

## **ESTIMATING FEEDLOT NUTRIENT BUDGETS AND MANAGING MANURE OUTPUT**

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### **INTRODUCTION**

More than ever before, cattle feeders need to be concerned with manure outputs and waste management of their feedlots. Manure and waste management have become increasingly more important for producers due to pressures from governmental agencies, environmental groups and the fact that responsible use of the environment is vital to the future of agriculture. Cattle feeders realize the importance of responsible manure management and utilization, not only from an environmental standpoint, but one of economics. Minimizing manure output reduces costs of handling manure and, furthermore, if minimizing output means reducing inputs, they can further realize cost savings.

The use of nutrient cycles and balances has gained a lot of attention in the recent years. By better balancing nutrient flow through the whole farming enterprise, cattle feeders may be able to reduce the need for importing nutrients such as nitrogen (N) and phosphorus (P). Better management of nutrients can have benefits beyond that of reducing waste, it can also reduce feed input costs and make better use of manure nutrients for crop production. Consequently, nutrient cycles and nutrient balances need to be developed for the whole farming enterprise. When developing a whole enterprise nutrient balance, producers need to consider the following: nutrient imports to animal system, nutrients excreted by animals, nutrient removal by plants, and potential losses of nutrients within the manure management system. Keeping these factors in mind, producers can begin to better understand the whole cycle of nutrients through the enterprise, rather than concentrating solely on what is leaving the feedlot.

Nitrogen and phosphorus are usually the two nutrients of greatest concern when dealing with feedlot waste. Fortunately, both N and P can be successfully managed and are valuable nutrients that can be used in crop production. However, they can also be detrimental to the environment if not managed properly. Run-off of nutrients from the feedlot and after application to crop land can end up in surface and ground water at which time it becomes a pollutant. Cattle feeders must also be concerned with other potential pollutants such as salts, volatile solids and odors. This paper will focus on ways cattle feeders can minimize, measure, manage and control N and P as these nutrients move through the cycle in a cattle feeding operation.

### **NUTRIENT BUDGETS**

The amount of N and P excreted by finishing cattle is very difficult to estimate. Diet composition and diet digestibility, among many other things, can play a large role on excretory concentrations. Midwest Plan Services (MWPS-18) reports that a 1,000-lb feeder produces approximately 0.34 lb N and .11 lb P/day. These estimates were averages taken for a range of cattle operations with various nutrition and management practices prior to 1985. To effectively manage nutrients moving through the feedlot, cattle feeders must accurately estimate the amounts of nutrients being excreted, considering factors such as diet nutrients and digestibility of the cattle fed. It is essential to estimate nutrients that are actually excreted by the animal and not be limited to what is removed from the lot at cleaning to account for the losses that occur between excretion and removal of nutrients. Cattle feeders can easily estimate nutrient excretion by simply taking the nutrient content of gain by cattle removed from the feedlot and subtracting it from the

total nutrient content of the feed supplied to get a yearly manure nutrient output of a feedlot (Van Horn et al., 1996). A key step in estimating nutrient budgets in this manner is to keep concise records of nutrient intakes and performance. This will help to accurately estimate nutrients going in, retained nutrients (those deposited in cattle tissues), and nutrients leaving the system. Estimating nutrient excretion in this manner is more accurate for budgeting purposes than extrapolation of a single daily excretion estimate based on body weight gain that does not consider diet composition, diet intake or performance. By determining nutrient excretion of cattle, producers can accurately account for the nutrients that are going through the operation. This can be very beneficial when estimating the amount of volatilization and run-off in a particular lot.

Once nutrient excretion by cattle in the feedlot is determined, there are several other factors that must be determined when considering the total nutrient budget of the feedlot. Producers that use bedding materials need to accurately determine how much is being used and what the nutrient content of the bedding material is. Using bedding material adds nutrients to the manure and needs to be considered when evaluating nutrient budgets.

Finally, sampling manure at cleaning of pens can help determine what is actually being removed from the lot and being applied as fertilizer to cropland. It may seem easier to simply measure the nutrients in the manure going out; however, this does not take into account the nutrients lost to volatilization or run-off, which is critical in determining the total budget.

## **MINIMIZING NITROGEN AND PHOSPHOROUS EXCRETION**

For years many researchers have explored ways to best handle livestock waste and waste nutrients while controlling run-off and pollution. However, it is often overlooked that the first step in a successful manure management system is to reduce the amount of nutrients or waste being excreted. Reducing dietary excesses, where they exist, is the easiest way to reduce nutrients in feedlot manure. Nutritionists should balance diets to meet minimum nutritional requirements without supplying in excess. Watts et al. (1994) reported that feedlot operators were feeding P concentrations such that excretion per steer would amount to 20 kg P/year, whereas feeding NRC (1984) recommended concentrations would have limited P excretion to about 7 kg/steer/year. Feeding minerals at concentrations that closely match animal requirements can help prevent excess excretion of nutrients in feedlots.

Additionally, mineral availability influences utilization and, therefore, excretion. Feedstuffs vary in availability of P, increasing maturity of some forages may result in reduced P availability (Valdivia et al., 1982), thereby increasing P excretion. By careful selection of feed ingredients, feedlot operators may be able to both reduce nutrient inputs while at the same reduce excretion. Feed additives that increase production efficiency may also have a positive effect on reducing nutrient excretion. Lewis and O'Beirne (1994) calculated that each unit of fossil fuel used in the production of an antibiotic used in the feed of broiler chickens, pigs, beef or dairy cattle, saved between 6 to 50 units of fossil energy, depending on application. Ionophore use has been shown to significantly reduce P excretion (Kirk et al., 1985; Spears, 1990), although any effect on P requirement has apparently not been investigated.

Proper balancing of rations for crude protein (CP) needs can greatly reduce N output. Van Horn et al. (1996) showed that simply balancing the ruminally degradable and undegradable protein could be expected to reduce N excretion by about 15% in dairy cattle when compared with cows fed diets based on NRC (1989) CP standards. Erickson et al. (1998) reported similar findings when applying NRC (1996) requirements to balancing finishing steer diets. They fed a control diet containing 13.5% CP and .354% P, and a diet balanced to NRC (1996) recommendations containing 11.5% CP and .22% P. Nitrogen and P intake was obviously reduced in steers fed the balanced diet; however, since performance was similar in both diets, N and P retention was also similar. With reduced intake of N and P and similar retention,

excretion of each from steers fed the balanced diet was reduced. Calculated N excretion was reduced from .5 to .42 lb/head/day and P excretion was reduced from .08 to .04 lb/head/day.

Tables 1 and 2 show theoretical N and P outputs at various concentrations of protein and P intake. Diets containing more than 10.0% CP for 3.1 lb average daily gain (ADG), 10.4% CP for 3.3 lb ADG, or 10.8% CP for 3.6 lb ADG would result in increased N excretion without additional improvements in performance. Diets containing more than .2% P for 3.1, 3.3 or 3.6 lb ADG would result in increased P excretion without additional improvements in performance. Feedlot nutritionists may apply the same concept to accurately meet protein and P needs of cattle without supplying excess or sacrificing animal performance.

Feedlot operators should recognize that different dietary ingredients affect manure N and P output. Low roughage diets, because of their high digestibility, should reduce N and P output. Calculated N and P excretion by steers fed diets containing 42% wet corn gluten feed (dry matter basis), 7.5% roughage (5% corn silage and 5% alfalfa hay, dry matter basis) or no roughage were: .47, .08; .41, .05; .38, .05 lb/head/day, respectively (Bierman et al., 1996).

Feedlot operators may find nutritional management as the easiest and most economical step in balancing nutrients in the operations. Selection of feed ingredients, ration balancing for critical amounts of nutrients and use of performance and feed efficiency-enhancing products all play an important role in reducing nutrient excretion. Meeting proper nutritional needs without supplying nutrients in excess will not only reduce output but can considerably save on inputs.

Table 1. Calculated nitrogen excretion of feedlot steers.<sup>a</sup>

Diet characteristics		ADG, lb/day		
		3.1	3.3	3.6
		Nitrogen retention, lb/day <sup>b</sup>		
		.059	.064	.070
		Nitrogen excretion, lb/day <sup>c</sup>		
CP, %	CP intake, lb/day	.309	.304	.298
9.6	2.3	<b>.325<sup>d</sup></b>	.320	.314
10.0	2.4	.341	<b>.336<sup>d</sup></b>	.330
10.4	2.5	.357	.352	<b>.346<sup>d</sup></b>
10.8	2.6			

<sup>a</sup> Finishing phase for steers from 700 to 1,200 lb with DM intake of 24 lb.

<sup>b</sup> Nitrogen retention based on ADG and NRC (1996) equation for retained energy and retained protein.

<sup>c</sup> Nitrogen excretion calculated as intake minus retention.

<sup>d</sup> Indicates diet meets N requirement; this would be the minimum N excretion if diet was balanced for N.

Table 2. Calculated phosphorus excretion of feedlot steers.<sup>a</sup>

Diet characteristics		ADG, lb/day		
		3.1	3.3	3.6
		Phosphorus retention, lb/day <sup>b</sup>		
		.015	.016	.017
Phosphorus, %	Phosphorus intake, lb/day	Phosphorus excretion, lb/day <sup>c</sup>		
.2	.048	<b>.033</b> <sup>d</sup>	<b>.032</b> <sup>d</sup>	<b>.031</b> <sup>d</sup>
.3	.072	.057	.056	.055
.4	.096	.081	.080	.079

<sup>a</sup> Finishing phase for steers from 700 to 1,200 lb with DM intake of 24 lb/head/day.

<sup>b</sup> Phosphorus retention based on ADG and NRC (1996) equation for retained protein, 3.9 g P/100 g protein gain.

<sup>c</sup> Phosphorus excretion calculated as intake minus retention.

<sup>d</sup> Indicates diet meets P requirements; this would be the minimum P excretion if diet was balanced for P.

## THE FATE OF EXCRETED NITROGEN AND PHOSPHOROUS

It is only realistic that we cannot balance rations to the animal's exact nutritional needs. Therefore, we will most likely need to feed excess nutrients to ensure animal performance. As responsible producers, we must properly handle nutrients that are excreted. In order to do this, one must understand what happens to the nutrients within the manure from the time of excretion to the time of application in the field.

### Nitrogen

Nitrogen loss from the feedlot surface is highly likely and variable. There are numerous ways N may be lost; however, the two most probable ways are leaching and ammonia volatilization. Power et al. (1994) estimated that as much as 50% of the N deposited on feedlots may be lost as ammonia. The major source of ammonia is urea from urine, which can easily be converted to NH<sub>3</sub>, a gas. Urea may account for 40% to more than 50% of N excreted in manure, therefore it has a potential for rapid loss. The volatilization of N as ammonia depends on temperature, moisture content, pH, air movement and other factors. Loss of N through volatilization of ammonia lowers the nutrient value of the manure and increases amounts lost to the environment. The amount of N lost can vary with waste management systems. Table 3 shows estimated N loss for typical manure handling facilities according to MWPS-18. Ammonia is soluble in water, which could be a potential threat if feedlot run-off comes in contact with surface or ground water. Leaching of N is another potential for loss, N in the form of nitrate is negatively charged, so are soil particles. Negative charges repel each other therefore nitrate does not attach to the soil, nitrate N can then be easily washed through the soil and into ground water; this is particularly of concern in sandy soils.

Table 3. Estimated nitrogen losses from different beef cattle waste management systems (MWPS-18).

System	Nitrogen loss, %
Open lot - unpaved mounds	40 to 60
Open lot - paved (scraped regularly)	10
Open lot (daily haul)	15 to 35
Stacks, bunkers, bedding packs	20 to 40
Earthen pit	20 to 40
Above ground storage	10 to 30
Anaerobic lagoon	79 to 80

### Phosphorous

Once excreted, P is fairly stable. The usual path of P loss is through run-off. Unlike nitrates, P has a positive charge and therefore attaches to soil particles, posing a problem if soil particle should carry into surface water. Phosphorous is usually the limiting nutrient in most aquatic systems; therefore, adding P increases plant growth. With increased plant growth and subsequent death and decay, the oxygen supply of the body of water decreases; thereby, reducing the number and species of fish it can support.

Cattle feeders must also be sure that they have adequate land available for application of nutrients leaving the feedlot. For producers who also raise crops this is usually not a problem; for those who do not raise their crops, it is essential to find adequate land to spread feedlot manure. It is also essential to properly apply the manure at rates that agronomically correct and in a manner that minimizes further nutrient loss.

### BEDDING

Cattle feeders in the upper Midwest often need to use bedding materials in the feedlot. Bedding materials add to the total nutrient balance of the feedlot and therefore must be considered when calculating the total nutrient balance. Bedding materials vary widely in the nutrient content; producers need to know the nutrient value and quantity of the bedding materials added to the feedlot. Table 4 gives some reference values for N and P in various bedding materials. Bedding use also varies between feedlots because of animal type, density, feedlot design, bedding material and precipitation; therefore, it is difficult to give estimates of general use rates. Producers can accurately estimate bedding inputs by keeping records of bedding used in their operations and sampling bedding material for N and P.

Table 4. Nitrogen and phosphorus concentrations in bedding materials.

Bedding material	Nitrogen, %	Phosphorus, %
Cornstalks <sup>a</sup>	.68	.14
MSW compost <sup>a</sup>	1.0	.29
Oat straw <sup>b</sup>	.70	.06

<sup>a</sup> Based on research conducted at the University of Minnesota.

<sup>b</sup> NRC, 1996.

## SUMMARY

Proper nutrient management is not always at the forefront of producer's minds. However, with pressure from legislature and environmental groups, nutrient budgeting is fast becoming a necessity rather than a luxury. Proper nutrient management is and must be perceived as a win-win situation for all involved; it assures environmental stability of agricultural land and can also save producers both time and money. With additional and more accurate information available about nutrient needs and nutrient excretion, it is becoming easier and more convenient for producers to manage nutrients through their feeding operations.

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