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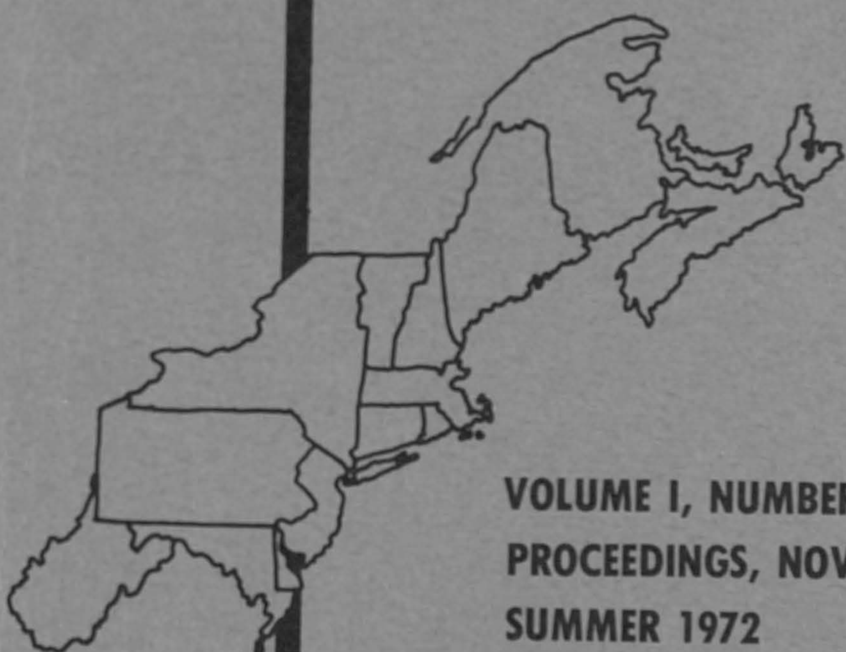

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FOUR-LEGGED RECYCLING MACHINES

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Introduction

Society's growing concern over environmental pollution has forced American industry to reevaluate its methods of waste disposal. No longer is it socially acceptable or, in many cases, legal to dump untreated by-products into the air, on the land, or into the rivers. Industries have developed various methods for complying with pollution legislation and social demands. Paramount among the programs now in effect are detoxification facilities and waste recycling programs.

Environmental protection movements are not unique to the highly industrialized sections of the country. The state of Maine, though not currently faced with extensive problems caused by heavy industry, is pursuing a vigorous regulatory campaign against agriculture, food processors, canneries, textile mills, and paper mills aimed at reducing further pollution. The irony is that these industries are the major source of employment in many Maine communities and the means of obtaining a clean environment may not be consistent with the profit motives of the firm. Failure or inability to meet pollution standards has resulted in forced cessation of some plant operations, with its inherent economic hardships on local residents, and may result in the closing of many other firms.

Purpose

The purpose of this paper is to propose an efficient, economically justified means for disposing of the waste by-products associated with several Maine industries. Specifically, consideration will be given to the feasibility of utilizing these waste products as a source of feed for swine and beef cattle. Thus, recycling is the concept employed. To be effective, the recycling program must meet several criteria. First, it must be a non-polluting alternative to the present method of waste disposal. Second, and perhaps more important, the recycling endeavor must be economically appealing; that is, the final product of the program must be a saleable item that will justify the sacrifices that individual entrepreneurs must make in order to pursue the program.

Available Waste Products

The first step in developing a successful recycling feeding program is to identify those by-products that provide ingredients essential to the growth and development of domestic animals. The agricultural sector is well endowed with waste products which can be classified as potential feedstuffs. Maine produces and processes 78 million chickens per year which provide approximately 28,860 tons of chicken offal per year. In addition, 471,000 tons of poultry manure are produced per year. If this manure were put on land at the rate of 10 tons per acre, it could cover 47,100 acres. Maine's potato production utilizes 150,000 acres of land so the only disposal problem here is the distance between the poultry and potato producing areas. Trucking poultry manure for long distances is not feasible but, under current technology poultry manure can be utilized as an ingredient in feed for livestock. Such use would get rid of the manure pollution problem and provide a low cost livestock feed ingredient. About 10 percent of the potato production is culled or waste, and about half again as much is produced by our processing plants. Much of our waste is utilized as starch, but the declining demand for starch has forced many of these operations to close and strict anti-pollution laws may force many of the remaining operations to close. This means that Maine may have about 270,000 tons of potato waste that has no economic use unless alternatives are developed.

Other wastes are available. For example, there are food freezing and canning operations that are large producers of waste. There are bakeries and dairy processing plants that produce waste. The production and preparation of human food provides a large supply of waste that could be usable as livestock feed. In other words, by-products from human food production and processing can be used as an input to produce livestock--a human food. Livestock by-products can be used as livestock feed and as fertilizer for our plant crops. The idea is to recycle the by-products as inputs in our food production process.

Recycling is not new to agriculture. No one really knows how long man has utilized manure, a by-product from livestock, to produce more grain and forage for his livestock. Waste by-products from breweries and distilleries have provided feed for animals which in turn produce by-products used as inputs to produce the grain for the breweries and distilleries. Today, as mentioned earlier, our beef producers are recycling poultry manure as an ingredient in livestock feed.

Highly competitive industries continually study methods of utilizing profitably their by-products. A good example of this in Maine is Potato Service, Inc., a potato processor in Presque Isle, located in the heart of Maine's potato country. Potato Service, Inc. created a subsidiary, Sal-Mor Farms, a business engaged in feeding about 4,000 steers per year. Sal-Mor's operation depends on the availability of potato waste from Potato Service's processing plant. Potato waste is combined with corn silage, hay, barley and a protein supplement to provide a nutritionally balanced diet. The bulk of this diet, potato waste, is obtained free, except for transportation cost. In this way, Sal-Mor obtains a cheap energy feed source and Potato Service can dispose of its waste in a non-cost, non-polluting manner.

Economic advantages exist in the Northeast that may permit feeding additional livestock. One advantage is that the Northeast's large population provides a good market and generally there is good transportation to these markets. Secondly, the processing of meat has gone through revolutionary changes. Efficient slaughter plants are now geared to single species of animals. This allows efficient processing operations to be located directly in the production area rather than in the terminal markets.

Many field crops produced in the Northeast require relatively strict grading before they are marketed, i.e., potatoes and this grading separates a certain percentage of total production as waste material. Most of this waste material can be utilized as feed for meat producing animals and as an organic fertilizer that can be recycled into the land to aid in the production of our crops, which, in turn, produce food for man and beast. The nutrient levels contained in potential feedstuffs are easily analyzed with today's technology. Nutrient requirements for domestic animals are readily available from the National Academy of Sciences.[1/] The basic objective of a four-legged recycling machine then is to make use of our waste resources while meeting the animal's essential nutrient requirements through a balanced, least-cost ration. Four-legged recycling machines that will be considered are swine and beef cattle.

Nutrient Requirements

There are six classes of nutrients required for growing and finishing swine. These are protein, energy, inorganic nutrients, vitamins, amino acids, and trace minerals. Protein and energy are the largest requirements in terms of volume, so an efficient ration must be high in its percentage of these nutrients, in addition to being inexpensive. The advantage of the traditional swine ration of corn and soybean meal is that it satisfies the protein and energy requirements, while making some contribution to the other four classes. That portion of the nutrient requirements not satisfied by corn and soybean meal is supplied through commercial feed supplements. While the cost of these supplements is relatively high in comparison to home grown products, their concentrated form enables a very small daily dosage to meet the hog's requirements.

With the exception of amino acids, beef cattle require the same type of nutrient intake as swine. Amino acids are synthesized within

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[1/] Nutrient Requirements of Swine, National Academy of Sciences, Sixth Revised Edition, 1968 and Nutrient Requirements of Beef Cattle, National Academy of Sciences, Fourth Revised Edition, 1970, Washington, D. C.

the rumen and provision through external means is not necessary. Daily dietary requirements used in this analysis are those recommended by the National Academy of Science. Requirements are increased by 10 percent of the published figures to compensate for waste and spillage during the feeding process.

The Model

Linear programming was used to analyze the various diet alternatives. The model, formulated in the standard form of Min Cx subject to $AX \geq b$, $X \geq 0$, had, as its objective, the specification of a least-cost ration that would satisfy the animal's minimum daily nutrient requirements.

The nutrients available for use in the swine ration included boiled potatoes, chicken offal, corn, soybean meal, ground limestone, dicalcium phosphate, and trace mineral salt. The A_{ij} matrix contains the nutrient content of these feedstuffs in terms of the hog's essential requirements. The nutrient content of the boiled potatoes and chicken offal were obtained through chemical analysis of samples, while the nutrient values of the remaining feeds were taken from published feed composition tables. Chicken offal was considered especially appropriate for the hog ration due to its relatively high content of protein and amino acids. This, plus its relatively low cost, which is limited to transportation and preparation, makes it an economically lucrative source of feed in northern Maine. Chicken offal was limited to not more than 25 percent of the dry matter intake since, in the absence of basic research data, production specialists felt higher quantities could have detrimental effects on the carcass quality of the animal.

The ingredients available for the beef cattle ration included alfalfa, clover, timothy, corn silage, soybean meal, ground limestone, dicalcium phosphate, corn, oats, high moisture ear corn, barley, 40 percent protein supplement, molasses, and potato waste. Molasses was included to enhance the palatability of the ration. Ideally, the model should be designed to ensure that the ration would exhibit a minimum palatability index. Unfortunately, inability to quantify palatability precluded such an approach. Further research could undoubtedly provide insight to the animal's willingness to eat these products.

The b vector of the model contained the minimum daily nutrient requirements and the costs were included in the C vector. The costs of the commercial feeds were the delivered prices to central Aroostook County, Maine. The costs of home grown products were based on average prices for the state of Maine. The costs of waste products were estimated and include transportation and preparation charges.

Results

Swine Ration: The optimal swine ration for five weight classes of hogs is shown in Table 1. Under the price structure assumed, it was found that cooked, cull potatoes and chicken by-products were sufficiently

TABLE 1

OPTIMAL RATION (LBS PER HEAD) AND TOTAL COST FOR GROWING AND FINISHING SWINE

Weight class - pounds	20-25	26-45	46-75	76-125	126-225	Total for 141 days		
Days in class	7	24	30	31	49	Total lbs. feed	Cost/lb.	Total cost/ head
Ingredients								
Boiled potatoes	30.00	252.20	400.50	662.40	1376.20	2721.30	$.005	$13.60
Chicken offal	3.40	39.60	68.80	102.00	255.00	468.80	.005	2.34
Poultry by-product meal	1.80	4.30	7.50			13.60	.070	.95
Dicalcium Phos								
Ground limestone	.02	3.10	12.40	1.90	47.60	65.00	.015	.97
Trace mineral salt	.06	.43	.69	.90	2.20	4.28	.005	.02
Methionine	.03	.09	.17			.29	.120	.03
Total	35.30	299.70	490.00	767.20	1681.00	3273.27		$17.91

high in nutrient value and low enough in cost to restrict commercial ingredients to 11 percent of the feed cost for the entire growing cycle. In other words, waste products inherent in many Maine industries can be recycled efficiently and cheaply, and at the same time produce a marketable economic product. The benefits of utilizing excess capacity to produce a product exhibiting low variable costs are obvious.

A proposed budget for raising 200 hogs from 25 to 225 lbs. is shown in Table 2.

TABLE 2

PROPOSED BUDGET FOR GROWING AND FINISHING SWINE ON AN INDIVIDUAL AND TRUCKLOAD BASIS

			Per Head		200 Head
Income					
225 lb. hog @ $23.00 per cwt.			$51.75		$10,350.00
Non-Feed Costs					
Veterinarian and medicine		$1.00		$ 200.00	
Machine cost, fuel, and repair		.40		80.00	
Electricity and phone		.07		14.00	
Death loss		.38		76.00	
Bldgs and Equip ($24/head)					
Repairs	2%	.48		96.00	
Taxes	1%	.24		48.00	
Insurance	.5%	.12		24.00	
Depreciation	15 years	1.00		200.00	
Total Non-Feed Costs		$3.69		$ 738.00	
Feeder Pig					
25 lbs @ $1.00/lb.		$25.00		$5,000.00	
Feed Cost		$17.91		$3,582.00	
Total Cost			$46.60		$ 9,320.00
Return to labor & management			$ 5.15		$ 1,030.00

The cost figures shown, excluding feed, are based on a recent

Pennsylvania study.[2/] The budget suggests that each hog grown returns $5.15 to management for investment and labor (assuming $23.00 per cwt. market price). Doane's Agricultural Report notes that the production costs for market hogs in Illinois in 1970 were $19.03 per hundredweight.[3/] Assuming $23.00 per hundredweight market price, the grower would receive a return to labor and management of $9.00 per head. This figure is based on hogs grown in confinement housing and on the grower raising his own feeder pigs. An endeavor of this nature is an inherently high risk proposition and is partly reflected in the gross profit figure. The high risk of confinement housing and farrowing facilities detracts from the apparent lucrativeness of the $9.00 per head return figure. In this respect, a passage from the 1969 Summary of Illinois Farm Business Record is worth noting. "The modest expansion in hog numbers suggests that a rather large profit margin is required to compensate farmers for the risk and detailed management involved in hog production when compared to other uses of the same resources. Large scale hog production in modern confinement facilities requires large scale capital investment. The future recovery of the capital is uncertain and a tight money market has added to the concern. Acquiring the managerial skills for successful production of a large volume of hogs in confinement is a problem."[4/] The Illinois study estimated a feed cost of $26.00 per head in raising a pig from 25 to 225 lbs., as compared to a cost of $17.91 by using Maine's waste products supplemented with commercial ingredients.

Beef Ration: The optimal rations for two weight classes of finishing steers are shown in Table 3. Under the price structure assumed, it was found that 60 percent of the feed cost consisted of potato waste priced at $5.00 per ton. (For the swine ration, recall that potatoes were priced at $10.00 per ton. This higher figure reflects the added expense incurred in cooking the potatoes for swine consumption.) The above rations, fed to a 500 lb. steer for 174 days, should produce 500 lbs. of gain at a total feed cost of $58.16. These rations should provide an average daily gain of 2.87 pounds. The feed cost per hundred pounds of gain is $11.63 and compares favorably with a reported average feed cost of $22.00 per hundredweight.[5/]

[2/] Figures derived from Pennsylvania Farm Management Supplement for Farm Credit Analysis Handbook, prepared by Pennsylvania Farm Management Extension Staff.

[3/] Doane's Agricultural Report, "Special Report: The Cost Side of Beef and Hog Operations," Doane's Agricultural Service, Inc., St. Louis, Missouri, February 18, 1972, p. 79.

[4/] Illinois Extension Service, Summary of Illinois Farm Business Records, 1969 Annual, Circular 1019 (Urbana: University of Illinois at Urbana-Champaign, 1969), p. 9.

[5/] Doane's Agricultural Report, op. cit., p. 78.

TABLE 3

OPTIMAL RATION (LBS PER HEAD) AND THE TOTAL COST FOR FINISHING YEARLING STEERS

			Total for 174 days		
Weight class - pounds	500-750	751-1000	Total		Total cost/
Days in class	87	87	lbs.	Cost/lb.	head
Ingredients					
Potatoes	5,881.2	8,138.8	14,020.0	$.0025	$35.05
40% mix	58.7	72.1	130.8	.0500	6.54
Alfalfa hay		158.5	158.5	.0175	2.77
44% SBM	253.3	20.0	273.3	.0500	13.65
Ground limestone	8.9	1.5	10.4	.0150	.15
Total	6,202.1	8,390.9	14,593.0		$58.16

The proposed budget for finishing 40 steers is shown in Table 4. The total cost of 500 lbs. of gain is $80.56 or $16.11 per hundred pounds, excluding labor and marketing costs. This is about $11.00 less than the expected costs per 100 pounds of gain.

Summary

The ideal pollution control system is one producing profits, as opposed to creating added costs that must be borne by society. Pollution control through detoxification facilities is an expensive, though noteworthy, proposition. The costs of pollution control technology, of legislation, and of policing the control system are paid eventually by the consumer. But, as suggested in this paper, pollution, in some cases, may be an economic blessing in disguise.

Utilizing waste products for livestock production is one method of reducing pollution while promoting the economic well being in a particular area. In the State of Maine alone, the 270,000 tons of potato waste produced annually could help produce 9,629 tons of beef or 19,853 tons of pork per year. This amounts to 38,500 beef animals or 198,500 hogs being finished per year, assuming sufficient poultry by-products were available. With a market price of $23.00 and $33.00

TABLE 4
PROPOSED BUDGET FOR FINISHING YEARLING STEERS ON AN INDIVIDUAL AND TRUCKLOAD BASIS

			Per Head		40 Head
Income					
10.0 cwt. @ $33.30/cwt.			$333.00		$13,320.00
Non-Feed Costs					
Veterinarian and medicine		$2.00		$ 80.00	
Machine cost, fuel and repair		.75		30.00	
Death loss		3.50		140.00	
Supplies		.35		14.00	
Bldgs and Equip ($120/head)					
Repairs	4%	4.80		192.00	
Taxes	2%	2.40		96.00	
Insurance	.5%	.60		24.00	
Depreciation	15 years	8.00		320.00	
Total Non-Feed Cost		$22.40		$ 896.00	
Feeder Steer					
5.0 cwt. @ $35/cwt.		$175.00		$7,000.00	
Feed Cost		$ 58.16		$2,326.40	
Total Cost			$255.56		$10,222.40
Return to labor & management			$ 77.44		$ 3,097.60

per cwt. for hogs and beef, respectively, the agricultural production sector in Maine would realize annual cash inflows of $9.1 million from the swine operation, or $6.4 million from the beef operation. These figures are, in reality, understated since they take no account of the multiplier effects on the State's economy.

As economists, we should continually be exploring alternative uses of our resources. Consider, for example, the opportunity costs of processing much of our poultry and fish by-products into meal. Might it not be more efficient and profitable both in terms of financial returns and social benefits, to use these same basic waste products for animal feed without the cost of processing them? Transformation of wastes into processed feed ingredients requires land, labor, capital, and management, and is yet another source of pollution. Economists are well equipped to answer this and similar questions. Instead of waiting for expensive technology to solve the pollution problem, let us take the initiative and seek out means for turning an economic cost into an economic gain. The four-legged recycling machine appears ideally suited for this purpose.