The North Carolina Phosphorus Loss Assessment Tool (PLAT): A Guide for Technical Specialists

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Introduction

Nutrient management is the correct placement of the correct amount of nutrients in the soil at the right time and in the right form. Nutrient management should always be used when applying fertilizer or animal waste.

For many applications in North Carolina, nutrient management must meet the standards set by the US Department of Agriculture's Natural Resources Conservation Service (NRCS). Specific instances in which NRCS nutrient management guidelines must be followed are:

- If the nutrient management plan is being written by a USDA-NRCS employee or by county Soil and Water District Conservation personnel.
- If the producer is receiving state or federal agricultural cost-share funds.
- If the animal waste is regulated under state .0200 laws.
- If the animal waste is regulated under NPDES permits.
- If the farm is in the Neuse or Tar-Pamlico River Basins.

Phosphorus (P) management is one important aspect of the USDA-NRCS 590 nutrient management standard, which mandates that anyone applying animal waste or fertilizer in a nutrient-impaired subwatershed must determine potential P loss from each field. Under the national 590 standard, each state was allowed to choose one of three methods for determining potential off-site P loss: agronomic soil-test level, environmental soiltest threshold, or a P index methodology. North Carolina chose the third option—a P index methodology.

A North Carolina interagency group composed of faculty from NC State University and personnel from the state Department of Environment and Natural Resources (NCDENR)—Division of Soil and Water Conservation (DSWC), state Department of Agriculture and Consumer Services (NCDA&CS), and USDA-NRCS[1] made the choice, electing to develop the site-specific P index because both the agronomic soil test and environmental threshold approaches were too strict and were not scientifically defensible. In addition, North Carolina has very diverse agricultural conditions and systems. While soil-testing approaches are valuable as site-specific estimators of P accumulation, they do not predict potential P losses, as loss is a function of soil-test P and the amount of soil loss and runoff.

The P index, which is referred to as the North Carolina Phosphorus Loss Assessment Tool, or PLAT for short, has the advantage of being applicable to all situations. It was adopted in November 2003 and is described below.

[1] Members included David Crouse, Wendell Gilliam, John Havlin, Eugene Kamprath, Rory Maguire, and Deanna Osmond (Soil Science Department, NC State University); Robert Evans, John Parsons, Wayne Skaggs, and Phil Westerman (Biological and Agricultural Engineering Department, NC State University); David Hardy and Richard Reich (NCDA&CS); Steve Coffey and Carroll Pierce (NCDENR-DSWC); and Roger Hansard and Lane Price (USDA-NRCS).

Loss pathways

Phosphorus loss from fields to waters occurs along four major pathways:

- Soil-attached P erosion.
- Soluble-P runoff.
- Soluble-P leaching.
- Source-P loss (fertilizer and/or animal waste).

The dominant loss pathway in any field depends on many factors. One or more pathways may contribute to significant P loss for a site.

The effects of each of the four loss pathways are calculated in PLAT and added together to estimate the total P loss for a field.

Total P Loss = Soil-Attached P Erosion Loss + SolubleP Runoff Loss + Soluble-P Leaching Loss + Source-P Loss

1. Soil-attached P erosion loss

Phosphorus added from fertilizers and animal waste usually attaches to soil particles. If these soil particles erode, the attached P will move with the soil when it erodes. Soils with higher soiltest P levels will have higher P in eroded particles.

Eroded soil (and the P attached to these soil particles) may be reduced by:

1. Redeposition in areas near the edge of the fields that are flatter (these are referred to as receiving slopes).
2. In-field and other best management practices (BMPs). Any in-field conservation practices that reduce soil erosion may be used (e.g., terraces, conservation tillage, cropping systems).

3. Non-field BMPs that reduce soil movement to surface waters, such as buffers, controlled drainage, ponds, and sediment basins.

The procedure for estimating the P lost through soil erosion is characterized as:

Soil-Attached P Erosion Loss = Soil Erosion Rate * Soil-Test P * Receiving Slope Width * Fe-P Faction * Best Management Practices

Factors used in the equation, information needed for each factor, and the source of the information needed are listed in Table 1.

Table 1. Estimating P lost through soil erosion.

Factor	Information Needed for Each Factor	Information Source
Soil erosion rate	• Revised Universal Soil Loss Equation (RUSLE)	• Site visit
Soil test P-Index (Mehlich-3)	• Mehlich 3 P-Index number • Soil mapping unit (to determine clay percentage)	• Soil test from certified lab • Soil survey
Receiving slope width	• Receiving slope wdith (to estimate edge-of-field-delivery of detached soil particles)	• Site visit
Fe-P fraction	• Soil mapping unit (to determine reductions due to Fe or Al content of the soil)	• Soil survey
Best management practices	• BMPs that reduce sediment-bound P	• Site visit or conservation plan records

2. Surface water runoff loss

When water runs off fields, it carries dissolved P. The amount of dissolved P in the 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.

Runoff depends on rainfall, soil texture, field slope, field practices, and drainage. If field practices reduce runoff (e.g., conservation tillage, soil cover, contour farming), then P losses through runoff will be reduced. For calculation of runoff in PLAT, soils are divided into two broad drainage categories: artificially drained soils (mostly in the eastern part of the state) or naturally drained soils (upper coastal plain and piedmont).

The procedure for estimating the P lost through runoff is characterized as:

Soluble-P Runoff Loss = Estimated Runoff * Soil-Test P

Factors used in the equation, information needed for each factor, and the source of the information needed are listed in Table 2.

Table 2. Estimating P lost through runoff.

Factor	Information Needed for Each Factor	Information Source
Soil test P-Index (Mehlich 3)	• Mehlich 3 P-Index number • Soil mapping unit (to determine general textural class)	• Soil test from a certified lab • Soil survey
Estimated runoff (in/yr)		
Natural drainage	• Soil mapping unit to determine hydrologic characteristics) • County • Hydrologic condition	• Soil survey • Site visit
Artifically drained	• Soil mapping unit • County • Drain spacing and depth	• Soil survey • Site visit or conservation plan records

3. Leaching loss

Phosphorus may be discharged into surface water as a result of subsurface flow processes on sites with tile drains and ditches. Soils with very high soil-test P and sandy textures can cause P to leach deeply into the soil and possibly into the shallow groundwater. This most often occurs when large applications of animal waste have been applied over long periods.

The procedure for calculating the soluble P lost through leaching is characterized as:

Soluble-P Leaching = Drainage * SoilTest P (30-inch depth)

Subsurface leaching losses will not be calculated in PLAT for sites where leaching is not expected to occur, i.e., low soil-test P in surface and/or claytextured soils.

When surface soil-test P is “high” for different soil textures (50 mg/kg organic soils; 100 mg/kg sandy soils; 200 mg/kg loamy soils; 500 mg/kg clayey soils), users are required to take a soil sample at a 30-inch depth. The sample at 30 inches is obtained with a 28- to 32-inch core. If the deep soil test indicates a P concentration of 50 mg/kg or higher, then PLAT will rate the site as at least *High*. The overall PLAT rating for the site may be *Very High*, depending on the combined P loss risk from all four transport pathways.

Factors used in the equation, information needed for each factor, and source of the information needed are listed in Table 3.

Table 3. Estimating P lost through leaching.

Factor	Information Needed for Each Factor	Information Source
Soil test P – at 30-inch depth	• Mehlich 3 P-Index number	• Soil test from certified lab
Estimated drainage (in/yr)		
Natural drainage	• Soil mapping unit (to determine hydrologic characteristics) • County • Hydrologic condition	• Soil survey • Site visit
Artifically drained	• Soil mapping unit • County • Drain spacing and depth	• Soil survey • Site visit or conservation plan records

4. Applied P loss

There is a strong relationship between the P application rate and the concentration of P in runoff following application. In manured or fertilized fields, the concentration of P in surface runoff increases with the type and form of the waste, the application rate, the application method, and the solubility of the applied P.

The procedure for calculating the source P lost through surface runoff is characterized as:

Source P Loss = Application rate * Application method * P content of applied source * Soluble P * Soluble P attenuation factor * Nonsoluble P * Nonsoluble P attenuation factor * BMP factor * Runoff fraction

Factors used in the equation, information needed for each factor, and the source of the information needed are listed in Table 4.

Table 4. Estimating P lost through surface runoff.

Factor	Information Needed for Each Factor	Information Source
Application rate	Amount of waste applied	Producer, conservation plan, or waste utilization plan records
Application method	Application method	Producer, conservation plan, or waste utilization plan records
P content of applied source	P content of the applied source (For animal waste applications, the preferred value is from a certified waste analysis report; otherwise the default value from the database will be used. For fertilizer, users may enter this information directly.)	Producer, conservation plan, or waste utilization plan records OR nutrient management databases
Soluble P	P source type (soluble P determined automatically from nutrient management database)	
Soluble P attenuation factor	P source type (soluble P attenuation factor determined automatically from nutrient management database)	
Nonsoluble P	P source type (nonsoluble P determined automatically from nutrient management database)	
Nonsoluble P attenuation factor	P source type (nonsoluble P attenuation factor determined automatically from nutrient management database)	

Factor	Information Needed for Each Factor	Information Source
Best management practice	Buffer BMP (one that reduces nonsoluble P)	Producer, conservation plan records, or site visit
Runoff fraction	Runoff	Already calculated

PLAT rating

Index values are computed for each of the four P loss pathways. These indices are added to produce the final PLAT rating for the field (Table 5). When commercial fertilizer is applied, soil-test P recommendations as specified in the nutrient management plan should always be followed. If animal waste is applied, PLAT ratings of *High* will limit the amount of waste that can be applied to the amount that will be removed by the crop, and a rating of *Very High* will prohibit any P application at all, except as a starter fertilizer.

Table 5. PLAT rating.

Rating	Index Value	Consequence of Rating
Low	0-25	Use nitrogen-based manure application rate.
Medium	26-50	Use nitrogen-based manure application rate.

Rating	Index Value	Consequence of Rating
High	51-100	Manure application rate is limited to phosphorus removal from the site in the harvested crop.
Very High	>101	No additional phosphorus application is allowed (except starter fertilizer P).

PLAT Results

The data necessary to run PLAT were collected from 1,379 fields throughout North Carolina. These data were used to predict P losses from the different pathways. It was apparent that loss of P from certain pathways was more significant than others. For example, *Soil-Attached P Erosion Losses* were generally low, due either to cropping systems that kept the soil in place (such as pastures) or to low soil-test P. Loss of P through *Soluble-P Runoff* was relatively more important to overall P loss, especially from sandy coastal plain sites that received animal waste. Soils from these sites tended to have much higher soil-test P levels. Sites with sandy soils were more susceptible to *Soluble-P Leaching* losses than other soil types.

Predicted P losses were higher from fields on which animal waste was applied, although there were differences in loss depending on which animal waste was used. More P was lost, in general, from fields receiving poultry waste because of the higher P content of the waste. Dairy waste has an equally high total P content, but application rates tend to be lower than those for poultry waste. Fields receiving swine waste tend to predict more P loss as soluble P in both surface runoff and subsurface drainage, rather than applied source P, because most of the P in this waste is in a soluble form

PLAT Website

North Carolina's PLAT tool is one of the most comprehensive of its kind. Its development over a three-year period was based on the integration of all the available research and science. Information about PLAT can be found on the NC State University Interagency Nutrient Management site. The North Carolina Agricultural Nutrient Assessment Tool, which includes the PLAT software, can be downloaded from this site. Additional materials, such as how to take deep soil samples and other information, are available on this site.

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