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Nebraska's Manure Resource

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Manure is a valuable resource that is sometimes perceived as a liability. For centuries, manure has provided needed nutrients which increased and stabilized food production. With the advent of inorganic chemical fertilizers, the value of manure as a nutrient source decreased because hauling and spreading costs were higher than the cost of chemical fertilizers. In addition, the water content of manure is high and even when the water is removed, its nutrient content is low compared to chemical fertilizers. Therefore, manure has often been viewed in American agriculture as a "waste" to be disposed of rather than a resource to be used.

Another important factor affecting the use of manure as a fertilizer resource is the increased animal number and concentration of animals in feedlots and confined housing. Livestock concentration generates large amounts of manure in very small areas, which increases the need for large areas of cropland near confinement facilities for utilization at crop recommended rates. This increases the distance for hauling and hauling costs. Therefore, manure is often viewed as a waste and in order to reduce cost, it has been land applied at disposal rates rather than crop utilization rates. This has resulted in environmental concerns over potential contamination of both surface and groundwater supplies.

How Much Manure?

Manure is produced by cattle, hogs, dairy cows, turkeys, chickens for eggs and meat, and to a lesser extent, sheep, horses, people and even fish and pets *(Table I)*. The largest manure source are the cattle and hog operations which represent 94 percent of the manure produced in the state.

Cattle on feed increased from about 200,000 in 1940 to over 2 million presently *(Figure 1)*. Hog population has also doubled to over 4 million in this period. Nebraska ranks first or second with Texas in numbers of cattle on feed and fourth in hog production. Because essentially all the increased production has been in confinement, the manure disposal problem has also greatly increased.

To put the magnitude of animal manure in perspective with our human population *(Table I)*, animal manure production in Nebraska approximately equals that produced by a human population

Table I. Approximate amounts of fresh manure from confined animal populations produced annually in Nebraska.†

Kind	*Animal numbers (thousands)*	*Assumed animal weight (pounds)*	*Manure produced tons/yr (thousands)*	*% of total production*
Cattle on feed	2,100	800	18,480	66.7
Swine	4,200	150	7,560	27.3
Chickens (layers)	7,800	4	312	1.1
Turkeys	2,500	12	330	1.2
Dairy Cows	104	1,200	187	0.7
People‡	1,500	—	822	3.0
Total			**27,691**	**100.0**

†Feces plus urine
‡Based on 3.0 lb/day excretion (fresh weight) only - does not include garbage disposal and other municipal industrial wastes that are processed in municipal waste systems.

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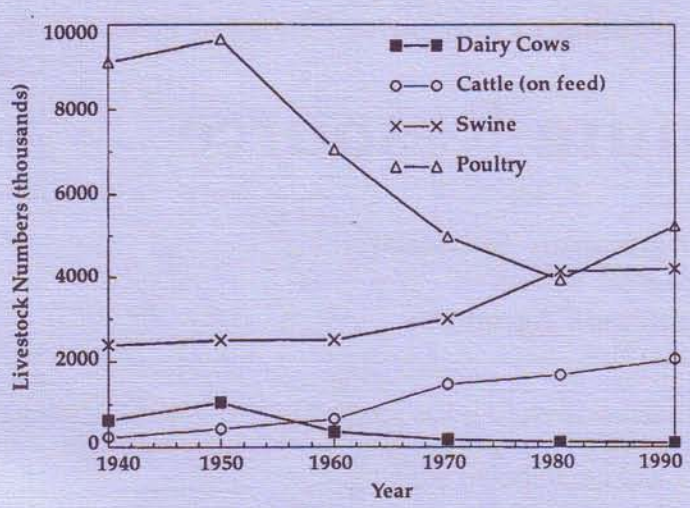

Figure 1. Livestock numbers in Nebraska from 1940 to 1990.

of 40 million — the combined population of New York City, Los Angeles, Chicago, Philadelphia, Detroit, San Francisco and Washington DC metropolitan areas. Our 1.6 million people in Nebraska produce about 3 percent of our total manure resource. This is not to infer that the municipal waste disposal problems are small. The economic impact of processing and distributing municipal wastes are much greater than for animal wastes because municipal wastes must be extensively processed prior to land application.

Livestock excretion varies greatly because of factors such as: kind of livestock, size, age, growth rates and whether pregnant or producing milk. Ration composition also greatly affects manure water and nutrient content. For example, beef cattle in a feedlot excrete about 47 pounds of fresh manure daily (800 pound animal) compared to about 11 pounds for a 400-pound gestating sow or 130 pounds for a 1300-pound lactating dairy cow.

How much Nitrogen and Phosphorus?

A 1,000-pound cow produces manure containing about 124 pounds nitrogen and 35 pounds phosphorus per year. Hogs produce about 29 pounds nitrogen and 11 pounds phosphorus per animal per year. Given the livestock population in Nebraska, this amounts to enough nitrogen to fertilize about 2.5 million acres of irrigated corn with 150 pounds nitrogen/acre or about one-half of Nebraska's irrigated corn production. If applied at removal rates for phosphorus, Nebraska's manure resource from cattle and hogs alone would fertilize about 70 percent of the irrigated corn acreage. However, it is important to understand that the nutrient composition of manure is extremely variable, depending on class, species, weight and age of livestock, ration fed, environmental conditions of the animal, manure handling and storage conditions, and water content of the manure.

As shown in *Table II*, nitrogen content of beef cattle manure, when expressed on a dry weight basis, can range from 0.55 to 4 percent (0.11 to 0.8 percent fresh weight basis at 80 percent water content). Therefore, it is extremely important to know both the nitrogen content and water content of manure to accurately calculate manure nutrient content. In addition to the extreme variability in composition resulting from factors mentioned above, it is common for beef feedlot manure to lose 50 percent of its nitrogen by volatilization before it is removed from the feedlot. Therefore, it is essential to know if nutrient composition represents fresh manure as excreted, fresh manure expressed on a dry weight basis, or manure as removed from the feedlot or storage.

Table II. Nutrient concentrations of beef feedlot manure on dry weight basis.

Nutrient	*Concentration*	
	Range	*Average*
	%	
Nitrogen	0.55 - 4.00	1.90
Phosphorus	0.12 - 1.60	0.65
Potassium	0.29 - 3.20	2.00
Calcium	0.17 - 3.60	1.30
Magnesium	0.19 - 1.50	0.69
Sodium	0.10 - 2.80	0.74
Iron	0.12 - 1.25	0.56
Zinc	0.001 - 0.014	0.008
Copper	0.0001 - 0.003	0.002
Manganese	0.006 - 0.115	0.038
Boron	0.014	0.014
Chlorine	1.4	1.4
Sulfur	0.5	0.5
Cadmium	0.0002	0.0002
Aluminum	0.52	0.52
Lithium	0.0009	0.0009
Lead	0.0002	0.0002

For useful calculations, one needs real values of manure composition. Average values may be in error by a factor of two to five or higher. Therefore, results from calculations using average values (as in this bulletin) may be greatly different than for a specific situation.

Obviously Nebraska's nitrogen and phosphorus resource in manure is sizeable. Actually cattle and hog manure produced each year would cover approximately 30 square miles (almost one township) to a depth of one foot. From an environmental viewpoint, however, distribution of this manure is of great importance and, if it is to be used as a resource, the amount of crop acres available to utilize the nitrogen

Table VI. Value of manure based on nitrogen and phosphorus content for the eight counties in Nebraska with the highest animal numbers (cattle and hogs) assuming 50 percent loss of nitrogen (N) and 10 percent loss in phosphorus (P) ($.12/lb N and $.46/lb P).

County	*Value of Manure*	
	$ per acre	*Total for county*
		million $
Wheeler	67	2.3
Cuming	35	5.4
Scotts Bluff	31	2.9
Dawson	20	4.0
Stanton	17	1.5
Colfax	14	1.7
Clay	11	2.2
Knox	11	1.4

Nebraska total = $23 million for nitrogen and $50 million for phosphorus ($8.56/acre average).

percent nitrogen loss of the ammonium nitrogen occurs, the value of the nitrogen would decrease about 20 percent.

How well is manure utilized in Nebraska?

It is not known what percent of Nebraska's manure resource is presently being applied at crop utilization rates and according to soil-test determined crop requirements. However, all crop acres in several counties would have to receive manure in order to use the manure effectively as a fertilizer resource and a few counties would have to export manure or use it on grassland. While many livestock producers use their manure effectively, many do not. Much manure has been distributed at disposal rates, which results in very high levels of available soil nitrogen and phosphorus. This nitrogen will probably eventually reach the groundwater unless it is utilized by crops. High soil phosphorus levels do not generally pose a problem to groundwater unless applied at high (disposal) rates for several years. When erosion and/or runoff occurs, excessive manure application rates can increase phosphorus content of surface waters, which increases potential for eutrophication of surface water.

Why isn't manure used more effectively?

The more important reasons are: 1) a lack of knowledge of the real value of manure; 2) a lack of adequate land restricts application; 3) animal numbers are so large that the costs of hauling are greater than the perceived value; 4) potential for introducing weed seeds unless manure is composted and 5) a lack of alternative economic uses for manure.

Lack of information on the real value of manure limits its use as a fertilizer. Precise predictions of mineralization rates of nitrogen and phosphorus and evaluating manure value as a soil tilth and physical conditioner are not widely available for most soils. Manure often cannot be sold as an economical alternative to easily applied commercial fertilizers without assessing its real value as an amendment. In evaluating economic value of manure, we must keep in mind that there is a cost associated with manure disposal by any means.

While studies evaluating the distance manure can be economically hauled are limited because of the lack of an adequate value determination, some studies using value only in terms of nitrogen, phosphorus and potassium content, indicate that manure can be hauled six to 9 miles from its source. Assuming 50 percent of the nitrogen in excreted manure is lost and only 50 percent of the land acres are cropped, it would require about 4.5 miles hauling distance for a beef feedlot of 40,000 head in order to find sufficient cropland for manure utilization at 125 pound nitrogen/acre *(Table VII)*. However, manure applied at 125 pounds nitrogen/acre would include 70 pounds phosphorus/acre, which is about three-times the grain removal rate in 120 bu/acre corn. This rate of manure application will increase soil available phosphorus and other nutrients very rapidly resulting in very high soil test levels. The long-term effect of very high soil phosphorus and

Table VII. Radial distance from the manure source required to haul manure to apply 125 pound nitrogen/acre assuming 50 percent loss of nitrogen from fresh manure for different size cattle feedlots.

Feedlot Capacity	*% of Land Area Receiving Manure*			
	100%		*50%*	
hd	*acres†*	*miles*	*acres*	*miles*
1,000	500	0.5	1,000	0.7
5,000	2,500	1.1	5,000	1.5
10,000	5,000	1.5	10,000	2.2
20,000	10,000	2.2	20,000	3.2
40,000	20,000	3.2	40,000	4.5

Phosphorus (P) applied, lbs P/acre/yr 70

†Nitrogen in manure applied at 125 lb/acre/yr

Table III. Nebraska counties with over 50,000 cattle on feed and 100,000 hogs showing the amount and manure nitrogen (N) and phosphorus (P) excreted each year per acre of cropland.

County	*Cattle*	*Amount of N and P in Manure*[1]	
		N	*P*
	(1000's)	lbs/acre of cropland/year	
		Cattle	
Cuming	180	143	40
Dawson	160	93	26
Wheeler	106 (estimated)[2]	363	104
Scotts Bluff	100	160	45
Phelps	88	46	13
Adams	66	37	10
Saunders	59	36	10
Clay	51	30	9
		Hogs	
Cuming	248	45	18
Holt	224	33	13
Clay	183	25	9
Platte	180	24	9
Cedar	168	33	12
Knox	144	32	12
Gage	130	33	12
Colfax	116	17	7
Boone	108	18	9
Fillmore	103	13	6

[1]Estimated amount of nitrogen and phosphorus available for application to each acre of corn, sorghum and wheat in the county assuming no nitrogen losses.
[2]Cattle numbers are not reported for Wheeler county. The numbers given were estimated from other counties.

and phosphorus in the manure needs to be determined.

Since cattle and hogs represent about 94 percent of the total manure producing capacity in Nebraska, distribution of these 2 animals is of primary importance. Of the two million cattle on feed, 40 percent are found in eight counties each with more than 50,000 head. Cuming county has the highest concentration with 180,000 head and Dawson county is second with 160,000 head *(Table III)*. Of the 4 million hogs in Nebraska, over 100,000 are found in each of 10 counties, representing 40 percent of the total hog population. Highest hog numbers are in Cuming and Holt counties with more than 200,000 head.

While animal numbers indicate total amount of manure available for application, some counties are more limited than others in available cropland for distribution. When the acres of corn, sorghum and wheat in each county (crops to which fertilizers are commonly applied) are compared to the amount of manure nitrogen and phosphorus that is available, Wheeler, Cuming, Scotts Bluff and Dawson counties all have enough manure nitrogen to apply over 100 pounds nitrogen per acre to all cropland in the county *(Tables III and IV)*. Wheeler county, because of high cattle numbers (106,000) and low crop acres (38,000), has 371 pounds nitrogen and 107 pounds phosphorus present in the manure for each cropland acre. With cattle and hogs combined, Cuming county also has nearly 200 pounds nitrogen and 60 pounds phosphorus available per cropping acre/year. Of course, manure could also be applied to grasslands, which are abundant in some of these counties, but returns would be less and manure may have undesirable effects on warm season grasses.

A major factor affecting the amount of nitrogen in manure is the losses from storage that generally occur from feedlots and confined housing. It has been determined that 15-60 percent of the nitrogen in manure is lost primarily as ammonia volatilization depending on the type of storage and method of handling. Up to 80 percent of the nitrogen in fresh manure may be lost from lagoons. Nitrogen losses also occur if manure is not incorporated soon after application (33 percent or more of the ammonium content when surface applied). Because of nitrogen losses from manure, nitrogen available for use in each county for land application can be reduced basically in half. However, this still leaves about 160, 95, 80 and 50 pounds nitrogen per each cropping acre in Wheeler, Cuming, Scotts Bluff and Dawson counties, respectively.

Table IV. Nebraska counties with more than 50 pounds nitrogen/acre produced in fresh manure from both cattle and hogs.

County	*Amount of Nitrogen (N) and Phosphorus (P) in Manure*[1]	
	N	*P*
	lbs/acre	
Wheeler	371	107
Cuming	188	58
Scotts Bluff	165	50
Dawson	106	31
Colfax	86	27
Stanton	76	24
Sioux	81	23
Morrill	64	19
Sarpy	64	14
Dixon	59	18
Clay	55	18
Knox	52	18
Holt	51	18

[1]Estimated amount of nitrogen and phosphorus produced per acre of corn, sorghum and wheat in the county assuming no nitrogen losses.

Phosphorus in manure is quite stable with perhaps 2 to 5 percent lost as runoff from open feedlots. Nearly all the phosphorus shown in *Table IV* is available for crops. Corn grain contains about 0.2 pounds of phosphorus in each bushel or 20 pounds phosphorus/acre for corn yielding 100 bushels/acre. Therefore, most of the counties shown in *Table IV* would have enough manure phosphorus to fertilize all of their crop acres, based on crop removal rates of phosphorus. Several counties would have manure available for export.

A major factor in using manures for crop fertilization is the cost of land application (especially of transport and uniform distribution on the land surface) as well as availability of land for manure application around feedlots. Fortunately in Nebraska, there is usually ample cultivated land within 5 to 10 miles of each feedlot to utilize all nutrients in the manure. Only in a few counties, as noted, is this a problem.

Value of Manure

A rough estimate of the potential value of manure can be calculated on the basis of its content of nitrogen, phosphorus and potassium. Since potassium is not generally deficient in Nebraska, the nitrogen and phosphorus content is of primary consideration *(Table V)*. However, if the soil does not require nutrients, then manure has no real value unless manure positively affects the soil's physical properties. Manure contains other valuable nutrients, especially zinc and sulfur and other minor nutrients,

Table V. Approximate nitrogen (N) and phosphorus (P) content of various animal manures at the time of application to the land (without bedding).

Type of Livestock	*N*	*P*
	lbs/ton	
Beef	21	6.1
Dairy	9	1.7
Swine	10	3.9
Poultry	33	20.9
Turkey	27	8.7
Sheep	18	4.8
Sludge (Lincoln)	15	15.8

which may be of value on some Nebraska soils. Manure does affect soil tilth, soil structure and bulk density, which may increase water infiltration and to some extent water holding capacity. Manure is also frequently used to enhance productivity of eroded and cut areas in a field and to control water and wind erosion. However, it is extremely difficult to put a value on these benefits of manure since its organic amendment value varies greatly depending on the soil — its organic matter content and textural/structural characteristics. This is why nitrogen and phosphorus content is primarily used to calculate a minimum value for manure. On some soils, the organic nature of manure may have value of two or even three times its nitrogen and phosphorus content. However, based on nitrogen and phosphorus content alone, several counties have manure values of $2 million or more, if the manure can be properly distributed and if valued at inorganic fertilizer prices *(Table VI)*.

Cuming county with its high cattle and hog numbers, has an estimated potential manure value of $5.4 million with Dawson county having $4 million. Statewide, even assuming a 50 percent loss of nitrogen (from the time of excretion) and a 10 percent loss of phosphorus, manure from cattle and hogs has a value equal to 34 percent of the nitrogen and phosphorus commercial fertilizers used in the state ($73 million manure value compared to $217 million nitrogen and phosphorus sales). These figures value fertilizer nitrogen and phosphorus at $0.12/pound nitrogen and $0.46/pound phosphorus, which are about equal to the last 10-year average, but well below 1995 prices, especially nitrogen.

Manure produced in Nebraska obviously is a very important resource if it can be distributed and largely incorporated, but distribution costs are substantial compared to commercial fertilizer and increases as hauling distance increases. However, economic studies indicate the value of nutrients in cattle manure may permit hauling distances of 5 to 10 miles. If the manure is surface applied and a 33

Table VIII. Radial distance from the manure source required to haul manure to apply 20 lbs Phosphorus/acre for different size cattle feedlots†.

Feedlot Capacity hd	% of Land Area Receiving Manure			
	100% of land		50% of land	
	acres*	miles	acres*	miles
1,000	1,750	0.9	3,500	1.3
5,000	8,750	2.1	17,500	3.0
10,000	17,500	3.0	35,000	4.2
20,000	35,000	4.2	70,000	5.9
40,000	70,000	5.9	140,000	8.3

†Nitrogen (N) applied assuming 50 percent nitrogen loss = 37 lbs N/acre/yr.

other nutrient levels are not known, but some regulations are being implemented in other states that would limit phosphorus application rates. If manure is to be applied at phosphorus removal rates, the distance for hauling increases to over eight miles which is probably near the limit for economical hauling *(Table VIII)*.

Future Implications

Nebraska is one of the top states in the US for feeding and growing livestock. Cash receipts in 1992 from livestock marketing in Nebraska was $5.7 billion. Much of our 800 million bushels of corn and 75 million bushels of grain sorghum is fed to livestock. About 80 percent of the nitrogen and nutrients in the grain passes through the livestock and into the manure, providing a fertilizer resource worth approximately $75 million in terms of 1993-94 commercial fertilizer nitrogen and phosphorus prices. This is about 35 percent of the money Nebraska farmers spend for fertilizers each year. Some estimate the real value of manure to be two or three times greater depending on the soil to which it is applied.

Others consider manure to have negative value and a waste that needs to be disposed of. Therefore, the most economical method of disposal has often been to simply allow it to accumulate in the feedlot area or apply it at disposal rates to nearby fields. This system of disposal may have helped provide the lowest possible meat cost to the consumer, but times have changed and these methods of disposal will soon be unacceptable. The public is now very concerned about the environment and the potential contamination of surface and groundwaters with manure and manure decomposition products. While livestock producers can in some instances market their manure in profitable niche markets, most livestock producers may have to assume that land application at crop requirement rates is a production cost. Unless fertilizer costs increase greatly, manure will continue to be a very excellent, but also at times an expensive nutrient source. It is expensive compared to commercial fertilizer, because its nutrient concentration is low and the spreading costs are high.

While small livestock producers have potential for polluting surface and groundwaters, most concern is concentrated on the large manure producers. In 1990, about 80 percent of the cattle were marketed from feedlots with greater than 1,000 head and over 40 percent were marketed from feedlots with more than 8,000 head.

While about 70 percent of the manure in Nebraska is associated with cattle on feed and 25 percent with confined hog production, other manures and/or organic wastes can also represent considerable local groundwater contamination risk if not adequately managed. For example, while only about 3 percent of the manure produced within the state comes from the human population primarily from Lincoln and Omaha, many millions of dollars are spent annually to treat and dispose of this material primarily by land application to crops.

How much manure contributes to nitrate contamination of surface and groundwater is not known, but the potential appears great considering the total amount of nitrogen and phosphorus that is being concentrated in the livestock feeding and growing areas as well as in our cities. From the viewpoint of the grain producer, the cost of adequately distributing this manure on a crop's need basis may well be in line with its benefits as a crop fertilizer. However, the costs for many livestock producers will increase since manure will need to be spread at rates to meet crop nutrient requirements in order to minimize environmental problems. Presently commercial fertilizers are often being purchased to replace the nutrients in manure that is not being returned to the soil. By failing to utilize the nutrients in manure, we are increasing the overall cost of animal production to society, especially if we consider the cost of cleaning up contaminated surface and groundwater.