



# Nitrogen Use Efficiency:

## A guide to conducting your own assessment

### What's inside:

Discovery Farms Nitrogen Use Efficiency Project Overview.....	2-3
Level 1: Standard Nitrogen Use Efficiency Assessment.....	4-6
Level 2: Intensive Nitrogen Use Efficiency Assessment.....	7-10
Nitrate Sampling Protocols.....	Appendix A-B
Data Collection Sheets.....	Appendix C-D
Cover Crop Assessment.....	Appendix E
Measuring yield for corn silage.....	Appendix F
Grain Nitrogen Assessment.....	Appendix G
Additional Resources.....	Appendix H



**Extension**  
UNIVERSITY OF WISCONSIN-MADISON



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# Discovery Farms NUE Project Overview

Efficient use of nitrogen is essential for crop production, whether the nitrogen source is commercial fertilizer, manure, legumes or some combination. Assessing the efficiency of N application on a per field basis is a valuable first step in evaluating your N fertilizer management plan. Calculating Nitrogen Use Efficiency (NUE) can be relatively simple and offers insight into how N management can be altered in order to achieve economically optimum yields while reducing nutrient losses to the environment.

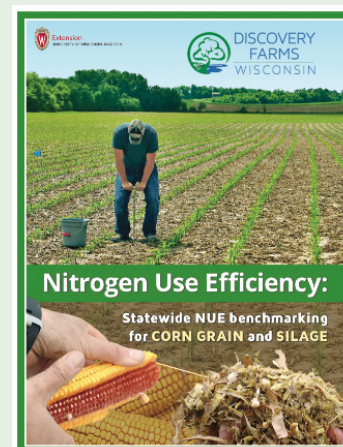
## In 2015, Discovery Farms established its NUE Project to:

- 1) calculate NUE for Wisconsin corn grain and silage fields
- 2) create benchmarks of achievable NUE within WI
- 3) give farmers, crop consultants and agronomists the tools to calculate NUE on their fields and determine what shifts in N management are appropriate

Fields from regions across WI with diverse soil types and management systems were monitored for NUE by establishing plots within a field to track N throughout the season.

Benchmarks for WI corn production and tools to evaluate your NUE values can be found in *Nitrogen Use Efficiency: Statewide NUE benchmarking for corn grain and silage*

[www.uwdiscoveryfarms.org](http://www.uwdiscoveryfarms.org)



A Nitrogen Use Efficiency (NUE) assessment will evaluate how efficiently you are managing nitrogen and what the potential economic and environmental impacts may be. With six years of monitoring, Discovery Farms has state and regional NUE benchmarks to help producers assess current practices and determine if improvements can be made.

This is a great opportunity for on-farm trials to understand the specifics of nitrogen management on your individual field and, within your region when participating as a Producer-Led Watershed group. While University N recommendations are a great place to start when determining N management decisions, the Discovery Farms NUE Project has determined that a lot can be learned from looking at producers' own fields.

## Information you will learn from an assessment:

- Yield produced per pounds of N (Partial Factor Productivity)
- Whether this efficiency value is above or below average for the state, for similar systems, or for your region
- An estimation of N that could potentially be leached to groundwater
- How much the soil can yield without any N inputs\*
- How efficiently the applied nitrogen was used to increase yields\*
- An estimation of how much N was supplied by the soil and how much of the N applied was not used\*

\*additional information learned through the intensive NUE assessment

## How NUE assessments work

NUE assessments are conducted through collaboration among producers, farmer groups such as producer-led watershed groups, local partners, and the Discovery Farms Program.

### Potential partners include (but are not limited to):

Land Conservation Department, Division of Extension, crop consultants, and co-ops. Discovery Farms will use all the information gathered to provide individual NUE assessments, group NUE reports, and other educational opportunities. In the assessment directions, you will find more information regarding the role of each participant.

This is a step-by-step guide to conducting an NUE assessment. It will walk you through the entire process: from what kind of NUE assessment you would like to do, protocols to collect data, and how to submit data at the end of the year.

### Corn silage

If you would like to know the NUE of your corn silage fields, there is an adjusted protocol found in [Appendix F](#).

## Deciding what type of NUE assessment and what fields you want to monitor

**Standard assessments** are the first step to determining if your NUE is higher or lower than WI specific benchmarks. A below average NUE can indicate that improvements to efficiency can be made.

**Benefits:** All you need to know is the yield and nitrogen applied on a given field! Because these assessments are easier to do, you can monitor many fields on your farm to give you a better overview of efficiency.

**Limitations:** This assessment does not account for the nitrogen supplied by the soil, so it will not indicate the yield gain attributed to the N applied.

**Intensive assessments** use test strips to better understand how nitrogen cycles through the soil and if there are opportunities to improve management. In an intensive assessment you can include more than one test strip, but we recommend including a zero-N test strip when possible.

1) **Zero-N test strip (ZN)**: this test strip does not receive any nitrogen, aside from that applied through starter fertilizer (where applied N is less than 30 lb/ac). It measures how much the field yields without any inputs to assess the nitrogen supplied by the soil and the true efficiency of the applied N.

2) **Manure-N test strip (MN)**: where manure was applied in the fall but no other nitrogen was applied for the remainder of the season. While this won't indicate how much nitrogen is supplied by the soil, it will demonstrate how efficient the additional fertilizer N was.

3) **Half-rate, or low-N, test strip (LN)**: this is a good complement to the zero-N test strip, since it will assess the efficiency of the higher rate and help evaluate if a reduction in rate is valuable to the producer for either economic gains or decreased environmental risk.

**Benefits:** Test strips are very valuable as a soil health indicator and to fine tune N management after accounting for the soil nitrogen. This assessment gives the true economic efficiency of N applied and the N at risk of being lost to the environment.

**Limitations:** This assessment requires more time and effort to set up the test strips at the beginning of the season, avoid N applications, and retrieve reliable yield data from specific strips.

## Required and Optional Additional Monitoring

Monitoring NUE has a few requirements, but more options to add on other components. The required information will provide enough information to calculate and assess NUE. Add-ons are valuable if a producer or producer-led group are interested in learning more about NUE or a certain practice as it relates to N management.\*

## Required Data:

**Management data:** An example of the data collection sheet is included in [Appendix C-D](#)

**Accurate yield data:** Preferably with a calibrated yield monitor, but opportunity to use weigh wagons if needed

**Routine soil sample:** From the past five years

## Optional data collection:

**Manure Analysis:** Given variability of nutrient content in manure, a manure analysis will help us better assess NUE and help you credit the manure and manage nitrogen accurately. If you use manure as a nitrogen source, we recommend a manure analysis.

**Cover crop assessment:** There are many questions around cover cropping and nitrogen, such as: how much nitrogen is stored in that cover crop?, and how will that cover crop affect available nitrogen and the following crop yield? This assessment will calculate coverage, biomass, and nitrogen content to provide insight on how the cover crop fits into your NUE. [Appendix E](#)

**Pre-plant or pre-sidedress nitrate sampling:** Soil sampling for nitrate will indicate how much plant available nitrogen is in the soil throughout the season. It can be useful to understand how N fluctuates throughout the season, especially if you use organic N sources that become available at different rates, which have variable N availability depending on weather and management. [Appendix A-B](#)

**Grain N content:** The nitrogen content of the grain can vary. In our Discovery Farms dataset, we have benchmarked values in order to estimate the amount of nitrogen removed at harvest based on your yield data. If you would like more detailed values, you can collect a grain sample to measure the nitrogen content for your crop, specifically. This will provide more accurate data to some of our calculations, like potentially leachable nitrogen. [Appendix G](#)

*\*Throughout the document you will come across "optional add-on" which you can ignore if it does not apply to you.*

**Access all of Discovery Farms NUE resources and data collection tools in this folder.**

## [NUE monitoring: A complete guide](#)

*Discovery Farms is always available to assist throughout NUE monitoring. Please let us know if you are planning to monitor NUE this season so we can make sure to provide you with information and support.*

*Get in touch with Discovery Farms if you have any questions throughout the process.*

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# Level 1: Standard NUE assessment of corn grain fields

**Goal:** Determine simple Nitrogen Use Efficiency (Partial Factor Productivity) and an estimated N balance of an overall field.

## Measurements performed in a standard NUE assessment

**Partial Factor Productivity** measures how efficient a field is relative to N inputs. Learn if you have a high or low efficiency relative to WI benchmarks and opportunities to improve efficiency when applicable.

**N balance** measures the amount of unused nitrogen that could potentially be leached. It is a valuable tool to assess risk to water quality. This assessment provides an estimation for N balance, but for more accurate data, you can measure the grain N content of your field.

Monitoring should be conducted in collaboration between producers and partners. Potential partners include (but are not limited to): County Extension educators, conservationists with NRCS or County Land & Water Conservation Departments, crop consultants, or co-ops.



## Requirements for performing a standard NUE assessment

	For Producers	For Partners
<b>Requirements</b>	Yield monitor (calibrated)  Short agronomic form  Routine soil test (from past 5 years)  Manure analysis (if applicable)	Agronomic data collection from farmers and fields  Facilitate educational component (meetings, regional and individual discussions, etc)
<b>Optional data</b>		Nitrate soil sampling  Cover crop assessment (agronomic data, biomass, surface cover, N content)  Grain N% content

## Timeline for standard NUE assessments

### Winter- Spring

- 1) Select fields you want to monitor
- 2) Cover crop add-on data collection (optional data) [Appendix E](#)
- 3) Manure analysis if manure is being applied (optional data)

### Spring, before planting

- 4) Take a routine soil sample if you do not have a routine soil sample from the past five years [Appendix H](#)
- 5) Pre-plant soil sample for nitrate (optional data) [Appendix A](#)

### Approximately one week before side dress N is applied

- 6) Take a pre-sidedress soil sample for nitrate (optional data) [Appendix A](#)

### Before harvest

- 7) Calibrate your yield monitor and review yield monitor data collection instructions

### Post-harvest

- 8) Submit soil, agronomic and yield data to Discovery Farms



## Collecting accurate yield data

### Calibrate your yield monitor

Calibrating your yield monitor is crucial to obtaining accurate yield data, and accurate NUE calculations. Please review [Appendix H](#).

### Combining best management practices

For standard fields, collect yield of the whole field. This decreases room for inaccuracies based on combine direction, but you still want to try to keep flow consistent as you move through the field. If you have divided up certain fields based on soil type, yield potential, or other reasons and manage them differently, then additionally obtaining separate yield data based on subsection of the field would be beneficial, but not required. See [Appendix F](#) for silage protocols.

### Weigh wagon used to calibrate a yield monitor



## Data Collection Process for standard assessment

At the end of the season, producers and county partners will work together to collect management data: general cropping management, nitrogen applied, and yield data (required) and soil, cover crop, manure analysis, and grain N content data (optional, if applicable). Calculate N applied with this [N Calculator](#).

A data collection form is located in [Appendix C](#). All data eventually needs to be submitted via the [google form](#). County partners should submit data electronically by December 15th, so that Discovery Farms can create individual and regional reports. Reports will be returned to individual producers and county partners over the winter and a virtual meeting to discuss the results can be scheduled. If you do not think you can submit data by this date, let Discovery Farms know so we can expect the data later on.



## Budget information for standard NUE assessments

Sampling cost per field (without any optional add-ons) is \$0 and minimum estimated time for the partner to work with a producer is two to three hours (most of which is outreach). Additional optional field work and sampling costs are included as “add-ons” below.

	Time, equipment & sampling costs	Costs per sample \$ (shipping not included)	Number of samples per field	Time
<b>Requirements</b>	Pre-season meeting			30-60 minutes
	Agronomic data collection			30-60 minutes
	Final report review			60 minutes
<b>Optional add-ons</b>	Routine soil test	10	Number of samples determined by size of field*	30- 45 minutes
	Pre-plant nitrate (0-1', 1-2')	15		30 minutes
	Pre-sidedress nitrate (0-1')	15		30 minutes
	Grain N content	15	1	15 minutes
	Manure analysis	22	1	15 minutes
	Cover crop assessment	20	1	30 minutes

\*Determine number of soil samples necessary to be representative of the field by reviewing *Sampling soils for testing* in [Appendix H](#).

# Level 2: Intensive NUE assessment of corn grain fields

**Goal:** Determine simple and intensive Nitrogen Use Efficiency metrics (Partial Factor Productivity and Agronomic Efficiency) and an estimation of N balance. Utilize a zero-N test strip and, if interested, half rate or manure test strips to evaluate the soil's ability to supply nitrogen without N inputs and the efficiency of any additional N inputs.

In this level of monitoring, you will measure overall how productive the field is relative to the N applied, as well as how efficient additional fertilizer was at increasing yield compared to the test strip. Test strips can be marked out either through a shape-file/precision agriculture technologies or physically flagging out the test strip in the field. Sampling will be localized around these test strips.

Monitoring should be conducted in collaboration between producers and partners. Potential partners include (but are not limited to): County Extension educators, conservationists with NRCS or County Land & Water Conservation Departments, crop consultants, or co-ops.

## Measurements performed in an intensive assessment

**Partial Factor Productivity** measures how efficient a field is relative to N inputs. Learn if you have a high or low efficiency relative to WI benchmarks and opportunities to improve efficiency when applicable.

**N balance** measures the amount of unused nitrogen that could potentially be leached. It is a valuable tool to assess risk to water quality. This assessment provides an estimation for N balance, but for more accurate data, you can measure the grain N content of your field.

**Agronomic Efficiency** measures how efficient additional N inputs were at increasing yield relative to the test strip. Learn if there are opportunities to decrease N applied given the efficiency of the test strip.

**N Budget** measures the maximum potentially leachable nitrogen by accounting for the nitrogen supplied by the soil. This assessment will provide an estimation for N budget based on previous Discovery Farms data.



## Requirements for performing an intensive NUE assessment

	For Producers	For Partners
<b>Requirements</b>	Flag/maintain zero-N test strip and/or half-rate test strip (different ways to do this)  Yield monitor (calibrated)  Short agronomic form  Routine soil test (from past 5 years)  Manure analysis (if applicable)	Agronomic data collection from farmers and fields  Facilitate educational component (meetings, regional and individual discussions, etc)
<b>Optional data</b>		Nitrate soil sampling  Cover crop assessment (agronomic data, biomass, surface cover, N content)  Grain N% content

### Timeline for intensive NUE assessments

#### Winter-Spring

- 1) Select fields you want to monitor
- 2) Cover crop add-on data collection (optional data) [Appendix E](#)
- 3) Manure analysis if manure is being applied (optional data)

#### Spring, before planting

- 4) Mark out zero-N and with-N strips with flags, or by using a shape-file
- 5) Take a routine soil sample if you do not have a routine soil sample from the past five years [Appendix H](#)
- 6) Take a pre-plant soil sample for nitrate (optional data) [Appendix B](#)

#### Approximately one week before sidedress N is applied

- 7) Pre-sidedress soil sample for nitrate (optional data) [Appendix B](#)

#### Before harvest

- 8) Calibrate your yield monitor and review yield monitor data collection instructions

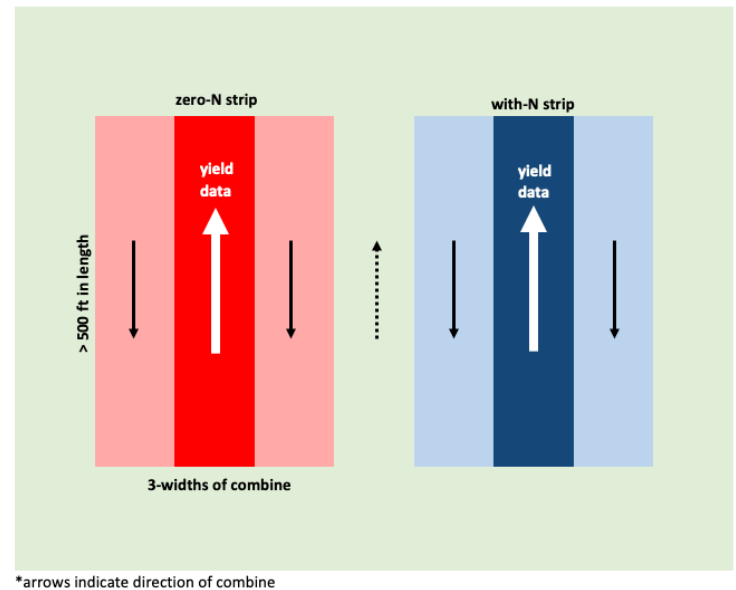
#### Post-harvest

- 9) Submit soil, agronomic and yield data to Discovery Farms



## Establishing a zero-N strip in an intensive field

- Select a representative spot in the field with a uniform soil type.
- You will have a *zero-N strip* and a *with-N strip*, which is a nearby strip that receives the full N rate and will serve as a direct comparison to the zero-N strip.
- A zero-N strip should be the width of 3 combine heads and a length of at least 500 feet. Note that the longer the length, the easier it will be to obtain accurate yield data.
- At planting, it is useful to create a boundary in the GPS software, so that it is easier to avoid in-season N applications to this plot and to obtain yield data from the monitor.
- Additionally, or if you do not have the software, flag off the four corners of the zero-N strip using tall stakes and flags so that you can see the plot during in season applications. This is especially important if you will not be the one applying the N. Also, at the field's edge, mark off the strips where the zero-N is located, so you know to look out for the strip during applications.



## Collecting accurate yield data

Collect yield data for the test strips, the with-N strip and, if possible, the whole field. Obtaining yield data for the strips can be more challenging and there are some practices that can be used to improve the accuracy of data. Please review [Appendix H](#) for how to correctly calibrate your yield monitor. Silage yield protocols can be found in [Appendix F](#).

If you created test strips using a shape-file: retrieve yield data for individual strips from your precision ag software.

If you created test trips by flagging out the area of the field, use one of the following options to collect your yield.

1. While going through the test strip, keep an eye on the yield monitor to get an estimate of yield in that area. *Note: make sure you keep speed of the combine*

*the same as the entire field in order to mitigate error. Do the same for a comparative with N test strip adjacent to the zero N test strip*

2. Harvest all of the field except for the two test strips and then harvest the test strips separately in order to keep yield data for those areas separate.

## Data Collection Process for intensive assessment

At the end of the season, producers and county partners will work together to collect management data: general cropping management, nitrogen applied, and yield data (required) and soil, cover crop, manure analysis, and grain N content data (optional, if applicable). Calculate N applied with this [N Calculator](#).

A data collection form is located in [Appendix D](#) or [Appendix F](#) for silage. All data eventually needs to be submitted via the [google form](#). County partners should submit data electronically by December 15th, so that Discovery Farms can create individual and regional reports.

Reports will be returned to individual producers and county partners over the winter and a virtual meeting to discuss the results can be scheduled. If you do not think you can submit data by this date, let Discovery Farms know so we can expect the data later on.



## Budget information for intensive NUE assessments

Sampling cost per field (without any optional add-ons) is \$0 and minimum estimated time for the partner to work with a producer is three hours (most of which is outreach). Additional optional field work and sampling costs are included as “add-ons” below.

	Time, equipment & sampling costs	Costs per sample \$ (shipping not included)	Number of samples per field (one test strip, two test strips)	Cost per field \$	Time
<b>Requirements</b>	Pre-season meeting and mark out test strips				30-60 minutes
	Agronomic data collection				30-60 minutes
	Final report review				60 minutes
<b>Optional add-ons</b>	Flags		4, 8		
	Routine soil test	10	1	10	30-45 minutes
	Pre-plant nitrate (0-1', 1-2')	15	4, 6	60, 90	30 minutes
	Pre-sidedress nitrate (0-1')	15	2, 3	30, 45	30 minutes
	Grain N content	15	2, 3	30, 45	15 minutes
	Manure analysis	22	1	22	15 minutes
	Cover crop assessment	20	1	20	30 minutes

\*Determine number of soil samples necessary to be representative of the field by reviewing *Sampling soils for testing* in [Appendix H](#).

# Appendix A

## Nitrate sampling for STANDARD fields:

### Pre-Plant Nitrate (0-1', 1-2'):

**NOTE:** Pre-plant soil samples need to be collected in early spring after frost and before planting or any pre-plant applications of nitrogen.

1. Push aside solid manure or crop residue on the surface
2. Insert the probe or auger to a depth of 1 foot in the soil
3. Dump core into first bucket
4. Insert the probe or auger back into the same hole and collect the second foot of soil
5. Dump core into second bucket
6. Repeat steps 1-5 fourteen times (depending on size of field) using a W-shaped sampling pattern over the whole sampling area, for a total of 15 cores per 20 acres
7. Thoroughly mix the cores in each bucket before placing cores from the first bucket into a sample bag, and cores from the second bucket into a separate sample bag
8. Identify both bags with name, field ID, sample number, depth and date
9. Freeze samples and send to a WI DATCP certified lab no later than 1 week after sampling date

### Pre-Sidedress Nitrate (0-1'):

**NOTE:** Side-dress soil samples need to be collected when the corn plants are 6 to 12 inches tall, usually 4 to 6 weeks after planting. The sampling protocols are very similar for pre-plant sampling, except that for pre-sidedress sampling, you will only sample at one depth: 0-1'.

1. Push aside solid manure or crop residue on the surface
2. Insert the probe or auger to a depth of 1 foot in the soil
3. Collect 15 cores per composite sample (for 20 acres). Use a W-shaped sampling pattern over the whole field
4. Thoroughly mix the cores before placing them all in the sample bag
5. Identify bag with name, field ID, sample number, depth and date
6. Freeze samples and send to a WI DATCP certified lab no later than 1 week after sampling date

## Soil test data

Record results from the lab in the table below and submit the data at the end of the season, with the rest of your management data. Reference this [Extension publication](#) to find the nitrate credit (lb N/ac)

		Pre-plant nitrate test		Pre-sidedress nitrate test	
Date sampled					
		NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac	NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac
Depth	0-1'				
	1-2'			N/A	N/A

# Appendix B

## Nitrate sampling for INTENSIVE fields:

### Pre-Plant Nitrate (0-1', 1-2'):

**NOTE:** Pre-plant soil samples need to be collected in early spring after frost and before planting or any pre-plant applications of nitrogen. For these samples, you will have separate samples for the zero-N (ZN) and with-N (WN) strips. Each composite sample will consist of 10 cores per strip. For each strip you will have a composite sample for two depths: 0-1' and 1-2'. \*So you will have a total of 4 soil sample bags that you send for analysis. When taking each core, follow these steps:

1. Find sampling point in the middle pass of the zero-N strip
2. Push aside solid manure or crop residue on the surface
3. Insert the probe or auger to a depth of 1 foot in the soil
4. Dump core into first bucket
5. Insert the probe or auger back into the same hole and collect the second foot of soil
6. Dump core into second bucket
7. Repeat steps 2-6 ten times using a W-shaped sampling pattern over the whole sampling area (see figure below).
8. Thoroughly mix the cores in each bucket before placing cores from the first bucket into a sample bag, and cores from the second bucket into a separate sample bag
9. Identify both bags with name, field ID, strip ID ("ZN" or "WN"), sample number, depth and date
10. Repeat steps 1-9 in the with-N strip
11. Freeze samples and send to a WI DATCP certified lab no later than 1 week after sampling date

### Pre-Sidedress (0-1'):

**NOTE:** Side-dress soil samples need to be collected when the corn plants are 6 to 12 inches tall, usually 4 to 6 weeks after planting. The sampling protocols are very similar for pre-plant sampling, except that for pre-sidedress sampling, you will only sample at one depth: 0-1'.

1. Find sampling point in the middle pass of the zero-N strip
2. Push aside solid manure or crop residue on the surface
3. Insert the probe or auger to a depth of 1 foot in the soil
4. Collect a total of 10 cores using a W-shaped sampling pattern over the whole sampling area [Appendix H](#)
5. Thoroughly mix the cores in each bucket before placing cores into a sample bag
6. Identify the bags with name, field ID, strip ID ("ZN" or "WN"), sample number, depth and date
7. Repeat steps 1-6 in the with-N strip
8. Freeze samples and send to a WI DATCP certified lab no later than 1 week after sampling date

## Soil test data

For each of the test strips, record results from the lab in the tables below. Label each table with the corresponding strip ID (ZN= zero-N, LN= low-N, MN= manure-N, WN=with N). At the end of the season, submit the data with the rest of your management data.

Strip ID: _____					
		Pre-plant nitrate test		Pre-sidedress nitrate test	
Date sampled					
		NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac	NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac
Depth	0-1'				
	1-2'			N/A	N/A

Strip ID: _____					
		Pre-plant nitrate test		Pre-sidedress nitrate test	
Date sampled					
		NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac	NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac
Depth	0-1'				
	1-2'			N/A	N/A

Strip ID: _____					
		Pre-plant nitrate test		Pre-sidedress nitrate test	
Date sampled					
		NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac	NO <sub>3</sub> - ppm <i>provided by the lab</i>	nitrate credit lb/ac
Depth	0-1'				
	1-2'			N/A	N/A

# Appendix C

## Agronomic data collection for STANDARD fields

Fill out [this form](#) and then submit the information via the electronic form.

### GENERAL

Farmer Name: \_\_\_\_\_

County: \_\_\_\_\_

Producer-Led/Farmer group: \_\_\_\_\_

Field Year: \_\_\_\_\_

Farm Name: \_\_\_\_\_

Field ID: \_\_\_\_\_

What management type best describes the farm operations?

☐ Dairy

☐ Beef or other livestock

☐ Grain

☐ Other: \_\_\_\_\_

### SOIL DATA

Irrigated? ☐ Yes ☐ No

Tiled? ☐ Yes ☐ No

Primary Soil Series Name: \_\_\_\_\_

Soil Texture: ☐ sand ☐ loamy sand ☐ fine sandy loam ☐ sandy loam ☐ silt loam  
☐ loam ☐ silty clay loam ☐ clay loam ☐ muck

### Routine Soil Test (from past 5 years)

Date Sampled: \_\_\_\_\_

pH: \_\_\_\_\_

OM%: \_\_\_\_\_

P (ppm): \_\_\_\_\_

K (ppm): \_\_\_\_\_

## **CROP DATA**

General Crop Rotation:

☐ continuous corn

☐ corn-soybean

☐ corn and soybeans with small grains

☐ crop rotation with perennial (alfalfa or red clover)

☐ Central Sands cropping system with potato

☐ other: \_\_\_\_\_ (fill in)

Current crop

☐ corn grain

☐ corn silage

Previous Crop:

☐ Corn grain

☐ Corn silage

☐ Alfalfa

☐ soybean

☐ wheat

☐ Other: \_\_\_\_\_ (fill in)

Tillage

☐ No-Till

☐ Rotational-no till (no tillage this season, but tillage in other years in the cropping rotation)

☐ Reduced tillage (one pass of strip or vert tillage)

☐ Conventional Tillage

If no-till, how long has the field been no-till? \_\_\_\_\_

Was there a cover crop in this field prior to this year's crop? ☐ Yes

☐ No

If yes, what cover crop? \_\_\_\_\_

In the past ten years, how many times was a cover crop planted: \_\_\_\_\_

## **NUTRIENT INPUTS**

What best describes your inorganic fertilizer application timing? (check all that apply)

☐ all before/at planting

☐ split application (before/at planting & in-season)

☐ all (besides starter) in season

☐ through irrigation

☐ No fertilizer

Total Inorganic Fertilizer N (lb/ac) applied: \_\_\_\_\_

How many times was manure applied this season? \_\_\_\_\_  
(after harvest of previous crop and before the harvest of this crop)

If manure was applied this season,

☐ No manure

☐ dairy, liquid

☐ dairy, solid

☐ beef, solid

what was the manure type? ☐ swine, liquid ☐ poultry, solid ☐ other: \_\_\_\_\_

If manure was applied this season, what was the timing? ☐ No manure ☐ summer (prior to corn crop) ☐ fall

☐ winter ☐ spring ☐ in-season

If manure analysis was done, first year available nutrients (per ton or 1000 gal): N: \_\_\_\_\_ P2O: \_\_\_\_\_ K2O: \_\_\_\_\_

Total Manure Available N (lb/ac) applied (1st year credit only): \_\_\_\_\_

How many times in the past ten years was manure applied? \_\_\_\_\_

Total Legume N Credit (lb/ac): \_\_\_\_\_ Legume source: \_\_\_\_\_

### **YIELD DATA**

Was the yield monitor calibrated? ☐ Yes ☐ No

Average yield of whole field (bu/ac): \_\_\_\_\_

Average moisture (%): \_\_\_\_\_

**Please include any notes that you would like to make:**

# Appendix D

## Agronomic data collection for INTENSIVE fields

Fill out [this form](#) and then submit the information via the electronic form.

### GENERAL

Farmer Name: \_\_\_\_\_

County: \_\_\_\_\_

Producer-Led group: \_\_\_\_\_

Field Year: \_\_\_\_\_

Farm Name: \_\_\_\_\_

Field ID: \_\_\_\_\_

What management type best describes the farm operations?

☐ Dairy

☐ Beef or other livestock

☐ Grain

☐ Other: \_\_\_\_\_

Check the types of test strips you monitored or, if not listed, describe "other" test strip you monitored. The IDs in parenthesis will be used throughout the form to collect nitrogen and yield data

☐ zero-N (ZN)

☐ manure only  
(MN)

☐ Half/Low rate  
(LN)

☐ Other (O): \_\_\_\_\_

Were your test strips set up through precision ag, flags, or other? (If other, describe)

### SOIL DATA

Irrigated? ☐ Yes ☐ No

Tiled? ☐ Yes ☐ No

Primary Soil Series Name: \_\_\_\_\_

Soil Texture: ☐ sand

☐ loamy sand

☐ fine sandy  
loam

☐ sandy loam

☐ silt loam

☐ loam

☐ silty clay  
loam

☐ clay loam

☐ muck

Routine Soil Test (from past 5 years)

Date Sampled: \_\_\_\_\_

pH: \_\_\_\_\_

OM%: \_\_\_\_\_

P (ppm): \_\_\_\_\_

K (ppm): \_\_\_\_\_

**CROPPING DATA**

General Crop Rotation:

☐ continuous corn

☐ corn-soybean

☐ corn and soybeans with small grains

☐ crop rotation with perennial (alfalfa or red clover)

☐ Central Sands cropping system with potato

☐ other: \_\_\_\_\_ (fill in)

Current crop

☐ corn grain

☐ corn silage

Previous Crop:

☐ Corn

☐ Corn silage

☐ Alfalfa

☐ soybean

☐ wheat

☐ Other: \_\_\_\_\_ (fill in)

Tillage

☐ No-Till

☐ Rotational-no till (no tillage this season, but tillage in other years in the cropping rotation)

☐ Reduced tillage (one pass of strip or vert tillage)

☐ Conventional Tillage

If no-till, how long has the field been no-till? \_\_\_\_\_

Was there a cover crop in this field? ☐ Yes ☐ No

If yes, what cover crop? \_\_\_\_\_

In the past ten years, how many times was a cover crop planted: \_\_\_\_\_

## **NUTRIENT INPUTS**

For the whole field, what best describes your inorganic fertilizer application timing?

☐ all at planting

☐ split application

☐ all (besides starter) in season

☐ irrigation

☐ No fertilizer

How many times was manure applied this season? \_\_\_\_\_  
(after harvest of previous crop and before the harvest of this crop)

If manure was applied this season, what was the manure type?

☐ No manure

☐ dairy, liquid

☐ dairy, solid

☐ beef, solid

☐ swine, liquid

☐ poultry, solid

☐ other: \_\_\_\_\_

If manure was applied this season, what was the timing?

☐ No manure

☐ summer (prior to corn crop)

☐ fall

☐ winter

☐ spring

☐ in-season

If manure analysis was done, first year available nutrients (per ton or 1000 gal):

N: \_\_\_\_\_

P2O: \_\_\_\_\_

K2O: \_\_\_\_\_

How many times in the past ten years was manure applied? \_\_\_\_\_

If there was a legume in the field;

Legume source: \_\_\_\_\_

N credit: \_\_\_\_\_

Fill out the lbs N/ac applied through fertilizer and manure to each of the test strips. Leave the column blank if you did not have that specific test strip

**zero-N (ZN)**

**manure-N (MN)**

**low-N (LN)**

**Field rate**

Total Inorganic Fertilizer N (lb/ac) applied:

Total Manure Available N (lb/ac) applied:

Any other information you'd like to share:

### **YIELD DATA**

Was the yield monitor calibrated? ☐ Yes ☐ No

Average yield of whole field in \_\_\_\_\_ Moisture (%): \_\_\_\_\_  
bu/ac (optional)

Fill out the yield and moisture of each of the test strips. Leave the column blank if you did not have that specific test strip

**zero-N (ZN)**

**manure-N (MN)**

**low-N (LN)**

**with-N (WN)**

Yield (bu/ac)

Moisture(%)

# Appendix E

## Cover Crop Assessment

Cover crops are a great tool--- but there is still a lot to understand how they fit into the nitrogen cycle of a particular field. Improving our understanding of this, especially with fall applied nutrients is valuable. Follow these steps to measure your cover crop growth and potential nitrogen uptake.

### For crops that will winterkill:

#### At freeze up:

- Estimate the average height of the cover crop
- Estimate the ground cover. You can do this through the app: [Canopeo](#)

#### Collect a biomass sample:

##### *If you drilled the cover crop:*

- In one row, measure out two feet.
- Clip all of the biomass within the two feet and put it in a ziploc bag.
- Label the bag with your field ID and "sample 1"
- Repeat this two other times in two different rows. You will have a total of three samples
- If possible, overnight the samples to a commercial lab

to measure total weight of the samples at DM, and N% and C%

##### *If you broadcast seed:*

- Make a quadrant 2ft x 2ft.
- Throw the quadrant on a random, representative spot of the field.
- Clip all of the biomass within quadrant and put it in a ziploc bag.
- Label the bag with your field ID and "sample 1"
- Repeat this two other times in two different rows. You will have a total of three samples
- If possible, overnight the samples to a commercial lab to measure total weight of the samples at DM, and N% and C%

### For crops that will overwinter:

#### At freeze up (not necessary, but if you would like to):

- Estimate the average height of the cover crop
- Estimate the ground cover. You can do this through the app: [Canopeo](#)

#### At termination:

- Estimate the average height of the cover crop
- Estimate the ground cover. You can do this through the app: [Canopeo](#)

#### Collect a biomass sample:

##### *If you drilled the cover crop:*

- In one row, measure out two feet.
- Clip all of the biomass within the two feet and put it in a ziploc bag.
- Label the bag with your field ID and "sample 1"

- Repeat this two other times in two different rows. You will have a total of three samples
- If possible, overnight the samples to a commercial lab to measure total weight of the samples at DM, and N% and C%

##### *If you broadcast seed:*

- Make a quadrant 2ft x 2ft.
- Throw the quadrant on a random, representative spot of the field.
- Clip all of the biomass within quadrant and put it in a ziploc bag.
- Label the bag with your field ID and "sample 1"
- Repeat this two other times in two different rows. You will have a total of three samples
- If possible, overnight the samples to a commercial lab to measure total weight of the samples at DM, and N% and C%

### Take note of certain details that you will record in the agronomic data submission:

1. Planting date
2. Cover crop species
3. Seeding rate
4. Planting method
5. Termination method
6. Date of termination



# Appendix F

## Measuring yield for corn silage

Monitoring corn silage fields for NUE can be a little bit more challenging than grain fields because it requires different methods to measure yield. If you are interested in monitoring corn silage, follow the NUE guide until it is time to measure yield. Use the following protocols to measure yield data. Note that there are different protocols if you are monitoring NUE on a standard field or an intensive field that has test strips.

### Standard Fields

1. Harvest the monitored field and measure how many feet of feed storage were produced for that field. Using the storage size, calculate total tons harvested and divide by the acreage to get tons/acre.
2. At harvest, grab a gallon sized subsample of chopped silage and put it in a ziploc bag. Freeze the sample immediately after harvest until you are ready to send it to the lab. Send it to the lab to be analyzed for % dry matter and % N.

### Date Collection for Standard Fields

Record results in the table below and submit the data at the end of the season, with the rest of your management data.

Yield (t/ac)	
Moisture (%)	
%N content	

### Intensive Fields

1. For each test strip, find a representative spot in the test strip and measure out 10-ft in three different rows.
2. Harvest all of the plants in each 10-ft sample, bundle the stalks and weigh each bundle separately. You can weigh each bundle using a hanging scale (like this scale).
3. If you have access to a chipper/shredder\*, select six representative stalks from the harvested corn plants to collect a biomass sample. Chop the plants, mix the chopped material and fill a gallon size ziploc bag. Immediately after harvest freeze the sample until you are ready to send it to the lab. Send it to the lab to be analyzed for % dry matter and % N.
4. If you do not have access to a chipper/shredder, collect a chopped biomass sample at the time the farmer is harvesting the field. In order to have accurate dry matter data, make sure you are measuring yield (steps 1 and 2) within a week of the farmer's harvest, if there is no projected rain between these two times. If rain is forecasted prior to the farmer's harvest, you will have to measure yield after any rain events. Fill a gallon sized ziploc bag with chopped silage and freeze the sample until you are ready to send it to the lab. Send it to the lab to be analyzed for % dry matter and % N.
5. Repeat steps 1-4 for each test strip, including the "with N test strip," which represents the field N rate.

*\*Chipper/shredders can be used to collect a biomass sample at the time you are measuring yield so that you do not need to grab a sample at the time of the farmer's harvest. We recommend using a one like this chipper/shredder. If you are interested in monitoring corn silage over a few years, investing in a chopper would be advantageous and possible through grant funding.*

## Date Collection for Intensive Fields

For each of the test strips, record results in the tables below. Label each table with the corresponding strip ID (ZN= zero-N, LN= low-N, MN= manure-N, WN=with N). At the end of the season, submit the data with the rest of your management data.

Strip ID: _____				
	Weight of silage in 10ft of row (lb/ac)		%DM	%N
Sample 1				
Sample 2				
Sample 3				

Strip ID: _____				
	Weight of silage in 10ft of row (lb/ac)		%DM	%N
Sample 1				
Sample 2				
Sample 3				

Strip ID: _____				
	Weight of silage in 10ft of row (lb/ac)		%DM	%N
Sample 1				
Sample 2				
Sample 3				

Strip ID: _____				
	Weight of silage in 10ft of row (lb/ac)		%DM	%N
Sample 1				
Sample 2				
Sample 3				

# Appendix G

## Grain Nitrogen Assessment

In our previous research, we analyzed the corn for nitrogen content to measure the total pounds of nitrogen in the corn. This information is valuable for a more precise measurement of nitrogen removed and nitrogen balance (or the nitrogen applied that was not removed in harvest). We have averaged values for grain N content to provide an estimated range for these calculations. However, if you would like more accurate data, specific to your crop, you can measure the grain nitrogen content by following this procedure.

### Standard Field:

- Collect two ears from three representative spots in different parts of the field
- Shell these ears to form one composite sample
- Fill a quart sized bag with the shelled corn so that it is full. Label the bag with the field name.
- Freeze the sample until you are ready to send it to the lab
- Send the sample to the lab to measure DM and %N

### Intensive Field:

#### For each test strip follow the steps below:

- Collect two ears from three representative spots in different parts of the test strip
- Shell these ears to form one composite sample
- Fill a quart sized bag with the shelled corn so that it is full. Label the bag with the field name and test strip.
- Repeat steps 1-3 for the remaining test strip(s).
- Freeze the samples until you are ready to send it to the lab
- Send the samples to the lab to measure DM and %N

# Appendix H

## Additional Resources

### NUE monitoring: A complete guide

[Google folder](#) including data collection forms and all mentioned resources

### Soil Sampling

*Sampling Soils for testing* (Publication A2100), by J. B. Peters and C. Laboski. 2013. UW-Extension. <https://learningstore.uwex.edu/Assets/pdfs/A2100.pdf>

*Wisconsin's Pre-Plant Soil Nitrate Test* (Publication A3512), by L.G. Bundy, S. J. Sturgul, and R. W. Schmidt. Nutrient and Pest Management Program, UW-Extension. <https://ipcm.wisc.edu/download/pubsNM/PPNT.pdf>

*The Presidress Soil Nitrate Test* (Publication A3630). 2009. Nutrient and Pest Management Program, UW-Extension. [https://ipcm.wisc.edu/download/pubsNM/PSNT\\_2009\\_web.pdf](https://ipcm.wisc.edu/download/pubsNM/PSNT_2009_web.pdf)

### Calibrating your yield monitor

*Calibrate your Yield Monitor for Greater Accuracy During Harvest* (Publication A4146), by B. D. Luck. 2017. UW-Extension. <https://learningstore.uwex.edu/Assets/pdfs/A4146.pdf>

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