2). Runoff/Annual Rainfall. Used to estimate maximum loss potential.
Delivery factor	Attenuation of surface soluble P with time

PLAT Ratings

Based on site-specific parameters, each loss pathway is assigned PLAT value (Table 5), and these values are summed to obtained the overall PLAT rating. Using this approach, the planner can readily determine which loss pathway is dominant, and thus, which BMPs may be needed to reduce P loss. According to the NRCS standard and policy, if any one pathway or the total results in a "High" rating (greater than 50, Table 6), P application is limited to the amount of P removed in the harvested crop until the loss potential is lowered. If any loss pathway or the total results in a "Very High" rating (greater than 100, Table 6), no additional P can be applied to this site until the loss potential is lowered.

Table 5. Overall PLAT Assessment

Loss Pathway	PLAT Value
1. Particulate P	
2. Runoff Soluble P	
3. Subsurface Soluble P	
4. Source P	
TOTAL	

Table 6. PLAT Ratings

Rating	PLAT Value
Low	0-25
Medium	26-50
High	51-100
Very High	>100

Advantages of the NC Phosphorus Loss Assessment Tool

- While imperfect, the results are scientifically credible, and based on the best available science and research data. Subjective assignment of criteria ratings and weightings is avoided.
- One tool works for all situations. Multiple worksheets with different ratings based on regions, manure systems or cropping systems eliminated.
- The tool uses standard inputs where possible:
    - Soil mapping unit
    - Erosion rate (RUSLE), receiving slope width
    - Current or planned type of manure, application rate, and method
- The results reflect site specific and local conditions:
    - Runoff and leaching estimates (based on soil mapping unit, crop, residue management, local climate, drainage conditions)
    - Soil test – Surface and 30 inch depth
    - Edge of field buffers and sediment trapping practices
- By assessing each pathway independently, PLAT helps the planner and the producer to understand how nutrients may move from the field to surface water.
- Best Management Practices are integrated into the assessment process. Current and planned BMPs can be used to make the assessment. This allows PLAT to be used as a flexible planning tool as well as an assessment tool.