FEED USE OF UREA IN THE UNITED STATES

(An Administrative Report)

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PURPOSE

This report was prepared for administrative use with the intent to draw together available information on urea and its growing use in the cattle and sheep feeding industry. Since much of the basic data needed was not readily available, conservative estimates of urea usage now and by 1970 were made. Published prices for urea were used in this report. However, it is quite possible that urea prices, by negotiation between buyers and sellers, are lower than assumed. If negotiated prices are widespread, more urea may be used than indicated herein.

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SUMMARY

1. Urea is a nonprotein nitrogen compound which is changed in the rumen into complex proteins by microorganisms which convert this material into their cellular structure. These microorganisms are then digested by the ruminant host, thereby supplying protein to body tissues. Urea furnishes no energy, vitamins, or minerals in the diet.

2. Scientific literature over the last 50 years contains hundreds of references stating the usefulness of urea in feeding cattle, sheep, and other ruminants.

3. Two grades of urea are commercially available, fertilizer grade (46 percent nitrogen), and feed grade (42 percent nitrogen). The protein equivalents are about 290 percent and 262 percent, respectively. Fertilizer urea within limits is nontoxic to plants and ruminant animals, but feed urea is toxic to some plants. One pound of urea plus 6 pounds of corn (or other feed grain) is equivalent to and can be substituted for 7 pounds of soybean meal. In some supplemental rations, molasses is substituted for feed grain.

4. Sale of urea as a feed supplement is regulated under feed control laws in most States. In general, if equivalent protein from urea exceeds one-third of the total crude protein, the label shall bear a statement of proper usage and the following statement: "WARNING: This feed should be used only in accordance with directions furnished on the label." Most feed manufacturers keep the amount of urea below the level for which the warning would be required.

5. The amount of urea used in milk-cow rations (complete feeds) should not, and need not, exceed 2 percent of the concentrate ration. For beef cattle and sheep, the amount of urea should not exceed 1 percent of the concentrate ration.

6. World urea production capacity by January 1, 1966 will be about 10 million tons per year, a fivefold increase since 1959. Most urea produced in nations other than the United States is, and probably will be, used as a fertilizer applied on food crops, and thus does not compete with oilseed meals in livestock feeding in those nations.

7. U. S. imports of urea amounted to 200,000 tons in 1963, a threefold increase since 1957. Although data are not available to indicate how much imported urea is used for feed, some trade sources indicate as much as a third may be so used. This would be in addition to domestic production used for feed.

8. About 142,000 tons of urea from domestic production was feed grade in 1963, equivalent to 760,000 tons of soybean meal. If as much as a third of the imported urea (or 70,000 tons) was used for feed, at least 210,000 tons (1,125,000 tons soybean meal equivalent) from these 2 sources would have been used. In addition, an undetermined about of fertilizer urea probably was used for feed.

9. The feeding of urea as a source of protein has gained in importance for cattle feeds because it has been cheaper than oilmeals. During the last 7

years, a substantial saving in cost of protein supplements would have resulted by substituting a grain-urea mixture for soybean or cottonseed meal. During the last 2 years, well over 25 percent could have been saved. Also many feeders have learned how to utilize urea safely and effectively in their rations. A carbohydrate-rich feed is needed with urea to provide a quick source of energy for microorganisms that utilize the urea in the rumen. Also vitamins and minerals must be added because urea does not contain these elements as do the oilmeals.

10. The use of urea could have been expanded, by at least 40 percent, in the current feeding program.

11. By 1970, at least 275,000 tons of urea could be used for feed--195,000 tons of feed grade from domestic production and 85,000 tons from imported urea and fertilizer urea. This tonnage is equivalent to about 1.5 million tons of soybean meal--about 20 percent of the consumption of high-protein meal projected for 1970.

12. The cost of urea may be reduced as much as 40 percent or more within the next 10 years by economies of large-scale production, by reduced freight costs because of plants being more strategically located, and by increased numbers of producing plants.

FEED USE OF UREA IN THE UNITED STATES

Urea for Ruminants

Urea is an organic chemical compound which occupies a unique position in chemistry and nutrition. It was first synthesized by the German scientist, Woehler, in 1828. It is a nonprotein nitrogen compound having the formula N_2H_4CO. In pure form, it contains approximately 46.7 percent nitrogen and has a protein equivalent of about 290 percent.

In 1918, a German scientist, W. Voltz, demonstrated that sheep could utilize urea. He added urea to a protein-poor ration and found that adult sheep maintained body weight and lambs gained in weight. Following this discovery, many investigations were made to check on various phases of the problem. In 1937, Fingerling added convincing proof that urea can be utilized by calves to supply part of the protein needs for growth. In 1936, studies were initiated at the Wisconsin Agricultural Experiment Station by Hart and his associates. Since that time, many studies have been reported by research agencies of this country. Work has been principally with dairy cattle, sheep, and beef cattle of various ages under various conditions extending from winter ranges to intensive dairy farming. In hundreds of references available in scientific literature, the usefulness of urea for cattle, sheep, and other ruminants is abundantly demonstrated. During World War II, use of urea as a feed supplement rose to significant proportions under pressure of protein shortages.

In mammals, urea is one of the main products resulting from metabolism of proteins and thereby is a principal excretory product. The reverse product by which urea added to feed is converted into protein occurs only in ruminants through the medium of microorganisms. In the rumen, microorganisms, with the ability to use simple compounds in the building of complex living matter, utilize nitrogen in urea to build up the proteins of their cells. Since the life spans of microorganisms are short, the dead cells are available to be digested in the alimentary tract of the ruminant host, thereby supplying protein to body tissues. Other simple nitrogen compounds can likewise serve as nutrients for these microorganisms.

Nitrogen Content of Urea

While urea contains over 46 percent nitrogen, feed urea because of added conditioner is only about 42 percent nitrogen, which is equivalent to 262 percent protein. One pound of feed urea contains as much nitrogen as 6.4 pounds of cottonseed or soybean meal of 41 percent protein content. As an illustration, a steer weighing 700 pounds requires approximately 12 pounds of total digestible nutrients and 1.4 pounds of digestible protein daily. A ration of 11 pounds of corn, 6 pounds of mixed hay, and 1 pound of cottonseed meal would meet these requirements. If cottonseed meal is omitted, 0.16 pound of urea could be added as nitrogen replacement, and about 0.8 pound of additional corn would be needed to replace the energy of cottonseed meal. Urea adds nitrogen but no energy, vitamins, or minerals to the feed. In lieu of corn, 1 pound of molasses may be added. These additions then replace the nutrients lost by removal of cottonseed meal from the ration. Thus, 1 pound of urea and 6 pounds of grain replaced 7 pounds of 41 percent protein meal.

Comparatively small amounts of urea are required to satisfy protein requirements of ruminants under average conditions. In the example just cited, percentage of urea in the total ration is only 0.9 percent and in the concentrate portion about 1.3 percent.

Regulations for Control of Urea in Feeds

The following definitions and standards for regulation of use of urea in feed mixtures are taken from the 1965 edition of the Official Publication of the Association of Feed Control Officials:

> "Urea is predominantly urea but may contain other non-toxic nitrogenous compounds which are present as by-products from the commercial synthesis and processing of urea. It shall contain not less than 45% nitrogen (equivalent to 281.25% crude protein). If it contains less than 45% N but 41% or more N it shall be designated as 'Urea and Conditioner(s).' If the name of the conditioner(s) does not appear in the product name, the ingredient listing shall contain the specific name of the conditioner(s).
>
> "If the urea and conditioner(s) contribute more than 0.5% conditioner(s) to the mixed feed, the conditioner(s) shall be named in the mixed feed ingredient list. (Proposed 1958, Amended 1962, 1963, 1964).
>
> "Urea is an acceptable ingredient in proprietary feeds for ruminant animals only and shall be considered an adulterant in proprietary feeds for other animals and birds; the maximum percentage of equivalent protein from non-protein nitrogen must appear immediately below crude protein in the chemical guarantee; and urea must appear in the ingredient list. If...more than 8.75 percent of equivalent protein (in a feed) comes from urea or if the equivalent protein from urea exceeds one-third of the total crude protein, the label shall bear (1) a statement of proper usage and (2) the following statement in type of such conspicuousness as to render it likely to be read and understood by ordinary individuals under customary conditions of purchase and use:
>
> "WARNING: "This feed should be used only in accordance with directions furnished on the label."

Factors Affecting Efficient Utilization of Urea

Experimental work on efficiency with which urea is utilized in the digestive tract of cattle and sheep has shown varying values depending on diet, level of protein in the original ration, level at which urea is fed, and other factors. As is true with protein feeds generally, better efficiencies are obtained with reduced or minimum levels than with exceedingly high levels. Ingredients in the diet are also important. A carbohydrate-rich feed is needed to provide a quick source of energy for microorganisms. Corn serves this purpose very satisfactorily. Small amounts of molasses are also effective and are much preferred over large amounts. Relatively less urea

nitrogen is digested and absorbed by the animal as formed protein products than is digested and absorbed from natural feed protein nitrogen. Higher comparative utilization figures of 80 percent and above generally occur when urea allowance is on the low side. Attempts to equal or exceed, by substitution of urea, optimum animal production records achieved by feeding liberal levels of natural protein supplements have not been fully successful as yet. Nevertheless, daily gains and total feed utilization per unit of gain are very satisfactory. Urea can be used to the best advantage in a mixed feed for feeding livestock which are also receiving a fairly liberal allowance of concentrate mixture.

Problems in Urea Usage

Urea is a toxic product in the sense that the animal body cannot tolerate accumulation of large amounts, and normally excretes, through the urine, the urea resulting from the metabolism of protein. Reports have shown damage to the kidneys and poisoning of cattle and sheep that have been fed high doses of urea. In urea poisoning, urease in the rumen breaks down urea to ammonia faster than it can be utilized by the microorganisms. Excess ammonia is taken into the blood stream resulting in a toxic condition which may result in death of the animal. The range between a toxic dose and amounts recommended for protein replacement, while not very wide, is still sufficient under good control and reasonable care in formulation and mixing of diets, to preclude dangers of poisoning. Proper mixing and close supervision of operations are essential in safeguarding feed mixtures containing urea.

After determining that the quantity of urea in a diet is not excessive, a further essential is to provide sufficient molasses, feed grain, or other carbohydrates to furnish those essential nutrients, lacking in urea, but present in oilmeals.

Urea in Feedlot Rations

Urea has been used in feeding beef cattle on pasture and range and in the feedlot. In the feedlot, generous levels of concentrates are ordinarily fed, thus permitting the mixing of urea with the other feeds. A common method is to add a mixture of urea and molasses to the rest of the concentrate or ground portion of the ration. Many large feedlots have their own mixing equipment and can make up rations according to formula using any desired ingredients. As much as 0.35 pound of urea per head per day has been fed to steers with good results, but this amount is generally in excess of requirements. Usually 0.25 pound of urea or even less is sufficient. Perhaps one reason why maximum gains are not obtained with urea as with cottonseed or other protein meals is because the appetite stimulation achieved by natural protein feeds is lacking in urea. Therefore, it is important to select an appetizing mixture for use with the urea supplement. In recent Iowa experiments with fattening steers, soybean meal, urea, and molasses were compared singly and in combinations as supplements to shelled corn and hay. Supplementation with urea produced average daily gains of 2.5 pounds per day, which was equal to soybean meal gains and considerably cheaper under prevailing price conditions.

Urea in Wintering Rations

In many areas, supplemental feeding of 1 to 2 pounds of cottonseed or soybean meal per head to range cattle during winter months is common practice. A pelleted mixture of urea, molasses, and ground grain has been as effective in Oklahoma experiments. A mixture with a protein equivalent of 25 percent has given very good results. Such a mixture has been used successfully as a supplement in the feedlot also.

One of the most effective ways of using urea is in winter rations of cattle either for maintenance of mature stock or for growth of young heifers and steers With urea, use can be made of low-grade dry roughages such as corn cobs, oat straw, soybean straw, and poorer grades of hay along with various silages, if adequate readily available carbohydrates are also present in the ration. Otherwise, poor utilization of urea will occur. Molasses is a valued supplement for supplying available carbohydrates and for improving the palatability of the ration. Combinations of urea, molasses, and roughages, plus mineral and vitamin A supplements, provide for maintenance of mature animals, or in case of young stock desired growth and development. Feeding tests at Purdue Agricultural Experiment Station have demonstrated economies which can be achieved by use of various combinations of these low-grade feedstuffs.

Urea in Lamb Rations

In feeding lambs, results have not been as uniformly good as with beef cattle. Tests in Illinois showed good utilization of urea as long as total protein equivalent was kept at a medium level of around 12 percent. New York experiments showed that addition of the amino acid (methionine) to a diet of urea, corn grain, corn silage, and hay brought considerable improvement over those with urea alone and approximated results with a natural protein supplement. As in the cattle tests in Oklahoma, a pelleted supplement containing the equivalent of 25 percent protein was satisfactory for lambs.

Urea in Dairy Rations

Results of experiments using urea as a protein substitute in feeding dairy cows for milk production have been variable. Results from Wisconsin and Massachusetts have shown that urea is effective in replacing protein in the grain ration of dairy cattle, while results from England and Norway have not been so encouraging.

At Wisconsin, where urea was used to increase protein level of the grain ration from 10 to 18 percent, almost as much milk was produced as when linseed meal was used to increase protein content of the grain ration to 18 percent. Timothy hay and corn silage were fed as roughages.

In England, in extensive experiments with 274 cows, addition of enough peanut meal to increase protein content of the ration from 12.9 percent to 17.9 percent resulted in a significant increase in milk production. On the other hand, the addition of enough urea to the same ration to increase the protein equivalent to 17.9 percent resulted in no significant change in the milk production. Furthermore, when more than 3 ounces of urea were fed per day,

there was a depressing effect on milk production. Because of the palatability problem, concentrate mixture should not contain more than 2 or 3 percent of urea.

Most experimental data indicate that urea is not effective when added to high-protein grain rations for milk-production purposes. Thus, urea should not be added to concentrate rations already containing 14 to 18 percent protein. It is most effective when added to grain rations containing 10 percent or less protein, or when added to rations containing only home-grown grains. When high-protein forages, such as good quality alfalfa hay, early cut grass, legume mixtures, or grass silage are fed along with home-grown grains, addition of urea or any other high-protein concentrate would probably not increase milk production.

For growing dairy stock and for maintenance of dry cows, recommendations for feeding urea to comparable classes of beef cattle may be followed.

World Urea Production Capacity

World production capacity for urea will have increased nearly fivefold from 1959 to 1966 according to estimates published in Chemical Week (table 1). Production capacity was about 2.1 million tons in 1959 and will be about 9.9 million tons by 1966. Although the source for this information indicates these data are worldwide, the capacity which is or probably will be installed in Russia and its satellite countries is probably omitted.

Nearly all of the urea produced in nations other than the United States is used for fertilizer. As such, it is not directly in competition with oilseed meals in livestock production in those nations. It is used primarily to stimulate production of food and other cash crops and only to a limited extent on forage crops.

U. S. Imports and Exports of Urea

U.S. imports increased from about 60,000 tons in 1957 to more than 270,000 tons in 1964 (table 2). Exports increased from 68,000 tons in 1958 to nearly 87,000 tons in 1962, but in 1963 declined to less than 33,000 tons. In 1964, exports increased to about 37,000 tons. No data are available on the amounts of imported urea used for feed. Some individuals in the trade believe that all of the imported urea is used for fertilizer and industrial uses. However, other sources have suggested that as much as a third was used for feed. If a third of imports was used for feed, the soybean meal equivalent of inshipments of urea used for feed would have increased from 106,000 tons in 1957 to about 355,000 tons in 1963. This amount from imports would be in addition to that shown in table 3 from domestic production. Thus, about 1.2 million tons of urea (soybean meal equivalent) may have been used for feed in 1963.

Urea Situation in U.S.

In calendar year 1963, sales of all urea (46 percent nitrogen basis) from domestic production (that is, excluding imports) totaled 1,015,000 tons, or nearly three times the sales in 1956 (table 3). Of this total, 80 percent was

Table 1.--Industrial capacity for production of urea, United States, Japan, Western Europe, and other nations, 1959, 1963, 1966 1/

Nation	1959		1963		1966 2/	
	1,000 tons	Percent	1,000 tons	Percent	1,000 tons	Percent
United States	814.8	38.8	1,150.1	21.7	1,445.4	14.6
Japan	779.1	37.1	1,335.6	25.2	1,494.9	15.1
Western Europe	459.9	21.9	1,499.9	28.3	1,890.9	19.1
Other nations	46.2	2.2	1,314.4	24.8	5,068.8	51.2
Total	2,100.0	100.0	5,300.0	100.0	9,900.0	100.0

1/ Taken from chart in Chemical Week, April 25, 1964, p. 186.
2/ Estimated.

Table 2.--Urea: Exports and imports, United States, 1957-1964

Calendar year	Imports	Exports
	Tons	Tons
1957	59,241	NA
1958	48,706	68,170
1959	63,733	64,574
1960	82,134	66,380
1961	107,018	72,317
1962	188,040	86,742
1963	198,834	32,725
1964	271,485	37,432

Compiled from reports of the U.S. Tariff Commission.

Table 3.--Urea: Distribution of domestic production and sales, United States, 1956-63 1/

Calendar year	Total, all urea		Feed		Fertilizer, solid and liquid		Other 2/	
	Production	Sales	Production	Sales	Production	Sales	Production	Sales
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1956	420.9	373.6	3/63.0	3/60.0	247.2	215.9	3/110.7	3/97.7
1957	480.2	448.2	68.2	65.1	292.1	276.0	119.9	107.1
1958	530.6	495.0	74.8	3/73.8	364.5	345.8	91.3	3/75.5
1959	630.6	576.5	3/85.0	80.9	444.1	413.7	3/101.6	81.9
1960	734.5	706.5	95.0	94.6	548.4	547.6	91.1	64.3
1961	921.8	889.0	101.5	107.4	734.5	707.7	85.8	73.9
1962	1,010.0	967.0	111.4	114.1	807.7	789.3	90.9	63.6
1963 4/	1,091.4	1,014.9	126.4	129.6	854.2	813.0	110.8	72.3

1/ For comparability, all data are shown on basis of 46 percent nitrogen content. Feed urea normally contains 42 percent nitrogen.

2/ Plastics and other industrial uses.

3/ Estimated; data not reported separately.

4/ Preliminary.

Compiled from reports of the U.S. Tariff Commission.

used for fertilizer, 13 percent for feed, and 7 percent for industrial use. Sales of fertilizer urea in 1963 (solid and liquid combined) amounted to 813,000 tons, nearly four times the sales 7 years earlier. Imported urea used for fertilizer would be in addition to sales from domestic production. Data for 1964 production and sales of feed-grade urea are expected to be released in August 1965.

Sales of feed-grade urea also have trended upward since the middle 1950's. In 1963, sales of feed urea (46 percent nitrogen) totaled nearly 130,000 tons, 14 percent above 1962 and a little more than double the sales in 1956. The 1963 sales would be equivalent to 142,000 tons of urea on a 42-percent nitrogen basis. Both fertilizer urea and feed urea can be utilized in feed formulation. Data are not available to indicate how much fertilizer urea is diverted into formula feeds.

Consumption of Urea and High-Protein Feeds

The 142,000 tons of feed urea (42 percent nitrogen basis) sold in 1963 from domestic production would be equivalent to approximately 760,000 tons of 44 percent soybean meal.1/ Imported urea and domestically produced fertilizer urea used for feed would be in addition.

The quantity of high-protein feed fed to all cattle and sheep has trended upward sharply in recent years. The 5.6 million tons fed in October 1962-September 1963 was 8 percent more than the year before and about 50 percent more than 7 years earlier (fig. 1 and table 4). Sales of feed-grade urea have increased at a faster rate than high-protein feeds consumed by cattle and sheep. In 1963, urea used for feed--in terms of 44 percent soybean meal equivalent--was equal to about 20 percent of oilmeals and grain proteins consumed by cattle and sheep, compared with 9 percent in 1956.2/ The expansion in beef cattle feeding operations and increased dairy cow feeding rates have contributed to more protein feeding. In recent years, the increase in sales of feed urea also has been influenced by the rise in sales of commercially-prepared beef cattle and dairy cattle feeds, and by price relationships between urea and oilseed meals.

Oilmeals Fed to Cattle

Oilmeals fed to cattle have increased at a faster rate than numbers of cattle on farms (fig. 2). The oilmeals, which include soybean meal (table 5), cottonseed meal (table 6), linseed meal, peanut meal, and copra meal have been

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1/ A pound of feed urea (42 percent nitrogen) is potentially equivalent to 2.62 pounds of protein, expressed on the basis of protein as a 262-percent protein feed ingredient. Assuming 90 percent is used to replace oilseed meals, this would be equal to about 5.36 pounds of oilseed meal carrying a protein content of 44 percent.

2/ In this calculation, a third of imported urea was allocated to feed and added to the domestic production of feed-grade urea. No allowance was made for use of fertilizer urea for feed. Sales from domestic production of feed-grade urea in 1963 was equal to about 13 percent of oilmeals and other high-protein feeds consumed by cattle and sheep.

Consumption of high protein feeds, all oilseed meals, and soybean meal, United States 1940-64 and projection of oilseed meal consumption by cattle and sheep to 1970.

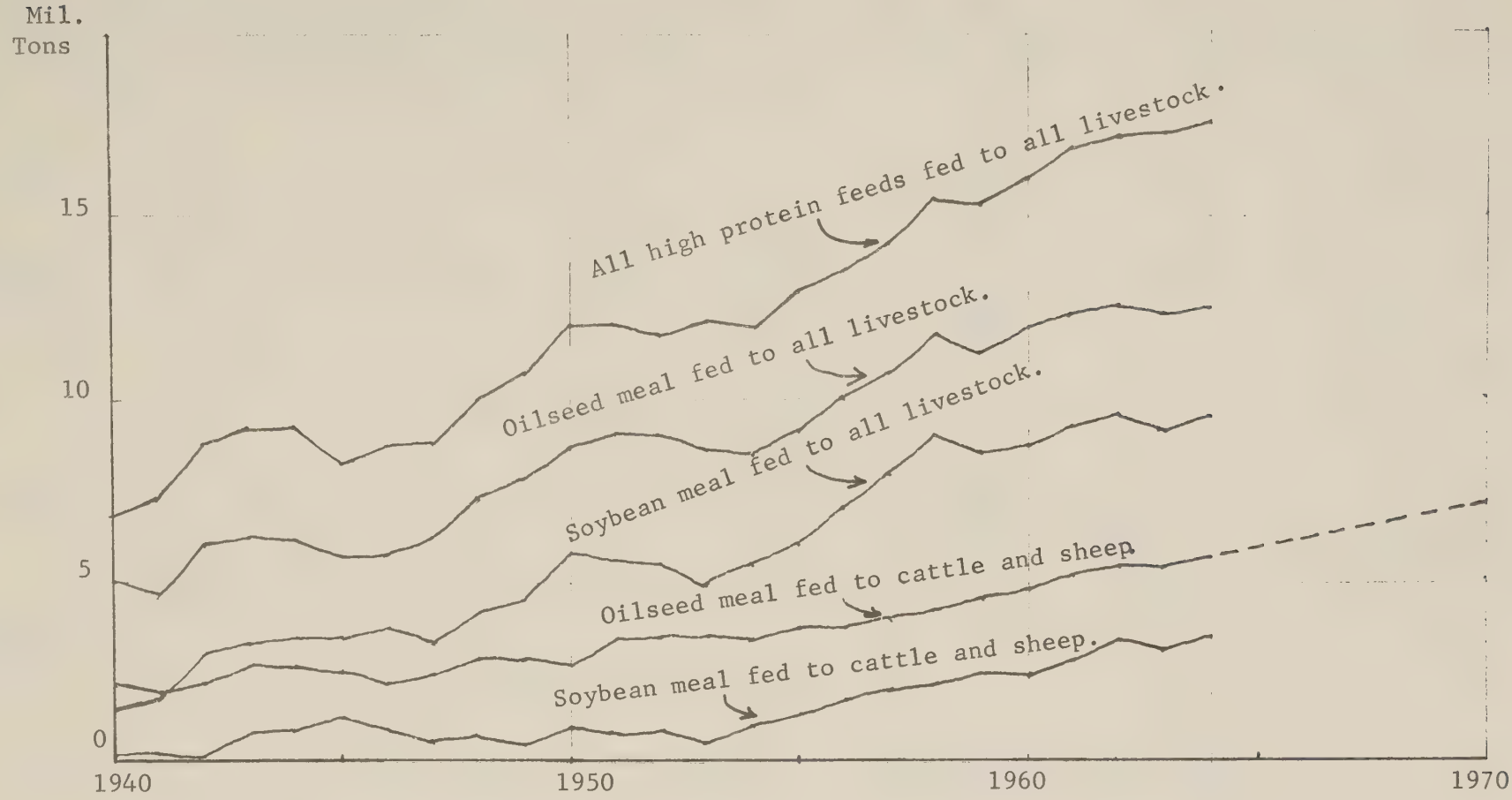


Figure 1

Table 4.--High protein feeds fed to cattle and sheep and sales of feed-grade urea, October-September 1955-62

Year beginning October	High-protein feed in terms of 44 percent protein soybean meal						
	Oilmeals, animal proteins, and grain proteins fed to livestock and poultry					Sales of feed-grade urea 1/	
	Total, all livestock and poultry	Beef cattle	Dairy cattle	Sheep	Total, cattle and sheep	From domestic production 2/	As a percentage of high-protein feeds fed to cattle and sheep
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	Percent
1955-56	12,601	1,832	1,690	189	3,711	350	9.4
1956-57	13,212	1,789	1,784	189	3,762	382	10.2
1957-58	13,813	1,789	2,034	192	4,015	433	10.8
1958-59	15,102	2,033	2,085	185	4,303	475	11.0
1959-60	14,730	2,277	2,108	200	4,585	555	12.1
1960-61	15,486	2,171	2,476	222	4,869	630	12.9
1961-62	16,168	2,698	2,282	210	5,190	670	12.9
1962-63	16,585	2,803	2,560	242	5,605	3/760	13.6

1/ Sales of 46 percent nitrogen feed-grade urea from table 3 converted to 42 percent nitrogen basis. Assuming urea is a 262-percent protein feed and 90 percent is directly substituted, a factor of 5.36 is used for converting urea to 44 percent protein soybean meal equivalent.

2/ Year beginning following January.

3/ Preliminary.

Urea data derived from reports of the U.S. Tariff Commission.

Cattle and calves on farms, January 1, and oilmeals fed to cattle, United States 1940-65

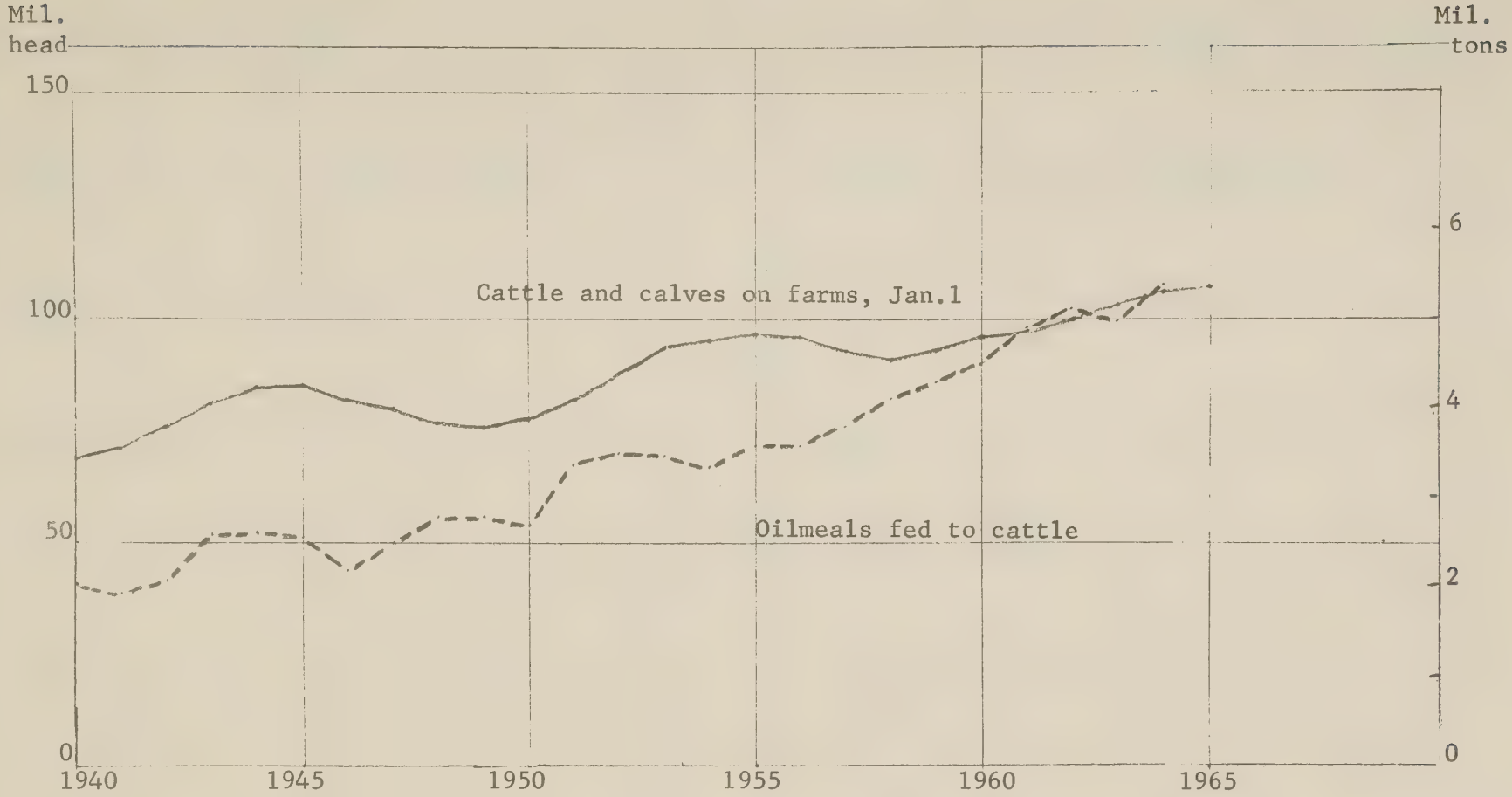


Figure 2

Table 5.--Soybean meal consumed, by kinds of livestock, 1950-63

Year beginning October 1	Dairy cattle	Beef cattle	Sheep	Hogs	Poultry	Other livestock 1/	Total soybean meal fed
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1950	401	595	25	1,305	3,055	337	5,718
1951	530	335	10	1,475	2,970	320	5,640
1952	726	195	20	1,434	2,940	195	5,510
1953	434	240	20	1,291	2,810	170	4,965
1954	552	600	20	1,201	2,835	220	5,428
1955	568	710	153	925	3,396	290	6,042
1956	784	860	170	950	4,039	290	7,093
1957	1,025	841	173	1,220	4,363	340	7,962
1958	1,100	957	155	1,871	4,510	345	8,938
1959	972	1,346	158	1,242	4,384	348	8,450
1960 2/	1,268	977	178	1,684	4,509	221	8,837
1961 2/	1,210	1,453	167	1,968	4,196	238	9,232
1962 2/	1,407	1,708	193	1,732	4,260	256	9,556
1963 2/	1,477	1,357	232	1,290	4,458	286	9,100

1/ Includes horses and mules, miscellaneous livestock on farms, and all livestock not on farms. 2/ Subject to revision.

Table 6.--Cottonseed meal consumed, by kinds of livestock, 1950-63

Year beginning October 1	Dairy cattle	Beef cattle	Sheep	Hogs	Poultry	Other livestock 1/	All cottonseed meal fed
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1950	470	935	40	195	100	113	1,853
1951	550	1,540	60	140	100	260	2,650
1952	729	1,465	50	142	100	185	2,671
1953	901	1,520	55	150	100	200	2,926
1954	780	1,170	55	150	100	150	2,405
1955	757	1,190	46	310	98	110	2,511
1956	552	963	25	470	100	110	2,220
1957	470	937	25	305	250	110	2,097
1958	550	990	38	200	300	120	2,198
1959	600	990	47	177	400	116	2,330
1960 2/	590	1,185	50	132	425	116	2,498
1961 2/	590	1,215	50	197	450	120	2,622
1962 2/	649	1,069	57	198	475	129	2,577
1963 2/	642	1,050	68	250	460	130	2,600

1/ Includes horses and mules, miscellaneous livestock on farms, and all livestock not on farms. 2/ Subject to revision.

the chief sources of new high-protein feeds. Of the oilmeals, soybean meal has increased the most in quantity. Since 1950, consumption of oilmeals by cattle has increased at a faster rate than consumption of oilmeals fed to poultry (tables 7 and 8). Consumption in 1961-1963 had increased about 65 percent for beef cattle and about 50 percent for poultry compared to consumption in 1950-1953.

The rate of feeding oilmeals to cattle (all oilmeals fed divided by all cattle and calves) increased from about 60 pounds per head in 1940 to almost 100 pounds during the last 5 years. Probably a chief cause of this has been increased grain feeding of cattle with a shift to a grain and supplement ration, with less reliance on forages and pastures in the fattening period. From 1954 to 1963, average live weight of cattle slaughtered under Federal inspection increased nearly 90 pounds per head.

While the amount of protein fed has approached requirements for growth and fattening (table 9), rates of feeding oilmeals to cattle have continued to increase during the last few years. The rate of increase was greater in the last 10 years than in the previous 10 years. This is shown by the two least-squares lines fitted to the data for 1940-52 and 1953-63 (fig. 3). The inclination of the latter line is greater than the former. Apparently more cattle are receiving a grain ration, including a protein supplement, before slaughter and are being fed more concentrates per head.

The increase of large feedlots where thousands of cattle are fed rather than hundreds has sharpened the economy of feeding. Such lots are not subsidized by other farm enterprises, and small economies in such large operations can return substantial extra profits. New technology has been adapted rapidly to favorable feeding conditions. Economies can be more readily realized with the large feedlots than with the smaller ones, where often only a sale for surplus forage and grain was being sought.

Eventually the rate of use of protein supplements per head should level off as requirements are met and the full effect of the use of grain rations is felt. Requirements per head form a ceiling for economical use of protein supplements. It is in large feedlots that substitution of urea for natural proteins could most easily take place, and perhaps in those small feedlots where a mixed protein supplement is purchased from a commercial feed manufacturer. The latter feedlots would hardly be large enough to obtain the full economy from the substitution of urea for oilseed meals as a source of protein, if they must rely on small, possibly inefficient, feed-mixing equipment not well adapted to the mixing of molasses and urea.

Urea Prices

The U.S. Department of Agriculture does not compile prices of urea, but since 1960, various trade papers have published wholesale prices of bagged and bulk urea used in feeds. During the last 4 years, wholesale prices of urea have been very stable--averaging from $95 to $100 per ton for bagged 42-percent feed-grade urea delivered from plants located east of the Rockies (table 10). Price of urea for bulk shipment is generally about $5 per ton below that of bagged urea. Urea prices before 1960 probably were no higher than the prices in the last 4 years. Although the above price quotations

Table 7.--All oilseed meals consumed, by kinds of livestock, 1950-63

Year beginning October 1	Dairy cattle	Beef cattle	Sheep	Hogs	Poultry	Other livestock 1/	All oilseed meals fed
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1950	1,069	1,660	65	2,090	3,305	470	8,659
1951	1,470	1,940	70	1,830	3,220	599	9,129
1952	1,685	1,825	70	1,741	3,195	400	8,916
1953	1,600	1,880	75	1,671	3,060	390	8,676
1954	1,450	1,920	75	1,601	3,085	390	8,521
1955	1,509	2,076	199	1,338	3,657	400	9,179
1956	1,557	2,023	195	1,545	4,304	400	10,024
1957	1,745	2,038	198	1,707	4,628	450	10,766
1958	1,800	2,305	193	2,181	4,830	465	11,774
1959	1,771	2,500	212	1,530	4,798	466	11,277
1960 2/	2,057	2,454	235	1,916	4,949	339	11,950
1961 2/	1,983	2,963	222	2,187	4,661	360	12,376
1962 2/	2,169	3,021	255	2,048	4,749	388	12,630
1963 2/	2,216	2,710	306	1,620	4,928	420	12,200

1/ Includes horses and mules, miscellaneous livestock on farms, and all livestock not on farms. 2/ Subject to revision.

Table 8.--Oilmeals fed to livestock, United States

(1950-53=100)

Year	Dairy cattle	Beef cattle	Poultry	Hogs	All oilseed meals fed
1950	73	91	103	114	98
1951	101	106	101	100	103
1952	116	100	100	95	101
1953	110	103	96	91	98
1954	100	105	97	87	95
1955	104	114	115	73	104
1956	107	111	135	84	113
1957	120	111	145	93	122
1958	124	126	151	119	133
1959	122	137	153	83	127
1960	141	134	155	104	135
1961	132	174	146	111	140
1962	153	173	149	108	144
1963	152	148	155	83	138

Table 9.--Percentage of digestible protein in concentrate ration, all livestock and poultry, 1940-1963

Year beginning October 1	With protein in corn calculated at--					Estimated digestible protein	
	6.5 percent	7.0 percent	7.5 percent	8.0 percent	8.5 percent	Total	Percent in corn
						(not including urea)	
1940	10.0	10.3	10.6	10.9	11.2	10.0	
1941	9.9	10.2	10.5	10.8	11.1	9.9	
1942	10.1	10.4	10.7	11.0	11.2	10.1	
1943	10.2	10.5	10.8	11.0	11.3	10.2	
1944	10.3	10.6	10.9	11.2	11.4	10.3	
1945	10.0	10.3	10.6	10.9	11.2	10.0	
1946	10.2	10.5	10.8	11.1	11.4	10.2	
1947	10.7	11.0	11.3	11.6	11.8	10.7	6.5
1948	10.7	11.0	11.3	11.6	11.9	10.7	
1949	10.7	11.0	11.3	11.6	11.9	10.7	
1950	10.9	11.2	11.5	11.8	12.1	10.9	
1951	11.0	11.3	11.6	11.9	12.2	11.0	
1952	11.2	11.5	11.8	12.1	12.4	11.2	
1953	11.2	11.5	11.8	12.1	12.4	11.2	
1954	11.3	11.5	11.7	12.0	12.3	11.3	
1955	11.3	11.6	11.9	12.1	12.4	11.3	
1956	11.5	11.8	12.1	12.4	12.7	11.5	
1957	11.1	11.4	11.7	12.1	12.6	11.4	7.0
1958	11.4	11.7	12.0	12.3	12.6	11.7	7.5
1959	11.1	11.4	11.7	12.0	12.3	12.0	
1960	11.2	11.5	11.8	12.1	12.4	12.1	8.0
1961	11.3	11.6	11.9	12.2	12.5	12.5	
1962	11.4	11.7	12.0	12.3	12.6	12.6	8.5
1963	11.4	11.7	12.0	12.3	12.6	12.6	

Oilmeals consumed by cattle, per head on farms January 1,

United States, 1940-64 and projection to 1970

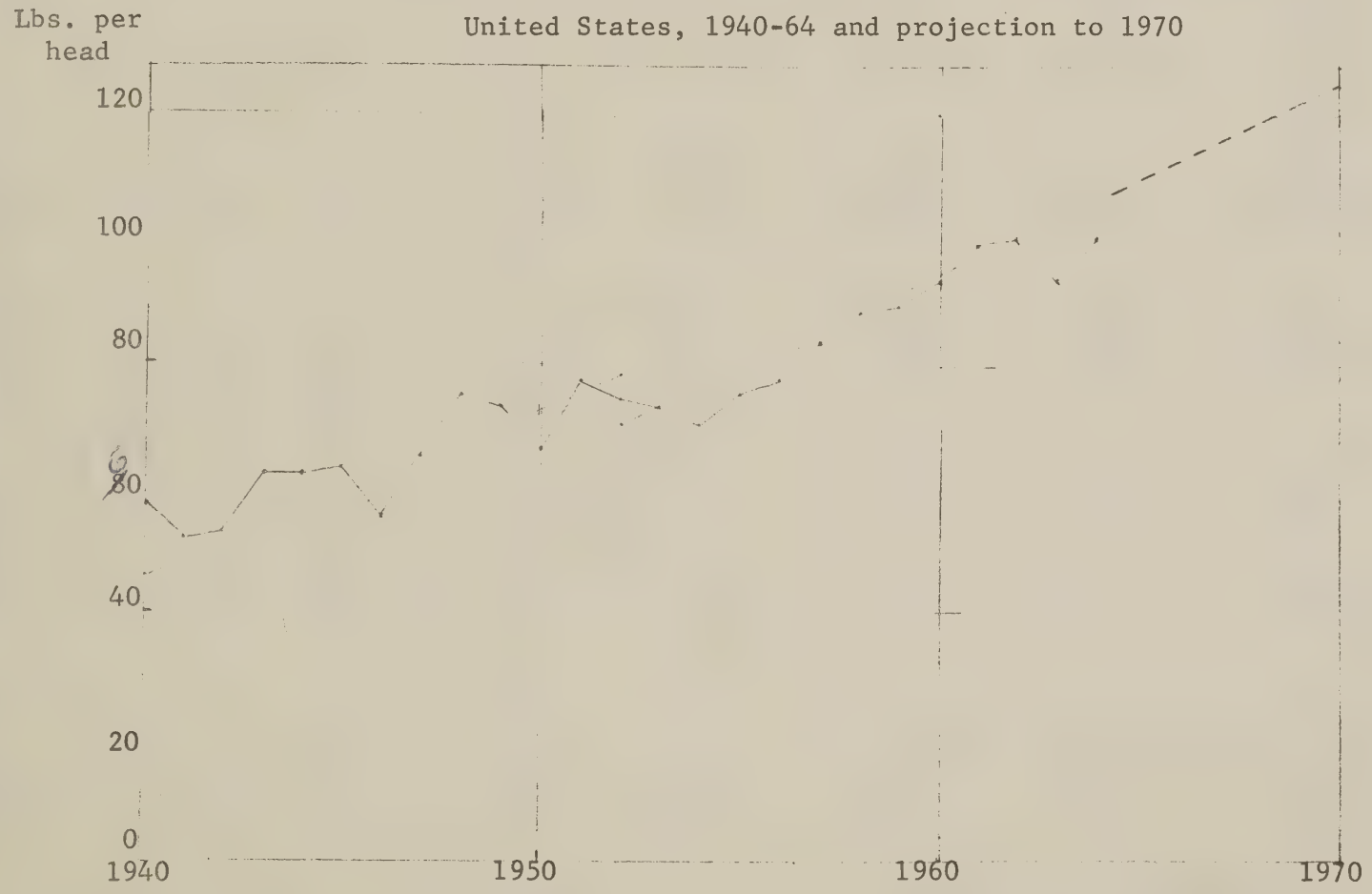


Figure 3

U. S. DEPARTMENT OF AGRICULTURE NEG. ERS ECONOMIC RESEARCH SERVICE

Table 10.--Urea, feed grade: Wholesale price, bagged, 42 percent nitrogen, at specified markets, by months, 1960-64

Year beginning October	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average
	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per ton
Points east of the Rockies 1/													
1960-61---	---	---	---	---	---	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
1961-62---	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
1962-63---	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	100.00	100.00	100.00	100.00	96.00
1963-64---	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1964-65---	100.00	100.00	100.00	100.00	100.00	100.00	100.00	---	---	---	---	---	---
Woodstock, Tennessee 2/													
1960-61---	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.00	103.00	103.00	105.00	100.00
1961-62---	105.00	105.00	105.00	105.00	105.00	105.00	105.00	---	95.00	95.00	95.00	95.00	101.00
1962-63---	95.00	95.00	95.00	95.00	---	95.00	95.00	---	95.00	95.00	95.00	95.00	95.00
1963-64---	95.00	100.00	100.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	96.00
1964-65---	95.00	95.00	95.00	95.00	95.00	95.00	95.00	---	---	---	---	---	---
Pryor, Oklahoma 3/													
1960-61---	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.00	95.00	95.00	95.00	98.00
1961-62---	95.00	95.00	95.00	95.00	95.00	95.00	95.00	---	95.00	95.00	95.00	95.00	95.00
1962-63---	95.00	95.00	95.00	---	---	95.00	95.00	---	95.00	95.00	95.00	95.00	95.00
1963-64---	95.00	100.00	95.00	100.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	96.00
1964-65---	95.00	95.00	95.00	95.00	95.00	95.00	95.00	---	---	---	---	---	---
Laplatte, Nebraska and South Point, Ohio 4/													
1960-61---	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.00	95.00	95.00	95.00	98.00
1961-62---	95.00	95.00	96.00	96.00	96.00	96.00	96.00	---	95.00	95.00	95.00	95.00	95.00
1962-63---	95.00	95.00	95.00	---	---	95.00	95.00	---	100.00	100.00	100.00	100.00	97.00
1963-64---	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1964-65---	100.00	100.00	100.00	100.00	100.00	100.00	95.00	---	---	---	---	---	---

1/ In carlots delivered east of the Rockies. 5-ton minimum quantity. 2/ F.o.b. seller's plant at Woodstock or Memphis in 3/ F.o.b. Pryor. 4/ Freight allowed.

Compiled from issues of the Oil, Paint and Drug Reporter and Feedstuffs.

reveal a considerable stability in urea prices, unofficial reports indicate that some urea is being sold at somewhat lower prices--especially where discounts are offered for volume purchases.

Cost of Grain-Urea Mixtures Compared With Oilseed Meals

For the last 13 years, the differences between the annual prices for soybean and cottonseed meals and for grain-urea mixtures equivalent to these oilmeals have ranged from $22 in 1962 to -$2.65 in 1956. These prices are not exact measures of differences in costs between grain-urea and oilmeals because feed ingredient prices vary seasonally and by areas. Also the quantity of urea used to replace natural protein varies according to kind of ration being formulated. In place of corn as an energy source, other types of carbohydrates could be used which would change the relative costs of a ration containing urea. However, these prices are illustrative of year-to-year changes in the relative cost of grain-urea mixtures compared with soybean meal and cottonseed meal.

In the October 1951 to September 1952 feeding year, prices of soybean meal were high in relation to the price of corn-urea mixture. Soybean meal at Chicago averaged $17.25 per ton more than corn-urea mixture. From 1952 to 1956, this difference gradually declined to about $4.20 per ton. This period was characterized by falling prices in both corn and soybean meal, with meal prices declining at a somewhat greater rate than corn. In the later 1950's, the advantage of urea over soybean meal varied from a -$2.65 per ton to a +$6.70 per ton. During the last 4 years, soybean meal prices have increased more than corn-urea prices (fig. 4). In 1960-61, the difference between corn-urea and soybean meal was about $14 per ton, rising to a little more than $20 in 1962-63 and 1963-64.

During October-March 1964-65, the spread between prices averaged about $18 per ton, $8 below a year earlier, because of rising corn prices and declining soybean meal prices. Since 1955-56, the cost of corn-urea has been very stable, ranging between $50 and $57 per ton. Soybean meal prices in this period ranged from $54 per ton in 1956-57 to around $75 in 1962-63 and 1963-64.

A similar comparison of prices of sorghum grain-urea mixture and cottonseed meal in table 11 shows a price advantage varying from $0.20 per ton in 1959 to $18.60 per ton in 1962.

Annual sales of urea have increased consistently in the last 7 years. The sales, although influenced by grain-urea and oilmeal prices, have not been controlled by these price relationships. The comparisons indicate that in general, price relationships have been such as to encourage the feeding of urea.

Competition With Urea

In the United States, two major oilmeals compete with urea in cattle feeding--cottonseed and soybean meals. These are found in rather distinct geographical areas. Cottonseed is produced in the cotton areas as a joint product with cotton, but secondary to it. These areas include the South and

Prices paid by farmers for cottonseed meal, 41 percent protein, January 15, 1965*

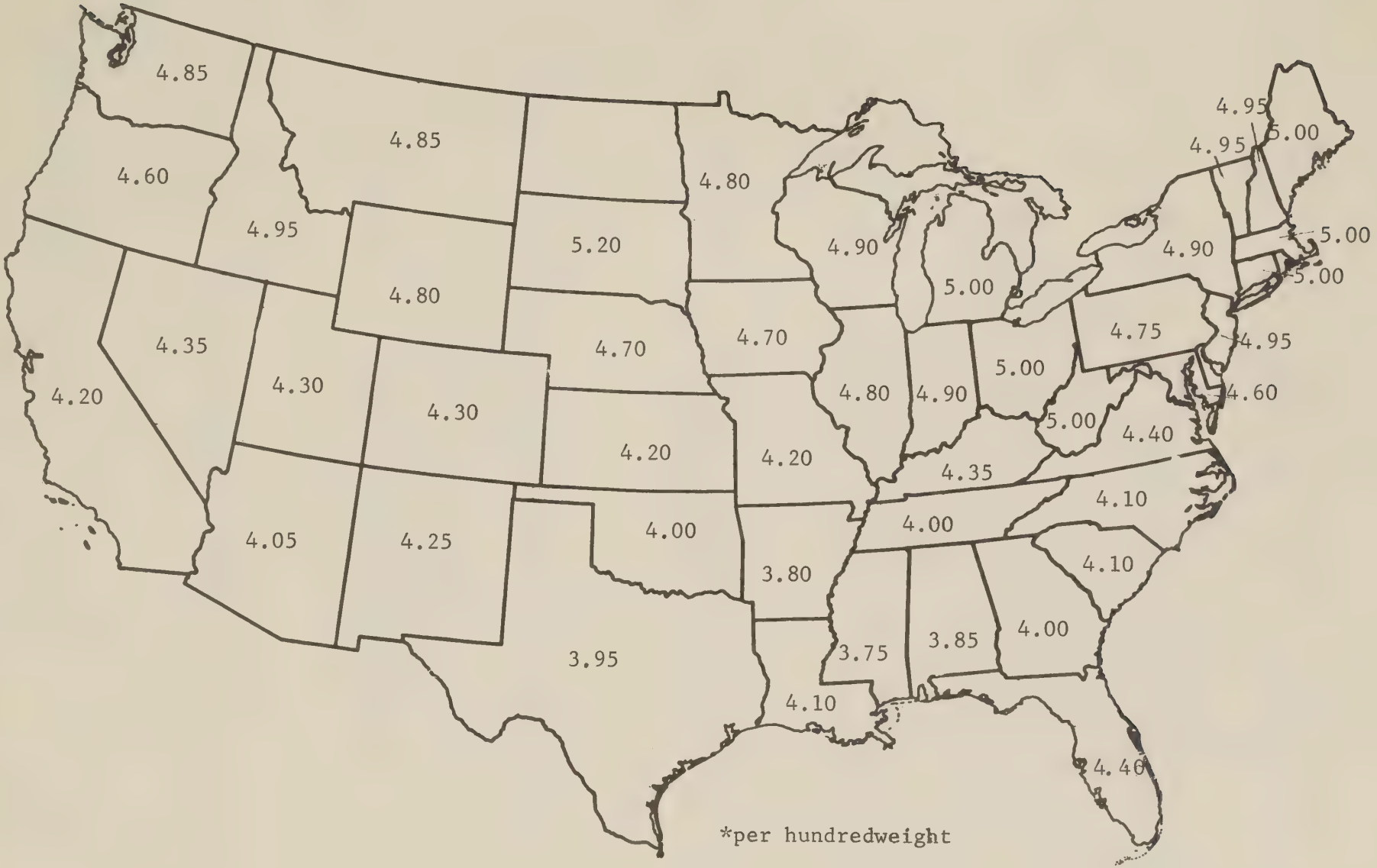


Figure 5

Table 11.--Comparative cost of grain-urea mixtures with soybean meal and cottonseed meal, 1951-64

Year beginning October	Corn-urea mixture and soybean meal				Sorghum grain-urea mixture and cottonseed meal			
	Corn, number 3 yellow, Chicago	Corn-urea mixture 1/	Soybean meal, 44 percent protein, Chicago	Difference	Sorghum grain number 2, yellow, Ft. Worth	Sorghum grain-urea mixture 1/	Cottonseed meal, 41 percent protein, Ft. Worth	Difference
	Dol. per bu.	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per cwt.	Dol. per ton	Dol. per ton	Dol. per ton
1951	1.826	72.70	89.95	17.25	3.16	71.00	89.55	18.55
1952	1.589	65.50	74.70	9.20	3.07	69.50	73.90	4.40
1953	1.534	63.80	85.30	21.50	2.78	64.50	65.10	.60
1954	1.475	62.00	67.00	5.00	2.51	59.90	66.20	6.30
1955	1.239	54.80	59.00	4.20	2.29	56.10	59.00	2.90
1956	1.312	57.00	54.35	-2.65	2.29	56.10	57.30	1.20
1957	1.211	53.90	60.40	6.50	2.20	54.60	54.80	.20
1958	1.207	53.80	60.50	6.70	2.23	55.10	63.55	8.45
1959	1.171	52.70	59.20	6.50	1.98	50.80	62.15	11.35
1960	1.096	50.40	64.30	13.90	2.04	51.80	60.10	8.30
1961	1.109	50.80	67.50	16.70	2.06	52.20	65.30	13.10
1962	1.189	53.20	75.20	22.00	2.13	53.40	72.00	18.60
1963:								
Oct.-Dec.	1.175	52.85	79.50	26.65	2.25	55.35	76.75	21.40
Jan.-Mar.	1.207	54.10	79.30	25.20	2.29	56.15	73.10	16.95
Apr.-June	1.257	55.65	71.50	15.85	2.29	56.10	59.80	3.70
July-Sept.	1.245	54.95	70.60	15.65	2.32	56.55	63.95	7.40
Year	1.196	53.40	75.20	21.80	2.29	56.10	68.40	12.30
1964:								
Oct.-Dec.	1.207	53.80	71.95	18.15	2.38	57.65	64.35	6.70
Jan.-Mar.	1.286	56.20	73.00	16.80	2.42	58.25	63.85	5.60
Apr.-June								
July-Sept.								
Year								

1/ Based on mixture of 1.715 pounds of grain and 285 pounds of urea at 5 cents per pound. Includes grain grinding allowance of 15 cents per cwt.

Southwest. Cottonseed meal is ordinarily the cheaper of the oilmeals in these areas (fig. 5). Here, urea would compete with cottonseed meal in cattle feeds. Cottonseed meal is used in small quantities in poultry and hog feeds in these areas, but its principal use is in cattle feed.

In the Corn Belt, where soybeans are grown and soybean meal is the lowest-priced, urea would, of course, compete with the soybean meal in cattle feeds (fig. 6). However, soybean meal has a definite advantage since feedlots tend to be smaller and urea would have to be purchased in mixed supplements for the most part. Other areas in which soybean meal forms the basis of most of the protein supplements include the New England States, the Northern and Central Plains, the Mountain States, and to some extent the Pacific Northwest.

In the Mississippi Delta and other southern areas where both soybeans and cotton are grown, urea would compete with both of the major oilseed meals since both are available locally. But in these areas there are not many large cattle feeding lots. The largest lots are found chiefly in Nebraska, Colorado, Kansas, Oklahoma, Texas, California, New Mexico, and Arizona.

Formula Feed Production

Formula feed production in 1963 is estimated by the American Feed Manufacturers Association at about 44 million tons (table 12), an increase of about 10 percent since 1958. About 8.5 million tons of dairy feed and about 5.1 million tons of beef and sheep feeds were manufactured. Probably most of these feeds contain urea.

Development of Large Feedlots

As indicated earlier, urea would most likely be used in cattle feeding where feedlots are of large size. Information is available to show the number of cattle fed in lots of greater than 1,000 capacity in 16 Western States and the number of such lots (table 13). As of January 1, 1964, about 3 million head of cattle were on feed in such lots in the 16 States. These cattle would most likely be fed urea. There are undoubtedly additional feedlots of this capacity in other States not included in this survey. If the number of cattle fed in large capacity lots continues to increase, the amount of urea consumed will also increase.

Current Possible Usage of Urea

Since data are not available to show how much fertilizer urea is used for feed, a rough and probably conservative calculation was made to determine how much urea could be used for livestock fed under conditions favorable to feed urea (appendix).

Under the assumption that cattle on feed in lots of more than 1,000 head capacity would receive urea, about 88,000 tons of urea would be used in these large lots.

Prices paid by farmers for soybean meal, 44 percent protein, January 15, 1965*

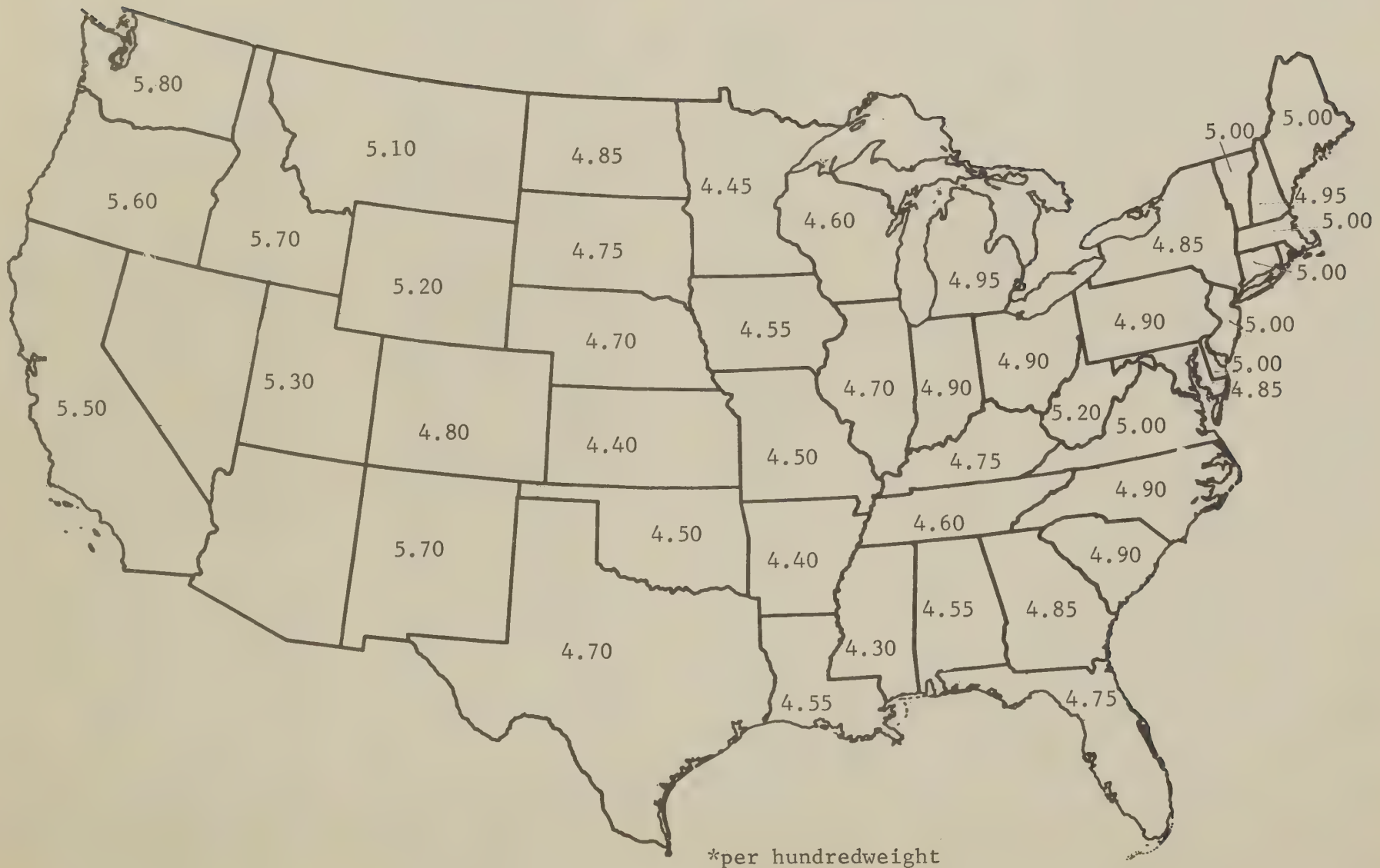
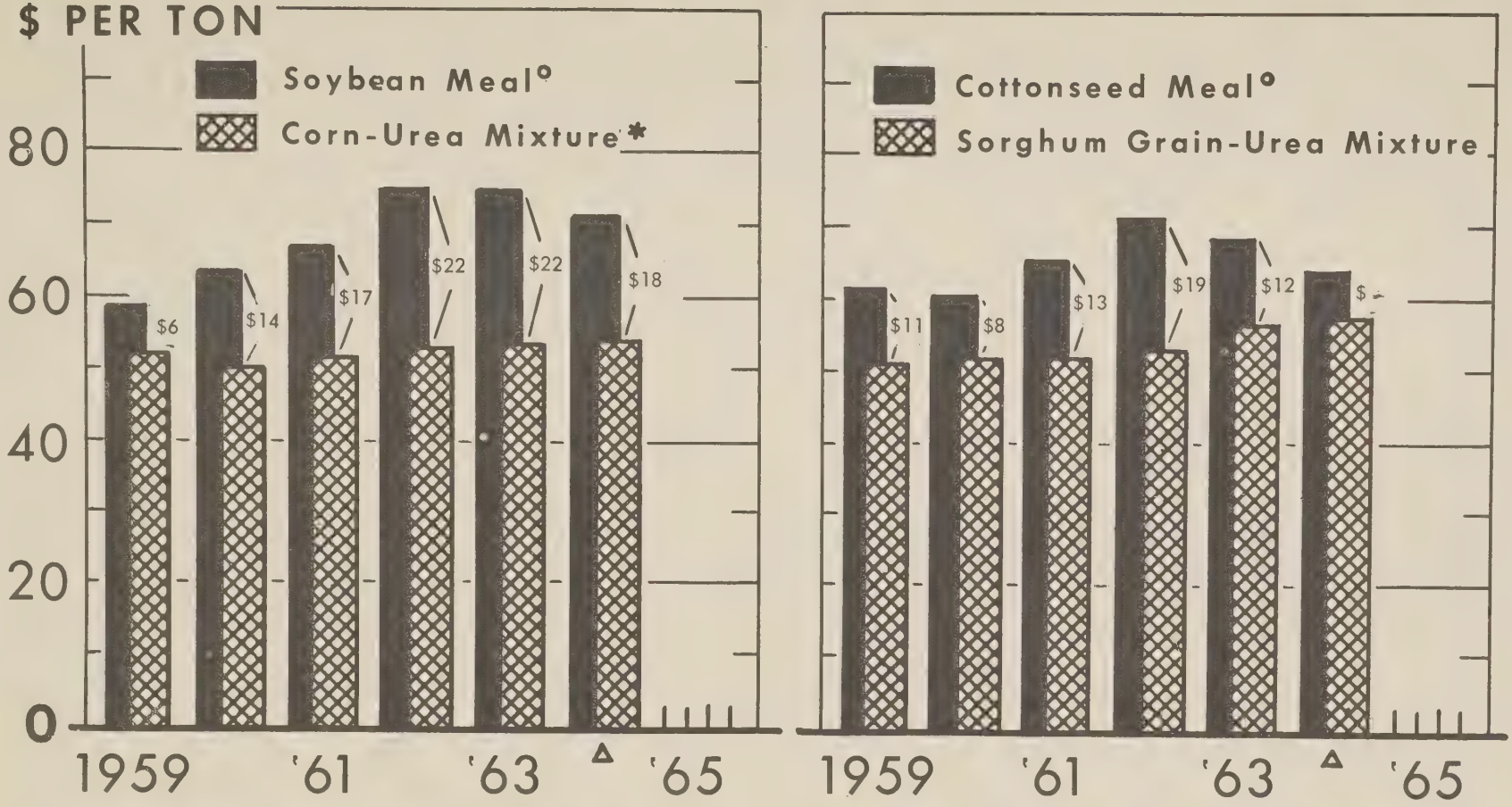


Figure 6

COMPARATIVE COST OF GRAIN-UREA MIXTURES WITH SOYBEAN MEAL AND COTTONSEED MEAL



° SOYBEAN MEAL, 44% PROTEIN, CHICAGO. COTTONSEED MEAL, 41% PROTEIN, FT. WORTH.

* BASED ON 1,715 LBS. OF GRAIN AND 285 LBS OF UREA AT 5¢ PER LB. INCLUDES GRAIN GRINDING ALLOWANCE OF 15¢ PER CWT. CORN, NO. 3 YELLOW, CHICAGO. SORGHUM GRAIN, NO. 2 YELLOW, FT. WORTH.

Δ OCTOBER-MARCH 1965

U. S. DEPARTMENT OF AGRICULTURE Figure 4 NEG. ERS 3473 - 65 (4) ECONOMIC RESEARCH SERVICE

Table 12.--Formula feed sales, United States, 1958-63

Year	Sales by AFMA reporting companies						Estimate for United States		
	Dairy		Beef		All formula feeds		Dairy	Beef	All formula feeds
	Tons	Percent	Tons	Percent	Tons	Percent	1,000 tons	1,000 tons	Million tons
1958	3,324,950	17.4	1,194,804	6.2	19,116,822	100.0	6,960	2,480	40.0
1959	3,330,148	17.4	1,444,289	7.6	19,126,866	100.0	6,960	3,040	40.0
1960	3,443,198	19.1	1,586,684	8.8	18,001,097	100.0	7,544	3,476	39.5
1961	3,687,137	19.1	1,700,026	8.8	19,255,537	100.0	8,079	3,722	42.3
1962	3,810,760	19.6	1,979,551	10.2	19,385,272	100.0	8,624	4,488	44.0
1963	3,775,269	19.4	2,265,042	11.6	19,430,512	100.0	8,536	5,104	44.0

Source: American Feed Manufacturers Association.

Table 13.--Number of feedlots and number of cattle and calves fed in lots with capacity over 1,000 head, Jan. 1, 1963, Jan. 1, 1964, and Jan. 1, 1965

State	Jan. 1, 1963		Jan. 1, 1964		Jan. 1, 1965	
	Number of feedlots	Number of cattle	Number of feedlots	Number of cattle	Number of feedlots	Number of cattle
		1,000 head		1,000 head		1,000 head
South Dakota	20	30	16	27	15	34
Nebraska	820	412	830	405	840	537
Kansas	54	150	59	183	63	200
Oklahoma	28	53	35	71	44	80
Texas	203	380	203	420	234	438
Montana	23	24	26	31	26	39
Idaho	60	92	60	87	47	86
Wyoming	13	8	12	8	15	11
Colorado	80	313	80	322	83	348
New Mexico	28	77	34	86	26	86
Arizona	84	367	77	315	75	342
Utah	14	25	14	21	19	25
Nevada	14	13	16	20	30	21
Washington	39	80	38	81	35	93
Oregon	45	47	40	52	20	59
California	299	979	317	923	323	893
Total	1,824	3,050	1,857	3,052	1,895	3,292

Under a second assumption that large feed manufacturing companies, making use of computers to determine the least-cost formula, would use urea in all formula feeds for dairy and beef cattle, about 171,000 tons of urea would be used for dairy formula feeds and 51,000 tons for beef formula feeds.

Thus, in these two assumptions, as much as 310,000 tons of urea, having a soybean meal equivalent of 1,660,000 tons could be fed. This is more than double the amount of feed-grade urea produced in this country, and about 40 percent more than such production plus a third of the imports of urea. It would appear that in the 1963-64 feeding program, use of urea could have been expanded by at least 40 percent. Some of the 40 percent may have been provided by feeding the fertilizer grade of urea.

Short-Run Projection to 1970

Past consumption data indicate an upward trend in the consumption of oilmeals by cattle, the main market for urea. Oilmeals consumed by cattle per head increased from about 70 pounds in 1953 to about 108 pounds in 1962. If this rate of increase were projected by fitting a straight line by least squares to the last 11 years and extending it to 1970, the consumption per head in 1970 would be about 125 pounds. This would indicate a total consumption of 6.9 million tons of oilmeals (assuming 110 million head of cattle) (fig. 3).

On the other hand, the expansion in the sales of urea has been at a somewhat greater rate--from about 60,000 tons in 1956 to 130,000 tons in 1963. A projection of domestic sales for feed to 1970 would indicate 195,000 tons, equivalent to 1,045,000 tons of soybean oilmeal. Any imports of urea used for feed would be in addition. The domestic sales would amount to nearly 15 percent of the oilmeal projection of 7.2 million tons.

By 1970, urea and oilmeals consumed by cattle would amount to about 150 pounds per head (for 110 million head) as compared to 125 pounds per head (106.5 million head) in 1963-64.

These calculations may not give adequate consideration to imports of urea nor use of fertilizer urea diverted into feed use. According to information obtained from the chemical and feed manufacturing industries, a considerable amount of fertilizer urea is diverted to feed use. Quality is practically the same except that a conditioner is added to feed urea. It is less expensive and of a slightly higher nitrogen content than feed urea.

Sources in industry have indicated that the price of urea could be reduced as much as 40 percent in 10 or 15 years, because transportation constitutes a large proportion of the present retail price. Some of this cost can be eliminated by establishing new plants at strategic locations.

The process of making urea is relatively simple and well known. Some impetus for increased production may result from the entry of petroleum companies into the chemical industry and the use of byproducts for the production of urea.

APPENDIX

Calculation of amount of urea that could have been fed in feeding year 1963-64

Cattle on feed--large feed lots:

3 million head of cattle on feed January 1, 1964, in lots with over 1,000 head capacity (0.16 pound of urea per head per day).

3 million x 0.16 = 480,000 pounds per day or 240 tons.

240 x 365 days = 87,600 tons of urea per year.

Dairy Formula Feeds 1963:

$\frac{3,775,269 \text{ dairy feeds}}{19,430,512 \text{ total feed.}}$ = 19.4 percent dairy formula feeds.

19.4 percent x 44 million tons = 8,536,000 tons dairy feed.

2 percent x 8,536,000 = 170,720 tons of urea per year.

Beef and Sheep Formula Feeds, 1963:

$\frac{2,265,042}{19,430,512}$ = 11.6 percent beef and sheep formula feeds.

11.6 percent x 44 = 5,104,000 tons beef and sheep formula feeds.

5,104,000 x 0.01 = 51,040 tons of urea per year.

170,720
+87,600
309,360 tons of urea
x5.36
1,658,170 tons of SBM equivalent