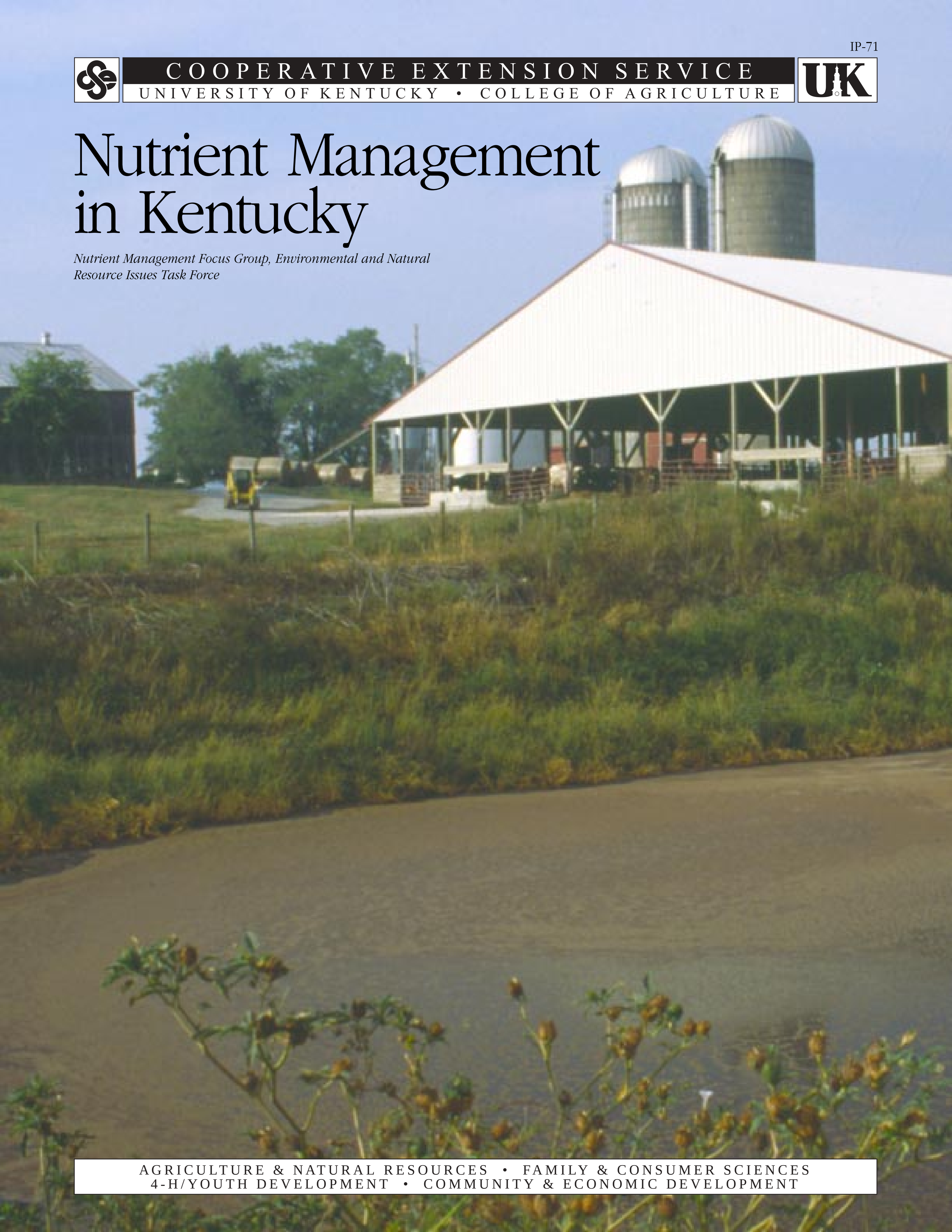
IP-71

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Nutrient Management in Kentucky

Nutrient Management Focus Group, Environmental and Natural Resource Issues Task Force



AGRICULTURE & NATURAL RESOURCES • FAMILY & CONSUMER SCIENCES
4-H/YOUTH DEVELOPMENT • COMMUNITY & ECONOMIC DEVELOPMENT

Photo courtesy of USDA NRCS.

Nutrient Management in Kentucky

Nutrient Management Focus Group, Environmental and Natural Resource Issues Task Force

Contributing Authors
Monroe Rasnake, University of Kentucky Department of Agronomy; Joe Taraba, University of Kentucky Department of Biosystems and Agricultural Engineering; Douglas H. Hines, USDA-Natural Resources Conservation Service; Ira Linville, Kentucky Department of Agriculture; Peggy Jackson, Kentucky Natural Resources and Environmental Protection Cabinet; William O. Thom, University of Kentucky Department of Agronomy; Amanda Abnee, Extension Associate for Environmental and Natural Resource Issues, University of Kentucky; Jennifer Cocanougher, County Extension Agent for 4-H/Youth Development, University of Kentucky; and Henry Duncan, Agricultural Water Quality Liaison, University of Kentucky.

Implementing a nutrient management plan can save on fertilizer costs while protecting water quality. The objective of nutrient management is to use nutrients (mainly nitrogen, phosphorus, and potassium) wisely for optimal economic benefit to the farmer while minimizing impact on the environment. Nutrients are essential for the growth of crops and must be supplied to plants in adequate amounts to achieve satisfactory yields and profits. Excessive application of fertilizers or manure can contribute to pollution of streams and groundwater resources and generally reduce profitability. A properly implemented nutrient management plan can assure the farmer that the correct amounts of nutrients are being utilized in the most efficient manner.

Nutrients on a farm can be cycled, accumulated, or passed through. They can come onto a farm in the form of feed, commercial fertilizers, manure, or compost. Nutrients leave the farm through harvested crops, livestock sold, or manure moved off the farm, or they can be lost through the air or water. Some crops have the ability to fix nitrogen from the atmosphere and thereby contribute to the nutrient content of the soil. Grazing animals cycle nutrients in pasture systems by consuming forage and then depositing nutrients back to the land in the form of manure and urine.

As a nutrient plan is developed, the long-term balance of soil fertility, plant uptake, and removal of nutrients and the potential loss of nutrients to the environment should be considered. An appropriate goal for the nutrient plan is to maintain a productive, fertile farm. A trend that indicates a decrease in the nutrient status of the farm means there will be a need to add nutrients in the future. A trend that suggests a continuing buildup of nutrients indicates a supply in excess of plant needs and will likely require a change in management to improve farm profitability and avoid potential environmental harm.

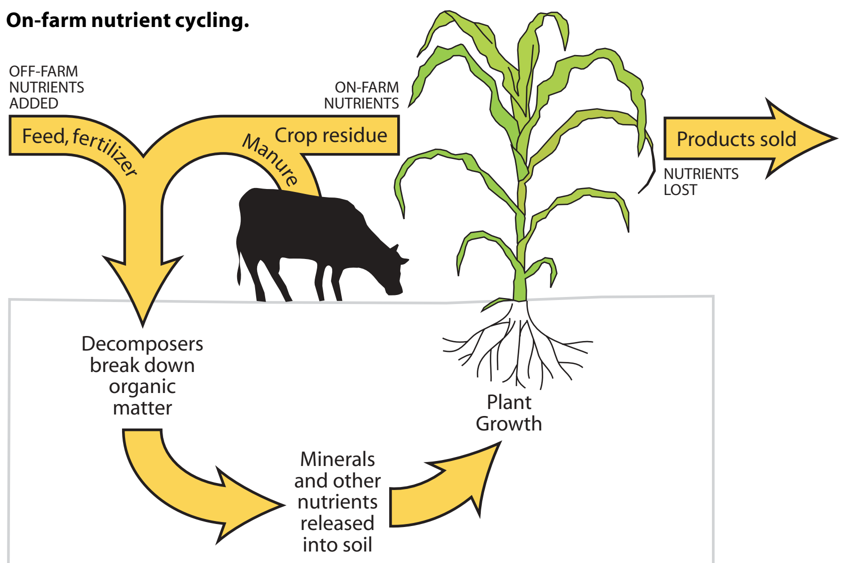
This publication will look at these trends and other factors that must be considered when developing a nutrient management plan. Carefully planning how nutrients are managed will help protect the long-term sustainability and profitability of the farm.

What Is a Nutrient Management Plan?

A nutrient management plan is an accounting of all nutrients present on the farm as well as all of the nutrients coming onto the farm in the form of commercial fertilizers or manure. The plan balances these nutrients with the amount of nutrients required for crop growth. Components of a nutrient management plan include:

- Soil maps with field designations.
- Crop plan.
- Conservation practices plan.
- Manure collection and storage facilities.
- Manure nutrient content.
- Manure utilization plan.
- Records, including soil tests, fertilizer recommendations, manure applications, and yield estimates.

On-farm nutrient cycling.



Adapted from: Natural Nutrient Cycle—1998 Project Food, Land, and People; Farm Nutrient Cycle—Douglas Beegle, The Pennsylvania State University

Nutrient Sources

Livestock Manure

The nutrient content of animal waste is quite varied and often specific to animal type. Manure quality depends on the nutritional quality of the animals' feed, handling of the manure, and storage conditions.

Commercial Fertilizers

Plant nutrients are often supplied to agricultural systems in the form of chemical fertilizers. Nitrogen, phosphorus, and potassium are the three primary nutrients added to cropping systems, although many other nutrients may be used to promote plant growth and development. When commercial fertilizers are applied at rates that exceed the plants' ability to remove the nutrients at a given growth stage, fertilizer runoff can occur. This runoff may be harmful to nearby water resources and is a waste of fertilizer.

Crop Residues

Crop residues contain valuable nutrients that can be left in the field to build soil organic matter. Crop residues decompose to provide nutrients over time. This slower release of plant nutrients reduces the risk of nutrient runoff.

Soil Mineral Weathering

The weathering of minerals (rocks) in the soil can be a source of nutrients, especially phosphorus and potassium. This is particularly of interest in the Bluegrass region of Kentucky, where phosphorus is naturally present in high concentrations in the soil.

Atmosphere

Some plants, such as legumes, maintain symbiotic relationships with bacteria that can fix atmospheric nitrogen. Fixed nitrogen is available for the host plant and sometimes non-fixing plants grown in association with nitrogen-fixing plants. However, plants will preferentially uptake mineral forms of nitrogen when available, such as from chemical fertilizers.

Manure Storage Systems

A covered structure provides manure storage until the appropriate application time.

A storage facility in an animal manure management system allows a producer control over the timing and scheduling of land application when:

- It does not interfere with other farm work.
- Field conditions are not too wet or frozen.
- Favorable weather conditions may reduce off-farm odor complaints.

The storage capacity should be based on these considerations. In Kentucky, a minimum storage capacity of 120 days is recommended to store the manure through the winter months when field conditions are often poor for application. In general, 12-month storage capacity for liquid manure systems gives the optimal flexibility for the situations cited above. If storage capacity is too small, the facility will fill before the manure nutrients can be used in an environmentally sound manner.

A lined earthen basin is an appropriate storage structure for liquid manure.

A manure storage system can be:

- A covered stack pad for solid manure with leachate collection.
- An above- or below-ground tank for liquid manure.
- A lined earthen basin to store or treat large volumes of liquid manure.

Selecting the most appropriate storage system depends on available capital and labor, manure sources, animal production system, soil type, cropping practices, topography, neighbors, convenience, aesthetics, and regulations. All storage systems are balances and compromises among these competing priorities. Economics and environmental regulations are key considerations when choosing a manure storage system.

Liquid manure applications may be applied within 30 days of the beginning of crop growth unless heavy precipitation is forecast before the liquid could be absorbed into the soil profile.

Other items to consider are the amount and type of land available for application, fresh water resources, and required odor control measures. The manure storage system selected should not be based solely on available equipment and facilities. All items should be considered to avoid costs associated with inefficient manure handling.

Stored manure nutrients can be applied to the land by:

- Surface application with a box or tank spreader wagon, followed by a light tillage operation to increase nitrogen retention and reduce odors.
- Liquid injection from tank wagons.
- Irrigation with an option to incorporate the nutrients into the soil.
- Towed hose, continuous injections with tractor-mounted tool bars.

Apply animal manure when the crop can best use the nutrients it supplies.

Irrigation reduces soil compaction and increases time available for manure application since post-planting application can occur. Land application can be performed by custom applicators. It reduces capital expenses and labor, but timeliness of application could be limited by the availability of an operator. Irrigation has the drawback of increased odor production.

Planning Manure Applications for Crop Production

Soil testing is the foundation of a sound nutrient management program.

Sample manure as close to the time of land application as possible.

Step 1. Soil Testing

Planning should start with taking a representative soil sample from the field and having it tested to determine the current fertility status. Soil pH, phosphorus, and potassium are the primary factors to consider. Other nutrients, such as calcium, magnesium, and organic matter, could be useful also, especially for long-term comparisons. Testing should be done by the University of Kentucky Soil Testing Laboratory. Other laboratories may be used if they have the same procedures as the University of Kentucky Soil Testing Lab. Extension publication AGR-1, *Lime and Fertilizer Recommendations*, lists the testing method used to develop soil test recommendations in Kentucky.

County Extension offices can provide information on how to take soil samples. They can also provide sample containers, record forms, and, in some cases, soil probes for taking samples. They will arrange to have samples tested and provide fertilizer recommendations based on the results. Soil samples should be taken well ahead of the time that manure applications are planned. It will take several weeks to get samples taken, have them tested, and determine fertilizer recommendations. If spring applications of manure are planned, it is a good idea to take samples in the fall. Likewise, soil samples taken in the spring will give time to plan manure applications for fall.

A good soil test is the only way to be sure enough nutrients are available for crop needs and to prevent the levels of some nutrients from becoming high enough to threaten water quality.

Step 2. Manure Testing

Although average "book values" of the nutrient content of manures can be used for short-term planning of manure application rates, farmers need to determine more accurate values for the manure they will be using in order to develop good long-term plans. This means that manure samples should be taken as soon as possible in the planning process to get a representative sample. In the case of broiler litter to be applied as soon as it is removed from the house, samples can be taken in the house between the last two flocks raised just prior to cleanout. However, if the litter is to be stacked for some time before it is to be applied, samples should not be taken until a few weeks before it is to be applied because nutrient content changes during storage.

Varying Nutrient Needs

Some examples of varying nutrient needs based on the factors mentioned are:

Crop*—Corn and soybeans have very different needs. Corn must have nitrogen supplied, while soybeans obtain their own through nitrogen fixation.*

Yield*—A 200-bushel per acre corn crop requires much higher fertility than a 100-bushel corn crop.*

Soil type*—The predominant soil type in a field affects yield potential and the availability of nutrients to crops. Soil characteristics such as depth, drainage, and ability to supply moisture are important.*

Previous crop*—Some crops, especially sod crops, build up nitrogen that can become available to succeeding crops.*

Prior manure applications*—Some of the nitrogen in manure is released slowly as the manure decomposes. This nitrogen will become available a year or more after it is applied.*

Soil test*—Results of a good soil test show what is already in the soil's nutrient "bank." These nutrients can be drawn on to provide for the needs of the next crop. Without a soil test, either an "overdraft" or excess of nutrients is likely to occur.*

For liquid manure systems, such as holding ponds or lagoons, the best time to get a representative sample is when the manure will be agitated during pumping prior to application. Sampling at this time means the test results cannot be used to plan current application rates. This is a case where book values can be used for the short-term, then modified in the future based on the sample analyses. It should be remembered that a bad sample (one that does not represent the manure being applied) is much worse than no sample at all because it can lead to poor long-term nutrient management.

Information on sampling and testing animal manure is available in Extension publication ID-123, *Livestock Waste Sampling and Testing.* This publication and other information regarding the utilization of animal manure as a nutrient source is available at county Extension offices.

Step 3. Determining Crop Nutrient Needs

The nutrients that need to be applied to grow a crop depend on:

- The crop to be grown.
- Realistic yield goals.
- Predominant soil type and drainage.
- The previous crop.
- Prior manure applications.
- Soil test results.

Fertilizer recommendations made by the University of Kentucky Cooperative Extension Service take all of these factors into consideration. Other factors such as nutrient source (commercial fertilizer or manures), timing, and method of application can also affect the application rate. Extension publication AGR-1, *Lime and Fertilizer Recommendations,* can be used to determine crop nutrient needs.

Step 4. Calculate Manure Application Rates

The rate of manure to apply for a particular crop depends on:

- The nutrient needs of the crop as determined in Step 3.
- The nutrients available from the manure to be used.
- Selecting a nutrient to base the application rate on. Rates are usually based on how much nitrogen or phosphorus the crop needs.

Information on how to calculate manure application rates for crops grown in Kentucky is given in Extension publication AGR-146, *Using Animal Manures as Nutrient Sources.* A worksheet is included that takes into account the nutrient recommendations, any residual nitrogen from manure, nutrients in pre-plant fertilizer, and the availability of nutrients in manure. A manure rate can then be calculated to supply either the nitrogen, phosphorus, or potassium recommended for the crop. A balance sheet also can be used to determine if additional nutrients are needed. Computer-based spreadsheet programs are also available to calculate application rates.

It must be remembered that nutrients in manure, especially nitrogen, are not as readily available to crops as nutrients in commercial fertilizers. Therefore, it is necessary to calculate manure rates based on nutrient availability to be sure crop nutrient needs are met.

Step 5. When Should Manure Be Applied?

The most important factor in determining when manure should be applied is *when the crop can best use the nutrients*. For annual crops such as corn, this usually means spreading manure just before seeding. For perennial crops, such as pasture or hay, timing of application is much more flexible. Most Kentucky farms have some fields that manure can be applied on during any season. Following are some examples:

- **Fall**—Kentucky has large acreages of cool-season pasture and hay fields that could benefit from fall applications of manure. Wheat fields and crop fields with cover crops are also good choices. Manure should not be applied in fall on crop fields that do not have a cover crop to take up and hold nitrogen.
- **Winter**—Opportunities for manure application in winter are limited. The best options are on cool-season forages and small grains in February or March. Manure should not be applied on frozen or snow-covered fields where subsequent rains could wash the manure off the field before it has a chance to move into the soil. Manure should not be applied in winter on crop fields that do not have a cover crop to take up and hold nitrogen.

Manure should not be applied on frozen or snow-covered fields where subsequent rains could wash the manure off the field before it has a chance to move into the soil.

- **Spring**—Spring is the best time to spread manure for a summer crop such as corn. Manure spread in early spring will lose less nitrogen and have the most nutrients available at the time the crop needs them. Spring is not the best time for applying manures to cool-season forages, especially after early April. Nitrogen losses from the manure will be greater at this time, and weed competition could be increased.
- **Summer**—Manure spread in the summer will have the greatest risk of nitrogen loss through ammonia volatilization. However, if storage facilities need to be emptied, there are options for use. Manure can be applied on alfalfa fields during summer. Select fields with older stands of alfalfa, and apply manure as soon after harvest as possible. Warm-season grass fields used for hay are one of the best options for manure application in summer. Sudangrass responds well to manure applied following harvest in July or August. Manure can be applied on bermudagrass fields any time after a harvest during the summer. Bermudagrass is a heavy user of nutrients, and if it is removed as hay, nutrient accumulation in the soil is reduced.

Spring is the best time to spread manure for a summer crop such as corn.

Manure should be applied close to the time the crop will need the nutrients it supplies. In order to accomplish this, it will be necessary for some farmers to store manure for several months. This need should be taken into account when planning for an animal production enterprise.

The Nutrient Value of Manure

The value of manure is highly dependent on the nutrient status of the field to which it is applied, the nutrient content of the manure, the nutrient needs of the crop to be grown, and the comparative cost of purchasing nutrients from other sources.

The value of any nutrient source is greater when applied to a soil that has a low soil test level for the nutrient(s) being supplied. Manure nutrients in excess of the amount recommended from a soil test are not given any value for comparison. Analysis of a manure sample will determine its nutrient content. Depending on the animal species, manure storage methods, and land application methods, the relative amount of nutrients available to plants can be estimated.

An economic value can be assigned to manure by multiplying these estimates by the cost of purchasing nutrients as commercial fertilizer. This gross value does not reflect differences in the cost of applying manure to the land versus the cost of applying commercial fertilizer. It is not advisable to determine an economic value of manure based on book or average values because nutrient content can vary greatly due to animal species, manure collection and storage, composition of livestock rations, amount of bedding, and the amount of water added.

Annual applications of manure will also add organic matter to the soil. However, this added value is inconsistent and difficult to determine but does provide an additional benefit to the soil.

The greatest benefits from any nutrients applied to the land are derived when those nutrients remain where they were placed.

Nutrient and Manure Use Benefits from Conservation

The greatest benefits from any nutrients applied to the land are derived when those nutrients remain where they were placed. A key factor for maximizing contributions to the soil is to minimize losses from runoff and erosion. Reducing the amount of runoff and erosion will also protect water quality of nearby streams and groundwater resources.

Minimizing water contamination involves reducing the amount of nutrients and manure sediment reaching the water body. Many conservation practices for the control of runoff and sediment movement have been developed, researched, and implemented. These practices include changes in land management and cropping, as well as the installation of complementary structural devices. Any of these practices used individually or in combination are effective in reducing nutrients and sediment from moving to surface water bodies.

Contour strip cropping is one practice that reduces non-point source loss of nutrients due to runoff and erosion.

Land Management Practices:	**Structural Devices:**
Cover crops	Grassed waterways
Diverse rotations	Vegetative filter strips
No-till	Terraces
Conservation tillage	Diversions
Contour farming	Grade stabilization structures
Contour strip cropping	

Crop Selection and Rotation

The selection of crops to include in a rotation has been shown to reduce nitrogen movement in soil profiles and lessen phosphorus buildup in the soil surface. Grass-type crops and legumes can effectively "scavenge" soluble nitrogen from previous crops or more recent manure applications. Also, crops with a low nitrogen requirement used in sequence either with previously grown crops that recover nitrogen ineffectively or that have a high nitrogen requirement can effectively reduce the amount of nitrogen needed over a number of years.

Including crops with a high phosphorus demand (alfalfa, corn silage, etc.) in a rotation can help draw down soil phosphorus levels following manure applications and reduce potential phosphorus losses in runoff water. Alfalfa's deep root system can also remove soluble nitrate-nitrogen from soils at greater depths than many other crops.

Including crops with a high phosphorus demand in a rotation can help draw down soil phosphorus levels following manure applications and reduce potential phosphorus losses in runoff water.

Cover Crops

Fall-seeded cover crops of small grains or forage grasses lengthen the time an active vegetative cover exists on a field. This vegetative cover reduces sediment in runoff and helps to slow water runoff, thus increasing infiltration. When used following a high nitrogen-requiring crop, the cover crop can usually satisfy its nitrogen needs by scavenging nitrogen from the soil. This practice is very effective in reducing nutrient runoff following row crops and fall manure application because it provides cover during much of the period of highest rainfall intensity.

No-Till and Conservation Tillage

A major objective for using no-till and conservation tillage is to manage crop residues to reduce runoff of water, nutrients, and sediment. Crop residues left on the soil surface can cover 60 to 100 percent of the land, depending on the timing, implement used, and tillage type. This residue cover reduces rainfall impact on the soil surface and slows runoff, which reduces the amount of nutrients and sediment reaching surface waters. Cover crops and contouring are often used with these tillage systems to further increase nutrient, water, and sediment retention.

Grassed waterways are able to slow water and filter out contaminants. They are often combined with buffer strips or stabilization structures.

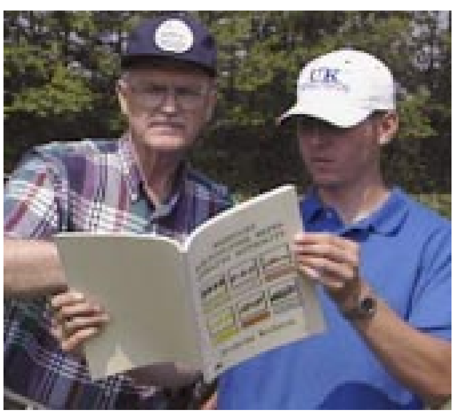
Contouring

Contouring will create some impediments to water movement. Any type of land roughness (chiseling, crop rows, etc.) or vegetation changes (alternate crop strips, etc.) that slows or impedes water flow will decrease runoff of nutrients and sediment. On less sloping land, row crops are often grown in alternating strips with forages. The forages provide a change in vegetation and serve as a filter. Manure can be applied during fall or spring to the row crop strips while leaving the forage strips to act as filters. A greater reduction in runoff occurs when cover crops are used on the row crop strips.

Filter or Buffer Strips

These 30- to 100-foot wide "strips" of actively growing vegetation are located below or around fields. Some may be located adjacent to and along streams or riverbanks, above lake shores, or above farm ponds. These vegetative buffers or filters slow down runoff from land areas above and can trap nutrients and sediment. They function best under these conditions:

- They are clipped regularly to maintain a plant height of 3 to 6 inches.
- They consist of a thick stand of forage grasses.
- They are not used as field roads. Traffic on these buffers reduces the vegetative cover and promotes gully formation in the wheel tracks.



The Kentucky Agriculture Water Quality Act requires nutrient management plans on farms 10 acres or greater in size where nutrients are applied and/or utilized.

Grassed Waterways

These grassed areas collect, direct, and manage runoff safely from side slopes to areas lower on the landscape. They have some ability to slow water and filter out contaminants. They are often combined with buffer strips or stabilization structures in a lower landscape position, depending on the width of the relatively flat buffer areas or the need to have water dropped several feet into a ditch, stream, or river. Grassed waterways are frequently used in conjunction with contouring for safe runoff management. Nutrients should not be applied directly to grassed waterways.

Terraces, Diversions, and Stabilization Structures

These structures are used where significant landscape alterations are needed for safe water management. Terraces have some capacity to trap water for significant periods to allow sediment collection and water infiltration. Diversions serve to direct some water around more sensitive areas or areas with higher risk of soil loss as sediment. Frequently, the water is directed into grassed waterways for safe handling. Stabilization structures may range from simple to extensive stream bank stabilization, drainage tile outlets, and water overflow structures at the end of a grassed waterway.

Pastures Need Some Special Considerations

Nutrient cycling in pastures can be monitored by a good soil testing program (Photo courtesy of USDA NRCS).

When forages serve as the sole feed source in pasture systems, nutrients from the manure and urine of grazing livestock will not exceed the amount required by the forages. Livestock concentration in some areas of the pasture, except with rotational grazing, may result in uneven distribution of nutrients. Nutrients leave the pasture system only through animal growth or milk production. In general, only 25 to 30 percent of the nutrients taken in by grazing animals are removed from the field in this manner. The remaining 70 to 75 percent are returned to the pasture in the manure and urine. This recycling of nutrients should be monitored carefully by a good soil testing program. If nutrient management with pastures involves using a crop removal basis for determining the amount of phosphorus and potassium to apply, then only about 30 percent of the calculated amount should be applied. Otherwise, soil test levels may increase rapidly due to the excess of additions over that removed.

Nutrient Management Plans Are Required For:

Cost-share funds for any Best Management Practice (BMP) on Animal Feeding Operations (AFOs) through the Clean Water Act §319 Non-point Source Program.

Cost-share funds for any BMP on AFOs through the Clean Water Action Plan (CWAP).

Cost-share funds for animal nutrient management BMPs through the Environmental Quality Incentives Program (EQIP).

Cost-share funds for animal nutrient management BMPs through the Kentucky Soil Erosion and Water Quality Program.

Nutrient Management and Conservation

Conservation and nutrient management practices must be coordinated in order to protect surface and groundwater. Reduced tillage and erosion control practices are effective when sediment and any attached nutrients contribute to water contamination. By slowing runoff, water and any associated nutrients are given more time to soak into the soil. Effective crop management and diverse rotations are more important in managing nutrients within a soil profile.

Required Nutrient Management Plans

Nutrient management plans are required by regulation when applying for a Kentucky Pollution Discharge Elimination System (KPDES) Operating Permit for a Confined Animal Feeding Operation (CAFO).

Nutrient management plans are required under the Kentucky Agriculture Water Quality Act and State Agriculture Water Quality Plan on farms 10 acres or greater in size where nutrients (commercial fertilizers or animal manure nutrients) are being applied and/or utilized.

This publication was funded by an award received by the University of Kentucky from the U.S. Environmental Protection Agency to the Kentucky Division of Conservation through 319(h) Non-point Source Implementation Program Cooperative Agreement #C9994659-95.

Some publications that will provide more detailed information on many practices for nutrient management include:

AGR-1 *Lime and Fertilizer Recommendations*
AGR-16 *Taking Soil Test Samples*
AGR-57 *Soil Testing: What It Is and What It Does*
AGR-91 *Cropland Rotations for Kentucky*
AGR-97 *Surface Water Management Systems*
AGR-99 *Tillage and Crop Residue Management*
AGR-100 *No-Till Corn*
AGR-101 *No-Till Soybeans*
AGR-102 *Erosion: Its Effect on Soil Properties, Productivity, and Profit*
AGR-103 *Controlling Soil Erosion with Agronomic Practices*
AGR-144 *The Nature and Value of Residual Soil Fertility*
AGR-146 *Using Animal Manures as Nutrient Sources*
AGR-165 *The Agronomics of Manure Use for Crop Production*
ID-123 *Livestock Waste Sampling and Testing*