Managing Nutrients in Pastures to Improve Profitability and Water Quality

JOHN LORY AND CRAIG ROBERTS

Plant persistence and productivity often depend on sources of nitrogen (N), phosphorus (P) and potassium (K) in excess of what the soil can provide. Pasture systems have lower fertilizer needs than hay and row crops because many of the nutrients consumed by the animals are returned to the pasture in the manure. In addition to recycling the nutrients in the forage, animals import nutrients into the pasture from purchased feeds. Phosphorus levels in a pasture-based dairy can increase without the addition of fertilizer because of nutrient contributions from purchased hay and concentrates.

Successful pasture management uses soil testing, an understanding of nutrient cycles, and the judicious use of lime and fertilizers to maximize the persistence of desirable pasture species and improve pasture productivity. This typically requires a departure from the fertilization strategies used in row crop systems. Management-intensive grazing (MiG) improves the recycling of nutrients within a pasture by better distributing nutrients from nutrients around the pasture. This minimizes, but does not eliminate, the need for fertilizer applications.

Much of Missouri's dairy production is in the Ozarks, a region known for clear-water streams and lakes. Surface waters in this region of the state are particularly sensitive to nutrient losses from agricultural practices. Pastures are among the most environmentally benign agricultural systems. However, significant nutrient losses can occur from pastures, particularly in winter feeding areas, from animal activity near stream banks and after the application of fertilizer. Maintaining riparian zones along the lakes and streams and carefully managing winter feeding areas can minimize these losses.

**Nutrient flow and cycling in dairy systems**

Lactating cows excrete in urine and feces more than 70 percent of the N, 60 percent of the P and 80 percent of the K they consume in their diets. A 75-cow dairy herd will generate more than 6,800 lb of P₂O₅ and 16,700 lb of N annually. The cows deposit this fertilizer in holding areas, along walking lanes and in pastures. Understanding the cycling and flow of nutrients will help maximize the fertilizer or manure nutrients in your grazing system. It also will help you identify when and where you need to purchase additional fertilizer to improve the productivity of your crops.

Nutrients enter the farm in purchased fertilizer, as part of purchased feeds and mineral supplements, and through natural processes such as nitrogen fixation by legumes. Nutrients leave the farm in the milk and crops and through natural processes such as ammonia volatilization and in runoff. On conventional dairies that rely on purchased hay, concentrates and mineral supplements, more nutrients enter the farm in feed than are exported from the farm as milk.

In a grazing system, most nutrients in the manure end up on the pastures. Nutrients fed in the milking parlor are transported to the pasture by the animals. In a grazing dairy, at least 65 percent of the nutrients in the concentrate are excreted on the pasture. This minimizes, but does not eliminate, the need for fertilizer applications.

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The flow of nutrients in a pasture system is different from that of hay or row crop fields. Most of the nutrients in the aboveground biomass are harvested and removed from hay and row crop fields. For example, 80 percent of the nutrients in standing hay are removed with the bales. The high removal rates of N, P and K from these fields may require equally large nutrient inputs to maintain soil fertility over long periods of time.
Table 10.1. Estimated removal of N, P and K from a field under different management systems.

<table>
<thead>
<tr>
<th>System</th>
<th>P</th>
<th>K</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay</td>
<td>6 lb/ton</td>
<td>40 lb/ton</td>
<td>50 lb/ton</td>
</tr>
<tr>
<td>Beef cow-calf pair</td>
<td>3 lb/pair</td>
<td>1 lb/pair</td>
<td>10 lb/pair</td>
</tr>
<tr>
<td>Pasture-based dairy (no concentrate)</td>
<td>15 lb/cow</td>
<td>23 lb/cow</td>
<td>84 lb/cow</td>
</tr>
<tr>
<td>Conventional dairy</td>
<td>Imports 32 lb/cow</td>
<td>Imports 94 lb/cow</td>
<td>Imports 148 lb/cow</td>
</tr>
<tr>
<td>Dry cows</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: To adjust values to a per acre basis, multiply hay values by the yield per acre in tons and divide the animal numbers by the annual stocking rate in acres per animal. Adjust P to P2O5 basis by dividing by 0.44. Adjust K to K2O basis by dividing by 0.83.

The philosophy of our current fertilization system was developed in these demanding systems. We recommend regular applications of P and K fertilizers unless soil test levels are very high. And we recommend annual applications of N fertilizers unless sufficient legumes are in the field to meet the N deficit through nitrogen fixation.

In pasture systems, the flow of nutrients from the field is either greatly reduced or in some cases will be less than what is exported (Table 10.1). Animal behavior and manure characteristics control the distribution and availability of most nutrients. Pasture-based systems require different soil testing and fertilizer management than row crops.

A nutrient cycle describes the flow of nutrients in, out and within a pasture. Figure 10.1 outlines the key nutrient-flow pathways for P, K and N. Nutrient pools in the pasture include the soil pools (plant-available nutrients and soil storage), plants, animals and the atmosphere. Note that each nutrient cycle has unique aspects. The greatest differences are between the N cycle and the P and K cycles. For example, the N cycle includes loss pathways to the atmosphere that do not exist in the P and K cycles.

Our objective in soil fertility management is to maintain the plant-available soil pool of nutrients at a sufficient level to support quality forage production for animals while protecting water quality. Exports from the pasture deplete the plant-available nutrient pool in the soil by transporting nutrients out of the pasture instead of recycling them back into the soil pool.

Harvested crops are the primary mechanism for P and K losses from the field. Phosphorus and potassium also can be lost in runoff water passing over the field. These losses are not large enough to affect fertilizer management. For example, phosphorus losses from pasture are typically less than 1 lb P/acre from well-managed pastureland.

There will be little change or even an increase in soil test P and K values over time in a pasture if manure is well-distributed in a field. The animals are either removing few nutrients from the system, or they are adding nutrients (Table 10.1). There are few uncontrolled losses to water and air. Consequently, annual applications of P and K are not needed to maintain soil fertility levels in well-managed pastures. Instead, soil test paddocks every 3 to 5 years and apply fertilizer when soil test levels drop below desired levels.

In contrast, the N cycle has uncontrolled losses that can exceed exports in hay, meat or milk. The most important loss pathway in pastures is ammonia volatilization. On average, 25 percent of the nitrogen in the urine and feces deposited in a field is lost as ammonia to the atmosphere, but losses can approach 50 percent under some conditions. A typical dairy cow excretes 220 to 260 lb of N annually, but up to half (110 to 130 lb) is lost to the atmosphere through ammonia volatilization. Some of the organic N in manure is unavailable to plants, which further reduces the value of manure N returned to the pasture. Plants in the pasture ultimately recover 10 percent of the N in the feces and 30 percent of the N in urine. Consequently, the annual N fertilizer value of dairy manure excreted in the field is 130 to 155 lb/cow.

Annual inputs of N are recommended for pasture systems. Dairies that feed high amounts of concentrates will need to apply lower rates of N, and dairies that depend more on forages will need to apply higher rates of N to the pastures. The source of N can be purchased fertilizer, manure from a manure-storage facility or fixed N from legumes in the forage mix. Maintaining a vigorous legume component of at least 30 percent of the forage stand all but eliminates a response to fertilizer N in pasture systems.

In summary, pasture systems are more efficient
Figure 10.1. Key aspects of the phosphorus (P), potassium (K) and nitrogen (N) cycles.
than other agricultural systems, such as hay and row crops, at recycling most nutrients. Nitrogen is the exception to this rule; an N source is needed to replace the N where it is removed by the animals, lost in uncontrollable ways such as ammonia volatilization or in a field with reduced availability of organic N.

**Manure distribution in pastures**

Feces and urine from grazing animals are a critical source of nutrients in pasture. In pasture systems, cows are fertilizer spreaders that control the distribution of these needed nutrients. A dairy cow defecates 7 to 15 times per day and urinates 8 to 12 times per day. Each time a cow urinates, it applies nitrogen at the rate of 500 to 1,000 lb N/acre and water at the rate of 100 inches/hour to a small portion of the field. Each time a cow defecates, it applies nitrogen at the rate of 200 to 700 lb N/acre.

These nutrients are of little use as a fertilizer unless they are well-distributed across the surface of a pasture. Grazing animals typically cover up to 20 percent of the pasture annually with urine and manure patches. These patches may not be uniformly distributed over the field.

As a general rule, the heavier the grazing pressure, the more uniformly manure and urine nutrients will be distributed across the pasture. Research at the Forage Systems Research Center determined the distribution of manure piles in a 3-, 12- and 24-paddock grazing system. In the 3-paddock system, manure piles (and nutrients) were concentrated within 150 feet of water and shade. Soil test P levels dramatically increased in these two areas, but they decreased or stayed constant in the main grazing areas. In the 24-paddock system, there was still some concentration of manure piles near water, but the main grazing area had 2 to 4 times the density of manure piles as the 3-paddock system.

This research was used to estimate how long it would take to have a manure pile land in every square yard of a pasture (Table 10.2). A continuously grazed pasture requires an estimated 27 years to ensure every square yard of the paddock has received at least one manure pile while other areas repeatedly receive manure. Meanwhile parts of the pasture are unfertilized with manure for 27 years.

The main grazing area in a continuously grazed pasture has a nutrient cycle more like a hay field than a pasture. Cows graze in the main paddock area and then move to the loafing areas near water and shade carrying forage nutrients in their gut. In the loafing areas they rest, rise, defecate and then return to the main grazing area ready to harvest and remove another load of forage nutrients.

As grazing intensity increases, the time required to ensure complete coverage of the pasture with manure decreases (Table 10.2). Improved nutrient distribution is a tangible benefit of adopting a more intensive grazing strategy.

**Table 10.2. The effect of grazing intensity on manure distribution in pastures.**

<table>
<thead>
<tr>
<th>Grazing frequency</th>
<th>Years to get 1 pile/sq. yard</th>
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<tbody>
<tr>
<td>Continuous</td>
<td>27</td>
</tr>
<tr>
<td>14-day rotation</td>
<td>8</td>
</tr>
<tr>
<td>4-day rotation</td>
<td>4-5</td>
</tr>
<tr>
<td>2-day rotation</td>
<td>2</td>
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</tbody>
</table>

**Making fertilizer decisions in pasture systems**

**Soil sampling pastures**

Soil sampling is an important tool for understanding the opportunities and limitations of a pasture for forage production. Soil fertility levels in pastures are highly variable, which makes accurate soil sampling difficult. A few general rules will help improve the quality of your soil test results.

A soil sample should represent a maximum of 20 acres and preferably much less. Divide fields based on topography, previous management and/or soil type. It often makes sense to sample each paddock in a grazing system separately, particularly if paddocks have had different fertilization histories or different management histories such as one being hayed and the other not.

- Avoid sampling within 150 feet of watering points, shade trees and other loafing areas. These areas typically have sufficient fertility, and their inclusion will overestimate nutrient levels in the main pasture areas.
- Sample the soil with a coring device, combining a minimum of 15 to 20 cores into a plastic bucket. Travel through the sampling area in a zigzag pattern collecting a core at regular intervals at random points in the field. After you have collected the cores from a sampling area, crumble and thoroughly mix the soil in your bucket and then remove a subsample to send in for analysis. Discard the excess soil.
- In continuously grazed pastures, avoid taking cores through manure piles and fresh urine patches. In pastures with high grazing densities, avoid the freshest manure piles.
- The lab where you send your samples determines sampling depth. Sending 3-inch samples to a lab expecting 6-inch samples or vice versa will result in inaccurate soil test results. The Missouri soil testing laboratory requires a 6-inch sampling depth.
- Send your soil samples to a qualified soil test laboratory that is accredited by the North American Proficiency Testing program as well as by your own state's accreditation program. Be sure to clearly label samples so you can identify which field is associated with each soil sample.
- In most cases, the lab will provide recommendations for N, P, K and lime based on soil test results, which you should receive within one week of submitting your soil samples.
- Sample your pastures' soil every 3 to 5 years. It is better to do a careful job of soil sampling every 5 years than a sloppy job every 3 years or less.

Interpreting soil test results

Soil testing provides information about the nutrient status of the soil needed to effectively manage pastures. The pH of the soil and the availability of nutrients provide critical information about the potential productivity of the pasture and the species likely to compete effectively.

Soils that test low for a particular nutrient are likely to increase yield if that fertilizer is added. Low- and very low-testing soils reduce the persistence of many forage species. While medium-testing soils may respond to fertilizer, the response will be smaller than for low- or very low-testing soils. In some fields, no benefit will be observed to adding fertilizer. The application of fertilizer to soils that test high will not increase forage production. In row crop fields and continuously grazed pastures, maintenance applications of phosphorus and potassium are recommended. No fertilizer is recommended for agronomic purposes on soils testing very high or excessive.

Maintenance applications of phosphorus and potassium are not needed in intensively grazed pastures that return high amounts of nutrients back to the field through urine and feces. For intensively managed pastures, monitor soil test levels with soil testing. Apply fertilizer when you need to raise soil test levels to a more desirable level.

Should I fertilize my pasture?

Before you can answer this question, you need to collect some information and answer some other questions. Critical information to address this question includes:

- What forage(s) do you want to grow?
- What are your soil test levels?
- What are other potential limitations to pasture productivity on that pasture?
- What is the value of your forage?

Answering these questions will allow you to determine your options.

Forage selection is a key part of any fertility decision. Forages differ in the minimum fertility

Table 10.3. Range of soil test levels of pH, K and P required for persistence of selected forages.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Soil test level</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Very low</td>
</tr>
<tr>
<td>Legumes:</td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td></td>
</tr>
<tr>
<td>Annual lespedeza</td>
<td></td>
</tr>
<tr>
<td>Birdfoot trefoil</td>
<td></td>
</tr>
<tr>
<td>Red clover</td>
<td></td>
</tr>
<tr>
<td>White clover</td>
<td></td>
</tr>
<tr>
<td>Cool-season grasses</td>
<td></td>
</tr>
<tr>
<td>Warm-season grasses</td>
<td></td>
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</table>
level needed for persistence and productivity (Table 10.3). In general, legumes require higher pH, P and K levels than most grass species. If you have medium to high soil test levels of pH, P and K, you will have few restrictions on your selection of forage and little need to build up P and K or raise pH. If soil test levels are low, you will need to apply fertilizer and lime if you want to maintain legumes in your pasture. Low-testing soils also reduce the quality and quantity of grass forages.

Forages have high value in dairy systems, which makes fertilization profitable. The following practices maximize returns on fertilizer in pasture systems.

- Maximize forage use. The animals in typical Missouri pastures use less than 50 percent of the forage. Intensive management can increase this to more than 75 percent.
- Apply N fertilizer only when you expect a yield response and when you can use the extra forage production.
- As milk prices rise, fertilization of pasture and hay becomes more profitable.

Remember that all pastures need annual inputs of N to maintain productivity. The N source can be from manure, fertilizer and/or nitrogen fixation by legumes. If soil test levels are too low to maintain a large legume component, annual applications of fertilizer N will be needed. Legumes must be at least 30 percent of the stand to eliminate response to commercial nitrogen fertilizer.

Nitrogen fertilization can happen in many forms. Investing in legume seed for interseeding is a form of N fertilization. Purchasing manure from a neighbor provides N for the crop. Investment in fencing to improve manure distribution is a form of fertilization for parts of the pasture. Purchased fertilizer is another alternative.

Only invest in fertilizer when you have a need for additional forage or higher-quality forage and there is a potential for fertilizer response. Summer and fall N fertilization can increase yield when there is a lack of forage while the same fertilizer applied in spring may grow excess forage with little value. If you don’t need the forage, don’t fertilize.

But remember that yield is not the only indicator of forage value. Fertilization will increase the nutrient quality of the forage and the persistence of desirable species. Phosphorus and potassium will pay for themselves by extending the stand life of forages such as alfalfa that have high establishment costs.

Fertilizer and lime is most likely to pay on low-testing soils. The biggest benefits in yield response, persistence and forage quality occur on very low and low-testing soils. With limited resources, focus your lime, P and K fertilizer programs on these low-testing soils and/or on maintaining your high-value forages such as alfalfa. Low rates of P and K on all low-testing soils is more likely to pay than higher rates on a subset of low-testing soils.

Fertilizing a mixed grass/legume pasture

Adding legumes to a grass pasture can improve pasture yield, increase animal gains and provide some N for the grass. But fertilizing a mixed sward is difficult. The thing to remember is this: Most legumes will not grow or persist well if soil fertility is low. This is especially true for alfalfa and red clover. The basic fertilizer strategy for keeping legumes in a pasture is:

1. Keep the soil pH between 6.0 and 7.5 with application of lime.
2. Maintain soil phosphorus and potassium in the medium to high range.
3. Avoid fertilizing mixed grass/legume pastures with nitrogen.

Phosphorus is particularly important in seedling establishment, and a “pop-up” application of 20 to 40 lb P2O5/acre should be applied at seeding to enhance seedling root development and growth. Potassium is particularly important to legume vigor, disease resistance and winter hardiness. Take care to replace K removed through harvest of excess forage as hay or silage.

Avoid applying fertilizer N to mixed legume/grass swards. Application of N to mixed swards will favor the grass over the legume. Added fertilizer N is unlikely to increase yields when 30 percent or more of the total biomass in a pasture is composed of legumes.

A pure stand of clover can provide more than 200 lb N/acre per year through N fixation. In mixed swards, legumes benefit grasses by transferring N from the legumes to grasses. Very little N is transferred from living legumes directly to grasses. Grasses primarily benefit from N fixed by legumes through turnover of the N when the legumes decompose. This includes decomposition
of unused forage tissues, decay of old roots and excreta return of N from legumes ingested by livestock. This means that the productivity of the mixed pasture should improve with time as a natural recycling process is established.

Using nitrogen to encourage fall versus spring growth of cool-season grasses

Applying nitrogen fertilizer will usually stimulate vegetative growth of cool-season grasses. Typically, grass growth will be greatest for 4 to 8 weeks immediately following an N fertilizer application. But applying N fertilizer at the wrong time of year creates more problems than it solves.

For years, many forage producers have applied 60 or more lb N/acre to grass pastures in early March. This amount of N fertilizer typically increases the supply of forage in spring by 20 to 60 percent. However, many farmers are not short of feed in the spring. In fact, most have excess feed during this period. Applying N fertilizer in the spring does not make much sense if you are already dealing with an oversupply of forage.

By far the most economical use of N fertilizer is to enhance fall growth for stockpiling. Almost all livestock producers are short of pasture during late fall and winter. Most are forced to feed hay to carry stock through the winter. Stockpiling can reduce these costs. Stockpiling takes advantage of the fall growth of cool-season grasses by applying N fertilizer in late summer and allowing growth to accumulate until a killing frost. Then the cows can graze the forage in the winter. The best way to stimulate stockpile growth is to remove accumulated summer growth in late July and then apply 40 to 60 lb N/acre in August. It is best to apply the N early in August to maximize the growth period prior to a killing frost.

Managing hay feeding to maximize nutrient return

Winter hay feeding can be a source of “fertilizer” if fed properly on pasture. A 1,000-lb bale of hay contains approximately 6 lb P2O5 and 25 lb K2O. If this is valued at 22 cents/lb P2O5 and 14 cents/lb K2O, the fertilizer value of hay fed on pasture is approximately $4/bale. Because animals excrete more than 60 percent of the P and K they consume in hay, these nutrients will be returned to the pasture. To maximize the nutrient benefit of hay feeding, producers must take care to regularly move feeding areas around pastures so that sod-trampling damage is reduced and returned nutrients are evenly distributed.

Remember that unless you feed hay on the same area where it was harvested, nutrients from one area of the farm are being mined while nutrients are being added where hay is fed. Hay fields will need to be fertilized to make up for this difference.

Purchasing manure as a pasture fertilizer

Manure can be an excellent inexpensive source of nutrients for pasture. Poultry litter and solid dairy manure can rapidly build up soil test P and K values on pastures. To maximize the value of this fertilizer source:

- Ask for the results of a manure analysis for the manure to be applied to a pasture.
- Assume P and K in the manure are equally available as with other fertilizer sources. Be aware that manure test results are sometimes reported as P and K while fertilizer requirement is reported as phosphate and potash. To convert: phosphate (P2O5) = P/0.44, and potash (K2O) = K/0.83.
- Contact your local University Outreach and Extension center or NRCS office for help in calculating the N availability of nitrogen in your manure source. All the N in the manure will not be available. Nitrogen in surface-applied manure may be only 60-percent available.
- Be sure manure is uniformly applied.

August is an excellent time to apply manure to pasture. The nutrients at that time promote fall growth while the potential for nutrient loss in runoff is low.

Managing pastures to improve water quality

Surface water quality

Nitrogen, phosphorus and potassium are required for growth by all animals and plants. Lack of these essential nutrients can restrict growth. Fertilizers containing nitrogen, phosphorus and potassium are applied to crops and forages to increase yield.

Similarly, nutrient levels in surface water often restrict the growth of aquatic plant and animal life.
In freshwater lakes and streams, phosphorus is typically the nutrient that most limits growth. Increasing the nutrients, particularly phosphorus and nitrogen, that are entering a stream or lake will increase the growth of aquatic plants and organisms. Although these nutrients are necessary, excessive levels overstimulate the lake or stream, which reduces the quality of the water. The progressive deterioration of water quality from overstimulation by nutrients is called eutrophication.

As nutrient concentrations increase, the process of eutrophication leads to a predictable reduction in water quality. Initially, increased nutrients will stimulate algae growth, which will reduce water clarity. Continued degradation of water by excess nutrients will reduce oxygen levels in the water, alter fisheries, lead to fish kills and reduce drinking water quality.

The majority of Missouri's dairies are located in the Ozark region of Missouri. The Ozarks are known for their clear streams and lakes. These clearwater lakes and streams are the most sensitive to increased nutrient concentrations. Small increases in phosphorus concentrations in these water bodies will dramatically reduce water clarity, which is a strong indicator of water quality for the general public. Increases in nutrient loads will impair water quality in other parts of the state, but changes will be less dramatic in these murkier waters.

Once a lake has excess phosphorus, it takes time to improve water quality. Excess phosphorus cycles between the bottom sediments and the water long after the phosphorus source has been eliminated. Consequently, water quality efforts must focus on prevention.

Managing pastures to maintain and improve water quality

Agriculture contributes to surface water quality problems through the nutrients carried in the runoff from fields. As runoff water passes over the soil surface, it picks up nutrients and soil particles and carries them into lakes and streams. This process is classified as nonpoint source pollution because it is delivered in the runoff from all the water reaching the stream from a watershed instead of being concentrated at one point, which would be the case with a discharge pipe from a sewage treatment plant. Nonpoint pollution from agriculture is now considered one of the leading causes of water pollution by the U.S. Environmental Protection Agency.

Pasture systems can be among the most benign agricultural systems in their impact on water quality. Well-managed pastures reduce the quantity of runoff from a field and the nutrient concentration in the water compared to row crop ground. A healthy stand of forage provides year-round protection from soil erosion; soil particles carry large amounts of nutrients to the soil. Forage systems promote water infiltration into the soil, which reduces the quantity of runoff and thus reduces the load of nutrient reaching the stream or lake. The extensive network of roots combined with a long growing season traps nutrients in the soil, which reduces the potential for leaching of nutrients through the soil.

However, mismanagement of pasture systems can result in high losses of nutrients and soil to lakes and streams. Overgrazing and poor-quality pastures can promote erosion and runoff. Particularly damaging is overgrazing near the banks of streams and lakes. Runoff from feeding areas and other areas where animals congregate can carry high nutrient concentrations. An excessive buildup of nutrients in pastures will increase the concentration of nutrients in runoff. Manure applied to cold and frozen soils can support high nutrient concentrations in runoff; animals in pasture systems often are depositing nutrients on pastures through winter. The site of a defecation or urination event represents a dramatic overapplication of nutrients in a small, localized area. Finally, many of our pasture systems are located on marginal agricultural land prone to erosion and higher rates of runoff.

The losses of nutrients from pastures are small compared to the quantities of fertilizer added to these systems. For example, phosphorus losses often are less than 1 lb/acre, an agronomically insignificant rate. However, these losses from many fields in a watershed combine to create a significant load to a downstream water body. Therefore, losses that have no agronomic importance can have a negative impact on water quality.

Stewards of pasture systems have many tools to minimize nutrient losses from their fields. They must effectively use these tools to successfully minimize the effect of grazing on water quality. The objective of this section is to highlight management practices that reduce potential losses from pastures to streams.
Prevent erosion and reduce runoff

The primary benefit of pasture systems is they maintain an actively growing ground cover through most of the year. Continuous ground cover of the forage combined with the high root density in the sod acts to protect the soil from erosion.

The leaves protect the soil from the impact of raindrops, which can dislodge soil particles. The dense plant community also slows the movement of runoff water over the surface of the soil, which reduces its erosive power and increases the opportunity for infiltration. The roots protect the soil from the erosive forces of water passing over the surface. The roots and lack of tillage promote a highly developed soil structure that promotes infiltration.

Management practices that damage a forage stand will promote greater losses through greater runoff volume, greater energy in the runoff and greater erosion. These practices include:

1. Overgrazing: Overgrazing reduces stand vigor and plant persistence, which causes thinner stands and less ground cover.
2. Poor soil fertility management: Soils with low pH or nutrient levels have lower persistence and vigor of forages, which leads to reduced ground cover. Low-fertility pastures are easier to overgraze.
3. Excessive traffic, particularly on saturated soils: Hoof action of animals will damage plants and pulverize soil structure on saturated soils. This will thin ground cover and reduce infiltration.

Protect water quality by maintaining sward health. To maximize the protective properties of the forage stand, maintain a well-balanced soil fertility program combined with the correct rotation of pastures to minimize overgrazing and allow sufficient regrowth periods.

Protect riparian zones along the edges of lakes and streams

Riparian zones are vegetative areas immediately adjacent to the edge of a lake or stream. This 15- to 60-foot wide buffer zone plays an important role in protecting water quality. Plant cover in this zone stabilizes stream banks and filters water, which reduces the quantity of soil particulates that enter the stream or lake.

Animals can damage riparian zones by over- grazing and by damaging stream banks with hoof traffic. Damage to this zone is particularly detrimental because it eliminates the protective zone from the edge of the stream and because elevated losses from the riparian zone are moved directly into the stream or lake.

Protect riparian zones by carefully managing grazing along stream and lake edges. Short, intensive grazing periods with sufficient recovery periods maintain strong forage communities along stream banks. Fencing animals out of streams is the ultimate method of protecting riparian zones.

Animals will inevitably damage stream banks when accessing drinking water in streams and lakes. Alternative water sources or construction of controlled entry and access points to streams and lakes will minimize damage on the banks.

One symbol of the negative impact of agriculture on water quality is the image of cattle defecating directly into a stream or lake. Total phosphorus content deposited by the cow is approximately 0.01 lb per defecation. Studies of simulated rainfall events estimate runoff from forage systems can contain 0.01 to 0.33 lb P in a single rainfall event. The phosphorus added to the water when a cow defecates directly into the water can be equivalent to the P load from 1 acre of land in one runoff event.

Manage winter feeding areas

Winter feeding areas concentrate nutrients and animal activity in a limited area; this increases the potential for nutrient losses to lakes and streams. Nutrients from imported hay and concentrates fed in the milking parlor are deposited in the limited area used by the animals in winter. Soils in winter often are wet or saturated, so animal activity often damages the stand and soil structure. Soils also are frozen or cold, which promotes runoff and slows the incorporation of added nutrients into forms less available for loss in runoff. Late fall and/or early spring are the periods of the year runoff is most likely to occur. Consequently, winter feeding areas create the potential for high concentrations of nutrients in runoff during times when runoff is likely to occur.

Winter feeding should only be done on pastures where runoff potential is low. Move the placement of bales around the pasture to spread nutrients around the field and minimize animal traffic in any specific area. Consider developing a confined area designed specifically for winter feeding. The
area can be designed to carry animal traffic in winter and collect and store manure until it can be applied at a more appropriate time of the year.

Prevent excessive buildup of nutrients in soil

As soil test levels increase, the concentration in the runoff water from the field also increases. Managing pastures to limit excessive buildup of soil test P will improve water quality.

Dairies have the potential to increase soil test phosphorus through grazing activities if they feed high amounts of concentrates and feed additives (Table 10.1). Fields with a long history of manure application usually have high soil test levels. The following activities will minimize the buildup of soil test phosphorus on pastures.

1. Do not overfeed nutrients to cattle. Excess nutrients fed to cows pass through the animal into the manure. On farms with excessive nutrient levels, overfeeding nitrogen and phosphorus adds unneeded nutrients into the manure, which exacerbates the problem. Surveys in Wisconsin show most dairy rations are significantly above the optimum phosphorus concentration for milk production. Every 0.1-percent increase in phosphorus concentration above the animal’s need increases phosphate excreted by 40 lb.

2. Rotate areas used for winter grazing or receiving the highest intensity grazing.

These areas are likely to be receiving more nutrients than are removed in a year. Focus winter grazing and high-intensity grazing on fields that would benefit from increased fertility levels.

3. Minimize potential for runoff on fields with high soil test phosphorus. Reducing the potential for runoff from the fields can reduce the effects of elevated soil test phosphorus levels on surface water quality. High soil test phosphorus only reduces water quality if runoff reaches a stream from the field. Avoid building soil test phosphorus levels on fields prone to high runoff and erosion rates.

Summary

- Nutrient flow in dairy pastures differs from nutrient flow in many other agricultural fields. Some fields may accumulate nutrients from grazing activities. Understanding the sources of nutrients for each field will help identify the fields with the greatest need or greatest excess of nutrients.
- Cows are fertilizer applicators in grazing systems. Increasing grazing intensity helps cows more uniformly distribute manure around the pastures.
- Runoff from agricultural fields is a major contributor to water pollution in many lakes and streams. Mismanagement dramatically increases the loss of nutrients from agricultural systems.