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Nitrogen Loss Assessment Tool (N-LAT) for Nebraska: Background and Users Guide

Charles S. Wortmann, Nutrient Management Specialist; Jim A. Jansen, Extension Educator; Michael W. Van Liew, Hydrologic Computer Simulation Modeler, Richard B. Ferguson, Soils Specialist; Gary W. Hergert, Nutrient Management and Soil Quality Specialist; Charles A. Shapiro, Soil Scientists – Crop Nutrition; and Tim M. Shaver, Nutrient Management Specialist

This publication provides the basis and procedure for using N-LAT to estimate average nitrogen (N) loss over several years for corn and soybean production to leaching, volatilization, denitrification, and nitrous oxide emission for specific field-management situations. The effects of alternative management practices can be assessed. N-LAT is not intended for short-term, in-season management decisions.

Nitrogen is an essential nutrient for crop growth. Soil N chemistry and the N cycle are complex with numerous transformations and several pathways for loss, including leaching, volatilization, denitrification, nitrous oxide (N_2O) emission, runoff, and soil erosion. In comparison, phosphorus loss from crop land, excluding removal in harvests, is nearly all through runoff and soil erosion.

All N losses have economic and environmental significance. Leached nitrate-N often contributes to contamination of ground water. Some volatilized ammonia is deposited in N-sensitive water bodies or natural ecosystems, contributes to acid rain, and reacts in the atmosphere to form N oxides and ammonium salts. Denitrification results in N loss but also contributes, together with the nitrification process, to the emission of N_2O. Nitrous oxide is a greenhouse gas and contributes to ozone depletion. Transport of N through soil erosion and runoff results in contamination of surface waters. Nitrogen losses are difficult to measure and vary greatly from year to year. The Nebraska N Loss Assessment Tool (N-LAT) quantifies these losses and the effects of alternative management practices considering precipitation, soil properties, and management practices.

N-LAT is a decision-aid and was developed to be used on either a whole field or sub-field basis for making pre-plant decisions. In many fields, risk of N loss may be considerably greater for one sub-field compared with other sub-fields due to differences in soil properties including pH, organic matter content, hydrology, and drainage.

The Structure of N-LAT

The Worksheets

Download Nitrogen Loss Assessment Tool N-LAT

N-LAT was developed as Excel® spreadsheets to ease calculations. Tabs of two worksheets are found at the bottom of the screen.

1. All data are entered into the **Data Entry** worksheet where the results are presented. The results also can be saved in the **Report** worksheet.
2. **Report** contains the summarized records for up to five N-LAT simulations. The records are numbered from one to five and coincide with the run number at the top of the **Data Entry** worksheet.

The Components

N-LAT has components for denitrification, leaching, volatilization, and N_2O emission. N-LAT does not estimate runoff and erosion losses of N, most of which would be in organic form and not necessarily available in the short term. All losses are estimated in pounds per acre per year (lb/ac/yr) of N. N-LAT was developed considering information from diverse sources, including simulations conducted with the Nitrogen Loss and Environmental Assessment Package (NLEAP; Delgado et al., 2010) and the California N-index (Delgado et al., 2008), but with final determination based on the consensus of the authors.

Functions were developed considering properties of soil and climate, and of inorganic N supplied from fertilizers and organic materials such as

- crop residues and manure,
- wet plus dry deposition of ammonium-N which was assumed to be 10 lb/ac/yr N,
- residual inorganic N assumed to be 46 lb/ac to the 4-foot depth, and
- nitrate-N applied in irrigation water.

Table I. Fertilizer use efficiency products available in the United States.

*Chemical or Compound Nitrogen Products**	*Common Product Names*	*Process Affected*
Dicyandiamide (DCD)	Guardian®	Nitrification
2-chloro-6 (trichloromethyl) pyridine (Nitrapyrin)	N-Serve®, Instinct®	Nitrification
N-butyl-thiophosphoric triamide (NBPT)	Agrotain®	N volatilization
Malic + itaconic acid co-polymer with urea	Nutrisphere®	Nitrification, N volatilization
Polymer-coated urea (PCU)	ESN®, Polyon®, Duration®	N release
Sulfur-coated urea (SCU)	SCU	N release
Polymer + SCU	Tricote, Poly-S®	N release
Urea formaldehyde	Nitroform®	N release
Methylene urea	Nutralene®, CoRoN®, NFusion®	N release
Triazone	N-Sure®	N release
NBPT + DCD	Agrotain®Plus, SuperU®	Nitrification, N volatilization
Methylene urea + triazone	Nitamin®, Nfusion®	N release
Triazone + NBPT	N-Pact®	N release, volatilization

*Mention or omission of a commercial company or trade name does not imply endorsement or censure by the authors or the University of Nebraska–Lincoln.

Nitrogen mineralization rates from corn and soybean residue of previous crops were estimated at 0.11 and 0.97 lb/bu of grain harvested, respectively. Therefore, for each 100 bu/ac of corn or 50 bu/ac of soybean harvested the previous season, N available to the current crop from decomposing crop residue was estimated to be 11 and 48.5 lb/ac, respectively.

Estimated N from soil organic matter (SOM) mineralization was 40 lb/ac/yr for each 1 percent soil organic matter. Therefore total N availability (TN), not considering leaching and N_2O emission loss, was:

$TN = 56 + \%SOM \times 40 + Irr_N$ (ac-in x ppm x 0.225) + (0.11 x bu of previous corn crop) or (0.97 x bu of previous soybean crop) + FertilizerN + ManureN – volatilization loss – denitrification loss.

Corn N uptake (N_u) was estimated as 1.2 x bu/ac grain yield. Soybean N uptake was estimated as 5 x bu/ac yield. The difference of total N available and corn N uptake ($TN - N_u$) was used in calculating NO_3^--N leaching loss. Manure N availability was determined according to information in the NebGuide, Determining Crop Available Nutrients from Manure (G97-1335).

Fertilizer use efficiency products intended to reduce N losses were considered in N-LAT (*Table I*). These included fertilizer additives such as nitrification or urease inhibitors for reducing leaching and volatilization losses, respectively, and controlled release fertilizers. Some products also affected denitrification and N_2O emission. The N-LAT drop-down list does not include all of these products but has options for "Other nitrification inhibitor" and "Other urease inhibitor."

The N Loss Processes

Denitrification

Denitrification is mostly affected by soil aeration, N availability, and source. The denitrification rate used by N-LAT for N available from sources other than fertilizer and manure was 5.5 percent on a soil of better than "somewhat poor drainage" and hydrology class B, according to USDA-NRCS Soil Survey soil descriptors. Exceptions for other fertilizers and manure were:

- 6 percent for UAN or urea surface-applied and 7 percent for UAN or urea incorporated/injected
- 5.5 percent for ammonium sulfate or ammonium nitrate
- 6 percent for NH_3 injected
- For surface or incorporated manure:
  - 6 percent x available manure N x (1 + 0.54 x t/25) for fall-applied
  - 6 percent x available manure N x (1+0.48 x t/25) for spring-applied
  - where t = ton per acre of dry weight of manure

The calculated sum for all fertilizer and manure N was then multiplied by one or more of the following, if these apply:

- 1.1 if fertilizer N other than anhydrous ammonia was incorporated.
- (0.33 + 0.65 x SOM %) / 2.5 to account for SOM level.
- 2 if drainage was "somewhat poor" and 3 if drainage was "poor" if not tile-drained, but 1 if these fields were tile-drained.
- 0.9 if more than 40 percent of the N was applied in-season by either side-dress or fertigation.
- 0.9 if fall- or spring-tilled.

Denitrification decreased as sand content of the soil increased. The adjustment for sand content was to add lb/ac N to the denitrification loss estimate according to (percent sand – 10) x -0.06.

Volatilization

Ammonia loss was affected by the total N supply, the ammonium and urea N application rate, the ammonia volatilization constant for the N source, fertilizer placement, soil pH, and whether a urease inhibitor was used. The volatilization rate used for N available from sources other than fertilizer and manure was 2 percent. The N-LAT equations to estimate a base loss of NH_3-N to volatilization on a neutral soil pH are given in *Table II*. The loss factor for each treated urea (including urea in UAN) application event was adjusted by multiplying by:

- 0.6 for use of a urease inhibitor
- 0.96 for use of Nutrisphere or ammonium thiosulfate

The loss factor for each fertilizer and manure application was then multiplied by the following one or more factors if applicable:

- 0.75 for some in-season applications, including either side-dress or fertigation
- 2.0 if soil pH > 7.2

Table II. Base estimates of NH_3 volatilization for application rates of ammonium and urea N (AmN).

Fertilizer Product	*Application Method*	*Adjustment Equations*
Urea N	Surface Incorporated/injected	NH_3-N_v = AmN x 0.05 NH_3-N_v = AmN x 0.01
Ammonium N	Surface Incorporated/injected	NH_3-N_v = AmN x 0.025 NH_3-N_v = AmN x 0.0015
Anhydrous ammonia	Injected	NH_3-N_v = AmN x 0.004
Manure	Surface	NH_3-N_v = AmN x (1.0-0.985 x power (0.65,d)); d = ≤7 days to incorporation
Manure	Injected	NH_3-N_v = AmN x 0.008

Leaching

Nitrate-N leaching is a function of water from precipitation and irrigation (TW), the difference in available N and N uptake (N_{diff}), soil hydrology class, application method, use of a nitrification inhibitor, split application, cover crops, and fertilizer compared with manure N. The base leaching rate for N available from all sources was equal to 0.00005 x TW^2 x (total available N – N uptake) in lb/ac/yr. The applied N leaching loss estimate for each fertilizer and manure N application event was multiplied as appropriate by one or more of the following:

- 1.1 if N fertilizer was incorporated
- 1.2 if fall-applied fertilizer or manure
- 0.75 or 0.90 if a nitrification inhibitor or controlled release fertilizer was used with spring or fall application, respectively
- 0.96 if ammonium thiosulfate or Nutrisphere was used with either spring or fall application

The above calculated sum of products for all fertilizer and manure application was multiplied as appropriate by one or more of the following:

- 1.7, 1.0, 0.6, and 0.4 for hydrologic class A, B C, and D
- 0.75 if > 40 percent of N was applied in June or July
- 0.80 if corn crop was preceded by a fall or winter cover crop
- 0.85 if >50 percent of supplied N was from manure that was surface-applied or incorporated
- 1.1 if tile drained but only if there was somewhat poor or poor drainage
- 1.2 if fall tilled
- 1.1 if spring tilled

Nitrous Oxide

Base N_2O emission with UAN surface-applied in lb/ac/yr was 0.94 + 0.015 x N + 0.15 x denitrification loss – 0.00039 x N x denitrification loss. A value of 1 percent of inches of annual precipitation plus irrigation amount was added to the base emission estimate. The base emission estimate for each fertilizer application event was then multiplied as appropriate by one or more of the following:

- 0.85 if a nitrification or a urease inhibitor was used; 0.95 for Nutrisphere
- 1.25 if N fertilizer was anhydrous ammonia
- 1.1 if N fertilizer was urea
- 1.1 if UAN was injected
- 0.75 for N applied as controlled release fertilizer.

The above calculated sum of products for all fertilizer applications was multiplied by the following (their product if more than one applies):

- 0.7, 1.00, 1.25, and 1.35 for hydrologic class A, B C, and D
- 1.5 if drainage was somewhat poor or worse

Crop Rotation

N-LAT estimates losses for the current crop of corn or soybean. Much less N was applied on average for the corn-soybean rotation compared to continuous corn. To estimate N losses with corn-soybean rotation, run N-LAT for corn and then for soybean as the current crop and use the estimated losses to calculate annual average losses for the rotation. For example with the corn-corn-soybean rotation, average the values obtained for corn with soybean as the previous crop, corn with corn as the previous crop, and soybean with corn as the previous crop.

N-LAT User Guide

In the **Data Entry** worksheet, select:

- county (determines default values for precipitation)
- soil unit (determines pH, hydrology class, SOM, and drainage)
- management practices (tile drainage, fall or spring tillage, and cover crop)
- current crop and expected yield
- previous crop and expected yield
- irrigation type (none, pivot, furrow, and drip), and enter amount applied and NO_3-N (ppm) concentration in irrigation water

Fertilizer type and application method are selected from a drop-down list. For each selection the user provides the rate, selects the time of application (fall, spring, or in-season), and checks a box indicating use of nitrification inhibitor, urease inhibitor, controlled release, or ammonium thio-sulfate.

Manure type is selected. A default unit of measurement is determined (t/ac, 1000 gal/ac, or ac-in/ac). Default values are given for NH_4-N, organic N, and water content. Rate of application and time to incorporation is entered.

Some default values can be revised, including rainfall, soil organic matter, soil pH, and for manure, NH_4-N, organic N, and water content.

The outputs are estimated N losses (lb/ac) due to:

- denitrification,
- leaching,
- volatilization, and
- N_2O emission.

The **Data Entry** sheet can be saved for a complete record of the field results. The results, with abbreviated input information, also can be transferred and saved in the **Report** worksheet for easy comparison of the results for different scenarios.

Report Sheet

Scenario number	*1*	*2*	*3*
Date			
Field			
Scenario name			
County			
Soil unit			
Previous crop			
Cover crop			
Tillage			
N fertilizer†	UreaSpSuUr150		
N fertilizer			
N fertilizer			
Manure	2012FL-Su25ON15AN4		
Irrigation	Pivot-8”-3ppm		
Total N supply			
N uptake			
Denitrification N loss lb/ac			
Leached NO_3-N lb/ac			
Volatilized NH_3-N lb/ac			
N_2O-N emission lb/ac			
Sum of all losses			

†Abbreviations:

For fertilizer,
- **Urea**SpSuUr150: Nitrogen fertilizer type: AmN, ammonium nitrate; Anh, anhydrous ammonia; UAN, urea ammonium nitrate
- Urea**Sp**SuUr150: Fa, Fe, Sp, and St are fall, fertigation, spring, and split application
- UreaSp**Su**Ur150: Ij, I7, and Su are injection, incorporation days after application, and surface application with no incorporation within seven days
- UreaSpSu**Ur**150: Co, Ni, and Ur are controlled release N fertilizer, nitrification inhibitor, and urease inhibitor
- UreaSpSuUr**150**: the rate of N application in lb/ac

For manure,
- **2012**FL-Su25ON15AN4: year of application
- 2012**FL**-Su25ON15AN4: FL, HP, Sl, SD, and Po are feedlot solid, feedlot holding pond, swine or dairy slurry, swine or dairy solid, and poultry solid
- 2012FL-**Su**25ON15AN4: Ij, I7, and Su are injection, incorporation days after application, and surface application with no incorporation within seven days
- 2012FL-Su**25**ON15AN4: Rate in t/ac for solids, ‘000 gal/ac for slurry, and ac-in for holding pond
- 2012FL-Su25**ON15AN4**: Content of organic (ON) and ammonium (AN) N in lb per rate unit

For irrigation,
- **Pivot**-8”-3ppm: Irrigation system
- Pivot-**8”**-3ppm: Water applied, in/yr
- Pivot-8”-**3ppm**: NO_3-N concentration in ppm

Resources

Nitrogen Loss and Environmental Assessment Package (NLEAP) with GIS Capabilities (NLKEAP-GIS 4.2): User Guide; J.A. Delgado, P.M. Gagliardi, D. Neer, and M.J. Shaffer. 2010. *http://www.ars.usda.gov/SP2UserFiles/ad_hoc/54020700NitrogenTools/NLEAP_GIS_4_2_Manual_Nov_29_2010.pdf*

California N Index: A Tool to Assess N Management for Environmental Conservation. Z. Kabir, D. Chessman, and J. Delgado, USDA-NRCS and USDA-ARS. *http://www.epa.gov/region9/ag/workshop/nitrogen/2013/kabir-epa-workshop-california-n-index2.pdf*

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