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Economic Impact of Meeting Environmental Standards on Utah Cattle Feeders

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ECONOMIC IMPACT OF MEETING ENVIRONMENT
STANDARDS ON UTAH CATTLE FEEDERS

by

P. Parry Olson

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

Agricultural Economics

Approved:

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ABSTRACT

Economic Impact of Meeting Environmental Standards on Utah Cattle Feeders

by

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Utah State University, 1972

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Department: Agricultural Economics

This thesis is an analysis and description of pollution problems caused by large feedlots in Utah. A description of pollution caused by cattle feedlots is undertaken as part of the study.

The 26 feedlots analyzed had a capacity to/or did feed over 1,000 head. They were broken down into four groups on the basis of their pollution problems: those having no apparent pollution problem, those having minor problems, those having major problems, and those requiring relocation.

The cost impact of meeting environmental standards with regard to runoff control was found to be very slight for the cattle feeding industry as a whole - only 18 cents per head fed on the average. The feedlots with minor problems averaged costs of slightly over 2 cents per head fed. The feedlots with major problems averaged costs of almost 5 cents per head fed using the least cost method of natural evaporation ponds and mechanical disposal systems. The feedlots requiring relocation were most affected, as they averaged $1.15 per head fed loss in value of assets through relocating.

(85 pages)

INTRODUCTION

Livestock is Utah's major agricultural industry. Cattle feeding is a large part of the industry; there are some 118,000 cattle fed in Utah annually (39). This represents considerable import in the agricultural economy by providing income and employment opportunities.

Cattle feeders are faced with solving several important problems in the future. Among the most important and pressing is the question of annual waste pollution. The State Board of Health has been pressed with solving industrial and municipal pollution but is now looking at animal waste pollution.

> "Pollution" means such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, or such discharge of any liquid, gaseous or solid substance into any waters of the state as will create a nuisance or render such waters harmful or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life. (17)

This thesis deals with waste problems originating from domestic animals, primarily those confined in feedlots or barnyards. Therefore, when animal waste is mentioned, reference is made to waste from animals concentrated in feedlots or barnyards.

Cattle feeders in Utah are already in a precarious competitive position, being required to import considerable quantities of feed from other states for local use. Most counties in Utah are deficit feed producing areas, especially in feed grains and other concentrates, which results in high feed costs relative to other states and forces the Utah cattle feeder to be more efficient in other areas of feeding in order to compete.

Because public pressure is forcing legislators to enforce more stringent environmental standards, the Soil Conservation Service is presently working closely with the State Board of Health to locate and remedy pollution problems within agriculture. When pollution problems are identified, the Agricultural Stabilization Committee Service (ASCS) makes financial assistance available to farmers if they are willing to build recommended pollution control structures.

Committees have been established in Utah to study pollution resulting from agriculture. Their purpose is to determine the magnitude of such pollution and to estimate the extent to which irradication or prevention is feasible.

Most cattle feeders are aware of current emphasis being placed on environmental quality and are willing and planning to make changes in their feedyards. Before they take these steps, however, they want to know that the improvements they make will be effective and how much these improvements will cost. They want initial estimates of investments and annual operating costs, which causes problems for public agencies advising cattle feeders because each feedlot is an individual problem. There are many types of soil and each is compatible to feedlot location in different degrees. For example, slope of different degrees affects the compatability of soils. Ground water is found at many different depths. Precipitation varies across the state, and the amount of precipitation compounded with the above factors greatly affects the amount of runoff from a feedlot and also the degree of ground water pollution.

These factors have an important impact on the nature of any analysis of this problem. Since it is difficult to make blanket statements or recommendations for Utah cattle feeders, statements concerning only individual units are meaningful. Each feedlot is a separate case study with its own special problems.

Animal wastes are considered to be the number one offender in pollution caused by agricultural industries (5). Therefore, cattle feeders can expect a continuous surveillance of their feedlots by control agencies. Extensive research is going on at present to determine the ways that animal wastes pollute the environment and the seriousness of this pollution.

Animal waste management involves four parts: (a) runoff control, (b) solid waste disposal, (c) percolation control, (d) odor control (12). This thesis deals primarily with runoff control but some discussion involving the other three parts is carried out. Runoff is the most apparent contributor to pollution as it causes visible discoloration of streams and lakes among other things that will be discussed later.

Now is the time to be concerned with animal waste pollution. Public agencies are beginning to take important steps to control pollution. As of July 1, 1971, all feedlots of 1,000 head or more capacity will be required to register with their Soil Conservation Districts. This regulation applies to all feedlots located in states that do not have laws governing pollution as strict or stricter than those laws of the federal government (25). Utah is such a state where registration is necessary.

OBJECTIVES

1. To explain how animal wastes pollute the environment.

2. To estimate the cost to feedlot owners of correcting runoff pollution.

3. To analyze the effect of various levels of government assistance with these corrective investments.

4. To discuss the cost impact on livestock feedlot owners and the consuming public of meeting environment standards.

NATURE OF ANIMAL WASTE POLLUTION

At the present time an abundance of literature is being printed on animal waste pollution. Experiments are being conducted to determine means of stream pollution by animal waste, the most effective ways to control pollution and estimates of control costs. Agricultural magazines carry articles on pollution in almost every publication, but most data cover only specific areas and circumstances which make the results questionable for a producer in a different area or under different circumstances.

Scientists know, however, how animal wastes pollute the environment. This pollution process is the same in all areas; differences come in the magnitude of the problem.

There is disagreement on just how much a steer in a feedlot contributes to the pollution problem. Martin (25) determined that steers contribute 75 pounds of nitrogen, 65 pounds of potash, 8 to 22 pounds of phosphorous per year per 1000 pounds of body weight. He also claimed that livestock in the United States (U.S.) produce manure and other solids equal to the waste produced by 1.9 billion people. Kennison (21) claimed that there are 11 million cattle at any one time in feedlots in the U.S. and that animal wastes in the U.S. equal 20 times the wastes caused by humans. Richter (25) claimed that animal wastes were 10 to 20 times greater than the wastes of humans. Many authors concurred that one steer gave off the same amount of waste as 16 humans (24). Krejci (6), however, proposed that one human gives off as much waste needing treatment as 22 steers. He said that one human produces 75 gallons of effluent which needs treatment per day where one steer produces only

3.4 gallons. He reasoned that the average annual precipitation in the U.S. was 30" and this would cause 3.4 gallons of runoff on the average day per steer.

The Senate Select Committee on National Water Resources (44) specifies eight general categories of water pollutants: (a) sediments, (b) sewage and other oxygen demanding wastes, (c) plant nutrients, (d) infectious agents, (e) organic chemical exotics, (f) salts and mineral substances, (g) radioactive substance, (h) heat. Agriculture contribtues substantially to all but the last two, and animal wastes are major contributors to items (b), (c), and (d). Williams (48) states that runoff from feedlots can carry plant nutrients and infectious agents. He claims it also carries organic materials which substantially increase the biochemical oxygen demand and rapidly deplete the life-giving oxygen in streams. Glymph and Carlson (16) state that animal wastes degrade water quality in about the same way as human wastes, adding oxygen consuming organic matter, nutrients, infectious bacteria and other pollutants.

Animal wastes are serious sources of water pollution. Bernard (5) of the Federal Water Pollution Control Administration referred to animal wastes as first among agricultural pollution problems. Ned Byerley, Director of Science and Education of the United States Department of Agriculture, agrees with Bernard.

Oxygen Demanding Wastes

Oxygen demanding wastes are those wastes that must be decomposed. This decomposition is usually done by oxidation - the process of decomposition that breaks down substances by combining them with oxygen and releasing heat. Solids in water are measured by their biochemical oxygen demand (BOD). BOD refers to the amount of oxygen required to decompose the organic matter present in a sample of water. It is expressed by the amount of oxygen used in decomposition of solid matter in a sample of the water when incubated for a five-day period at 68 degrees F. Water using one part per million (ppm) is considered pure. Three ppm is considered clear and five ppm has doubtful quality characteristics, i.e., too high a concentration of organic solids to be considered good water. Water with high BOD requirements is not suitable for fish habitat. The oxygen used in the decomposition of the solids in the water is the same available oxygen that fish utilize. If too much of this oxygen is used up in the decomposition of solids, there is not sufficient oxygen left for the fish and they suffocate. Instances of fish suffocation have been observed in many waters of Utah.

Wadleigh (44) measured organic solids in runoff from feedlots. He found the BOD requirement varied from 100 to 1500 ppm depending on dilution and degree of decomposition of the wastes. He also gave the following breakdown of BOD requiring solid producers.

Table 1. Animal solid waste production

Contributor	Grams/Day	Human Population Equivalent
Man	150	1.0
Cow	23,600	16.4
Pig	2,700	1.9
Sheep	1,130	2.45
Chicken	182	.014

Wadleigh also pointed out that lagoons have been relatively ineffective in solving this pollution problem for animal wastes.

Gilbertson (15) found that winter runoff is much more concentrated with solids than rainstorm runoff. Total solids removed in winter runoff ranged from 6.2 to 7.9 tons per acre-inch of runoff for lots with 200 square feet per animal and 17.9 to 21.6 tons per acre-inch for lots with 100 square feet per animal. Rainstorm runoff contained 1.2 to 2 tons per acre-inch of runoff. No differences were observed due to cattle density in the rainstorm runoff analysis.

Plant Nutrients

The adding of plant nutrients to water is known as eutrophication. The plant nutrients that are important in eutrophication are nitrates and phosphates.

Eutrophication leads to noxious algal blooms that alter the taste of water, reduce its value for water sports and consume oxygen as the algae die and decompose. Eutrophication is based on the same principles that make field crops grow better when fertilizer is added to crop land.

Sawyer (34) found, on the basis of analyses of waters from 17 different Wisconsin lakes, that 0.015 milligrams per liter (mg/l) of inorganic phosphorous and 0.3 mg/l of inorganic nitrogen are critical levels, beyond which blooms can normally be expected. This is not to say that blooms will not occur at lower concentrations but that there is a higher probability of occurrence at these levels of concentration and greater.

Nitrates

About half the nitrogen of feces is in the urine as urea, which quickly hydrolyzes to ammonia. The feces contain no nitrates; the nitrates are produced by nitrifying bacteria acting upon the ammonia.

Ammonia and nitrate forms of nitrogen are very soluble in water. Kenison (21) observed that falling rain dissolves these two compounds and if given a chance, the water carries them into the soil. Therefore, only in heavy fast rains are nitrates carried off a feedyard. Soil percolates contain more nitrates than runoff according to Kennison.

Gilbertson (15) found in his experiments in Nebraska that nitrate forms of nitrogen ranged from 0 to 17 ppm in rainfall-runoff and 0 to 80 ppm for winter runoff. Ammonium from nitrogen ranged from 26 to 82 ppm. Differences were not obvious by seasonal changes in weather other than winter runoff. Total nitrogen was estimated to range from 70 to 151 pounds per acre-inch of rainfall-runoff for all treatments. Winter runoff yielded an average of 400 and 1040 pounds of nitrogen per acre-inch for low and high density lots respectively. No effect of slope on nitrogen amounts was noticed.

Because much of the nitrate is carried to soil, as explained by Kenison, ground water pollution is serious under feedlots. Stewart (38) found evidence that feedlots were polluting ground water 30 to 35 feet below the surface. This was eight times the pollution of adjacent irrigated fields. The nitrate content of the water ranged from 8.6 to 18 ppm. Excessive nitrates in ground water are harmful to man and animals (45). Of course, the quantity of nitrates reaching ground water is determined by precipitation, soil differences and depth of ground water.

Todd (41) reports that water containing large amounts of nitrate (more than 100 ppm) is bitter-tasting and may cause physiological distress. Water from shallow wells containing more than 215 ppm of nitrate has been reported to cause methemoglobinemia in infants.

Viets (43) cites an experiment that was conducted where cattle urine was added to soil columns every 4 days for 8 weeks to simulate a feedlot with 150 square feet per animal. The soil pH rose from 7.0 to 9.9. No nitrate was formed from ammonia but ammonia accumulated to about 670 ppm, probably the result of high acidity deactivating the nitrifying bacteria. Pure water was then added for two weeks--the pH went down, nitrates were formed, and ammonia decreased. This, of course, excluded the effect that precipitation has on decreasing soil pH and leaching the nitrates that are formed.

Ammonia, which has odor and is a health hazard, can also be carried by air to water. One lake 1/4 mile from a large feedlot absorbed 65 pounds of nitrogen per surface acre per year. Another lake 1 mile from the lot absorbed only about half as much, but it was enough to cause eutrophication if other factors were right (43).

Phosphorus

Phosphorus behaves almost exactly opposite to nitrogen compounds. Kennison (21) explains that falling rain carries phosphorus to the soil where tight chemical bonds are formed and very little phosphorus is leached out of the soil into groundwater. Walsh and Keeney (46) states that practically all soluble phosphorus in manure or fertilizer is converted to water insoluble phosphorus within a few hours after application to soil. Hence phosphorus does not leach even in sandy soil.

Hanson and Fenster (18) believe that phosphorus is of primary importance in algae growth promotion in water. He states that one experiment showed that application of three pounds of phosphorus resulted in one ton of additional algae in one acre-foot of water during a 60 day period in Lake Minnetonka, Minnesota. He also states that if manure is not spread on soil where it becomes water insoluble, it contributes large quantities of phosphorus to runoff water.

Walsh and Keeney (46) state further that fast spring thaws result in large quantities of phosphorus entering runoff water from ground where manure was spread while the ground was frozen and snow-covered. His experiment showed that 15 tons of manure applied to one acre in the winter resulted in a loss by runoff of 5.15 pounds of phosphorus per acre. Manure applied in the spring at the same density resulted in a loss of only 0.86 pounds of phosphorus per acre in runoff.

Experiments conducted by Gilbertson in Nebraska showed a range of 64 to 258 pounds of phosphorus lost per acre in winter runoff from experimental lots and 24 to 48 pounds in rainfall runoff (15).

Dr. David White (47) of the Zoology Department at Brigham Young University reported that the existing properties of water determine how important phosphorus is in water pollution. His studies of Utah Lake show that phosphorus is already abundant; therefore, the nutrients determinant in algae growth are nitrates.

Viets (43) also reasons that plant nutrients properly handled are not pollution problems; the problems are caused by misuse of manure. He states that one acre of irrigated cropland can produce feed for 1.62 animals which would produce 2,340 pounds of dry waste. He says that the same acre of land can safely use 23,400 pounds of such dry waste; therefore, so only one-tenth as much land is needed to spread wastes to grow the feed for the animals producing the wastes.

Infectious Agents

Many chemicals and toxins are added to water through animal waste pollution. Most of these are in such minute quantities as to be insignificant. Certain types of bacteria, however, are very important and bear consideration.

Coliform bacteria are used as standards for measuring quality of water relative to infectious agents. They are always present in animal feces and represent a potential of harmful bacteria in water. Geldrich (14) claims that a cow will excrete 5,428 million coliform per day. The greater the number of coliform in water, the higher the probability of animal waste present. Coliform can also originate from human wastes.

Willrich and Smith (50) name and discuss many types of illnesses transmitted to man from animals in various ways. There are two that are of importance to this discussion because they are transmitted from animal feces and urine through water to humans. Salmonellosis is the most common. They claim that one to two million probable cases of this illness in humans occur each year. The bacteria which cause this disease have been found in concentrations of 10 million organisms per gram of feces in infected cattle. These bacteria commonly live for three weeks to three months in water. In 1966 they cite a large water-borne outbreak of human cases that occurred at Riverside, California. The source was not positively identified but was thought to be seepage into wells from distant cattle feedlots.

The other disease they cite, leptospirosis, is far less common--only a few cases have been reported in recent years. Bacteria that cause this illness have been found at concentrations of 100 million per milliliter of urine in infected cattle. These bacteria are capable of living in water for several weeks, and humans come in contact with them in water used for drinking, swimming, and other activities.

Todd (41) cites the quality standards for water as the following for coliform bacteria:

USE	Max. number per 100 mil.
Domestic water supply (before treatment)	50, after treat. - 0
Fresh water for bathing and swimming	1
Fresh water for boating and fishing	100
Fresh water for wildlife propagation - fish	100
- waterfowl	1000

Class C water, that water quality standard sought after by the Department of Health for most water affected by feedlots, should have coliform bacterial content of a representative number of samples averaging less than 240 coliform per 100 milliliters and should not exceed this number in more than 20 per cent of the samples examined when associated with domestic sewage.

The Department of Civil Engineering (42) at Utah State University in a report on water quality control and management, claims that harmful bacteria entering water through agricultural practices was not significant relative to domestic sources.

Dr. David White (47) of Brigham Young University claims, however, that coliform bacteria entering water systems because of animal wastes can be significant where animals are concentrated. He has experiments that show concentrations of 300 to 2,200 coliform per milliliter.

REVIEW OF LITERATURE ON POLLUTION CONTROL EXPENSES

Costs to correct pollution problems must be considered on individual feedlots. Most references to costs of control refer to one given situation, and no broad estimates are given. Control costs vary according to geographic area and nearness to population centers, streams, and other industries.

On the national level the estimated expenditure on animal waste pollution prevention in 1969 was 2.3 million dollars for the United States Department of Agriculture; 0.5 million for the Department of Health, Education, and Welfare; and 1.1 million for the United States Department of Interior (10). This constitutes a total of 3.9 million dollars for these three departments in 1969.

Lessiter (23) considers the legal costs of fighting law suits leveled against feedlots as one of the major costs to be considered. He cites three examples of such costs. They range from $300 to $25,000 for legal fees, and two to 120 days of time lost in fighting legal battles. He also cited that three feedlots faced additional estimated expenses of $97,000, $50,000-$100,000, and $10,000 to correct pollution problems.

Connor and Schmid (11) give an example of a feedlot in Texas that investigated several different methods for solving pollution problems. They determined that the cost for a 25,000 head feedlot would require an investment of $1.04 per head and annual operating costs of $.18 per head to put the surface runoff back onto the land. The investment costs were $0.83 per head and operating $0.13 annually to dispose of the runoff into a lake system. Their final consideration showed an investment of

$1.49 per head and annual expenses of $0.14 for a natural evaporation and cleanup procedures.

Liquid manure systems are generally considered to be most expensive (4). Examples are cited for three different systems. The first is an evaporation ditch system for a feedlot of 500 head capacity with costs as follows:

Construction:

Concrete for walls, pits, etc. and labor	$13,500.00
Aerators, with motors, switches, etc.	6,854.00
Total investment	$20,354.00
Per head investment	39.91

Operating: per head

Electricity	$2.11
Annual fixed costs	7.18
Total per head operating	$9.29

The second was for slatted floors and a scrapper system for a 600 head lot. Only construction costs were available.

Construction:

Concrete walls	$9,390.00
Drag	2,280.00
Heating system	1,800.00
Total investment	$13,470.00
Per head	22.45

The third system was an open lot system of cleaning corrals and containing runoff. It was budgeted for a lot with 4,500 head capacity.

Investment:

Scoop		$21,000.00
Spreader		4,000.00
Tractor		15,000.00
	Total	$40,000.00
	Per head	8.88

Operating:

Labor		$3,380.00
Annual fixed cost		7,200.00
Gas & oil (est.)		2,700.00
	Total	$13,280.00
	Per head	2.95

Smith and Abott (35) discuss a feedlot covering 100 acres. This feedlot has a system of two ponds, one for retaining solids from runoff and one for holding liquids. The system is capable of holding the runoff from a 3.5 inch rainfall. The feedlot is located in Kansas in an area receiving 18 inches of precipitation annually. The system was relatively cheap to build, costing approximately $2,500. Liquids are pumped and solids are hauled onto crop land after being allowed to dry in the ponds.

Examples are cited by Smith and Abott where the cost was $5 to $50 per head to cure runoff pollution. The same article talks about odor control and tells of one operator who spends $0.08 a year per head for odor depressant which is only 50 to 70 percent effective in a liquid manure system (24).

There is some discussion on the possibility of putting manure from feedlots back onto land at such concentrations that ruin the land. One experiment was done where 900 tons of manure was plowed under per acre. This of course ruined the land for cropping potential but cost only four and one half cents per ton to accomplish. The same experiment showed that 10 tons could be applied to an acre without damaging the land.

Experiments have been done to determine the feasibility of recycling animal wastes for the production of feed for poultry or cattle. Caution should be given to those considering this possibility, however, because such action is not sanctioned by the Federal Drug Administration (45).

Owens and Griffen (31) did an extensive study in Texas on the economics of feedlot pollution control. Their experiment covered model feedlots of 5,000, 10,000, and 25,000 head capacity. They worked with systems of impounding surface runoff. The runoff was handled in three different ways: (a) it was pumped onto crop or pasture land, (b) it was put into a playa lake structure, or (c) it was put into a pond permitting natural evaporation of liquids. Their study considered surface runoff only, but they did recognize that groundwater pollution as well as odor and dust were problems.

The costs they calculated depended on the system of liquid disposal, the rate of disposal, the fine for overflows, and the size of feedlot. Spreading the liquids on the ground by pumping and sprinklers incurred costs ranging from $1.13 to $1.36 per head capacity for investment and $0.16 to $0.18 annual costs for feedlots of 5,000 head capacity. For 10,000 head capacity the costs ranged from $0.68 to $1.02 and $0.11 to $0.15 for investment and annual costs respectively. The costs were $0.48 to $0.73 investment and $0.10 to $0.12 annual for lots of 25,000 head capacity.

The playa lake system, a system where much of the liquid is allowed to seep into the ground instead of evaporating, was somewhat more expensive to build but cheaper to operate with initial investment costs ranging from \$1.31 to \$1.47 and \$0.19 to \$0.21 annual costs for feedlots of 5,000 head capacity. Costs on the 10,000 head lots were \$0.74 to \$1.07 for investment and \$0.12 to \$0.15 for annual operating. The 25,000 head lot was cheaper with investment ranging from \$0.45 to \$0.70 and annual costs of \$0.08 to \$0.11 per head capacity.

The natural evaporation system was the most expensive to build but the cheapest to operate. For 5,000 head capacity investment ran from \$1.63 to \$1.72 per head but annual costs were on from \$0.15 to \$0.16. The costs for the lot with 10,000 head capacity were \$1.21 to \$1.57 for investment and \$0.12 to \$0.14 for annual costs. The 25,000 head lot had costs of \$1.14 to \$1.49 and \$0.11 to \$0.14 for investment operating costs respectively.

THEORETICAL BASIS FOR COST BEARING

Eight categories of water pollution were named previously of which animal waste contributes significantly to three. Each of these three--oxygen demanding wastes, plant nutrients, and infectious agents--present major economic problems involving externalities which are very difficult to handle even in theoretical models and become even more difficult to analyze empirically. At least three major economic considerations appear to be of importance in talking about environment quality: first, opportunity cost of pollution; second, internalization of costs; third, optimal economic levels of environmental control.

Opportunity Costs of Pollution

Walter Heller, former chairman of the council of Economic Advisors, argues that we overestimate our country's productive capacity when we ignore pollution. He suggests that the country's gross national product be calculated only after deductions are made for the waste that pollution causes. Considering only the value of what a feedlot produces is deceptive if it causes water pollution so that a lake can no longer be used for swimming or fishing. A resource has been consumed in the process of production, and this should be recognized by subtracting the loss due to pollution from the value of the feedlot's output (19).

As suggested, several opportunity costs arise from the external diseconomies associated with pollution. One definition of this type of diseconomy is "disservices rendered free without compensation by one producer to another" (44 p. 29).

Internalization of Costs

Several approaches which might be taken to pollution control are: first, direct regulation including licences, permits, compulsory standards, and zoning registration; second, payments, including not only direct subsidies but also reductions in collections that would otherwise be made; third, fees for the discharge of different amounts of specific pollutants and excise or other taxes on specific sources of pollution (27).

If it is granted that something must be done to preserve environment quality at a level tolerable to human, plant, and animal life, then society is faced with two alternatives: either the costs of pollution must be internalized (make those who pollute pay), or the government must assume these costs.

Milton Friedman (13), a recognized free enterpriser, suggests that in nearly all cases private enterprise through the working of the marketplace can do a more efficient job of resource allocation. Although he seems to favor private enterprise rather than government intervention, his opinions are not quite so decisive in areas involving neighborhood effects.

He points out that neighborhood effects impede voluntary exchange because it is difficult to identify the effects on third parties and to measure their magnitude; but this difficulty is present in government activity as well. It is difficult to know when neighborhood effects are sufficiently large to justify particular costs in overcoming them and even harder to distribute the cost in an appropriate fashion. Consequently, he says, when government engages in activities to overcome neighborhood effects, it will in part introduce an additional set of neighborhood effects by failing to compensate individuals properly. Whether the original or the new neighborhood effects are more serious can only be judged by the facts of the individual case, and even then, only approximately. Every act of government intervention directly limits the area of individual freedom and indirectly threatens the preservation of freedom.

Buchanan and Stubblebine (8) argue that externalities may remain even in pareto equilibrium. Just because externalities exist does not mean a maldistribution of resources exists. Inefficiency must be shown to determine whether intervention should take place. They suggest that at full pareto equilibrium an internal economy implies an external offsetting diseconomy. They suggest that those who gain from an externality must pay those who cause the externality. Conversely, those who lose from an externality must be paid by those causing the externality. These compensations, they argue, should not be paid by government; but taxes of various types might be levied which would have the same effect as compensation between individuals.

It seems clear that at least as far as possible, private businesses responsible for pollution should pay the cost of environmental control. Insofar as past pollution problems requiring clean-up are concerned, perhaps government may have to pay the cost through means of taxing individual members of society.

However, in the last analysis whichever institution pays the cost, consumers cannot avoid bearing the burden. President Nixon said recently, "To the extent possible, the price of goods should be made to include the cost of producing and disposing of them without damage to the environment" (40).

Connor and Schmid (11) have the opinion that if controls on pollution in agriculture are applied uniformly, so as to eliminate any effects on interregional competition, probability is increased that the costs eventually may be passed on to consumers in the form of higher prices. The short run however will be difficult for the farmer. They say that even if the government helps pay the immediate costs this will just be another method of transferring the costs to the consumer in the form of taxes.

Various methods of internalizing costs have been suggested. Senator William Proxmire of Wisconsin has proposed a system of "effluent charges" under which industries would pay by the pound for the pollutants they discharge into water. He suggests that under this system, government would obtain the funds necessary to combat pollution and if the charge were sufficiently high, companies may find it less expensive to clean up their wastes rather than to pollute the environment (40). The problem with this method is measuring the effluent and determining exactly what is needed to clean it up.

Optimal Level of Environment Control

To say we are going to completely eliminate pollution is like saying we are going back to the caveman days, if there were such a period in time. To clean up all pollution would be a physical impossibility because there are just too many of us. If an industrialized economy is to exist, a certain quantity of waste discharge is an absolute necessity.

Ayres and Kneese (2) write that nature does not permit destruction of matter except by annihilation with antimatter; and disposal of unwanted residuals, which when done by units concerned with maximizing internal return, are discharged into the environment, mainly in water courses and the atmosphere. Water and air are traditionally examples of free goods in economics. But in reality, in developed economies, they are common property resources of great and increasing value presenting society with important and difficult allocation problems which exchange in private markets cannot resolve.

Ayres and Kneese go on to say that technological means for processing to purify various types of waste discharge do not destroy the residuals but only alter their form. Therefore, with the levels, pattern and technology or production and consumption, recycle of materials into productive uses or discharge into an alternative medium are the only general options for protecting a particular environmental medium such as water. The sensible approach for an industrialized society like ours then is to determine in some way an optimal amount of pollution consistent with the amount of consumption and resource use which the aggregate of society desires equated to some acceptable level of environmental control or pollution.

This system should attempt to achieve a balance of waste control and disposed so as to place relatively equal burdens on the various residual-receiving environmental media. For a region to adopt a policy which would keep the air perfectly pure of waste and at the same time place a heavy residual load upon water resources would not be wise. Nor would the opposite be desirable.

Theoretical Economic Solutions

This thesis deals mainly with water pollution by feedlots. Therefore, the discussion of economic models for environmental control will concern mainly water pollution. However, the models would likely find use in solving other environmental problems with some revisions.

Simplified model for measuring the cost of pollution and internalizing costs

In a well-functioning competitive economy each productive resource will be used to the point where the cost of an additional unit is just equal to its contribution to the value of production. Consumers attempting to achieve maximum satisfaction from a given amount of income tend to allocate their expenditures so that the last dollar spent for any particular item will yield an amount of satisfaction equal to the last dollar spent on any other item.

Societies like that of the United States and which rely on a decentralized decision-making system in which externalities occur will find that certain resources are not used optimally. This is especially true of the national environment which has a certain extremely valuable capacity to assimilate residual wastes. To completely eliminate all residual waste would be very costly. But on the other hand if no value is put on environmental use, the environment will be used too quickly.

If the advantages of decentralized decision-making mechanisms (the market) are to be realized, ways to optimally control these external effects must be found. This means that in some fashion the external costs stemming from residual waste discharged to the environment must be weighed against, and balanced with, the costs of controlling the amounts of these residuals (22). Suppose a firm (feedlot) is anticipating locating on the fork of a stream. The feedlot's waste discharge will be detrimental to the stream, since it will add organic materials, plant nutrients, and infectious agents. A firm (society) downstream is engaged in water recreation (swimming and fishing). Figure 1 shows one way of looking at costs of waste control and damages from pollutions of this type of situation.

The line YX' indicates the marginal recreation damage. The X axis indicates the level of pollution control. At point X', all waste is removed. For each point on the X axes, there is an optimum combination of pollution control methods which is associated with a certain cost. The marginal cost of optimal combinations of methods is indicated by the function AB. If public authority were able to impose the incremental damages resulting from waste discharge upon the waste discharger, the latter would withhold waste to point X. At this point the costs (internal and external) associated with the feedlot's waste disposal (damage costs and abatement costs OACX') are minimized. Alternatively, one can say that net benefits (ACY) associated with abatement activity are maximized (22).

Economic incentives for reducing waste discharge

Economists have long held that technological spillovers can be counteracted by levying a tax on the unit responsible for the diseconomy and by paying a subsidy to the damaged party. Some individuals have demonstrated that under certain conditions the appropriate tax is just large enough to pay the appropriate subsidy. However, in the case of waste loads, and from the point of view of resource allocation, both levying a tax and paying a subsidy are not necessary if the waste

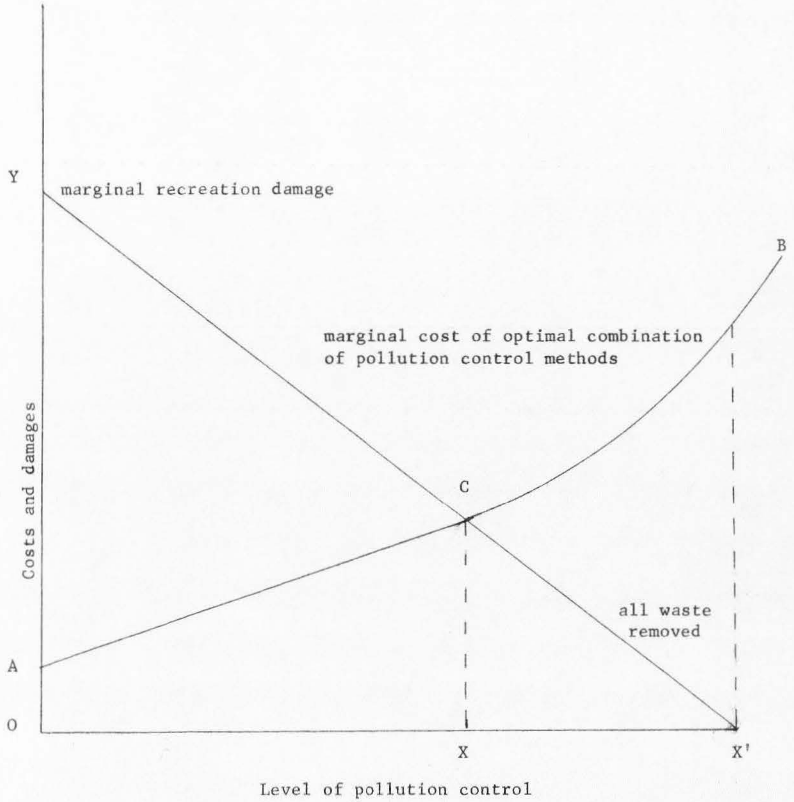

Figure 1. Graphic model for measuring the cost of pollution and internalization of costs

discharger and the damaged party do not themselves bargain about the externality. In principle, either a charge on effluents or a payment to reduce discharge will serve to induce the combination of measures that will minimize the cost associated with waste disposed in a region. But if bargaining takes place, a unilateral fee or a subsidy will not produce an efficient result.

Charges. If the authorities were to levy a charge equal to the damages associated with each level of pollution, government would collect just enough in tolls to cover the residual damages (area XCX' in Figure 1). From the viewpoint of efficiency, compensation must be paid to the damaged party (party 2) if the parties can and do negotiate. Otherwise, optimal resource allocation will not be present both in short and long run.

Figure 2 illustrates this point. Function AC indicates the marginal damage costs imposed on the waste discharger (party 1) and YX' indicates the marginal gain to the waste discharger due to not having to employ pollution control. As the cost of damages is levied on the waste discharger, his net gain becomes function YX. The distance between curve YX and X axes equals the difference between the YX' function and AC function. At point B, or X on the X axes, the waste discharger's net gain is zero, or it can be said that X is the optimal point. As waste damage costs are levied on him, he will be motivated to employ pollution control to level X.

At point X party 2 is still being damaged by the waste discharger. If allowed to, party 2 will possibly come to the waste discharger and offer to pay up to the value of the damage (XB). He would do this on the condition that the waste discharger use the payment to employ

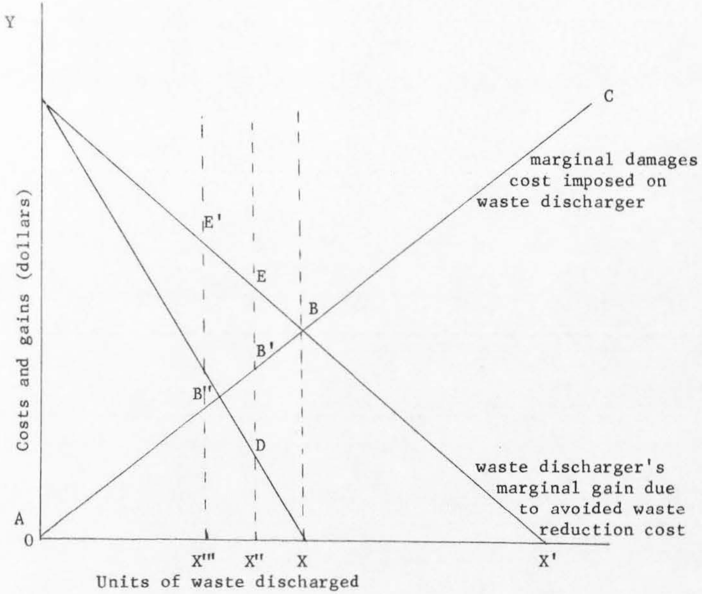

Figure 2. Graphic model for measuring extent of pollution after placing charges on the polluter

pollution control. Assume pollution control is increased to point X''. The waste discharger would accept payment because it now costs less to clean up the waste than to pay the fine imposed by the authorities, i.e., the waste discharger pays B'E (the damaged party pays X''B') which is less than X''B', the amount of the fine. This negotiation would continue until the waste discharger reduced waste to the point where his marginal net gain equals the marginal damage imposed. This would be at B'' with the level of pollution control at point X'''.

However, X''' is not society's optimum level of control. This can be illustrated by assuming the polluter and the damaged party are two segments of society. One segment discharges waste that damages the other segment's activities. At X''' the value of the damage caused by waste discharge equals X'''B'' but the society would be spending X'''E' to clean up the pollution. At X the value of the damage imposed and the cost to clean it up are equal, so X is the optimum point (22).

From society's point of view, the process of the two parties bargaining causes inefficiencies and misallocation of resources. If authorities charge the waste discharger for his wastes and allow the damaged party to negotiate with the waste discharger, society will possibly be paying more to clean up pollution than the actual value of damage caused by pollution. If the parties cannot or do not negotiate, the social optimum can be attained by taxing the waste discharger and not compensating the damaged party (22).

Payments. A system of payments or bribes could achieve the same result as an optimal charge plan. Figure 3 illustrates this point. Assume that a profit-maximizing firm has an incremental production

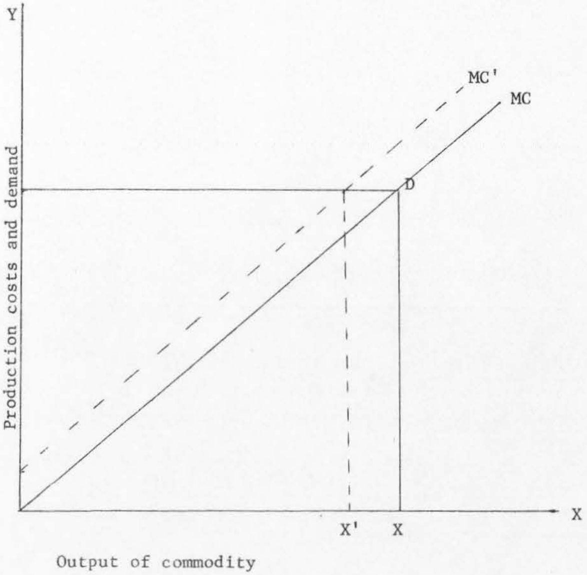

Figure 3. Graphic model for measuring extent of pollution after giving payments to the polluter

cost curve as shown by MC and that the firm can sell the commodity as represented by D, and the only way the firm can diminish the amount of waste discharge into a stream is by reduced production. Residual waste per unit is constant. Under these conditions if a regulatory authority imposes a unit charge on the waste of the firm, the incremental production cost function will shift upward by the amount of the charge per unit of output (i.e., charge per unit of waste times waste per unit of output) from MC to MC'. However, if the regulatory authority offers to pay the same amount per unit for reducing waste discharge, i.e., for reducing output, the incremental cost function will still be at MC'. A firm rationally trying to maximize its profits will view the payments as an opportunity cost of production because waste discharge is, by assumption, a straight forward function of production (22).

Model for Studying and Planning Environmental Control

Ayres and Kneese (2) have formulated a mathematical framework for tracing residual flows in the economy and related it to the general equilibrium model of resources allocation, altered to accomodate recycle and containing unpriced sectors to represent the environment. This formulation, in contrast to the usual partial equilibrium treatments, implies knowledge of all preference and production functions including relations between residual discharge and external costs and all possible factor and process substitutions. They suggest that it represents reality with fair accuracy; but it implies a central planning problem of impossible difficulty, both from the standpoint of data collection and compilation.

They suggest that their complicated approach may serve as a warning that partial equilibrium approaches, while more tractable, may lead to serious errors. They suggest that it can predict future waste residuals in an economy much more accurately than the normal aggregative extrapolations usually made.

Their article has a complicated series of mathematical equations to accomplish the above. They are not reproduced here, but a graphic model presented by them is shown to give an idea of the magnitude of the models which may be necessary for studying and planning environmental control in a region or a whole economy. See Figure 4.

Social Issues

The social issue is how society determines and then reacts to basic goals on the use of resources where pollution is involved. Such points as whether there is a "right to pollute" and whether waste disposal constitutes a "beneficial use" of a resource are being raised. The central question is, however, how much prevention and abatement society wants in view of the costs required and how to organize to accomplish this. Where should the division be between a laissez-faire approach at one extreme and an uncompromising goal of pure air, pristine water, and uncontaminated land at the other? How much are we willing to pay in higher product prices, taxes, and cost economic opportunities to achieve pollution control?

A related issue is how the cost of preventing and abating pollution is to be borne. Should those who benefit from the use of protected resources pay? Or should society pay the cost? What share should be assigned to general welfare of Federal subsidy? Or should those who use the resource pay?

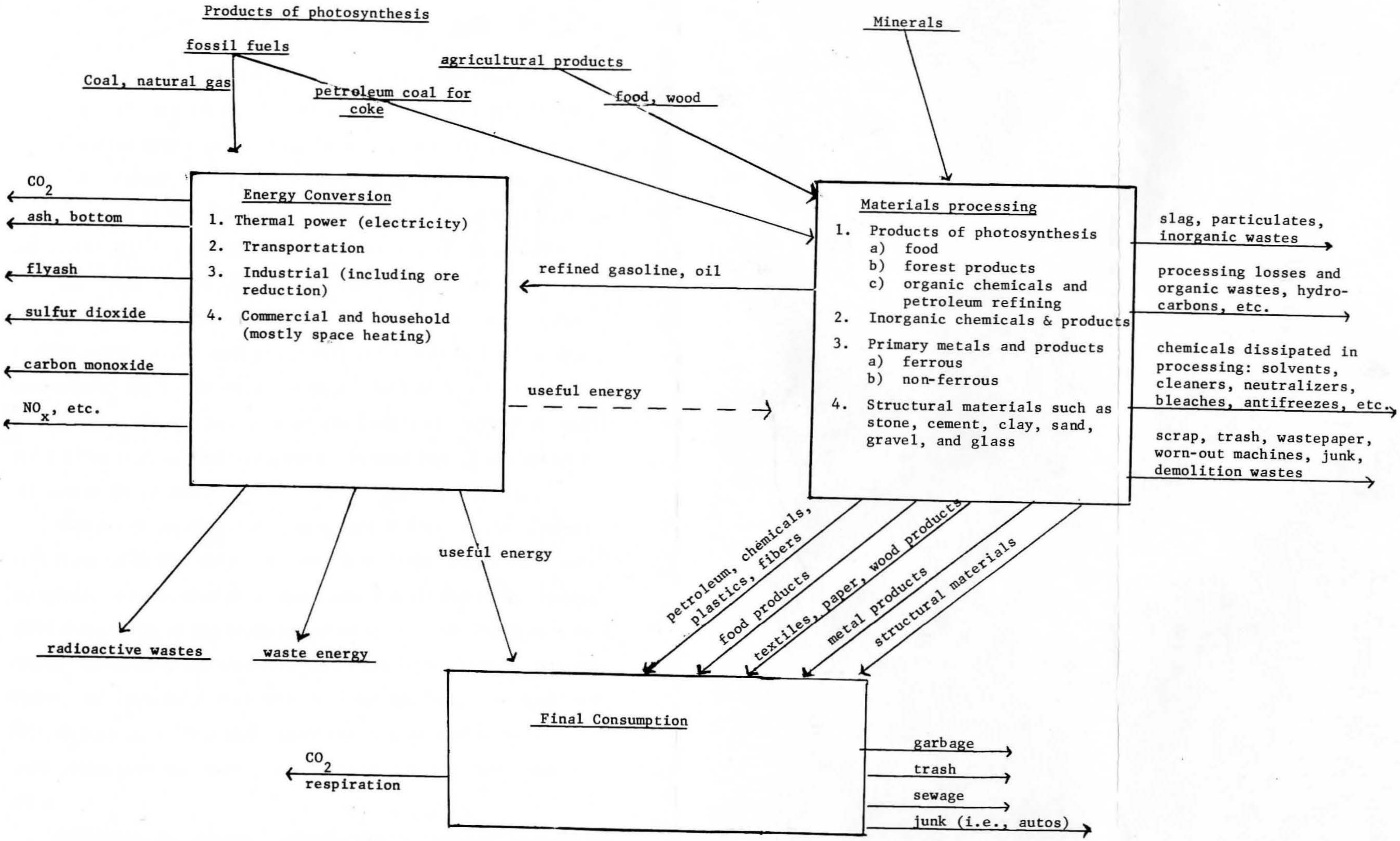

Figure 4. Flow of raw materials through processing and consumption into wastes (20)

SOURCES AND PROCEDURES

Taylor, et al., (39) did a study in 1968 on the feasibility of expanding the livestock feeding and slaughter industry in Utah. The questionnaires from this study were made available for use. Costs of all feedlots which fed 1,000 head of cattle or more per year or had the capacity to do so were taken by this author from these questionnaires and summarized on a new questionnaire as illustrated in Appendix 1.

Twenty-six feedlots of the size mentioned were sampled using the new questionnaire. The costs were updated in general form by the feedlot owner. Any changes in capacity and/or number fed annually were noted. Out of the estimated 118,000 head of beef cattle fed in Utah in 1968, the feedlots surveyed fed 68,482. In 1971 these feedlots fed a total 77,118, which represents a reasonably high percentage of all cattle fed in Utah.

Sketches of physical layout were made of the feedlots. These were drawn in as much detail as possible with the feedlot owner contributing what he knew about soil types, runoff drainage areas, and water level data. Size of the feedlots and areas of runoff drainage were noted. Surrounding features were also noted such as canals, streams, swamps, and man-made objects such as houses and roads. No data were collected on exactly how much runoff and seepage were present. Observations were only made to determine whether they were present at all.

A qualified agricultural engineer, who is presently concerned with animal waste pollution was then consulted for opinions on what needed to be done, which structures if any were necessary, and whether it would be wiser for the feedlot to relocate. Detailed plans for some of the recommended structures were obtained.

Contractors in the general area of the feedlots in question were contacted to gain estimates of building costs and maintenance. Estimates of operating costs were gained from contacting either feedlot owners or dairy operators who had similar structures on their farms.

For the feedlots which were recommended to relocate, rather than invest in pollution control structures, data on the present worth of feedlots were obtained from the 1968 questionnaire which listed all assets and their depreciation schedule in detail.

ANALYSIS AND PRESENTATION OF DATA

The survey showed some feedlots in the state are located so that they have no pollution problems from runoff. Of the 26 feedlots there were 12 where no runoff problems were evident. These 12 feedlots were found in four different counties, six in Millard, two in Utah, two in Davis, and two in Weber. The non-polluting feedlots will bear no further discussion until the section on marginal cost analysis where they will be considered along with the lots having pollution problems.

Number and Description of Polluting Feedlots and the Cost to Correct Their Pollution

Feedlots requiring correction measures were divided into three groups for analysis.

Feedlots requiring minor corrections

Six feedlots require only minor correction. They were located in four counties, two in Sevier, two in Box Elder, one in Weber, and one in Davis.

Minor corrections are such things as simple dirt dikes or ditches. They are used to convey runoff water away from feedlots to prevent water passage through the feedlot and adding to the runoff from the feedlot or to keep runoff from the feedlots from entering streams or canals and to convey it to open fields or pastures where it will do no harm. In one case, a cement retaining wall for part of the feedlot was recommended because of concrete corrals and a road-way directly adjacent to the corrals.

Itemized costs of the structures are shown in Table 2. The costs of these structures were obtained by consulting several contractors and using the average of the prices quoted by them.

Table 3 shows the breakdown of the cost of the structures according to capacity and number of head fed. The structures or improvement are all depreciated over twenty years; an interest rate of eight percent is used to obtain the annual expenditures. The amortization factor for this period and interest rate is .1019. The feedlots in question have a total capacity of 12,000 and fed 21,600 cattle in 1970. Pounds of gain per animal range from 280 to 400 pounds with an average of 315. The cost of corrective structures varied from $88.80 to $1,815 and totaled $3,571.40 for the six feedlots. Annual cost was approximately one tenth of the initial building cost (amortization rate .1019). Obviously, the annual cost on a per head capacity and per head fed were very small. In the operating budget of a feedlot six cents (0.057 was highest) per head fed is very slight, if not negligible.

Table 2. Description and cost of structures for feedlots requiring minor corrections

Feedlot No.	Type of structure	Dimensions	Cost per unit		Total cost
1	dirt dike	600 ft. long, 2 ft. high equals approx. 200 cubic yds.	$0.55		$110.00
2	dirt dike	3500 ft. long, 4 ft. high equals 3,630 cubic yds.	0.55		1815.00
3	dirt dike	350 ft. long, 2 ft. high equals 116 cubic yds.	0.55	$64	
	concrete retaining wall	350 ft. long, 18" high equals 350 ft. steel mesh	0.235	82	
		8.2 cubic yds. concrete	16.83	138	374.00
4	dirt dike	500 ft. long, 4 ft. high	0.55		468.00
5	ditch	1000 ft. long, 2 ft. by 2 ft.	0.60		88.80
6	dirt dike	3900 ft. long, 2 ft. high equals 1300 cubic yds.	0.55		715.00

Table 3. Size of feedlots requiring minor corrections and costs of correcting their pollution problem

Feedlot No.	Capacity 1970	# Fed 1970	Lbs. gain per annual	Cost of structure	Annual cost	Cost per head capacity	Cost per head fed
1	2500	3500	360	$110.00	$11.21	$0.004	$0.003
2	4000	7500	290	1815.00	184.95	0.046	0.023
3	1200	1200	400	374.00	38.11	0.032	0.032
4	800	1600	245	468.60	47.75	0.060	0.030
5	1600	1600	480	88.80	9.05	0.057	0.057
6	2500	6200	280	715.00	72.86	0.029	0.012
Total	12,600	21,600		$3571.40	$445.37		
Average	2,100	3,600	315	595.23	74.23	$0.035	$0.021

Alternatives for feedlots requiring major corrections

Most literature giving recommendations to feedlot operators contains the idea of using a pond system of one type or another for collecting and holding runoff from the feedlot. There are three basic types of systems mentioned. First, a system of two ponds; the first for collecting all runoff and separating the solids from the runoff, and the second for holding the filtered (there would be a filter system between the two ponds) runoff water until pumping the liquid onto crop land is possible. This system is normally used in areas of very high precipitation. Second, a single pond system to catch all runoff and hold it until it can be pumped onto crop land. Third, a single pond system that holds the liquid until it is allowed to evaporate by natural means. This system could possibly be improved very simply by adding a small pump and nozzle to throw the liquid into the air allowing greater evaporation to take place.

The first system will be eliminated from the discussion because Utah is mostly very arid. Alternatives two and three will be discussed and break-even points established for the two systems depending on feedlot location, in relation to crop land and feedlot size.

There were five feedlots surveyed that would require pond systems to solve their runoff problems. These feedlots are located for the most part on sloping land which accounts for the greater quantities of runoff. The feedlots were located in Millard, Utah, Weber, Box Elder, and Cache counties.

A study to determine the amount of runoff to be expected from feedlots was done in Kansas. Results determined that soil had very little to do with the amount of runoff occurring because all feedlots are coated with manure, and in a rainstorm the manure coating would be the determining factor in how much runoff there was. The experiment was conducted on feedlots having a slope of approximately five percent. The following equation was produced:

$K = -0.3819 + 0.8732P$ when:
K = inches to runoff
P = precipitation in inches for a 24 hour period

This equation suggests that the first .3819 inches of precipitation to fall in a 24 hour period would be absorbed by the manure in the feedlot and 87.32 percent of all additional precipitation would be runoff. The need is to find the number of days each year when more than .38 inches of precipitation falls and then determine the runoff expected during the period (29).

This presents a special problem in Utah because during the winter months most precipitation comes in the form of snow and does not immediately melt and run off. Also the ground and manure are often frozen and therefore would absorb less of the initial precipitation.

After consulting an authority on Utah climate, altering the equation used in Kansas and using a different approach to determining the amount of runoff that can be expected from these five feedlots was decided. The fact that no actual measurements were made to determine runoff is a major limiting factor. That all the feedlots have a five percent slope is assumed. Mr. Richardson (33) surmized that under Utah conditions assuming that the manure in the feedlot would absorb .38 inches of moisture, that 13 percent of all precipitation would be absorbed by the soil underneath the manure as indicated by the formula arrived at in Kansas would be best. He indicated, however, that since in Utah large amounts of rain in a given twenty-four hour period do not normally occur, taking into account the possibility of moisture accumulating in the manure and building up to the runoff point over a number of days would be most wise.

Evaporation then plays a significant part. Table 4 summarizes the essential evaporation data required for this analysis. Evaporation stations are not numerous and wide spread in the State so only limited data could be found. The Bear River refuge station provided data for analysis in Box Elder and Weber County. The Logan station was used for Cache, the Lehi station for Utah County, and the Milford station was nearest for the Millard County area. The distance from the evaporation station to the feedlot site is a limiting factor as well as the nature of evaporation studies.

Evaporation pans are put on a site which is typical of the surrounding area as to soils and conditions of the area. Weeds and grass around the site are kept mowed and trimmed. The distance from ponds or swamps should be as great as possible. The pan itself is four feet in diameter and ten inches in depth. The pan is raised off the ground by a wooden support approximately eight inches high. Obviously, evaporation studies are accurate for only a small area.

Lake evaporation as a proportion of pan evaporation varies with the area being studied. Lake evaporation for the Bear River refuge and the Logan sites is .71 of the pan evaporation and for the Milford and Lehi sites is equal to .70 of the pan evaporation (30). Evaporation from manure as compared to lake or pan evaporation has not been studied, so it was assumed the evaporation from manure would be 25 percent of that occurring from lakes.

Table 4. Evaporation rates for four selected Utah areas for pan (29), lake (30), and feedlot surface over 33 year period (1937-1969)

	Bear River Refuge					Logan				
	Pan	Lake		Feedlot		Pan	Lake		Feedlot	
	Mo.	Mo.	Day	Mo.	Day	Mo.	Mo.	Day	Mo.	Day
		inches					inches			
Jan.	1.00	.71	.02	.18	.01	.90	.64	.02	.16	.01
Feb.	1.40	.99	.03	.25	.01	1.20	.85	.03	.21	.01
Mar.	2.50	1.78	.06	.45	.02	2.30	1.63	.05	.41	.01
April	5.60	3.59	.12	.90	.03	4.39	3.12	.10	.78	.03
May	7.84	5.57	.19	1.39	.05	6.24	4.43	.15	1.11	.04
June	9.32	6.62	.22	1.66	.06	6.95	4.93	.16	1.23	.04
July	11.13	7.90	.26	1.98	.07	8.68	6.16	.21	1.54	.05
Aug.	9.99	7.09	.24	1.77	.06	7.72	5.48	.18	1.37	.05
Sept.	6.50	4.62	.15	1.16	.04	5.22	3.71	.12	.93	.03
Oct.	3.54	2.51	.08	.63	.02	3.11	2.21	.07	.55	.02
Nov.	1.38	.98	.03	.25	.01	2.10	1.49	.05	.37	.01
Dec.	1.00	.71	.02	.18	.01	.90	.64	.02	.16	.01
		43.07					35.29			

Table 4. Continued

	Milford					Lehi				
	Pan	Lake		Feedlot		Pan	Lake		Feedlot	
	Mo.	Mo.	Day	Mo.	Day	Mo.	Mo.	Day	Mo.	Day
		inches					inches			
Jan.	2.00	1.40	.05	.35	.01	1.00	.70	.02	.18	.01
Feb.	3.60	2.52	.08	.63	.02	1.90	1133	.04	.33	.01
Mar.	5.20	3.64	.12	.91	.03	3.20	2.24	.07	.56	.02
April	7.59	5.31	.18	1.33	.04	4.91	3.44	.11	.86	.03
May	10.74	7.52	.25	1.88	.06	7.50	5.25	.18	1.31	.04
June	13.67	9.57	.32	2.39	.08	8.15	5.71	.19	1.43	.05
July	15.18	10.63	.35	2.66	.09	9.72	6.80	.23	1.70	.06
Aug.	13.40	9.38	.31	2.35	.08	8.42	5.89	.20	1.47	.05
Sept.	10.13	7.09	.23	1.77	.06	5.85	4.10	.14	1.03	.03
Oct.	6.54	4.58	.15	1.15	.04	3.64	2.55	.09	.64	.02
Nov.	3.60	2.52	.08	.63	.02	2.10	1.47	.05	.37	.01
Dec.	2.00	1.40	.05	.35	.01	1.00	.70	.02	.18	.01
		65.56					40.08			

Using this information, the expected runoff from these five feedlots was calculated. The year with the most precipitation over the last twenty years was analyzed. The amount of moisture in the manure at the first of the year was determined by using the precipitation that had fallen immediately before and how much of it had evaporated. The year was then analyzed day by day to see what precipitation was and what expected runoff would be, given expected evaporation. For example, if on January 15 there was 0.25 inch of moisture in the manure, and the evaporation rate from manure was 0.01 inch per day, the moisture in the manure would decrease by this amount daily. Suppose that on January 20, 0.85 inch of moisture fell. The resulting runoff would be 0.25 inch minus .05 inch (the evaporation for five days) plus 0.85 inch minus 0.38 inch (the amount of moisture the manure itself would hold). The calculated expected runoff is given in Table 5.

Natural evaporation systems. Table 6 shows the surface area of the feedlot -- that area covered by corrals; if roadways between corrals were present, they are included.

Table 6 also shows the expected runoff as calculated and the total yearly evaporation. From these data it is possible to calculate the minimum pond surface that would be necessary to facilitate evaporation of all runoff. By calculating the volume of runoff one is able to determine the required depth of these ponds. The cost of building these ponds and additional structures necessary for collection is shown. Value of the land used for the pond is included.

Operating costs are calculated on the basis of $1.50 per ton to remove solid matter that will settle out of the runoff while being

Table 5. Maximum precipitation and expected runoff for one year from feedlots in five selected Utah areas for period 1951-1970

	Weber (1970)		Box Elder (1963)		Cache (1968)		Millard (1965)		Utah (1964)	
	Precip.	Runoff	Precip.	Runoff	Precip.	Runoff	Precip.	Runoff	Precip.	Runoff
	inches		inches		inches		inches		inches	
Jan.	3.16	2.53	2.41	.97	1.10	.60	.45	.18	1.69	1.23
Feb.	.48	.27	1.59	.53	1.49	1.07	.14	.00	.36	.12
Mar.	1.06	.42	.88	.23	2.09	1.51	.34	.00	2.71	1.80
April	2.03	.92	2.72	1.58	1.19	.42	.69	.02	2.36	1.31
May	1.23	.42	1.07	.10	1.35	.32	1.06	.03	4.25	2.76
June	3.44	2.38	2.66	.73	3.67	2.47	.52	.00	3.72	2.07
July	.47	.00	.08	.00	.10	.00	1.38	.81	.06	.00
Aug.	.17	.00	.57	.00	4.14	2.17	2.46	1.25	.68	.00
Sept.	2.33	1.27	1.95	.77	.33	.00	1.17	.16	.56	.03
Oct.	1.65	.73	2.33	1.33	2.11	1.22	.00	.00	.22	.00
Nov.	2.40	1.63	2.80	2.31	1.79	.98	1.05	.35	2.47	1.78
Dec.	2.94	2.30	.83	.40	1.05	.60	.69	.27	5.48	4.57
TOTAL	21.36	12.87	19.89	8.95	20.41	11.36	9.95	3.07	24.56	14.05

Table 6. Pond size and cost to contain runoff from feedlots in five selected Utah areas

County	Feedlot area (acres)	Runoff (inches)	Evaporation (inches)	Minimum size of pond to facilitate evaporation (acres)	Minimum depth to hold water (inches)	Costs to build (dollars)	Operating costs (dollars)
Weber	4	12.87	43.07	1.172	44	2,513	60.00
Box Elder	4	8.95	43.07	.622	58	1,487	41.25
Cache	25	11.36	35.29	7.733	37	12,442	328.50
Millard	10	3.07	65.56	.316	97	1,045	36.00
Utah	21	14.05	40.08	7.362	41	12,202	340.50

held in the ponds. Owens and Griffen (31) calculated the quantity of solids that would have to be removed from the ponds by the following equation:

$$TS = G \times 8.33 \times \frac{8,950}{1,000,000} = .075\ G$$

where:
TS = pounds of solid matter in runoff.
G = gallons of runoff per acre.
8.33 = weight of one gallon of water in pounds.
$\frac{8,950}{1,000,000}$ = proportion of runoff weight that would be solids.

This same formula was used to calculate the amount of solids expected to be removed from the pond system, and the total cost is figured by using \$1.50 per ton expense on the moving. Obviously, the operating cost is almost insignificant on three of the lots and only minor on the other two.

Table 7 lists the size in area and number of animals fed in each of the five lots and annual costs of correcting their pollution problem through natural evaporation. The structures were amortized at eight percent for twenty years, and the annual operating costs were added to arrive at the total annual cost. As illustrated by this table, the costs on a per-head-fed basis is quite minor for most of the lots. The highest was \$.53 and the lowest \$.06 with an average of \$.15 per head fed.

Mechanical runoff disposal system. The second system to be considered is a pond and collection system with a pump and sprinkler system to facilitate more rapid disposal of the runoff from the pond. This system makes it possible to construct smaller ponds and use less land for the ponds.

Table 7. Size of feedlots requiring major corrections and costs of correcting their pollution problem through natural evaporation

Feedlot No.	Capacity 1970	# fed 1970	Lbs. gain per animal	Cost of structure (dollars)	Annual cost (dollars)	Per head capacity (dollars)	Per head fed (dollars)
1	1,000	600	475	2,513	316.07	.316	.527
2	1,200	1,200	400	1,487	192.78	.161	.161
3	5,000	11,168	325	12,442	1,596.34	.319	.143
4	2,500	2,500	555	1,045	142.49	.057	.057
5	4,000	11,000	310	12,202	1,583.88	.396	.144
Total	13,700	26,468		29,689	3,831.56		
Average	2,740	5,294	350	5,938	766.31	.280	.145

Table 8 gives the amount of runoff expected during the heaviest year of precipitation during a twenty year period and the maximum amount of runoff to be expected during a twenty four hour period in twenty years. Using this information the minimum size of pond necessary to hold this runoff can be calculated, and the cost to build it is in Table 7. The cost of the pump and sprinkler system is based on the cost of a high pressure pump and enough sprinkler pipe to dispose of the runoff over adjacent ground. The cost for these devices is approximately equal for all of the lots because the pump price is the largest part of the investment, and the smallest size available was used in all cases. Operating costs include electrical power for the pump, labor for moving the pipe, and removal of any dry matter that would settle to the bottom of the pond. In the Texas study the settling solids were shown to equal about one-fifth the amount in the natural evaporation system (31).

Table 9 gives the feedlot size and the number of head fed in 1970 and the cost on a total, capacity, and per-head-fed basis, of correction runoff pollution problems. The feedlots are in the same order as in Table 7. The annual costs are again figured by amortizing the cost of the investments over twenty years at eight percent and then adding the yearly operating costs.

The costs are not large on a per-head-fed basis. Only one feedlot was affected by as much as \$.35 and the average equals \$.05.

Comparison of natural evaporation systems with mechanical runoff disposal systems

Table 10 shows the costs of the two systems compared and the amount that it will cost the feedlots on an annual basis for implementing

Table 8. Costs of implementing a mechanical runoff disposal system for five selected feedlots

Feedlot No.	Yearly runoff inches	Max. expected runoff for 24 hr. period	Cost of minimum size pond to hold max. expected 24 hr. runoff (dollars)	Cost of pump and sprinkler system (dollars)	Operating costs (dollars)
1	12.87	1.94	224	1,600	18.25
2	8.95	2.39	234	1,610	18.25
3	11.36	1.83	734	1,785	76.70
4	3.07	1.30	310	1,630	23.25
5	14.05	1.94	698	1,775	76.20

Table 9. Size of feedlots requiring major corrections and costs of correcting their pollution problem through mechanical disposal of runoff

Feedlot No.	Capacity 1970	# fed 1970	Lbs. gain per animal	Cost of structure (dollars)	Annual cost (dollars)	Per head capacity (dollars)	Per head fed (dollars)
1	1,000	600	475	1,884	210.23	.210	.350
2	1,200	1,200	467	1,834	205.13	.171	.171
3	5,000	11,168	325	2,519	333.39	.067	.030
4	2,500	2,500	555	1,940	224.10	.090	.090
5	4,000	11,000	310	2,473	328.20	.082	.030
Total	13,700	26,468		10,650	1,297.89		
Average	2,740	5,294	350	2,130	259.58	.095	.049

Table 10. Comparison of natural evaporation system with a mechanical disposal system

Feedlot No.	Annual cost of natural evaporation (dollars)	Annual cost of mechanical disposal (dollars)	Least cost procedure (dollars)	Least cost procedure per head fed (dollars)
1	316.07	210.23	210.23	.350
2	192.78	205.13	192.78	.161
3	1,596.34	333.39	333.39	.030
4	142.49	224.10	142.49	.057
5	1,583.88	328.20	328.20	.030
Total	3,831.56	1,297.89	1,207.09	
Average	766.31	259.58	241.42	.046

the least cost solution. Two feedlots would adopt the natural evaporation system and three would adopt the mechanical disposal system. The two largest feedlots gain the most by adopting the mechanical disposal system. This can be attributed to the smaller size pond which is much cheaper to build and does not require as much land. The two feedlots adopting the natural evaporation system are smaller and are located in more arid areas of the state. One of the latter feeds 2,500 head per year but is located in the area of least total precipitation and greatest evaporation. The other one feeds the least number of cattle of any in the entire analysis and is located where land is cheap and a large pond is feasible. The three feedlots using the mechanical disposal system would probably reap some benefits from the water that would be sprinkled on the land surrounding the feedlot and pond and also from the animal waste solids that would help to fertilize the soil.

Feedlots requiring relocation

Of the twenty-six feedlots surveyed, relocation was deemed necessary for three. The three lots were located very close to bodies of water and were situated on steep slopes so that they sloped into the water. Of these three, one feedlot was in Millard, Box Elder, and Sevier Counties.

Table 11 lists the assets and values of the three feedlots. By interviewing feedlot owners which of these assets would be lost through relocation was determined. The other assets could maintain their full value after relocation. The assets which would lose value would do so because of difficulty of moving or because of the cost of structures necessary to put them in operating condition.

Table 11. List of assets for three feedlots requiring relocation

	Feedlot numbers					
	No. 1		No. 2		No. 3	
Asset	cost now	present value	cost now	present value	cost now	present value
	dollars		dollars		dollars	
Feedyard						
Land	6,000	6,000	10,000	10,000	3,000	3,000
*Corrals & mangers	10,000	5,500	4,000	2,261	20,000	9,600
*Sheds	5,000	2,750	-----	-----	-----	-----
*Water	600	240	3,000	1,700	-----	-----
Feed storage						
*Grain	5,000	2,750	800	560	7,000	21,194
*Silage	3,000	2,100	200	131	-----	-----
Feeding & miscellaneous						
Auto feeder	9,000	1,800	4,000	1,335	9,000	5,400
Trucks	8,000	3,100	2,500	1,250	11,000	7,000
Tractor & scoop	8,000	5,600	6,000	1,500	5,500	1,925
Scales	3,000	2,200	1,200	432	600	742
*Feedmill	2,700	1,430	500	66	4,000	2,200
Augers	-----	-----	200	70	-----	-----
Cattle squeeze	400	300	425	42	100	14
*Sprayer & dipping	1,000	693	-----	----	-----	-----
TOTAL	61,700	34,483	32,825	19,347	61,200	31,375
*Total	27,300	15,463	8,500	4,718	37,000	15,994

*Those assets whose value would be lost through relocation

Table 12 summarizes the effect relocation will have on their feedlots. The same amortization rate was used as in the previous two considerations. These feedlots have a combined capacity of 3,500 head. None of the three filled their lots more than once, and two of the three did not fill their lots to capacity in 1970. The loss in value of assets ranged from $15,994 to $4,718. As mentioned earlier, the annual cost was calculated using an amortization rate of eight percent for twenty years. The per-head capacity and per-head fed were significant in all three lots, and on a per pound basis one lot was affected almost a cent a pound. This all means that because these three feedlots will probably be required to move, the cost of beef production will be increased. These costs ignore the fact that the operator will also have pollution control costs at the new site.

Even with the costs of relocation this high, estimates were cheaper for these feedlots to be relocated than to build extensive structures only to be required to move a few years later because of more stringent rules.

Marginal Cost Analysis Before and After Pollution Control Expenditures on Feedlots

Marginal cost without considering pollution problems

Table 13 gives the size and costs as listed by the 26 feedlot operators surveyed. The feedlots ranged from 550-hand capacity to 5,000 and from 600 total head fed per year to over 11,000. The feedlots put on an average of 334 pounds per animal but ranged from 200 to 600 pounds. The average cost per pound of gain ranged from 17.01 cents to 26.48 cents with an average of 22.57 cents.

Table 12. Size of feedlots requiring relocation and costs accruing to them through value loss in assets resulting from relocation

Feedlot No.	Capacity 1970	# fed 1970	Lb.s gain per animal	Value loss in assets	Annual cost	Cost per head capacity	Cost per head fed
25	1,000	750	315	$15,463	$1,575.68	$1.576	$2.010
17	1,400	1,400	350	4,718	480.76	0.343	0.343
20	1,100	1,050	600	15,994	1,629.79	1.482	1.552
Total	3,500	3,200		36,175	3,686.23		
Average	1,167	1,067	424	12,058	1,228.74	1.053	1.152

Table 13. Size and costs of twenty-six feedlots surveyed, 1971

Feedlot No.	Capacity	No. fed	Pounds gained
1	5,000	11,168	3,629,600
2	4,000	11,000	3,380,000
3	4,000	7,500	3,480,000
4	3,000	6,500	1,325,000
5	2,500	6,200	1,750,000
6	6,000	4,000	1,200,000
7	2,500	3,500	1,250,000
8	1,600	3,500	1,086,440
9	2,500	2,500	1,387,500
10	1,350	2,000	800,000
11	1,500	2,000	620,000
12	1,200	2,000	840,000
13	1,200	1,650	520,000
14	800	1,600	390,000
15	1,600	1,600	763,000
16	1,000	1,400	421,600
17	1,400	1,400	489,000
18	1,200	1,200	480,000
19	1,200	1,200	720,000
20	1,100	1,050	637,000
21	550	1,000	481,072
22	1,000	1,000	250,000
23	1,200	800	300,000
24	650	800	400,000
25	1,000	750	237,500
26	1,000	600	285,000
Total	50,050	77,918	26,023,471
Average	1,925	2,997	1,000,903

Table 13. Continued.

Feedlot No.	Total costs	Average cost per Cwt. gained	Pounds gained per animal	Adjusted per heads fed cost
1	745,920	20.55	325	68.637
2	840,559	24.87	310	83.006
3	625,830	26.30	320	87.842
4	267,457	20.18	200	67.401
5	371,145	21.21	280	70.841
6	284,460	23.71	300	79.191
7	309,500	24.76	500	82.698
8	266,180	24.50	310	81.830
9	272,264	19.62	555	65.531
10	149,841	18.73	400	62.558
11	151,906	24.50	310	81.830
12	204,076	24.29	420	81.129
13	89,492	17.01	315	56.813
14	82,656	21.19	245	70.775
15	167,742	21.96	475	73.346
16	96,179	22.81	300	76.185
17	86,008	17.59	350	58.751
18	101,438	21.13	400	70.574
19	152,859	21.23	600	70.908
20	168,980	26.48	605	88.443
21	110,335	22.94	480	76.620
22	53,509	21.40	250	71.476
23	64,838	21.61	375	72.177
24	88,957	22.24	500	74.282
25	56,241	23.68	315	79.091
26	65,220	22.88	475	76.419
Total	5,873,592	-----	---	------
Average	225,907	22.57	334	74.170

Figure 5 shows the adjusted cost per head fed plotted against the number of head fed. The cost per head fed is adjusted to put it on an equal basis for all feedlots. The cost was adjusted on the basis that all feedlots put an average of 334 pounds on each animal fed. This was done because later in the analysis the costs of pollution control will show up better on this basis than on the average cost per pound of gain.

Figure 5 shows that costs for feedlots of this size are increasing with number of head fed. The regression for the feedlots as they are, without pollution control costs, is:

$$Y = 72.971 + .00040\ X$$

where Y is the predicted adjusted cost per head fed and X is the number of head fed. The R^2 for this regression model equaled .022 which means that size or number of head fed explains only a small part of the cost per head fed. The R^2 of this and following equations are unimportant to this study as the author merely attempted to show the shifts in the functions when constants were added to the dependent variable. Other variables which have some bearing on this are such things as the operations, whether they were warm-up or finishing, (no distinction is made in this study), and management, especially in answering the part of the questionnaire pertaining to costs.

Marginal cost where feedlots pay all pollution expense

Table 14 gives the costs to feedlots of correcting their pollution problem with and without government assistance. The per-head-fed costs are adjusted as explained above. The costs involving government assistance are figured on the basis of information gained from the

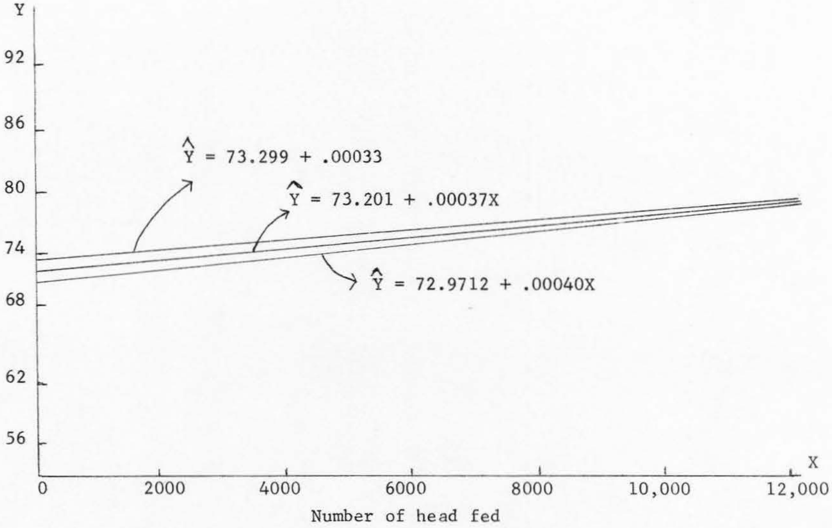

Figure 5. Relation of cost of head fed and number of head fed

Table 14. Costs to feedlots of correcting pollution problems with and without government assistance

Feedlot No.	Number fed	Adjusted per head fed cost	Per head fed annual pollution cost
1	11,168	68.637	.030
2	11,000	83.066	.030
3	7,500	87.842	.023
4	6,500	67.401	.000
5	6,200	70.841	.012
6	4,000	79.191	.000
7	3,500	82.698	.003
8	3,500	81.830	.000
9	2,500	65.531	.057
10	2,000	62.558	.000
11	2,000	81.830	.000
12	2,000	81.129	.000
13	1,650	56.813	.000
14	1,600	70.775	.030
15	1,600	73.346	.006
16	1,400	76.185	.000
17	1,400	58.751	.343
18	1,200	70.574	.161
19	1,200	70.908	.032
20	1,050	88.443	1.482
21	1,000	76.620	.000
22	1,000	71.476	.000
23	800	72.177	.000
24	800	74.282	.000
25	750	79.091	2.010
26	600	76.419	.350
Total	77,918	------	-----
Average	2,997	74.170	.178

Table 14. Continued.

Feedlot No.	Total adjusted per head fed cost	Per head fed pollution cost with government assistance	Total adjusted per head fed pollution costs with government assistance
1	68.666	.019	68.655
2	83.094	.018	83.083
3	87.864	.012	87.853
4	67.401	.000	67.401
5	70.865	.006	70.846
6	79.191	.000	70.191
7	82.701	.002	82.701
8	81.830	.000	81.830
9	65.626	.036	65.591
10	62.558	.000	62.558
11	81.830	.000	81.830
12	81.129	.000	81.129
13	56.813	.000	56.813
14	70.797	.015	70.786
15	73.354	.003	73.350
16	76.185	.000	76.185
17	59.110	.161	58.920
18	70.767	.098	70.574
19	71.037	.016	70.937
20	91.127	1.310	90.815
21	76.620	.000	76.620
22	71.476	.000	71.476
23	72.177	.000	72.177
24	74.282	.000	74.282
25	80.986	1.761	80.752
26	76.917	.190	76.689
Total	------	----	------
Average	74.348	.140	74.310

chairman of the ASCS who pointed out that only one level of government assistance would be made available and that was assistance with the primary investment or construction of the structures up to $2,500. This would require structures on the feedlot of $5,000 or more because only half the bill could be paid through the ASCS and to gain that, the farmers would have to build those structures recommended by engineers working with the ASCS. If the feedlot operator had more than one lot, or at a later date acquired another lot, he would be eligible for up to $2,500 on each of the lots. No loans or other assistance are available except from the sources commonly used by farmers and at the usual expense.

The regression for the feedlots after they implement the pollution control measure suggested in this study is:

$$\hat{Y} = 73.299 + .00035\ X$$

where Y and X are the same as mentioned earlier. This is assuming that the feedlot operators bear the entire cost themselves. Note that the Y intercept is higher and that the slope is less than when no pollution control is undertaken, implying that larger feedlots will be affected less by pollution control measures. The R^2 for this equation was also somewhat lower at .0159.

Marginal cost of feedlots when government assistance is used

The regression equation for the feedlots after government assistance is implemented:

$$\hat{Y} = 73.201 + .00037\ X$$

with an R^2 of .0168. To consider the effect of government assistance in this study, all feedlot owners who have pollution problems would apply for the maximum that they were eligible for was assumed. Therefore, if they have initial expense of $5,000 or less, they would receive half of this; therefore, in figuring annual cost, half of the cost of the structures costing $5,000 or less was amortized at the rate used previously and then operating costs were added. For feedlots with initial costs of more than $5,000 the costs over $2,500 were amortized at the usual rate and period and then the operating costs were added.

When government assistance is used, the slope is almost the same as when no attention is paid to pollution, but the function is about 30 cents above the function where no pollution is considered.

SUMMARY

Cattle feedlots can contribute to many types of pollution. They contribute plant nutrients to water through runoff. This process is known as eutrophication and causes excessive algae growth in the water. The main plant nutrients are nitrates and phosphates; the nitrates are water soluble and can be leached into ground water where they are also harmful. Feedlots also contribute organic solids to water, which cause available oxygen to be used in decomposition processes. Infectious agents, such as bacteria can be introduced to water through animal wastes, causing many diseases in humans. Cattle feedlots also give off an offensive odor and dust which can cause problems. They are also breeding grounds for many undesirable insects.

Feedlot operators have to deal with pollution problems because public pressure is being put on government agencies to enforce environmental quality control. Feedlot operators are being forced to pay the costs of correcting these problems with some assistance from government programs. It is likely that in the long run as the standards are enforced throughout the industry, the consuming public will pay the bill through increased prices or taxes.

This study concerned itself with water runoff pollution. Other types of pollution are mentioned, but the first action taken by enforcement will deal with the question of surface water pollution caused by runoff from the corrals of feedlots.

The 26 feedlots surveyed in this study were divided into four groups: the first were those without pollution problems; the second were those with only minor problems; the third were those with more serious problems but problems that could be corrected; the fourth were those feedlots which would probably be required to relocate. Six feedlots in the group had only minor problems, which could be corrected at minimal expense. On a per-head-fed basis the costs ranged from 0.3 cents to 4.7 cents per head fed. The average for the group was 2.1 cents per head fed.

The group with more serious problems will have higher costs. They were given two alternatives, a natural evaporation system and a mechanical disposal system. If the least cost method of pollution control was adopted, the annual costs for the five feedlots in this group ranged from 35 cents per head fed to three cents with an average of .046 cents.

Three feedlots would be required to relocate. The annual costs to them were figured on a value of lost-assets basis. This value was amortized at eight percent for 20 years. On a per-head-fed basis the costs ranged from $2.01 to $.34 with an average of $1.15 per head fed.

As far as affecting the industry as a whole, meeting these pollution standards will not have much impact--the average increase in per-head-fed cost being only $.178. One level of government assistance was also analyzed, and this dropped the per-head-fed costs to $.04 per head. Government assistance would amount to half the costs up to $5,000. In other words, if the structures or improvements cost more than $5,000, the government through the Agricultural Stabilization Committee Service would pay $2,500 and the feedlot operator would be required to pay the balance.

CONCLUSIONS AND RECOMMENDATIONS FOR FEEDLOT OPERATORS

Feedlot operators in Utah will be required to make investments on their feedlots to curb pollution. These investments vary a great deal from one feedlot to another depending on the particular problems. The feeding industry could gain a comparative advantage over other areas in the nation where large concentrations of cattle are fed in areas of heavy precipitation, thus high costs of pollution control. Utah has an arid climate which does not cause problems with extremely heavy runoff and nitrate leaching under feedlots.

The feedlots surveyed in this study are permanently located. Because of location choice, some operators will have to relocate, while others will have to make substantial improvements on existing lots to control pollution. Many of the lots having problems with pollution located before there was much thought given to pollution; however, this does not excuse them from the responsibility of control. They will have to do their part to help keep the environment suitable for habitation. Most operators surveyed expressed willingness to control pollution and bear added expenses provided that the improvements would satisfy the requirements for pollution control. Most also expressed a concern over the amount of government assistance that would be made available because they believe they are victims of a popular movement in society. Since society wants the changes, it should be willing to pay a portion of the bill.

Existing feedlot operators can do many things to help keep themselves out of the courts because of pollution caused by their feedlots. Some of the more general improvements that feedlot operators could consider are such things as diking around the top of feedlots to prevent runoff resulting above the feedlot from running through, compounding the problem of runoff from the feedlot. Feedlot operators should think about cleaning corrals, not only when it is convenient, but rather when it needs to be done to control odor and percolation of animal waste constituents into the ground water.

Potential feedlot operators should consider pollution problems when they are choosing a site for their feedlots. It is not wise to locate next to bodies of water such as lakes, streams, or even irrigation canals. Sites should be chosen which allow room for containing all runoff and keeping it away from these bodies of water. Building at the top of a slope is best to prevent runoff from above through the lot. Where this is not possible, ditches and dikes should be built and maintained to divert upslope runoff. Locating as far away from population centers as possible and always downwind of prevailing breezes to keep the odor away from the population is best. One final point that both potential and existing feedlot operators should work for is county zoning to insure against serious population encroachment. Zoning ordinances can help limit the spread of subdivisions into farming areas.

NEED FOR FURTHER RESEARCH

The section on the nature of animal waste pollution pointed out several ways that animal waste damages the environment. Knowledge about how extensive preventive measures must be to stop environmental damage is still lacking. Many unanswered questions remain: How far do the constituents of animal waste travel through soil? Does running water in streams purify itself? If so, how far does it have to run to accomplish purification?

The condition relative to pollution and location of the smaller feedlots in the state should be surveyed. Do they have greater or lesser pollution problems than the larger feedlots considered in this study?

Studies on the actual amount of runoff from feedlots in given years should be made to measure pollution. The lack of this type of information was mentioned as a serious limitation in this study.

A question remains about ground water pollution in Utah. Is there enough precipitation in Utah to cause leaching of animal waste ingredients into the ground water? Is this leaching serious enough to warrant hard surfacing of all corrals?

Odor control poses a question. How can odor be controlled? Will this necessitate hard surfacing of feedlots? Are there some additives that can be used on manure to control odor?

Beneficial studies could be made to determine whether or not pollution in other areas of the nation will help shift some measure of comparative advantage to more arid areas such as Utah. Will feedlot operators actually benefit from this environmental movement now so popular with society?

Research should be done to find better and more economical methods of handling the manure in feedlots. Different uses of manure should be given consideration. The question of recycling manure for feed for other animals or poultry should be studied. Some marketing of steer manure for fertilizers on home gardens is now being done, perhaps more of this is feasible. Are there other ways of disposing of manure such as burning or using chemicals to break it down?

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APPENDIX

Example Questionnaire

Feedlot NAME Location COUNTY

Costs: 1968

Utilities 280 Vet 5,000 Interest 3,600 Depreciation 1350

Repair 450 Labor 25,200 Feed 733,129 Death 10,000

Misc. 56 Fuel 273 Total 779,338

Pounds Gained 3,200,000 Ave. Cost/lb. Gain 24.35

Capacity 1968 3500 # Head Fed 10,000

Capacity 1970________ # Head Fed________

Changes:

Utilities________ Vet________ Interest________ Depreciation________

Repair________ Labor________ Feed________ Death________

Misc.________ Fule________ Total________

Pounds Gained________ Ave. Cost/lb. Gain________

Sketch of Feedlot and Surrounding Area

VITA

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