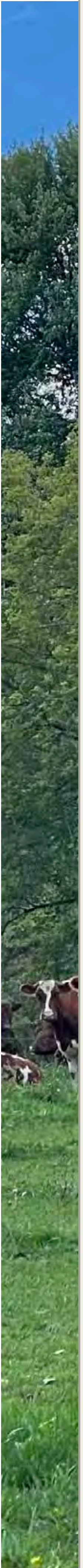

NPM

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REGIONAL

Chris Clark, Northeast
715-850-2888, clark3@wisc.edu

Michael Geissinger, Northwest
608-640-0650, michael.geissinger@wisc.edu

Dan Marzu, Northcentral
608-381-6702, dan.marzu@wisc.edu

Jordan Kampa, Southeast
414-399-0373, jordan.kampa@wisc.edu

Landon Baumgartner, Southwest
608-228-5125, landon.baumgartner@wisc.edu

UW-MADISON CAMPUS

Daniel H. Smith, Program Manager
608-219-5170, dhsmith@wisc.edu

This publication is available from the NPM Program.
Contact us at:
npm@extension.wisc.edu
website (ipcm.wisc.edu)

CERTIFIED CROP ADVISER

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Extension
UNIVERSITY OF WISCONSIN-MADISON

*Welcome to the new **Nutrient Management Fast Facts magazine!** The Nutrient and Pest Management (NPM) Program has produced many stand alone publications to help learn the basics of what is involved in writing and implementing a nutrient management plan. This new format combines many of these existing publications with new materials to provide a comprehensive reference guide!*

NUTRIENT MANAGEMENT Fast Facts magazine

NUTRIENT MANAGEMENT

Nutrient Mgmt

SOILS

Soils

NITROGEN

Nitrogen

PHOSPHORUS AND POTASSIUM

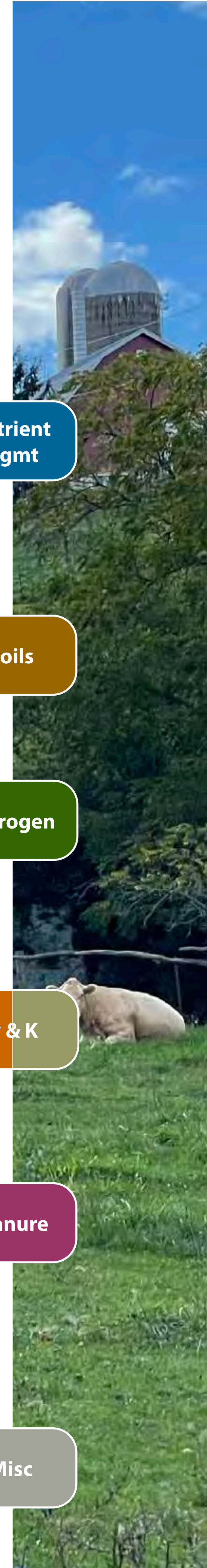
P & K

MANURE

Manure

MISCELLANEOUS

Misc



What Is A Farm Nutrient Management Plan?

A farm nutrient management plan is a strategy for obtaining the maximum economic return from both on- and off-farm nutrient resources in a manner that optimizes soil conservation and protects the water quality.

A successful plan makes sense agronomically, economically and environmentally!

Developing a plan requires some basic information and thoughtful consideration during the planning process. Although plans can range from simple to complex, all plans include the following five basic components:

1. Soil testing and results

Complete and accurate soil tests are the starting point of a farm nutrient management plan. All cropland fields must be tested or have been tested within the last four years.

From the soil test results, the base fertilizer recommendations for each field are given. To learn more, see the soils section (pg. 9-12).

2. On-farm nutrient resources inventory and nutrient credits

The amount of crop nutrients supplied to fields from on-farm nutrient resources such as manure, legumes and organic wastes need to be determined so those nutrients can be deducted from the base fertilizer recommendations. Legume crops, such as alfalfa and clover, supply nitrogen to the crops that follow them. Manure applications to fields supply crops with nitrogen, phosphorus, and potassium — as well as sulfur and organic matter.

On farms with livestock, a key step in the planning process is developing a manure inventory. This involves estimating the annual manure volume produced on the farm. This applies to both stored liquid and solid manure, as well as any pastured animals. If the farm uses any biosolids or other organic wastes, these nutrients should also be included in the inventory. To properly credit nutrients supplied from manure, both the crop available nutrient content of the manure and application rate are required. The most accurate method to determine application rate is by calibrating the manure spreader. This is done by weighing the spreader, spreading, measuring area and calculating the tons/acre rate. To learn more, see the manure section (pg. 24-27).

Legume credits are determined by assessing previous stands based on regrowth height, stand density and soil texture. Once all on-farm nutrient resources are inventoried and manure spreaders calibrated, then nutrient credits can be determined.

3. Cropping plan

A cropping plan for each field (full rotations) along with yield goals and planned tillage is an important part of developing a nutrient management plan. Pre-planning rotations can optimize legume credits and manure applications, as well as identify areas where management practices for soil and nutrient loss can be improved.

4. On-farm conservation practices inventory

A nutrient management plan should be consistent with the farm's soil farm conservation plan, which includes information used to determine the soil erosion rate. The slope and critical soil map symbol for each field determines how vulnerable that field is to soil loss and is an important tool for planning future nutrient applications and tillage.

Other practices that limit soil erosion and phosphorus runoff, such as filter strips and fields farmed on-contour, are important to inventory during the planning process to ensure your plan accurately estimates the soil erosion and phosphorus losses resulting from crop management activities.

5. Nutrient application plan

The nutrient application plan is the culmination of all of the other parts of the plan. The goal is to have planned nutrient application rates for both commercial fertilizer and manure that makes sense agronomically, economically and environmentally. A good plan does not exceed crop nutrient needs as identified in the soil test report. If the farm has manure, the plan prioritizes those fields that would benefit the most from the manure-supplied nutrients (while posing little threat to water quality) and also clearly identifies fields that have spreading restrictions — fields adjacent to lakes and streams, sloping fields where the threat of spring runoff prohibits manure applications in the winter, and fields in the vicinity of wells, sinkholes or fractured bedrock.

Keep in mind that nutrient application is only one important piece of the agronomic puzzle!

There are many factors that influence a successful yield, including moisture, growing degree days, soil stucture, soil biology, crop variety, and weed, insect & disease pressure.

A note about the 590 Nutrient Management Planning Standard

You may have heard or read about something called the "590 standard" and wonder what it has to do with nutrient management planning. The United States Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS) 590 Nutrient Management Planning Standard defines the minimum requirements and components of an acceptable nutrient management plan; a compliant plan with the 590 standard is a requirement for participation in some federal and state farm programs (with some state having additional rules for compliance).

Benefits of a Nutrient Management Plan

A Nutrient Management Plan (NMP) is a living document outlining the planned use of nutrient sources — manure, legumes, organic wastes and commercial fertilizers — to supply plant essential nutrients on crop fields and pastures. NMPs are also used to evaluate the impact of field operations, including crop rotations and tillage practices, on potential soil erosion and surface water quality.

Writing and following an NMP often increases a farm's profitability through improved nutrient management and cropping system practices.

A 2012 study of over 250 Wisconsin farms with NMPs found:

- ✓ 69% of farms saved money with an NMP, with an average savings of approximately $ 18/acre
- ✓ 65% of farms decreased nitrogen applications by an average of 54 lbs N/acre
- ✓ 51% of farms decreased phosphorus applications by an average 32 lbs P_2O_5/acre

With these nutrient reductions:

- ✓ 74% of farms cited no change in corn yield
- ✓ 18% of farms cited increased corn yield

Gensko, K.D. (2012). *Taking stock of voluntary nutrient management: Measuring and tracking change.* Journal of Soil and Water Conservation, 67(1): 51-58

IMPROVED NUTRIENT MANAGEMENT

Writing an NMP in SnapPlus allows farms to target applications of nutrients based on crop production goals.

SnapPlus nutrient management planning software automatically:

- ✓ **Calculates crop nutrient** need based upon University of Wisconsin recommendations, crop yield goals, soil test levels, crop rotation and previous nutrient use.
- ✓ **Accounts for nutrient availability from manure applications** based upon laboratory manure test results or University book values, as well as 1st, 2nd and 3rd year legume and manure nutrient credits, where appropriate.
- ✓ **Produces nutrient spreading maps** and identifies restricted and prohibited areas for nutrient applications according to state and local regulations.

By knowing which fields require nutrients and at what rates, farms can optimize their use of both on-farm nutrient sources and commerical fertilizers, potentially resulting in increased crop productivity and/or decreased farm input expenses.

All Wisconsin farms — regardless if they have livestock or not — should write and follow an NMP.

Most farms and agronomists use the free **SnapPlus** software program* to write NMPs.

*University of Wisconsin-Madison Soil Science Department

Download at:

snapplus.wisc.edu

To watch SnapPlus tutorial videos, click or scan the QR code:

In 2022, approximately 37% of Wisconsin's 3.5 million crop acres had NMPs. Although many farms are required to have an NMP*, many farms write an NMP because it just makes good sense!

*Farms required to have an NMP include those: offered cost-share with an NMP being a condition of the agreement; participating in the Farmland Preservation Program; with a Wisconsin Pollutant Discharge Elimination System (WPDES) permit; regulated under a local ordinance for manure storage or livestock siting; or issued a Notice of Discharge for causing significant discharge.

An NMP identifies fields where water erosion is potentially reducing soil health and crop production.

Wisconsin farms are, on average, losing an estimated 1-3 tons of soil per acre per year in northern Wisconsin and 3-8 tons per acre per year in southern Wisconsin by water erosion.

Estimated replacement value of soil of $20/ton = $20 - $160 loss/acre/year

Robinson, D.A., et al. (2014). *On the value of soil resources in the context of natural capital and ecosystem service delivery.* Soil Science Society of America Journal, 78(3): 685-700

IMPROVED CROPPING SYSTEM PRACTICES

Writing an NMP in SnapPlus also provides field-by-field estimates of crop rotation and tillage impacts on key soil health indicators.

SnapPlus, on a field-by-field basis, automatically:

- ✓ **Estimates soil loss from water erosion,** allowing for the identification and alteration of cropping practices to promote long-term crop productivity, soil health and local water quality.
- ✓ **Calculates a phosphorus index (PI),** an estimate of phosphorus transport from a field to a nearby water body. Knowing a field's PI allows a farm to alter its cropping practices to maintain phosphorus in the field, reducing crop nutrient loss and improving surface water quality.
- ✓ **Calculates a field's soil conditioning index (SCI),** which predicts potential changes in soil organic matter due to crop management. Soil organic matter is key to soil health. Altering farming practices to increase a field's SCI can result in the long-term improvement of crop and soil productivity.

Farmers can write their own NMP by completing a DATCP-approved training course once every four years. Contact your county land conservation department to inquire about available training: https://wisconsinlandwater.org/events

Farmers can also work with a certified nutrient management planner to develop an NMP. A listing of certified planners can be found at: datcp.wi.gov/Documents/AvailableNMPlanners.xlsx

Nutrient Management on Pastures

ATCP 50 implements soil and water conservation standards adopted by the Department of Natural Resources (DNR), which includes the requirement that pastures comply with the soil loss and Phosphorus Index (PI) standards. This document explains the conditions under which ATCP 50 pasture requirements apply and the flexibility allowed in ATCP 50 when developing a nutrient management (NM) plan for pastures to demonstrate compliance with the soil loss and PI standards. Farmers may continue to claim Farmland Preservation tax credits while planning pastures with a performance scheduled developed by the county land conservation department. SnapPlus (v2 or later) can be used to determine soil loss and PI values under a number of pasture and dry lot management scenarios. If a pasture is included in a NM plan developed using SnapPlus that meets the PI limits in NR 151.04, the plan can be used to demonstrate compliance with DNR's standards.

DEFINITIONS

Animal unit [NR 243.03 (5)]: a unit of measure used to determine the total number of single animal types or combination of animal types, as specified in s. NR 243.11, that are at an animal feeding operation.

Feedlot [NR 151.015 (8)]: a barnyard, exercise area, or other outdoor area where livestock are concentrated for feeding or other purposes and self—sustaining vegetative cover is not maintained. "Feedlot" does not include a winter grazing area or a bare soil area such as a cattle lane or a supplemental feeding area located within a pasture, provided that the bare soil area is not a significant source of pollution to waters of the state. Note that grazed woodlands are considered feedlots.

Grazing Season [ATCP 50.04 (3) b. Note]: Includes the months of the year when pasture vegetation is actively growing.

Pasture [NR 151.015 (15m)]: Land on which livestock graze or otherwise seek feed in a manner that maintains the vegetative cover over the grazing area. Pasture may include limited areas of bare soil such as cattle lanes and supplemental feeding areas provided the bare soil areas are not significant sources of pollution to waters of the state.

WHEN MUST A PASTURE BE INCLUDED IN A NM PLAN?

INCLUDE A PASTURE IF ANY APPLIES:

- ✓ It receives mechanical applications of nutrients. *Develop a NM plan for this pasture using soil samples collected at the frequency of 1 sample per 5 acres every four years and analyzed by a DATCP certified soil testing laboratory [ATCP 50.04(3)].*
- ✓ It is stocked at an average of MORE than 1 ***animal unit*** (AU) per acre*. *Develop a NM for this pasture either using soil tests according to ATCP 50.04(3) or 'assumed soil test values' of 150 ppm P and 6% OM.*
- ✓ It has a herd present in the winter and is not a ***feedlot***. *Develop a NM for this pasture either using soil tests according to ATCP 50.04(3) or 'assumed soil test values' of 150 ppm P and 6% OM.*

DO NOT INCLUDE A PASTURE IF EITHER APPLIES:

- ✓ It is a ***feedlot***, **OR**
- ✓ It is stocked at an average rate of 1 AU per acre or LESS* at all times during the ***grazing season***,

AND

- ✓ It does not received mechanical nutrient applications.

HOW TO CALCULATE THE GRAZING SEASON'S AVERAGE STOCKING RATE FOR PASTURES (AU/ACRE)

There are two methods available to calculate a pasture's average stocking rate. The first method is to use the **Grazing Application Estimator** in SnapPlus (available for free at http://snapplus.wisc.edu/). The second method is to calculate it manually using the equation below along with the DNR's publication for calculating animal units, Form 3400-025A (http://dnr.wi.gov/topic/agbusiness/documents/3400025a_wt.pdf).

Represents the average grazing season from April through November

$$\left[\frac{\text{(Animal Units in herd} \times \text{Days pastured} \times \text{Percent of day grazed)}}{\text{Acres of pasture}}\right] \div \text{244 grazing season days} = \text{AVERAGE STOCKING RATE during the grazing season (AU/acre)}$$

Example scenario

Does this pasture need to be included in a NM plan?

A 15 dry cow herd grazes on a 5 acre pasture for 100 days during the summer. The herd spends 50% of the day on the pasture.

15 current number in herd × 1.43 equiv. factor = 21 AU

21 AU in herd × 100 days pastured × .50 (50% of day) = 1050 AU/day

1050 AU/day ÷ 5 acre pasture = 210 AU/day/acre

210 AU/day/acre ÷ 244 days = 0.9 AU/acre

The average stocking rate for this pasture is LESS than 1 AU/acre; ***it does not need to be included*** *in the NM Plan.*

What is the Wisconsin Phosphorus Index?

The Wisconsin Phosphorus Index (P Index) is a planning and assessment tool for managing phosphorus runoff from cropland and pastures.

✓ **The P Index** uses general cropping, soil test and long-term weather information to estimate a field's annual phosphorus runoff to nearby surface waters.

✓ **The P Index is reported as a whole number** — the higher the number, the greater the potential for that field to contribute phosphorus to nearby lakes and streams; even very low additions of phosphorus in water can grow an abundance of algae and degrade water quality! Another way of thinking about it is *the P Index estimates how well phosphorus is kept in the field*.

What does the P Index have to do with nutrient management planning?

The P Index is one of the two phosphorus strategies used to meet the USDA-NRCS 590 Nutrient Management Planning Standard (the other strategy uses the field's soil tests phosphorus levels to determine nutrient applications). To calculate the Wisconsin P Index, you must use the nutrient management software SnapPlus.

Can a P index value be reduced?

Yes! The following management strategies can be used to reduce a field's P Index value.

1. Use in-field pra tices that reduce erosion/runoff

- ☑ Use crop rotations that maximize crop residues — grasses, alfalfa, cornstalks left in the field
- ☑ Add a nurse crop to alfalfa seedings
- ☑ Work the field on the contour
- ☑ Reduce tillage intensity
- ☑ Strip-crop
- ☑ Install in-field grass contour buffer strips

2. Plan manure and fertilizer applications carefully

- ☑ Avoid or reduce winter applications of manure when possible
- ☑ Apply high solid content manure to fields that have little residue at the time of application

3. Reduce soil test phosphorus to optimum level

- ☑ Apply manure to fields where much of the phosphorus will be removed over the rotation (i.e. fields in rotation with alfalfa)
- ☑ Reduce or eliminate applications of manure to fields that do not have a recommendation for phosphorus.

4. Use below-field grass fi er areas or buffers on critical slopes

- ☑ Install grassed filter strips following design specifications set by the Natural Resource Conservation Service

Does the P Index work on pastures?

Yes! The P Index is calculated for pastures with the same equations as for cropland. Manure rates are estimated according to the number, type, and time of animals present and an average excretion rate for each type of animal.

- ☑ Managed pastures that have a stocking density low enough to maintain sod cover generally have very low soil loss and rainfall runoff, and therefore have low P Index values compared to most cropland.
- ☑ Exercise-area type pastures where sod cover is not maintained can have high soil erosion rates and also can have comparatively high manure rates, resulting in higher P Index values.
- ☑ Pastures used for over-wintering, especially those on medium to heavy textured soils, can have high P Index values in snowmelt or winter rain.

A note about the forms of phosphorus in runoff

The total runoff phosphorus concentration is made up of two forms: soluble P (dissolves in water) and insoluble P (particles that don't dissolve in water). Soluble P can come from the soil, manure and fertilizer. Insoluble or particulate P comes from the soil in the form of eroded sediment. Since most phosphorus is bound to the soil, **reducing soil loss from fields and pastu es is a key strategy for reducing the P Index value.**

Soil Loss T Scenarios

Soil loss tolerance (T) is the maximum amount of soil loss in tons per acre per year that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely. An effective strategy to reduce soil loss is to orient the rotation to ensure sufficient residue each year, especially over the winter months and prior to planting. Additions of manure may also act as additional residue and help reduce soil loss even further, but you must keep in mind your farm's phosphorus soil test levels and potential phosphorus loss from manure when planning applications.

Important Note: This publication is only intended to be used as a reference guide. It should in no way be used as a replacement for running soil loss equations with your own data in SnapPlus. These scenarios were run using SnapPlus version 1.132.8

Dane County Soils

A: BbA, Batavia, T=4
B: KdB, Kidder, T=5
B2: BaB2, Basco, T=3
C: DpC, Dodgeville, T=3
C2: DuC2, Dunbarton, T=2
D2: DuD2, Dunbarton, T=2
E2: DuE2, Dunbarton, T=2

more residue = reduced soil loss

Crop Key:
OfAs= oatlage with alfalfa seeding
cg=corn grain
sb30=soybean (30-36")
csl=corn silage
a=alfalfa
as=alfalfa seeding
[Csl+cv]=corn silage to small grain cover crop
[Wwg-Fs]=winter wheat (grain) to late-direct seeded legume forage
ab=alfalfa brome

Tillage Explanations:
fall or spring chisel, no disk = 2 pass system
spring cultivate = 1 pass system
no-till = no soil disturbance except 15% of surface at planting

* disking cover crop vs. no-till planting of cover crop prior to planting will increase soil loss.

			Tillage			A	B	B2	C	C2	D2	E2
4 year rotation	cg-sb30-cg-sb30	NOT on contour	fall chisel	no disk		1.0	3.1	4.2	6.0	8.8	16.2	20.4
			spring chisel	no disk		0.9	2.7	3.6	5.1	7.6	14.1	17.9
			spring cultivate			0.7	2.1	2.9	3.9	6	11.1	14.0
			fall chisel **cg**	no disk **cg**	no-till **sb**	0.8	2.5	3.4	4.8	7.2	13.4	17.0
			fall chisel **sb**	no disk **sb**	no till **cg**	0.7	2.1	2.8	3.8	5.9	11.0	14.2
			no-till			0.1	0.3	0.4	0.4	0.7	1.4	2.0
		on contour	fall chisel	no disk		0.7	1.7	2.3	3.3	4.9	9.9	15.3
			spring chisel	no disk		0.6	1.5	2.1	2.9	4.4	8.7	13.5
			spring cultivate			0.6	1.2	1.7	2.2	3.5	7.1	11.3
			fall chisel **cg**	no disk **cg**	no-till **sb**	0.6	1.5	2.1	2.9	4.4	8.9	14.6
			fall chisel **sb**	no disk **sb**	no-till **cg**	0.6	1.4	1.9	2.5	3.8	7.9	11.6
			no-till			0.1	0.2	0.3	0.3	0.5	1.0	1.7
7 year rotation	csl-csl-csl-as-a-a-a	NOT on contour	fall chisel	no disk		1.0	3.3	4.4	6.3	9.3	17.1	21.6
			spring chisel	no disk		0.8	2.6	3.5	5.1	7.5	14.1	18.1
			spring cultivate			0.8	2.3	3.2	4.4	6.7	12.5	16.0
			no-till			0.4	1.2	1.5	2.1	3.3	6.4	8.6
		on contour	fall chisel	no disk		0.8	2.2	3.0	4.2	6.4	12.9	19.1
			spring chisel	no disk		0.7	2.0	2.7	3.8	5.8	11.4	16.9
			spring cultivate			0.7	1.8	2.4	3.3	5.1	10.2	15.2
			no-till			0.4	1.0	1.3	1.7	2.7	5.5	8.0
Nurse crop and/ or cover crop rotations	csl-csl-csl-**OfAs**-a-a-a	on contour	fall chisel	no disk		0.8	2.0	2.7	3.8	5.7	11.6	17.2
	csl-csl-csl-[**Wwg-Fs**]-a-a-a		fall chisel	no disk		0.7	1.9	2.6	3.6	5.4	10.9	16.2
	*[**Csl+cv**]-[**Csl+cv**] -csl-[**Wwg-Fs**]-a-a-a		fall chisel	no disk	no-till **cv**	0.6	1.6	2.2	3.0	4.6	9.2	14.1
	csl-csl-csl-[**Wwg-Fs**]-a-a-a		spring chisel	no disk	no-till yr 1	0.5	1.4	1.9	2.6	4.0	7.8	11.6
	csl-csl-csl-[**Wwg-Fs**]-a-a-a		spring cultivate		no-till yr 1	0.5	1.3	1.8	2.4	3.7	7.5	11.4
	csl-**cg**-csl-[**Wwg-Fs**]-a-a-a		spring chisel	no disk		0.5	1.2	1.6	2.2	3.3	6.5	9.8
	*[**Csl+cv**]-[**Csl+cv**] -csl-[**Wwg-Fs**]-a-a-a		spring chisel	no disk	no-till **cv**	0.4	1.0	1.4	1.9	2.8	5.5	8.6
	*[**Csl+cv**]-[**Csl+cv**] -csl-[**Wwg-Fs**]-a-a-a		spring cultivate		no till **cv**	0.3	0.7	0.9	1.2	1.9	3.7	5.8
	*[**Csl+cv**]-[**Csl+cv**] -csl-[**Wwg-Fs**]-a-a-a		no-till			0.2	0.4	0.6	0.7	1.1	2.2	3.4
Alfalfa/ grass rotations	csl-csl-csl-[**Wwg-Fs**]-ab-ab-ab	on contour	no-till			0.2	0.4	0.6	0.7	1.1	2.3	3.5
	csl-csl-[**Wwg-Fs**]-ab-ab-ab-ab		no-till			0.1	0.4	0.5	0.6	1.0	1.9	3.0
	csl-csl-[**Wwg-Fs**]-ab-ab-ab-ab		no-till			0.1	0.2	0.2	0.2	0.4	0.8	1.3

Columns A–E2: Soil Slope Class

Soil Testing Basics

Routine analysis of soil samples includes plant-available phosphorus (P) and potassium (K) levels, organic matter content (%), and soil pH. **These analyses are combined with information you provide about your field, your planned crop and yield goals to make crop-specific fertilizer and lime recommendations.**

WHY SOIL TEST?

- ☑ **Soil testing is an effective method** for reliably predicting fertilizer and lime needs before crops are planted. It is a good business practice, one that can provide a high return for the investment of a few dollars per acre.
- ☑ **Soil testing can help increase profitability** by indicating fields where fertilizer or lime applications can improve crop yields. On the other hand, soil testing can also identify fields where soil nutrient levels are already high, so that only minimal amounts of fertilizer, if any, should be applied.
- ☑ **Soil tests provide useful information** that can help you determine how to most profitably allocate your fertilizer dollars. Applying fertilizer without soil testing can either lead to excess nutrient applications, which may reduce profits and contribute to water pollution, or inadequate nutrient applications that may reduce potential crop yields.

HOW TO SOIL TEST →

WHEN TO SOIL TEST?

- ☑ Most fields should be sampled every three to four years (every two years for sandy soils).
- ☑ The best time for routine soil sampling is in the fall, in order to get results back in time to plan for the next cropping season.
- ☑ Soil tests can also be taken in the early spring after frost has left the ground. Regardless of when you sample, it is best to be consistent from one year to the next.
- ☑ Although many people have a few fields sampled every year, there is an advantage to sampling your farm all at once. When you know the fertility status of every field, you can apply fertilizer, manure and lime on the fields where it will do the most good.

Understanding Your Soil Test Report

Keep in mind

N — Test results **do not directly** indicate the amount of nitrogen (N) in the soil; the test measures soil organic matter. Soil organic matter along with soil type information (texture, yield potential, irrigation), crop to be grown, tillage, and previous crop determine the N fertilizer recommendation.

P / K — Test results **do** indicate the plant availability of phosphorus (P) and potassium (K). The result of these analyses is called the soil test level of the nutrients.

The report you receive with you soil test results is usually divided into 3 main sections. This example is based on the University of Wisconsin's Soil Test Report.

1 NUTRIENT RECOMMENDATIONS

This section shows the amounts of nutrients and lime to apply for the specificied crop rotation and yield goals that are listed in the last box.

The recommendation is:

Crop Nutrient Need – Nutrient Credits = Nutrients to Apply

2 TEST INTERPRETATION

This section is a graphic interpretation of the soil test levels. It shows where the soil's test levels falls on a relative low to high scale for both the soil and crops. The fertilizer, rotation pH and lime rec's are based on this interpretation. Rotation pH is the target pH for the most acid-sensitive crop in the rotation. The lime recommendation is also based on this interpretation.

Interpretations are based on extensive Wisconsin field trials conducted that determined the response of crops to varying amounts of fertilizer at different soil test levels. The trials have been run at locations with a wide range of soil and climatic conditions. Through these trials, the amount of additional P_2O_5 or K_2O needed to maximize economic return at a particular soil test level was measured. At optimum soil test levels, nutrient application recommendations are about equal to the amount of nutrient removed by the harvested portion of the crop.

3 LABORATORY RESULTS

The actual results of the individual soil samples and the adjusted averages are listed in this section.

It is interesting to look at the numbers and see the variation (or lack thereof) among the samples.

HOW TO SOIL TEST

- ☑ **Get the most from your results by following the correct procedures.**
- ☑ **Accurately sample your fields.**
- ☑ **Avoid areas in the field that seem very different** from the majority of the field when soil sampling (like fence lines and fertilizer bands).
- ☑ **Use a DATCP certified soil testing lab,** see next page for more information.
- ☑ **Make sure you receive the full results.** *Complete soil test reports include field-by-field information on the analysis results as well as crop specific fertilizer and lime recommendations for a four-year rotation. Some labs may only supply a fertilizer application plan. To get the full value from your soil tests and to use them to evaluate future cropping plans, you should get both the analysis results and the interpretation.*

For more information on how to soil test:

A2100 ***Sampling Soils for Testing***
http://learningstore.uwex.edu/Assets/pdfs/A2100.pdf

A2809 ***Nutrient Application Guidelines for Wisconsin Field and Vegetable Crops***
http://learningstore.uwex.edu/Assets/pdfs/A2809.pdf

Basic Soil Sampling for Wisconsin Soils
http://ipcm.wisc.edu/video/

What is the right number of soil samples for each field?

University of Wisconsin-Madison Extension guidelines recommend **1 sample per every 5 acres for responsive field** . The field is considered to be in the responsive range if either soil test phosphorus (P) or potassium (K) levels are in the high (H) category or lower. A **nonresponsive fiel** is one where both soil test P and K levels are in the very high (VH) or excessively high (EH) categories.

Responsive Fields

To figure out how many samples you need for a **responsive field**, take the acres in the field and divide by 5, then round to the nearest whole number of samples.

Example 1 : Field size = 36 acres

$$36 \text{ acres} \times \frac{1 \text{ sample}}{5 \text{ acres}} = \frac{7.2 \text{ samples}}{\text{acre}}$$

or $36 \div 5 = 7.2$

7.2 rounds to 7
7 samples are required

Example 2: Field size = 58 acres

$58 \div 5 = 11.6$

11.6 rounds to 12
12 samples are required

For fields that are less than 5 acres, take 1 sample for the entire field. Strips that are smaller than 5 acres can be combined for sampling if they have the same management history.

Nonesponsive Fields

If the field was sampled within the last 4 years and all samples were in the nonresponsive range, fewer samples are required.

Nonresponsive fields tested within the last 4 years

Field size (acres)	Suggested number of samples
15-25	3
26-40	4
41-60	5
61-80	6
81-100	7

Grid point sampling is used to map variability in soil test levels and guide precision nutrient application. Grid point sampling should always have fewer than 5 acres per sample. Ideal grid sizes have no more than 1 to 2 acres per sample. **Note for contour strips:** Verify that there is 1 sample per strip or 1 sample per five acres depending on the size of the strip size.

A QUICK NOTE ABOUT STARTER FERTILIZER AND CORN

In Wisconsin corn, low rates of **subsurface** starter applications are common. Keep in mind that starter applications count towards the total fertilizer recommended and that the response is influenced by many factors, including:

- ☑ Starter rate, composition and placement
- ☑ Corn planting date (chance for economic return is signfiantly higher with later planting dates)
- ☑ Soil test level
- ☑ Soil compaction
- ☑ Tillage

When soil tests are in the responsive range, starter usually results in increased yield. **When soil tests are in the nonresponsive range,** starter response is similar, however likely caused by the placement of the fertilizer. Note that broadcast applications do not duplicate these results. *Starter fertilizer should not be used on soybean.*

Sampling & SnapPlus

When sampling soils for testing with the intention of creating a nutrient management plan in SnapPlus, you do not have to complete the entire Soil Submission sheet for the soil testing lab. Only minimal information is needed — all contact information (including email so you receive results in a format that can be uploaded into SnapPlus), field name and soil sample number. You will enter the rest of the information needed to get your recommendations directly into SnapPlus. **Note:** If you want recommendations as soon as you receive your soil sample results prior to uploading into SnapPlus, then you should fill out the entire submission form.

DATCP Certified Labs

A Wisconsin nutrient management plan must be based on soil tests conducted at the soil testing laboratory certified by the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP). This requirement ensures soil test results and recommendations will be generated through analytical procedures approved by the University of Wisconsin with consistent results. Laboratories must perform with a certain level of success to remain certified.

All **DATCP Certified oil Testing Laboratories** listed below except Waypoint Analytical Illinois are participating in the Manure Analysis Proficiency Program.

Waypoint Analytical Illinois 2902 Farber Dr. Champaign, IL 61822 (217)359-7680 supportil@waypointanalytical.com https://waypointanalytical.com/	**UW Soil & Forage Analysis Lab** 4702 University Avenue Madison, WI 53705 (715) 387-2523 soil-lab@mailplus.wisc.edu https://uwlab.soils.wisc.edu/
Rock River Laboratory 710 Commerce Dr. Watertown, WI 53094 (920) 261-0446 office@rockriverlab.com https://rockriverlab.com	**Minnesota Valley Testing Labs** 1126 N Front St. New Ulm, MN 56073 (800) 782-3557 mnsoil@mvtl.com http://mvtl.com/
Midwest Laboratories Inc. 13611 B St. Omaha, NE 68144 (402) 334-7770 contactus@midwestlabs.com https://midwestlabs.com/	**AgSource-Bonduel** 106 North Cecil Street Bonduel, WI 54107 (715) 758-2178 bonduel@agsource.com https://agsource.com/
A&L Great Lakes Laboratories, Inc 3505 Conestoga Dr. Fort Wayne, IN 46808 (260) 483-4759 lab@algreatlakes.com https://algreatlakes.com/	**AgSource-Stratford** 117609 Forward St. Stratford, WI 54484 (715) 687-9997 stratford@agsource.com https://agsource.com/

Label your sampling bags correctly!

1. Obtain a field map, soil sample bags and a Soil Submission Form from a DATCP certified lab.
2. Name your fields on the map. The Field ID can be simply a number or a combination of numbers and characters. Make the ID both descriptive and logical. For example, if you have field that are North of your farm, the label them starting with N1, N2, etc.

   If you have more than 10 fields, consider adding 0 to the number so they sort in correctly in SnapPlus. For example, fields that are labeled 01, 02, 03...10 will sort better than those labeled 1,2,3...10.
3. Determine how many samples you will need for each field. See the previous page for more information, as well as UWEX publicaton, A2100 *Sampling Soils for Testing*.
4. Fill out Soil Submission Form with your Field IDs and the correct number of samples per field.
5. Gather your bags and label them neatly and accurately using permanent marker **before** you head out to sample.
6. Place the your map (preferably on a clipboard) and labeled bags in a box large enough to accommodate the bags when full.
7. Submit your samples along with the Soil Submission Form to the lab.
8. Store your map in a safe location.
9. After you have a SnapPlus plan and the next time you need to soil sample, you can generate labels for your sampling bags right from SnapPlus. See the next page for instructions! If you choose to do labels manually, **make sure to use the exact same Field IDs as previous years**.

SOIL pH

Nutrient availability

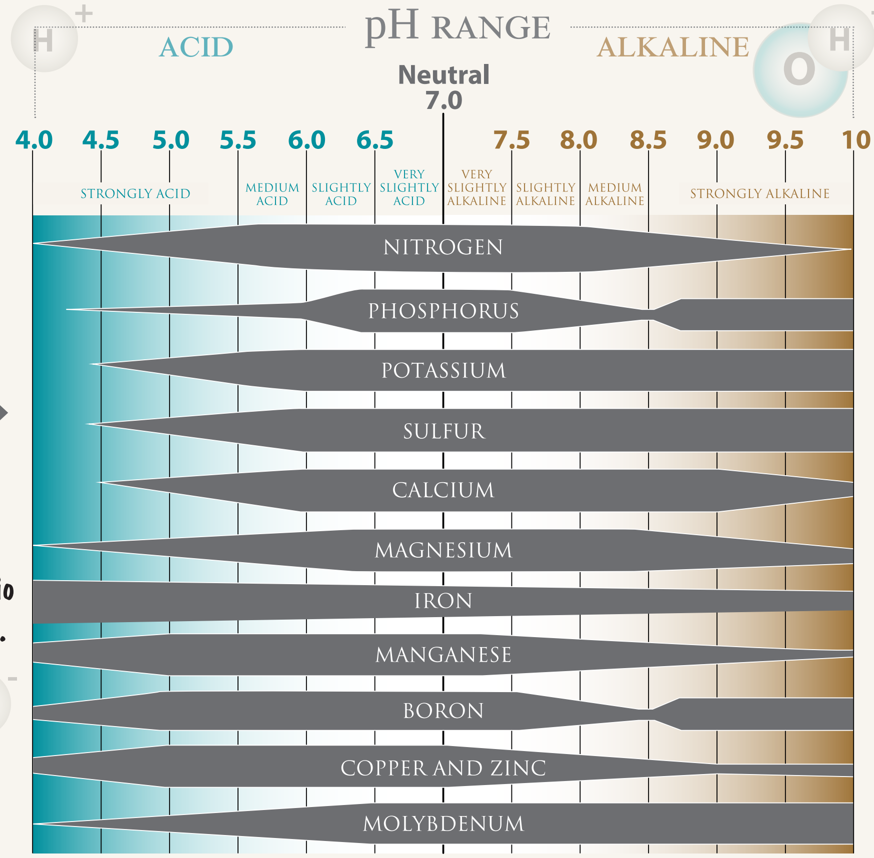
One of the most important results from a soil test is the soil's pH!

Soil pH influences:

- Nutrient availability and plant uptake →
- Soil biology activity
- Organic matter degradation/mineralization
- The effectiveness of applied fertilizers

pH is the measure of the soil's acidity — the ratio between hydrogen (H+) and hydroxyl (OH-) ions.

- pH of 7 is neutral
- Lower pH indicates stronger acidity
- Higher pH indicates stronger alkalinity



Liming recommendations

- Lime should be applied and incorporated at least 6 to 12 months prior to planting an acid sensitive crop such as alfalfa.
- Lime recommendations are made using the target pH for the most acid sensitive crop in a 4-year rotation.
- Application rates for lime should never exceed 12 ton/acre (8 ton/acre for potato). The minimum application rate is 1 ton/acre on sandy soils with <1% OM; all other soils 2 ton/acre.
- No additional lime should be applied until the most recent application has had 2-3 years to equilibrate with the soil.

Crop	Target pH
Alfalfa	6.8
Red Clover, Soybean	6.3
Corn (silage or grain), Pastures, Wheat, Potato (scab resistant)	6.0
Oat	5.8
Rye, Cranberry	5.6
Potato (not scab resistant)	5.2

LABORATORY ANALYSIS															
Sample Identification	Soil pH	O.M. %	Phosphorus ppm	Potassium ppm	60-69 Lime Req (T/a)	Calcium ppm	Magnesium ppm	Estimated CEC	Boron ppm	Manganese ppm	Zinc ppm	Sulfate-Sulfur ppm	Sulfur Avail. Index	Texture Code	Sample Density	Buffer pH
1	6.2	1.8	50	111	4.8									2	0.47	6.8
Adjusted Averages	6.2	1.8	50	111												

Liming example from soil test results:

1 Using the Laboratory Analysis section, find the category for the Lime Requirement in tons/acre. In this example where the target pH of the rotation is 6.8, the lime required (60-69 Neutralizing Index) is 5 tons/acre.

2 To convert it to 80-89 lime, use the equation:

Lime requirement (tons/acre) of lime being used = (ton/acre of 60–69 lime recommended) x (65 ÷ NI of lime being used)

(5 tons/acre of 60-69 lime) x (65 ÷ 85) = 4 tons/acre of 80-89 lime

When a range is given, for the neutralizing index, use the midpoint (for 80–89 grade lime, use 85).

How the liming reaction ties up H^+ ions in acidic soils to raise the pH

Soil with exchangeable hydrogen (H^+) + Lime calcium carbonate ($CaCO_3$) → Soil with exchangeable calcium (Ca^{2+}) + Water (H_2O) + Carbon dioxide gas (CO_2)

Crop Nutrients 101

Extension
UNIVERSITY OF WISCONSIN–MADISON

Chris Clark, Michael Geissinger & Mimi Broeske
Nutrient and Pest Management Program

NPM
08/2024

In this publication is an overview of essential plant nutrients and the ways they interact with one another. Farmers and agronomists can use this guide as a tool in conjunction with a good soil testing program to help diagnose agronomic problems and consider their nutrient management strategy. For detailed information on a specific plant nutrient and its role in plants, refer to publications located at extension.soils.wisc.edu and ipcm.wisc.edu.

Plant Essential Nutrients

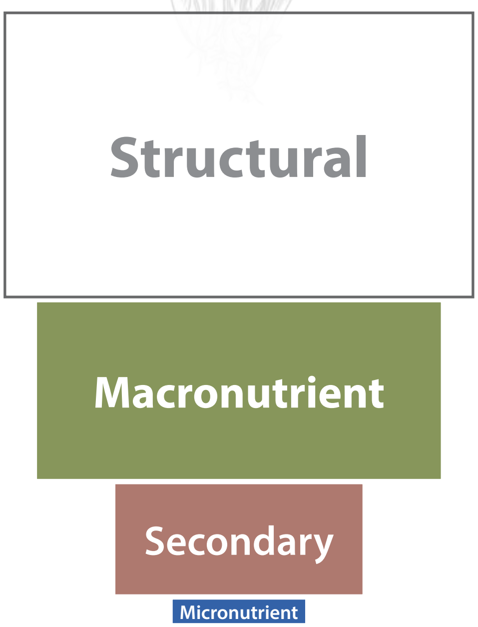
Nutrients that are needed by all plants to complete their vegetative and reproductive life cycles that are irreplaceable by another nutrient are called plant essential nutrients. There are 17 plant essential nutrients, and they are divided into four categories based on the quantity used by the crops: struc-tural nutrients, macronutrients, secondary nutrients, and micronutrients.

Structural nutrients are crop nutrients obtained from air and water. They include carbon (C), hydrogen (H), and oxygen (O).

Macronutrients are needed in large quantities for plants and include some of the nutrients commonly applied with commercial fertilizer. They include nitrogen (N), phosphorus (P), and potassium (K).

Secondary nutrients are needed in medium quantities for plants, in comparison to macronutrients and micronutrients. They include calcium (Ca), magnesium (Mg), and sulfur (S). While calcium deficiencies are rare in Wisconsin, sulfur is often needed in high demanding crops like alfalfa, corn silage, and soybeans, since atmospheric levels of sulfur have decreased in response to clean air efforts.

Micronutrients or trace elements are needed in very small quantities by the plant. They include iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), nickle (Ni), and chlorine (Cl).



Understanding Nutrient Availability & Interactions

In addition to soil-derived nutrients, plants utilize nutrients derived from air, water, organic matter, and agricultural inputs like manure. Some nutrients are readily plant-available, while others often need to be assimilated by the plant or broken down by microbes in the soil into plant-available forms. External conditions like the following can affect the availability of nutrients to plants:

- Nutrient availability is restricted for some nutrients at very high or very low pH. Most crop nutrients are readily available at 6.0-7.0 pH.
- Extreme environmental conditions like heavy rainfall or low temperatures that affect factors like soil temperature and oxygen levels can decrease nutrient uptake.
- Variations in soil texture like very low or very high organic matter and sandy soils tend to exhibit more nutrient deficiencies.

In addition to these external factors, sometimes the concentration of cer-tain nutrients will decrease the availability of others, especially if the uptake forms are of similar size, valency, and charge and are competing for the same binding sites in the soil or in the plant. To help consultants and farmers assess nutrient deficiencies and better understand interactions between nutrients when solving agronomic issues, we have developed the following table demonstrating the plant uptake form, ideal soil pH, limiting soil characteris-tics, and inter-nutrient dynamics for the soil-derived plant essential nutrients.

UNDERSTANDING FACTORS AFFECTING NUTRIENT AVAILABILITY CHART

Content adapted from: *Marschner, H. (2023). Marschner's Mineral Nutrition of Plants (4th ed.). Elsevier* ***and*** *René P. J. J. Rietra, Marius Heinen, Chistian O. Dimkpa & Prem S. Bindraban (2017) Effects of Nutrient Antagonism and Synergism on Yield and Fertilizer Use Efficiency, Communications in Soil Science and Plant Analysis, 48:16, 1895-1920, DOI:10.1080/00103624.2017.1407429*

	Element (symbol) plant available form			
Macronutrients	**Nitrogen (N)** nitrate (NO_3^-) ammonium (NH_4^+)	**Soil pH <5.5 or >8.5** limits uptake	**Most common on** coarse soils	**Deficien y** can result from low soil phosphorus levels can also result from high chlorine **Excess** from high rates of nitrification, mineralization or fertilizer applications can limit K, Ca, or Cl uptake
	Phosphorus (P) hydrogen phosphate (HPO_4^{-2}) dihydrogen phosphate ($H_2^+PO_4^-$)	**Soil pH <5.5 or >7.2** limits uptake	**Most common on** poorly drained, wet soils	**Excess** can result from a history of repeated manure applications; it can also limit Zn, Fe, or Cu uptake
	Potassium (K) potassium ion (K^+)	**Soil pH <5.5** limits uptake	**Most common on** cold wet soils	**Deficien y** can be caused by excessive N applications or low K fertilization **Excess** can limit uptake of Ca, Mg, or N (especially the NH_4^+ form)
Secondary	**Calcium (Ca)** calcium ion (Ca^{+2})	**Soil pH <6.0** limits uptake	**Most common on** soils with low cation exchange capacity (CEC)	**Deficien y** can be caused by high soil K or N levels **Excess** Ca can limit B, Mg, Cl, or P uptake Note: Samples from old/diseased tissue often test high
	Magnesium (Mg) magnesium ion (Mg^{+2})	**Soil pH <6.0** limits uptake	**Most common on** naturally calcareous soils or low Mg soils with a history of high calcium lime	**Deficien y** can be caused by high soil K, N, Ca, or Mn levels **Excess** Mg can limit Ca, or K uptake Note: Samples from old/diseased tissue often test high
	Sulfur (S) sulfate (SO_4^{-2})	**Soil pH <5.5** limits uptake	**Most common on** low organic matter soils with excessive N applications	**Excess** S can limit K or Mo uptake (or be used to help reduce Mo toxicity) Note: Excess S can also limit selenium (Se); selenium is a soil nutrient needed for animal nutrition
Micronutrients	**Zinc (Zn)** zinc ion (K^{+2})	**Soil pH > 7.5** limits uptake	**Most common on** muck soils, soils with low organic matter, or cool wet soils with corn, which may recover as soil warms	**Deficien y** can be caused by high soil test P levels **Excess** Zn can limit Fe and Mn uptake
	Manganese (Mn) manganese ion (Mn^{+2})	**Soil pH > 7** limits uptake	**Most common on** soils with high or very low organic matter, or soils with high moisture	**Excess** Mn can result from recent fungicide applications or high N or P applications on low pH soils; it can also limit Fe, Mo, or Mg uptake
	Boron (B) boric acid (H_3BO_3) borate (BO_3^{-3}) borate ion ($B_4O_7^{-2}$)	**Soil pH > 7.5** limits uptake	**Most common on** coarse sandy soils (low organic matter) and heavy clays	**Excess** B can result if soil pH is lowered from 7 to below 6.5 (acidic)
	Iron (Fe) ferrus iron (Fe^{+2}) ferric iron (Fe^{+3})	**Soil pH > 6.5** limits uptake	**Most common on** high calcareous soils, soils in regions with high rainfall, or soils with recent heavy lime applications	**Deficien y** can be caused by excessive Zn, P, Cu, or Mn levels **Excess** Fe can result when Zn is deficient; it can also limit Mn uptake
	Copper (Cu) copper ion (Cu^{+2})	**Soil pH > 7.5** limits uptake	**Most common on** soils with high organic matter	**Deficien y** can be caused by high Fe or Mn levels **Excess** Cu can result from recent chemical application that contain copper; it can also limit Mo, Fe, Mn, or Zn uptake
	Molybdenum (Mo) molybdate (MoO_4^{-2})	**Soil pH ≤ 5.5** limits uptake	**Most common on** soils with high organic matter	**Deficien y** can be caused by high soil test P levels **Excess** Mo can result from soils with pH > 6.0 or K deficiencies; it can also limit Cu or Fe uptake

The Nitrogen Cycle for general cropping systems

A FEW KEY CONCEPTS

In order of abundance, the three main types of nitrogen in soil are:

Organic nitrogen ●

Nitrate ■

Ammonium ⬬

Organic nitrogen ● is <u>not</u> plant available.

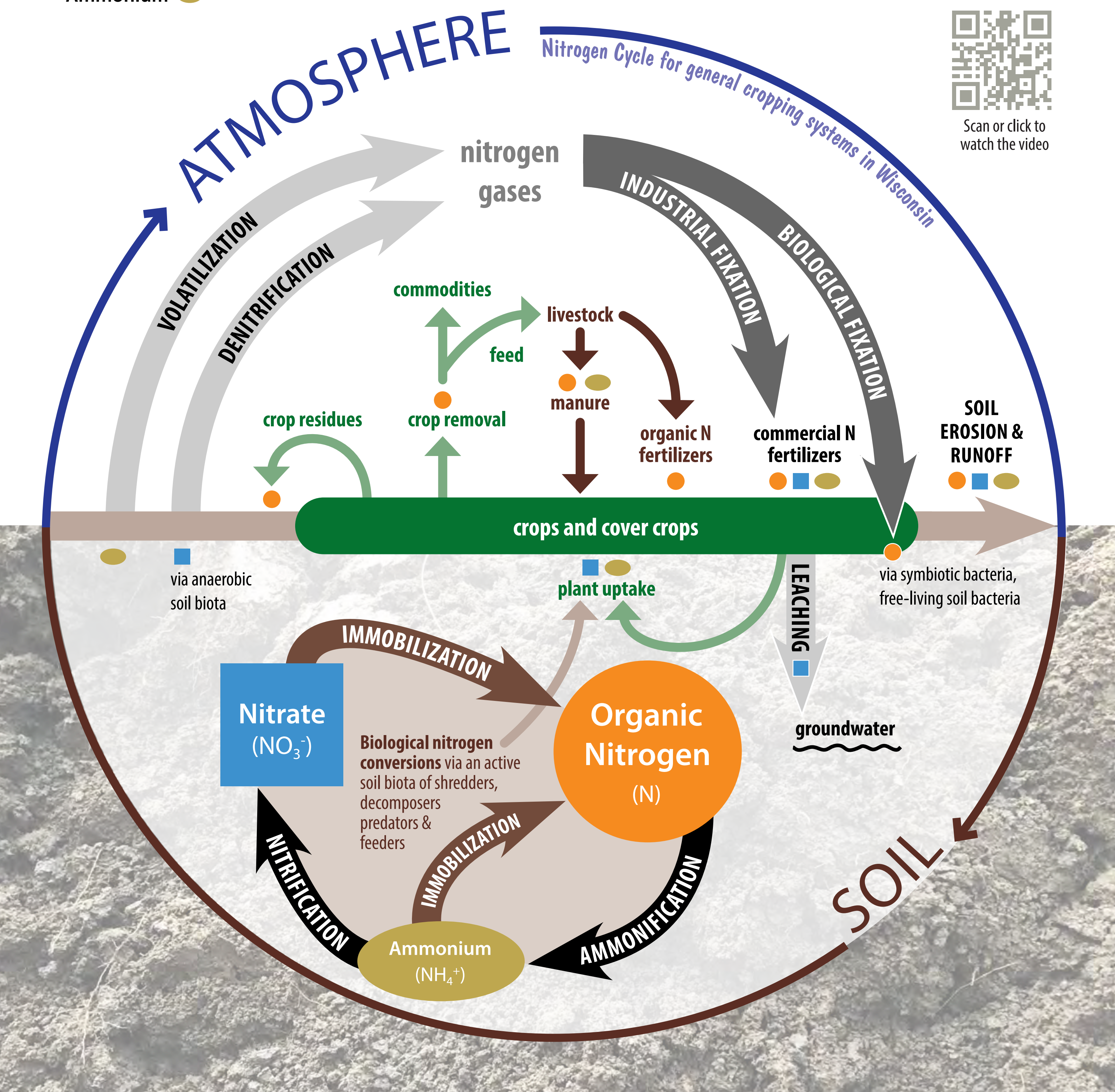
It must first be converted in the soil via ammonification (mineralization) with the main product being ammonium ⬬

From there, the process of nitrification produces nitrate ■

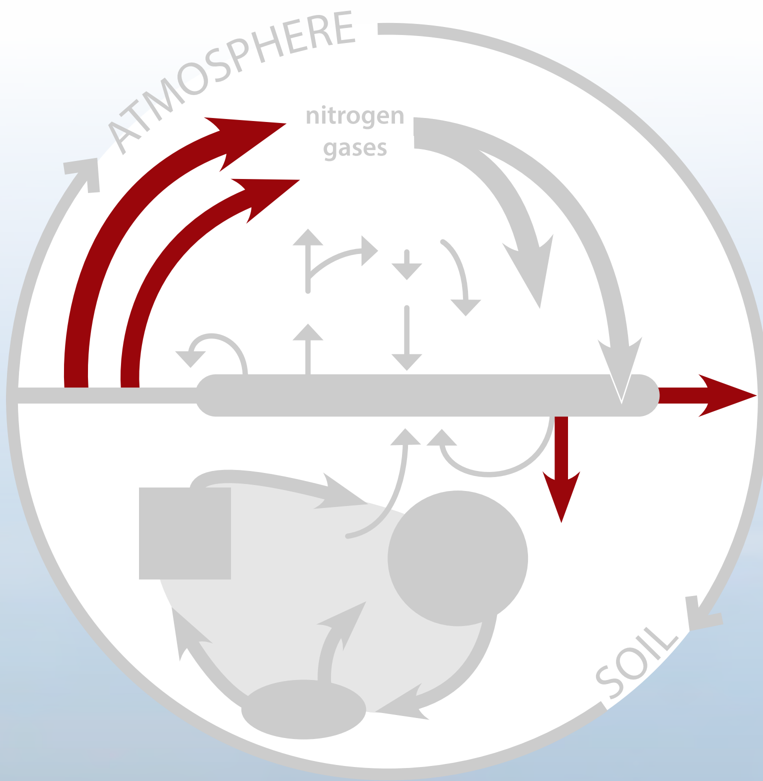
Nitrate ■ and **ammonium** ⬬ are plant available.

Most of the plant available nitrogen is in the **nitrate** ■ form.

Scan or click to watch the video



What you can do to Reduce nitrogen losses



VOLATILIZATION

1 Incorporate or inject ammonium-based fertilizer and manure applications

2 Plan ammonium-based fertilizer applications when precipitation or irrigation is anticipated

3 Consider using a urease inhibitor with non-incorporated urea fertilizers where appropriate

DENITRIFICATION

4 Avoid fall applications of nitrogen fertilizers and manure where possible

5 Apply nitrogen when plant uptake is likely; avoid times and areas when soil is saturated

6 Use agronomic practices to improve/protect soil aggregation and drainage

SOIL EROSION & RUNOFF

7 Maintain year-round soil cover with crop residues, cover crops or perennial vegetation

8 Use cropping practices to improve/maintain soil aggregation and infiltration capacity

9 Practice contour and/or strip cropping on sloping fields

10 Utilize controlled drainage, bioreactors and edge-of-field nitrogen reduction practices

LEACHING

11 Use soil maps to determine soil type and geologic variability within a field; reduce or eliminate applications in vulnerable areas

12 Apply nitrogen at recommended rates and times, utilizing all appropriate legume and manure credits

13 Irrigate at proper rates based on soil, plant and weather conditions

14 Plant cover crops to tie-up residual and mineralized nitrogen

15 Utilize perennial crops in highly susceptible areas

Want to know how to calculate fertilizer rates?

The fertilizer grade (N-P-K) necessary to determine application rate. The grade is calculated as a percentage of the total weight of nitrogen (N), plant available phosphorus (P_2O_5) and plant available potassium (K_2O).

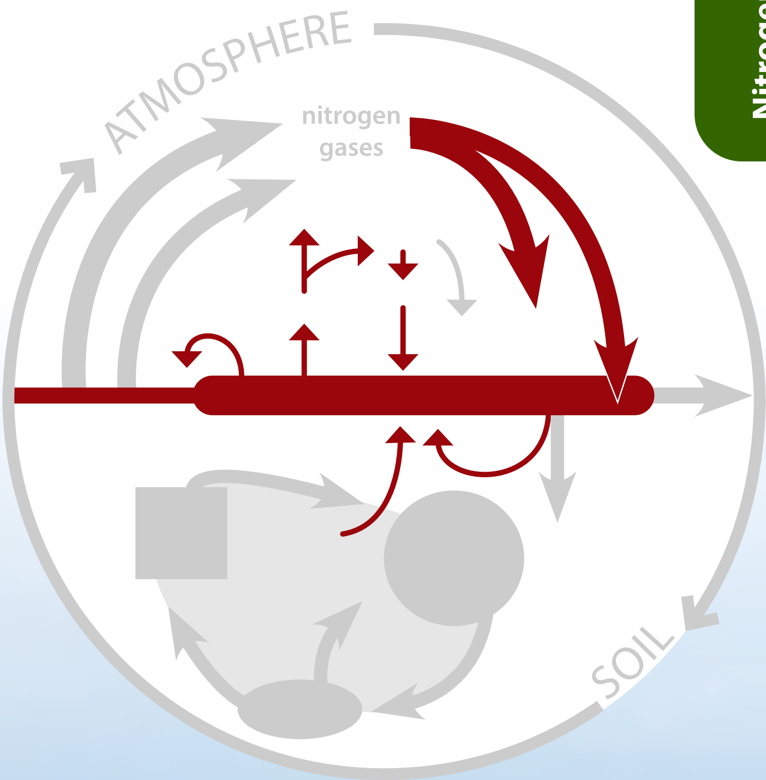
Example: 5-10-30 = 5% N - 10% P_2O_5 - 30% K_2O

Calculating a fertilizer application rate:

To apply 120 lb of nitrogen using 46% urea
100 lb of urea fertilizer contains 46 lb of nitrogen
$120 \div 0.46 = 261$ lb application rate of urea

To apply 120 lb of nitrogen using 28% UAN solution
One gallon of 28% UAN weights 10.6 lb
$0.28 \times 10.6 = 3$ lb of nitrogen/gallon
120 lb application rate $\div$ 3 = 40 gallon application rate of UAN

What you can do to
Improve nitrogen efficiencies



GENERAL

1 Understand that nitrogen application recommendations for a field are influenced by soil properties — use current soil maps to determine the soil series and soil test results for organic matter content

2 Maintain an appropriate soil pH, and phosphorus (P) and potassium (K) fertility

3 Account for all nitrogen applications and credits (manure and legume)

4 Credit nitrate in irrigation water, if applicable

5 Utilize soil nitrate and plant tissue testing to guide nitrogen applications where appropriate

6 Follow the 4Rs of nutrient stewardship — right rate, right time, right place, right source

7 Observe state/local regulations and setbacks for nitrogen fertilizer and manure applications

MANURE

8 Test all manure types regularly to better inform manure nutrient crediting

9 Use second and third year nitrogen credits from manure on non-sandy soils

10 Consider spring or in-season manure applications vs. fall applications for most crops

COMMERCIAL FERTILIZER

11 Select fertilizers based on cost, potential to minimize nitrogen loss, ease of application and crop needs

12 Apply nitrogen in split applications to increase potential of crop uptake

13 Choose appropriate nitrogen source, rate, timing and placement to minimize seed, root and plant damage

ORGANIC FERTILIZERS & AMENDMENTS

14 Consider testing for nutrient content if no analysis is available

15 Understand nitrogen release may take weeks, months or years depending on the amendment's C:N ratio

BIOLOGICAL FIXATION

16 Properly inoculate legumes including cover crop seed

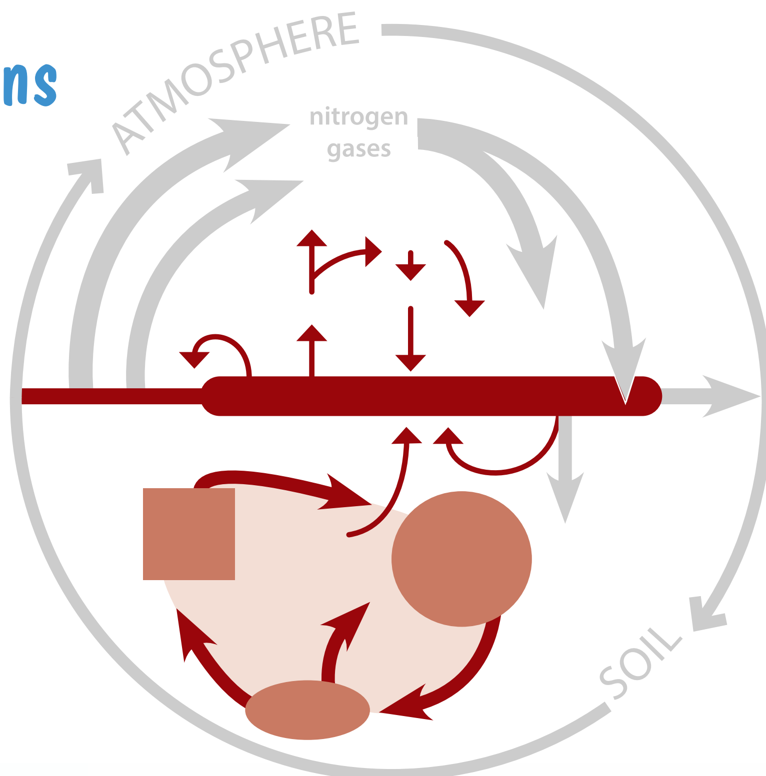
17 Use soybean legume credits in all crops except corn and wheat — for corn and wheat, the soybean rotational credit is automatically integrated into the recommended nitrogen rate

18 Determine an appropriate cover crop/green manure nitrogen credit based upon legume density, growth and maturity

19 Credit nitrogen from forage legume crops for two growing seasons after termination where appropriate

20 Use legume credits for all leguminous vegetables (except soybean) in non-sandy soils

What you can do to
Manage transformations



ENHANCE SOIL NITROGEN CYCLING

1 Use agronomic practices that maintain or increase soil organic matter

2 Maintain adequate soil pH and fertility

3 Follow proper trafficking guidelines to minimize soil compaction potential

4 Promote soil biological communities by practicing key soil health principles when possible — cover the soil, minimize soil disturbance, increase diversity, maintain continuous living plants/roots, integrate livestock

MAINTAIN NITROGEN IN THE AMMONIUM FORM

5 Use nitrification inhibitors to temporarily suppress nitrification where warranted

6 Apply ammonium-based fertilizers and manures after fall soil temperatures are consistently below 50° F

REDUCE EARLY SEASON NITROGEN IMMOBILIZATION

7 Consider early season nitrogen applications to offset immobilization caused by decomposing crop or cover crop residues

8 Harvest crop or cover crop residues if immobilization is a concern; consider conservation consequences

9 Terminate cover crops when C:N ratios are low; consider impact to other potential cover crop benefits

10 Plant cover crop mixes with lower final C:N ratios to hasten decomposition

Does the C:N ratio of residue affect nitrogen availablity?
Yes, the ratio determines whether the N is released or immobilized.

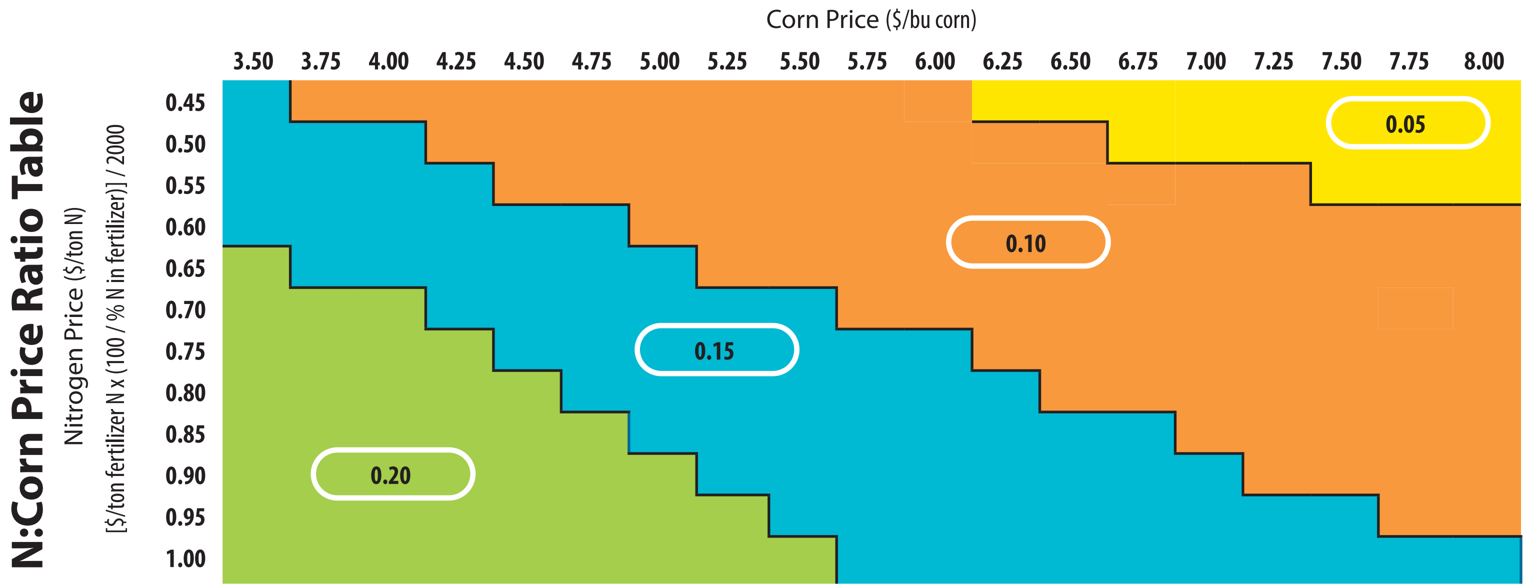
C:N ration less than	C:N ration more than
< 20:1	**> 30:1**
will mineralize (release) N	**will immobilize (tie-up) N**
Alfalfa hay: 12:1	Corn stalks 60:1
Rotted manure 15:1	Straw 80:1
	Sawdust 300:1

The University of Wisconsin's nitrogen (N) fertilizer guidelines for corn allow growers to determine N application rates that provide maximum economic returns based on the cost of N and an anticipated corn price. These guidelines also provide a range of profitable N rates that are within $1/acre of the maximum return rate. See UWEX publication A2809 *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*.

University of Wisconsin Nitrogen Guidelines for Corn

Soil[1]	Previous Crop	N:Corn Price Ratio (see table below) 0.05	0.10	0.15	0.20
		lbs N/acre (total to apply)[2]			
loamy: high yield potential soils	**Corn**, Forage legumes, Legume vegetables[5] & Green manures	**190**[3] 170-------210[4]	**165** 155----180	**150** 140---160	**135** 125----150
	Soybean & Small grains[6]	**140** 125------160	**120** 105----130	**105** 95--115	**90** 80----105
loamy: medium yield potential soils	**Corn**, Forage legumes, Legume vegetables[5] & Green manures	**145** 130-----160	**125** 115----140	**115** 105---125	**105** 95--110
	Soybean & Small grains[6]	**130** 110-------150	**100** 85------120	**85** 70---95	**70** 60---80
sands/ loamy sands	Irrigated—**All crops**[5]	**215** 200-----230	**200** 185----210	**185** 175---195	**175** 165---185
	Non-irrigated—**All crops**[5]	**140** 130---150	**130** 120---140	**120** 110---130	**110** 100---120

N:Corn Price Ratio Table



NOTES

[1] To determine soil yield potential, consult UWEX publication A2809 or contact your county agent or agronomist.

[2] Includes N in starter.

[3] Maximum return to N (MRTN) rate.

[4] Profitability range within $1/acre of MRTN rate.

[5] Subtract N credits for forage legumes, legume vegetables, animal manures, green manures.

[6] Subtract N credits for animal manures and second year forage legumes.

ADDITIONAL GUIDELINES

- ☑ For maximum silage yield, use N rate for 0.05 price ratio. To adjust rates for silage, use price ratio that reflects typical prices for N and grain.
- ☑ If >50% residue at planting, use upper end of range.
- ☑ If all N is from organic sources, use top end of range. Plus, up to 20 lb N/acre as starter may be used.
- ☑ For loamy (medium & fine-textured) soils with >10% soil organic matter (OM), use low end of range.
- ☑ For all soils with <2% soil OM, use high end of range.
- ☑ For sandy (coarse-textured) soils with <2% OM, use high end of range; 2-10% OM, use mid to low end of range; 10-20% OM, use non-irrigated guidelines–regardless of irrigation status; >20% OM, apply 80 lb N/acre.
- ☑ When corn follows small grains on loamy soils, use the mid to low end of range.
- ☑ For loamy irrigated <u>or</u> drained soils, use rates for high yield potential soils.
- ☑ If potential for carry-over (residual) N, use low end of range <u>or</u> use the high end and subtract preplant soil nitrate test (PPNT) credits.

Nitrogen Credits for Alfalfa and Soybean in Wisconsin

First year credit:

Alfalfa (stand density)	MEDIUM & FINE TEXTURED SOILS > 8 inches of regrowth	MEDIUM & FINE TEXTURED SOILS < 8 inches of regrowth	SANDS & LOAMY SANDS > 8 inches of regrowth	SANDS & LOAMY SANDS < 8 inches of regrowth
	Nitrogen Credit (lb N/acre)			
Good.....(70-100 % alfalfa, > 4 plants/ft^2)	**190**	**150**	**140**	**100**
Fair.........(30-70 % alfalfa, 1.5 - 4 plants/ft^2)	**160**	**120**	**110**	**70**
Poor........(0-30 % alfalfa, < 1.5 plants/ft^2)	**130**	**90**	**80**	**40**

Second year credit: In the second cropping year following fair and good stands on medium and fine textured soil, you can take a 50 lb N/acre credit.

Soybean

20 lb N /acre is available to crops following soybean in a rotation. **No credit** on sandy soils.

The University of Wisconsin's nitrogen (N) fertilizer guidelines for wheat allow growers to determine N application rates that provide maximum economic returns based on the cost of N and an anticipated wheat price. These guidelines provide a range of profitable N rates that are within $1/acre of the maximum return rate. For more information, see UWEX publication A2809 *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*.

University of Wisconsin Nitrogen Guidelines for Wheat

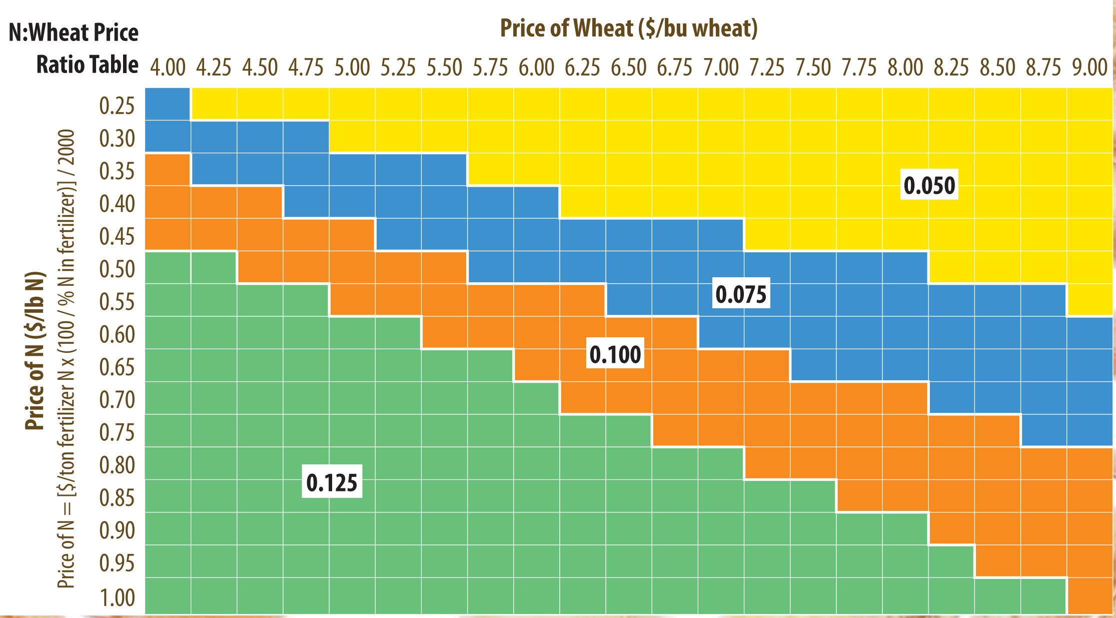
N : Wheat Price Ratio (see table below to determine ratio)`

Soil Group	Previous Crop	PPNT (lb NO_3- N/a)	0.050	0.075	0.100	0.125
			lbs N/acre (total to apply)[1]			
LOAMY	Corn	< 50 or no PPNT	**75** 65 ------- 85	**70** 55 ------- 80	**60** 50 ------- 70	**55** 40--------65
		51 to 100	**45** 35 ------- 55	**40** 30 ------- 50	**35** 25 ------- 40	**30** 20--------35
		> 100	**0** 0 ------- 0	**0** 0 ------- 0	**0** 0 ------- 0	**0** 0--------0
	Soybean, small grain	All results[2] or no PPNT	**55** 45 ------- 65	**50** 40 ------- 60	**45** 35 ------- 50	**40** 35 ------- 45
SANDY	All crops	PPNT is not recommended on sandy (sand and loamy sand) soils.	**105** 95 ------- 115	**100** 95 ------- 110	**90** 80 ------- 100	**85** 70--------95

[1] On loamy soils with < 2% organic matter, add 30 lb N/a to all rates. On soils with more than 10% organic matter, reduce rates by 30 lb N/a.

[2] If the PPNT is < 50 lb N/a, use top end of the profitable range; if the PPNT is 51 to 100 lb N/a, use bottom end of the profitable range; if the PPNT is > 100 lb/a, no additional N is needed.

- When wheat follows a forage legume or leguminous vegetable, use the N rate for wheat following corn with a PPNT less than or equal to 50 lb N/a and take the legume credit.
- Manure N credits must be subtracted from the N rates.
- No N is required on organic soils.
- If 100% of the N will come from organic sources, use the top end of the range.
- Reduce N rates by 10 lb N/a for spring wheat on all soils.



Soil Nitrate Tests for Corn in Wisconsin

What is the PSNT?
How to do a PSNT
Scan or click to watch the video

Improving the efficiency of nitrogen (N) applications to corn is fundamental to promoting farm profitability and environmental quality in Wisconsin.

By implementing the 4Rs of nutrient stewardship — right rate, right time, right place, and right source — farms can tailor nutrient applications to maintain nutrient availability for crop growth while protecting water quality.

Soil nitrate tests are examples of available tools to help determine the "right rate" of N for corn grain, corn silage, and sweet corn.

The amount of nitrogen available for crop uptake is influenced by many factors, so it is important to choose the proper soil nitrate test for your specific situation.

Field specific considerations include:

- *Soil texture*
- *Timing of manure and nitrogen fertilizer application*
- *Previous growing season and overwinter precipitation*
- *Previous crop and its nitrogen status*

Terms used in this fact sheet

Nitrogen (N) *is a general term referring to all nitrogen containing compounds including organic nitrogen, ammonium, nitrate, and various gaseous N forms.*

Nitrate (NO_3^-) *is the most common plant available form of nitrogen in the soil. Nitrate cannot be held on soil exchange sites, leaving it susceptible to loss via leaching (movement out of the root zone via water) and denitrification (gaseous loss).*

Mineralization *is the microbial conversion of organic, non-plant available nutrients into inorganic, plant available nutrients. The rate of N mineralization in soil is influenced by the availability of organic nitrogen sources (soil organic matter, plant residues, and manure), as well as soil temperature, pH, moisture, and microbial population abundance and diversity.*

AVAILABLE SOIL NITRATE TESTS

PPNT

Preplant Nitrate Test

(PPNT) assesses nitrate carry-over from the previous growing season and is used to adjust preplant or sidedress N application rates.

A PPNT is most effective when corn follows corn in rotation. A PPNT is used to assess N carry-over in the top three feet of soil if the previous season's N applications were:

- In excess of crop need,
- Previous growing season and overwinter precipitation was below normal,
- N fertilizer was applied and the crop was not planted due to weather conditions (prevent plant), **or**
- When manure or legumes were not fully credited for the previous growing season.

Due to sample collection in early spring (post-frost, but before planting and any N application), a PPNT does not measure N released from previous fall, winter or spring applications of manures or N released from the mineralization of forage legume residue. If a PPNT is used to adjust a N fertilizer rate, manure should be properly credited using established book values or manure analysis results. Likewise, legume nitrogen credits should be properly credited where appropriate. (See Chapter 9, A2809, *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*)

When corn follows corn, the PPNT is the preferred soil nitrate test to evaluate potential N carryover into the second growing season after a manure application or alfalfa crop termination. However, the PPNT does not measure N released during the second growing season after application/termination.Therefore, total N application rates should be adjusted using second-year manure or legume N credits, as well as PPNT results.

PSNT

Pre-sidedress Nitrate Test

(PSNT) assesses early season N mineralization, as well as N carry-over from the previous growing season and is used to adjust sidedress N application rate.

PSNT samples are collected in early to mid-June when corn is at V3 to V5 (approximately 6 to 12 inches tall) or approximately two weeks before sidedress application of N. As soil microbial populations are active during this time, conversion of organic N to plant-available N is occurring. Therefore, the PSNT is used to predict the amount of N released from previous alfalfa, clover or legume crops, fall, winter, or spring manure applications, and soil organic matter.

PSNT should not be used on fields with pre-plant broadcast or incorporated N fertilizers during the current growing season. Banded starter applications of N should not interfere with PSNT results, as long as PSNT soil samples are collected midway between fertilizer bands.

Due to its later sampling date, PSNT is better able to estimate N released by manure or legumes during the second cropping year after application/termination. If using PSNT in these situations, MRTN recommendations should not be adjusted for second year manure or legume credits. Only PSNT credits should be used.

PSNT sampling is particularly useful in fields where manure was applied, but the rate and/or nutrient concentration is questioned or when manure was applied in summer or early fall the preceding season.

PSNT can be used to gauge potential N tie-up from cover crops. Research has shown high biomass producing cover crops may render some fall-applied N unavailable during the following growing season. PSNT can be used to adjust manure N crediting in this situation.

SAMPLE COLLECTION

Collect soil samples randomly from a 20-acre (or less) area in one-foot increments to the correct depth (see below) with a minimum of 15 soil cores from each depth. Thoroughly mix the cores for each sample and then place a one-cup subsample in a bag to be delivered to the soil testing laboratory (see A2100, *Sampling Soils for Testing*). Samples should not be collected near fences or roads or in headlands, low spots, near lime or manure piles, etc. All soil samples should be representative of the area sampled. Therefore, areas of different soil textures or past management practices should be sampled individually.

PPNT

Soil samples for the PPNT are collected in the early spring after frost has dissipated and prior to planting or any preplant applications of N.

PPNT samples are collected from 0 to 1-foot and 1 to 2-foot depth increments of the soil profile.

The amount of nitrate-N in the 2 to 3-foot depth is estimated in the laboratory recommendation program using the nitrate content of the 1 to 2-foot depth sample. Alternatively, a 2 to 3-foot depth sample can be taken.

PSNT

Soil samples for PSNT should be collected when corn is at V3 to V5 (approximately 6 to 12 inches tall) or approximately two weeks before a planned sidedress N application. Samples collected before this time will not provide an adequate estimation of N release and will underestimate PSNT N credits.

PSNT samples are collected from the top 1 foot of the soil profile. Samples should be collected from between the rows, avoiding areas of starter fertilizer application.

GENERAL PRECAUTIONS WITH SOIL NITRATE TESTS

PPNT and **PSNT** **should only be used** in medium to fine textured soils.

Due to the high permeability of sand and loamy sand soils, retention of nitrate in the soil profile is unlikely. Therefore, PPNT and PSNT should not be used in sand or loamy sand soils.

PPNT

PPNT **should only be used** in years of corn following corn when the previous growing season and over-winter period experienced normal or below normal precipitation.

When above normal precipitation occurs in the preceding growing season and overwinter period, little residual soil nitrate is likely to carry-over. In normal or below normal precipitation years, the PPNT is the preferred soil nitrate test to assess carry-over N, as its deeper sampling depth provides a more complete assessment of residual N in the rooting zone.

PPNT **should not be used** on first year corn following alfalfa or other forage legumes.

As samples are collected in very early spring, a PPNT does not measure N released from alfalfa or legume forage crops immediately preceding the corn crop. Instead, legumes should be properly credited using established values.

PPNT **should not be used** on fields where manure was applied the previous summer or early fall.

Considerable plant available N can be released from summer and early fall applied manure prior to PPNT sampling. Therefore, using a PPNT could potentially lead to overcrediting of N, particularly if manure crediting is used along with PPNT results. In this situation, a PSNT should be used.

PSNT

PSNT **may underestimate N availability** when average air temperatures in May and June are 1° F or more below the long-term average.

As N mineralization from soil organic matter, manure, and crop residues is controlled by soil microbes, the concentration of N measured by PSNT is influenced by weather and soil conditions before sample collection. Cool, wet springs can slow N release, causing the PSNT to underestimate the amount of N that will become available during the growing season. In these situations, book value N credits for manure and previous legume crops should be used in combination with the PSNT credit to determine an appropriate N sidedress application rate. Lower than expected PSNT N credits in these conditions are more likely to occur with spring manure applications or corn following spring terminated alfalfa stands.

PSNT **should not be used** to adjust N application rates in a soybean-corn rotation.

N fertilizer rate recommendations for corn following soybean in Wisconsin already reflect N availability based upon the crop rotation effect. Therefore, N application rates should not be adjusted using a PSNT.

PSNT can be used to confirm a first year alfalfa N credit.

If the PSNT result is <21 ppm N, apply no more than 40 lb/a N.

SAMPLE STORAGE

PPNT and **PSNT** samples should be delivered to the soil testing lab within 24 to 48 hours after being collected. Samples should be kept cool (<50 degrees F) between the time of collection and time of delivery to the laboratory. If timely delivery or shipping to the laboratory is not possible, the samples should be frozen or air-dried to prevent changes in nitrate content during storage.

SAMPLE ANALYSIS

PPNT and **PSNT** can be analyzed at several commercial labs across the state. Consult Wisconsin Department Agriculture, Trade and Consumer Protection's website to obtain a list of certified manure and soil testing labs: https://datcp.wi.gov/Documents/NMSoilManureLabs.pdf

ADJUSTING PLANNED NITROGEN FERTILIZER APPLICATIONS WITH LAB RESULTS

PPNT and **PSNT** results are used to adjust MRTN application rates based from University of Wisconsin recommendations.

Adjusting MRTN Applications to Corn

UW recommended N application rates to corn are based upon the Maximum Return to Nitrogen (MRTN) concept. MRTN uses the cost per unit of N fertilizer and an anticipated corn price per bushel to determine the N rate that maximizes economic return on fertilizer investment. N credits for forage legumes, legume vegetables, animal manures, and green manures are subtracted from the MRTN recommended N rate to account for potential increased N availability. However, the N fertilizer adjustment for a preceding soybean crop is already reflected in the MRTN fertilizer recommendation and so, no N credit adjustment is needed. (See Chapter 6, A2809, *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*).

PPNT

Using PPNT lab results, adjust UW nitrogen fertilizer recommendations as follows:

Results between 0 to 50 lbs N/acre

PPNT N credit = 0

Use MRTN recommendations without adjustment.

Results between 51 to 200 lbs N/acre

PPNT credit = PPNT test value – 50 lb N/a

50 lb/acre N in the 0-3 foot soil profile in the spring is considered background in medium and fine textured soils.

Adjusted MRTN recommendation = MRTN recommendation – PPNT credit

A minimum application of 50 lb N/acre is recommended.

Results over 200 lbs N/acre

No supplemental N is needed.

PSNT

Using PSNT lab results, adjust UW nitrogen fertilizer recommendations as follows:

Adjusted N recommendation = MRTN recommendation – PSNT credit

PSNT Nitrogen Credits[1] for Corn

	Soil Yield Potential[2]	
PSNT Result	High	Medium
ppm N	---- lb N/acre credit ----	
≥ 21	No additional N needed	
20-18	**100**	**80**
17-15	**60**	
14-13	**35**	**40**
12-11	**10**	
≤ 10	**0**	**0**

[1] Pounds of N/acre credit to subtract from base MRTN fertilizer application rate
[2] Consult A2809, *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*

When corn follows alfalfa, the maximum N recommendation is 40 lb N/A for all PSNT results < 21 ppm N.

PPNT and MRTN example

Using MRTN, the target N application rate for corn following corn with < 50% residue cover, in a high yield potential soil when the N:Corn Price Ratio is 0.1 is 165 lbs N/acre.

The PPNT result indicates 70 lbs N/acre available N.

The resulting adjusted N application rate should be 145 lbs N/acre

165 lbs N/A – (70 lbs N/A – 50 lb N/acre) = 145 lbs N/acre

To meet this recommendation, ***total preplant, starter, and in-season N applications should not exceed 145 lbs N/acre.***

PSNT and MRTN example

Using MRTN, the target N application rate for corn following corn with < 50% residue cover, in a high yield potential soil when the N:Corn Price Ratio is 0.1 is 165 lbs N/acre. Starter was applied at 40 lbs N/acre.

The PSNT result of 13 ppm indicates a 35 lb N/acre credit.

The resulting adjusted sidedress application rate should be 90 lbs N/acre

165 lbs N/A – 40 lbs N/A – 35 lb N/acre = 90 lbs N/acre

NPM

The Phosphorus Cycle

for general cropping systems in Wisconsin

FOR RECOMMENDATIONS, SEE PAGES 2 – 4

KEY CONCEPTS ABOUT SOIL PHOSPHORUS

In many soils more than 90% of soil phosphorus (P) is contained in organic and mineral (inorganic) solids.

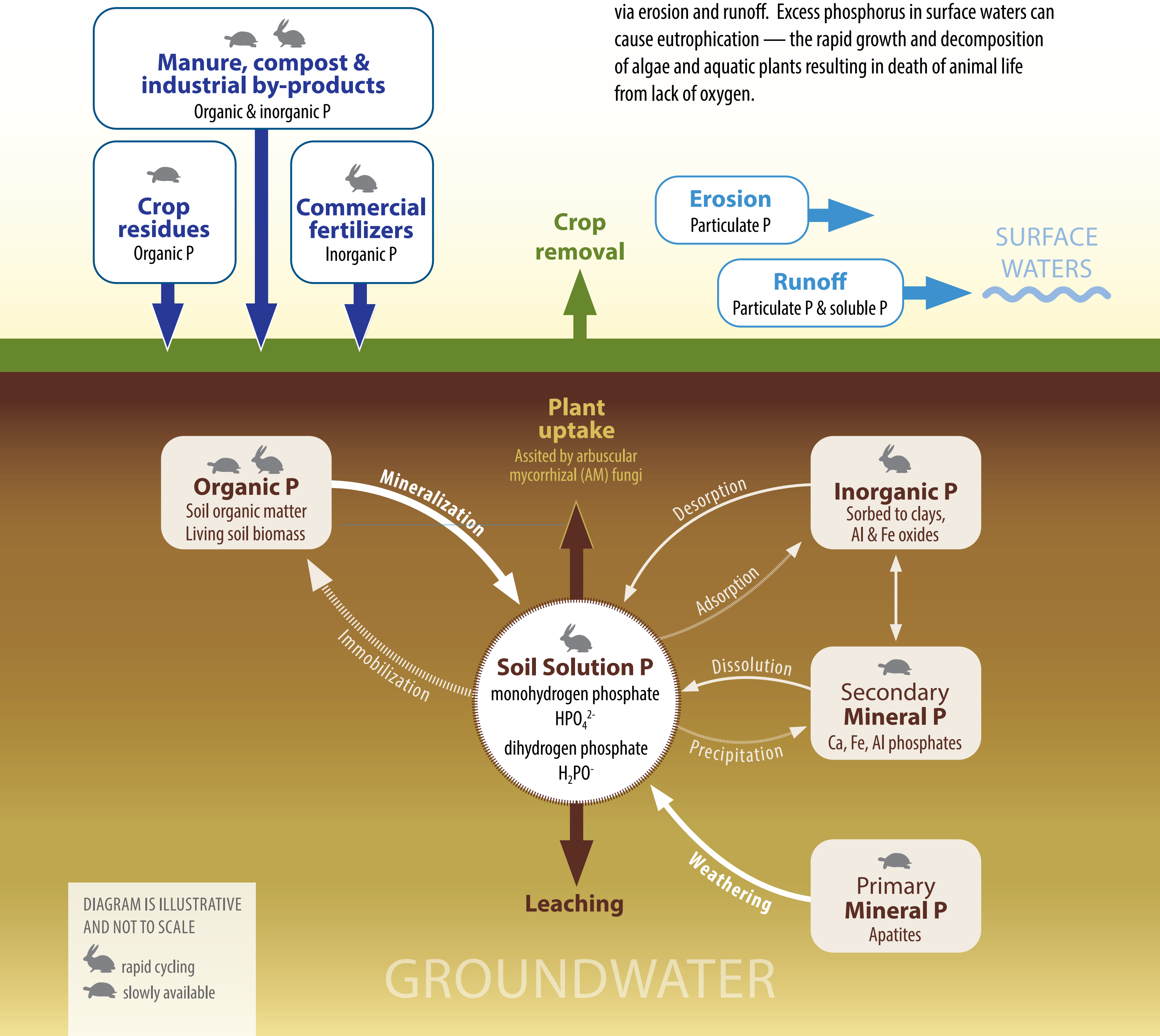
Organic and inorganic P solids are not plant available. To become available, they must be converted to dissolved, inorganic P via mineralization (organic P) or weathering (mineral P).

Dissolved, inorganic P is plant avaialble in the soil solution as mono or dihydrogen phosphate.

Rapid cycling and slowly available pools of both organic and inorganic P exist in the soil.

Particulate P (organic and inorganic P solids) and **soluble P** (dissolved, inorganic P) can enter waterways, lakes and rivers via erosion and runoff. Excess phosphorus in surface waters can cause eutrophication — the rapid growth and decomposition of algae and aquatic plants resulting in death of animal life from lack of oxygen.

Note that fertilizer P content and soil test P recommendations are reported as phosphorus pentoxide (P_2O_5). This is a standard for reporting nutrient content and is not the form of P found in the soil or fertilizers.



What you can do to

Reduce phosphorus losses & potential water quality risks

MANAGE MANURE PHOSPHORUS

1 Work with a nutritionist to reduce dietary P (and ultimately, manure P) levels.

2 Apply manure to meet P needs rather than N recommendations; N-based strategies often lead to the build-up of soil test phosphorus (STP) levels.

3 Prioritize manure applications to low P testing fields.

4 Properly credit the fertilizer value of manure.

5 Separating liquid manures concentrates phosphorus into higher solid content manure, allowing for more economical transport and targeted P applications.

REDUCE POTENTIAL FOR PHOSPHORUS LEACHING

6 Apply manure when soils are below field capacity, tile drains are not running, precipitation is not in the imminent forecast, and large cracks are not present in the soil.

7 Reduce or eliminate fall and winter P applications, particularly in soils susceptible to preferential water flow.

8 Reduce preferential flow of water in highly susceptible soils by pre-tilling the soil prior to manure applications.

9 Consider phosphorus removal structures to filter and/or trap P within tile drainage water.

SOIL EROSION & RUNOFF

10 Maintain soil tests levels at optimum and strategize to reduce STP levels in high and excessively high testing soils.

11 Reduce surface applications of P through fertilizer and manure incorporation, injection or banding in fields with lower erosion risk.

12 Eliminate manure applications on frozen or snow-covered ground where possible.

13 If winter applications of manure are required, follow local and state requirements for rate and site selection.

14 Maintain year-round soil cover with crop residues, cover crops or perennial vegetation.

15 Use cropping practices to improve/maintain soil aggregation and infiltration capacity.

16 Practice contour and/or strip cropping on sloping fields.

17 Reduce potential dissolved P loss by planting overwintering crops and cover crops in rotation; consider all aspects of a cropping system to assess potential water quality risks.

18 Use waterways, vegetated buffers, and other conservation practices to reduce off-site water and sediment transport.

19 Use the P Index calculations in SnapPlus to strategize P applications to fields and parts of fields with low risk for off-site P movement.

20 Follow all nutrient application setbacks and restrictions; know the location of all surface water quality management areas (SWQMA), surface tile inlets, karst features and other sensitive areas.

21 Use the Wisconsin Runoff Risk Advisory Forecast prior to manure application to assess potential runoff risks.
http://www.manureadvisorysystem.wi.gov/runoffrisk/index

What you can do to

Improve phosphorus efficiencies

GENERAL

1 P application recommendations are influenced by crop rotation, soil test levels, soil properties, and crop removal rates— use current soil test results and realistic crop yield goals.

2 Wisconsin P recommendations are calibrated to the Bray 1 soil extractant. Use a DATCP-certified lab for soil fertility analyses when writing a NRCS 590 compliant nutrient management plan.

3 Maintain an appropriate soil pH. P solubility is increased when soil pH is between 6 and 7.

4 Maintain STP levels at optimum to optimize economic returns and reduce potential environmental risk.

5 Reduce STP levels to optimum by reducing or eliminating P applications where appropriate.

6 Fall vs. spring applications of P have negligible effects on crop yield. If using ammoniated P, timing of application may impact potential N loss.

7 Observe state/local regulations and setbacks for phosphorus fertilizer and manure applications.

MANURE

8 Account for all P applications and credits, including manure and organic amendments.

9 Test all manure types regularly to better inform manure nutrient crediting.

10 Manure P levels may be reported as P_2O_5 or total P. Total P results are converted to P_2O_5 by multiplying by 2.29.

11 Do not take manure P credits over multiple years, as most P is available in the first year after application.

12 Calibration of manure application equipment is essential for proper P application and crediting.

COMMERCIAL FERTILIZER

13 Account for both nitrogen and phosphorus contained in ammoniated phosphates in your nutrient management plan.

14 Choose fertilizers based on cost, availability, and ease of handling. Ortho and polyphosphate fertilizers are typically equally effective at improving yield, as are liquid and dry phosphorus fertilizers.

15 Adjust STP levels prior to establishing of alfalfa or other long-term forages.

16 For corn or sweet corn, use of up to 20 lbs of P_2O_5 per acre as an incorporated or subsurface applied starter is allowed on high and excessively high testing soils.

17 Evaluate starter fertilizer placement and rate when using ammoniated phosphate to reduce seed, root, and seedling damage.

ORGANIC FERTILIZERS, BYPRODUCTS & AMENDMENTS

18 Test for nutrient content if no analysis is available.

19 Account for potential reduced solubility of some certified organic fertilizers (rock phosphate) when calculating application rates.

20 Reconsider use of bone meal and rock phosphate on high pH soils (pH>7) due to low P availability.

21 Apply compost to meet crop P need, as N-based applications overapply P by 2 to 5x depending on crop.

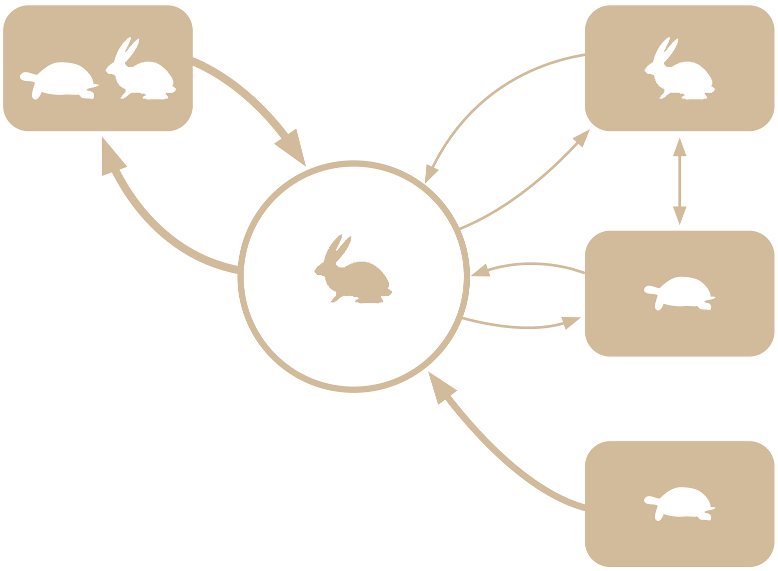
ENHANCING NUTRIENT UPTAKE

22 Address soil compaction and pest issues limiting crop root growth to improve crop P uptake.

23 Utilize soil health practices and maintain optimum STP levels to promote beneficial fungi aiding in P uptake.

24 Manage high STP levels to reduce potential antagonism with uptake of other nutrients, such as zinc.

What you can do to
Manage phosphorus transformations



REDUCE SOIL PHOSPHORUS STORAGE

1 Wisconsin soils are highly buffered — an estimated 18 lbs P_2O_5/A in loamy and organic soils and 12 lbs P_2O5/A in sandy soils are required to change STP levels by 1 ppm.

2 Incorporating P fertilizer may encourage deeper rooting as compared to banded applications.

3 If banding P fertilizer, consider reducing applications up to 50%, depending on crop and soil STP levels. Corn and small grains often respond more favorably to banded P than soybean.

UNDERSTAND PHOSPHORUS MINERAL WEATHERING

4 P mineral weathering is often slow and influenced by soil moisture, temperature, and pH.

5 P mineral weathering is enhanced by organic acids and enzymes released by plant roots and microbes.

6 Use of cover crops to increase P availability in Wisconsin soils is not well documented.

7 Subsoil P content of many Wisconsin soils is low, limiting the ability for crops to solubilize and transfer P from the subsoil to the soil surface.

ENHANCE PHOSPHORUS MINERALIZATION

8 Use agronomic practices that maintain or increase soil organic matter.

9 Maintain adequate soil pH and overall soil fertility to promote plant and microbial growth/activity.

10 Promote soil biological communities using soil health promoting practices.

Authors: Jamie Patton, Mimi Broeske & Michael Geissinger

NPM 03/2024

This publication is available for download from the Nutrient and Pest Management Program's website: ipcm.wisc.edu

Extension
UNIVERSITY OF WISCONSIN–MADISON

The Potassium (K) Cycle

for general cropping systems in Wisconsin

NPM 08/2024

Potassium deficiency symptoms first manifest in older leaves, because potassium is highly mobile in plants and moves from older to younger tissue.

Potassium is one of the 17 essential nutrients necessary for optimal plant growth and health. After nitrogen, it is the nutrient needed in the largest amount by crops.

losses –

CROP REMOVAL

Potassium is removed by crop uptake and harvest. Alfalfa, grass mixes, pastures, corn silage and small grains with straw remove large amounts and can cause potassium levels to drop quickly.

EROSION & RUNOFF

Potassium losses from erosion and runoff do not threaten water quality like nitrogen and phosphorus can.

LEACHING

Potassium leaching occurs when soils lack enough negatively charged clay particles to retain strong bonds with positively charged K^+ ions. This is of particular concern in sandy soils.

+ additions

CROP RESIDUES

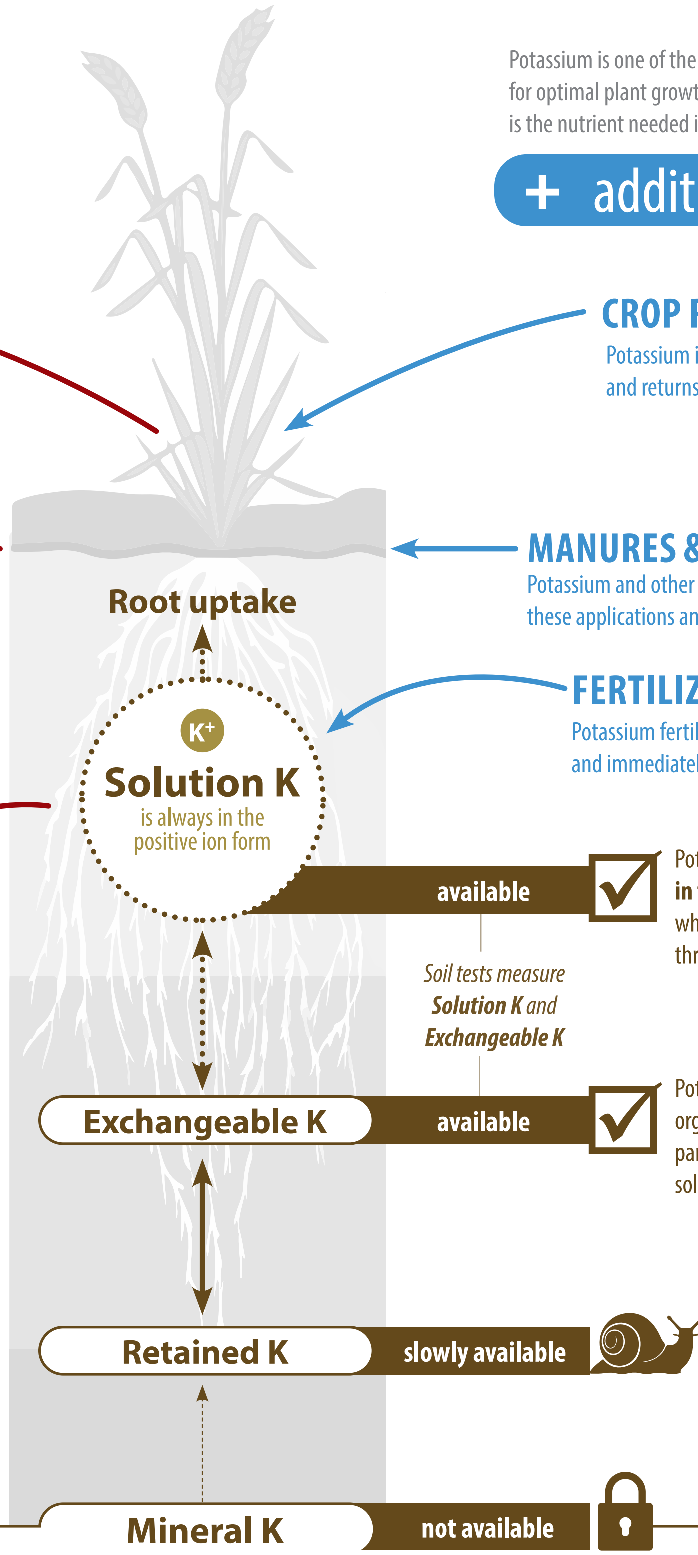
Potassium is lost quickly from residue and returns to the solution K.

MANURES & BIOSOLIDS

Potassium and other nutrients are provided by these applications and should be credited.

FERTILIZERS

Potassium fertilizers are highly soluble and immediately supply the solution K.



Potassium in solution K is always **in the positive ion form (K^+)**, which is taken-up by plant roots through adsorption.

Potassium diffuses from organic matter and clay particle surfaces when the solution K becomes depleted.

Potassium enters (is "retained") and exits the interlayers of clay particles when changes in soil moisture and temperature occur.

Potassium is confined within the structure of soil minerals and clay. Although a very small amount is released over time as weathering occurs, the majority is unavailable.

90–98% of soil K is in the mineral form

Authors: Mimi Broeske, Chris Clark and Jordan Kampa | This publication is available for download from the Nutrient and Pest Management Program's website: ipcm.wisc.edu

DIAGRAM IS ILLUSTRATIVE AND NOT TO SCALE | FOR K MANAGEMENT RECOMMENDATIONS, SEE FOLLOWING PAGE

KEY POTASSIUM (K) CONCEPTS

☑ **K fertilizer recommendations** vary by soil type because soils vary in the amount of K they can supply and retain.

☑ **K uptake** by plants is dependent on available soil moisture: lack of precipitation can affect this.

☑ **K availability** is improved by incorporating organic amendments.

☑ **Crops recycle K** which can lead to stratification especially on no-till fields and pastures.

☑ **To increase soil test K by 1-ppm,** it takes 8 lb of K_2O/acre (to convert K to K_2O multiply by 1.2).

GENERAL CONSIDERATIONS

Monitor soil K levels with routine soil testing:

- Use results to identify fields that need and do not need additional K.
- For soils testing Very Low to Low, fertilize to replace crop removal and build soil-test K levels.
- For soils are testing Optimum, High, or Very High, fertilize at crop removal, 1/2 crop removal, and 1/4 crop removal.
- Prioritize fields testing low for K for manure applications; to ensure the most accurate credits, test manure for nutrient content.
- Phosphorus (P) and K affect N use efficiency. Correct both K and P deficiencies before investing in additional N.
- For fields where the majority of the plant is removed (corn silage, alfalfa, other forage crops), test soil every two years since these crops remove large amounts of K, and levels can drop quickly.

Identify the highest demanding crop in the rotation to meet K requirements:

- Consult Table 7.2 of UW Extension A2809 *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin* for recommendations based on the crop demand level. From highest to lowest:

  Level 4 — Potatoes
  Level 3 —Tomatoes, peppers, brassicas, leafy greens, root, vine, and truck crops
  Level 2 — Alfalfa, corn silage, wheat, beans, sweet corn, peas, fruits
  Level 1 — Corn grain, soybean, clover, small grains (except wheat), grasses, oilseeds, pasture

SPECIFIC SITUATIONS

1— **In poorly drained clay soils:** K is trapped between the clay layers during wetting and drying cycles.

- As the layers expand (wet) and contract (dry), K is released into the soil solution for plant uptake or bound tightly (fixed K).

2— **In coarse & organic or irrigated soils:**

- It is difficult to build up K levels in these soils as they do not retain K. They may require annual K applications; spring split applications are preferred to fall.
- In soils with low K buffering, K should be monitored by soil testing every two years.
- For irrigated sandy soils growing high-dollar vegetable crops, annual soil testing is recommended.
- On sandy soils, plant tissue test compliments K management.
- In sandy to silt loam soils, K movement can be underestimated.
- Organic soils hold very little K and are not suited for high K removal crops.

3— **For corn on soils that are slow to warm in the spring:** A minimal amount of starter fertilizer (10 lb N - 20 lb P_2O_5 - 20 lb of K_2O per acre) can be beneficial.

- On medium to fine textured soils, salt injury may occur if more than the recommended amount of starter is applied.
- For soils that test in the excessively high K range, no K should be applied.
- Any nutrients (N, P, and K) applied as starter fertilizer need to be credited against the overall nutrient recommendation from the soil test report.

4— **Manure on hay or forages prior to seeding** is an effective way to both supply K and distribute manure.

5— **Manure on forages or hay as a topdress fertilizer** is also an effective way to both supply K and distribute manure. Be certain to:

- Target older hay stands (do not damage young stands with increased traffic, weed seed introduction, and stimulation of grass growth).
- To avoid smothering and salt injury, limit application rates to 10–12 tons/acre or 3,000–5,000 gallons/acre.
- To avoid compaction, spread on firm dry soils.
- To avoid burning alfalfa regrowth, spread as soon as possible after cutting.

6— **Forage from fields with excessively high K level:** Test forage for excessive K levels (> 3%) to prevent increased incidence of milk fever and other related illnesses in cattle.

Determining soil test P&K categories

These tables can help you determine your soil test categories, which you will need when using the University of Wisconsin's recommendations for P_2O_5 and K_2O fertilizer application rates; there are different application rates for each of the soil test categories.

To determine your soil test **phosphorus (P)** category:

1) Choose the highest demanding crop in your rotation.
2) Choose the soil group for the predominant soil in the field.
3) Find your soil test category by using the analysis number for phosphorus from your soil test results.

	Soil test category				
	Very low (VL)	**Low (L)**	**Optimum (O)**	**High (H)**	**Excessively high (EH)**
Soil group	----------soil test P (ppm)----------				
*demand level 1: **Corn grain, Soybean, Clover, Small grains (but not wheat), Grasses, Oilseed crops, Pasture***					
Loamy	< 10	10–15	16–20	21–30	> 30
Sandy, Organic	< 12	12–22	23–32	33–42	> 42
*demand level 2: **Alfalfa, Corn silage, Wheat, Beans, Sweet Corn, Peas, Fruits***					
Loamy	< 12	12–17	18–25	26–35	> 35
Sandy, Organic	< 18	18–25	26–37	38–55	> 55
*demand level 3: **Tomato, Pepper, Brassicas, Leafy greens, Root, Vine, and Truck crops***					
Loamy	< 15	15–30	31–45	46–75	> 75
Sandy, Organic	< 18	18–35	36–50	51–80	> 80
*demand level 4: **Potato***					
Loamy	< 100	100–160	161–200	> 200	
Sandy, Organic	< 30	30–60	61–90	91–120	> 120

To get started, you will need your soil test results for P and K in parts per million (ppm) from a Wisconsin DATCP certified soil testing lab along with information about your crops and soils.

The goal of the UW soil testing and nutrient applications guidelines program is to maintain soil test levels near optimum. This ensures maximum economic yield and provides flexibility in nutrient management planning.

*For soils that test greater than optimum, the objective of the nutrient application guidelines is to rely on the soil to supply the bulk of the nutrients needed for crop growth **and** to reduce the soil test level to optimum. For soils that test less than optimum, the objective is to build-up soil test levels to optimum.*

If the desired crop is not listed on the table or you are unsure of your soil group, consult tables 4.1 and 4.2 in the UWEX publication A2809 Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin.

To determine your soil test **potassium (K)** category:

1) Choose the highest demanding crop in your rotation.
2) Choose the soil group for the predominant soil in the field.
3) Find your soil test category by using the analysis number for potassium from your soil test results.

	Soil test category					
	Very low (VL)	**Low (L)**	**Optimum (O)**	**High (H)**	**Very high (VH)**	**Excessively high (EH)**
Soil group	---------- soil test K (ppm) ----------					
*demand level 1: **Corn grain, Soybean, Clover, Small grains (but not wheat), Grasses, Oilseed crops, Pasture***						
Loamy	< 70	70–100	101–130	131–160	161–190	> 190
Sandy, Organic	< 45	45–65	66–90	91–130	—	> 130
*demand level 2: **Alfalfa, Corn silage, Wheat, Beans, Sweet Corn, Peas, Fruits***						
Loamy	< 90	90–110	111–140	141–170	171–240	> 240
Sandy, Organic	< 50	50–80	81–120	121–160	161–200	> 200
*demand level 3: **Tomato, Pepper, Brassicas, Leafy greens, Root, Vine, and Truck crops***						
Loamy	< 80	80–140	141–200	201–220	221–240	> 240
Sandy, Organic	< 50	50–100	101–150	151–165	166–180	> 180
*demand level 4: **Potato***						
Loamy	< 80	80–120	121–170	171–190	191–220	> 220
Sandy, Organic	< 70	70–100	101–130	131–160	161–190	> 190

If phorphorus is called P, why is potassium called K?

K stands for kalium, Latin for alkali, which is derived from Arabic "al qalīy" (the soda ash). Many modern languages use the name kalium instead of potassium.

Potassium was named in 1807 by Humphry Davy when he first isolated the pure element using electrolysis; it is derived from the English term pot-ash; the process first used to isolate potassium salts by evaporating wood ash/water leachate in iron pots.

University of Wisconsin

P_2O_5 & K_2O nutrient recommendations

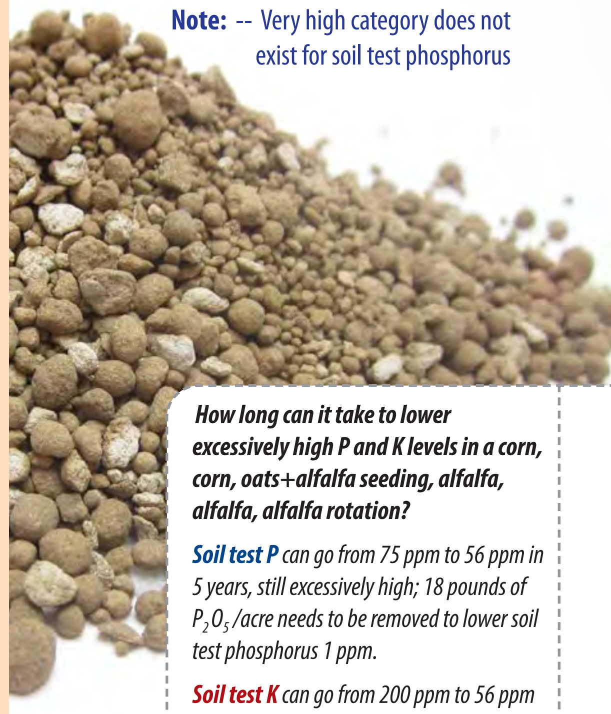
for corn, alfalfa and soybean

Note: -- Very high category does not exist for soil test phosphorus

CORN

SOIL TEST LEVEL OF THE FIELD

		Yield goal	Very Low	Low	Optimum	High	Very High	Ex. High
GRAIN		Yield goal (bu/acre)	--------------------lb P_2O_5 or K_2O/acre to apply---------------------					
GRAIN	Phosphate (P_2O_5)	91-110	80	70	40	20	-	0
		111-130	85	75	45	25	-	0
		131-150	95	85	55	30	-	0
		151-170	100	90	60	30	-	0
		171-190	110	100	70	35	-	0
		191-210	115	105	75	40	-	0
		211-230	125	115	85	45	-	0
		231-250	130	120	90	45	-	0
		251-270	140	130	100	50	-	0
	Potash (K^2O)	91-110	75	60	30	15	10	0
		111-130	80	65	35	20	10	0
		131-150	85	70	40	20	10	0
		151-170	90	75	45	25	10	0
		171-190	95	80	50	25	15	0
		191-210	105	90	60	30	15	0
		211-230	110	95	65	35	15	0
		231-250	115	100	70	35	20	0
		251-270	120	105	75	40	20	0
SILAGE		@ 35% DM (tons/acre)	--------------------lb P_2O_5 or K_2O/acre to apply---------------------					
SILAGE	Phosphate	15-20	105	95	65	35	-	0
		20-25	120	110	80	40	-	0
		25-30	140	130	100	50	-	0
		30-35	155	145	115	60	-	0
		35-40	175	165	135	70	-	0
	Potash	15-20	200	185	145	75	35	0
		20-25	240	225	185	95	45	0
		25-30	285	270	230	115	60	0
		30-35	325	310	270	135	70	0
		35-40	365	350	310	155	80	0



How long can it take to lower excessively high P and K levels in a corn, corn, oats+alfalfa seeding, alfalfa, alfalfa, alfalfa rotation?

Soil test P *can go from 75 ppm to 56 ppm in 5 years, still excessively high; 18 pounds of P_2O_5/acre needs to be removed to lower soil test phosphorus 1 ppm.*

Soil test K *can go from 200 ppm to 56 ppm or very low in just 5 years; 6-7 pounds of K_2O/acre needs to be removed to lower soil test potassium 1 ppm.*

ALFALFA

Where an alfalfa stand is to be maintained for more than three years **increase** the annual top-dressed K_2O by 20%.

SOIL TEST LEVEL OF THE FIELD

	Yield goal	Very Low	Low	Optimum	High	Very High	Ex. High
	Yield goal (tons/acre)	---------lb P_2O_5 or K_2O/acre to apply--------------					
Phosphate (P_2O_5)	1.5-2.5	65	55	25	15	-	0
	2.6-3.5	80	70	40	20	-	0
	3.6-4.5	90	80	50	25	-	0
	4.6-5.5	105	95	65	35	-	0
	5.6-6.5	120	110	80	40	-	0
	6.6-7.5	130	120	90	45	-	0
	7.6-8.5	145	135	105	55	-	0
	8.6-9.5	155	145	115	60	-	0
Potash (K_2O)	1.5-2.5	160	145	105	55	25	0
	2.6-3.5	235	220	180	90	45	0
	3.6-4.5	295	280	240	120	60	0
	4.6-5.5	355	340	300	150	75	0
	5.6-6.5	415	400	360	180	90	0
	6.6-7.5	475	460	420	210	105	0
	7.6-8.5	535	520	480	240	120	0
	8.6-9.5	595	580	540	270	135	0

SOYBEAN

SOIL TEST LEVEL OF THE FIELD

	Yield goal	Very Low	Low	Optimum	High	Very High	Ex. High
	Yield goal (bu/acre)	-----------lb P_2O_5 or K_2O/acre to apply-------------					
Phosphate (P_2O_5)	26-35	65	55	25	15	-	0
	36-45	70	60	30	15	-	0
	46-55	80	70	40	20	-	0
	56-65	90	80	50	25	-	0
	66-75	95	85	55	30	-	0
	76-85	105	95	65	35	-	0
	86-95	110	100	70	35	-	0
	96-105	120	110	80	40	-	0
Potash (K_2O)	26-35	85	70	40	20	10	0
	36-45	100	85	55	30	15	0
	46-55	115	100	70	35	20	0
	56-65	130	115	85	45	20	0
	66-75	145	130	100	50	25	0
	76-85	155	140	110	55	30	0
	86-95	170	155	125	65	30	0
	96-105	185	170	140	70	35	0

Credit What You Spread

Not seeing the manure you need? Find more in UWEX publication A2809 ***Nutrient Application Guidelines for Field, Vegetable and Fruit Crops in Wisconsin.***

Estimated **Available Manure Nutrient Content**

for crop use in the first year after spreading

See the example below for calculating 1st year nutrient credits for unincorporated solid beef manure using a spreading rate of 15 tons/acre

Time to incorporation →	N more than 3 days	N 1 hour to 3 days	N less than 1 hour	P_2O_5	K_2O
Solid Manure					
	lb/ton				
(solid: >20% dry matter) Dairy	2	3	3	3	6
(semi-solid: 11-20% dry matter) Dairy	2	2	3	3	5
Beef	3	4	5	6	10
Swine	7	9	12	10	8
Goat	3	4	5	6	8
Sheep	5	6	7	7	19
Horse	2	3	4	5	6
Chicken	24	27	29	35	26
Liquid Manure					
	lb/1,000 gal				
(slurry: 4-11% dry matter) Dairy	7	10	12	6	17
(liquid: <4% dry matter) Dairy	4	6	7	3	11
Beef	5	6	8	6	12
(finish, indoor pit) Swine	17	22	28	14	22
(finish, outdoor pit) Swine	7	9	12	6	8
Poultry	6	7	7	6	7

Steps to determine manure nutrient credits

1. Enter the available nutrient content of manure using the above table or from the results of an anaylsis.
2. Multiply the nutrient content by the manure application rate (see example calculation on pg. 27) to get the lb/acre of each nutrient.

	lb/ton or lb/1,000 gal		tons or gallons/acre		lb/acre
N	3	x	15 tons/acre	=	45 lb/acre
P_2O_5	6	x	15 tons/acre	=	90 lb/acre
K_2O	10	x	15 tons/acre	=	150 lb/acre

Estimated **Manure Output**

(volume as excreted)

Animal & weight	lb/day	ton/year	gal/day	1000 gal/year
Dairy 1400 lb	148	27	17.7	6.5
Beef 1100 lb	80	15	9.5	3.5
Swine 150 lb	9.5	1.7	1.2	0.44
Chicken (broiler) 2 lb	0.18	0.033	0.02	0.007
Horse 1000 lb	50	9.1	6.0	2.2

To estimate manure quantity output, use the table here or scan (or click) the QR code to view a comprehensive list of animals from the Midwest Plan Service.

Midwest Plan Service publication number MWPS-18 "Manure Characteristics" Section 1, © 2000

SAMPLING MANURE FOR ANALYSIS

WHY TEST MANURE?

No two farming systems are exactly alike, neither is the manure produced on them. Nutrient content of manure varies from farm to farm due to a number of factors — including animal type, bedding, ration, storage/handling, and other herd management practices.

Nutrient values can be assigned by using University of Wisconsin "book "nutrient values for manure; however, testing manure for your farm will better indicate how animal management and other factors affect nutrient content. Ultimately, the goal is to identify the most accurate estimate of nutrient content of the manure to ensure accurate crediting of the manure when applied to cropland.

Manure sampling techniques can greatly influence the results. Following the recommended sampling procedures outlined in this publication will improve the accuracy of the manure nutrient analysis results from the testing lab.

However, variability can exist among different samplings even when they are taken by the same individual under ideal conditions. Due to these variations over time, manure nutrient concentration values used to determine field nutrient credits should ideally be based on long-term farm averages, assuming herd and manure management practices have not changed significantly. If an established baseline level does not exist for a farm, manure testing needs to be done frequently and consistently to develop a historic record that spans at least 2-3 years. Preferably, manure sampling and analysis should be done just prior to land application, with the time of year noted to monitor potential seasonal variability.

Note about submitting samples: Keep manure sample frozen until shipped or delivered to a laboratory. Ship early in the week (Mon-Wed) and avoid holidays and weekends.

RECOMMENDED SAMPLING PROCEDURES

For all samples, identify the sample container with information regarding the farm, animal species and date. This information should also be included on the Manure Analysis Information submission sheet.

SOLID MANURE – DAIRY, BEEF, SWINE

While Loading

Take a pitchfork and grab multiple samples (at least 5) while loading several spreader loads and mix them in a bucket to create one composite sample. After thoroughly mixing, fill a one gallon plastic bag half full, squeeze out excess air, close and seal. Store sample in a freezer if not immediately delivered to a lab.

Daily Haul

Place a 5 gallon bucket under the barn cleaner 4-5 times while loading a spreader. Thoroughly mix the 4-5 samples together to create one composite sample. After thoroughly mixing, fill a one gallon plastic bag half full, squeeze out excess air, close and seal. Store sample in a freezer if not immediately delivered to a lab.

Stack or Bedded Pack

Sampling from a stack or bedded pack is not recommended. If sampling is necessary, use one of the other listed methods.

SOLID MANURE –POULTRY

Commonly 5-6 batches of birds are grown out before litter is removed. Poultry houses are normally sampled when the last batch of birds is removed from the house, since the nutrient content in poultry litter will change over time. Therefore, sampling earlier is not recommended.

Collect approximately 10 samples from throughout the house, sampling to the depth the litter will be removed. Avoid feeding and watering areas. Thoroughly mix the samples together to create one composite sample. After thoroughly mixing, fill a one gallon plastic bag half full, squeeze out excess air, close and seal. Store sample in a freezer if not immediately delivered to a lab.

LIQUID MANURE – DAIRY, BEEF, SWINE

From Storage

Agitate storage facility thoroughly before sampling. Collect several samples (at least five) from the storage facility or during loading using a bucket. Combine samples in a 5 gallon pail and thoroughly mix them together to create one composite sample. After mixing, fill a one quart plastic bottle ¾ full and tightly screw on lid. Store sample in a freezer if not immediately delivered to a lab.

During Application-Irrigated Manure

Place several buckets around field to catch manure from irrigation equipment. Combine samples in a 5 gallon pail and thoroughly mix them together to create one composite sample. After mixing, fill a one quart plastic bottle ¾ full and tightly screw on lid. Store sample in a freezer if not immediately delivered to a lab.

Know How Much You Haul !

To get the most value from your manure, you must accurately determine your spreading rate. All you need to get started is a worksheet, portable axle scales, measuring wheel (or field records with loads spread) and a calculator. This whole process can take less than a hour! Contact your land conservation department, county extension agent or the Nutrient and Pest Management Program for assistance with scales. After you have your spreading rate, it's only a few steps to calculate your nutrient credits and then subtract them from your nutrient recommendations.

STEP 1. DETERMINE LOAD WEIGHT

TOOLS NEEDED: CALCULATOR, WORKSHEET, PORTABLE AXLE SCALES

Using a typical load size, the tractor with spreader is weighed empty and full, axle by axle. This determines your load size in tons.

It's a good idea to repeat all three steps for any different types of spreaders or manure you routinely apply on your farm.

STEP 2. DETERMINE SPREADING RATE

TOOLS NEEDED: CALCULATOR AND FIELD RECORDS OR MEASURING WHEEL

You can now calculate your tons per acre spreading rate by using either field records on how many loads you put on a particular field of known acreage or by measuring a test manure swath, [length (ft) x width (ft)] ÷ 43,560 ft^2/acre, being careful to account overlap or load tapering.

This rate can be considered the "standard" for the farm. Make sure you use typical ground speed, PTO speed and spreader settings.

To develop variable rates (such as high, medium and low) experiment with different speeds and spreader settings. These rates could be useful when dealing with fields that have special fertilizer, tillage or environmental considerations.

STEP 3. DETERMINE MANURE NUTRIENT CREDITS

TOOLS NEEDED: CALCULATOR

Using University of WI guidelines, you can estimate the available nutrient content per ton of the type of manure you are spreading. You can also use the results from a manure analysis. From either of those numbers, you can figure manure nutrient credits per acre (see page 24 for an example)!

KEY STEPS TO GOOD MANURE MANAGEMENT

- ☑ Inventory on-farm nutrient sources
- ☑ Weigh and calibrate your spreader
- ☑ Obtain accurate manure nutrient values
- ☑ Determine nutrient credits
- ☑ Follow a manure spreading plan and keep track of any changes

Manure Load Weight Worksheet

Farm Name/Producer ______
Manure Analysis (optional):
Calibration Date ______
Analysis Date: ______
Manure Source/Type ______
Sample ID: ______
Spreader Name/Load Size (manufacturer's estimate) ______

FULL

	Left wheel		Right wheel
Rear tractor axle			
	+		+
Front spreader axle			
	+		+
Rear spreader axle			
		+	

= **Full total** ______ lb

EMPTY

	Left wheel		Right wheel
Rear tractor axle			
	+		+
Front spreader axle			
	+		+
Rear spreader axle			
		+	

= **Empty total** ______ lb

To calculate **Manure weight** subtract the Empty total from Full total

Manure weight = ______ lb / 2,000 lb per ton

Load size = ______ tons

To calculate **Load Size** divide the Manure weight by 2000

Not sure if conditions are right for spreading manure?

Check out the RRAF! The Runoff Risk Advisory Forecast map is a key "on the ground" tool that displays the runoff risk not just for the current day, but 72 hours into the future based on precipitation model forecasts.

www.manureadvisorysystem.wi.gov

Determining an accurate application rate is the foundation for using manure as a quality, dependable fertilizer.

It is preferred that it be done in advance of spreading for better targeting of nutrient applications but also can be done after spreading by keeping track of loads applied to the field.

Steps to determine manure application rate

1. Figure load size using the above worksheet. (for liquid manure, use 90% tank capacity)
2. Determine acerage of test manure swath or use a field with known acerage
3. Calculate manure application rate

$$\frac{[\ (\#\ \text{of loads}) \times (\text{load size})\ ]}{\text{acres}} = \text{tons or gallons/acre}$$

EXAMPLE CALCULATION

60 loads on a 24 acre field with a 6 ton load size

$$\frac{[\ (60\ \text{loads}) \times (6\ \text{tons/load})\ ]}{24\ \text{acres}} = 15\ \text{tons/acre application rate}$$

This rate is used to calculate manure credits on page 24

Want to learn more?

go.wisc.edu/nmfe

Check out the online UW Nutrient Management Farmer Curriculum!

FERTILIZER ANALYSIS & CONVERSIONS

	N	P_2O_5	K_2O	other
Nitrogen	--% content--			
Ammonium nitrate	34	0	0	
Ammonium sulfate (AMS)	21	0	0	24(S)
Ammonium thiosulfate (ATS)	12	0	0	26(S)
Anhydrous ammonia	82	0	0	
Aqueous ammonia	20	0	0	
Calcium nitrate (CN)	15	0	0	17(Ca)
Urea	46	0	0	
28% Urea ammonium nitrate (UAN)	28	0	0	
32% UAN	32	0	0	
Phosphorus				
Ammonium polyphosphate (dry)	15	62	0	
Ammonium polyphosphate (liquid)	10	34	0	
Diammonium phosphate (DAP)	18	46	0	
Monoammonium phosphate (MAP)	11	52	0	
Triple superphosphate (TSP)	0	46	0	
Potassium				
Potassium chloride (muriate of potash)	0	0	60-62	
Potassium-magnesium sulfate	0	0	22	22(S),11(Mg)
Potassium nitrate	13	0	44	
Potassium sulfate	0	0	50	18(S)

Liquid weights:
1 gallon water weighs 8.3 lbs
1 gallon UAN (28%) weighs 10.6 lbs
1 gallon 10-34-0 weighs 11.6 lbs
1 gallon 9-18-9 weighs 11.1 lbs

To get column 3, multiply column 1 by column 2

1	2	3
acre (a)	43,560	square feet (ft²)
acre (a)	0.405	hectare (ha)
square mile (mi²)	640	acres (a)
cubic yard (yd³)	27	cubic feet (ft³)
cubic feet (ft³)	7.48	gallons (gal)
bushel (bu)	1.244	cubic feet (ft³)
bushel (bu)	8	gallons - dry
bushel (bu)	9.31	gallons - liquid
ounces (oz)	29.6	milliliters (ml)
gallon (gal)	3.78	liters (l)
gallon (gal)	128	fluid ounces (fl oz)
gallon (gal)	4	quart (qt)
acre-foot	43,560	cubic feet (ft³)
acre-foot	325,851	gallons (gal)
chain (ch)	66	feet (ft)
chain (ch)	4	rods (r)
rods (r)	16.5	feet (ft)
mile (mi)	5,280	feet (ft)
ton (t)	2,000	pounds (lb)
gallons/acre (gal/a)	9.354	liters/hectare (l/ha)
miles/hour (mph)	88	feet/minute (ft/min)
pounds/acre (lb/a)	1.12	kilograms/hectare (kg/ha)
P_2O_5 (lb)	0.44	P (lb)
K_2O (lb)	0.83	K (lb)
ppm-plow layer (6 in)	2	lb/acre (lb/a)
ppm-top soil (12 in)	4	lb/acre (lb/a)

To get column 1, divide column 3 by column 2

PLANTING & HARVEST INFORMATION

DETERMINING PLANT POPULATIONS

Row Width	20″	28″	30″	32″	36″	38″	40″
Row Length*	26′1″	18′8″	17′5″	16′4″	14′6″	13′9″	13′1″

* required to equal 1/1000 acre

Calculation: (# of plants in row length) x 1000 = plants/acre

NUTRIENTS REMOVED BY CROP AT HARVEST

	P_2O_5	K_2O
	lb per yield unit	
Alfalfa* / Red clover, per ton (dry matter)	13	60
Barley, Grain, per bu (1 bu = 48 lb @ 14.5% moisture)	0.40	0.35
Straw, per ton (dry matter)	10	32
Corn, Grain per bu (1 bu = 56 lb @ 15.5% moisture)	0.38	0.29
Silage, per ton (65% moisture)	3.6	8.3
Sweet, per ton (fresh)	3.3	6.0
Stover, per ton (dry matter)	4.6	32
Small grain silage, per ton (dry matter)	11	44
Oats, Grain, per bu/a (1 bu = 32 lb @ 14% moisture)	0.29	0.19
Straw, per ton (dry matter)	9.4	47
Potatoes, per cwt (fresh)	0.12	0.50
Rye, Grain, per bu/a (1 bu = 56 lb @ 14% moisture)	0.41	0.31
Straw, per ton (dry matter)	3.7	21
Sorghum, Grain, per bu (1bu = 56 lb @ 14% moisture)	0.40	0.40
Sorghum-sudan, Forage, per ton (65% moisture)	15	60
Soybean,* Grain, per bu (1 bu = 60 lb @ 13% moisture)	0.80	1.4
Straw, per ton (dry matter)	5.4	19
Wheat, Grain, per bu (1 bu = 60 lb @ 13.5% moisture)	0.50	0.35
Straw, per ton (dry matter)	6.0	28

*Nitrogen removal by alfalfa is 60 lb N/ton and by soybeans is 4 lb N/bu.

CONVERTING (lbs) HARVESTED TO (bu) with % moisture content corrections

Shelled Corn [lbs harvested x (1 - % moisture in corn)] ÷ 47.32 = bu @ 15.5% moisture

Ear Corn lbs harvested ÷ number from chart below = bu @ 15.5% moisture

moisture %	15	15.5	16	17	18	19	20	21	22	23	24	25	26	27
equation #	68.1	68.2	69.2	70.4	71.6	72.8	74.1	75.4	76.6	78.0	79.4	80.7	82	83.4

Soybean lbs harvested x (1 - % foreign matter) = adjusted lbs
[adjusted lbs x (1 - % moisture)] / 52.2 = bu @ 13% moisture

Wheat lbs harvested x (1 - % foreign matter) = adjusted lbs
[adjusted lbs x (1 - % moisture)] / 51.9 = bu @ 13.5% moisture

EXAMPLE WITH SHELLED CORN HARVESTED BY COMBINE:

Step 1: 12,580 lbs corn harvested @ 21.35% moisture
12,580 lbs x (1 - .2135) ÷ 47.32 = 209 bu of corn @ 15.5 % moisture

Step 2: Four-row harvester: 16 rows , each 30 inch (2.5 ft) row is 1210 feet long
(1210 ft x 2.5 ft x 16 rows) ÷ 43,560 ft²/acre = 1.10 acres

Step 3: 209 bu of corn ÷ 1.10 acres = 190 bu/acre