

**NATURAL RESOURCES CONSERVATION  
SERVICE CONSERVATION PRACTICE STANDARD**

**NUTRIENT MANAGEMENT**

(Ac.)

**CODE 590**

**DEFINITION**

Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments.

**PURPOSE**

To budget, supply, and conserve nutrients for plant production.

To minimize agricultural nonpoint source pollution of surface and groundwater resources.

To properly utilize manure or organic by- products as a plant nutrient source.

To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.

To maintain or improve the physical, chemical, and biological condition of soil.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all lands where plant nutrients and soil amendments are applied.

**CRITERIA**

**General Criteria Applicable to All Purposes**

A nutrient budget for nitrogen, phosphorus, and potassium must be developed that considers all potential sources of nutrients including, but not limited to, green manures, legumes, crop residues, compost, animal manure, organic by- products, biosolids, waste water, organic matter, soil biological activity, commercial fertilizer, and irrigation water.

Enhanced efficiency fertilizers, used in the State must be defined by the Association of American Plant Food Control Officials (AAPFCO) and be accepted for use by the State fertilizer control official, or similar authority, with responsibility for verification of product guarantees, ingredients (by AAPFCO definition) and label claims.

For nutrient risk assessment policy and procedures see Title 190, General Manual (GM), Part 402, Nutrient Management, and Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation.

To avoid salt damage, the rate and placement of applied nitrogen and potassium in starter fertilizer must be consistent with land-grant university guidelines, or industry practice recognized by the land-grant university.

Soil Erosion

Each field must be planned and managed to maintain soil erosion at or below the tolerable soil loss limits (T) as determined by the current NRCS soil loss technology. Areas of gully erosion shall be addressed with appropriate conservation practices.

Vermont Nitrate Leaching Index (VTNLI) The VT NLI must be completed on all fields.

The planned rates of nitrogen application must be consistent with the VT NLI risk assessment and associated management recommendations per field as follows:

**<2 inches (LOW)** – Nitrogen application rates based on UVM recommendations.

**2-10 inches (MODERATE)** – Nutrient management practices such as split nitrogen application rates, pre-sidedress nitrogen testing (PSNT) and use of nitrification inhibitors should be considered.

**>10 inches (HIGH)** – Requires intense nitrogen management to minimize nitrate movement, including: careful management of applied nitrogen, avoidance of fall spreading on bare ground or dormant crop, precise timing to match crop utilization, conservation practices that resist water percolation and leaching, and cover crops that capture and retain nutrients in the upper soil profile. Additional nitrogen management requirements include the following actions:

For row and cereal crops, including corn, maintain starter fertilizer nitrogen rates below 50 lbs/acre actual nitrogen under normal conditions.

Evaluate the need for sidedress nitrogen applications on corn based on PSNT or other soil nitrate-nitrogen tests.

Do not incorporate sod crops in the Fall and chemical herbicide treatment of sod shall not be carried out until soil temperatures at 4 inches are below 45°F (October 1 or later).

Vermont Phosphorus Index (VT PI)

The Vermont Phosphorus Index (VT PI) must be completed on all fields. The planned rates of phosphorus application must be consistent with VT PI risk assessments and associated management recommendations per field as follows:

**0-30 (LOW)** – There is a low probability of adverse impact to surface waters from phosphorus losses from this site given current management practices and site characteristics. Nitrogen-based nutrient management planning is satisfactory for this site. Soil phosphorus levels and phosphorus loss potential may increase in the future due to continued nitrogen- based management.

**31-60 (MEDIUM)** – Practices shall be implemented to reduce phosphorus losses by surface runoff, subsurface flow, and erosion. Nitrogen based management can be implemented UNTIL AVAILABLE PHOSPHORUS LEVELS REACH 20 PPM OR MORE during which time phosphorus applications should be limited to crop removal rates of phosphorus or soil test recommendations for phosphorus, whichever is greater.

**61-100 (HIGH)** – Phosphorus based nutrient management planning shall be limited to crop removal rates for phosphorus or soil test recommendations for phosphorus. All practical management practices for reducing phosphorus losses to surface runoff, subsurface flow, or erosion shall be implemented.

**>100 (VERY HIGH)** – No manure or phosphorus containing fertilizers shall be applied to this site. Active remediation techniques shall be implemented to reduce phosphorus loss potential from this site.

The crop nutrient removal rates are found in UVM's "Nutrient Recommendations for Field Crops in Vermont".

When manure or organic by-products are applied, the soil erosion input of the VT PI must be based on the annual soil loss rate for the year in which the manure is applied.

On organic operations, the nutrient sources and management must be consistent with the USDA's National Organic Program.

Areas contained within minimum application setbacks (e.g., sinkholes, wellheads, gullies, ditches, or surface inlets) must receive nutrients consistent with the setback restrictions.

Applications of irrigation water must minimize the risk of nutrient loss to surface and groundwater.

Soil pH must be maintained in a range that enhances an adequate level for crop nutrient availability and utilization. Refer to [University Vermont's \(UVM's\) "Nutrient Recommendations for Field Crops in Vermont"](#) for guidance.

### **Soil, Manure, and Tissue Sampling and Laboratory Analyses (Testing).**

Nutrient planning must be based on current soil, manure, and (where used as supplemental information) tissue test results developed in accordance with [UVM](#) guidance, or industry practice, if recognized by the university.

Current soil tests are those that are no older than 3 years, but may be taken on an interval. The area represented by a soil test must be [20 acres or less](#).

Where a conservation management unit (CMU) is used as the basis for a sampling unit, all acreage in the CMU must have similar soil type, cropping history, and management practice treatment.

The soil and tissue tests must include analyses pertinent to monitoring or amending the annual nutrient budget, e.g., pH, electrical conductivity (EC) and sodicity where salts are a concern, soil organic matter, phosphorus, potassium, or other nutrients and test for nitrogen where applicable.

[Soil test analyses shall be performed by laboratories where results are based on the Modified Morgan analysis. Available phosphorus is extracted with a modified Morgan solution and reactive Aluminum in the same extractant. Available potassium is extracted using ammonium acetate, pH of 4.8.](#)

Soil test analyses must be performed by laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program- Performance Assessment Program (NAPT-PAP) under the auspices of the Soil Science Society of America (SSSA) and NRCS, or other NRCS- approved program that considers laboratory performance and proficiency to assure accuracy of soil test results. Alternate proficiency testing programs must have solid stakeholder (e.g., water quality control entity, NRCS State staff, growers, and others) support and be regional in scope.

Nutrient values of manure [and/or waste](#), organic by-products and biosolids must be determined prior to land application.

[These](#) analyses must include, at minimum, total nitrogen (N), ammonium N, total phosphorus (P) or P<sub>2</sub>O<sub>5</sub>, total potassium (K) or K<sub>2</sub>O, and percent solids, or follow [UVM](#) guidance regarding required analyses.

Manure [and/or wastes](#), organic by-products, and biosolids samples must be collected and analyzed at least annually, or more frequently if needed to account for operational changes (feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations. [Manure and/or waste storages will be sampled annually as close as possible to the time of application \(upon thorough agitation of liquid systems\)](#). If no operational changes occur, less frequent manure testing is allowable where operations can document a stable level of nutrient concentrations for the preceding three consecutive years, unless federal, State, or local regulations require more frequent testing.

Samples must be collected, prepared, stored, and shipped, following [UVM](#) guidance or industry practice.

When planning for new or modified livestock operations, acceptable "book values" recognized by the NRCS (e.g., NRCS Agricultural Waste Management Field Handbook) and the [UVM](#), or analyses from similar operations in the geographical area, may be used if they accurately estimate nutrient output from the proposed operation.

Manure testing analyses must be performed by laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification program (MTLCP) under the auspices of the Minnesota Department of Agriculture, or other NRCS- approved program that considers laboratory performance and proficiency to assure accurate manure test results.

### **Nutrient Application Rates.**

Planned nutrient application rates for nitrogen, phosphorus, and potassium must not exceed [UVM](#) guidelines or industry practice when recognized by the university.

At a minimum, determination of rate must be based on crop/cropping sequence, current soil test results,

realistic yield goals, [N contributions from any manure applications in the past two years, prior crop N credits and VT NLI and VT PI.](#)

If [UVM](#) does not provide specific guidance that meets these criteria, application rates must be based on plans that consider realistic yield goals and associated plant nutrient uptake rates.

Realistic yield goals must be established based on historical yield data, soil productivity information, climatic conditions, nutrient test results, level of management, and local research results considering comparable production conditions.

Estimates of yield response must consider factors such as poor soil quality, drainage, pH, salinity, etc., prior to assuming that nitrogen and/or phosphorus are deficient.

For new crops or varieties, industry- demonstrated yield, and nutrient utilization information may be used until land-grant university information is available.

Lower-than-recommended nutrient application rates are permissible if the grower's objectives are met.

Applications of biosolids, starter fertilizers, or pop-up fertilizers must be accounted for [field by field](#) in the nutrient budget.

[If all agricultural waste on an operation is exported to land not owned or controlled by the producer, a nutrient management plan is not required. In situations where only a percentage of agricultural waste is to be exported, a nutrient management plan is required only on the land that is controlled or owned, receiving application of nutrients. In both cases, documentation shall be furnished regarding the amount of waste being exported, the nutrient analysis of the material and who will be responsible for the use of the exported waste.](#)

#### **Nutrient Sources.**

Nutrient sources utilized must be compatible with the application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

[Starter fertilizers containing nitrogen, phosphorus and potassium may be applied in accordance with UVM recommendations, or industry practice if recognized by UVM. When starter fertilizers are used, they shall be included in the nutrient budget.](#)

#### **Nutrient Application Timing and Placement.**

Timing and placement of all nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results.

[Setbacks from down-gradient surface waters, surface inlets, wells, sinkholes, and springs must be maintained for mechanical applications of manure, litter, and process wastewater.](#)

Nutrients must not be surface-applied if nutrient losses offsite are likely. [Do not apply nutrients over bedrock outcrops.](#)

This prevents spreading on:

- frozen and/or snow-covered soils, and
- when the top 2 inches of soil are saturated from rainfall or snow melt.

Exceptions for the above criteria can be made for surface-applied manure when specified conditions are met and adequate conservation measures are installed to prevent the offsite delivery of nutrients. The adequate treatment level and specified conditions for winter applications of manure must be defined by NRCS in concurrence with the [VT Agency of Agriculture, Food and Markets](#). At a minimum, the following site and management factors must be considered:

- slope,
- organic residue and living covers,
- amount and form of nutrients to be applied, and

- adequate setback distances to protect local water quality.

The Vermont Accepted Agricultural Practices (AAP's) impose a manure spreading ban between December 15 and April 1. [Waivers for the winter spreading ban](#) may be granted by the VT Agency of Agriculture, Food and Markets on a case-by-case basis. These waivers should be coordinated with NRCS when the waivers involve producers with NRCS funded nutrient management plans.

#### Ground Water Protection

No agricultural activities including nutrient (organic or inorganic) applications will occur within 200 feet of a public well (Zone A of the Source Protection Areas (SPA), Vermont Water Supply Rule); and no manure or nitrogen fertilizer can be applied within 50 feet of a private well. All other nutrient applications around a private well, with the exception of nitrogen, will be limited to commercial fertilizer applied during the growing season according to soil test and corresponding fertilizer recommendations. When the VT NLI shows a rating of greater than 10 inches directly adjacent to a private well, the setback distance will be increased to 100 feet.

#### Surface Water Protection

A perennial vegetative buffer is required within 25 feet of the top of the bank of the adjoining surface water, including intermittent waterways that are determined to potentially transport significant waste or nutrients. These vegetative buffers may be harvested and commercial fertilizer can only be applied during the growing season according to soil test and corresponding fertilizer recommendations. No manure application will occur in these vegetative buffers.

Additional conservation practices such as Filter Strips (393), Riparian Forest Buffers (391), and Riparian Herbaceous Cover (390) should be installed in certain sensitive areas. The location of sensitive areas and conservation practices that are needed to protect them shall be discussed with the producer during the development of the plan and documented in the plan.

Do not apply nutrients within intermittent ditches, diversions, grassed waterways, drainage ditches or other areas of concentrated flow.

Avoid applying nutrients during normal flooding periods on fields with historical flooding. On row crops fields with overland flows, manure shall be incorporated within 24 hours to the degree possible based on limiting site conditions.

#### **Additional Criteria to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater**

Planners must use the [VT NLI](#), [VT PI](#) and [current](#) soil erosion risk assessment to assess the risk of nutrient and soil loss. Identified resource concerns must be addressed to meet current planning criteria (quality criteria).

Technical criteria for risk assessments can be found in NI-190-302.

When there is a high risk of transport of nutrients, conservation practices must be coordinated to avoid, control, or trap manure and nutrients before they can leave the field by surface or subsurface drainage (e.g., tile). The number of applications and the application rates must also be considered to limit the transport of nutrients to tile.

Nutrients must be applied with the right placement, in the right amount, at the right time, and from the right source to minimize nutrient losses to surface and groundwater. The following nutrient use efficiency strategies or technologies must be considered:

- slow and controlled release fertilizers
- nitrification and urease inhibitors
- enhanced efficiency fertilizers
- incorporation or injection
- timing and number of applications
- soil nitrate and organic N testing

- coordinate nutrient applications with optimum crop nutrient uptake
- Corn Stalk Nitrate Test (CSNT), Pre- Sidedress Nitrate Test (PSNT), and Pre- Plant Soil Nitrate Test (PPSN)
- tissue testing, chlorophyll meters, and spectral analysis technologies
- other [UVM](#) recommended technologies that improve nutrient use efficiency and minimize surface or groundwater resource concerns.

### **Additional Criteria Applicable to Properly Utilize Manure or Organic By-Products as a Plant Nutrient Source**

When manures are applied, and soil salinity is a concern, salt concentrations must be monitored to prevent potential crop damage and/or reduced soil quality.

The total single application of liquid manure:

- must not exceed the soil's infiltration or water holding capacity
- be based on crop rooting depth
- must be adjusted to avoid runoff or loss to subsurface tile drains.

Crop production activities and nutrient use efficiency technologies must be coordinated to take advantage of mineralized plant-available nitrogen to minimize the potential for nitrogen losses due to denitrification or ammonia volatilization.

Nitrogen and phosphorus application rates must be planned based on risk assessment results as determined by NRCS-approved nitrogen and phosphorus risk assessment tools. Manure or organic by-products may be applied on legumes at rates equal to **75% of** the estimated removal of nitrogen in harvested plant biomass.

[Applications should be split applied before significant re-growth occurs for each crop to be harvested – in early spring, and after each harvest except the last harvest of the year.](#)

Manure may be applied at a rate equal to the recommended phosphorus application, or estimated phosphorus removal in harvested plant biomass for the crop rotation, or multiple years in the crop sequence at one time. When such applications are made, the application rate must not exceed the acceptable phosphorus risk assessment criteria, must not exceed the recommended nitrogen application rate during the year of application or harvest cycle, and no additional phosphorus must be applied in the current year and any additional years for which the single application of phosphorus is supplying nutrients.

### **Additional Criteria to Protect Air Quality by Reducing Odors, Nitrogen Emissions and the Formation of Atmospheric Particulates**

To address air quality concerns caused by odor, nitrogen, sulfur, and/or particulate emissions; the source, timing, amount, and placement of nutrients must be adjusted to minimize the negative impact of these emissions on the environment and human health. One or more of the following may be used:

- slow or controlled release fertilizers
- nitrification inhibitors
- urease inhibitors
- nutrient enhancement technologies
- incorporation
- injection
- stabilized nitrogen fertilizers
- residue and tillage management

- no-till or strip-till
- other technologies that minimize the impact of these emissions

Do not apply poultry litter, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material offsite.

### **Additional Criteria to Improve or Maintain the Physical, Chemical, and Biological Condition of the Soil to Enhance Soil Quality for Crop Production and Environmental Protection**

Time the application of nutrients to avoid periods when field activities will result in soil compaction.

In areas where salinity is a concern, select nutrient sources that minimize the buildup of soil salts.

### **CONSIDERATIONS**

Elevated soil test phosphorus levels are detrimental to soil biota. Soil test phosphorus levels should not exceed State-approved soil test thresholds established to protect the environment. [Use of the VT PI will determine this.](#)

Use no-till/strip-till in combination with cover crops to sequester nutrients, increase soil organic matter, increase aggregate stability, reduce compaction, improve infiltration, and enhance soil biological activity to improve nutrient use efficiency.

Use nutrient management strategies such as cover crops, crop rotations, and crop rotations with perennials to improve nutrient cycling and reduce energy inputs.

Use variable-rate nitrogen application based on expected crop yields, soil variability, soil nitrate or organic N supply levels, or chlorophyll concentration.

Use variable-rate nitrogen, phosphorus, and potassium application rates based on site-specific variability in crop yield, soil characteristics, soil test values, and other soil productivity factors.

Develop site-specific yield maps using a yield monitoring system. Use the data to further diagnose low- and high- yield areas, or zones, and make the necessary management changes. See Title 190, Agronomy Technical Note (TN) 190.AGR.3, Precision Nutrient Management Planning.

Use manure management conservation practices to manage manure nutrients to limit losses prior to nutrient utilization.

Apply manure at a rate that will result in an “improving” Soil Conditioning Index (SCI) without exceeding acceptable risk of nitrogen or phosphorus loss.

Use legume crops and cover crops to provide nitrogen through biological fixation and nutrient recycling.

Modify animal feed diets to reduce the nutrient content of manure following guidance contained in Conservation Practice Standard (CPS) Code 592, Feed Management.

Soil test information should be no older than 1 year when developing new plans.

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, e.g., high soil test phosphorus levels can result in zinc deficiency in corn.

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or availability of the primary nutrients.

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in the NRCS' National Nutrient Policy in GM 190, Part 402, Nutrient Management.

Potassium should not be applied in situations where an excess (greater than soil test potassium recommendation) causes nutrient imbalances in crops or forages.

Workers should be protected from and avoid unnecessary contact with plant nutrient sources. Extra caution must be taken when handling anhydrous ammonia or when dealing with organic wastes stored in unventilated enclosures.

Material generated from cleaning nutrient application equipment should be utilized in an environmentally safe manner. Excess material should be collected and stored or field applied in an appropriate manner.

Nutrient containers should be recycled in compliance with State and local guidelines or regulations.

**Considerations to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater.**

Use conservation practices that slow runoff, reduce erosion, and increase infiltration, e.g., filter strip, contour farming, or contour buffer strips. These practices can also reduce the loss of nitrates or soluble phosphorus.

Use application methods and timing strategies that reduce the risk of nutrient transport by ground and surface waters, such as:

- split applications of nitrogen to deliver nutrients during periods of maximum crop utilization,
- banded applications of nitrogen and/or phosphorus to improve nutrient availability,
- drainage water management to reduce nutrient discharge through drainage systems, and
- incorporation of surface-applied manures or organic by-products if precipitation capable of producing runoff or erosion is forecast within the time of planned application.

Use the agricultural chemical storage facility conservation practice to protect air, soil, and water quality.

Use bioreactors and multistage drainage strategies when approved by the land-grant university.

**Considerations to Protect Air Quality by Reducing Nitrogen and/or Particulate Emissions to the Atmosphere.**

Avoid applying manure and other by-products upwind of inhabited areas.

Use high-efficiency irrigation technologies (e.g., reduced-pressure drop nozzles for center pivots) to reduce the potential for nutrient losses.

**PLANS AND SPECIFICATIONS**

The following components must be included in the nutrient management plan:

- aerial site photograph(s)/imagery or site map(s), and a soil survey map of the site,
- soil information including: soil type surface texture, pH, drainage class, permeability, available water capacity, depth to water table, restrictive features, and flooding and/or ponding frequency,
- location of designated sensitive areas and the associated nutrient application restrictions and setbacks,
- for manure applications, location of nearby residences, or other locations where humans may be present on a regular basis, and any identified meteorological (e.g., prevailing winds at different times of the year), or topographical influences that may affect the transport of odors to those locations,
- results of approved risk assessment tools for nitrogen, phosphorus, and erosion losses,
- documentation establishing that the application site presents low risk for phosphorus transport to local water when phosphorus is applied in excess of crop requirement.
- current and/or planned plant production sequence or crop rotation,
- soil, water, compost, manure, organic by- product, and plant tissue sample analyses applicable to the plan,
- when soil phosphorus levels are increasing, include a discussion of the risk associated with phosphorus accumulation and a proposed phosphorus draw-down strategy,
- realistic yield goals for the crops,
- complete nutrient budget for nitrogen, phosphorus, and potassium for the plant production sequence or crop rotation,

- listing and quantification of all nutrient sources and form,
- all enhanced efficiency fertilizer products that are planned for use,
- in accordance with the nitrogen and phosphorus risk assessment tool(s), specify the recommended nutrient application source, timing, amount (except for precision/variable rate applications specify method used to determine rate), and placement of plant nutrients for each field or management unit, and
- guidance for implementation, operation and maintenance, and recordkeeping.

In addition, the following components must be included in a precision/variable rate nutrient management plan:

- Document the geo-referenced field boundary and data collected that was processed and analyzed as a GIS layer or layers to generate nutrient or soil amendment recommendations.
- Document the nutrient recommendation guidance and recommendation equations used to convert the GIS base data layer or layers to a nutrient source material recommendation GIS layer or layers.
- Document if a variable rate nutrient or soil amendment application was made.
- Provide application records per management zone or as applied map within individual field boundaries (or electronic records) documenting source, timing, method, and rate of all applications that resulted from use of the precision agriculture process for nutrient or soil amendment applications.
- Maintain the electronic records of the GIS data layers and nutrient applications for at least 5 years.

If increases in soil phosphorus levels are expected (i.e., when N-based rates are used), the nutrient management plan must document:

- the soil phosphorus levels at which it is desirable to convert to phosphorus based planning,
- the potential plan for soil test phosphorus drawdown from the production and harvesting of crops, and
- management activities or techniques used to reduce the potential for phosphorus transport and loss,
- for AFOs, a quantification of manure produced in excess of crop nutrient requirements, and
- a long-term strategy and proposed implementation timeline for reducing soil P to levels that protect water quality,

## **OPERATION AND MAINTENANCE**

Conduct periodic plan reviews to determine if adjustments or modifications to the plan are needed. At a minimum, plans must be reviewed and revised, as needed with each soil test cycle, or a **10% or greater** change in manure volume or analysis, crops, or crop management **or land base**.

Fields receiving animal manures and/or biosolids must be monitored for the accumulation of heavy metals and phosphorus in accordance with **UVM** guidance and State law.

Significant changes in animal numbers, management, and feed management will necessitate additional manure analyses to establish a revised average nutrient content.

Calibrate application equipment to ensure accurate distribution of material at planned rates.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation for the change.

Records must be maintained for at least 5 years to document plan implementation and maintenance. As applicable, records include:

- soil, plant tissue, water, manure, and organic by-product analyses resulting in recommendations for nutrient application,
- quantities, analyses and sources of nutrients applied,
- dates, and method(s) of nutrient applications, source of nutrients, and rates of application,
- weather conditions and soil moisture at the time of application; lapsed time to manure incorporation; rainfall or irrigation event,
- crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass, and crop residues removed,
- dates of plan review, name of reviewer, and recommended changes resulting from the review, and
- all enhanced efficiency fertilizer products used.

Additional records for precision/variable rate sites must include:

- maps identifying the variable application source, timing, amount, and placement of all plant nutrients applied, and
- GPS-based yield maps for crops where yields can be digitally collected.

## REFERENCES

- Association of American Plant Food Control Officials (AAPFCO). 2011. AAPFCO Official Publication no. 64. AAPFCO Inc., Little Rock, AR.
- Follett, R.F. 2001. Nitrogen transformation and transport processes. *In* Nitrogen in the environment; sources, problems, and solutions, (eds.) R.F. Follett and J. Hatfield, pp. 17-44. Elsevier Science Publishers. The Netherlands. 520 pp.
- Jokela, W., Magdoff, F., Bartlett, R., Bosworth, S. and D. Ross. 2004. Nutrient Recommendations for Field Crops in Vermont. [http://pss.uvm.edu/vtcrops/articles/VT\\_Nutrient\\_Rec\\_Field\\_Crops\\_1390.pdf](http://pss.uvm.edu/vtcrops/articles/VT_Nutrient_Rec_Field_Crops_1390.pdf)
- Schepers, J.S., and W.R. Ruan, (eds.) 2008. Nitrogen in agricultural systems. Agron. Monogr. no. 49, American Society of Agronomy (ASA), Crop Science Society of America (CSSA), Soil Science Society of America (SSSA). Madison, WI.
- Sims, J.T. (ed.) 2005. Phosphorus: Agriculture and the environment. Agron. Monogr. no. 46. ASA, CSSA, and SSSA, Madison, WI.
- Stevenson, F.J. (ed.) 1982. Nitrogen in agricultural soils. Agron. Series 22. ASA, CSSA, and SSSA, Madison, WI.
- U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Agronomy Technical Note, (TN) 190-AGR-3, Precision Nutrient Management Planning. Washington, DC.
- U.S. Department of Agriculture, Natural Resources Conservation Service. 2011. Title 190, General Manual, (GM), Part 402, Nutrient Management. Washington, DC.
- U.S. Department of Agriculture, Natural Resources Conservation Service. 2011, Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation. Washington, DC.