2. How Adapt-N Determines a Recommendation

Sources of Nitrogen

Nitrogen comes to the crop from several sources:

1. Mineralized soil organic matter
2. Other organic sources like manure, and rotation or cover crops, especially legumes
3. A small amount from atmospheric deposition (minor contribution)

How much N the crop gets from sources 1 and 2 depends on several factors. For example, how much manure was applied, how much N was in each of its components and was it incorporated? Was there a sod, when was it plowed under or was it surface killed? What percentage of it was a legume? How much organic matter is in the soil?

And then there’s the important weather question! How warm and how wet has it been? Warmer weather will allow for more N to be mineralized than colder weather. But not all mineralized or added N will be available, because high rainfall may cause large losses during the ‘Critical Time Period’ (see graph on page 10). It depends on how much and when it occurs.

What info does Adapt-N use?

- **Latitude, longitude, and region** for the field location. This can be found by using the map tool in the interface.
- **Preplant, starter, and additional/sidedress N fertilizer.** Type, date of application, depth and rate of each application. Up to 6 applications can be entered for the current growing season. (Enhanced efficiency fertilizer additives will be included in a future version of the tool.)
- **Cultivar.** Silage, grain, or sweet corn, maturity class, planting date, expected harvest population, and expected yield in the field that year.
- **Soils.** Soil textural class or soil series, rooting depth (defaults available), approximate field slope. Organic matter content from recent soil test is highly recommended.
- **Tillage.** Fall plowing, spring plowing (date and depth), or conservation tillage (percent of residue remaining on surface: 25, 50, 75, or 100%).
- **Manure Applications.** For current season (and past 2 growing seasons depending on region), date, rate (in gallons/acre or tons/acre), N content (in lbs ammonium-N and organic-N contents per 1000 gals or per ton), and method of application (surface applied or incorporated immediately, within 1, 2, or 5 days).
- **Sod in the rotation in the last 3 years.** Percent legume in the sod, method and timing of sod management (surface kill or incorporation).
2. How Adapt-N Determines a Recommendation

Sources of Nitrogen

Atmospheric N

Mineral N

Urea N/organic N from manure

Mineralization of:

- Soil Organic Matter (SOM)
- Manure
- Previous Crops and Cover Crops

Processes occur over variable time periods and are influenced by environmental factors.

Pathways for Nitrogen Loss

Denitrification (and nitrification) losses

Ammonia volatilization losses

Surface runoff losses

immobilization

Processes strongly influenced by weather and management

Crop N uptake

Nitrate Leaching Losses
Nitrogen Losses

You might call a corn field a “very leaky system” with respect to N. Corn will not be able to take up all the N that becomes available (from fertilizer or the other sources), because N can be lost by:

1. Nitrate leaching below the root zone
2. Surface runoff losses
3. Volatilization of ammonia
4. Denitrification to the atmosphere, primarily in the forms of N2 or N2O.

These losses are of environmental concern as they contribute to groundwater contamination, hypoxia in estuaries, and global warming. But how much is lost? That depends on the weather, soil type and management practices. N losses from leaching and denitrification can be especially large in a wet, warm spring (see page 2). In some cases these losses need to be compensated for through a higher sidedress N rate, while in other cases when losses are low and/or N mineralization is high, you may need little or no sidedress fertilizer.

Nitrogen Needs Differ Every Year

Management may not change much, but the weather is different every year. Rainfall may even be different between fields that are a few miles down the road from each other, because it can be very spotty during the growing season. A warm, dry spring may provide so much soil N that you only need to sidedress half as much as in another year when losses are greater. On the other hand, one 2-inch rain storm might mean you lose 50 lb of N per acre, and so you may need to apply that much more at sidedress time. To be precise, many calculations of a complex system with many interacting factors need to be made. That’s what the Adapt-N tool was designed to do. Adapt-N uses daily high-resolution climate data (on a 3 mile grid) and your expected economic yield, to calculate a sidedress N recommendation for your field. The recommended N rate becomes more accurate as the season progresses, because more of the season’s weather is then accounted for.

Adapt-N Infrastructure

Adapt-N uses dynamic simulations of soil and crop processes. These feed into a mass balance equation that calculates the optimum N rate for a location based on field-specific early season weather that actually occurred, as well as post-sidedress estimates. The latter are based on probabilities calculated from long-term climate data. Adapt-N also provides a confidence range for recommended N rates, and incorporates economic considerations (crop-fertilizer price ratio and risk). It offers extensive additional diagnostic information on simulation results (N mineralized, leached and denitrified; soil N levels, etc.) and enables you to test alternative management scenarios as well. A feature allows for automatic daily updates of simulation results via email or text message, and provides opportunities for more precise variable rate nitrogen application.
Users of Adapt-N provide inputs via the web-interface from any internet enabled device (location, soils, crop, management, see Chapter 4 on how to use Adapt-N). These inputs are sent via the web to access the PNM model, which queries a database of high resolution weather data using the coordinates you entered. The weather data from the Northeast Regional Climate Center (NRCC) and your field management inputs are then used by the PNM model to dynamically simulate corn growth and N uptake, as well as soil processes affected by rainfall and temperature. The model calculates a field-specific sidedress N recommendation (see page 17, and also provides graphs that help you understand the fate of N during the simulated season.

Adapt-N provides a N sidedress recommendation and a full pdf report with additional simulation results.
More about the Model & High Resolution Climate Data

The PMN (Precision Nitrogen Management) model that is at the core of Adapt-N (Melkonian et al, 2005) was developed from two re-coded and integrated models: a corn N uptake, growth and yield model (Sinclair and Muchow, 1995), and the LEACHN model which simulates soil, water, and N processes (Hutson, 2003). The crop model uses temperature, rainfall, and solar radiation data to simulate:

- Growth, development and yield of the crop
- Concurrent uptake of N and water

The soil model (LEACHN) uses information on soil properties and weather to simulate:

- Redistribution of water and N in the rootzone as affected by each rain event and soil characteristics (“tipping bucket” approach)
- Water storage in the rootzone
- Water drainage and evaporation out of the rootzone
- Biological and chemical N transformations in the rootzone
- N losses from the rootzone (leaching, ammonia volatilization, and denitrification)

Both models simulate these processes on a daily time step. The models have been extensively tested and validated in field trials. On-farm beta-testing of the Adapt-N tool has been ongoing in New York and Iowa in 2011-2012 (see page 63 for trial results), and more recently also in other Midwestern and Northeastern states (results will be available on our website, and in future versions of this manual).
Soils information used in Adapt-N is derived from NRCS SSURGO datasets. The model was developed through a collaborative effort among the Department of Crop and Soil Sciences, Department of Earth and Atmospheric Sciences, Northeast Regional Climate Center, and Center for Advanced Computing, with primary funding from a USDA Special Grant on Computational Agriculture.

The High Resolution Climate Data consist of daily maximum and minimum temperature and precipitation on a 4x4 km grid, and are a critically important feature of the Adapt-N tool. These data allow for field-specific and timely daily adjustments of N recommendations. The weather database is derived from routines using National Oceanic & Atmospheric Administration’s (NOAA) Rapid Update Cycle weather model (temperature) and operational Doppler radars (precipitation). For both, observed weather station data are used to correct NOAA estimates and to generate spatially interpreted grids (DeGaetano and Wilks, 2009; Wilks, 2008). Adapt- N uses the most recent data, currently with a 1 day lag.

### Calculation of Sidedress N Rate

The basic equation underlying the Adapt-N calculation of a sidedress N recommendation is as follows:

\[
\text{Sidedress N rate} = \text{CropN}_{\text{Harvest}} - \text{CropN}_{\text{Current}} - \text{SoilN}_{\text{Current}} - \text{SoilN}_{\text{Post sidedress}} - \text{SoybeanN}_{\text{Credit}} + \text{Loss}_{\text{post application}} - \text{Correct}_{\text{profit}}
\]

- **CropN\text{Harvest}** is the amount of N estimated to be in the corn crop at harvest time. This is calculated from the “Expected Yield” input, and estimates of N contents of grain, stover and roots.

- **CropN\text{Current}** is the amount of N in the crop on the day you run the model (or the season end date if you are running a retrospective analysis). This is determined by the model’s corn growth and N uptake routines, using the high resolution weather data for a specific field location.

- **SoilN\text{Current}** is the current amount of mineral N available to the crop from the soil. This is determined by the model based on input information on soil type, rooting depth, slope, organic matter content, tillage system, previous organic and inorganic N applications, rotations, and corn variety, maturity class, and population, where mineralization and losses are affected by the weather to date.

- **SoilN\text{Post sidedress}** is the net mineral N that is estimated to become available (mineralized N – losses of N) from the soil between the day you run the model and crop harvest. This incorporates future weather effects that cannot be predicted at sidedress time, but can be estimated through long-term probabilities. The post-sidedress N contribution is based on a 35 year average of simulated weather effects on N-availability in the post-sidedress-to-harvest time period, for the texture, organic matter content, and management practices of the field.

- **SoybeanN\text{Credit}** is the partial credit given to the additional N availability from a previous soybean crop. This is supplemental to the simulated effects of N immobilization from incorporation of previous-crop residues.
**Loss postapplication** is the estimated N loss (leaching, gaseous N losses) from the recommended sidedress N application itself. These losses were estimated by PNM model simulations over 35 climate years for locations in the Northeast and Midwest using different times/rates of N applications. Post-sidedress losses from other N sources, e.g. manure applications, pre-plant N applications, N mineralized from soil organic matter, are also accounted for in SoilNpostsidedress.

**Correct profit** is a correction factor to optimize profits to N application. It integrates the combined effects of the fertilizer-to-grain price ratio and the risk (which equals probability * cost) associated with Adapt-N predictions. The price ratio correction accounts for the cost of fertilizer relative to the returns from additional yield with higher N inputs. This results in lower recommended N rates with more expensive fertilizer or lower corn grain prices. The risk correction accounts for the fact that a nonlinear yield response to N inputs entails a greater profit penalty for under-prediction than over-prediction of the optimum N rate, and therefore the need for an upward adjustment of the recommended economic optimum N rate. Correct profit is based on a price ratio of 0.1 for grain corn and silage, and 0.01 for sweet corn, and an uncertainty standard deviation of the N recommendations of 20 lbs N/ac for most scenarios.

**The Sidedress N Rate** is therefore the difference between net N availability (a function of N inputs, weather-affected mineral N gains and losses, and management) and the final expected N content of the crop. This difference can be made up by sidedressing the recommended rate to achieve full yield with limited environmental or profit losses.

### In a Nutshell: How to Make Best Use of Adapt-N

- Plan to apply the majority of N fertilizer at sidedress time
- Use Adapt-N for a N recommendation at or after V6 (ideally V6-V12; Adapt-N is not designed to provide starter/preplant N rates, as weather impacts are not yet known at that time)
- Make sure your model inputs are accurate and representative of the management unit for which you are calculating a recommendation (see more on this in the section on Prioritizing Inputs, p 43)
- Take penetrometer measurements to account for compaction and rootzone limitations
- Consider weather influences that may impact rooting depth (e.g., very high rainfall tends to reduce rooting depth)
- Base expected yields on farm data for past years (we recommend the fourth highest yield from the last five years)
- Re-evaluate your crop’s expected yield and population density before sidedress based on that season’s conditions to date
- Use Adapt-N for variable rates based on changes across a field in texture, organic matter, and expected yield
- Enter sidedress applications into Adapt-N once completed to monitor mid and late-season N status
- Run end-of-season evaluations to understand field N dynamics, and assess whether N management practices can be improved