Paper No. 994066
An ASAE Meeting Presentation

Marketing of Livestock Manure

by
Rick Koelsch, University of Nebraska, Biological Systems Engineering
Keith Glewen, University of Nebraska Cooperative Extension, Saunders County
Tom Trewhitt, Nebraska Department of Environmental Quality
Dan Walters, University of Nebraska, Department of Agronomy

Written for Presentation at the
1999 ASAE Annual International Meeting, Toronto, Canada
Sponsored by ASAE
July 19-21, 1999

Abstract:
Concentration of nutrients on many livestock operations is a growing environmental concern. Export of manure nutrients to off-farm users of manure provides an opportunity for addressing this environmental concern. This paper reports on two surveys designed to understand the critical issues involved in a successful management program for exporting manure.

A survey of Nebraska feedlots suggest that the majority of feedlots do not export manure to off-farm customers despite a common lack of land base for utilizing the nitrogen and phosphorus in manure. Only a small portion of the feedlots in Nebraska are actively marketing manure as a product with value. These individuals are packaging agronomic and nuisance avoidance services with the manure in an effort to enhance its value. Critical services designed to assist the crop producer in realizing the agronomic value of manure and avoiding community concerns with manure related nuisances were important to a successful manure marketing effort.

A separate survey of manure users suggests that the reason for purchasing manure was for its crop nutrient value. More than one third of the growers indicated that it improved yield performance. However, many users felt uncomfortable relying on the nutrients in manure and so supplemented the manure with commercial fertilizer. A need exists for improving crop producers' ability in determining the nutrient value of manure. The cost of application and the potential for soil compaction were the major factors limiting expanded markets for manure.

Keywords: Manure marketing, nutrient management

Marketing of Livestock Manure

Introduction

"Concentrated livestock enterprises" dominates the production of meat, milk, and eggs in the United States. These production systems have proven capable of producing a high quality, competitively priced product for national and international markets. These farms also provide substantial benefits to rural economies. However, these systems can be detrimental to the environment and quality of life of rural communities. The concentration of nutrients is a common environmental concern for many larger livestock operations.

Exporting of manure nutrients to off-farm users represents one potential practice for reducing the concentration of nutrients. A survey was designed and implemented to identify the practices of Nebraska feedlot managers to deliver manure to off-farm users of this by-product. In addition, a survey instrument was completed by users of Mead Cattle Company manure. This paper will review the findings of both surveys.

Definition of Issue

Livestock enterprises have undergone substantial structural change in recent years including the concentration of livestock and poultry industry into fewer farms (Council for Agricultural Science and Technology, 1996). A reduction in number of farms with cattle by 50% and farms with swine by 80% between 1965 and 1995 has occurred while numbers of hogs and cattle in inventory has stayed nearly constant (USDA, 1965-1995).

Agricultural production involves complex cyclical relationships between soil, water, crops, animals, and climate. The integration of manure into these cycles can impact the environment if not managed correctly. Livestock and poultry produces annually 3.2 million Mg (3.5 million tons) and 2.8 million Mg (3.1 million tons) of plant-available nitrogen and phosphorus, respectively, as collectible manure (Council for Agricultural Science and Technology, 1996). A GAO report (Lugar and Leahy, 1995) to the US Senate suggested that manure was the source of 37% of the total nitrogen and 65% of the total phosphorus inputs (including point sources, fertilizer, manure, and atmosphere) into watersheds in the central states. Livestock production can negatively impact surface water quality from pathogens, phosphorus, ammonia and organic matter, ground water quality from nitrate, soil quality from soluble salts, copper, arsenic, and zinc, and air quality from odors, dust, pests, and aerial pathogens (Council for Agricultural Science and Technology, 1996).

Achievement of a nutrient balance between nutrient inputs (feed, fertilizer, animals, and legumes) and managed outputs (crop and animal products) is key to minimizing the risk of environmental impact of livestock production (Frick, 1969; Aarts et al. 1992; Lanyon and Beegle, 1993; Klausner, 1995; Watts et al.; 1994). Nutrients brought onto the farm and not exported as managed outputs are either lost to the environment directly or added to nutrient reserves in the soil, increasing the risk for future environmental losses (Klausner, 1995). Thus, an imbalance of nutrients becomes a driving force behind the potential environmental risk from a livestock operation.

The imbalance between total nitrogen inputs and managed outputs was observed to be 59% to 79% for 17 New York dairies (Klausner, 1995). Watts et al. (1994) noted that between 36% and 66% of all imported phosphorus was retained within two Australian beef feedlots and supporting cropland

representing 39 Mg (43 tons) and 161 Mg (177 tons) of phosphorus added annually to the soil reserves. Koelsch and Lesoing (1998) observation of 33 Nebraska confinement operations suggest that a nitrogen imbalance existed on most operations and a phosphorus imbalance existed on the majority of operations.

One opportunity to improve nutrient balance is to export manure to off-farm users. This adds an additional output of nitrogen and phosphorus from a livestock operation and should contribute to a more favorable nutrient balance for the livestock farm. Exporting manure serves a similar function as expanding the crop land base and allows the opportunity for crop utilization of manure nutrients and reduced water quality risk.

The objectives of this study are as follows:

1. Summarize current practices on Nebraska cattle feedlots relative to exporting of manure to off-farm users.
2. Review of the perceived benefits and costs by neighboring crop producers who accept manure.
3. Identify innovative marketing and management strategies that encourage export of manure from concentrated livestock operations to off-farm users of manure.

Materials and Methods

To address these objectives, two surveys were conducted.

1. A mail survey with cover letter from the Nebraska Cattlemen was conducted of 210 feedlot owners using a mailing list from the Nebraska Cattlemen. Following the initial mailing, a postcard reminder was sent one week later and a copy of the survey and cover letter was sent two weeks later. A response rate of 117 of the original 210 (55%) surveys resulted.
2. A second mail survey was prepared for users of manure from a single large Nebraska feedlot. The survey instrument was mailed to 100 individuals. Similar methods were used for encouraging a higher rate of response. Sixty completed surveys were returned.

The following discussion summarizes the responses to individual questions. No statistical analysis of the data has been completed at this time.

Results...Manure Producer Survey

Characteristics of Surveyed Feedlots. The individuals responding to the survey were characteristic of the medium and large feedlots types found in Nebraska (Table 1). Outdoor feedlot or confinement building were the primary animal housing used by those surveyed (97%). On average, these operations maintained a one-time population of 5650 animal units (AU)[1] which were primarily finishing cattle. A few operations housed yearlings/calves and breeding stock in their feedlots. The average land base under the management of the operator was 535 hectare (1,323 acres) with a range of between 0 and 4000 hectare (10,000 acres).

Most feedlots less than 10,000 AU distributed manure over only part of the land that they owned or manage. On average, three quarters or more of the land under the farm's management did not receive

[1] Animal unit equals 454 kg (1000 lbs.) of live weight.

manure for those operations with less than 10,000 AU. Those over 10,000 AU utilized most of their available land for manure application on an annual basis. Although larger feedlots had a smaller total land base for manure application, they tended to use a similar land base for manure application per animal unit as the medium size farms. In addition, the larger lots were more likely to export manure to off-farm uses. These indicators would suggest that the manure from the largest feedlots (>10,000 AU) is typically spread at lower nutrient application rates than manure from the medium sized lots (1,000 to 10,000 AU).

Table 1. Characteristics of feedlots involved in survey.

Size of Livestock Operation	<1000 Animal Units (11 farms)	1000 - 4,999 Animal Units (52 farms)	5,000 - 10,000 Animal Units (27 farms)	>10,000 Animal Units (15 farms)
Average Size				
- Animal Units	581	2,635	6,944	17,517
- Cropland (hectares)	275	417	572	633
- AU/Hectare	2	6	12	28
Manure Distribution				
- % of Land Manured	24%	19%	26%	88%
- AU/Hectare Manured	9	33	47	31
Exporting Manure				
- % of total farms	9%	29%	41%	80%
- Do not export due to sufficient owned land.[1]	82%	60%	52%	20%

[1] Based upon livestock producer's judgment.

To provide sufficient land base for utilizing the nutrients in manure, a feedlot requires approximately one hectare of land per 15 AU (6 AU/acre) for nitrogen utilization and one hectare per 2.5 AU (1 AU/acre) for phosphorus utilization. Less than 10% of those surveyed had sufficient land to maintain a density of less than 2.5 AU per hectare. About half (54%) reported livestock to crop land density between 2.5 and 16 AU per hectare of crop land. More than one-third (36%) reported a density in excess of 15 AU per hectare and 1 in 5 maintained a density in excess of 50 AU per hectare (20 AU per acre).

Typically, those lots under 1,000 AU were likely to have access to sufficient land for meeting both nitrogen and phosphorus needs. Those farms between 1,000 and 10,000 animal units had sufficient land for utilizing the nitrogen. However, a comparison of animal units per cropland manured suggest that many may not be utilizing sufficient land for nitrogen management. These farms also lack sufficient land for managing phosphorus. The largest feedlots were short on land for both nitrogen and phosphorus management. Most of this group recognizes this concern as represented by 80% of these individuals exporting manure.

Regarding the export of manure nutrients to off-farm customers, 72 (64%) of the respondents said they did not export manure nutrients off-farm (Table 2). The most common reason for not exporting (89%) was the producer's perception that sufficient owned or managed land base for utilization of the manure was available. The next most common reason for not exporting manure off-farm (24%) was lack of time for exporting manure off-farm. Those farms that exported manure have, on average, 74 AU per available

crop hectare (30 AU per acre). Those who chose not to export manure averaged 17 animal units per available crop hectare (7 AU per acre).

Table 2. Likelihood that feedlots will export manure and reasons for not exporting manure.	
Yes, I currently export manure to off-farm users.	36%
No, I do not currently export manure to off-farm users.	64%
Reasons for not exporting manure:	
I have sufficient land for utilization.	89%
I do not have time for exporting manure.	24%
I don't know what value to charge for the sale of manure.	19%
I do not have equipment for transporting and spreading manure.	17%
There are no users for manure in my area.	10%
Other.	3%

Practices of Those Exporting Manure. Fifty producers provided information about their efforts to export feedlot manure to off-farm users. Crop producers (96%) were the primary user of exported manure. Approximately one-third of those surveyed were also exporting manure to other users including local homeowners, landscaping services, and businesses marketing gardening products.

The most common financial arrangements was to give manure away at no charge (54%) to at least some users (Table 3). More than half of producers were charging some or all customers for manure. The most common charge was per unit volume, weight, or load (30%). For those who charged for manure, a wide range of approaches for charging were reported (Table 4). Many producers combined a charge per unit volume or weight with a charge for application area or distance traveled. Very few producers charged for manure as an organic fertilizer with a charge based upon the nutrient content of the product.

Table 3. Common financial arrangement for transfer of manure to primary user.	
I pay users of manure to accept manure.	2%
I give manure away at no charge.	54%
I charge per unit volume, weight, or load.	30%
I charge per unit distance manure is hauled.	20%
I charge per unit of nutrients provided.	4%
I charge for specific services provided.	4%

Table 4. Common financial charges made for sale of feedlot manure.

Charge per unit volume, weight, or load
$1.1 to $2.2 per Mg ($1 to $2 per ton)...5 responses
$1.1 per Mg ($1 per ton) loading fee
$15 to 65 per load...3 responses

Charge per acres of application area
$62 per hectare ($25 per acre) for 22 Mg/h (10 ton/ac) application rate
$74 to $86/h ($30 to $35/ac)...2 responses

Combination Charges
$3.3 to $5.5/Mg ($3 to $5/t) plus $60 per hour for spreader
$11/Mg ($10/t) plus $10/ha ($4/acre) application area
$5/Mg ($4.5/ton) of compost plus hauling and spreading cost
$0.51/km/Mg ($0.75/mi/t) and $65 per load minimum
$5/ha ($2/ac) loading cost plus $1.3/Mg ($1.2/t)hauling cost plus $12/ha ($5/ac) application cost.

Charge per distance hauled
$2 per loaded mile

Manure Export Services Provided. The survey attempted to identify those services that were packaged with the export of manure to off-farm customers. At this time many producers do not offer any services to enhance the value of manure (Table 5). Of those exporting manure to off-farm users, 40% offered no agronomic services, 51% provided no nuisance avoidance services, and 70% offered no manure processing services.

However, there were a number of feedlots that offered services designed to enhance the value of manure. Most producers offered one or more agronomic services with manure sampling, measurement of manure application rate, and adjustment in application rate for individual crop and field conditions being the most common. Of those marketing manure, 12.5% provided one agronomic service, 12.5% provided two services, and 30% provided three or more services. To minimize nuisance issues, daytime application to avoid noise nuisance and setback distance were the most commonly reported efforts. Composting of manure was reported by almost one-quarter of the feedlots exporting manure. Most feedlots are providing those services with resources from within the feedlot and have not partnered with other businesses or individuals to export manure (90%). Two feedlots indicated that they were working with a crop consultants.

Table 5. Services provided with the export of manure by feedlot.

Agronomic Services		Nuisance Prevention Services	
No Services	40%	No services	51%
Manure sampling	38%	Daytime application to avoid noise nuisance	33%
Measure of application rate	38%	Maintain setback distances	19%
Adjustment of rate for individual fields/crops	31%	Advance notification of neighbors	9%
Soil testing	24%	Same day incorporation to avoid odor and fly nuisances	9%
Crop consulting services	20%	Morning manure application to limit odor	5%
Customer report of nutrient appl. rate	16%	Notification of local governments in advance of application	2%
Incorporation of manure within 24 hrs. to conserve ammonia	9%		
Deep tillage to address compaction from manure application	4%	**Manure Processing**	
		No Processing Services	70%
		Composting of manure	23%
		Supplement with commercial nutrients	5%

Environmental/Nuisance Problems Encountered. Most feedlots exporting manure (60%) have encountered some form of environmental or nuisance related concern. The three most common issues encountered were odors (28%), road traffic (26%), and road maintenance (24%). When asked who expressed these concerns, homeowners was the most common response. Forty-one percent of feedlots indicated that no one has raised concerns with them.

Composting is an effective practice used to minimize environmental nuisances associated with livestock manure. Ten feedlots indicated that composting was used for manure exported to off-farm users. Four and three of these responses indicated that odor and fly complaints, respectively, were encountered. However, other written comments suggested that composting had been very effective in minimizing nuisance concerns.

Experiences of most producers currently exporting manure to off-farm users has been sufficiently positive to warrant continuation of this practice. Eighty-three percent of feedlots currently exporting manure indicated they intend to continue or increase the marketing of manure despite recent changes in Department of Environmental Quality regulations. Of those feedlots not previously exporting manure, only 11% planned to begin this practice.

Many individuals shared their insights as to efforts that enhanced manure export including:

- "It has become a valuable product for farmers. I can usually get a lot hauled at another's expense." Similar comment shared by 9 feedlots.
- "Go the extra mile to establish good relationships with neighbors." The importance of community relations was shared by 5 feedlots.
- "Work very closely with the customer." Four feedlots stressed the importance of customer relations.
- "Provide as many services as possible to enhance the value of the manure being spread." Eight feedlots emphasized the importance of enhancing the value of manure with additional services.

Comments provided by those surveyed also highlighted issues that hampered the export of manure:

- "Most people look at manure as being a nuisance and don't want to pay anything for it." Cost and neighbor willingness to pay was a concern expressed by 7 feedlots.
- "Make sure transporting equipment is in tip-top shape. Manure spills or traffic accidents are very detrimental to public opinion." The importance of preventing public nuisance issues was stressed by seven feedlots.

Those surveyed identified three critical information needs related to establishing or maintaining a manure marketing program. The three highest priority information needs included 1) Avoidance of environmental/nuisance problems; 2) Estimating agronomically based manure application rates; and 3) Pricing of manure for competitive and profitable marketing of the manure resource.

Marketing of Manure as a Valued Product Approximately half of those feedlots who exported manure believed manure had sufficient value to warrant charging users for the product. Most were trying to recover some of the associated handling costs.

A small number of those responding were taking a more entrepreneurial approach and attempting to market the manure as a product with value. The marketing package assembled by three of these feedlots is summarized in Table 6. Each of these three feedlots assemble a package of agronomic services to help crop producers take advantage of the crop production value of manure. Some of the more common services offered included manure nutrient sampling, measurement of application rate, and adjustment of rate for individual situations. One feedlot provided a report to the crop producer of nutrient application rate while another included a soils testing service.

Some nuisance avoidance services was a common feature of these three highlighted feedlots. One feedlot relied on composting to limit those concerns and reported road traffic as the only nuisance issue that had been encountered to date. Properly composted feedlot manure should be free of odor and fly concerns. Another feedlot encountered the whole range of nuisance and environmental concerns raised by neighbors and local government. In response to these community concerns, this lot has assembled a package of nuisance avoidance services including advance notification of neighbors and county government of spreading plans and same day incorporation of manure to minimize exposure to odor and flies. Successful manure exporting programs should include an appropriate set of services designed to limit neighbor and community concerns.

Table 6. Summary of three feedlots effort to actively market manure as a valued product to off-farm users.

	Feedlot #1	Feedlot #2	Feedlot #3
Animal Capacity Crop Acres	4,500 head finishing capacity 140 hectares (340 acres)	20,000 head finishing capacity 800 hectares (2000 acres)	3,000 head finishing capacity 40 hectares (100 acres)
Users of Feedlot Manure Customers	Crop producers	Crop producers and landscaping services	Crop producers and landscaping services
Financial Arrangement	Charge per unit volume or load	$5/ha ($2/ac) loading cost + $1.3/Mg ($1.2/t)hauling cost + $12/ha ($5/ac) application cost.	$5/Mg ($4.5/ton) of compost + hauling and spreading cost
Who Transport Manure	Feedlot	Independent contractors	Feedlot
Services Provided Agronomic	Manure sampling, measured application rate, rate adjustment for individual field/crop, and customer report of nutrient application rate	Manure sampling, measured application rate, rate adjustment for individual field/crop, incorporation within 24 hours, and deep tillage for compaction.	Manure sampling, measured application rate, rate adjustment for individual field/crop, and soil sampling.
Nuisance Prevention and Manure Processing	Maintain setbacks	Advance notification of neighbors and local government, and same day incorporation.	Composting
Environmental/Nuisance Issues Concerns raised	None	Odors, flies, noise, surface and ground water quality, and road traffic and maintenance.	Road traffic
Source of concerns	No one	Homeowners, other farms, & government.	Homeowners
Lessons Learned and Advice for Others	- Manure applied to clay hills noticeably increases yields and helps control runoff. - Important to get manure tilled into soil soon as possible in spring when hauled in winter - Someone that has problems getting rid of manure should haul to neighbors for free 1 year to determine benefit. Following year may have good demand.	- Provide as many services as possible to enhance the value of manure being spread. - Make sure transporting equipment is in tip-top shape. - Manure spills are very detrimental to public opinion. - If you claim fertilizers nutrients in the manure - make sure they are in the manure.	- This is a composting operation that sells to local crop producers. After composting, we have had no negative reaction as to smell, flies, and pollution possibilities.

Results...Feedlot Manure Customer Survey

User Survey Background: A more in-depth review of the issues encountered by one feedlot involved in manure marketing (Feedlot #2, Table 6) was also conducted. For this livestock operation, less than 15% of the nitrogen and 10% of the phosphorus in the manure could be utilized within the cropping program on land owned by this business. Approximately 3,040 hectares (7,500 acres) of land would be required annually and 9,100 hectares (22,500) acres in a three year rotation to distribute the manure at agronomic rates.

The feedlot had implemented a rather ambitious manure marketing program. The feedlot markets a liquefied product from confinement barns that is trucked by tanker trailers to fields to be surfaced applied and deep chiseled into the soil. The majority of the fields receiving manure application (70%) were an average distance of ten miles or less and (7%) were a distance of fifteen miles or greater. The feedlot had encountered several obstacles with this effort. As part of a larger collaborative effort to understand these issues, a survey of the customers of this feedlot's manure was conducted. The results of this survey follows.

Manure Utilization Preferences: In a given year, respondents indicated that they applied Mead Cattle manure on an average of 103 acres. The most common application (83%) was made on fields following soybeans. Growers also noted that the most preferred crop to be grown following application was corn. A majority (69%) noted that they had used this product five years or less and survey results suggest that producers using Mead Cattle manure preferred that it be applied after harvest but before winter freeze. They also indicated that they preferred to apply it to land they owned versus land they rented.

The survey results showed that (37%) of the users indicated that it improved yield performance. While at the same time other reasons for purchasing Mead Cattle manure included: organic matter source, deep tillage when incorporated, and lower cost nutrient source. Forty-five percent of the users of Mead Cattle manure indicated that nitrogen was the primary nutrient of interest while 35% indicated that phosphorus was the primary nutrient.

Obstacles to Manure Sales: Manure was applied at a rate to meet crop nitrogen needs (based on irrigated corn production levels). An alarming 45% of the growers preferred annually to apply additional nitrogen as an insurance against late season deficiencies while 22% said they did occasionally. However, only 10% preferred to apply additional phosphorus. The largest percentage of respondents (43%) indicated that they annually use their crop consultant or fertilizer dealer to advise them on the need for supplemental nitrogen.

The unwillingness of crop producers to rely completely on manure as a nutrient source was partially explained by their reservations with manure. Lack of uniform manure coverage was a (58%) and variation in nutrient analysis from load to load (63%) were commonly expressed perceptions of these users. When users were asked the question, "What was the main reason that other farm operators do not purchase and use manure?", the largest concern was the cost of manure/application and the second highest response was soil compaction.

Nuisance issues was also of concern to many users. Concerning potential complaints from neighbors, 35% expressed a high level of concern. However, the recent level of neighbor complaints have been relatively low. Users of Mead Cattle manure (65%) indicated they did not receive any complaints from neighbors relative to spreading manure. Twenty-three percent indicated one complaint and 7% indicated multiple complaints. The source of these complaints were related to odors (38%), noise and traffic

(17%), and flies (10%). According to the responses, the majority of manure application were made within 400 to 1,600 meters (¼ to 1 mile) of a neighboring residence, business, or a public facility, 23% indicated 90 to 400 meters (300 feet to ¼ mile) and 23% noted an application was made less than 90 meters (300 feet).

Preferred Customer Services: When asked what services might be provided by Mead Cattle Company to minimize neighbor nuisance concerns, 60% of the respondents indicated same day incorporation of manure to limit odor and fly nuisances would be very effective. Twenty percent indicated they felt that notification of neighbors in advance of application would also be effective. When asked "What additional information or services are needed?", these customers suggested a need for manure analysis (65%), an estimate of manure nutrient availability (63%), and soil sampling (38%).

Conclusions

1. The majority of feedlots in the state-wide survey do not export manure to off-farm customers. However, most feedlots over 1000 AU lacked the land base to utilize the nitrogen and phosphorus in manure.

2. Approximately half of the feedlots in the state wide survey who export manure are charging for the manure or the services associated with its application. A wide range of pricing structures have been used to date.

3. Successful programs to export manure to off-farm users includes a package of supporting services. These services should be designed to assist the crop producer in realizing the agronomic value of manure and avoiding community concerns with manure related nuisances.

4. Only a small portion of the feedlots in Nebraska are actively marketing manure as a product with value. These individuals are packaging agronomic and nuisance avoidance services with the manure in an effort to enhance its value.

5. The majority feedlot manure users indicated that the reason for purchasing manure was for its crop nutrient value. More than one third of the growers indicated that it improved yield performance.

6. Many users felt uncomfortable relying on manure and so supplemented the manure with commercial fertilizer. Forty-five percent of users supplemented manure application (applied to meet crop nitrogen needs) with additional commercial nitrogen fertilizer.

7. The cost of application and the potential for soil compaction were the major factors in limiting the marketing of manure. The response from manure users would suggest that their level of concern about complaints and nuisances was a less critical factor limiting manure use.

References

Aarts, H. F. M., E. E. Biewinga, and H. Van Keulen. 1992. Dairy farming systems based on efficient nutrient management. Netherlands Journal of Agricultural Science. 40:285-299.

Council for Agricultural Science and Technology. 1996. Waste Management and Utilization in Food Production and Processing.

Frick, C. R. 1969. Water pollution potential estimated from farm nutrient budgets. Agronomy Journal. 61:550-553.

Klausner, S. 1995. Nutrient management: crop production and water quality. NYS Water Resources Institue at Cornell University. 40 pages.

Koelsch, R. K. and G. Lesoing. 1998. Nutrient balance on livestock confinement systems. Unpulished document submitted to Journal of Animal Science (fall, 1998).

Lanyon, L. E. and D. B. Beegle. 1993. A nutrient managment approach for Pennsylvania: plant nutrient stocks and flows. Penn State Agronomy Facts 38-B. 8 pages.

Lugar, R.G. and P.J. Leahy. 1995. Animal Agriculture. Information on Waste Management and Water Quality Issues. GAO Briefing Report to the Committee on Agriculture, Nutrition and Forestry, U.S. Senate.

U.S. Department of Agriculture, U.S. National Agricultural Statistics Service. 1960-1996. Agricultural Statistics Board Reports, U.S. Department of Agriculture, Washington, D.C.

Watts, P. J. E. A. Gardnes, R. W. Tucker, and K. D. Casey. 1994. Mass-balance approach to design of nutrient management systems at cattle feedlots. Great Plains Animal Waste Conference on Confined Animal Production and Water Quality. National Cattlemen's Association. Englewood, Colorado. p. 27-33.