THE ECONOMIC FEASIBILITY OF ESTABLISHING OIL SUNFLOWER PROCESSING PLANTS IN NORTH DAKOTA

Department of Agricultural Economics
NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION
NORTH DAKOTA STATE UNIVERSITY
of Agriculture and Applied Science
FARGO, NORTH DAKOTA 58102
in cooperation with
ECONOMIC DEVELOPMENT ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE
WASHINGTON, D.C.

Bulletin 503

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by
Delmer L. Helgeson, David W. Cobia, *et al.*

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17	Paragraph 8, Line 7:	(*Figure 8, p. 31*) read (Figure 8, p. 14)
23	Paragraph 5, Line 4:	(*Table 18, P. 58*) read (Table 18, p. 24)
28	Paragraph 5, Line 6:	*Refer to Chapter 4, p.* . read Refer to Chapter 4, p. 55, . . .
31	Paragraph 2, Line 2:	*full plant utilization (see p.).* read full plant utilization (see p. 33).
33	Paragraph 1, Line 6:	*pollutants air considered* read pollutants are considered
57	Paragraph 1, Line 7:	(*Table 20, p. 26*) read (Table 21, p. 27)

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by

Delmer L. Helgeson (Project Leader), David W. Cobia,
Randal C. Coon, Wallace C. Hardie, LeRoy W. Schaffner, and Donald F. Scott
(Staff Members of the Department of Agricultural Economics,
North Dakota State University, Fargo, North Dakota)

Project No. 05-06-01485

Department of Agricultural Economics
North Dakota Agricultural Experiment Station
North Dakota State University, Fargo, North Dakota

and

The United States Department of Commerce,
Economic Development Administration Cooperating

This technical assistance study was accomplished under a grant from the Economic Development Administration. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the Grantee and do not necessarily reflect the views of the Economic Development Administration.

Highlights

The economic feasibility of establishing processing facilities for oil-type sunflowers in North Dakota is provided in this report. Costs and returns for four processing plant sizes (500; 1,000; 1,500; and 2,000 tons per day) were analyzed. Market penetration required for the output of the four processing plant sizes was analyzed and comparative analysis of competing products was made for the qualitative aspects of sunflower oil and oilseed meal. Historical and potential supply of sunflower seeds in North Dakota and surrounding areas was related to raw material requirements needed to operate the various plant sizes at alternative levels of plant capacity. Domestic and export demands were studied as an integral part of locating processing plants in North Dakota. Alternative North Dakota and existing sunflower processing locations were evaluated with respect to their impact on inbound and outbound transportation costs. The economic impact of each model sunflower processing plant on multicounty regions in which plants might locate was estimated for the construction and operational phases.

Results indicated that plants approaching 1,000 tons per day would be needed to take advantage of economies of size. Domestic demand for sun oil has not developed sufficiently to support producer prices at levels that will sustain production requirements needed to support economically sized processing units. Current export demand conditions and excess processing capacity in the Upper Midwest readily absorb current production. It is very possible that the supply of raw material could expand to justify an economically sized processing plant in North Dakota given an increase in domestic demand for end products and the removal of certain institutional constraints. A 1,000 ton/day plant would result in estimated new employment for 46 people and stimulate the local economy by injecting an estimated $1.9 million in direct annual expenditures, plus $3.5 million in secondary expenditures.

Acknowledgments

Research of this nature is impossible without cooperation and financial support from various private and governmental agencies.

The financial support making this project possible was provided by the Economic Development Administration of the U.S. Department of Commerce, the National Sunflower Growers Association, North Dakota Business and Industrial Development Department, the Community Development Corporation of Wahpeton, the Fargo-Cass County Industrial Development Corporation, and the North Dakota Agricultural Experiment Station.

Industrial cooperation throughout the duration of this study has been excellent. While it is not possible to single out every individual in this connection, the authors wish to express particular thanks to the following organizations that have contributed important data and provided advice and counsel:

American Crystal Sugar Co., Moorhead, MN
Burlington Northern, Inc., Fargo, ND
California Pellet Mills, Minneapolis, MN
Cargill, Inc., Minneapolis, MN
CEA Carter-Day Co., Minneapolis, MN
Crown Iron Works Co., Minneapolis, MN
EMI Corporation, Des Plaines, IL
Extraction De Smet, Edegen-Antwerp, Belgium
The French Oil Mill Mach. Co., Piqua, OH
Honeymead Products Co., Minneapolis, MN
Lipp System USA, Inc., Schiller Park, IL
Mill Mutual, Minneapolis, MN
Northwest Iron Fireman, Inc., Fargo, ND
Northwestern Refining Co., Minneapolis, MN
Red River Scales, Inc., Sabin, MN
St. Paul Bank for Cooperatives, St. Paul, MN
Unilever, Rotterdam, The Netherlands

The authors are also indebted to colleagues in the Department of Agricultural Economics for review of procedures and assembly and analysis of portions of the data. Special mention is made of Donald E. Anderson, Edward V. Dunn, Thor A. Hertsgaard, Roger G. Johnson, Karl M. Schmidt, Fred R. Taylor, and Harvey G. Vreugdenhil. Additionally, several NDSU staff and USDA personnel stationed at NDSU served as consultants on the project. These individuals are William Dinusson, Animal Science; Gene C. Griffin, Upper Great Plains Transp. Inst.; Stanley Klemetson, Civil Engineering; William C. Nelson, Agricultural Economics; John T. Schultz, Entomology; Robert J. Tosterud, Upper Great Plains Transp. Inst.; David Zimmer, ARS, USDA; and Don C. Zimmerman, ARS, USDA.

Mrs. Bea Williams and her co-workers in the secretarial pool were responsible for typing. The charts, other than those provided by the USDA, were prepared by Mrs. Carol VavRosky. To these and other colleagues, the authors are indebted and acknowledge their contribution. The use of firm and equipment names is for acknowledgment and identification and not intended as an endorsement. Analysis and conclusions are the sole responsibility of the authors.

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SUMMARY AND CONCLUSIONS

Summary

The purpose of this report was to explore the economic feasibility of establishing processing facilities for oil-type sunflowers in North Dakota. Frequent requests from community and industry leaders for this type of information were one of the primary reasons this study was undertaken. A broad set of topics was covered because production, processing, and marketing of sunflowers and sunflower products in the U.S. are relatively recent.

The first sustained commercial production of oil-type sunflowers occurred in 1966. Since then, total sunflower acreage has increased dramatically and irregularly to 1.2 million acres in 1975. Over 80% of the acreage was oil-type sunflowers in 1975. The remaining sunflowers were non-oil varieties which are used for dehulled and in shell roasted human food and bird food markets. North Dakota has remained the major sunflower producing state since 1966, accounting for 45% of total U.S. production in 1975.

Most of the oil sunflowers have traditionally been exported to Europe where consumers pay premiums for sunflower seed oil (sun oil). Historically, about one-fourth of the crop has been processed domestically in flaxseed processing plants in Minnesota and to a limited extent in cottonseed plants in the South. Sun oil has been used primarily in edible vegetable oil products and also in paints and varnishes. Sunflower oil seed meal (sun meal) has been used in livestock feed.

Four processing plant sizes (500; 1,000; 1,500; and 2,000 tons/day) were analyzed. Equipment manufacturers, engineering, and sunflower processing firms were consulted in the design and estimation of construction and operating costs. Besides the basic processing equipment, the overall plant facility included receiving facilities for both rail and truck; drying equipment for incoming high-moisture sunflowers; and storage for whole seed, sunflower meal, and crude sun oil. The costs of each major component were summarized into receiving and storage, preparation/prepress, extraction, meal conditioning, and service and auxiliary requirements. The additional cost of dehulling sunflowers before processing and pelleting the hulls, together with that of providing the capability of processing flaxseed and soybeans, was also provided but was not included in total estimated investment and operating costs.

The relative quality of sunflower oil and oil seed meal was reviewed and the potential for these two products in domestic markets explored. Market penetration of the domestic oil and meal markets required to absorb the output of the four plant sizes was estimated. Foreign market influences were also described.

Historical sunflower production patterns were presented, together with two estimates of future production. One estimate was based on an attitudinal survey of farmers and a second on a maximum long-run projection for North Dakota. The supply of whole seed sunflowers from current and the two projections was related to processing requirements for each of the four plant sizes. Linear programming models incorporated crop rotation requirements and the net income potential of sunflowers compared with small grains and flax — the major competing crops.

A linear programming transportation model was used to evaluate alternative sunflower plant locations in North Dakota compared to existing processing locations. The objective of the model was to allocate product flows of sunflowers, crude sun oil, and sun meal on the basis of least-cost transportation flows. Commodity movements included the shipment of sunflowers from grower to processor and export points, crude sun oil from processor to refiner and export points, and sun meal from processor to feed ingredient markets. Three North Dakota locations representing the northeast, east central, and southeast areas of the state were used in the analysis. Minneapolis-St. Paul and Lubbock, Texas, represented the areas where sunflower processing facilities were presently located. Truck, rail, and barge modes were considered where feasible. The least-cost mode was selected for each commodity movement.

The economic impact of each of the model sunflower processing plants on multicounty regions in which they might locate was estimated for the construction and operational phases. Allowances were made for expenditure leakages to other regions within the state and for out-of-state expenditures that were expected to occur. Both primary and secondary impacts were considered.

Conclusions

The establishment of a specialized sunflower oil processing plant in North Dakota is not economically feasible at this time. Undeveloped domestic markets for specialized sunflower products, unfavorable import taxes, limited sunflower production compared to economically sized processing plants, and current excess processing capacity are the basic factors supporting this conclusion. Future developments that have reasonable expectations of occurring that would create conditions favorable to the establishment of a sunflower processing plant in North Dakota are:

1. An increased and stable supply of sunflowers to supply the requirements of an economically sized processing plant and other market requirements is feasible. Sunflower production is expanding geographically as farmers become more aware of the advantages of the crop, agronomic requirements, and economic potential. Based on farmer surveys and linear programming model results, supplies sufficient to provide the volume of raw product for economically sized processing plants and other market

requirements are promising. Increased sunflower production will be augmented by higher yielding and more disease resistant hybrids. Introduction of these hybrids to the grower is occurring rapidly. Hybrids will make sunflowers more competitive with other crops. Increased yields from hybrids would also permit sun oil to be more competitive with the lower priced oils.

2. The development of premium consumer products, such as margarine, cooking oils, and shortening (whose major ingredient would be sun oil), has possibilities which could result in premium prices for crude sun oil produced domestically. Such a premium would be based primarily on the ideal fatty acid composition of sun oil. Premium prices for sun oil will be needed to permit domestic processors to compete with the export demand for whole seed sunflowers.

3. Expansion in the use of sun oil in the paints and varnish market is taking place. While this is a limited market, increased sales to meet the demand in this market will add to total domestic requirements.

Other developments, with lower expectations of occurring in the near future, that would advance the economic feasibility for sunflower processing in North Dakota are:

1. Elimination of the Common Market levy on imported vegetable oil, permitting domestic processors to compete with foreign processors.

2. Domestic development of higher value uses for sun meal, which would enhance the ability of domestic processors to compete with the export market. Sun meal has certain advantages for high-protein foods for human consumption, but developmental research is lacking. Research directed at sun meal for this purpose is not expected to be pursued vigorously until an abundant and stable supply of sun meal is attained.

If the production and market conditions become favorable, results from this study suggest the following recommendations for the establishment of a sunflower oil processing plant in North Dakota:

1. An oil sunflower processing plant with a capacity of about 1,000 tons/day is required to achieve the necessary economies of size which will result in generating a sufficiently competitive rate of return on investment necessary to attract capital.

2. A plant of this size would require 300,000 tons of sunflowers on an annual basis to operate at 100% capacity. This requires the production from 665,000 acres, representing 66% of the total U.S. oil sunflower production in 1975. By comparison, only 36% of the 1974 oil sunflower crop was crushed domestically. The same size plant would require 47% of the production from a projected base of 1.4 million acres.

3. A 1,000 ton/day plant would produce 115,500 tons of crude sun oil, representing 2.3% of the total vegetable oil utilized domestically in 1975. Sun meal output would reach 168,000 tons, representing 10% of the protein meal requirements in 1975 for the northern tier of eight states from Wisconsin to the West Coast.

4. Aggregate production of raw sunflowers balanced with an efficient size processing plant must allow for buffer supplies for exports, reduced yields attributable to an adverse growing season, and allocations to other competing markets.

5. North Dakota locations can compete favorably with existing processing facilities in the U.S. Of the three North Dakota locations analyzed, the southeastern North Dakota location would receive and crush the largest quantity of sunflowers on a least-cost transportation basis.

6. When the 1975 production estimate was coupled with 75% exports, the quantity of sunflowers shipped to the North Dakota processing locations was too small to even approach the volume necessary to support the smallest size plant considered.

7. Under the production estimate based on a survey of North Dakota farmers and assuming sunflower exports of 75%, the flow of sunflowers to the southeastern North Dakota plant location would be approximately 50% of the daily capacity of a 500 ton/day plant. Only under the maximum sunflower production estimate assuming sunflower exports of 75% would a sufficient volume of sunflowers flow to each of the North Dakota locations to support a 500 ton/day plant. The southeastern North Dakota processing location would receive the largest volume of sunflowers, approaching the requirements for a 1,000 ton/day plant (908 tons).

8. A basic assumption underlying the transportation analysis was that 75% of whole seed sunflower production is exported. If the export assumption is reduced from 75% to 25% and the maximum sunflower production estimate is used, the southeastern North Dakota plant location would crush 1,156 thousand tons of sunflowers annually (3,853 tons/day), while the Minneapolis-St. Paul location would crush 106 thousand tons annually (353 tons/day).

The remaining section of this chapter highlights additional findings of this study.

Total estimated investment costs for four model sunflower processing plants with capacities of 500; 1,000; 1,500; and 2,000 tons/day were $5,010,000; $7,060,000; $8,770,000; and $10,450,000, respectively. This results in a total capital investment outlay of $33.40, $23.53, $19.49, and $17.42/ton at full plant capacity levels.

While economies of size were found to exist throughout the range of processing plant sizes considered, these economies were primarily associated with spreading fixed costs over larger total plant volumes. Futhermore, economies of size were more evident over small processing plant size ranges than for the larger processing plants.

Results provided in this study indicate that underutilization of the larger processing plants does not result in a rapid depletion of size economies. For example, the 1,000 ton/day processing plant operating at 50% capacity resulted in average total cost of $16.79/ton compared with an average total cost of $17.18/ton for the 500 ton/day plant operating at full capacity or $0.39/ton less for the larger plant operating at only 50% capacity. This tends to demonstrate large sunflower processing plants can operate well below designed capacity levels before sizeable average total cost increases would be encountered. This is due primarily to spreading the extra cost of excess capacity over a volume equal to or greater than the full capacity level of the smallest processing plant. It also necessarily follows that at an exceptionally low volume, a large plant will incur exorbitant costs well above a sunflower processing plant designed to process a lower level of output.

The lower average variable costs in the larger 1,000 ton/day plant more than offset the increased per unit fixed cost at 50% capacity when compared to the 500 ton/day plant at 100% capacity. The lower average variable costs for the larger plant are obtained because the larger equipment does not require a proportional increase in fuel, electricity, labor, and other inputs.

This suggests that in determining the minimum size processing plant to construct, the larger 1,000 ton/day plant is economically desirable even if the processing plant's utilization level is not expected to exceed 50% in beginning operations. This holds true if raw product supply will be sufficient to prevent the larger processing plant from being forced to operate at extremely low levels of plant capacity, with expectations of reaching the more economical plant capacity levels for which the plant was designed.

Economic feasibility may be further evaluated on the basis of the rate of projected returns on investment. Given a processing margin of $19.51/ton the 500 ton/day plant at full capacity generated a net return on investment before taxes of only 6.99% compared with 23.34% for the 1,000 ton/day plant; 34.14% for the 1,500 ton/day plant; and 42.15% for the 2,000 ton/day plant. At 50% capacity, the return on investment was positive for the three largest processing plants and negative for the smallest 500 ton/day plant.

The present value of the earnings stream for the 500 ton/day plant failed to generate returns sufficient to recapture the initial investment even after 60 years. Assuming a processing margin of $19.51/ton, the rate of return for the three largest processing plants was sufficiently high to indicate their economic desirability in terms of plant size. This analysis helps to substantiate the economic desirability of not considering construction of a processing plant much smaller than 1,000 tons/day.

When an annual inflationary rate of 5% was introduced in the analysis, the rate of return on invested capital was, as expected, even more favorable for each of the model plants. The smaller (500 tons/day) plant, however, continued to show, at best, a high risk potential with a 34- and 56-year payback period, using 100% and 75% of estimated returns for recapturing the initial investment.

Markets for specialized sunflower products are not yet developed because of their recent introduction and limited supply in the U.S. Their relative quality, especially sun oil, suggests a market potential warranting the development of sunflower products by private firms.

Sun oil has an ideal balance of fatty acids for most edible uses and for limited uses in paints and varnishes. The saturated, unsaturated, and polyunsaturated fatty acid content for edible purposes is important because of the controversial linkage of saturated fats to cardiovascular diseases.

Properly processed sun meal is a quality protein meal for livestock. Sun meal has some limitations in nonruminant rations because of higher fiber and lower lysine content than soybean meal. Its chalky color and current lack of year-round dependable supply are also drawbacks in the U.S. Research on sun meal as a source of vegetable high-protein human food is encouraging. However, more developmental research is necessary before sun meal human foods would be commercially feasible.

Sunflower hulls can be removed before or after extraction of the oil, creating a higher protein meal. The hulls are generally sold as livestock feed. They could, however, be used as a source of energy. Unpelleted sunflower hulls have been selling for feed at an average of $14.00/ton, but are worth about $9.24/ton in place of lignite and $27.00/ton in place of #5 residual fuel oil.

Sun oil is considered a premium oil in the European Common Market where it sells in bulk for 5 to 8 cents/lb. over soybean oil in central markets. The difference at retail is reported to be 10 to 13 cents/lb. However, in the U.S. sun oil has been selling at cottonseed oil prices or 27 cents/lb. in 1975. Cottonseed oil sells for 1 to 3 cents/lb. over soybean oil in domestic markets.

The willingness of European consumers to pay premiums for sun oil products coupled with the Common Market import levy of 10% on the oil creates a $17 to $24/ton barrier to U.S. processors. Since processing costs are in this range, merchandisers can obtain almost as much for unprocessed sunflowers as for sun oil and meal. As long as premiums paid in Europe for the oil are greater than those obtained domestically and the import levies exist, it will be uneconomical to build new sunflower processing facilities in the U.S. The removal of the Common Market import levies would make it feasible for U.S. processors to export oil and meal. This action is unlikely. If the import levies are not reduced, the development of a domestic sun oil market that would result in a 5 to 8 cent/lb. premium over soybean oil must take place before new sunflower processing capacity would be profitable in the U.S. Such markets have and are being developed, but not at a rate that would make new processing plants feasible in the next three to five years. Other factors which would increase the likelihood of being able to process sunflowers profitably in North Dakota are sufficient world supplies of sunflowers to satisfy European Common Market requirements and an increase in efficiency of producing sunflowers in the U.S. This would reduce export demand for U.S. sunflowers and permit sunflowers to receive a relatively lower price and still compete favorably with other crops.

The sunflower supply area used in this study included the eastern two-thirds of North Dakota, western Minnesota, and northeastern South Dakota. Estimated acreage of sunflowers grown in the study area was 615,000 acres in 1975. A projection based on a survey of farmers indicated a potential of 1,403,000 acres. Estimated yield for projected acreage was 906 pounds/acre resulting in 635,559 tons of whole seed. The maximum sunflower acreage projection for North Dakota (with Minnesota and South Dakota acreage held constant) was 3.334 million acres.

If net returns from sunflowers are equal to or greater than the net returns from wheat, sunflower acreage will continue to increase in the major sunflower production areas and expand to other geographic areas where sunflowers have not been grown. Linear programming supply response models indicate that sunflowers are profitable, entering solutions at their maximum limitation. Increased sunflower production potential was further substantiated on the basis of a 1975 attitudinal survey of farmers in North Dakota. Survey results indicated farmers in the eastern two-thirds of North Dakota would be willing to commit from 5 to 13% of their cropland to sunflowers depending on the level of experience with the crop.

An analysis based on transportation costs for three possible plant location sites in North Dakota suggests that a processing facility at any one of these locations would compete successfully with other locations. Of the three North Dakota locations considered, the southeastern location competes the most effectively.

Given extremely high levels of sunflower production throughout North Dakota and a reduction in exports of whole seed sunflowers, any of the North Dakota locations would crush substantial quantities of sunflowers. The crush would depend on the level of sunflower production and the level of exports. If production approached the maximum production estimate used in this study and the proportion of sunflowers moving to export was less than 75%, a plant in southeastern North Dakota could economically crush in excess of 1,000 tons/day.

The quantity of sunflowers moving to export is an important variable in the transportation analysis. If sunflower production continues to increase in the state and the level of exports declines over time, the prospects for a North Dakota processing facility will be enhanced.

Only part of the total plant construction expenditures would be made in the multicounty region in which the plant is located. Estimates of the construction expenditures for each of the four model plants made in the locating region were $449,000; $615,000; $872,000; and $991,000, respectively, for the smallest through the largest plants. These nonrecurring expenditures which were assumed to accrue to the construction, retail, and household sectors resulted in a combined primary and secondary economic impact to the regional economy of $1.3, $1.7, $2.4, and $3.0 million for the 500; 1,000; 1,500; and 2,000 ton/day plants.

The estimated economic impact from annual operating expenditures which forms the base for long-term employment opportunities was more substantial. Funds expended annually in the locating region to operate the processing plants of $1.2, $1.9, $2.4, and $3.00 million from the smallest to the largest plant resulted in a combined estimate of primary and secondary economic impact within the locating region of $3.6, $5.4, $7.0, and $8.7 million, respectively.

Chapter 1

INTRODUCTION

This study investigates the economic feasibility of processing oil-seed sunflowers in North Dakota. Sunflowers are a relatively new crop in the U.S.; therefore, this study requires a more comprehensive approach than is normally required for a feasibility study.

This research was an outgrowth of conferences and special meetings held with a cross section of North Dakota community leaders, state agencies, industry representatives, and other interested citizens concerned with evaluating the expansion of the agricultural industry in the state. Further processing of agricultural products constitutes a nucleus around which the economic impact of agriculture can contribute to the overall development of the economy. Increased interest by farmers in raising sunflowers suggested this crop may have reached a level of production sufficient to consider processing as a profitable extension for increasing income in North Dakota. However, what may appear initially to be profitable, may after analyzing the factors influencing feasibility prove to be an uneconomic investment. To answer the question of feasibility, it is necessary to concentrate upon the availability of raw material supply, the product transformation process, costs and returns, markets, transportation, and other internal and external factors that must be incorporated into the decision making process. The research reported in this study will provide basic information needed to more fully evaluate the feasibility of processing sunflowers in the area of major production.

Because of the limited domestic market, most oilseed sunflower production is presently exported to Europe where premiums are paid for sun oil. The limited quantity of sunflowers processed domestically has been crushed primarily in plants which normally process flax and cottonseed.

Justification

A need exists for investigating the potential of oilseed sunflower processing in North Dakota for a number of reasons. No local processing facility exists in the area of greatest sunflower production. As sunflower production continues to increase with the advent of hybrid varieties and westward expansion in acreage, there may be some advantages to processing sunflowers in the production area rather than at more distant points. A potential local market exists for meal and hulls. The high fiber content of the meal suggests a market where ruminant animals are the major consumption units. Cattle and sheep numbers in the surrounding region could provide a market outlet. These and other important considerations are delineated in detail in this report.

This publication is intended for local farm and community leaders, as well as private industry. Also, since commercial production of sunflowers in the U.S. is relatively recent, only limited information pertaining to markets for this crop is generally available. Therefore, the report includes descriptive material necessary to more fully evaluate an emerging commodity that has a more limited historical base compared with the more traditional crops produced in the state.

Project Objectives

Overall objectives of the study were to:

1. estimate investment requirements, operating costs, and returns for alternative size sunflower processing plants;
2. define existing and potential domestic and foreign markets for sunflowers and end products (oil, meal, and hulls);
3. estimate potential sunflower production;
4. evaluate alternative plant sites within North Dakota based on analyses of transportation costs;
5. estimate the economic impact of sunflower processing facilities on selected state planning regions.

Scope and Relevance of Projections

Supply areas for sunflowers included North Dakota, western Minnesota, and northeastern South Dakota. Sunflower production costs were analyzed for North Dakota with cost and returns made for five areas in North Dakota using 1975 prices.

Four processing plant sizes were selected and costs and returns were estimated on the basis of 1975 prices. Primary emphasis was placed on domestic markets, although foreign markets were considered.

For purposes of the transportation analyses, 1975 production estimates and two alternative production estimates reflecting higher levels of production were used. It was necessary in the transportation and economic impact analyses to select specific locations in North Dakota. This site selection should not be interpreted as advocating a specific location for a sunflower processing plant.

Questions concerning the feasibility of a sunflower processing plant in North Dakota must be answered in the light of many changes which have and will continue to take place. Factors, such as inflation, export and import policies, production practices, and a host of other considerations, may drastically alter current projections. The newness of the crop creates additional uncertainty in projecting future developments. Projections are necessary; however, there is a recognizable risk involved in basing decisions on projected estimates alone. For these reasons, the format of this study was designed to facilitate updating if future developments suggest this may be desirable.

Chapter 2

DESCRIPTION OF SUNFLOWER INDUSTRY

Major Types of Sunflowers and End Uses

The two types of sunflowers grown domestically are (1) oilseeds — which are used primarily as a source of vegetable oil and vegetable oil meal and (2) non-oil types — used primarily for human food (as dehulled sunflowers or nut meats and whole roasted seeds) and for bird food. Other major, as well as minor and potential, uses of sunflowers are given in Table 1. Oilseed varieties are black with a thin hull which adheres to the kernel (Figure 1). They contain about 45% oil, 30% meal, and about 25% hulls.* Non-oil sunflowers have also been referred to as confectionery, striped, or large seeded varieties. They have a striped seed and a relatively thick hull which remains free of the kernel, thus permitting easier and more complete dehulling. Their oil content is about 30%, meal — 26%, and hulls — 44% (1).* Non-oil sunflowers are generally larger than the oilseed types. Oilseed types weigh about 27 to 32 pounds per bushel and non-oil types weigh 22 to 28 pounds per bushel.

*These yields were obtained by laboratory procedures. Individual commercial processes may deviate from these yields.

Production Patterns

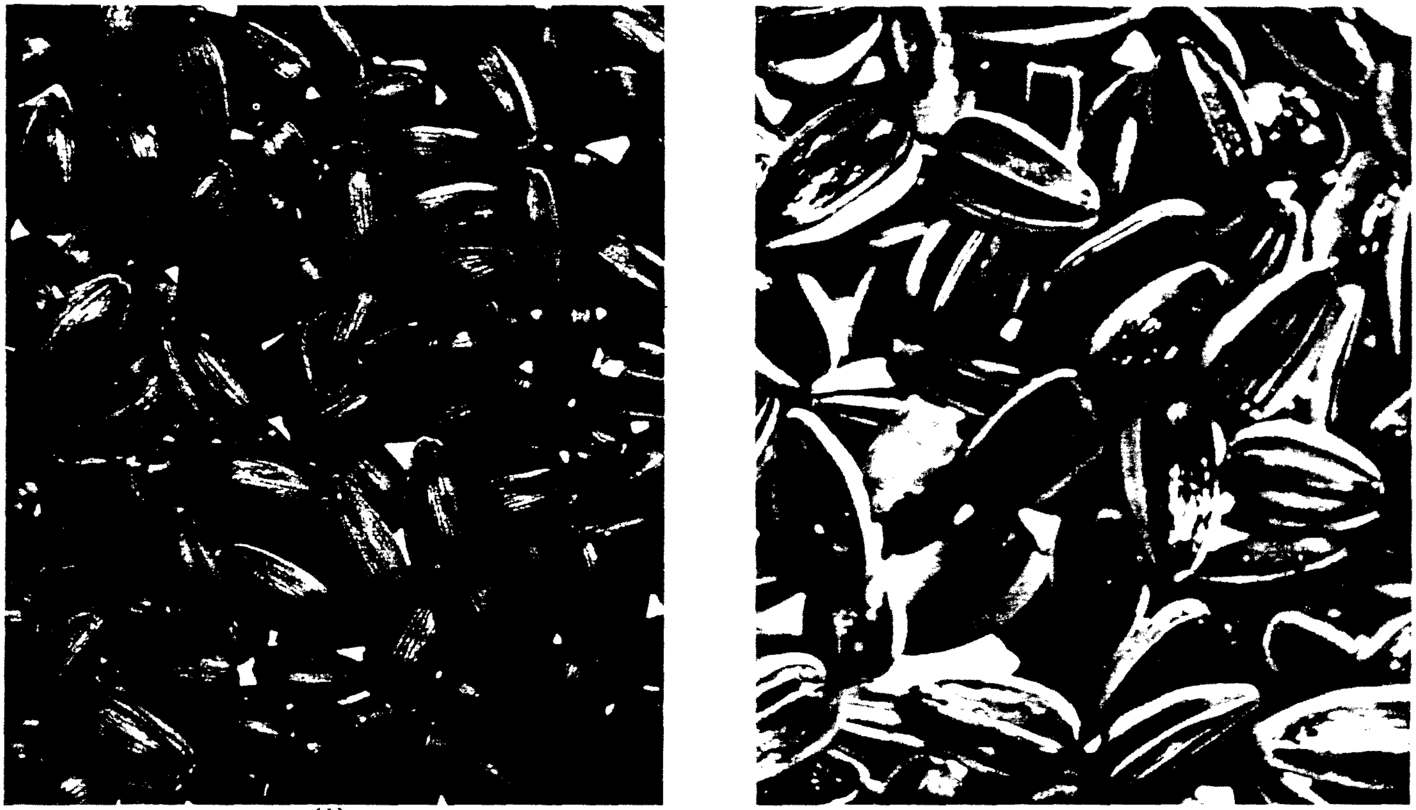
World sunflower production has expanded in the past 10 years to become the second leading source of vegetable oil in the world — surpassed only by soybeans (Figure 2). Sunflowers are widely grown in the Soviet Union, in other eastern European countries, and in Argentina where the climate is not particularly favorable for soybean production (Table 2).

Sunflowers are at this time considered a minor crop in the U.S. They have been grown primarily on the northern fringes of the Corn Belt where corn and soybeans have not performed exceptionally well either because of a shorter growing season or lack of adequate rainfall during critical periods.

The first sustained commercial production of oilseed sunflowers in the U.S. occurred in 1966 when high-oil Russian varieties were introduced. To date, production has centered in eastern North and South Dakota and western Minnesota (Table 3). Considerable interest has

TABLE 1. Major, Minor, and Potential Uses of Specified Parts of the Sunflower Plant

Part of Sunflower Plant	Major Uses	Minor Uses	Potential Uses
Whole Seed	vegetable oil and protein meal, roasted in shell and nutmeats for human food, bird, and pet food	livestock feed	livestock feed for the production of polyunsaturated animal products
Oil	margarine, shortening, salad dressing, cooking oils, paints, varnishes		carrier or adjuvant for pesticides, caulking compounds, other industrial uses
Meal	animal feed		high-protein foods for human consumption
Hulls	livestock feed, fuel for generating steam (in eastern Europe and South America)	fireplace logs, livestock bedding, and poultry litter	packaging and insulating material, fiber board
Stalks	left in the field to supply soil nutrients and tilth	livestock feed	fuel, fiber board, insulation material
Heads	left in the field to supply soil nutrients and tilth	livestock feed	source of pectin, fuel
Entire Plant			silage



(1) (2)

Figure 1. The Two Classes of Sunflowers are Based on Seed Characteristics: (1) Oilseed Varieties, Grown as a Source of Oil and Meal, and (2) Non-Oil Varieties, Grown for Human and Bird Food

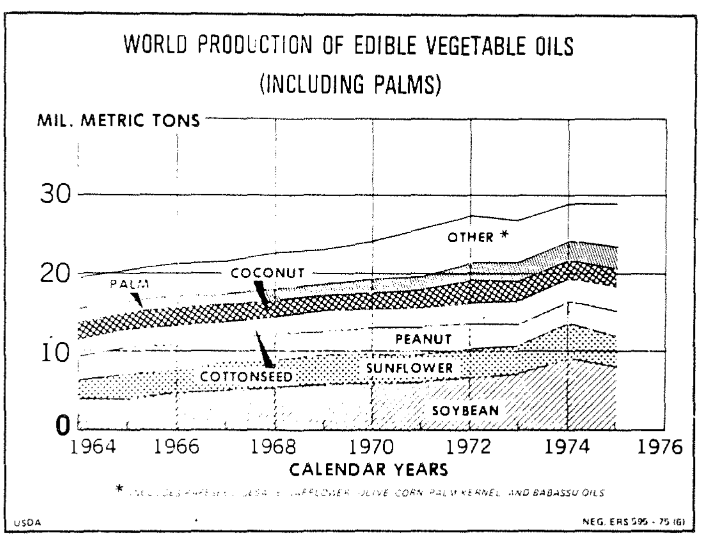


Figure 2

TABLE 2. World Sunflower Production, 1975

Rank	Country	1,000 Short Tons	Percent of Total	Harvest Season
1	USSR	5,511	52.9	Sep.-Oct.
2	Argentina	772	7.4	Mar.-May
3	Romania	772	7.4	Aug.-Sep.
4	United States	558	5.4	Sep.-Oct.
5	Bulgaria	463	4.4	Aug.-Sep.
6	Yugoslavia	419	4.0	Sep.
7	Turkey	386	3.7	Aug.-Sep.
	Others	1,547	14.8	
Total		10,428	100.0	

MAJOR SOURCE: (2, February 13, 1976, p. 122).

TABLE 3. Planted Sunflower Acreage[1] by States, 1969 to 1975

State	1969	1970	1971	1972	1973	1974	1975
	Year						
	(acres)						
Minnesota	85,000	92,000	162,000	301,000	260,000	193,000	215,000
North Dakota	110,000	127,000	243,000	418,000	418,000	382,000	542,000
South Dakota	100	400	15,000	42,000	81,000	88,300	178,000
California	3,500	1,100	2,000	4,000	2,000	2,000	4,500
Texas	750	—	—	500	1,000	7,000	265,000
Other States	2,200	1,500	6,100	95,700	4,000	4,000	4,000
U.S. Total	201,550	222,000	428,100	861,200	766,000	676,300	1,213,500

[1]Includes both oil and non-oil varieties.

also developed in other regions of the U.S., especially in Texas. Total U.S. planted acreage for 1975 exceeded 1,000,000 acres for the first time.

A large increase in sunflower acreage occurred in 1972 in the Corn Belt states in addition to North Dakota, Minnesota, and South Dakota because of the 1972 farm program. Under this program, farmers were allowed to grow sunflowers on diverted acres without forfeiting their entire set-aside payment. An estimated 435,000 acres of sunflowers were grown under this set-aside program in 1972 in the U.S. Acreage in major Corn Belt states returned to pre-1972 levels when the program was discontinued in 1973 (Table 3).

As markets have improved and growers have gained experience, sunflower acreage has expanded westward in the Dakotas. Sunflowers seem to be well-adapted to this region.

The acres planted to oil varieties have increased more rapidly than non-oil varieties because of the strong export demand for oil sunflowers. The development of a strong domestic human and bird food market has resulted in increased production of non-oil varieties in the U.S. Non-oil sunflower production increased to over 100,000 short tons in 1971 and has remained relatively stable since then. The increase in the production of oil varieties has been more dramatic and erratic, averaging over 60% per year since 1969 (Figure 3).

Agronomic Practices

Advantages of growing sunflowers in the northern production region include a longer rotation; they are more tolerant to drought, flooding, hail, and frost than most other competing crops. Sunflowers also provide opportunities for better labor and equipment utilization rates, particularly at harvest; and they require very little investment for special equipment at the producer level.

Shortcomings associated with sunflowers are the several insects and diseases that attack them and birds often feed on the standing crop. Although significant progress has been made in minimizing losses from these pests, problems still occur. Sunflowers may cause a problem for following crops that need a seedbed free of residue. Because sunflowers grow full season, they tend to remove more soil moisture later in the season than cereals.

Cropping practices and costs are similiar to soybeans and pinto beans. Average sunflower yields per harvested acre for the oil-type have ranged from 922 to 1,115 lbs./acre for the 1967 to 1974 period (Figure 4). Agronomic practices and production costs of oil and non-oil varieties are identical. More care may be needed during harvest and drying for non-oil types. Oil varieties have generally yielded about 100 lb./acre more than non-oil varieties (Figure 4). The development of disease resistance and hybrids has been more rapid with high-oil sunflowers. Non-oil sunflowers have been gaining relative to oil varieties because the increase in oil acreage is with inexperienced growers on land with lower rainfall and also because of the recent development of disease resistant non-oil varieties and hybrids. The introduction of superior disease-resistant hybrid varieties should result in increased yields of both oil and non-oil types.

Between 1967 and 1972 the average price of oil sunflowers ranged from 3.9 to 4.7 cents/lb. (Figure 5). Sunflower prices increased more than most other crops in 1974. Prices of oil varieties reached a high of 22 cents/lb. and averaged 17 cents for that year. The average 1975 price was 11.5 cents/lb. The price fell to a low of 9.0 in December, 1975, in response to a greater worldwide supply of vegetable oil. The difference in yield between oil and non-oil types (Figure 4) explains, in part, why buyers have paid about 1 cent more per pound for non-oil varieties to attract sufficient supplies. The break with the traditional price relationship in 1974 was the result of a dramatic increase in world vegetable oil prices after planting.

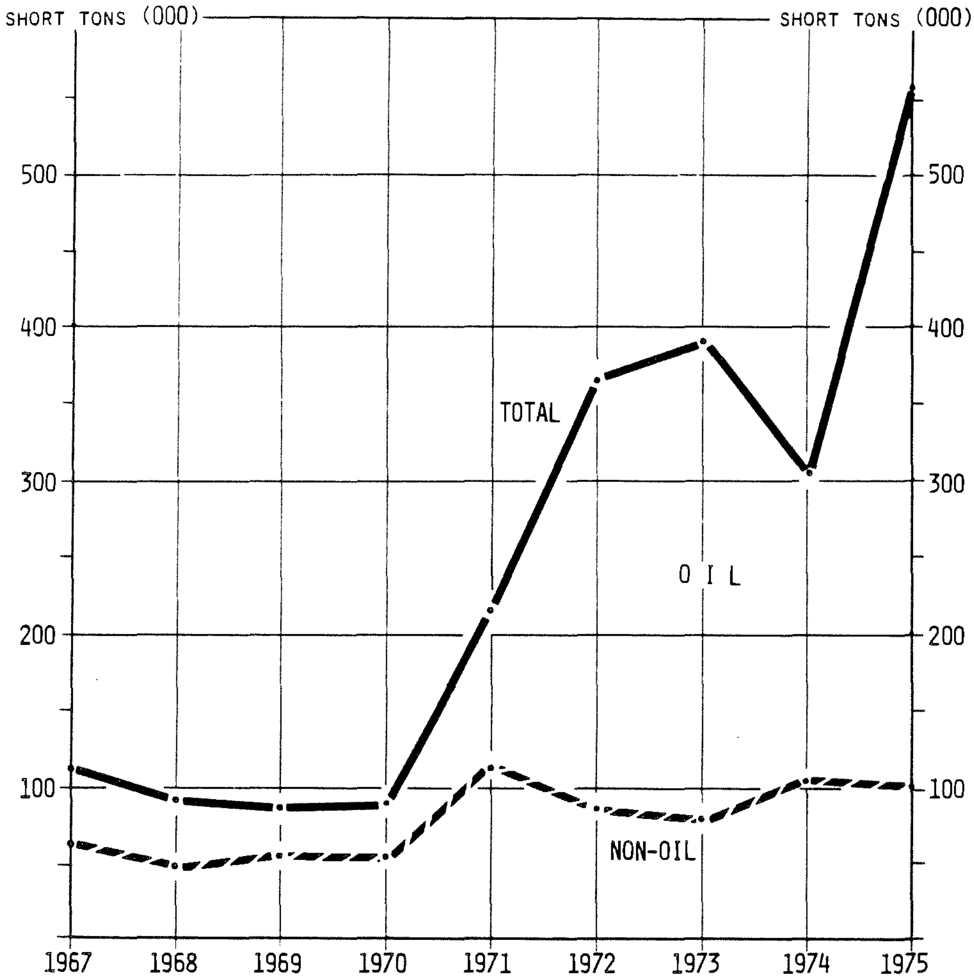


Figure 3. U.S. Oil and Non-Oil Sunflower Production, 1967 to 1975

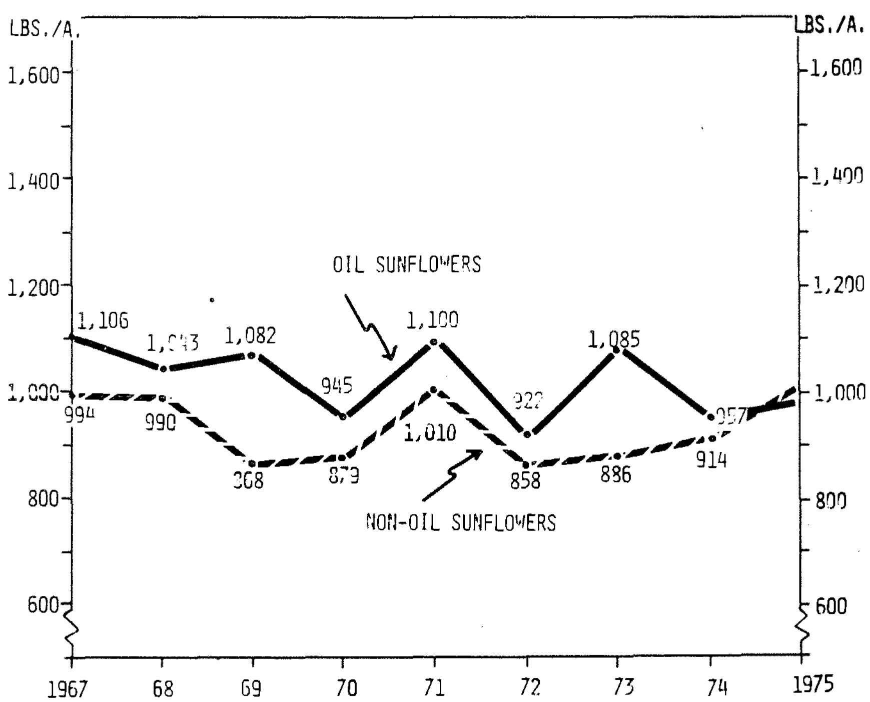


Figure 4. Average U.S. Sunflower Yields Per Harvested Acre, 1967 to 1975

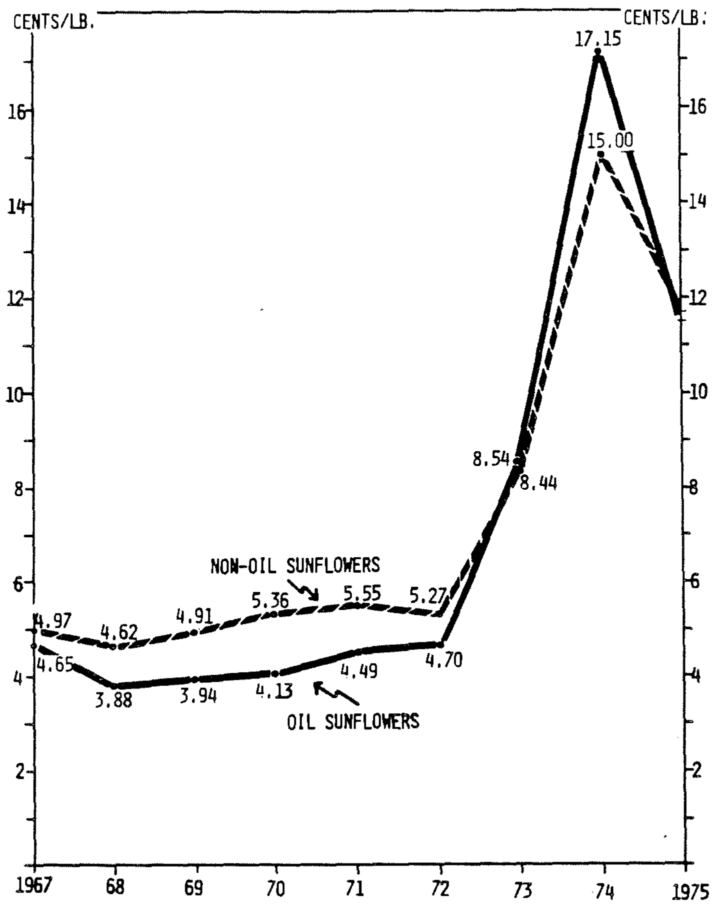


Figure 5. Average Prices Received by U.S. Farmers for Sunflowers, 1967 to 1975

Marketing Channel

Flows of sunflowers through the hands of marketing intermediaries and processors have become more complex with time. Estimates of the flows of oil and non-oil sunflowers through various agencies depicted in Figure 6 are for the 1973-74 crop.

No federal and very limited state funds have been appropriated for the USDA's Statistical Reporting Service to gather sunflower industry production and utilization statistics. Therefore, only limited production data are available. Seed production, stocks, and utilization are not collected by the SRS. The data in Figure 6 are based on a survey conducted in 1974 of major sunflower handlers and processors.

Generally oil varieties are not diverted into non-oil uses. However, market conditions have arisen which prompted the flow of oil varieties into the bird food market. Oil sunflowers have not been used for the human food market in the U.S. because of the difficulty in removing the hull. They are used for human food in some parts of the world. Non-oil sunflowers are not blended with oil varieties because of the negative effect on the test weight and oil yield. Some rejects and chips from the dehulling operation for human food have been diverted to oil processing.

The marketing channel for oil-type sunflowers has become more like that of small grains. The practice of major processors and buyers contracting production with individual growers has almost been abandoned for oil, but not non-oil varieties. Farmers are beginning to store a fairly large proportion of the crop. Previously, nearly all of the production was moved to Duluth-Superior for export before freeze-up or acquired for processing at harvest. Most of the crop is still trucked to country elevators where it is cleaned and shipped by truck or rail to export points. A few farmers have their crop trucked direct to Duluth-Superior. Several merchandisers (country originators, originator exporters, and grower marketing and bargaining associations) and a few processors who also merchandise sunflowers acquire their supplies from country elevators. Some grower associations have agreements with country elevators to handle the crop from their members for a handling fee. Exporters acquire their supplies at country origin points and from other intermediaries for overseas commitments. Most of these sunflowers move out through the Great Lakes via Duluth-Superior to Rotterdam where they are transferred to barges for movement to inland processing points. Very little processed product is imported to the EEC countries because of the 10% ad valorem import tax on crude vegetable oil. No import tax is in effect on whole seeds.

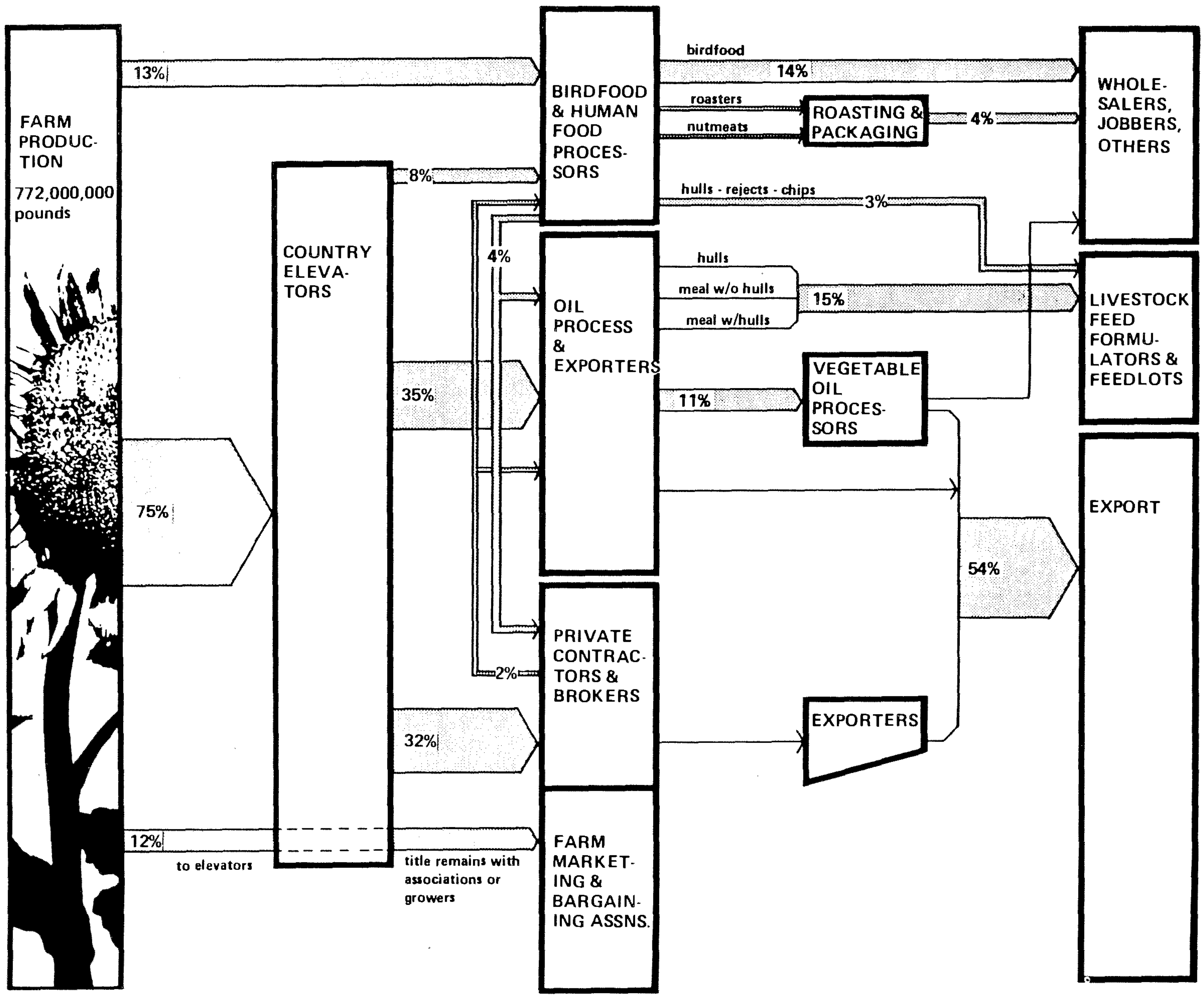


Figure 6. Major Marketing Channels for U.S. Sunflowers, Showing the Estimated Flow of Product for the 1973 Crop

In 1974-75 an estimated 36% of the total oil crop or 137 million pounds were crushed domestically. Most of the domestic processed sunflowers were crushed in two flax processing plants in Minneapolis that have been modified to process sunflowers. Small amounts of sunflowers have or are being processed at small plants in Gonvick, Minnesota, and Culbertson, Montana, in addition to cottonseed plants in the South which have processed some sunflowers in the past. As indicated in Figure 7, an estimated 57.5% of all domestically produced sunflower seed oil (hereafter referred to as sun oil) was sold to vegetable oil processors for domestic human consumption — primarily as margarine and also other vegetable oil products. About 17.5% of the oil went into paints and varnishes and 25% of the oil was exported.

Most of the sunflower oil meal (hereafter referred to as sun meal) was sold to animal feed manufacturers near the crushing plants for use in dairy rations.

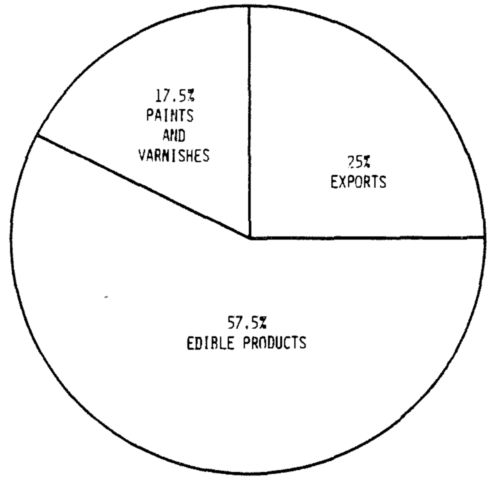


Figure 7. Utilization of Domestically Processed Sun Oil, 1974 Crop

Chapter 3

PROCESSING PLANT COST ANALYSIS

The purpose of this section is to estimate costs associated with the construction, maintenance, and operation of facilities for processing oilseed sunflowers. Four plant sizes were analyzed on the basis of total cost and total revenue associated with each plant size. An identification of the resources required by such facilities, such as labor, electricity, fuel, and water, was also undertaken.

Capital investment required and operating costs for sunflower processing plants were estimated in the following manner:

1. The initial investment cost for sunflower processing plants, as well as the added investment costs associated with processing other oil seeds, were estimated.
2. The fixed and variable costs of operation for alternative size plants were estimated at various levels of plant capacity.

Engineering costs obtained from equipment manufacturers were used to estimate capital requirements and to synthesize four model processing plants. The four model plants have sunflower crushing capacities of 500; 1,000; 1,500; and 2,000 tons/day to represent a range of alternatives.*

The cost estimates were verified with several engineering firms who have had considerable experience in planning and constructing similiar types of oilseed crushing facilities. Previous studies and other published data were also used as sources when applicable.

A continuous 24-hour, 300-day processing season was assumed in computing the initial cost estimates. Shutdown periods for maintenance are essential for smooth plant operations. A 65-day margin was considered reasonable by industry sources for this purpose.

The investment costs were specified according to plant departments and required several distinct, but related, procedures to formulate. The estimating procedure depended on the relative complexity of the component, its total cost and importance, and the amount of data available concerning physical plant requirements and costs.

Most machinery costs for the four plant sizes were based on quotations received directly from manufacturers' representatives. From their recommendations of building specifications, published building cost digests were used to formulate construction costs. These prices were used because building material prices are highly variable and unit costs in dollars or cents per gallon, per square foot, or per cubic foot can be quickly updated. Material unit costs included allowances for waste, labor, and contractor's overhead and profit.

Processing Techniques

Three main techniques employed in vegetable oil extraction are (1) the screw press method, (2) the solvent method, and (3) the prepress-solvent method. The screw press method of extraction includes cooking and mechanically pressing the oil out of the meat portion of the seed. It is adaptable to a wide variety of oilseed crops, but has higher energy and maintenance cost requirements than either solvent process. About 3.5 to 6% of the oil remains in the cake portion making the process less efficient in extraction of oil.

*Units expressed in short tons — 2,000 pounds.

The solvent method is used most frequently for those oilseeds having an oil content less than 25%. It involves cracking and rolling the seed into flakes. A hot liquid solvent called hexane (a petroleum fraction with a narrow evaporating range) is added to the flakes. This fluid washes the oil from the flakes and after repeated washes the solvent-laden oil enters a series of evaporators and condensers which removes the solvent from the oil. Solvent extracted oil meal usually contains less than 1% residual oil.

The prepress-solvent method is a combination of the above methods and is generally used for processing oilseeds with more than 25% oil content, such as sunflowers which have an oil content of about 40%. The advantage over direct extraction is much less difficulty with fines in the oil-solvent fraction and a much smaller solvent extraction plant can be used.

The screw press method is used up to about 200 tons/day capacity in most areas of the world, especially in developing countries. These plants have been able to compete well within their economic setting on a lower investment base (small tonnage plants). The smaller capacity plants have made it possible for these countries to operate with lower-skilled labor.

A conventional screw press plant can be changed to a prepress-solvent version at twice the capacity. Maintenance costs for prepress-solvent plant will equal only about one-sixth of the high maintenance costs incurred by a straight screw press operation. In addition, a lower oil residual is possible with the prepress-solvent method. Prepressed cake requires approximately one-half the solvent extraction capacity of a full or straight solvent extraction process for high-oil bearing material. Straight solvent plants can be operated more efficiently by converting to prepress, doubling the processing plant's capacity.

Sunflowers may be processed with the hull intact or decorticated (hull removed). Foreign processing plants decorticate the seed just prior to extraction, but only small quantities of seed are dehulled in the U.S. at the present time (3, p. 216). Additionally, it may be necessary to pellet sun meal and hulls for some purposes. Investment costs for decorticating and meal pelleting equipment were provided, but not included in the computation of total plant cost.

Technical and Capital Requirements of Model Plants

Plant costs for alternative size sunflower processing plants were placed on a comparable basis by designing plants which have similiar equipment and facilities then estimating their capital requirements. The criteria used to specify plant design were that they should be practical, similiar to existing plant designs,and correspond to the best technology available.

The plant layout shown in Fiqure 8 is similiar to plants presently in operation and fits the four sizes of plants without major adjustments. Although many plants were designed with all processing equipment under one roof, regulations currently require the solvent extraction building to be located less than 100 feet, but more than 50 feet from all fire hazards since hexane is extremely flammable.* The extraction building was located more than 50 feet away from all other structures, except those directly associated with the extraction operation since there were few space limitations.

No capital requirements were included for utility connections, roads, and railroads to the boundary of the plant site because of the variance of these costs from one location to another.

Receiving and Storage Facilities

Relatively more storage space per ton of seed is required for sunflowers than for most other crops because of their light test weight.** The amount of on-site storage needed for continuous plant operations is highly variable from firm to firm. Industry officials conclude, however, that proportionately less storage capacity is required for larger plants because of a highly developed off-site storage network associated with larger plant operations. Northern Great Plains farmers and country elevators have relatively more storage capacity than in other areas of the nation.

Sunflower storage capacity represented approximately one-fifth to one-sixth of the total annual sunflower crushing capacity — 30,000; 55,000; 80,000; and 100,000 tons, respectively, for the four plant sizes. This amount of storage (between 2.1 and 7.1 million bushels) is large enough to permit a firm to take advantage of lower harvest season prices and provides the plants with raw product supplies for 50 to 60 days of operation.

Facilities to receive sunflowers at the plant by truck and rail were included. Direct purchases from farmers would generally be transported by truck; whereas, large quantity purchases from elevators later in the processing season may be received by rail.

The shape and texture of the sunflower seed is believed to cause a considerable amount of horizontal pressure on tall silo-type structures. Industry sources have concluded that flat storage buildings are advisable in many cases because of their high volume and low cost relative to other forms of storage, such as the concrete-silo and wood-frame types. A combination of steel silo bins of various designs and capacities along with A-frame structural steel buildings were the types of storage selected for this study.

The equipment required for receiving, storing, drying, and cleaning sunflowers is given in Table 4. The basic elevator equipment is standardized, although individual plants may vary from the standard. The capacity of the legs were used as the basis for all other elevator componemts. Their size and level of utilization are extremely important for continuous receiving operations.

Sunflowers are usually sampled and graded before being unloaded. In northern areas sunflowers are often

*For additional information see (4, Chapter 5, Section 5050 and 5051).

**The test weight used in this study for sunflowers was 28 pounds bushel.

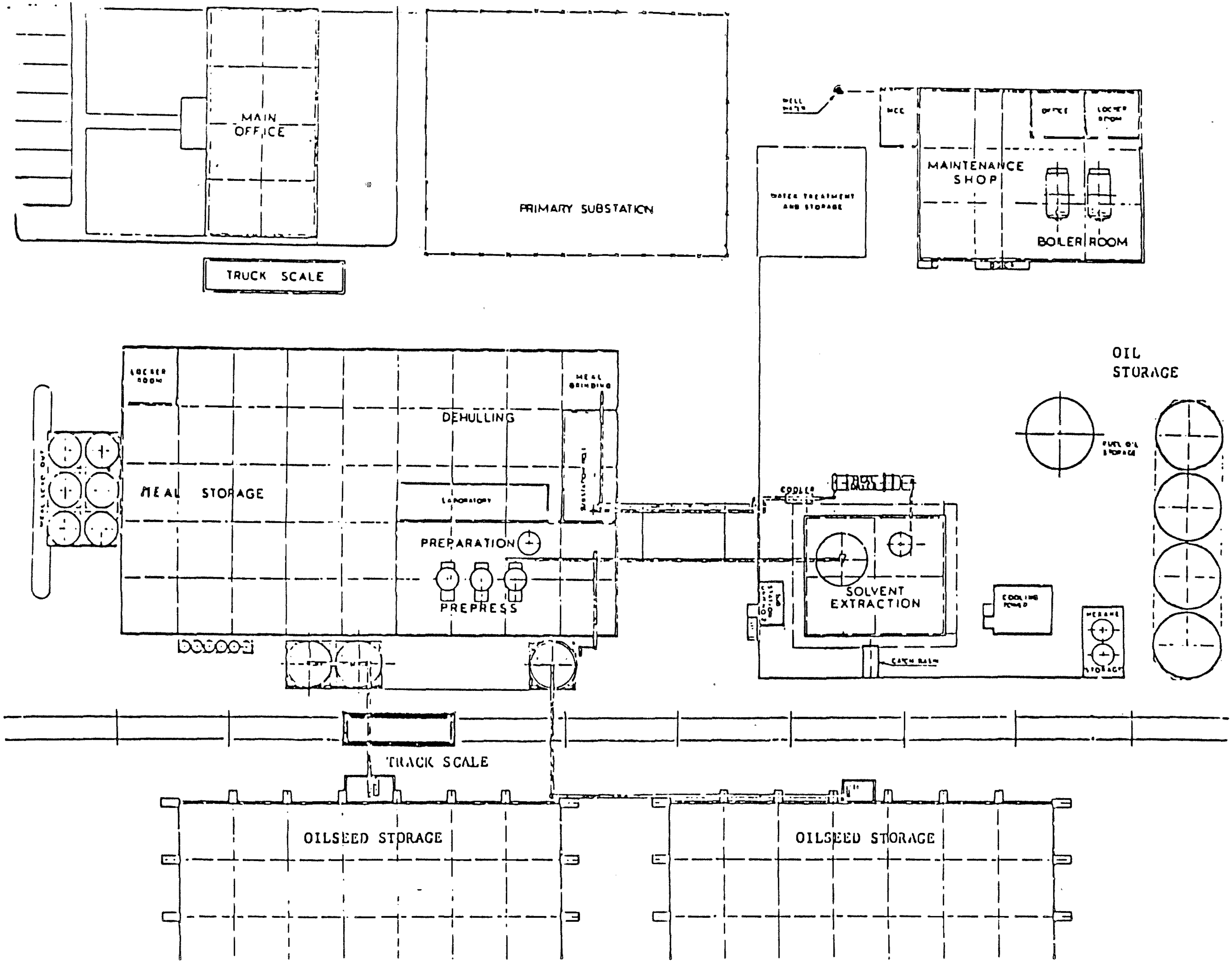


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TABLE 4. Estimated Receiving and Storage Equipment Costs for Specified Sizes of Sunflower Processing Plants, North Dakota, 1975

	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
Item	No.	Cost	No.	Cost	No.	Cost	No.	Cost
70' X 10' Truck Scale	1	$20,000	1	$20,000	1	$20,000	1	$20,000
Rail Scale and Dump	1	33,000	1	33,000	1	33,000	1	33,000
Conveyer from Track	1	1,500	1	1,500	1	1,500	1	1,500
40' Legs[1]	2	10,500	3	14,600	4	18,500	5	22,000
Scalperator	1	3,800	1	5,400	1	7,000	1	7,700
Vibrator	1	4,000	1	5,000	2	8,000	2	10,000
Seed Dryer	1	130,000	1	140,000	2	200,000	2	250,000
Distributors	4	2,000	5	2,500	8	4,000	11	5,500
Bottom Conveyers	1	3,000	2	6,000	3	9,000	4	12,000
Final Cleaner	1	14,700	2	25,000	2	29,500	3	34,300
Air Filtration System[2]	1	52,500	1	63,000	1	73,500	1	84,000
Temperature Detecting System[3]	1	3,000	1	6,000	1	9,000	1	12,000
Total		278,000		322,500		413,000		492,000

[1]Leg capacities are rated at 4,000 and 8,000 bushels/hour for 60 lb. grain.
[2]Computed at the rate of $3.50/CFM (cubic feet of air/minute) installed.
[3]Computed at the rate of $300/detector.

SOURCE: 1975 North Dakota Sunflower Plant Cost Survey.

harvested with a high-moisture content and may contain relatively large amounts of foreign material. The processor can expect to receive seeds with moisture level up to 20%. Sunflowers with such a high moisture level should be dried to 10.5% moisture within 24 hours (12% with aeration). This moisture level is considered optimum for safe long-term storage.

Two high-capacity, precleaning devices, a scalperator and a vibrator, are used to separate most of the foreign matter from the seed before drying. Ordinary commercial grain dryers often require certain refinements to avoid fire hazards that arise in drying sunflowers.

Final cleaning of the raw product occurs before it is transported to the processing section. Virtually all the chaff, dirt and other light-weight material is removed through the use of screens and air separators. The dust created by the plant's loading, unloading, and cleaning operation is controlled by air filters.

Estimated total investment for storage facilities was $775,000; $1,152,000; $1,683,000; and $2,200,000, respectively, for the four plant sizes according to specified structural recommendations (Table 5). These investment requirements per ton of crushing capacity were $5.16, $3.84, $3.74, and $3.67, respectively. There was a reduction of $1.49/unit between the small and large plants in storage investment. Storage facilities account for 15% of total plant investment in the 500-ton plant and 21% of total plant investment in the 2,000-ton plant.

It is recognized that requirements for storage will vary with plant location. The total storage capacity depends upon the number and storage capacity of individual growers and country elevators from which the plant can obtain sunflowers and whether large rail shipments can be handled rapidly.

Processing Departments

The transformation of raw sunflowers into oil, meal, and hulls occurs in four phases. Corresponding departments are described in terms of buildings and equipment for (1) seed decortication (optional), (2) meat preparation-expelling, (3) cake extraction, and (4) meal conditioning. The flow of sunflowers through the above processing sections is given in Figure 9.

Seed Decortication

As already mentioned, most domestic firms process sunflowers intact without decorticating. A specialized plant, however, could include decortication equipment (Table 6) as part of its initial investment since removal of the hulls increases crushing capacity by 15-19%, produces a higher quality meal, and provides a source of energy if hulls are burned as a fuel. Maintenance costs on screw presses are also substantially reduced when sunflowers are decorticated. Some industry sources believe that decorticating the seed

TABLE 5. Estimated Receiving and Storage Structure Costs by Size of Plant, North Dakota, 1975

	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Steel Storage Bins[1]	3	$162,000	3	$162,000	5	$ 270,000	7	$ 378,000
Steel-Frame Building[2]	1	320,000	2	640,000	8	960,000	4	1,280,000
Electrical[3]		15,000		27,500		40,000		50,000
Total		$497,000		$829,500		$1,270,000		$1,708,000

[1]Cost per bin is $54,000 for 60,000-bushel capacity ($.90/bushel erected).
[2]Building is 500' long, 125' at base, and 16' to eaves, includes concrete floor ($5.12 square foot) erected cost.
[3]Based on a rate of $5.00 per ton of sunflower storage capacity.

SOURCE: (5) and 1975 North Dakota Sunflower Plant Cost Survey.

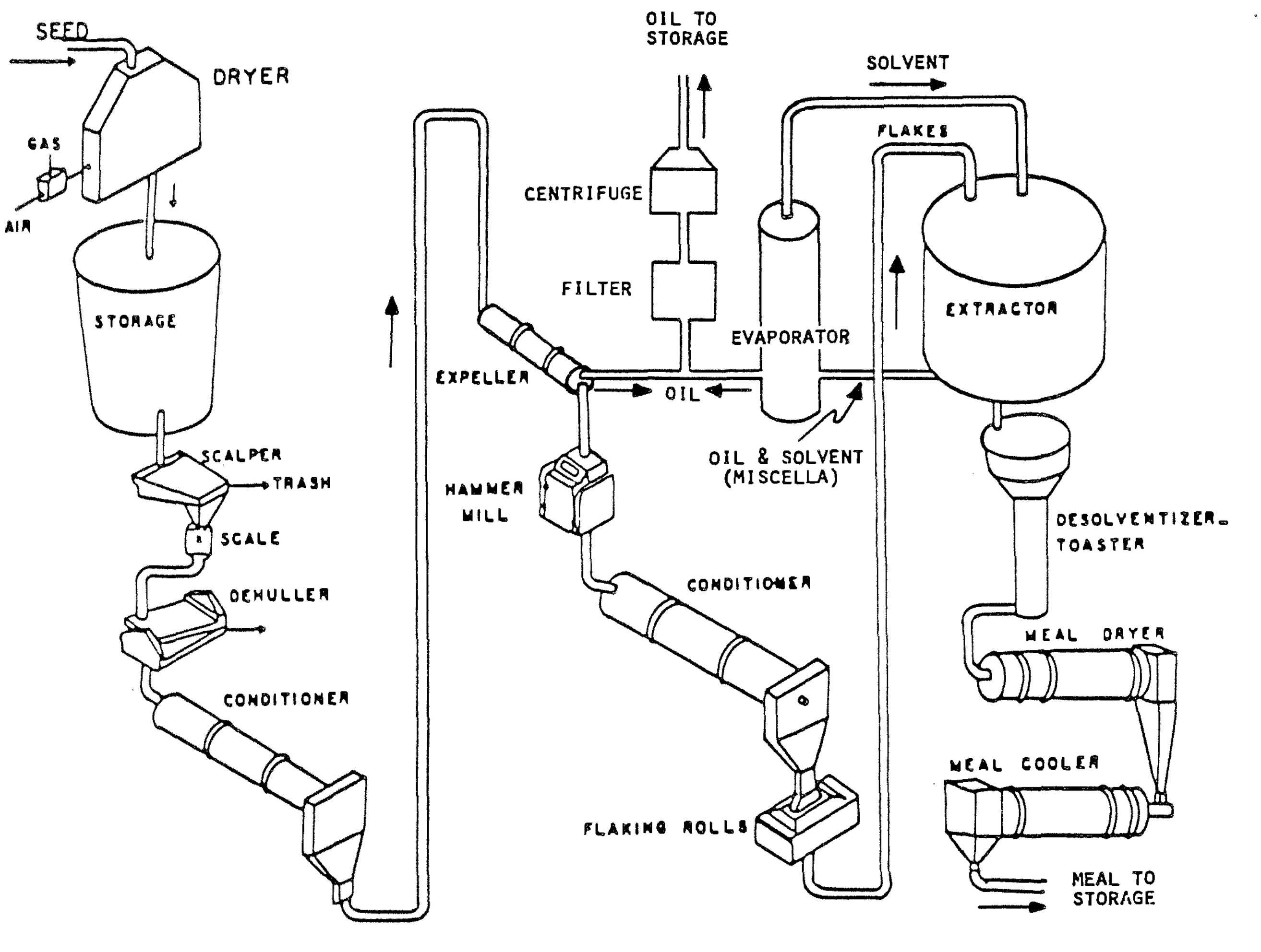


Figure 9. Flow Chart of Prepress Solvent Sunflower Plant (adapted from chart provided By Honeymead Products Company, Minneapolis, Minnesota)

TABLE 6. Estimated Decortication Equipment Costs by Size of Plant, North Dakota, 1975

	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
Item	Weight	Cost	Weight	Cost	Weight	Cost	Weight	Cost
	(tons)	($)	(tons)	($)	(tons)	($)	(tons)	($)
Basic Equipment[1]	29	$266,000	55	$490,000	82	$ 812,000	108	$1,020,000
Conveyers	11	127,000	14	176,000	18	209,000	22	354,000
Electrical	2	13,000	3	17,000	4	27,000	6	36,000
Accessories[2]	10	86,000	17	163,000	20	290,000	23	330,000
Total	52	$492,000	89	$846,000	124	$1,338,000	159	$1,740,000

[1]Includes hull and seed separators and rotary drum-type decorticators.
[2]Includes spare parts, large diameter pipes, and set of elevators.

SOURCE: 1975 North Dakota Plant Cost Survey.

prior to prepress is absolutely essential if heavy maintenance costs on the screw presses are to be avoided.

A disadvantage of this approach, in some cases, is that channeling of the solvent may occur when there is lack of fiber in the cake material. Lack of efficient methods of dehulling has also been a major problem although recent technology has helped to reduce the loss of the meat portion (kernel) into the hulls to 1% or less.

Seeds are passed through a bar dehuller (a cylinder equipped with longitudinally arranged knife-like bars) which cuts the seed hulls. Separation of the hulls from the meat is done by using a series of different sized screens, sieves, and air or shaker separators.

An alternative to decorticating before processing is to separate the hulls as part of the meal conditioning process. Whether or not to decorticate is an option each firm must evaluate individually. This decision would largely depend on the relative prices of low- and high-fiber meal and hulls. The decortication option was not included in the computation of total plant costs.

Preparation-Prepress

The preparation and prepress department would usually be located in the same building as the decortication department. In this section sunflowers are crushed by roller mills and conditioned to specified temperature and moisture level before being fed into a number of screw-type presses.

Products of the screw press operation are raw sun oil and cake (oil and meal mixture with 14-17% oil content). The oil is filtered to remove impurities and then transported to storage tanks. The cake is flaked by special rollers and transported to the extraction department for removal of the remaining oil. A breakdown of equipment components and costs is given in Table 7 for the preparation-prepress department.

The building housing the preparation-prepress operations is usually of steel frame; metallic siding construction; and trussless, rigid-frame design. It is designed with three main floor levels. The first floor is concrete with some recesses and pits and is one foot above ground level.

The second floor is constructed of steel grating supported on beams and columns and is 14 feet above ground level. The third floor is of similar construction, 24 feet above the ground. The entire building is 36 feet from the top of foundation to the eaves in all four plant sizes (Table 8).

TABLE 7. Preparation-Prepress Building Dimensions and Costs by Size of Plant, North Dakota, 1975

Size (Tons/Day)	Dimension in Feet	Cost[1]
500	90 X 50	$103,680
1,000	90 X 50	103,680
1,500	120 X 50	138,240
2,000	120 X 50	138,240

[1]Includes adequate lighting, minimum plumbing, space heaters ($.64/cubic foot erected cost).

SOURCE: (5) and 1975 North Dakota Sunflower Plant Cost Survey.

Cake Extraction

After being rolled into flakes, the cake material is conveyed to the oil extraction department which is located in a separate building. Here the remaining oil is extracted by the solvent washing process and the meal is desolventized, toasted, dried, and cooled. The cooled meal is conveyed back to the meal processing department (Figure 8, p.31).

Equipment from several manufacturers was available and the equipment priced and included in cost estimates was relatively uniform for most plant departments.

TABLE 8. Estimated Preparation-Prepress Equipment Weights and Cost by Size of Plant, North Dakota, 1975

Item	Plant Size in Tons Per Day: 500 Weight (tons)	500 Cost ($)	1,000 Weight (tons)	1,000 Cost ($)	1,500 Weight (tons)	1,500 Cost ($)	2,000 Weight (tons)	2,000 Cost ($)
Breakers	93	$106,000	177	$131,000	277	$ 192,000	353	$ 238,000
Cookers and Presses	122	414,000	244	513,000	366	760,000	488	967,000
Filters	10	39,000	18	49,000	26	72,000	34	90,000
Conveyers	13	110,000	17	115,000	21	128,000	24	140,000
Electrical	4	26,000	7	27,000	9	30,000	13	38,000
Accessories[1]	11	60,000	14	65,000	17	68,000	21	77,000
Total	253	$755,000	477	$900,000	716	$1,250,000	933	$1,550,000

[1]Includes vibrating screen; oil pump; oil scale; and all necessary pipes, valves, and fittings.

SOURCE: 1975 North Dakota Sunflower Plant Cost Survey.

However, relatively few manufacturers design, fabricate, and install the basic equipment for the solvent extraction department. Therefore, more technical differences exist among solvent extraction components than in any other department. The manufacturer usually sells all of the machinery going into this department to each customer, although this is not always the case in other departments. The equipment estimates enumerated in Table 9 approximate the costs of solvent extraction equipment from several manufacturers.

The solvent extraction building is normally of steel-frame construction with asbestos-cement siding. The dimensions and design of the building vary with the manufacture of equipment, as well as with the size of plant (Table 10). The standard height is 25 feet from the top of the foundation to the eaves.

Meal Conditioning

The extracted meal arrives back in the preparation-prepress building where it is further processed to reduce the particle size. Meal screens are used to separate all meal above a certain size and hammer mills grind the larger particles until a fine material is obtained. The cost groupings included in Table 11 account for the conveying, screening, grinding, and accessory equipment required by size of plant.

Pelleting

Sun meal and hulls are relatively difficult and expensive to handle in their loose state. Sun meal and especially hulls are light, making it almost impossible to

TABLE 9. Estimated Cake Extraction Equipment Weights and Costs by Size of Plant, North Dakota, 1975

Item	Plant Size in Tons Per Day: 500 Weight (tons)	500 Cost ($)	1,000 Weight (tons)	1,000 Cost ($)	1,500 Weight (tons)	1,500 Cost ($)	2,000 Weight (tons)	2,000 Cost ($)
Extractor	48	$275,000	96	$ 514,000	127	$ 620,000	195	$ 770,000
Desolventizer-Toaster	36	236,000	50	338,000	88	572,000	110	646,000
Distillation	11	70,000	17	93,000	21	111,000	25	156,000
Steam Economizer	6	25,000	9	43,000	12	63,000	17	87,000
Solvent Recovery	3	24,000	3	25,000	6	41,000	7	42,000
Accessories[1]	22	120,000	29	150,000	37	193,000	43	199,000
Total	126	$750,000	204	$1,163,000	291	$1,600,000	397	$1,900,000

[1]Includes necessary air pipes, electric motors, switches, and electric cables.

SOURCE: 1975 North Dakota Sunflower Plant Cost Survey.

transport the necessary volume in normal carriers to achieve an economic weight. Meal can also be very dusty if moisture content is low and may cake up if it is high. In order to merchandise the large volumes of meal or meal and hulls associtaed with the size plants considered in this report, it may be necessary to install pelleting equipment to overcome these difficulties. The capacity of three sizes of pelleting equipment is related to the maximum output of the four plant sizes in Table 12. A 200 horsepower pelleting unit complete with cooler, electrical equipment, conveyers, and installation would require an investment of $78,000. Operating costs for this size of pelleting mill were estimated at $2.75/ton for meal and $3.75/ton for hulls. Hulls are more abrasive and would have to be ground prior to pelleting.

Processing Cost Summary

Total building and equipment costs, excluding equipment installation for the processing department, were $1,794,980; $2,437,980; $3,338,740; and $3,988,740, respectively, for the four model plants (not including decortication and pelleting equipment). On a per ton basis, these investments were $11.97, $8.13, $7.42, and $6.65 by size of plant. These figures represent 36 to 38% of the total investment, with a $5.32 decline in investment per ton between the small and large model plants.

TABLE 10. Solvent Extraction Building Dimensions and Costs by Size of Plant, North Dakota, 1975

Size (Tons/Day)	Dimension in Feet	Cost[1]
500	40 X 30	$21,300
1,000	40 X 30	21,300
1,500	50 X 40	35,500
2,000	50 X 40	35,500

[1]Includes adequate lighting, minimum plumbing, and space heaters ($.71/cubic foot erected cost).

SOURCE: (5) and 1975 North Dakota Sunflower Plant Cost Survey.

Product Handling, Storage, and Shipping Facilities

The cost estimates for oil storage include tank, foundation, manifold piping, and fire protection dike. The minimum amount of oil storage necessary for orderly operations was estimated to be equivalent to seven days oil production. Facilities listed in Table 13 were based on this assumption.

Meal shipping requirements include facilities for temporary storage and shipment of bulk sun meal. A portion of the preparation-prepress building was used for overflow meal storage. For purposes of orderly marketing, steel tank storage capacity of approximately three days' meal production was included in the cost estimated (Table 13).

Hull storage requirements are rather difficult to assess because of the possibility that hulls may be burned as a fuel source for steam generation as commonly practiced in European and Latin America plants. It was assumed that excess hulls were blown into the vacant areas of the raw product storage area until they were needed as a component for livestock feed or steam generation.*

Service and Auxiliary Facilities

The service and auxiliary facilities of sunflower processing plants are described in terms of (1) boiler room, maintenance shop, and locker room; (2) electric power substations; (3) office and laboratory equipment; (4) cooling tower and fire protection system; and (5) land and railroad trackage.

Boiler Room, Maintenance Shop, and Locker Room

The building for housing the boilers, maintenance

*See p. 48.

TABLE 11. Estimated Meal Conditioning Equipment Weights and Costs by Size of Plant, North Dakota,1975

Item	500 Tons	500 Cost	1,000 Tons	1,000 Cost	1,500 Tons	1,500 Cost	2,000 Tons	2,000 Cost
Basic Equipment[1]	12	$ 80,000	20	$121,000	23	$151,000	40	$163,000
Conveyers	3	44,000	5	66,000	6	85,000	10	105,000
Accessories[2]	8	41,000	8	63,000	10	79,000	17	97,000
Total	23	$165,000	33	$250,000	39	$315,000	67	$365,000

Plant Size in Tons Per Day.

[1]Includes drying, cooling, and grinding equipment.
[2]Includes air fans, necessary air pipes, electric motors, starting switchgears, and electric cables.

SOURCE: 1975 North Dakota Sunflower Plant Cost Survey.

TABLE 12. Pelleting Equipment Capacity Related to Size of Plant[1]

Item	Size of Unit (HP)		
	150	200	250
Meal			
Capacity (tons/hr.)	7.5	12.0	15.0
% of Plant Output Handled by One Unit (high fiber)			
500 Ton Plant	64	103	129
1,000 Ton Plant	32	51	64
1,500 Ton Plant	21	34	43
2,000 Ton Plant	16	26	32
% of Plant Output Handled by One Unit (low fiber)			
500 Ton Plant	97	102	195
1,000 Ton Plant	49	78	97
1,500 Ton Plant	32	52	65
2,000 Ton Plant	24	39	49
Hulls Only			
Capacity (tons/hr.)	5.0	7.5	10.0
% of Plant Output Handled by One Unit			
500 Ton Plant	126	189	252
1,000 Ton Plant	63	95	126
1,500 Ton Plant	42	63	84
2,000 Ton Plant	32	47	63

[1]Yield assumed: 56% high-fiber meal or 37% low-fiber meal and 19% hulls.

shop, and locker room is of steel frame construction with steel siding. It is 16 feet from the foundation to the eaves. This building also contains an office which may be used by supervisors or purchasing agents. Dimensions and costs are given in Table 14.

The cost of steam generating equipment includes steam generators, feedwater softeners, feedwater heaters and pumps, instruments and controls, fuel oil pumps and heaters, piping, and auxiliary equipment.

Boilers which burn coal, as well as oil or gas, were specified because of the relative availability of lignite coal in North Dakota. The cost of a specialized boiler for burning sunflower hulls approximates the cost of a coal-fired type boiler.

Estimated costs of shop equipment and storeroom supplies include allowances for tools and equipment for maintenance and repair work, such as drill presses, lathes, welders, workbenches, etc. (Table 14).

The cost of the locker rooms was based on the number of men served per day. One locker was allowed per employee along with sufficient plumbing facilities for serving a full shift (Table 14).

Electric Substations

It was assumed that three-phase electrical power from public utility was available at the plant boundary and that metering and lighting protection was provided by the utility. All other facilities for transforming power to lower voltages and distribution were included in the plant cost.

Most of the power used in a plant is for the elevator and the processing departments. The large electric

TABLE 13. Estimated Product Storage and Shipping Structure and Equipment Costs by Size of Plant, North Dakota, 1975

Item	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Oil Tanks, 50,000 Gal.[1]	4	$30,800	4	$ 30,800	6	$ 46,200	8	$ 61,600
Tank Scale[2]	1	17,000	1	17,000	1	17,000	1	17,000
Bulk Meal Loader	1	3,000	1	3,000	1	3,000	1	3,000
Meal Tanks, 250 Tons[3]	3	24,000	6	48,000	8	64,000	10	80,000
Set of Elevators	1	15,000	1	20,000	1	25,000	1	30,000
Total		$89,800		$118,800		$155,200		$191,600

[1]Costs are averages of 12 to 14 gauge tanks, erected on a concrete slab foundation, including conical roof with manhole (15.4 cents/gallon, erected).
[2]Includes pumps and housing. An option would be to use a meter in conjunction with the truck and rail scale.
[3]Costs are averages of 12-gauge bolted galvanized tanks, including sand and gravel foundations, fittings, and roof.

SOURCE: (5) and 1975 North Dakota Sunflower Plant Cost Survey.

motors in the elevator department require substantial amounts of power. The size of transformer required for each plant size is 285 kwh., 470 kwh., 855 kwh., and 1,140 kwh., respectively, for the four plant sizes.

Main Office and Laboratory Equipment

The costs of building and equipment for the main office and laboratory equipment for the preparation-prepress department are given in Table 14. The costs were not estimated in detail because of the variability in the degree of sophistication that is possible for this component of the plant.

Cooling Towers and Fire Protection System

A tower for supplying cooling water for screw presses, extractors, meal coolers, and fire protection is a necessary investment item (Table 14). Other items included for fire protection are fire pumps, hose stations, and automatic sprinkler systems. It is recommended that the sunflower storage department have small hoses available at every operational location.

Land and Railroad Trackage

Land requirements and costs are given in Table 14 with the acreages shown as approximate minimums for the different size plants. The $6,000/acre cost included a small amount of preparation, such as clearing and filling.

The costs for railroad trackage were not estimated in detail because of different track and switch arrangements possible.

Processing of Other Oilseeds

The equipment components for the complete prepress-solvent sunflower processing plants presented are designed to be adaptable for other oilseeds. The two commodities most likely to be substituted for sunflowers in North Dakota are flaxseed and soybeans.

Essentially all of the facilities required to process flaxseed are included in a sunflower processing plant. The operational complications created by a shift in the commodity processed require that the plant employ knowledgeable and experienced personnel in certain departments.

TABLE 14. Estimated Service and Auxiliary Building and Equipment Costs by Size of Plant, North Dakota, 1975

Item	Plant Size in Tons Per Day			
	500	1,000	1,500	2,000
Oil and Gas-Fired Boiler	$ 23,000	$ 33,800	$ 49,500	$ 52,500
Coal-Fired Boiler[1]	(17,250)	(33,800)	(49,500)	(63,000)
Fuel Storage Tank (50,000 Gal. Capacity)	30,800	30,800	30,800	30,800
Workshop Equipment	53,000	53,000	73,000	73,000
Locker Room	8,000	9,000	9,500	10,000
Electric Substations (3-6 750 Kilovolt Amps)	39,000	52,000	65,000	78,000
Office Equipment	25,000	25,000	30,000	30,000
Cooling Tower and Fire Protection	90,000	90,000	95,000	95,000
Laboratory Equipment	15,000	15,000	18,000	18,000
Total	$283,800	$308,600	$370,800	$387,300
Building for Housing Boilers, Maintenance Shop, and Lockers (60' X 30')[2]	21,000	21,000	21,000	21,000
Main Office Building (40' X 20')[3]	19,700	19,700	19,700	19,700
Land ($6,000/Acre)	90,000[4]	90,000[4]	120,000[5]	120,000[5]
Railroad Tracks	75,000	75,000	75,000	75,000

[1]Not included in total cost, approximates hull boiler costs.
[2]Furnished office area, adequate lighting and plumbing, and space heaters ($.73/cubic foot erected cost).
[3]Steel frame, good metal and glass, ornamentation, plaster walls, acoustic ceilings, office lighting, plumbing, and central air conditioning ($1.64/cubic foot erected cost).
[4]Fifteen acres.
[5]Twenty acres.

SOURCE: (5) and 1975 North Dakota Sunflower Plant Cost Survey.

Additional seed preparation equipment is needed to process soybeans. More cracking rolls (breakers) are needed for breaking beans into small pieces which may be more easily heated. Special oil degumming equipment may be used as a additional oil handling component of a plant that processes soybeans.

The processing capacities of flaxseed and soybeans as compared to sunflower processing capacity are presented in tabular form (Table 15). The additional cost of the seed preparation equipment required for processing soybeans and degumming equipment, if used, is specified.

The total investment requirements of the various departments for complete prepress sunflower processing plants are given in Table 16. The cost figures in Table 15 must be added to these totals for complete multi-oilseed processing capability.

Processing Costs of Model Plants

Fixed Costs

Cost items that remain at a constant level regardless of the output produced per unit of time are depreciation,

TABLE 15. Daily Capacities and Added Costs for Flaxseed and Soybean Processing in Model Sunflower Plants, North Dakota, 1975

	Sunflower Processing Capacity in Tons Per Day			
	500	1,000	1,500	2,000
Equivalent Processing Capacity:				
Flax (Tons/Day)	750	1,400	2,050	2,700
Soybeans (Tons/Day)	650	1,250	1,850	2,450
Added Equipment:				
Preparation	$150,000	$300,000	$500,000	$850,000
Degumming[1]	$130,000	$150,000	$186,000	$218,000

[1]Not considered essential for crude soy oil.

TABLE 16. Summary of Estimated Total Investment Costs for Specific Sizes of Sunflower Processing Plants, North Dakota, 1975

	Plant Size in Tons Per Day			
Item	500	1,000	1,500	2,000
Storage Facilities				
Equipment	$ 278,000	$ 322,500	$ 413,000	$ 492,000
Buildings and Silos	497,000	829,000	1,270,000	1,708,000
Processing Departments:				
Preparation-Prepress Equipment	755,000	900,000	1,250,000	1,550,000
Cake Extraction Equipment	750,000	1,163,000	1,600,000	1,900,000
Meal Conditioning Equipment	165,000	250,000	315,000	365,000
Preparation-Prepress Building	103,700	103,700	138,300	138,300
Extraction Building	21,300	21,300	35,500	35,500
Product Storage and Shipping:	89,800	118,800	155,200	191,600
Service and Auxiliary Facilities:				
Equipment	283,800	308,600	370,800	387,300
Buildings	40,700	40,700	40,700	40,700
Land and Trackage	165,000	165,000	195,000	195,000
Cost of Equipment Installation and Freight	1,860,700	2,837,400	2,986,500	3,446,600
Total Estimated Investment	$5,010,000	$7,060,000	$8,770,000	$10,450,000

SOURCE: Tables 4 through 14.

interest, salaries and administrative, insurance, taxes, and building maintenance. Model plants were placed on a comparable basis with respect to cost by designing new plants and estimating their investment requirements by departments. Fixed plant costs were calculated by applying to these investments the depreciation, interest, salary and administrative, insurance, tax and maintenance rates which are presented in Table 17 and described in the following paragraphs.

Depreciation

Depreciation cost for all plant facilities was calculated by using the straight-line method with zero salvage value.* Three depreciation rates were applied to the various departments, depending upon the estimated length of useful life of the structure and equipment or facility involved. These rates were selected after discussions with plant operators and equipment suppliers.

The total annual depreciation cost per ton of sunflower processing capacity was $1.14, $.77, $.70, and $.64, respectively, for the four plant sizes.

Interest

Interest on invested capital was calculated at 8.5% of the average plant investment, whether the operator used his own or borrowed funds. This made an average interest cost of 4.25% on initial investment over the life of the total facility (average investment was calculated as one-half of initial investment cost). Eight and one-half percent interest was thought to be the most acceptable rate for which funds could be borrowed by representatives of financial institutions providing capital to commercial ventures of this type.

Interest charged on plant investment was the most expensive fixed cost component, representing 30 to 34% of total per unit fixed cost. Interest cost per ton of processing capacity was $1.37, $.98, $.81, and $.73, respectively.

Salaries and Administrative

The cost of administering a plant of this type included the salary expense for general manager and two to four department heads, depending upon the size of plant (Table 18, p. 58).

Other administrative costs include secretarial expenses, travel, advertising, auditing services, legal fees, telephone, office supplies, postage, and miscellaneous expenses. These costs were estimated at 1.7% of total investment cost, an estimate derived from preliminary research and verified by industry sources.

Insurance

Insurance is usually available under a single blanket policy for all insurable property and generally includes fire, wind, and supplemental perils*. This protection was available at the rate of $6.00 per $1,000 of the full insurable value of buildings and their contents. This figure was based on basic steel construction with average quality wiring and plant safety devices.**

With 100% coverage, costs per ton of processing ca-

*If the estimated salvage is not in excess of 10% of the original cost, it is frequently ignored in calculating straight-line depreciation.

*Supplemental perils include vandalism, civil disorder, smoke, etc.

**Concrete rates are $1.00 to $2.50 per $1,000 and wood frame rates are $8.00 to $10.00 per $1,000.

TABLE 17. Estimated Fixed Cost of Crushing Sunflowers by Size of Plant, 300-Day, Crushing Season, North Dakota, 1975

Item	Plant Size in Tons Per Day			
	500	1,000	1,500	2,000
Depreciation:				
Storage Facilities 25 Years, 4%	$ 31,000	$ 46,080	$ 67,320	$ 88,000
Processing Departments 15 Years, 6.7%	120,260	163,340	222,700	267,250
Product Storage and Shipping 25 Years, 4%	3,590	4,750	6,210	7,660
Service and Auxiliary Facilities 20 Years, 5%	16,230	17,460	20,580	21,400
Total Annual Depreciation	$171,080	$231,630	$ 316,810	$ 384,310
Interest on Capital	$205,280	$293,250	$ 364,440	$ 435,630
Salaries	48,000	63,000	76,000	81,000
Administrative	82,110	117,300	145,780	174,250
Insurance (Plant)	17,900	24,350	33,530	40,850
Property Taxes	57,960	82,800	102,900	123,000
Building Maintenance	13,250	19,900	29,690	38,450
Total Fixed Cost	$595,580	$832,230	$1,069,150	$1,277,490
Average Fixed Cost, $/Ton	3.97	2.77	2.38	2.13

pacity were 11.0 cents, 8.1 cents, 7.4 cents, and 6.8 cents, respectively, for the four plant sizes.*

Taxes

An assessment ratio of 16% of total initial plant investment was used to derive the assessed value of calculating state and local property taxes. Fifty percent of this figure was the tax factor used to determine the taxable value.** Local mill rates were applied to this value. Since a plant of this type would probably be located outside city limits, a levy of 150 mills was used as the estimated average tax charge on rural property in North Dakota.

Building Maintenance

A specific level of maintenance is required on the plant buildings regardless of the level of output. This figure, which is included in Table 17, was calculated at an annual rate of 2% of the initial building costs.

Variable Costs

Cost items that vary with a given level of output per unit of time were grouped into nine categories: wages, social insurance expenses, utilities, fuel and solvent, repairs and maintenance, interest on working capital, insurance on inventory, product selling expense, and inventory loss.

Wages

Certain plant departments require skilled and experienced operators, while other departments can begin operation with unskilled help. For this reason, the labor requirements for both types of labor were included by size of plant. The labor requirements and the corresponding labor costs are provided in Table 18. Wage rates of $4.00/hour for unskilled and $6.50 for skilled labor corresponded to the rates paid by local sugarbeet processors. These rates were verified by the State Employment Office.*

*Calculated at .6% of total investment cost less installation.

**Based on information furnished by the Cass County Tax Equalization Department.

*Rates were as follows — Technician I: $6.55 to $6.74, Technician II: $5.97 to $6.42, Technician III: $5.06 to $5.87. General Labor: $3.47 to $4.06.

Social Insurance Expenses

Three types of costs were included in the category of social insurance expenses: (1) workmen's compensation; (2) general liability; and (3) social security. These costs are a function of wages and a figure of 32% of wages paid was used for the purpose of this study.

Utilities

Utilities included two types of services — electric power and water. Estimated electrical requirements for the four plant sizes in kwh./processed ton were 75, 72, 70, and 69, respectively (Table 19). A standard rate of 3.01 cents/kwh. was used for study purposes assuming a load factor of 27% (6, p. 2).

Water used for sanitation, steam production, condensing vapored solvent, cooling, and fire protection would cost approximately the same whether a plant secured its water from a municipal supply or installed its own well and pumps. Although five to six thousand gallons of water were required per ton of sunflowers processed, all plant designs included cooling facilities for recirculating the water which allows the actual consumption to be only about 3% of the total circulation. Daily water requirements were 90,000 gallons, 172,000 gallons, 236,000 gallons, and 300,000 gallons, respectively. At a rate of $.30 per 1,000 gallons, the cost of water per ton of seed processed was 5.4 cents, 5.2 cents, 4.7 cents, and 4.5 cents, respectively.

TABLE 18. Estimated Salary and Wage Requirements for Sunflower Processing by Size of Plant, 300-Day Crushing Season, North Dakota, 1975

	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
Item	No.	Cost	No.	Cost	No.	Cost	No.	Cost
General Manager	1	$ 18,000	1	$ 18,000	1	$ 21,000	1	$ 21,000
Department Heads	2	30,000	3	45,000	3	54,000	4	60,000
Skilled Labor[1]	9	140,000	10	156,000	12	187,200	13	202,800
Unskilled Labor[2]	27	226,800	32	268,000	36	302,400	41	344,400

[1]Computed at the rate of $6.50/hour.
[2]Computed at the rate of $4.00/hour.

TABLE 19. Estimated Electric Power Consumption Requirements Per Ton of Sunflowers Processed by Type of Operation for a 500-Ton Per Day Plant

Operation	Power Consumption (kwh.)
Receiving, Storing, and Drying Sunflowers	9.0
Breaking Seeds	1.0
Conditioning[1]	3.4
Screw Presses	30.0
Flaking	8.2
Extraction	1.0
Water Cooling and Pumping	4.5
Desolventizing and Toasting Meal	3.5
Cooling Meal	2.0
Grinding Meal	4.0
Aspiration	1.0
Lighting for Entire Mill	1.4
Miscellaneous[2]	6.0
Total	75.0

[1]Does not include decortication.
[2]Includes conveying sunflowers from elevator and throughout the preparation, screw-press, extraction, and meal processing departments, loading of finished meal and oil, and other miscellansous power needs.
SOURCE: 1975 North Dakota Sunflower Plant Cost Survey.

Fuel and Solvent

Fuel consisting of natural gas, fuel oil, coal, or sunflower hulls* may be used to produce steam for plant operations and costs approximately the same per ton processed, regardless of plant output. Gas and oil-fired steam generating plants are instrumented to operate with less supervision than coal-fired plants, counteracting the higher unit cost of fuel. The figure used to calculate fuel costs per ton was based on an industry consumption rate of 9.05 gallons No. 6 fuel per 1,000 pounds of steam with 550, 539, 528, and 506 pounds of steam required per processed ton, respectively, for the four plants. The price used for No. 6 fuel oil was 28.5 cents/gallon, f.o.b. Minneapolis, plus a freight charge of 4.5 cents/gallon when shipped in 23,000 gallon jumbo tank cars. Fuel costs per ton of processed seed were $1.64, $1.61, $1.58, and $1.51.

A plant's solvent loss depends largely upon its equipment, maintenance, and operating practices. For the plant sizes evaluated, solvent loss per processed ton was estimated to be .71, .66, .62, and .58 gallons, respectively. The price of hexane solvent is variable, but a figure of $.42/gallon was used.

*See p. 48 for a discussion of the value of hulls used for fuel.

Repairs and Maintenance

Repairs and maintenance on equipment was computed at an annual rate of 6% of total initial cost of machinery and equipment.* Cost per ton of processed material was $1.63, $1.16, $.93, and $.82, respectively.

Interest on Seasonal Capital

Plants usually acquire a large part of their annual supply of sunflowers in the early part of the season and large amounts of capital are needed to meet expenses during the time lag between initial processing and product sales. Funds are also needed during shutdown repair periods, for purchases of supplies and working inventories, and for other variable operating costs incurred in processing.

Such funds involve a cost equivalent at the prevailing interest rate on short-term credit, whether borrowed or paid with equity capital. A rate of 8.5% was assumed to be representative of short-term interest rates. In order to approximate the capital charges, interest was charged against the average quantity of stocks equivalent to 16% of the annual raw product volume of sunflowers at a price of $216.60/ton (7, p. 22). Seasonal interest expenses were $2.95/processed ton, accounting for 22 to 29% of total plant operating costs.

Insurance on Inventory

Inventory insurance was also calculated on the basis of average sunflower stocks in storage at the rate of $6.00 per $1,000 valuation. The estimated annual cost per processed ton for each of the four plants was $.21.

Product Selling Expense

Costs of sales services mainly include brokerage on oil and meal, taxes, and licenses. Industry sources estimated these costs at $.25/processed ton regardless of volume handled.

Inventory Loss

Inventory loss due to shrinkage in the seed, feed, and oil, as well as moisture losses, plus waste and spoilage varied from 2 to 4% of the average stocks of sunflowers in storage. The average storage was calculated at 16% of total crush, using a raw product price of $216.60/ton resulting in a loss of $.69/processed ton.

Summary

Comparison of the short-run average costs in Table

*Includes equipment figures in Table 16, along with the product storage and shipping department and installation costs.

20 reveals economies from increasing plant size.* Average total costs per processed ton were $17.18, $14.02, $12.86, and $12.17, respectively, at full utilization, for the four plants. Since the full capacity level of output results in minimum average costs for each plant size, a curve connecting costs at this level describes a long-run, cost-volume relationship.** Such a curve is illustrated in Figure 10 by the down-sloping line.

*The short-run refers to the time period so short that the processing firm does not have time to vary the quantity of such resources as land, buildings, heavy equipment, and top management.
**The long-run average cost curve indicates the average cost per ton for processing any given volume of sunflowers when all costs (both fixed and variable) are allowed to vary with the number of tons processed.

Variation of Cost and Utilization Level

The assumption that the model plants would operate at 100% utilization is unrealistic for several reasons. Changes in the international markets, interface of crushing capacity with raw product supply and demand for end products, and unexpected changes in the supply of raw products are important factors that may affect the

TABLE 20. Estimates and Distribution of Variable and Fixed Costs of Processing Sunflowers by Size of Plant, 300-Day Crushing Season, North Dakota, 1975

Item	Plant Size in Tons Per Day			
	500	1,000	1,500	2,000
Wages	$ 366,800	$ 424,000	$ 489,600	$ 547,200
Social Insurance Expenses	117,380	135,680	156,670	175,100
Electricity	338,630	650,160	948,150	1,246,140
Water	8,100	15,600	21,150	27,000
Fuel	246,000	483,000	711,000	906,000
Solvent	44,730	83,160	117,180	146,160
Repairs and Maintenance	244,640	348,890	419,730	493,950
Interest on Seasonal Capital	441,860	883,730	1,325,590	1,767,460
Insurance on Inventory	31,190	62,380	93,570	124,760
Product Selling Expense	37,500	78,000	121,500	174,000
Inventory Loss	103,970	207,940	311,900	415,870
Total Variable Cost	1,980,800	3,372,540	4,716,040	6,023,640
Average Variable Cost Per Ton	$13.21	$11.24	$10.48	$10.04
Total Fixed Cost	595,580	832,230	1,069,150	1,277,490
Total Cost	$2,576,380	$4,204,770	$5,785,190	$7,301,130
Average Total Cost Per Ton	$17.18	$14.02	$12.86	$12.17

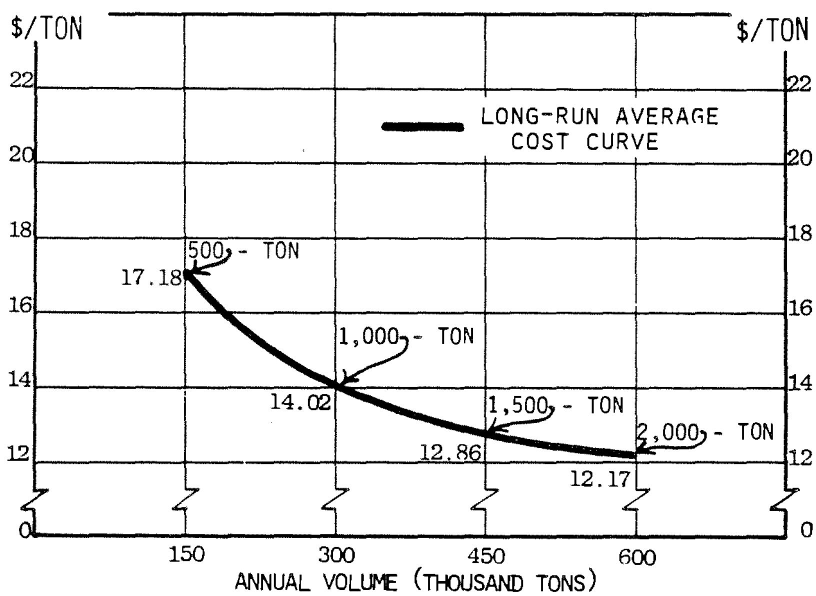


Figure 10. Average Total Costs, Model Sunflower Processing Plants Operating at 100% Capacity, North Dakota, 1975

level of utilization.

The 1,000-ton plant operating at full capacity would have to attract 108% of the total oilseed sunflower acreage, using 1975 sunflower production figures. Refer to Chapter 5, Table 60, p. 67, for more detailed discussion and figures indicating the percent of the area's production that each plant would require.

Flax and soybeans could be processed, initially, if the supply of sunflowers is inadequate to support the plant at full capacity. However, decision makers should be aware of the competition from existing processors for these commodities.

The average total costs of processing sunflowers at levels other than full capacity (50 and 75% capacity) are given in Table 21 for the four plants. As utilization of each decreases, average variable costs remain at a constant level.* Average fixed cost, however, increases as plant utilization decreases. Average fixed cost for the 1,000-ton plant increases from $2.77 to $5.55 as utilization falls from 100 to 50% of plant capacity.

The combined effect was an increase in average total cost as the plant was utilized less and less. Data from Table 21 were plotted as short-run average cost curves in Figure 11. The short-run average cost curves emphasize economies from increased short-run output. The short-run average cost curve represents the cost of processing a ton of sunflowers given that capacity size of the processing plants. For example, the cost of processing a ton of sunflowers ranges from $17.18 at full utilization of the 500-ton/day plant to $21.15 at 50% utilization.

All short-run cost curves should be examined when trying to decide which plant to construct since more than one plant could process the same annual volume of sunflowers. For example, the 500-ton plant at full utilization and the 1,000-ton plant at 50% utilization would both process an annual volume of 150,000 tons of sunflowers. The average total cost for processing 150,000 tons for the 500-ton plant would be $17.18/ton, while the 1,000-ton plant would process the same volume for a cost of $16.79/ton.

This tends to demonstrate large sunflower processing plants can operate well below the designed capacity levels before sizable average total cost increases would be encountered. This is due primarily to spreading the extra cost of excess capacity over a volume equal to or greater than the full capacity level of the smallest proc-

*No important change in average variable costs occurred under the study techniques employed.

TABLE 21. Estimated Annual Operating Costs at Specified Utilization Levels, Model Sunflower Processing Plants, North Dakota, 1975

Plant Size and Percent Utilization[1]	Annual Sunflower Input	Total Fixed Cost	Average Fixed Cost	Total Variable Cost[2]	Total Cost	Average Total Cost
	(tons)	($)	($/ton)	($)	($)	($/ton)
500 Ton						
100%	150,000	595,580	3.97	1,980,800	2,576,380	17.18
75%	112,500	595,580	5.29	1,486,130	2,081,710	18.50
50%	75,000	595,580	7.94	990,750	1,586,330	21.15
1,000 Ton						
100%	300,000	832,230	2.77	3,372,540	4,204,770	14.02
75%	225,000	832,230	3.70	2,529,000	3,361,230	14.94
50%	150,000	832,230	5.55	1,686,000	2,518,230	16.79
1,500 Ton						
100%	450,000	1,069,150	2.38	4,716,040	5,785,190	12.86
75%	337,500	1,069,150	3.17	3,537,000	4,606,150	13.65
50%	225,000	1,069,150	4.75	2,358,000	3,427,150	15.23
2,000 Ton						
100%	600,000	1,277,490	2.13	6,023,640	7,301,130	12.17
75%	450,000	1,277,490	2.84	4,513,500	5,790,990	12.87
50%	300,000	1,277,490	4.26	3,009,000	4,286,490	14.29

[1]Plants have an operating capacity based on 24 hours/day, 300 days/year.
[2]Average variable costs/ton are $13.21 for the 500-ton; $11.24 for the 1,000-ton; $10.48 for the 1,500-ton; and $10.04 for the 2,000-ton plant.

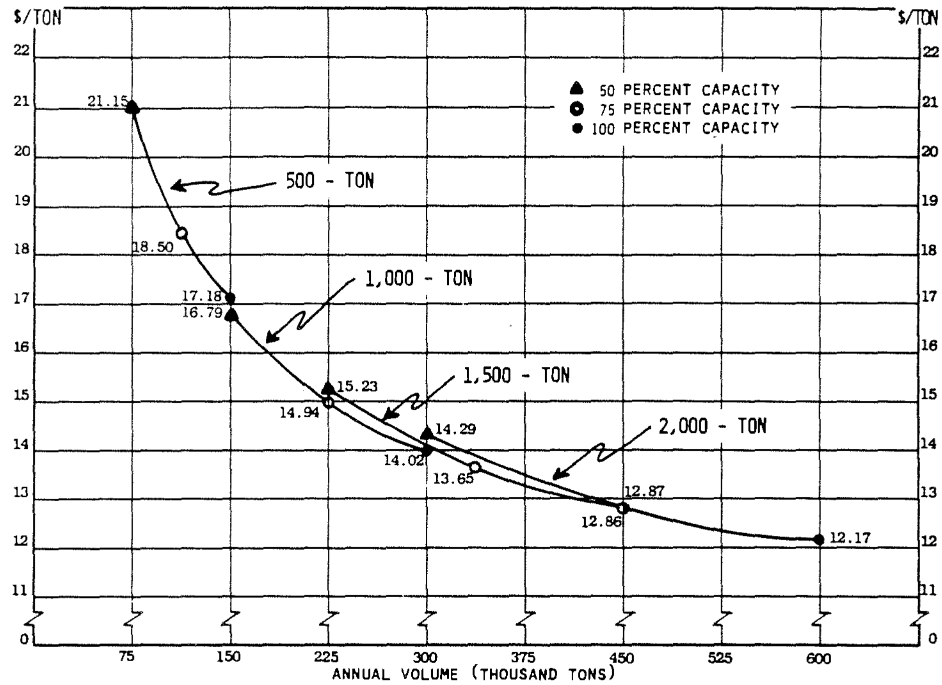


Figure 11. Short-Run Average Total Operating Costs, Model Sunflower Processing Plants Operating at Varying Utilization Levels, North Dakota, 1975

essing plant. It also necessarily follows that at an exceptionally low volume, a large plant will incur exorbitant costs well above a sunflower processing plant designed to process a lower level of output.

The lower average variable costs in the larger 1,000-ton plant more than offsets the increase per unit fixed cost at 50% capacity when compared to the 500-ton plant at 100% capacity. Lower variable costs for larger plants result from less than proportional increases in fuel, electricity, and labor with larger equipment.

The estimate of total cost of production for the 1,000/ton plant for five years is presented in Table 22. The cost figures for the first year reflect less than full capacity (75%). It was assumed that the plant would not operate at 100% capacity for the first year because of start-up considerations. The cost for the four remaining years was at 100% capacity. An 8.5% interest charge on capital (average plant investment) was included as a fixed cost. If a different interest rate is used, the interest on capital would have to be recomputed to obtain a new total cost of production

Sunflower Prices

Sunflowers are the most important input into the production of crude sun oil and meal. The price of oil and meal minus the price of sunflowers per unit is the gross margin or crushing margin, the most crucial factor in the profit and loss situation of the processing firm. A price of 10.83 cents/lb. of seed ($216.60/ton) was used as a basis for deriving certain operating costs. For a more detailed discussion on the price of sunflower seeds, refer to Chapter 4, p. 54.

Estimated Revenue Generated

Oil and meal are the most important sources of revenue to a firm processing sunflowers. The prices of sun oil and sun meal less the raw sunflower price result in the gross operating margin. The end products of the crushing process from incoming sunflowers at 10.5% moisture were estimated to be 38.5% oil and 56% high fiber meal (hulls included). Total shrink was 5.5% composed of 3.5% moisture loss and 2% product loss and assumes that the meal includes 12.5% moisture. The prices used to project expected revenue from these products were on an f.o.b. plant basis.

Oil and Meal Prices

A sun oil price of $496.50/ton was assumed to represent the price received by any of the four plants evaluated under typical operating conditions. The sun meal price used in the revenue analysis was $80.28/ton for high fiber meal (hulls included). Refer to Chapter 4, p. , for a more detailed discussion on the prices used. These figures were used in the profitability analysis shown in Tables 23, 24, and 25.

Net Revenue and Return on Investment

Estimated gross receipts generated by each model plant were derived and the cost of sunflowers deducted to determine the gross operating margins. The cost of processing was then deducted from this figure to arrive at the net operating margin before state and federal income taxes.

The return on investment before taxes was calculated

TABLE 22. Total Annual Operating Costs and Raw Materials Costs (Direct and Indirect), 1,000-Ton Sunflower Processing Plant, 1976-1980[1]

Cost Items	1976[2]	1977[3]	1978[3]	1979[3]	1980[3]
Depreciation	$ 231,630	$ 231,630	$ 231,630	$ 231,630	$ 231,630
Interest on Capital	293,250	293,250	293,250	293,250	293,250
Salaries	63,000	63,000	63,000	63,000	63,000
Administrative Expenses	117,300	117,300	117,300	117,300	117,300
Insurance (Plant)	24,350	24,350	24,350	24,350	24,350
Property Taxes	82,800	82,800	82,800	82,800	82,800
Building Maintenance	19,900	19,900	19,900	19,900	19,900
Wages	318,000	424,000	424,000	424,000	424,000
Social Insurance Expenses	101,760	135,680	135,680	135,680	135,680
Electricity	487,620	650,160	650,160	650,160	650,160
Water	11,700	15,600	15,600	15,600	15,600
Fuel	362,250	483,000	483,000	483,000	483,000
Solvent	62,370	83,160	83,160	83,160	83,160
Repairs and Maintenance	261,670	348,890	348,890	348,890	348,890
Interest on Seasonal Capital	662,800	883,730	883,730	883,730	883,730
Insurance (Inventory)	46,780	62,380	62,380	62,380	62,380
Product Selling Expense	58,500	78,000	78,000	78,000	78,000
Inventory Loss	155,950	207,940	207,940	207,940	207,940
Cost of Sunflowers	48,735,000	64,980,000	64,980,000	64,980,000	64,980,000
Total Cost	$52,096,630	$69,184,770	$69,184,770	$69,184,770	$69,184,770

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost.
[2]Figures reflect 75% capacity.
[3]Figures reflect 100% capacity.

TABLE 23. Estimated Revenue and Returns for Model Sunflower Processing Plants, 300-Day Crushing Season, North Dakota, 1975[1]

Item	Plant Size in Tons Per Day			
	500	1,000	1,500	2,000
Sales:				
Oil	$28,672,880	$57,345,750	$ 86,018,630	$114,691,500
High Fiber Meal	6,743,520	13,487,040	20,230,560	26,974,080
Total Annual Sales	35,416,400	70,832,790	106,249,190	141,665,580
Less: Cost of Sunflowers	32,490,000	64,980,000	97,470,000	129,960,000
Gross Operating Margin	2,926,400	5,852,790	8,779,180	11,705,580
Less: Operating Expenses — Plant Costs	2,576,380	4,204,770	5,785,190	7,301,130
Net Operating Margin Before Taxes	350,020	1,648,020	2,994,000	4,404,450
Net Operating Margin Before Taxes $/Ton	2.33	5.49	6.65	7.34
Rate of Return on Investment[2] Before Taxes	6.99%	23.34%	34.14%	42.15%
Less: Total Taxes	162,260	785,300	1,431,370	2,108,390
Net Margin	$ 187,760	$ 862,720	$ 1,562,630	$ 2,296,060
Rate of Return on Investment[2] After Taxes	3.75%	12.22%	17.82%	21.97%

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost.
[2]Refers to total estimated investment, Table 16, p. 22.

based on total plant investment costs. State and federal taxes were then applied assuming a 25% tax bracket for taxable income up to $25,000. Income over this amount was taxed at 48% to arrive at the net return after taxes.

The high cost of processing the seed in the 500-ton plant caused the net return to remain rather low when compared with the other three plants (Tables 23 through 25). At 50% utilization, the 500-ton plant's cost of processing the sunflowers was greater than the revenue generated by the sale of the oil and meal, thereby, yielding a negative net operating margin before taxes. The fact that the processing cost per ton declined appreciably with increases in the sizes of plants made the larger plants appear very profitable. It should be kept in mind, however, that the meal and oil prices were assumed to be constant at $80.28 and $496.50/ton, respectively.

TABLE 24. Estimated Revenue and Returns for Model Sunflower Processing Plants, 225-Day Crushing Season, North Dakota, 1975[1]

	Plant Size in Tons Per Day			
Item	500	1,000	1,500	2,000
Sales:				
Oil	$21,504,660	$43,009,310	$64,513,970	$ 86,018,630
High Fiber Meal	5,057,640	10,115,280	15,172,920	20,230,560
Total Annual Sales	26,562,300	53,124,590	79,686,890	106,249,190
Less: Cost of Sunflowers	24,367,500	48,735,000	73,102,500	97,470,000
Gross Operating Margin	2,194,800	4,389,590	6,584,390	8,779,190
Less: Operating Expenses — Plant Costs	2,081,710	3,361,230	4,606,150	5,790,990
Net Operating Margin Before Taxes	113,090	1,028,360	1,978,240	2,988,200
Net Operating Margin Before Taxes $/Ton	1.01	4.57	5.86	6.64
Rate of Return on Investment[2] Before Taxes	2.26%	14.57%	22.56%	28.60%
Less Total Taxes	48,530	487,860	943,810	1,428,590
Net Margin	$ 64,560	$ 540,500	$ 1,034,430	$ 1,559,610
Rate of Return on Investment After Taxes	1.29%	7.65%	11.80%	14.92%

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost.
[2]Refers to total estimated investment, Table 16, p. 22.

TABLE 25. Estimated Revenue and Returns for Model Sunflower Processing Plants, 150-Day Crushing Season, North Dakota, 1975[1]

	Plant Size in Tons Per Day			
Item	500	1,000	1,500	2,000
Sales:				
Oil	$14,336,440	$28,672,880	$43,009,310	$57,345,750
High Fiber Meal	3,371,760	6,743,520	10,115,280	13,487,040
Total Annual Sales	17,708,200	35,416,400	53,124,590	70,832,790
Less: Cost of Sunflowers	16,245,000	32,490,000	48,735,000	64,980,000
Gross Operating Margin	1,463,200	2,926,400	4,389,590	5,852,790
Less: Operating Expenses — Plant Costs	1,583,330	2,518,230	3,427,150	4,286,490
Net Operating Margin Before Taxes	-120,130	408,170	962,440	1,566,300
Net Operating Margin Before Taxes $/Ton		2.72	4.28	5.22
Rate of Return on Investment[2] Before Taxes		5.78%	10.97%	14.99%
Less: Total Taxes		190,170	456,220	746,070
Net Margin		$ 218,000	$ 506,220	$ 820,230
Rate of Return on Investment[2] After Taxes		3.09%	5.77%	7.85%

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost.
[2]Refers to total estimated investment, Table 16, p. 22.

Economic Feasibility

The previous analysis presents the potential returns of a processing plant at a specific time. In order to determine whether an undertaking is economically feasible, the future returns also need to be evaluated.

The present value of the earning stream of the plant during its lifespan can be compared with the initial capital outlay as an estimate of plant feasibility. The following equation was used to estimate the present value of each plant's income stream:

$$Pv = \sum_{i=1}^{n} \frac{R_i}{(1+r)^i}$$

where: Pv = accumulated present value of the income stream,
R_i = expected profit for each respective year,
r = rate of interest — considered at 8.5% per annum for this study,
i = year, and
n = payback period.

The returns for the first year reflected less than full plant utilization (see p.). Full utilization was assumed to prevail after the first year. The price of the raw sunflower seed was assumed to be $216.60/ton with the end products (oil and high-fiber meal) valued at $496.50 and $80.28, respectively. Under these assumptions, $3,102,670 or 43.9% of the initial capital investments would be recovered in the first five years for the 1,000-ton plant (Table 26).

TABLE 26. Expected Profit and Accumulated Annual Discounted Capital Value for the First Five Years of Operation, 1,000-Ton Sunflower Plant, North Dakota[1]

Year	Expected Profit	Present Value of Profit Stream	Accumulated Capital on a Discounted Earnings Basis
1976	$540,500	$498,160	$ 498,160
1977	862,720	732,860	1,231,020
1978	862,720	675,420	1,906,440
1979	862,720	622,500	2,528,940
1980	862,720	573,730	3,102,670

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost.

Payback Period

As an extension of the analysis previously mentioned, the accumulated capital value on a discounted earning basis can be used to derive the payoff period of the plant. The accumulated capital value shown in Table 26 is extended over the estimated payback period of the 1,000-ton plant in Table 27 (the initial investment cost of $7,060,000 in Table 16 is recovered in 16 years with 100% of the expected profits used to recapture the initial plant investment). Since most decision makers would reserve a portion of their profits for future plant investments, replacement of depreciated equipment, and as a cash reserve, a payback period was also estimated when 75% of the expected profits were used to recover the initial plant investment. The payback period increased from 16 to 39 years when only 75% of the expected profits were used to recover the initial capital outlay.

The 500-ton plant did not have a payback period. After 60 years, the plant was still approximately $3,000,000 short of paying back the initial plant investment of $5,010,000 in Table 16. The plant would be completely depreciated and would have to be replaced before the 500-ton plant paid back the initial plant investment.

Effect of Inflation on Payback Period

Inflation has an effect on the cost and revenues for each of the processing plants also influencing the payback period. A ten-year trend line (1964-73) indicated that inflation was increasing at a rate of approximately 4.5% a year. For the purpose of this study, inflation was figured at 5% per year.

All costs were inflated, except depreciation and interest on capital investments. The total cost of operation for the 1,000-ton plant in the fifth year was $69,184,770 when no inflation was included in the analysis (Table 22) to $83,981,460 when inflation was included as given in Table 28. Inflation increased the operating and raw material costs by approximately $36,000,000 by the end of the fifth year of operation.

Expected profits also increased from $862,720 to $1,106,190 in the fifth year of operation. Expected profits for the first five years of operation increased approximately $594,000 due to inflation. The payback of initial plant investment also increased by $429,050 to $3,531,720 as shown in Table 29. This was an increase from 43.9% to 50% of the initial plant investment payback for the 1,000-ton plant by the end of the fifth year of operation due to a 5% inflation rate.

The required payback period for the 1,000-ton plant decreased from 16 to 10.25 years, with an inflation rate of 5% per year when 100% of the expected profits were used to recapture the initial plant investment (Table 30). The payback period decreased from 39 to 15.25 years when only 75% of the expected profits were used to recapture the initial capital outlay of $7,060,000 (Table 30). Similar decreases occurred for each of the four plants when inflation was included in the analysis.

Environmental Impact

The environmental impact associated with a potential sunflower processing plant located in North Dakota is of

TABLE 27. Accumulated Present Value of Income Stream of Model Sunflower Processing Plants, North Dakota, 1975[1]

	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
	Per Cent of Profits Used to Recapture Initial Plant Investment		Per Cent of Profits Used to Recapture Initial Plant Investment		Per Cent of Profits Used to Recapture Initial Plant Investment		Per Cent of Profits Used to Recapture Initial Plant Investment	
Year	100%	75%	100%	75%	100%	75%	100%	75%
1976	$ 59,500	$ 44,630	$ 480,880	$ 373,620	$ 953,390	$ 775,820	$ 1,437,430	$ 1,078,070
1977	219,000	164,250	1,132,020	923,260	2,280,800	1,771,380	3,387,870	2,540,910
1978	366,000	274,500	1,906,440	1,429,830	3,504,190	2,688,920	5,185,460	3,889,110
1979	501,480	376,110	2,528,940	1,896,700	4,631,710	3,534,560	6,842,190	5,131,660
1980	626,350	469,760	3,102,670	2,327,000	5,670,900	4,313,950	8,369,130	6,276,870
1981	741,430	556,070	3,631,460	2,723,590	6,628,690	5,032,290	9,776,460	7,332,370
1982	847,500	635,620	4,118,820	3,089,110	7,511,430	5,694,350	11,073,520	8,305,170
1983	945,260	708,940	4,567,990	3,425,990	8,325,000	6,304,530		9,201,740
1984	1,035,360	776,510	4,984,960	3,736,470	9,074,820	6,866,900		10,028,060
1985	1,118,400	838,790	5,363,510	4,022,630		7,385,220		10,789,660
1986	1,194,930	896,190	5,715,170	4,286,370		7,862,930		
1987	1,265,470	949,090	6,039,280	4,529,450		8,303,220		
1988	1,330,480	997,970	6,338,000	4,775,490		8,709,010		
1989	1,390,400	1,042,910	6,613,310	4,959,970		9,083,010		
1990	1,445,620	1,084,330	6,867,050	5,150,280				
1991	1,496,520	1,122,500	7,100,910	5,325,680				
1992	1,543,430	1,157,680		5,487,330				
1993	1,586,670	1,190,110		5,636,320				
1994	1,626,520	1,220,000		5,773,640				
1995	1,663,250	1,247,550		5,900,200				
1996	1,697,100	1,272,940		6,016,850				
1997	1,728,300	1,296,340		6,124,360				
1998	1,757,050	1,317,910		6,223,450				
1999	1,783,550	1,337,790		6,314,770				
2000	1,807,970	1,356,110		6,398,940				
2001	1,830,480	1,372,990		6,476,520				
2002	1,851,230	1,388,550		6,548,020				
2003	1,870,350	1,402,890		6,613,920				
2004	1,887,970	1,416,110		6,674,640				
2005	1,904,210	1,428,290		6,730,630				
2006	1,919,180	1,439,520		6,782,220				
2007	1,932,980	1,449,870		6,829,770				
2008	1,945,700	1,459,410		6,887,590				
2009	1,957,420	1,468,200		6,913,980				
2010	1,968,220	1,476,300		6,951,210				
2011	1,978,180	1,483,770		6,985,520				
2012	1,987,360	1,490,650		7,017,140				
2013	1,995,820	1,496,990		7,046,290				
2014	2,003,620	1,502,840		7,073,150				
Payback Period			16 Years	39 Years	8.25 Years	13.25 Years	6.5 Years	9.5 Years

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost.

TABLE 28. Total Annual Operating and Raw Material Costs (Direct and Indirect), Reflecting a 5% Annual Inflation Rate of All Costs Except Depreciation and Interest, 1,000-Ton Sunflower Processing Plant, 1976-1980[1]

Cost Items	1976[2]	1977[3]	1978[3]	1979[3]	1980[3]
Depreciation	$ 231,630	$ 231,630	$ 231,630	$ 231,630	$ 231,630
Interest on Capital	293,250	293,250	293,250	293,250	293,250
Salaries	63,000	66,150	69,460	72,930	76,580
Administrative Expenses	117,300	123,170	129,330	135,800	142,590
Insurance (Plant)	24,350	25,570	26,850	28,190	29,600
Property Taxes	82,800	86,940	91,290	95,860	100,650
Building Maintenance	19,900	20,900	21,950	23,050	24,200
Wages	318,000	445,200	467,460	490,830	515,370
Social Insurance Expenses	101,760	142,460	149,580	157,060	164,910
Electricity	487,620	682,670	716,800	752,640	790,270
Water	11,700	16,380	17,200	18,060	18,960
Fuel	362,250	507,150	532,510	559,140	587,100
Solvent	62,370	87,320	91,680	96,260	101,070
Repairs and Maintenance	261,670	366,340	384,660	403,890	424,090
Interest on Seasonal Capital	662,800	927,920	974,320	1,023,040	1,074,190
Insurance (Inventory)	46,780	65,500	68,780	72,220	75,830
Product Selling Expense	58,500	81,900	86,000	90,300	94,820
Inventory Loss	155,950	218,340	229,260	240,720	252,760
Cost of Sunflowers	48,735,000	68,229,000	71,640,450	75,222,470	78,983,590
Total Cost	$52,096,630	$72,617,790	$76,222,460	$80,007,340	$83,981,460

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost. All costs except depreciation and interest on average capital investment were inflated at a rate of 5% per year.
[2]Figures reflect 75% capacity.
[3]Figures reflect 100% capacity.

TABLE 29. Expected Profit and Accumulated Annual Discounted Capital Value for the First Five Years of Operation, Assuming a 5% Annual Inflation Rate on All Costs Except Depreciation and Interest, 1,000-Ton Sunflower Plant[1]

Year	Expected Profit	Present Value of Profit Stream	Accumulated Capital on a Discounted Earnings Basis
1976	$ 540,500	$498,160	$ 498,160
1977	919,200	780,840	1,279,000
1978	978,510	766,080	2,045,080
1979	1,040,790	750,990	2,796,070
1980	1,106,190	735,650	3,531,720

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost. All costs and revenues except depreciation and interest on capital investments were inflated at a rate of 5% per year.

concern to the general public. Air pollution, water pollution, and solid waste disposal are the three main areas of concern for this type of facility. An analysis of North Dakota environmental regulations (as they apply to sunflower processing) and the control of potential environmental pollutants air considered in this section.

Air Pollution

General Provision 1.090 of Regulation 23-25, Air Pollution Control Regulations, states:

> No person shall construct or cause the construction of any new installation of source without first obtaining approval from the Department of the location and design of such new installation of source and the approval to operate the completed new installation or source for the trial operation and compliance testing period (8, p. 6).

Four sources of air pollution that may arise from a vegetable oil extraction processing plant are dust, hexane evaporation, smoke, and odors. Controlling dust and hexane loss are also extremely important in controlling fire and explosion hazards and in minimizing hexane loss (an expensive solvent material). Dust particles origi-

TABLE 30. Accumulated Present Value of Income Stream of Model Sunflower Processing Plants, Assuming Annual Inflation Rate of 5% for All Costs Except Depreciation and Interest, North Dakota, 1975[1]

	Plant Size in Tons Per Day							
	500		1,000		1,500		2,000	
	Expected Profits Used to Recapture Initial Plant Investment		Expected Profits Used to Recapture Initial Plant Investment		Expected Profits Used to Recapture Initial Plant Investment		Expected Profits Used to Recapture Initial Plant Investment	
Year	100%	75%	100%	75%	100%	75%	100%	75%
1976	$ 59,500	$ 44,630	$ 498,160	$ 373,620	$ 953,390	$ 775,820	$ 1,437,430	$ 1,078,070
1977	235,040	176,290	1,279,000	871,100	2,361,980	1,832,260	3,503,260	2,627,450
1978	412,350	309,270	2,045,080	1,320,920	3,738,730	2,864,820	5,518,860	4,139,150
1979	590,790	443,100	2,796,070	1,727,330	5,083,610	3,873,480	7,484,540	5,613,430
1980	769,790	577,350	3,531,720	2,094,250	6,396,700	4,858,300	9,400,830	7,050,640
1981	948,830	711,630	4,251,850	2,634,350	7,678,120	5,819,370	11,268,210	8,451,170
1982	1,127,560	845,680	4,956,280	3,162,670	8,928,040	6,756,810		9,815,420
1983	1,305,380	979,040	5,644,940	3,679,160		7,670,790		11,143,850
1984	1,482,020	1,111,520	6,317,780	4,183,790		8,561,540		
1985	1,657,160	1,242,880	6,974,830	4,676,580		9,429,410		
1986	1,830,520	1,372,900	7,616,130	5,157,560				
1987	2,001,860	1,501,400		5,626,790				
1988	2,170,960	1,628,220		6,084,360				
1989	2,337,630	1,753,230		6,530,330				
1990	2,501,720	1,876,300		6,964,880				
1991	2,663,090	1,997,300		7,388,120				
1992	2,821,620	2,116,230						
1993	2,977,230	2,232,940						
1994	3,129,840	2,347,400						
1995	3,279,380	2,459,560						
1996	3,425,810	2,569,380						
1997	3,569,090	2,676,840						
1998	3,709,200	2,781,930						
1999	3,846,140	2,884,630						
2000	3,979,890	2,984,950						
2001	4,110,470	3,082,880						
2002	4,237,890	3,178,440						
2003	4,362,160	3,271,650						
2004	4,483,320	3,362,520						
2005	4,601,390	3,451,070						
2006	4,716,410	3,537,330						
2007	4,828,420	3,621,340						
2008	4,937,460	3,703,120						
2009	5,043,570	3,782,700						
2010		3,864,410						
2011		3,939,720						
2012		4,013,040						
2013		4,084,210						
2014		4,153,390						
2015		4,220,620						
2016		4,285,980						
2017		4,349,490						
2018		4,409,670						
2019		4,466,480						
2020		4,521,640						
2021		4,575,190						
2022		4,627,160						
2023		4,680,520						
2024		4,729,460						
2025		4,776,940						
2026		4,823,000						
2027		4,867,670						
2028		4,911,000						
2029		4,953,010						
2030		4,993,750						
2031		5,033,250						
Payoff Period	33.75 Years	55.5 Years	10.25 Years	15.25 Years	7 Years	9.25 Years	5.75 Years	7.5 Years

[1]An interest charge of 8.5% on average capital investment was included as a fixed cost. All costs and revenue except depreciation and interest on capital investments were inflated at a rate of 5% per year.

nate from sunflower handling, drying, cleaning, desolventizing, and milling and drying the meal.

Ambient air quality standards for dust particles as measured by settled particulate are not to exceed an average of 15 tons/square mile/month in residential areas with the monthly concentrations computed as the arithmetic mean of any consecutive 3-month period and 30 tons/square mile/month in heavy industrial areas (8, p. 20). The maximum permissible concentration of suspended particulate is 60 micrograms/cubic meter of air with concentrations calculated according to the annual geometric mean, 150 micrograms/cubic meter of air is the maximum permissible 24-hour concentration and is not to be exceeded more than once per year.

Except for desolventizing, it is expected that no greater air pollution would be created from sunflower processing than is associated with other types of grain currently being received, cleaned, milled, and dried in a similar manner in existing facilities located in the state. Plants under consideration are designed and equipped to meet or exceed existing pollution standards. Model plants include pneumatic equipment and modern continuous closed systems for controlling dust particles.

Hexane, which is a highly flammable hydrocarbon, is the most widely used solvent for vegetable oil extraction. Current air quality standards place maximum permissible concentrations of hydrocarbons at 160 micrograms/cubic meter of air calculated according to a three-hour concentration from 6:00 to 9:00 a.m. The maximum is not to be exceeded more than once per year (8, p. 20). Besides the legal requirements, there are other compelling reasons to minimize hexane loss. The explosive nature of hexane requires that stringent standards be adhered to in both construction and operation of the plant to insure human safety. Also, the high cost of hexane provides an economic incentive to ensure all feasible measures are taken to avoid hexane loss.

Equipment proposed in this study maintains the solvent under vacuum or slight underpressure, thereby ensuring increased safety, and avoids any escape of the solvent due to leakage. All shafts are equipped with mechanical seals and the valves are either glandless or of the lubricated plug type. This equipment is very efficient in preventing hexane loss.

If sunflower hulls are used as a fuel source for steam generation in the plant, the problem of smoke from specialized boilers must be considered. Section 5.221 or Regulation 23-25 states:

> No person shall cause or permit the emission of particulate matter, caused by combustion of fuel in any existing fuel burning equipment, from any stack or chimney in excess of 0.80 pounds of particulate per million Btu heat input (8, p. 32).

Since the combustion of sunflower hulls tends to create emissions which approach this figure, it is important to emphasize the necessity of adequate devices for capturing most of the smoke emitted.

Air quality standards regarding odors are designed so that the health of even sensitive or susceptible segments of the population will not be adversely affected and concentration of pollutants will not cause public nuisance or annoyance (8, p. 17). If it can be proven that excessive odors cause such a situation, some restrictive action would be taken. This is unlikely in the sunflower processing industry since the raw material, end, and byproducts are not fermented or in a state that gives off offensive odors. As in any food processing, a problem could arise if spoilage of raw or finished products were not properly controlled.

Water Pollution

North Dakota Regulation 61-28-05.2 (Standards of Surface Water Quality) states that the maximum water temperature for discharge is to be no more than 85° F in any case, and shall not be greater than 5° F above natural background conditions (9, p. 7).

Water pollution is not generally regarded as a problem in processing sunflowers. Large quantities of water are used in the process (about 172,000 gallons/day for the 1,000-ton plant), but it is used almost exclusively for cooling purposes and acquires few contaminants. More than 95% of the water is recirculated after cooling with an adequate cooling tower. As a result, very small amounts of water are discharged as waste into a municipal sewage system or an existing surface watercourse. Water will enter at about 68° F and will exit at about 80.6° F.

Solid Waste

Residues from plant cleanout and cleanup are considered to be one of the biggest pollution problems in a sunflower processing plant. The plants considered in this study are designed for bulk crude production of oil and meal. The potential for solid waste is much less than if there were vegetable oil refining and bagging operations for the meal. It is expected that the actual waste residues of such a plant will be in small enough quantities to be eliminated by disposal in sanitary landfills or in a municipal incinerator.

Chapter 4

MARKET POTENTIAL FOR END PRODUCTS

The economic feasibility of any productive effort depends primarily upon obtaining combinations of prices and quantities in the market to cover costs of production and sufficient profit to attract the necessary risk capital and management. Covering production costs and profit margins is necessary at every stage of the production process from initial farm production to retail. The raw material or farm price is the residual or what the consumer is willing to pay for the final product less the intermediate costs of processing and marketing. For sunflowers, the crop's farm value is derived from the value of joint end products of oil and meal.

Oil contributes more value to all oilseed crops than meal because the price is generally two to three times more than the price of meal. This is especially true of sunflowers because compared to other oilseeds produced in the U.S., they yield more oil and less meal (Table 31).

The objectives of this section are to describe the relative qualitative characteristics of sun oil and sun meal, the conditions giving rise to discounts and premiums compared to competing oils and meals, describe the markets in which they compete, and to compare the output of the processing plant sizes analyzed in Chapter 3 with the size of each market.

Sun Oil

Qualitative Position of Sun Oil

Within limits, vegetable oils and animal fats can be substituted for each other for edible and industrial uses. Each oil or fat has unique characteristics which determine the desirability for specific uses. The availability and specialized uses create price differences between the oils and fats.

Fatty acid composition is an important chemical characteristic that determines oil quality. Fatty acids are classified as saturated, monounsaturated, and polyunsaturated (Table 32). The composition for each vegetable oil varies slightly depending on variety and growing conditions, but the values in Table 32 are typical. For

TABLE 31. Commercial Yields of Oil, Meal, and Other Products in Specified Vegetable Oilseeds

Oilseed	Average Yield: Oil	Oil Meal	Hulls
	(..................%..................)		
Sunflowers	40	40	18
Soybeans	18	80	
Cottonseed	17	46	35
Peanuts	31	42	25
Flax	36	64	
Rapeseed	35	60	
Safflower	36	62	

SOURCE: (10, p. 180).

TABLE 32. Fatty Acid Composition of Selected Fats and Oils

Oil	Major Data Source	Saturated: Palmitic (16:0)[1]	Saturated: Stearic (18:0)[1]	Saturated: Other	Saturated: Total	Unsaturated: Monounsaturated or Oleic (18:1)[1]	Polyunsaturated: Linoleic (18:2)[1]	Polyunsaturated: Linolenic (18:3)[1]	Polyunsaturated: Total	Unsaturated: Other	Unsaturated: Total	Other Fatty Acids
	(....................						%					....................)
Sunflower (N)[2]	1	5	6		11	19	68	[3]	68		87	2.0
Sunflower (S)[4]	1				9	47	44	[3]	44		91	
Safflower	2	7	3		10	13	77		77		90	
Soybean	3	12	4		16	24	51	9	60		84	
Corn	3	13	2		15	31	54		54		85	
Peanut	3	10	4	7	21	61	18		18		79	
Cotton	3	28	3		31	18	51		51		69	
Rapeseed	3,4	4	2		6	25	18	10	28	41	94	
Linseed	3,4	6	3		9	17	14	60	74		91	
Coconut	3,4	9	4	80	93	6	1		1		7	
Palm	3,4	43	5		48	44	8		8		52	
Butter	3,4	33	11	24	68	29	1		1	2	32	

[1]Both the common name and numeric abbreviation are given. The leading numeral of the numeric abbreviation of the fatty acid designates the number of carbon atoms and the second designates the number of unsaturated centers (13, p. 12).
[2]Northern grown sunflowers (Dakotas and Minnesota).
[3]Trace amounts (.1% or less).
[4]Southern grown sunflowers (Texas, Georgia, and California).

SOURCES:
1. (3, p.213).
2. (11, p. 4).
3. (13, p. 156).
4. (14, pp. 167-226).

example, the ratio of oleic to linoleic content in sun oil is partially dependent on the temperature during seed maturation. Sun oil from seed grown in the warmer climates of the southern U.S. has a much higher oleic acid content, while oil from seed grown in cooler northern areas has a higher linoleic acid content. Sun oil from Canada is reported to have 17% oleic and 73% linoleic acid (3, p. 213). No significant difference in the fatty acid composition of oil from the various commercial varieties of sunflowers has been observed. However, researchers feel that breeding for different levels of oleic and linoleic acids is feasible (3, p. 212). For example, a special safflower variety has been developed which has about 77% oleic acids versus 11% for the common variety (11, p. 14).

Stability and the saturated to polyunsaturated fatty acid ratio are two important characteristics of vegetable oils for human consumption. Stability is the capacity of an oil to maintain its flavor (not go rancid) and to resist changes in viscosity (not congeal or leave deposits on cooking vessels) after prolonged periods at high temperatures. This characteristic is particularly important to the rapidly growing fast food and snack industries where deep fat frying is used. Oils which can be reused without flavor reversion and which allow maximum shelf life of products are desired.

The saturated/unsaturated fatty acid ratio refers to the relative amounts of saturated, monounsaturated, and polyunsaturated fatty acids in edible oils. The controversial linkage of dietary saturated fatty acids with cardiovascular diseases frequently makes fatty acid composition an important consideration in the selection of fats and oils for human consumption

In general, the more stable an oil, the lower is its polyunsaturated acid content. Therefore, to achieve maximum quality for one aspect, sacrifices must be made for the other. Linolenic acid oxidizes about two to three times as fast as linoleic and linoleic oxidizes 10 times as fast as oleic. Presence of linolenic acid in a vegetable oil poses serious flavor problems for food use. This is why linseed oil is not used for edible oil in the U.S. It is also the major reason soybean oil is considered a lower quality oil. It has about 9% linolenic acid. The use of dark bottles or cans as containers for edible oil minimizes oxidation prompted by light. Linolenic acid content can be lowered by selective hydrogeneration which reduces the seriousness of the oxidation in soybean oil. The presence of linoleic acid in vegetable oil poses no problems for general home use and as a cooking, salad, and margarine oil. Vegetable oils high in linoleic acid are undesirable for commercial deep fat frying. Vegetable oil high in oleic acid, a monosaturated fatty acid, can be used in significant amounts in commercial deep fat frying.

Of all the oils currently produced in the U.S., sun oil strikes an ideal compromise between the amount of polyunsaturated fatty acids and stability for most edible uses. Its polyunsaturated fatty acid composition is superior to all oils except safflower oil. It contains only trace amounts of linolenic acids, which makes it a fairly stable oil. Oil from sunflowers grown in warmer climates seems to be satisfactory for the deep fat fry industry because of its high oleic acid content. It has been claimed (15, p. 120) that even when sun oil oxidizes, it has a nutty flavor rather than a beany, grassy, or fishy flavor developed by some vegetable oils (especially soybean oil).

It can be seen by inspection of the fatty acid values in Table 32 that sun oil is slightly less stable than either corn or peanut oil and much less stable than cottonseed and coconut oil. On the other hand, sun oil's saturated to polyunsaturated ratio is correspondingly more favorable.

The possible substitution of dietary polyunsaturated for saturated fats as one of several approaches to the prevention and/or cure for cadiovascular diseases is important to the potential demand for sun oil because of its high linoleic acid content. Cardiovascular disease is the leading cause of death and disability in the U.S. (16, p. 393). Early studies and writings implicated the consumption of fat as the main factor in atherosclerotic cardiovascular disease. Several other factors, such as dietary fiber, tobacco consumption, life style, obesity, dietary zinc to copper ratio, and hereditary factors, have also been associated with heart disease (17, p. 2; 16, p. 393). Klevay is still of the opinion that the "quality and quantity of dietary fat probably is accepted most widely" as the major explanation for the high incidence of heart disease (16, p. 393).

The basic idea of the relationship between fat consumption and heart disease is that high levels of dietary saturated fats lead to high levels of cholesterol in the blood, which in turn is related to abnormal thickening and hardening of arterial walls. These developments restrict circulation and increase the load on the heart. Research which has attempted to document these relationships has been reviewed and analyzed by several authors and groups with different conclusions. The lively controversy on this issue is yet to be resolved (12, 18, 19, 20).

Even though the evidence collected thus far is not conclusive, the Netherlands Nutritional Council (an official governmental agency) felt that the signals were sufficiently clear to make official dietary recommendations to all Dutch citizens. The council's recommendations which were intended to reduce the incidence of heart disease in their country were the following:

> Although our current knowledge does not allow to give a quantitative norm for the optimal ratio between the different saturated and mono and polyunsaturated fatty acids in the diet for the whole population, the Council is of the opinion that particularly in cases of an increased or increasing serum cholesterol level, besides a calorie-balanced diet, also a replacement of saturated fatty acids in the diet will contribute to a decrease of the cholesterol and lipid levels in the blood. This means that the diet should contain a higher amount of linoleic acid than the average diet has at present. In this way, one of the risk factors for atherosclerosis and its complications will have decreased.

According to the majority of the members of the

Council it is justified to expect that if high blood lipid levels are induced by high percentage of dietary fat calories and an insufficient physical activity, polyunsaturated fats will only decrease effectively the cholesterol and lipid levels in the blood if about one-third of the total amount of fatty acids is present as linoleic acid.

This means in practice that for these cases roughly a doubling of the present average amount of polyunsaturated fatty acids seems desirable (10-13% of the total caloric intake) (21, p. 4).

The position outlined above was qualified in the following way:

The actual causes of atherosclerosis are only partly known. As a result, its prevention is still connected with many uncertainties and therefore, the quantitative effect of the correction of only one of the causal factors — namely the incorrect eating habits — is difficult to predict. Relevant investigations are still in progress. Although some of the conclusions from the results obtained are not unanimous and sometimes even controversial, there are very strong indications of a useful contribution to the prevention of atherosclerosis by dietary modifications — in addition to the other measures — because a certain number of nutritional factors are known to contibute in a considerable way to an increase in cholesterol and other lipid levels in the blood, the correlation of which with atherosclerosis and in particular with its complications, is generally accepted. By influencing these factors, it is possible to restrict the severity of the disease and its disastrous complications (21, p. 1).

Although the Nutritional Council's advice was only concerned with nutrition, the council was " . . . of the opinion that atherosclerosis and its complications in the Western world can only be greatly decreased if also the other causal factors are fought in an effective way" (21, p. 2).

A similar governmental body in England, after reviewing the evidence, concluded that they could not make official dietary recommendations regarding dietary fat. This illustrates the inconclusiveness of research on this topic to date.

If future research showed conclusively that there was a linkage between dietary fats and heart disease, it would be potentially beneficial to the demand for sun oil. Currently the hypothetical linkage of dietary saturated fats with cardiovascular disease seems to be deeply imbedded in the minds of a large proportion of the medical profession and to segments of the general populace in the U.S. This seems to be the result of press coverage of research on this topic and skillful promotion of proprietary products billed as high in unsaturated fatty acids. Credibilty of these promotional efforts and media reports has no doubt been enhanced by recommendations by the American Heart Association and other members of the medical profession that heart disease prone patients should reduce their consumption of saturated fats (22, p. 16).

The Food and Drug Administration has considered regulations which would require food manufacturers to list the proportion of saturated, unsaturated, and polyunsaturated fatty acids on vegetable oil product labels because of the widespread interest in fatty acid composition of foods. Such a regulation would shift emphasis from the current animal-vegetable awareness to fatty acid content. This change in labeling requirements would be beneficial to sun oil demand because of its high linoleic acid content and because sun oil is relatively unknown to the American consumer. The potential for sun oil to receive a premium price and/or a substantial increase in demand at current relative price levels would be enhanced if these developments were realized. Food processors would be motivated to develop consumer vegetable oil products whose major ingredients are high in polyunsaturated fats. This has occurred in Europe for sun oil. In the U.S. corn oil has been successfully promoted as unsaturated vegetable oil even though it is lower in polyunsaturates than sunflower, safflower, and even soybean oil (Table 32, p. 36).

It may be unrealistic to expect that many consumer products will be tied to sun oil in the near future as they are to corn oil because of some differences in supply. Food manufacturing firms are understandably hesitant to risk an investment of 10 to 20 million dollars to develop and promote a new consumer product based on an ingredient which, to them, has an unestablished or uncertain supply.

Because corn oil is a by-product of wet and dry corn milling (it accounts for 3.5% of product yield), its supply is very inelastic or unresponsive to changes in corn oil price. Corn production is distributed over a wide geographic area, making a total crop failure unlikely. For these reasons, there is a reliable supply of corn for these industries. Wet and dry corn milling utilizes only 7% of all corn produced. Processors could, therefore, bid corn away from animal feeding if total corn supply were greatly reduced.

Sun oil, on the other hand, contributes most of the value to sunflower seeds. Therefore, relatively small changes in the price of sun oil have a substantial impact on the farm value (see p. 55). Also commercial sunflower production in the U.S. is relatively recent (since 1966) and until recently has been concentrated in the Red River Valley of North Dakota and Minnesota. Information on the stability of the crop's yield in comparison to several other domestic crops (in the face of several seasons of adverse weather, diseases, and insects) is limited. Willingness of growers to produce the crop when prices are not favorable is also not well known.

However, objections to the use of sun oil as the major ingredient in consumer products based on uncertain supply are being overcome. Vigorous plant breeding programs by public and private agencies have and are developing important disease and insect resistant genetic stock. These characteristics are finding their way into new American hybrids (see p. 59). Adverse weather (specifically hail, drought, and flooding) in the Dakotas and Texas in 1974 and 1975 showed that sunflowers were generally less susceptible than commonly grown crops to these hazards. Production of sunflowers is spreading westward in North Dakota and south and west in South Dakota. Production in Texas increased dramatically from 1973 to 1974 and from 1974 to 1975. Primarily because of the recent introduction of this crop to Texas, it is not known what direction future sunflower acreage will take. Food manufacturers should be less hesitant to develop new proprietary products based primarily on sun oil because of the substantial genetic stock, breeding programs, apparent willingness of farmers to grow the crop year after year on an expanded basis, and resistance to adverse weather conditions.

A special market for sun oil cannot be expected in the near future, even if events prove favorable to the development of important sun oil consumer products. It takes several years to develop and test consumer products. According to one survey, the success rate of new consumer products introduced into the market is approximately 60% (23, p. 20). In the opinion of senior marketing executives of manufacturing companies in this survey, the preferred competitive feature was product superiority (23, pp. 16-24). Sun oil has several desirable features on which to base consumer products. Its ideal combination of stability and polyunsaturated fat content is probably the most important. The colorful plant would also lend itself to promotional efforts.

International Situation

Vegetable oils (including palms) account for over 60% of the world's total production of fats and oils; animal fats (butter, lard, and tallow) account for 30%; and industrial and marine oils 6% (Figure 12). Sunflowers are second to soybeans as a source of vegetable oil with 15% of the total (Figure 13). World output of vegetable, animal, and marine oils has been increasing about 3% annually for the past 10 years. This increase came primarily from vegetable oils. Production of sun and palm oils nearly doubled, soybean oil more than doubled, and cottonseed oil increased 45% since 1964. Peanut and coconut oil production showed little change.

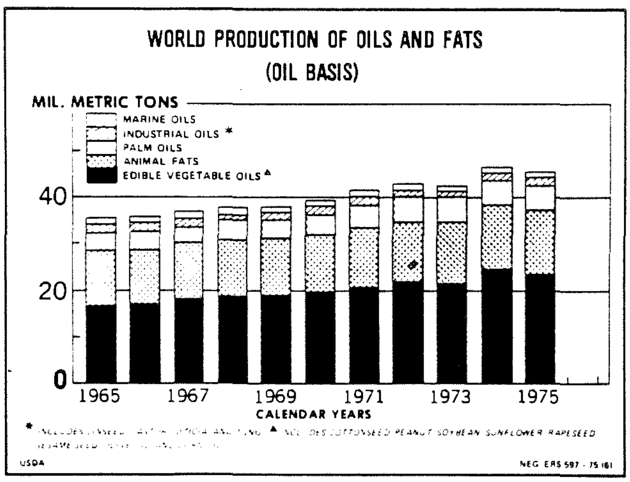


Figure 12

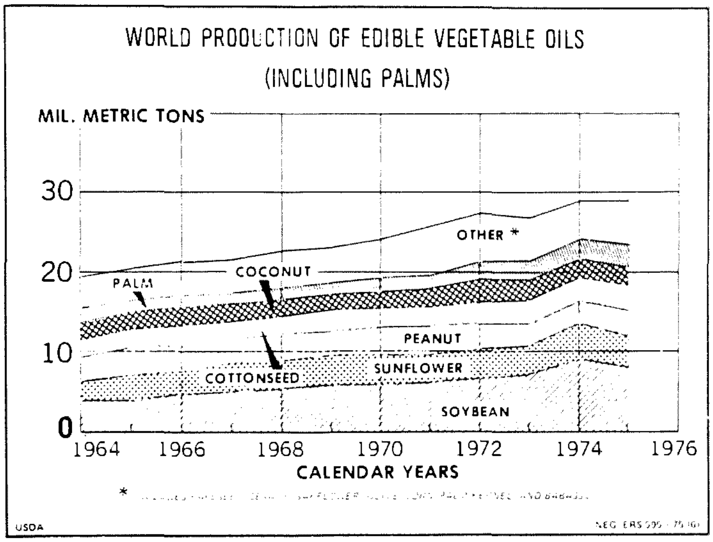


Figure 13

World vegetable oil production in the near future is expected to be ample. Current production levels will be augmented by substantial increases in palm oil. Some estimates indicate that palm oil production could more than double from 2.5 million short tons in 1973 to over 5.6 million tons in 1980 (24, December, 1975, p. 1). Palm oil is produced in West Malaysia, Sabah, Indonesia, and the Ivory Coast where substantial acreage is being shifted from rubber trees to palm trees. About 40% of the area planted has not reached fruit bearing stage. Each acre produces about 1.5 to 2.0 tons of palm oil. Since domestic needs have been met, increases in output are available for export. Brazil has reported substantial increases in soybean production and continued increases are expected. These increases are associated with replacing reduced coffee acreage, increased double cropping with wheat, and relatively better technology compared to corn. Their 1976 crop is expected to be about 13 million short tons. This represents about 35% of the 1975 U.S. soybean crop. The world supply of other major vegetable oils has stabilized except for weather and other exogenous factors.

Sunflower production seems to have stabilized in the Soviet Union, eastern bloc countries, Argentina, and Turkey (Table 33). The U.S., France, Spain, South Africa, and Australia have been increasing production in recent years. Substantial changes in the export market can easily be and have been caused by the USSR's changes in sun oil export policy and/or supplies in excess of domestic needs because of its dominance of world sunflower production. The USSR accounted for nearly 60% of world production during the 1969-1975 period.

Exports of sun oil reached a peak in 1968 because of a large Soviet Union disposal action which depressed the price of all vegetable oil. Sun oil exports in that year amounted to 1.3 million short tons, which was equivalent to 23% of all vegetable oil traded. Sun oil exports were just .86 million tons short of surpassing soybean exports. Even though world production of sunflowers has shown some increase, world trade steadily declined until 1974 (Table 34 and Figure 14) when the USSR

TABLE 33. World Sunflower Production, 1969-1975

Country	1969	1970	1971	1972	1973	1974	1975
	(…1,000 short tons…)						
USSR	7,008	6,772	6,242	5,564	8,140	7,478	5,511
Argentina	1,257	1,010	1,077	1,036	1,069	807	1,047
Romania	825	849	872	937	833	751	772
USA	86	94	216	368	389	304	558
Bulgaria	601	449	509	545	494	406	463
Yugoslavia	430	291	382	305	478	328	419
Turkey	341	413	513	617	617	463	386
Spain	61	176	246	268	324	315	373
South Africa	98	106	144	166	257	279	236
Hungary	119	89	144	133	152	111	143
France	33	54	75	78	93	81	121
Australia	22	65	163	112	94	141	131
Canada	16	28	85	85	45	9	33
Uruguay	72	54	66	78	53	55	88
Others	214	270	288	310	333	366	422
World	11,183	10,720	11,023	10,604	13,371	11,894	10,703

MAJOR SOURCE: (2, February 13, 1976, p. 122).

TABLE 34. Net Exports of Whole Seed Sunflowers and Sun Oil, 1972-1974

Country	Whole Seeds 1972	Whole Seeds 1973	Whole Seeds 1974	Sun Oil 1972	Sun Oil 1973	Sun Oil 1974
	(…1,000 short tons…)					
USSR	82	81	70	435	377	530
Argentina					68	3
Romania	42	4	2	142	156	181
USA	154	187	146[1]			5[1]
Bulgaria	101	36	11	29	20	28
Yugoslavia	3	3	15	4	1	3
Hungary	24	25	26	31	30	32
Australia	84	25	9			
Canada	27	34	23			
Other Countries	16	20	76	[2]	1	3
Total	533	417	378	637	652	785
Oil Equivalent	213	167	151			

[1] 1974-1975 crop.
[2] Less than 500 tons.

SOURCE: (2, December 12, 1975, p. 1,153).

accounted for 68% of the oil and 18% of the whole seed exports. Romania has consistently accounted for more than 20% of total sun oil exports. The U.S. is still a minor exporter of sun oil, but it has become the major exporter of whole seeds (Table 34), accounting for 39% of all whole seeds exported in 1974. However, an estimated 3,000 tons of the U.S. exports were non-oil varieties.

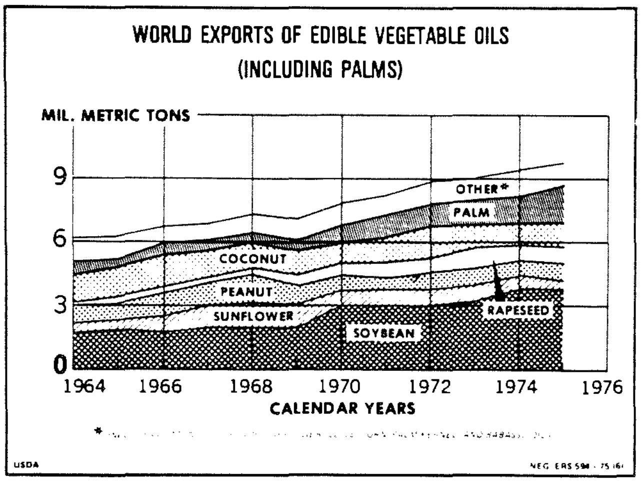


Figure 14.

Prices for vegetable oils generally move together because of their substitutability. Note that sun oil on the export market followed soybean oil very closely until the Soviet disposal action of 1967-1969 (Figure 15). Since that time sun oil has been closer to cottonseed prices (Table 35). The reason for the current favorable market for sunflowers is the situation in the European Economic Community (EEC) countries or the Common Market. These countries have become the prime world market for sunflowers because they have a preference for sun oil, are heavily populated, have relatively high per capita incomes, and have limited domestic supplies of sunflowers. France and Spain have some potential for sunflower production (Table 33). Consumers in most Common Market countries have been willing to pay premiums for sun oil products. In 1975, these premiums amounted to 10 to 13 cents/lb. at the retail level over soybean oil where sun oil products have been effectively promoted (25, February, 1976, p. 28). No such consumer awareness or preference has been developed in the U.S.

Perhaps the single most important factor that influences the whole seed versus oil exports from the U.S. is the ad valorem (based on value) import taxes the EEC has levied on vegetable oil, but not on the seed. A 10% import tax is placed on crude and 15% import tax is placed on refined vegetable oil. Primarily because of this import tax, a higher domestic price for sunflowers can be obtained by selling whole seeds to EEC processors than by processing sunflowers domestically and exporting the oil. At current prices a 10% import tax on sun oil results in a $17 to $24/ton barrier for domestic processors to overcome. Also, many European manufacturers of vegetable oil products are vertically integrated and, therefore, prefer to import whole seeds to keep their processing plants operating.

An adequate crushing margin in the U.S. will be difficult to realize until sun oil obtains a premium as it does in Europe and/or the EEC's import levy is removed. A domestic supply of sunflowers in excess of export demand would also enhance the likelihood of profitable sunflower processing margins in the U.S.

The Domestic Market

Domestic consumption for all fats and oils is 75 lbs./person or 16 billion lbs. (Figure 16). About two-thirds is consumed as food products and one-third for industrial purposes. Until 1974, the edible market was growing 2.8% annually, but since that time per capita consumption has fallen off (Figure 17). Most likely this is a reaction to the high vegetable oil prices in 1974 and 1975. Total domestic supply and use of food fats and oils is depicted in Figures 18 and 19. Total industrial nonfood use has been relatively stable or growing slightly. Increased use as fatty acid in animal feed has about offset the decline in soaps and drying oil (Figure 20).

Total market requirements (domestic and export) are met by several types of oils, with soybean oil the predominant domestic source (Figure 21). Coconut and palm oils are the most important imports (Figure 22). Palm oil imports increased dramatically during the latter part of 1975, primarily because of the substantial price advantage.

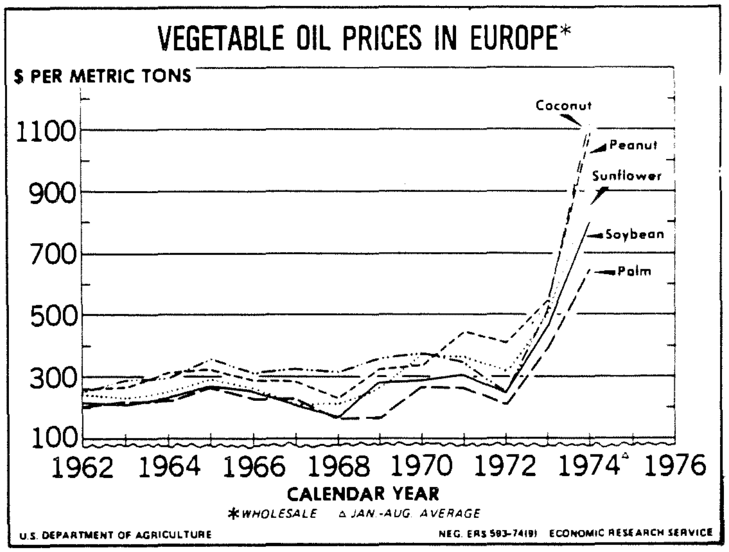


Figure 15.

TABLE 35. Price of Sun Oil at European Ports and Price Premiums (+) of Sun Oil Over or Discounts (−) of Sun Oil Under Selected Oils

Oil	Period Average 1969-72	September/October 1971-72	1972-73	1973-74	1974-75	Oct. 1974	Oct. 1975
	(¢/lb.)						
Sunflower	14.1	15.2	18.2	38.3	39.2	52.6	30.3
Peanut	−2.9	−2.3	−3.8	−4.7	−.7	+2.0	−4.0
Cottonseed	−1.3	−.3	−1.5	+.5	+1.9	−4.1	−3.2
Soybean	+2.5	+3.6	+1.9	+5.4	+7.7	+5.2	+7.8
Palm	+3.7	+5.4	+3.6	+9.8	+16.2	+16.4	+11.7
Coconut	+1.0	+4.9	+1.6	−7.4	+16.6	+12.9	+14.5

SOURCE: (2, November 4, 1975, p. 1,072).

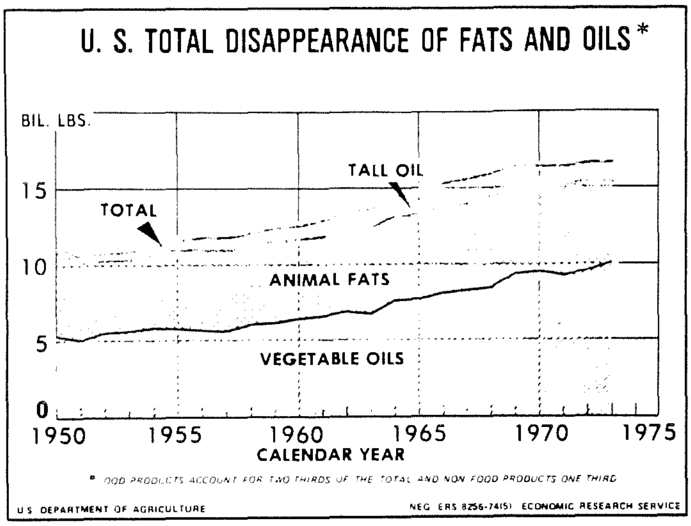


Figure 16

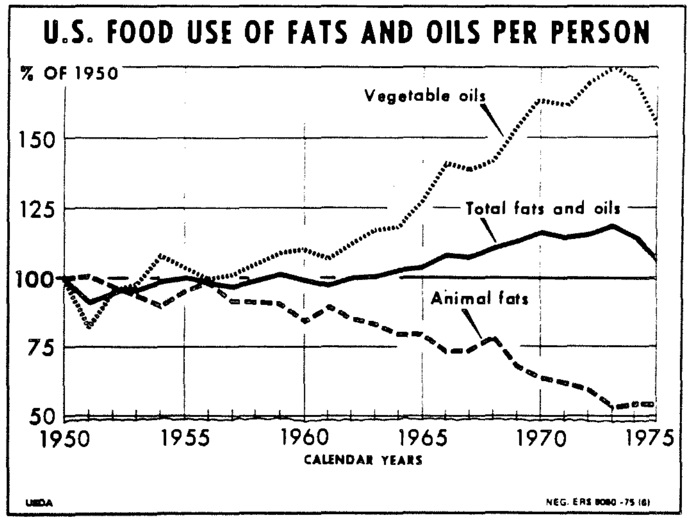


Figure 17

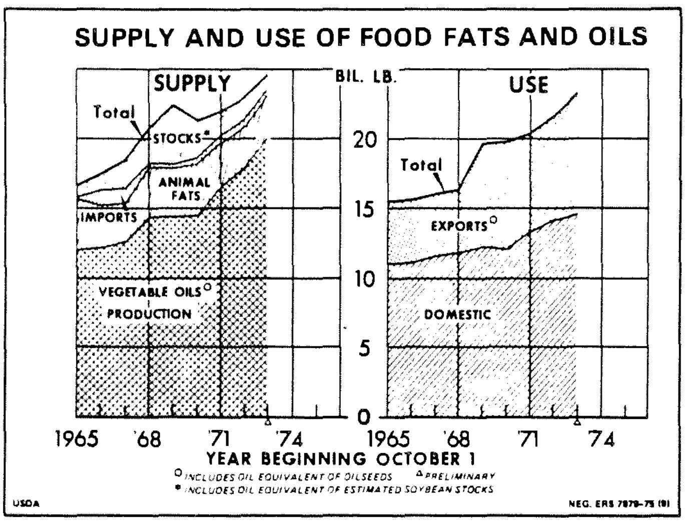


Figure 18

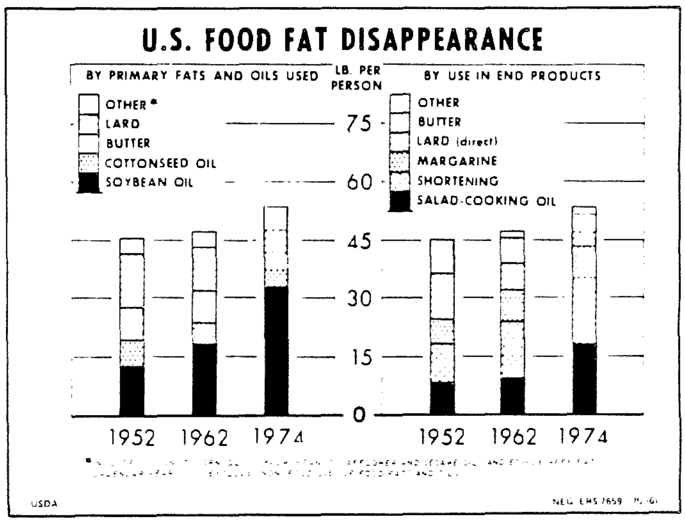


Figure 19

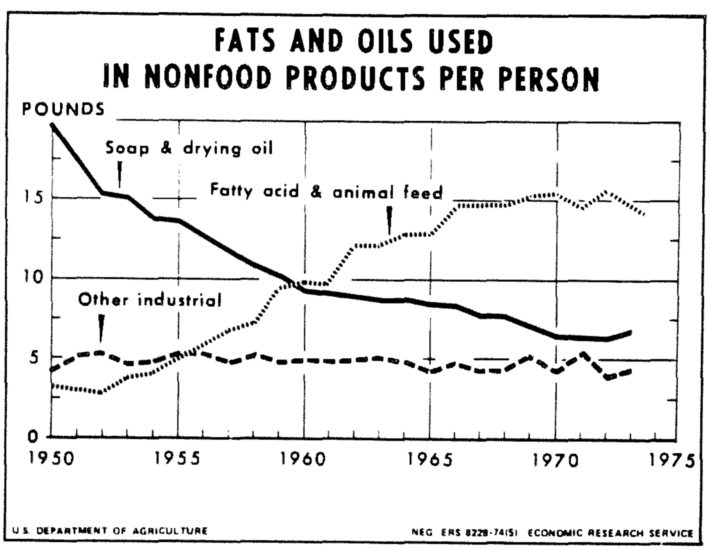


Figure 20

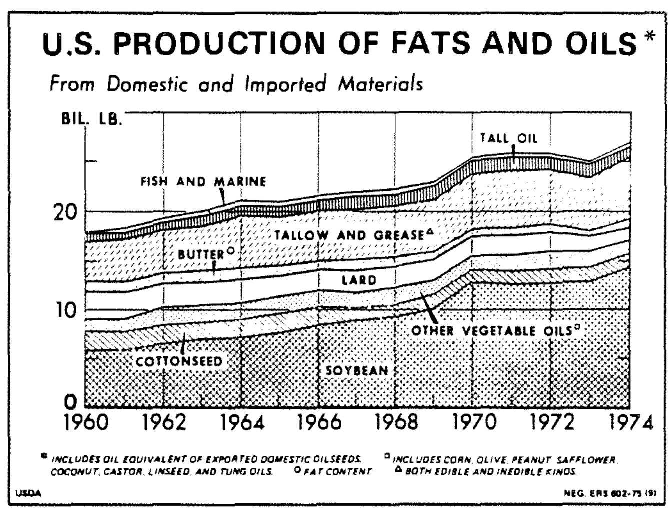


Figure 21

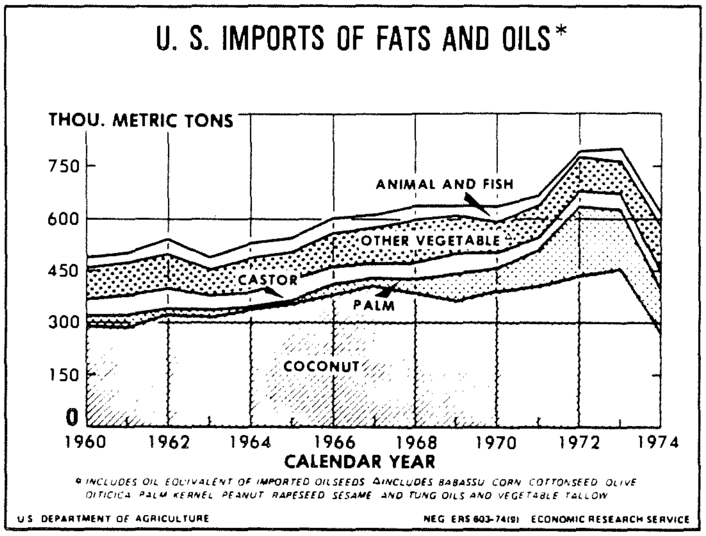


Figure 22

A 1973 USDA report authored by Trotter, Doty, Givan, and Lawler (22) provided a concise discussion of the potential of sun oil in several consumer products. Their conclusions are quoted with minor changes shown in brackets to reflect information that has become available since their report was published.

> Sunflower oil is suitable for use in a wide variety of products. It is highly regarded as a salad oil, gives excellent performance as a cooking oil, and can be used to manufacture premium-grade margarines and shortening. In addition, there is interest in using the more highly unsaturated sunflower oil in drying oil products.
>
> *Salad and Cooking Oils*
>
> The U.S. pattern of oil use in salad and cooking oils during [1958-1972] shows a sharp upward trend for soybean oil (Figure 23). In [1975], soybean oil accounted for three-fourths of the total salad and cooking oils used, compared with 55 percent in 1962. Cottonseed oil is second in importance, but its use has declined in recent years, . . . because of declining cotton production. Use of corn oil, peanut oil, and safflower oil in salad and cooking oils has expanded some in recent years.
>
> Anderson (15) reports that dewaxed, refined sunflower oil results in a salad oil with excellent stability and a high nutritional value. As a salad oil, it has a light yellow color and a delicate flavor. Even when off-flavor develops, sunflower oil has a mild, nut-like but still pleasant flavor. When off-flavor develops in most other domestically produced oils, the average consumer finds them varying in flavor from slightly disagreeable to highly disagreeable.
>
> Hlavacek (26) found that the most highly unsaturated domestic sunflower oil available to date gave excellent performance as a consumer salad and cooking oil. However, he suggested that a narrower range of unsaturation would be highly desirable to simplify plant operations, including raw material monitoring and storage.
>
> . . . cooking oils in recent years have been the fastest growing segment of the U.S. fats and oils market. Much of this growth may be attributed to the rising importance of snack items, such as potato chips, and rapid emergence of fast-food outlets featuring fried chicken, seafood, and other items. In these type operations, the oil is used over several times; therefore, a highly stable oil is required. Without special processing, soybean oil may develop off-flavors after repeated use at elevated temperatures because of its unstable linolenic-acid component.
>
> Suflower oil makes a more desirable frying medium than does soybean oil because of its lack of linolenic acid, which, when heated, results in a catalyzed polymer formation. This creates a thickening and darkening of the oil, which causes a buildup on the frying or deep-fat frying vessel (15).
>
> A standard frying oil used by the potato chip industry is a 70:30 cottonseed-corn oil mixture. In potato chip frying tests comparing this mixture with sunflower oil, Evans and Shaw (27) found that in every evaluation of chips stored at room temperature, the taste panel scored those fried in sunflower oil above those fried in the cottonseed-corn oil mixture. In many comparisons, a statistically significant difference was observed in favor of the sunflower oil. The results indicated that after four weeks of storage at room temperature, all chips were acceptable and had satisfactory flavor.

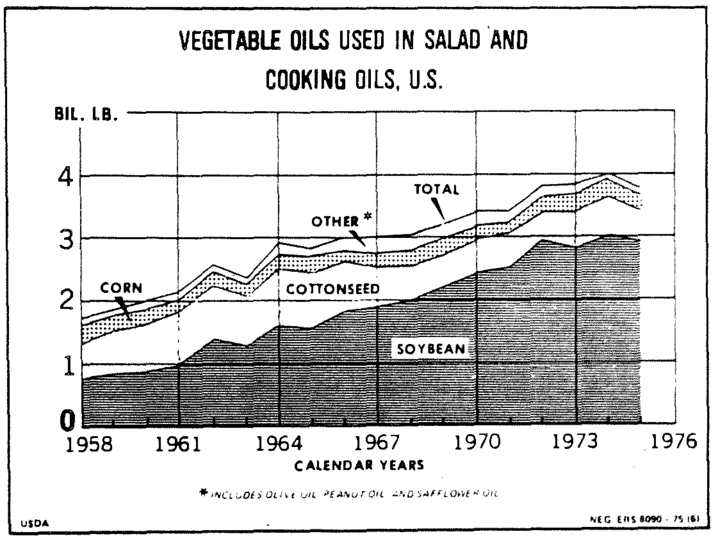


Figure 23

> The above results indicate that sunflower oil should have good market potential in the rapidly expanding salad and cooking oil market. It appears

to be particularly well suited for use in the growing snack food industry. [The bulk of sun oil used in the cooking oil market would likely be restricted to sun oil from sunflowers grown in the southern U.S. because of the higher oleic and corresponding lower linoleic acid content of this oil.]

Margarine

In addition to its potential use in cooking and salad oils, there is considerable interest in expanded use of sunflower oil in margarine. The sunflower's name and attractive flower, the use of the seed as an edible nut-like food, and the relatively high level of polyunsaturated fatty acids in the oil are all factors that would contribute to successful market promotion of a margarine containing sunflower oil.

One company has placed a polyunsaturated margarine on the market with sun oil as the prime ingredient, but the margarine has only recently been promoted as a sun oil product.

Soybean oil is by far the leading oil used by the domestic margarine industry (Figure 24). Soybean oil's share of this market during [1950 to 1975] varied from a low of [41] percent in [1950] to a high of [86] percent in [1959]. Use of corn oil, safflower oil, and animal fats has increased some in recent years, while use of cottonseed oil has declined.

Sunflower oil is used extensively for the manufacture of margarine and shortening in Europe and for margarine in the USSR (15, p. 20). The outlook for future U.S. use of sunflower oil in the manufacture of margarine is good, assuming dependable supplies at competitive prices. The more highly unsaturated oil could be used in margarine designed for consumers concerned with reduced intake of saturated fats and the more saturated sunflower oil could be used in regular margarine.

Shortening

Shortening prepared from sunflower oil has improved flavor stability and performs in baking at least equal to shortening produced from soybean oil (15). For frying shortening, it is superior to soybean oil with respect to polymer buildup and flavor retention. In some instances, it results in lower oil retention in the fried pieces. Thus sunflower oil appears well suited technically for use in baking and frying shortening.

Soybean oil and animal fats accounted for most of the fats and oils used in the manufacture of shortening during [1950-1975] (Figure 25). Soybean oil has accounted for most of the increase in production of shortening since [1950]. Use of cottonseed oil has declined, while use of coconut and palm oil has increased. Use of animal fats in shortening also has shown some increase recently.

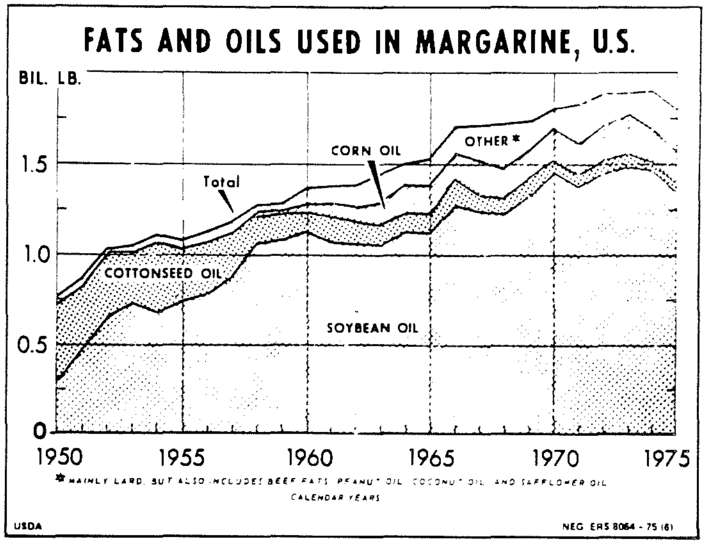


Figure 24

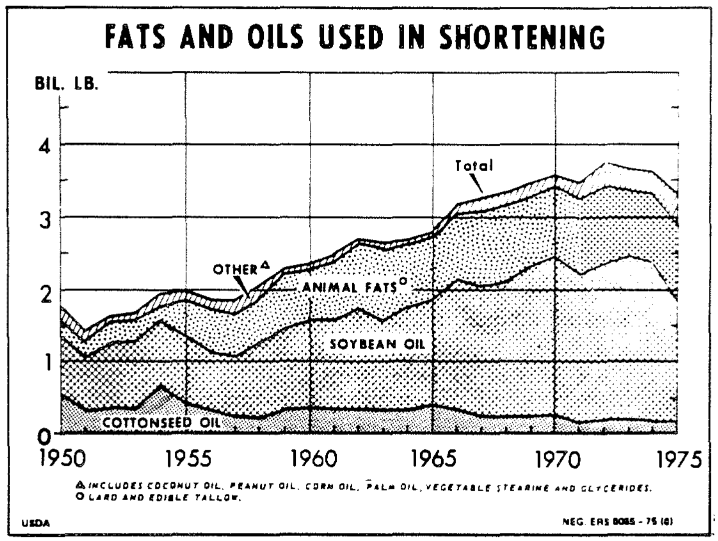


Figure 25

Substantial quantities of sunflower oil could be used domestically in the manufacture of shortening in the future, pending development of dependable supplies at competitive prices. Sunflower oil containing more saturates probably would be preferred over the more highly unsaturated oil in the manufacture of shortening.

Drying Oil Products

Of the various industrial uses for fats and oils, drying oil products appear to offer the most potential for sunflower oil and will be the only nonfood market considered in this report. The more highly unsaturated sunflower oil, which is produced in the northern latitudes . . . [is finding use] in the surface coating market. Because of the low linolenic-acid content and good drying-oil properties of sunflower oils, the American paint industry is interested in using the oil in white and pastel shades of paint. This segment of the paint market . . . [has been] held primarily by safflower oil. Natural oils with a high linolenic-acid content, such as linseed oil, cause yellowing of white and pastel shades of paint upon aging. This has been a major problem with the use of linseed oil, causing some shift away from its use in favor of other natural oils or synthetic materials.

. . . this market is not considered a major potential outlet for sunflower oil. Unless there is substantial economic incentive, it is difficult to introduce a new oil into this market because of the reluctance of manufacturers to change formulations. Also since World War II, the protective coatings industry has been shifting to synthetic chemicals, which has resulted in continuous downward trend in the industry's use of natural fats and oils. . . . (Figure 26).

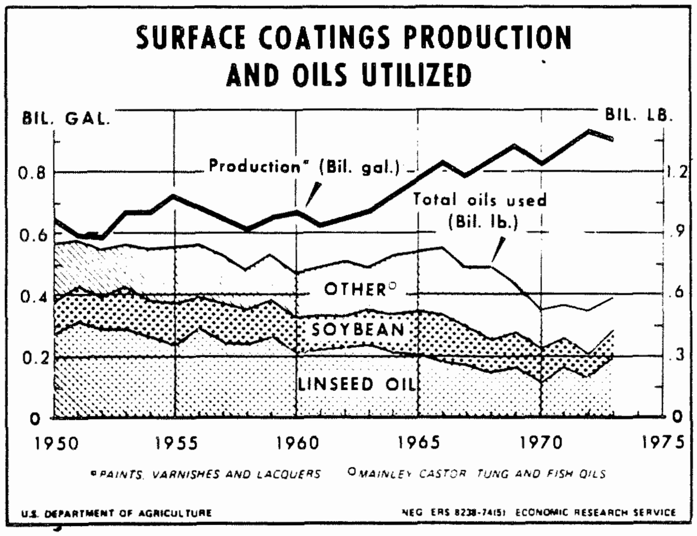


Figure 26

During the past 20 years, there has been a growing demand for paints better suited to the "do-it-yourself" homeowner. Latex emulsion paints, which contain little or no drying oils, have aided the home maintenance trend because of ease of application and cleanup, quick drying, relative lack of odor, and effective industry promotions. Such properties have been incorporated into oil-based emulsion paints, but to date these paints have not enjoyed widespread use.

Vegetable Oil Market and Plant Output

Until 1974 both total and per capita utilization of vegetable oil for food had been increasing at a constant rate (Figure 16, p. 42). Per capita consumption declined in 1974 and 1975 in part as a result of the substantially higher prices in those years (Figure 32, p. 53). The highest monthly average wholesale price for crude vegetable oil at major supply points nearly doubled from 1973 to 1974. Low monthly prices in 1973 for major domestic oils ranged from 10.1 cents/lb. for soybean oil to 18.0 cents/lb. for peanut oil. In 1974, the lowest monthly price for soybean oil was 43.3 cents/lb. in August and 48.3 cents/lb. for peanut oil in October. These increases were reflected in retail prices. Average salad and cooking oil prices for a 24 ounce container increased from $0.71 in 1973 to $1.07 in 1974 to $1.27 in the first quarter of 1975. Wholesale prices for December, 1975, had fallen to 16.8 cents/lb. for soy oil and to 21.9 cents/lb. for cottonseed oil. It is expected that food utilization of vegetable oil will recover its lost market as these lower wholesale prices are reflected at retail.

In contrast to food utilization, linseed and soy oil used in surface coatings (paints and varnishes) declined from over .6 billion pounds in 1950 to a low of a little more than .3 billion pounds in 1972. Since 1970, no clear utilization pattern has emerged.

Total domestic vegetable oil utilization was estimated for 1985 for illustrative purposes in this study. Because of the stable growth since 1950 (Figure 16, p. 42), the trend for this period was used to estimate 1985 utilization. During the 1950-1973 period the average annual increase in vegetable oil utilization was 112,000 tons. On the basis of this trend, domestic oil utilization will be 6.1 million tons by 1985. This rate of growth is slightly less than that projected in the Fats and Oils Situation (4, February, 1976).

The proportion of this total market that sun oil can satisfy will depend, of course, on acceptance by the American consumer and the relative price of sun oil. The share of estimated domestic vegetable oil utilization represented by the output of four plant sizes for 1975 and 1985 are given in Table 36. For example, a 1,000 ton/day plant operating at 100% capacity for 300 days would produce 116,000 tons of oil. This output represents 2.3% of estimated 1975 vegetable oil utilization and 1.9% of projected 1985 vegetable oil utilization.

Sun Meal and Hulls

Commercial use of sun meal and hulls has, thus far, been as animal feed. Other potential markets are as a high-protein human food for meal and as fuel for steam generation for the hulls. Several other uses have and are being investigated.

This section provides the relative merits of sun meal, use of sun meal as human food, hulls as a source of fuel, and briefly describes the market for protein feeds. It also places the demand for protein feeds in perspective with potential supply from the four plant sizes analyzed in Chapter 3.

Qualitative Position of Sun Meal and Hulls

Nutrient Value of Sun Meal in Animal Feed

Several investigations on sun meal as a feed ingredient have been completed.* However, a great deal of

*See (28) for a comprehensive review and evaluation of the literature on sun meal.

research remains to be done before definitive recommendations for use of sun meal in animal rations can be made. Some of the work done to date is contradictory or out-of-date. Earlier investigations used meal from varieties not used for oil or the meal was produced by out-of-date processing methods or problems existed in research design (28). Nevertheless, some generalizations can be made that will place sun meal's competitive potential in perspective.

The composition of sun meal (high- and low-fiber) generally reported in the literature is given in Table 37. Additional meals and other feed-stuffs are included for comparison purposes. The sun meal values given in Table 37 may change as more experience is gained in the laboratory and feeding trials.

As with other oilseed meals, considerable evidence has been accumulated relative to the influence of processing on sun meal quality. Although processing temperatures up to 200° F improve the quality of sun meal, temperatures above 240° F are very detrimental to lysine, arginine, and typtophan.

Amino acid content of sun meal as reported in the literature is fairly consistent. Lysine is the most limiting amino acid. This is a major drawback when fed to non-ruminants. Evidence from feeding trials have led nutritionists to believe that there are other limiting amino acids besides lysine, i.e., as compared to the performance of soybean, meat, or fish meal.

The other major drawback to sun meal is the high fiber content and associated lower energy level. Fiber content is a direct function of the proportion of hulls removed. Meal containing hulls has about 28% protein and 26% fiber. Dehulled meal, depending on the extent of hull removal, may contain up to 44% protein and as low as 14% crude fiber. If sun meal is to make significant penetration of the high-protein market for nonruminants, significant technological progress must be made in hull removal by decorticating or tail-end screening. Though there is no commercial process for completely removing the hulls, potential exists for further reducing fiber content. In one experiment 49% protein meal with 7% hulls was screened to improve protein and fiber content. This meal was screened into three fractions of 53, 48, and 40% protein with 12, 15, and 20% crude fiber, respectively (28). Advances along these lines will make sun meal more competitive for nonruminant feeds.

Sun meal in swine and poultry rations is low in the essential amino acid lysine, low in energy, and high in crude fiber. Because of these factors, the extent that sun meal can be substituted for other protein sources in these rations is limited. Feeding trials to date have not provided consistent results, especially for poultry.

Compared to soybean meal in swine rations, sun meal has been shown to be poor in lysine but good in tryptophan, arginine, glycine, and methionine. It is inferior to soybean meal when used as the only source of supplemental protein. This is especially true for pigs up to 40 pounds. Inferior performance seems to result from lower palatabilty, as well as nutrient content. One test on swine feeding recommended that sun meal could be used as 20-30% of protein supplement of fattening pigs,

TABLE 36. Share of Domestic Disappearance of Vegetable Oil Represented by Potential Output of Sun Oil From Four Sizes of Sunflower Processing Plants

Plant Capacity	Annual Sun Oil Production	Proportion of Disappearance 1975	1985
(tons/day)	(000 tons)	(.........%.........)	
500	57	1.1	.9
1,000	116	2.3	1.9
1,500	173	3.4	2.8
2,000	231	4.5	3.8
Estimated Domestic Disappearance of Vegetable Oil (000 tons)		5,132[1]	6,140[2]

[1]Estimated.
[2]Projected.

preferably those over 75-100 pounds.

Very little feeding trial research of sun meal fed to ruminants has been reported even though most of this meal is fed to ruminants. Evidence collected, thus far, indicates no differences in rate of daily gain for steers compared with cottonseed meal and no adverse effect on milk yield or quality for milk cows. In one case cottonseed was reported as being more palatable.

Sun meal has other limitations for use in feeds. Its color is not particularly attractive. Sun meal is generally a chalky-black rather than the golden rich looking color of soybean meal. Since sun meal is not readily available in the U.S. on a sustained basis, feed processors would understandably hesitate to handle it because of the inconvenience in handling small amounts, adjusting ration formulations and labels, and the separate storage facilities required. Most of these objections would be overcome with a suitable volume on a sustained and dependable basis.

Feed processing and other firms handling sun meal must also become familiar with adjustments in equipment for optimum productivity and ideal moisture levels for storage, handling, and processing. These limitations are associated with most new products and must, at least initially, be overcome by an economic incentive or discount.

Nutrient Value of Sunflower Hulls in Animal Feed

Hulls account for 18 to 20% of the weight of commercially processed oil sunflowers. Dehulling could take place if hulls had a greater value as a separate product rather than as a part of the meal or if increased crushing capacity was desired. Capacity of the screw presses and solvent extraction unit could be increased by up to 19% if the hulls were removed.

Prior to 1972, disposing of sunflower hulls at a profit in the U.S. had at times been a problem. They were sometimes disposed of by burning. This has not been as

TABLE 37. Nutrient Composition of 44 and 28% Protein Sun Meal and Other Selected Oilseed Meals and Feedstuffs (100% Dry Matter)

Ingredient	SFM 44%	SFM 28%	Soybean Meal	Linseed Meal	Cotton-seed Meal	Rapeseed	Alfalfa Dehy 17%	Beet Pulp	Barley	#2 Corn	Feather Meal	Middlings
Crude Protein %	45.2	30.1	49.1	37.4	45.4	44.0	19.1	8.8	12.9	10.1	91.2	20.0
Crude Fat %	2.5	.53	5.6	.57	2.3	1.2	2.81	.55	2.13	3.98	2.68	4.04
Crude Fiber %	3.9	25.6	7.8	10.76	12.5	10.1	39.2	23.1	5.6	3.3	1.61	7.9
Calcium %	.43	.37	.28	.4	.18	.72	1.46	.66	.09	.01	.21	.17
Phosphorous %	1.1	.9	.67	.85	1.1	1.01	.26	.11	.47	.28	.75	1.02
Ash %	8.08	6.4	6.7	6.8	7.1	7.8	10.78	4.2	2.81	1.7	4.18	6.2
Ruminant T.D.N. %	64.5	56.6	87.1	79.3	79.6	70.9	60.7	74.9	83.1	90.9	67.6	91.0
Ruminant Digestible Prot. %	44.2	23.8	41.9	32.5	32.6	NA	13.8	4.74	9.7	6.6	75.2	13.7
Poultry — M.E.[1] Mcal/kg	1.89	1.50	2.50	1.59	1.57	[2]	1.86	.73	2.94	3.82	2.53	2.76.
Swine — M.E.[1] Mcal/kg	2.80	1.80	3.15	2.27	2.36	2.90	1.11	2.58	3.23	3.60	2.44	3.32
Arginine %	3.76	2.46	3.79	3.06	5.16	2.63	.84	.01	.64	.15	4.21	.11
Cystine %	.75	.51	.75	.66	.69	[3]	.19	.33	.19	.59	3.22	.21
Lysine	1.83	1.06	3.23	1.25	.19	2.54	.82	.66	.60	.25	1.13	.67
Methionine	1.61	.56	.73	.51	.56	.91	.31	.01	.20	.19	.59	.14
Choline mg/kg	31.18	1.559	3.061	1.993	2.993	.570	1.702	.681	1.154	.500	.944	1.124

[1]Metabolizable energy.
[2]Estimated 2.255 M.E. by Diamond Shamrock feed chart.
[3]Estimated at 0.52% by Diamond Shamrock feed chart.

SOURCE: (29).

much of a problem since the higher agriculture prices beginning in 1972. They have been sold as poultry litter, binders, packing material, and fireplace logs. The large volume market for hulls has been as a roughage ingredient for ruminant livestock feeds. However, supplies from sunflower processing plants contemplated in this study could easily swamp this market. Their use as a fuel is also explored since sunflower hulls have a relatively high Btu level (see p. 48).

Sunflower hulls are high in fiber and low in protein and energy and, therefore, have a relatively low nutrient value (Table 38). They are used as a carrier or to add bulk to rations for ruminant animals when finely ground. They are normally ground and pelleted at processing points to reduce bulk for shipping and handling.

Studies on the value of sunflower hulls in beef cattle rations found that the acid detergent fiber and lignin (undigestible fiber) were high (Table 38). This suggests a low usable energy content and, therefore, the hulls should be used in limited amounts in cattle rations.

Sunflower hulls have a higher protein content than either flax shives (a flax-straw by-product of the paper manufacturing industry) or wheat straw (5.96% for hulls compared to 4.2% and 3.6% for flax shives and wheat straw).

Satisfactory results were obtained when sunflower

TABLE 38. Ingredient Analysis of Sunflower Hulls and Other Selected High-Fiber Feedstuffs (100% Dry Matter)

	Feedstuff					
Ingredient	Sun Hulls	Wheat Straw	Oat Hulls	Alfalfa Hay	Corn Silage	Prairie Hay
	(%					)
Crude Protein	5.96	3.6	6.0	17.2	8.4	8.1
Crude Fat	.5	1.7	2.2	2.0	2.7	2.8
Crude Fiber[1]	(62.8)	(47.3)	29.0	(46.4)	26.3	32.1
Calcium	.0	.17	.17	1.35	.28	.34
Phosphorous	.11	.08	.2	.22	.21	.21
Ash	3.75	8.1	6.5	8.5	6.2	9.6
Ruminant T.D.N.	36.7	48.0	40.0	58.0	70.0	50.0
Ruminant Protein	2.0	.4	2.2	12.1	4.9	4.1

[1]Acid detergent fiber ratings are given in parentheses.

SOURCES: (30, 31).

hulls were mixed and pelleted in equal parts with alfalfa and fed to finishing steers. Consumption of the ration was over three lbs./hundred lbs. of body weight. Alfalfa pellets (sun-cured), as half of the roughage, made the sunflower hulls more acceptable and improved the overall quality of the roughage. This ration resulted in cattle gains of 6% faster than cattle on the corn-roughage pellets. There was no difference in feed efficiency because they consumed more alfalfa-sunflower pellets than corn-roughage pellets.

*Sun Meal for Human Use**

Preliminary investigations of sun meal as a source of high-protein human food have provided some encouraging results. Even though sun meal is deficient in lysine, it has adequate levels of other essential amino acids. Research has shown that high-quality sun meal "is more digestible than most vegetable proteins and is comparable in biological value" (3, p. 230). Toxic compounds present in several vegetable proteins have not been found in sun meal. A major advantage is that it does not cause flatus (gases) in the digestive tract as do soybean meal products.

Sun meal also has certain disadvantages that have not yet been overcome which would limit its commercial use. Sun meal protein may turn off-color (generally to beige, green, and brown) during processing. These off-colors are caused by the oxidation of chlorgenic acid and high pH values. Several efforts have been made to develop a technique that could remove this acid from sun meal products. Techniques developed to date have not proven commercially feasible. Sun meal proteins also have a relatively high fiber content. This results in what is considered excessive bulk and fiber in finished products. Investigations on several other properties, such as water and oil absorption and whipping properties, indicate that sun meal proteins have unique features which would make it preferred to soybean meal proteins for several uses.

The major deterrents to the use of sun meal as a human protein source seems to be the lack of developmental research and an adequate and stable supply. Overcoming these development problems and achieving consumer acceptance is too uncertain to include edible use as a major market for sun meal at this time.

*A more technical review of sun meal for human food is found in (3, pp. 230-237).

Hulls as a Source of Fuel

Except in the U.S., sunflower hulls are removed from the kernel during processing. Generally, dehulling takes place before the prepress operation, but sometimes is done by a tail-end screening process. Removing the hulls before processing results in an increase of up to 19% in the capacity of the prepress and solvent extraction units. The resultant meal, depending on the proportion of hulls removed, is higher in protein and lower in fiber. This higher quality meal could have wider use than the high-fiber meal in nonruminant rations.

Hulls are typically used as a fuel to generate steam in other countries. In light of the energy crisis, this may be more profitable than leaving the hull in the meal or selling them separately as a roughage feed. According to two private sources, commercially prepared sunflower hulls have about 14 million Btu's/ton. This compares to an average of 13.342 million Btu's/ton for North Dakota lig-

TABLE 39. BTU Content and Relative Value of Sunflower Hulls Compared to Selected Energy Sources, 1976

Fuel Source	Unit	Btu/Unit	Price/Unit	Price/ Million Btu	Equivalent Value of Sunflower Hulls
					($/ton)
#2 Fuel	Gallon	139,966[1]	$0.34[2]	$2.43	34.00
Residual Fuel (#5)	Gallon	146,964[3]	0.284[4]	1.93	27.00
Lignite	Ton	13,342,000[5]	8.81[6]	0.66	9.24
Sunflower Hulls	Ton	14,000,000[7]	14.00[8]	1.00	14.00

[1]Average Btu/gallon of #2 fuel for North Dakota (32).
[2]Price of #2 fuel delivered to Fargo-Moorhead area as of February 2, 1976.
Source: (refining and pipeline company).
[3]Btu content/gallon of residual fuel for North Dakota is assumed to be 5% above #2 fuel which was 139,966/gallon (32 and private company).
[4] Residual fuel cost at source of supply plus transportation to a processing location. Source: (private refining and transportation companies).
[5]Based on average Btu content/ton of North Dakota lignite coal (32).
[6]Price includes cost of lignite coal plus transportation to Fargo, North Dakota. Source: (North Dakota State University Purchasing Agent, Physical Plant Records, January 31, 1976).
[7]Midpoint estimate from two private sources.
[8]Average price received by non-oil processors for unground sunflower hulls, December, 1975.

nite coal. The February 2, 1976, prices and costs/ million Btu of Number 2 and Number 5 fuel oil, lignite, and sunflower hulls are given in Table 39. Assuming that adequate pollution control and efficient burning technology are available, it would be more profitable to use lignite coal as a fuel until sunflower hull prices would fall below $9.24/ton. For the past four years, sunflower hulls have been priced from $4 to $20/ton depending on the supply of high-fiber feedstuffs, particularly hay. The demand for sunflower hulls has been very seasonal. It is strongest during the winter months and almost nonexistent during the warmer part of the year when adequate pasture is available.

Hulls have also been pressed in cylinders and sold as fire logs in Canada and Turkey. They burn best when intermingled with natural wood logs. To date, this use has not been tried on a commercial scale in the U.S. Other nonanimal feed uses have been as a litter for poultry, packing for fragile items, and as a carrier. Developmental research has been conducted at the University of Minnesota on its use as a building board.

International Situation

Sun meal accounts for only 6% of the total world production of oilseed meal and only 2% of oilseed meal exports (Figures 27 and 28). Soybean meal has become increasingly important in international trade, especially since 1968 (Figure 29).

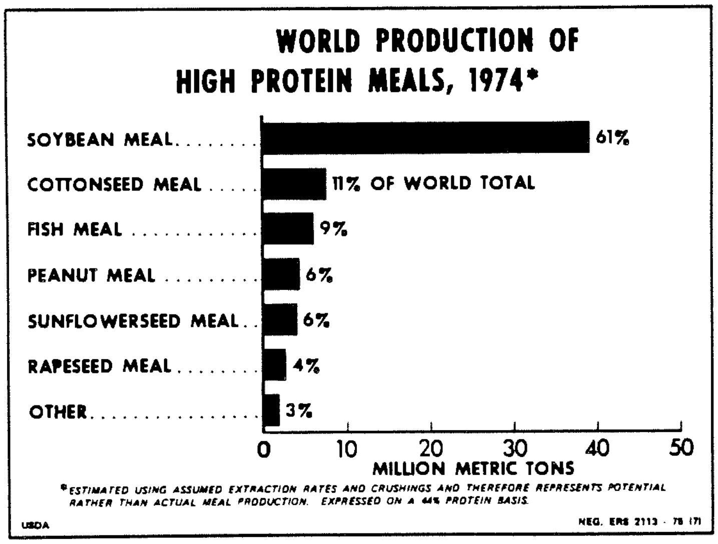


Figure 27

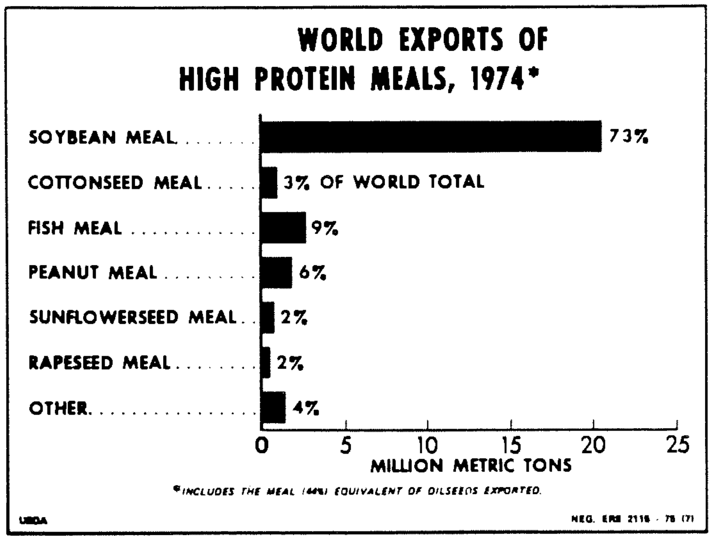


Figure 28

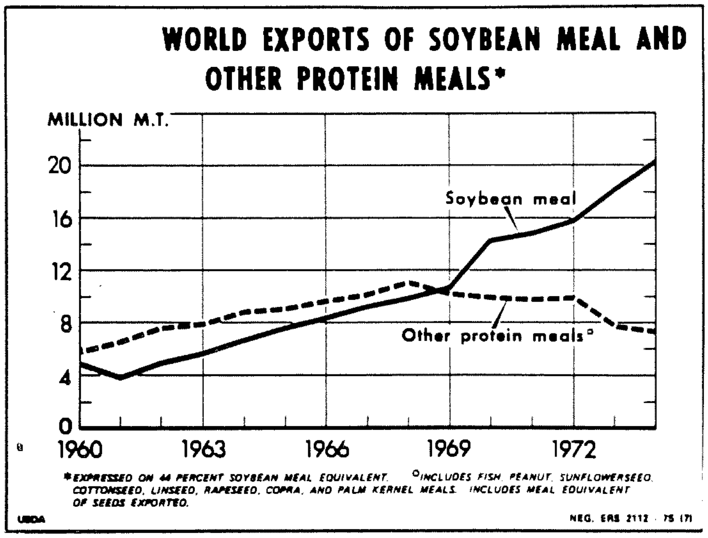


Figure 29

The European price of sun meal and those of competing meals are given in Table 40. Sun meal in Europe is traded at discounts from all meals except rape meal. Cottonseed meal price was the next closest. The price of sun meal as a percent of cottonseed meal ranged from 83% in October, 1975, to a high of 100% in 1972-1973.

Domestic Situation

Commercially prepared feeds are composed of high-protein feeds and feed grains fortified with vitamins, minerals, and disease preventatives. High-protein feeds are generally by-products from other industries. Sun meal currently available in the U.S. includes the hulls. This results in a meal with 28% protein and 24% fiber. In processing plants outside the U.S., the hulls are removed resulting in protein levels up to 44% and fiber levels down to 14%. Sun meal is listed at 38% protein in Europe (2).

Utilization of the major protein ingredients in the U.S. for 1974 is given in Table 41. Soybean meal is by far the most important high-protein feed accounting for 62% of all such feeds. Some by-products not listed in Table 41, such as sun meal and copra meal, may be important in isolated instances, but are not very important overall.

The proportion of all oilseed meal consumed domestically by each animal class has changed little over time. However, in recent years dairy has been consuming about 10%, beef 20%, hogs 15%, other livestock 15%, broilers 20%, and other poultry 20%. Soybean meal has a larger share of the nonruminant market. Consumption

TABLE 40. Average European Prices of Selected Protein Meals

Protein Meals[1]	Sept.-Oct. 1969-72	Sept.-Oct. 1971-72	Sept.-Oct. 1972-73	Sept.-Oct. 1973-74	Sept.-Oct. 1974-75	Oct. 1974	Oct. 1975
	($ per short ton)						
Sun Meal Pellets (38%)	96	100	220	178	154	183	151
Soybean (44%)	118	126	312	212	180	231	180
Linseed (38%)	118	136	237	216	207	241	201
Cottonseed	108	105	220	208	177	215	183
Rape (34%)	86	84	184	162	146	159	141
Fish (64%)	214	207	535	488	274	349	287

[1]Reported protein levels are given in parentheses. No protein level was given for cottonseed.

SOURCE: Computed from data in (2, November 14, 1975, p. 1,052).

TABLE 41. Protein Feeds Used in Animal Feed, 1974

Feed Ingredient	Utilization (1,000 tons)
Oilseed Meals	
Soybean	12,200
Cottonseed	2,030
Linseed	90
Peanut	95
Total	14,415
Animal Proteins	
Tankage and Meat Meal	1,950
Fish Meal	425
Dried Milk Solids	740
Total	3,115
Grain Proteins (gluten feed and dried brewers and distilled grains)	2,190
Grand Total	19,720

SOURCE: (29, p.26).

of soybean meal by animal classes is depicted in Figure 30.

Oilseed Meal Market and Plant Output

The transportation cost per dollar value of sun meal is higher than for sun oil. Sun meal is, therefore, less likely to compete in as wide a geographic market as sun oil. This is also true to a more limited extent of sun meal compared to soybean meal. Therefore, location of the sunflower processing plant will impose more geographic constraints and greater limitation on market penetration on meal than on oil. Major supply points of oilseed meal are currently in the Midwest for soybean meal and in the South for cottonseed meal. In a general way, the price surface for these meals raises in expanding concentric circles from major supply points to compensate for transportation (see p. 73). Protein meal from these supply points is shipped to geographic extremities of the U.S. For example, feed processors in the western states acquire their meal from distances that converge on the major supply points (Figure 31). Sun meal produced in North Dakota would, therefore, likely move to the western states. To do otherwise would be moving the meal against the traditional price pattern. No doubt considerable meal could, however, move into Minnesota and Wisconsin for dairy formulations for which sun meal is particularly well suited.

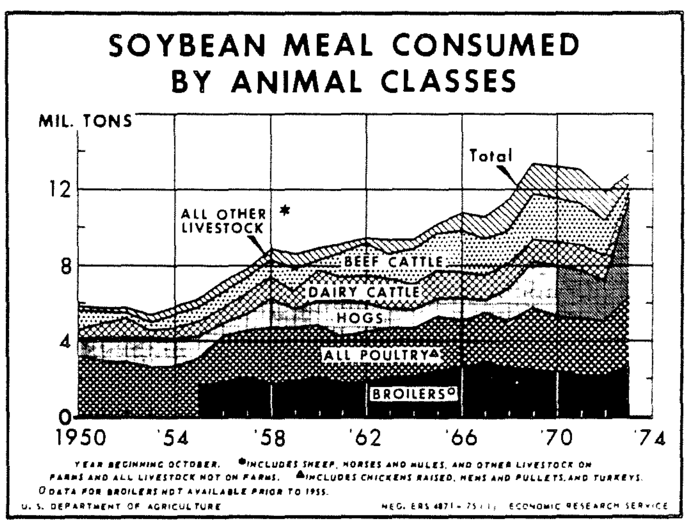


Figure 30

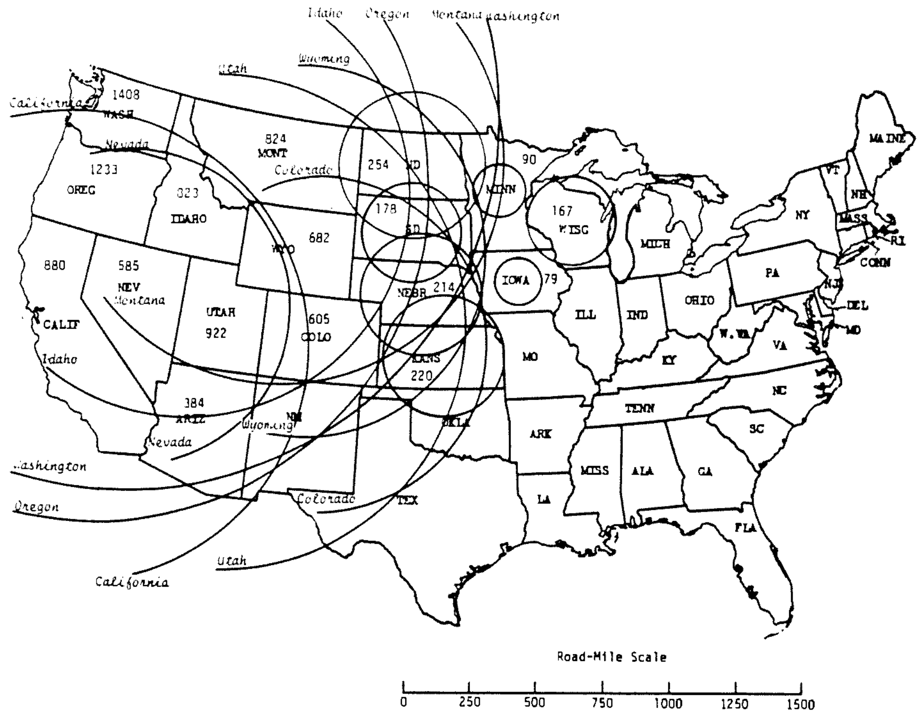


Figure 31. Average Distance of Feed Manufacturing Establishments From Principal Suppliers of Oilseed Meals

SOURCE: (33, p. 21).

The crude protein utilization from selected feedstuffs and states is given in Table 42 to place the meal production potential of sunflowers in perspective. The discussion comparing sun meal output with utilization in this section uses only crude protein from oilseed meals, even though sun meal could compete with other feedstuffs. Production of sun meal from four sizes of plants is compared with total 1969 crude oilseed meal utilization in selected states in Table 43. Meal from even the 500-ton/day plant would completely overwhelm North Dakota requirements. No doubt some feeding enterprises would develop near processing plants to take advantage of the new source of crude protein. It is very unlikely that such a development would compete for a significant proportion of even the 500-ton/day plant's output. The data in Table 43 suggest that a large proportion of the meal output of these plants would have to be shipped to distant points. No doubt some would also move into Minnesota and Wisconsin for dairy feed formulations for which sun meal seems particularly well suited. Because of the limited nearby markets for sun meal and the transportation advantage of soybean meal to states with the highest utilization (such as Iowa and Illinois), it may be necessary to dehull at least some sunflowers in processing to obtain a higher protein and energy and, hence, higher value so that sun meal could penetrate some of the meal markets for nonruminants and for export. Most of the sun meal currently being exported is being traded as 38% protein.

Prices

No public price and production statistics on sun oil and meal are available in the U.S. Prices and quantities of these products reported by processors to the U.S. Department of Commerce are withheld to avoid disclosure. This is the common practice when data reflect the operation of only one or two firms. Therefore, the prices of closely related products are presented.

Prices of Vegetable Oils

Like several other agricultural commodities, vegetable oil prices have been erratic since 1973 (Table 44). The average year-to-year per cent change in price was 14% for soybean, cottonseed, and corn oil and 11% for peanut oil from 1950 through 1972. From 1972 to 1974, the average price nearly tripled for all of these oils (295%). Prices have since declined because of more adequate vegetable oil supplies worldwide (Table 44 and Figure 32).

TABLE 42. Crude Protein Sold by Feed Manufacturers in Selected States by Protein Source, 1969

State	Oilseed Meal: Soybeans	Oilseed Meal: Other	Oilseed Meal: Total	Other Major Protein Sources: Animal	Other Major Protein Sources: Grain[1]	Other Major Protein Sources: Total	Alfalfa Meal: Dehy. Alfalfa	Alfalfa Meal: Sun-Cured Alfalfa	Alfalfa Meal: Total	Grand Total
	(tons									)
Colorado	23,625	28,844	52,469	17,158	13,821	83,448	8,568	12,776	21,344	104,792
Idaho	7,952	7,168	15,120	9,173	4,258	28,551	3,520	15,625	19,145	47,696
Iowa	521,572	19,890	541,462	144,865	73,629	759,956	28,750	1,739	30,489	790,445
Kansas	110,025	28,162	138,187	28,703	36,031	202,921	18,491	9,388	27,879	230,800
Minnesota	179,057	3,824	182,881	73,985	33,924	290,790	6,586	3,026	9,612	300,402
Montana	7,816	4,821	12,637	4,782	4,969	22,388	1,657	4,067	5,724	28,112
Nebraska	169,119	16,390	185,509	37,171	35,796	258,476	20,192	9,757	29,949	288,425
North Dakota	12,038	1,225	13,263	4,737	2,202	20,202	1,308	1,014	2,322	22,524
Oregon	17,095	9,139	26,234	17,006	10,639	53,879	1,457	4,342	5,799	59,678
South Dakota	49,828	4,113	53,941	15,609	12,513	82,063	5,888	3,007	8,895	90,958
Utah	8,073	13,577	21,650	11,121	4,863	37,634	1,804	1,959	3,763	41,397
Washington	23,205	12,839	36,044	17,883	25,253	79,180	2,062	3,876	5,938	85,118
Wisconsin	160,356	9,979	170,335	52,661	37,257	260,008	5,573	1,487	7,060	267,068
Wyoming	682	691	1,373	542	383	2,280	307	646	953	3,233
Total for Selected States	1,290,443	160,662	1,450,860	435,378	295,538	2,181,776	106,163	72,709	178,872	2,360,648

[1]Brewers and distillers dried grains and corn gluten feed and meal.

SOURCE: Computed from data in (33) by multiplying feed sold by crude protein content.

TABLE 43. Share of Oilseed Meal[1] Protein Utilization in Selected Regions Represented by the Potential Output of Sun Meal From Four Sizes of Sunflower Processing Plants

Plant Capacity tons/day	Annual Production of Crude Protein (1,000 tons)	States in Regions: ND	ND,SD	ND,SD,WY, OR,ID,WA	ND,SD,WY,OR, ID,WA,MN,WI
		(%			)
500	24	181	30	15	5
1,000	47	354	59	30	9
1,500	71	535	89	45	14
2,000	94	709	118	59	18
		Crude Protein Utilization 1969			
		(1,000 tons			)
		13.26	79.8	159	512

[1]Soybean, cottonseed, linseed, and other oilseed protein meals.

TABLE 44. Average Annual Crude Vegetable Oil Prices at Major Supply Points, 1950-1975

Year	Vegetable Oil Corn (Decatur)	Cottonseed (Valley)	Peanut Oil (S.E. Mills)	Soybean (Decatur)
	(cents/lb.)			
1950	16.0	15.8	17.3	14.0
1951	19.0	18.4	20.2	16.8
1952	13.3	12.8	17.0	11.0
1953	14.1	14.1	21.1	12.4
1954	14.0	13.5	18.2	13.3
1955	13.0	12.7	17.6	11.6
1956	14.1	13.7	15.9	13.2
1957	13.8	13.5	15.1	12.2
1958	13.4	12.7	16.3	10.5
1959	11.8	11.2	12.6	9.0
1960	13.1	9.9	15.1	8.9
1961	18.3	13.0	16.1	11.5
1962	14.6	11.5	16.4	9.0
1963	12.1	10.4	11.7	8.9
1964	11.1	10.3	12.9	9.2
1965	14.0	11.7	13.5	11.2
1966	16.1	14.3	13.7	11.6
1967	12.4	11.8	11.9	9.6
1968	15.2	13.1	13.2	8.2
1969	14.0	11.0	13.7	9.1
1970	16.5	13.5	15.9	12.0
1971	19.8	15.2	17.3	12.6
1972	16.4	11.5	17.0	10.6
1973	22.6	19.5	23.0	19.8
1974	40.7	38.1	46.4	35.8
1975	32.4	27.2	38.9	25.4

SOURCE: (10, 34).

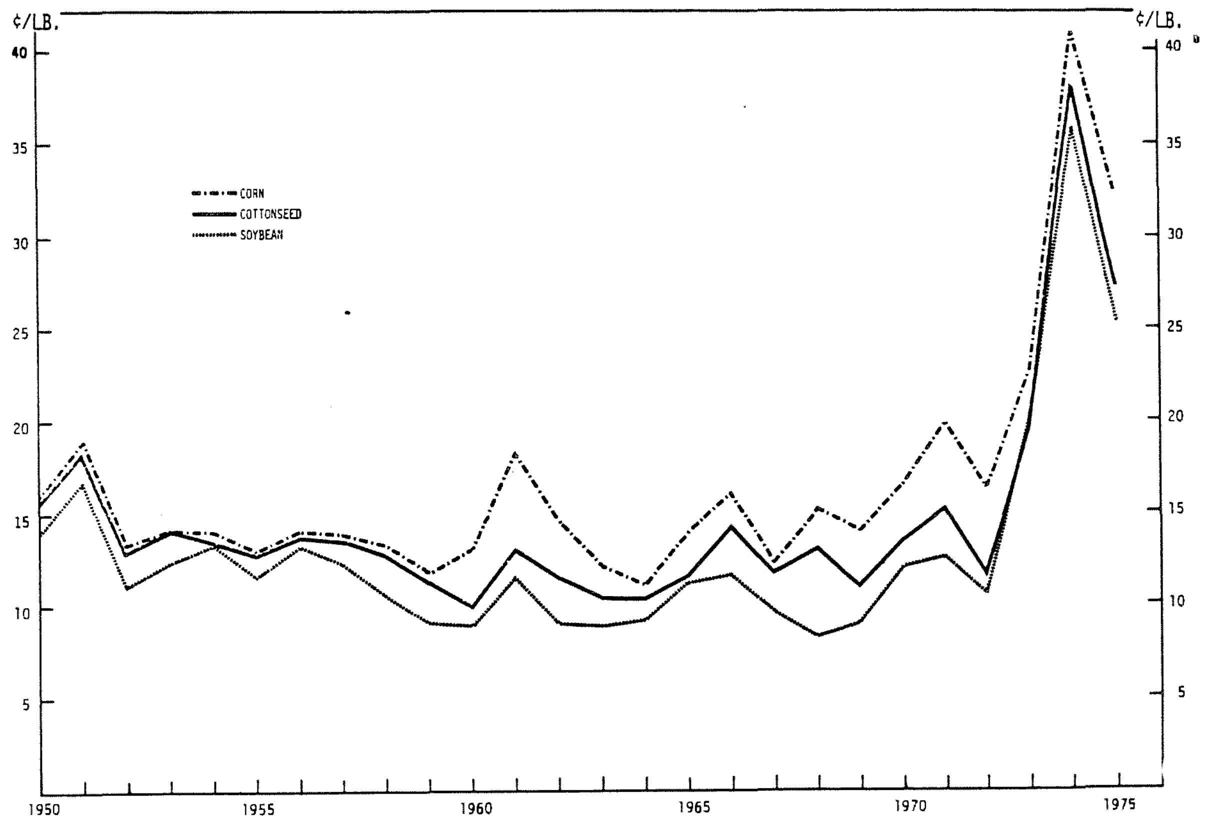


Figure 32. Vegetable Oil Prices at Major Supply Points, 1960-1975

The prices of these oils are closely related because of their substitutability. The correlation coefficient for the 1950-1975 period ranges from 0.948 between peanut and corn oil to 0.986 between soybean and cottonseed oil prices.

Prices of Oilseed Meals

Prices of major oilseed meals produced in the U.S. (soybean, cottonseed, and linseed) are given in Table 45 and illustrated in Figure 33. These prices also exhibit a high degree of correlation. The correlation coefficient ranges from .960 between soybean and linseed meal to .981 between linseed and cottonseed meals. The high oilseed meal price in 1973 was due in part to the suspension of anchovy fishing in Peru where most of the world's supply of fish meal originated.

Derivation of Processing Margin

The processing margin used to illustrate returns from processing plants discussed in Chapter 3 was derived by using proxy prices from sun oil and meal for the last four months of 1975 and average prices received by farmers for sunflowers in 1975. Proxy prices were required because no published price series is available in the U.S. for sun oil and meal. As discussed elsewhere, domestic processors generally cannot obtain profitable margins because of the import levies on oil in the Common Market. However, a recent period was found during which prices provided a processing margin to illustrate profitable returns from processing. Although September-December, 1975, is a relatively short period, it does represent the period when most of the sunflower crop

TABLE 45. Annual Average Wholesale Prices of Selected Bulk Oilseed Meals at Major Supply Points, 1950-1975

Year	Cottonseed (41% Memphis)	Linseed (34% Minneapolis)	Soybean (44% Decatur)
	(..........	$/ton	..........)
1950	68.25	67.50	64.20
1951	78.80	66.50	67.90
1952	89.00	79.15	83.80
1953	65.30	68.55	64.30
1954	69.70	70.95	79.70
1955	60.40	63.90	56.85
1956	51.80	52.50	51.30
1957	50.85	49.80	47.05
1958	58.55	53.80	55.95
1959	60.10	69.30	56.45
1960	54.25	55.30	53.10
1961	57.75	55.80	63.15
1962	61.10	69.40	66.50
1963	67.70	65.80	72.50
1964	60.25	56.50	69.15
1965	60.10	64.10	71.45
1966	76.70	77.10	83.80
1967	76.85	72.75	76.45
1968	74.95	75.90	77.45
1969	66.00	67.70	74.50
1970	73.80	67.15	79.20
1971	72.05	62.40	77.85
1972	89.69	84.45	104.95
1973	170.47	166.92	238.36
1974	124.44	125.33	140.85
1975	120.75	124.33	124.05

SOURCE: (10).

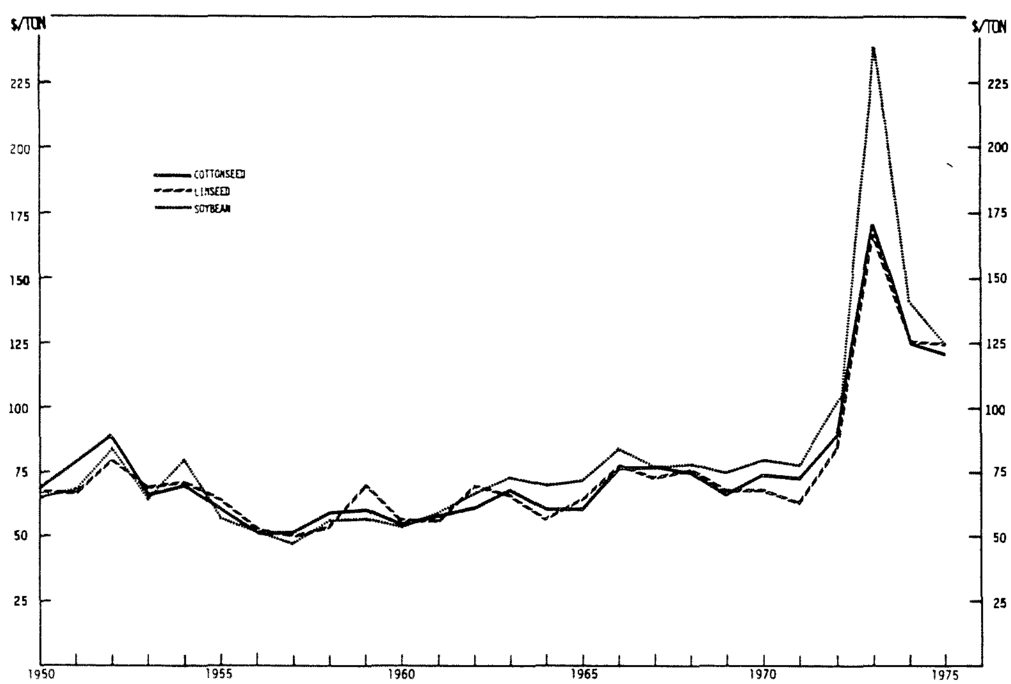


Figure 33. Wholesale Prices of Selected Oilseed Meals at Major Supply Points, 1950-1975

SOURCE: (10).

was sold off farms.

Crude cottonseed oil prices at a major supply point were used as a proxy for sun oil prices. Industry sources indicated that in 1975 sun oil generally sold at the same or slightly better than cottonseed oil in the U.S. The prices of sun and cottonseed oil are also closely associated in the European market (Table 34, p. 40). The September-December, 1975, cottonseed oil price was 24.8 cents/lb. or $496.50/ton (Table 46).

The proxy used for 28% protein sun meal was 44% protein soybean meal at Decatur discounted for protein. This would make sun meal worth 28/44 or 63.6% as much as soybean meal. Soybean meal (44%) averaged $126.15/ton for the September-December period. This amounts to $80.28/ton for sun meal (Table 47).

Assuming the above end product prices and processing yields of 38.5% oil, 56% high-fiber meal, and 5.5% shrink, the end product value of 10.5% moisture sunflowers would be $236/ton.

Subtracting $216.60/ton for sunflower seeds, the processing margin amounts to $19.51/ton (Table 46).

TABLE 46. Product Yields, Prices, and Computation of a Sunflower Processing Margin

Item	Processing Yield	Price	Revenue
	(%)	(····$ per ton····)	
Oil	38.5	496.50	191.15
Meal	56.0	80.28	44.96
Shrink	5.5		
Subtotal			236.11
Less Sunflower Seeds		216.60	216.60
Processing Margin			19.51

TABLE 47. Price Series Used for Sun Oil and Meal for Processing Margin, 1975

Month	Cottonseed[1] Oil (Proxy for Sun Oil)	Soybean[2] Meal	Proxy for[3] Sun Meal
	(············$ per ton ···········)		
September	582	134	85
October	516	126	80
November	450	120	76
December	438	125	80
September-December Average	496.5	126	80
Average for Year	544	124	79

[1]Crude cottonseed oil at major processing locations or "Valley."

[2]Decatur 44% protein.

[3]Proxy for 28% protein sun meal = 28/44 of soybean meal price.

Farmers in North and South Dakota and Minnesota received $10.43/cwt. or $208.60/ton. An additional $8.00/ton was included to compensate for transportation to a nearby processing plant and a minor handling charge. This cost may vary depending on the proportion of sunflowers shipped directly to the processor from the farm.

Processing margins are very sensitive to product and raw material prices as in most food processing industries. For every $.01/pound ($20.00/ton) change in sun oil prices, the processing margin would change $7.70/ton. Such a change is only 4% of the September-December cottonseed oil price. The processing margin would change only $1.79/ton if meal price was changed 4%. A 1 cent/lb. or $20.00/ton change in farm value changes the processing margin by $20.00.

Farm Prices

Estimates of prices received by farmers for oil and non-oil sunflowers have been released by the Crop and Livestock Reporting Service of North Dakota and Minnesota since 1967 (Figure 5, p. 10). This price series provides a weighted average for each year. The first daily prices were reported in the *Daily Market Record* (35) beginning in August, 1974 (Table 48). Cash and frequently new crop prices have been quoted for Duluth and/or Minneapolis. Duluth prices are for export and Minneapolis prices are primarily for domestic processing. An average of the prices given in Table 48 does not reflect the average price paid because most of the crop has historically been sold at harvest. Note that 1,298 or 65% of all cars sampled at central markets were sampled in October. It has been reported that storage by growers at harvest increased substantially in 1975. If this trend continues, more sales will likely take place throughout the year.

A procedure to estimate the value of processed and unprocessed sunflowers from oil and meal is given in Figure 34. The yield of oil, meal, and shrink used in this figure is given on p. 56. A processing and handling margin of 1 cent/lb. ($20.00/ton) is assumed in the scale giving the central market value. Transportation and handling expenses from farm to processor would have to be subtracted to obtain farm value. Other processing and handling margins could be used by subtracting a different margin from the product values on the left-hand side of the center scale.

To find the value of sunflowers derived from oil and meal, enter the price of oil in the left-hand scale (price of oil) and the price of meal on the right-hand scale (price of meal) and draw a straight line between these two points. The point where this line intersects the center scale is the value of the seed. The value to the processor is on the left-hand side of the center scale and the value to the farmer is on the right-hand side of the scale.

The example (shown by the dotted line in Figure 34) assumes a sun oil price of 19.25 cents/lb. and a sun meal price of $110.00/ton. The line between these two values intersects the value of the sunflower seed at $10.5/lb. to the processor. The value of unprocessed sunflowers is the value on the right-hand side of the center scale or 9.5 cents/lb. and is 1 cent/lb. less than the processor value.

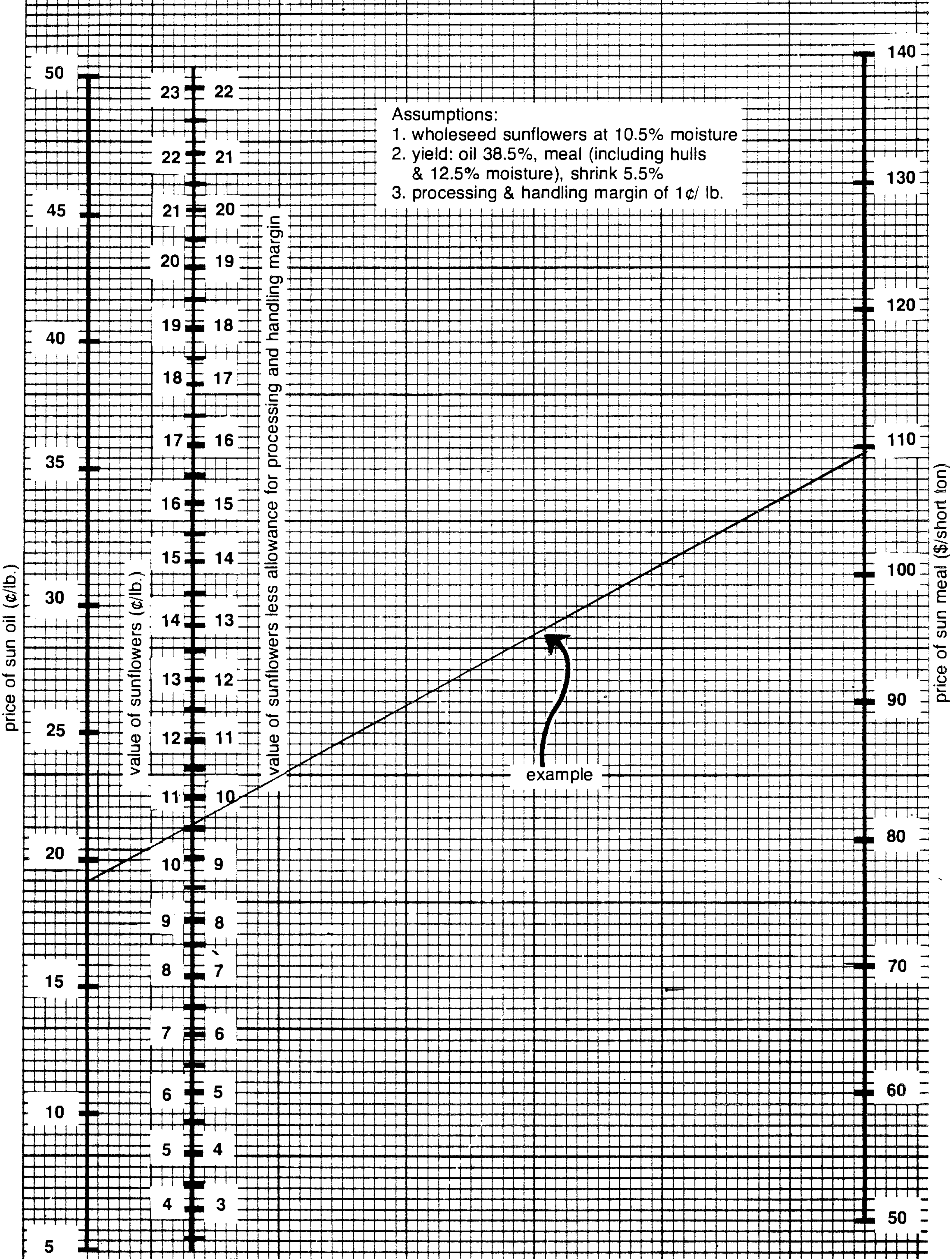


Figure 34. A Nomograph to Derive the Value of Sunflowers From Sun Oil and Sun Meal Prices (nomograph prepared by Stanley Klemetson)

TABLE 48. Average Reported Cash Price for Oil Sunflowers at Minneapolis, Minnesota, and Number of Cars Sampled by Month, 1975

Month	Price			Cars Sampled
	Average	Range Low	Range High	
	(············¢/lb············)			number
Jan	16.40	15.75	18.00	14
Feb	16.70	12.75	18.00	27
Mar	14.60	13.50	16.00	27
Apr	15.40	14.75	16.00	33
May[1]	10.70	10.00	10.75	18
Jun[1]	9.60	9.25	10.00	0
Jul[1]	10.95	10.50	12.00	2
Aug	12.85	11.50	13.75	2
Sep	13.15	12.15	13.75	15
Oct	11.55	11.10	12.15	1,298
Nov	9.80	9.25	10.80	441
Dec	9.60	9.25	10.00	123
Year	12.63	9.25	18.00	2,000

[1]Prices for Duluth, Minnesota.

SOURCE: (35).

Chapter 5

POTENTIAL SUPPLY OF RAW PRODUCT

A sunflower processing plant needs a stable supply of raw material to be able to operate efficiently. For example, a 1,000 ton/day sunflower processing plant operating at 100% capacity would have an estimated processing cost of $14.02/ton. The cost increases to $14.94/ton when the plant operates at 75% of capacity, and at 50% the cost increases to $16.79/ton (Table 20, p. 26). The purpose of this chapter is to review past production and to estimate potential production for oil sunflowers.

Production Patterns in North and South Dakota and Minnesota

Only 12 farmers reported sunflower production in North Dakota in the 1939 *Census of Agriculture*. They harvested 1,482 pounds from three acres for an average yield of 494 lbs./acre. Commercial production started increasing in North Dakota in the late 1940's, but did not exceed 10,000 acres until 1957. North Dakota is the leading state in the production of sunflowers and Minnesota ranks second (Table 3, p. 8). Production in South Dakota started expanding rapidly in 1973. Interest in sunflower oil as a result of the introduction of high-oil Russian varieties brought an expansion in acreage in 1967 (Table 49). There has been an upward trend with wide fluctuations in acreage from 1967 through 1976 in the three state area.

A three-year average (1972 to 1974) of sunflower harvested acreage by counties in North Dakota and Minnesota is given in Figures 35 and 36. County data are not available for South Dakota. The major sunflower production area in North Dakota is the east central portion of the state. The heavy concentration of sunflower acreage in Minnesota is the west central area.

Cost and Returns Compared to Competing Crops in North Dakota

A stable supply of sunflowers is largely determined by the profitablity of sunflowers compared to competing crops. In general, sunflowers compete with HRS wheat, durum, barley, oats, flax, and other row crops for acreage. The costs and returns of these five crops were compared with sunflowers for five areas in North Dakota using long-term and current price relationships (Tables 50 and 51). The profitability of crops varies by areas of the state. Five areas were selected which are presently growing sunflowers or may be having some acreage in the near future. The location of the five production areas in North Dakota is given in Figure 37.

Two price series were used. One represents a long-term price period which provides approximately the same relationship between prices paid and prices received that occurred during the 1963 to 1972 period (Table 50). As a basis for determining product price relationships, the average prices occurring over the 10 years — 1963 to 1972 — were used. The base period selected was long enough to reflect long-term trends in relative prices, while at the same time not being influenced unduly by cyclical price patterns. The prices during this 10-year period were stable and were not influenced by the sharp price fluctuations which started in 1973. Monthly average wheat prices ranged from $1.89 to $5.32 during the period 1973 to 1975. Other product prices also had a similar price trend.

A level of product prices was selected to generate approximately the same net farm income that occurred during the 1963 to 1972 base period. This was done by increasing prices 71% to account for increases in prices paid and 16% for deletion of government payments to farmers for a total of 87%. During the 1963 to 1972 period, wheat and feed grain program payments averaged 16% of combined crop and livestock sales. Commodity prices were increased by 16% to account for an assumed deletion of these program payments.

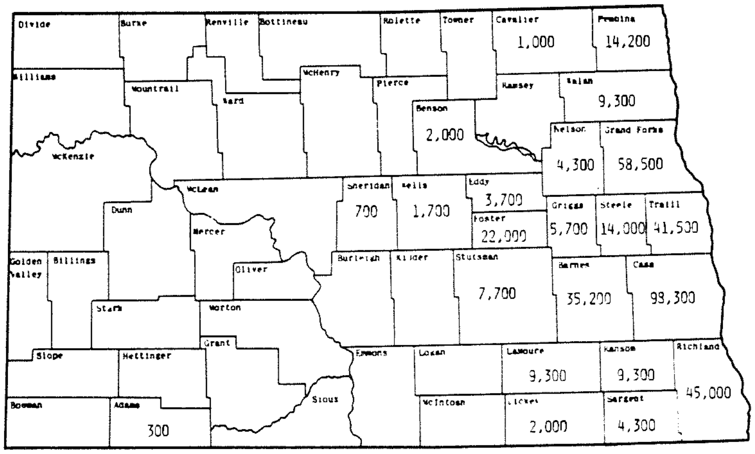
Average prices for September to December, 1975, were used to illustrate the current period (Table 51). This four-month period was estimated to be a better base than the long-term price relationship to show the effect of current prices on the profitability of small grains and flax compared with sunflowers. Prices during this period were adjusting downward to a level where farm prices in the next year or so might be expected to stabilize. Production costs include a charge for all resources, including

TABLE 49. Sunflowers: Planted Acreage, Yield Per Planted Acre, and Production for North Dakota, Minnesota, and South Dakota, 1967-1976

State and Year	Planted Acreage			Yield/Planted Acre in Pounds		Production in Tons		
	Oil	Non-Oil	Total	Oil	Non-Oil	Oil	Non-Oil	Total
North Dakota								
1967	52,800	74,200	127,000	1,104	1,000	29,138	37,112	66,250
1968	20,000	68,000	88,000	1,120	988	11,205	33,600	44,805
1969	22,200	87,800	110,000	1,086	833	12,050	36,550	48,600
1970	40,000	87,000	127,000	902	878	18,050	38,180	56,230
1971	95,000	148,000	243,000	1,077	954	51,150	70,560	121,710
1972	274,000	144,000	418,000	906	836	124,155	60,200	184,355
1973	305,000	113,000	418,000	1,082	894	165,000	50,505	215,505
1974	193,000	186,000	379,000	974	885	94,000	82,340	176,340
1975[1]	369,000	173,000	542,000	936	929	172,710	80,340	253,050
1976[1]	320,000	168,000	488,000					
Minnesota								
1967	43,000	51,000	94,000	1,011	941	21,730	24,000	45,730
1968	34,000	34,000	68,000	1,068	875	18,150	14,880	33,030
1969	33,000	52,000	85,000	982	804	16,200	20,915	37,115
1970	37,000	55,000	92,000	889	751	16,450	20,655	37,105
1971	69,000	93,000	162,000	1,071	1,014	36,960	47,170	84,130
1972	236,000	65,000	301,000	910	772	107,350	25,075	132,425
1973	190,000	70,000	260,000	1,175	927	111,600	32,430	144,030
1974	128,000	65,000	193,000	969	738	62,012	24,000	86,012
1975[1]	170,000	45,000	215,000	971	754	82,500	16,975	99,475
1976[1]	179,000	31,000	210,000					
South Dakota								
1973	76,950	4,050	81,000					
1974	86,000	2,300	88,300	733	530	31,500	610	32,110
1975[1]	176,000	2,000	178,000	664	775	58,388	775	59,163

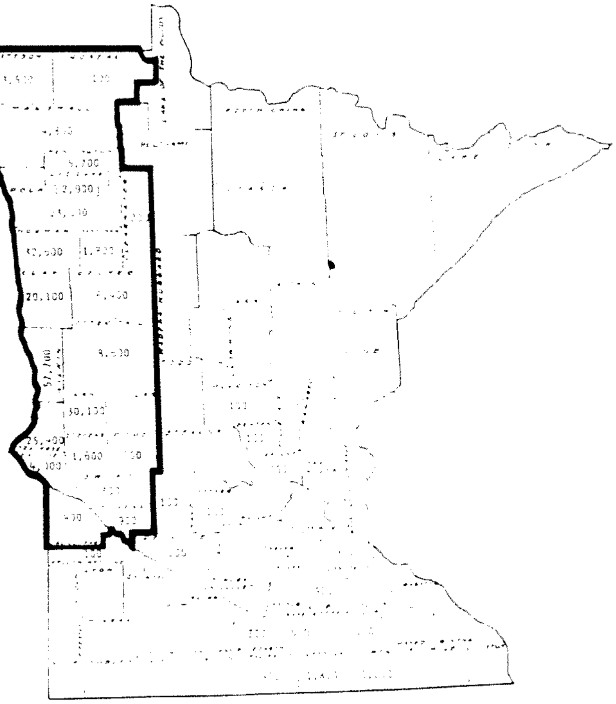
[1]Preliminary.

SOURCE: (36).



Other counties listed 5,000 acres.

Figure 35. Average Harvested Acres of Sunflowers by Counties, North Dakota, 1972-1974



Area included in supply estimates

Figure 36. Average Harvested Acres of Sunflowers by Counties, Minnesota, 1972-1974

land, labor, and capital. Gross income less production costs is the return to management which was used to compare sunflowers with the other crops.

The data in Tables 50 and 51 indicate that sunflowers can compete with small grain and flax using returns to management as a measure. Sunflowers ranked first in the Southeast Central, North Red River Valley, and South Red River Valley areas when the 1963 to 1972 price relationship was used (Table 50). They ranked second in the other production areas in returns to management. When the September to December, 1975, average prices were used, sunflowers ranked fourth with the crops compared in all areas except the Northwest Central area where they ranked fifth (Table 51). Returns to oats were less than sunflowers in all of the areas.

The estimated prices of small grain and flax required to return the same profit as sunflowers at specified prices are given in Table 52 for the Southeast Central and Northwest Central areas of North Dakota. The data in Table 52 are useful for determining the price needed for the other crops if the price of sunflowers was known or what price would be needed for sunflowers if the price of the other crops was known. For example, if the price of wheat in the Southeast Central area was estimated to be about $4.30/bushel, then the price for sunflowers would need to be about 11.76 cents/lb. to give the same return. If the price for barley in the Northwest Central area was expected to be $2.20/bushel, the price needed for sunflowers to give the same return would need to be 10.64 cents/lb.

Sunflower Attitudinal Study

A recent unpublished survey on the attitude of farmers toward the growing of sunflowers has been conducted (38). Results from this survey indicated that to grow sunflowers farmers who have never grown sunflowers would need a gross income from sunflowers greater than small grains and flax and equal to row crops, such as corn, pinto beans, and soybeans (Table 53). Farmers presently growing sunflowers indicated they would take less gross income compared to small grains or row crops. Three-fourths of the farmers growing sunflowers indicated that their production costs were lower than for wheat and barley, while about one-half of the farmers not growing sunflowers thought the production cost to be less than for wheat and barley. Farmers were asked to compare the gross income from sunflowers with wheat and barley. About one-half of the farmers currently growing sunflowers rated gross income from sunflowers better than wheat and 69% rated them better than barley (Table 54). Only 34% of the nongrowers rated sunflowers better than wheat and 43% rated them better than barley. The data in Table 54 show that sunflowers are strongly competitive with small grains and flax.

Hybrid Sunflowers

Hybrid sunflowers are rapidly taking over acreage from the open-pollinated varieties. It is estimated that about one-fifth of the oilseed acreage in 1975 was planted to hybrids. Hybrid seed of the oilseed varieties was

TABLE 50. Per Acre Average Yields, 1975 Production Costs, and Returns to Management Using 1963-72 Prices Paid to Prices Received Relationship for Specified Crops in Five North Dakota Regions

Region	Sunflowers	HRS Wheat	Durum	Barley	Oats	Flax
North Red River Valley						
Yield per acre[1]	10.25 cwt.	33.10 bu.	26.90 bu.	43.60 bu.	52.60 bu.	11.40 bu.
Price ($)	8.79	2.92	2.92	1.72	.99	5.12
Gross income ($)	90.10	96.65	78.55	74.99	52.07	58.37
Production cost ($)	75.83	82.48	85.65	84.37	72.95	63.11
Return to management ($)	14.27	14.17	(7.10)[3]	(9.38)[3]	(20.88)[3]	(4.74)[3]
South Red River Valley						
Yield per acre[1]	11.40	34.00	28.00	45.00	60.30	12.30
Price	9.00	2.99	2.98	1.78	1.04	5.22
Gross income	102.60	101.66	83.44	80.10	62.71	64.21
Production cost	80.33	87.25	90.85	86.66	81.39	69.67
Return to Management	22.27	14.41	(7.41)[3]	(6.56)[3]	(18.68)[3]	(5.46)[3]
Northeast Central						
Yield per acre[1]	8.00[2]	26.70	23.40	38.60	45.10	11.20
Price	8.73	2.90	2.91	1.71	.98	5.10
Gross income	69.84	77.43	68.09	66.01	44.20	57.12
Production cost	55.93	61.08	64.19	62.49	52.95	51.90
Return to management	13.91	16.35	3.90	3.52	(8.75)[3]	5.22
Southeast Central						
Yield per acre[1]	9.50	27.10	23.40	41.10	50.90	11.20
Price	8.94	2.97	2.97	1.75	1.01	5.18
Gross income	84.93	80.49	69.50	71.92	51.41	58.02
Production cost	61.73	66.53	69.58	66.65	60.67	54.69
Return to management	23.20	13.96	(.08)[3]	5.27	(9.26)[3]	3.33
Northwest Central						
Yield per acre[1]	7.00[2]	20.20	21.20	34.70	44.20	10.80
Price	8.46	2.81	2.85	1.63	.94	4.97
Gross income	59.22	56.76	60.42	56.56	41.55	53.68
Production cost	58.08	57.36	60.70	59.96	51.99	49.34
Return to management	1.14	(.60)[3]	(.28)[3]	(3.40)[3]	(10.44)[3]	4.34

[1]SOURCE: (37).
[2]Estimated using Experiment Station and Statistical Reporting Service data.
[3]The parentheses indicate a negative return.

available for most of the 1976 acreage. Hybrids have been tested extensively in North Dakota and Minnesota. Seed yields in 1975 of hybrids have been as much as 30% higher than those of open-pollinated check varieties in North Dakota tests (25, January, 1976, p. 12). Newer hybrids have higher oil content than the standard open-pollinated varieties.

Most hybrids offer greater uniformity, which facilitates specific agronomic practices that minimize weather damage, shatter, lodging, and harvest losses. They also provide resistance to rust, downy mildew, and Verticillium wilt disease (which in some years combine to reduce yield by 10 to 15%). Hybrids have a higher degree of self-compatibility or self-pollination in addition to higher yield potentials.

The yield trials for 1975 at seven locations in North Dakota involving currently available hybrids are given in Table 55. Hybrids out-yielded the open-pollinated varieties at all locations. The hybrids had about a 16% yield advantage over Peredovik at the seven locations. The yield advantage for hybrids ranged from a low of 8% to a high of 30% over the Peredovik variety. One can look for even higher yields with improved hybrids in the near future.

Supply Response Model

A supply response model was used in the East Cen-

TABLE 51. Per Acre Average Yield, 1975 Production Cost, and Return to Management Using September to December, 1975, Average Price for Specified Crops in Five North Dakota Areas

Area	Sunflowers	HRS Wheat	Durum	Barley	Oats	Flax
North Red River Valley						
Yield per acre[1]	10.25 cwt.	33.10 bu.	26.90 bu.	43.60 bu.	52.60 bu.	11.40 bu.
Price ($)	9.96	4.29	5.13	3.31	1.32	6.16
Gross income ($)	102.09	142.00	138.00	144.32	69.43	70.22
Production cost ($)	75.83	82.48	85.65	84.37	72.95	63.11
Return to management ($)	26.26	59.52	52.35	59.95	(3.52)[2]	7.11
South Red River Valley						
Yield per acre[1]	11.40	34.00	28.00	45.00	60.30	12.30
Price	9.99	4.32	5.16	3.37	1.33	6.18
Gross income	113.89	146.88	144.48	151.65	80.20	76.01
Production cost	80.33	87.25	90.85	86.66	81.39	69.67
Return to management	33.56	59.63	53.63	64.99	(1.19)[2]	6.34
Northeast Central						
Yield per acre[1]	8.00[3]	26.70	23.40	38.60	45.10	11.20
Price	9.79	4.26	5.10	3.29	1.27	6.08
Gross income	78.32	113.74	119.34	126.99	57.28	68.10
Production cost	55.93	61.08	64.19	62.49	52.95	51.90
Return to management	22.39	52.66	55.15	64.50	4.33	16.20
Southeast Central						
Yield per acre[1]	9.50	27.10	23.40	41.10	50.90	11.20
Price	9.86	4.30	5.14	3.35	1.29	6.12
Gross income	93.67	116.53	120.28	137.68	65.66	68.54
Production cost	61.73	66.53	69.58	66.65	60.67	54.69
Return to management	31.94	50.00	50.70	71.03	4.99	13.85
Northwest Central						
Yield per acre[1]	7.00[3]	20.20	21.20	34.70	44.20	10.80
Price	9.64	4.19	5.03	2.09	1.22	6.01
Gross income	67.48	84.64	106.64	72.52	53.92	64.91
Production cost	58.08	57.36	60.70	59.96	51.99	49.34
Return to management	9.40	27.28	45.94	12.56	1.93	15.57

[1]SOURCE: (37).
[2]The parentheses indicate a negative return.
[3]Estimated using Experiment Station and Statistical Reporting Service data.

tral and Northwest Central areas to evaluate the competitiveness of sunflowers with crops commonly grown in each of the areas. Long-term average and current prices used in this analysis are given in Table 56. Prices employed in a similar study by Herman are also given. Maximum acreage allowed in each model was dictated by rotation requirements for sunflowers. It has been estimated that under ideal conditions sunflowers should not be grown on the same land more frequently than once every three years. A six-year rotation was assumed in the model to account for land on which sunflowers may not be grown.

East Central Area

Crops included in the model for the East Central area included wheat, durum, and barley grown on continuous and summer fallow land; flax, oats, corn grain, soybeans, and sunflowers on continuously cropped land. The long-term prices in Table 56 were used.

Results of the supply response model indicate that 22% of the cropland could be profitably planted to sunflowers using these price relationships. The proportion of land devoted to sunflowers was sensitive to changes in sunflower prices. If sunflower prices were

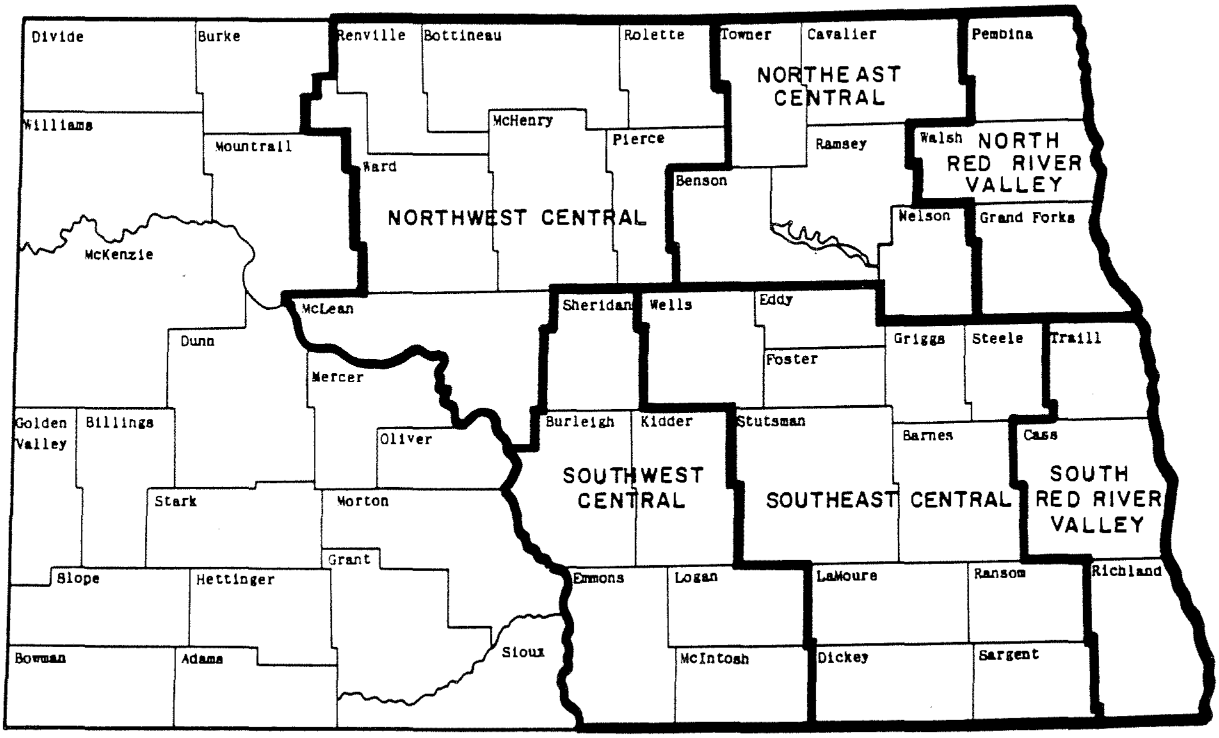


Figure 37. North Dakota Areas for Which the Supply of Sunflowers Was Estimated

TABLE 52. Estimated Price of Small Grain and Flax Required to Return the Same Profit at Specified Prices of Sunflowers in the Southeast Central and Northwest Central Areas of North Dakota for 1975

Sunflower Price in Cents/Pound	HRS Wheat	Durum	Barley	Oats	Flax
	(..........	....	$/bu.	....	..........)
Southeast Central Area					
8	2.98	3.58	1.97	1.47	6.16
10	3.68	4.40	2.43	1.75	7.85
12	4.38	5.21	2.89	2.22	9.55
14	5.08	6.02	3.36	2.59	11.25
(..........	....	Estimated Average Yield/Acre	....	....	..........)
950 lbs.	27.1 bu.	23.4 bu.	41.1 bu.	50.9 bu.	11.2 bu.
Northwest Central Area					
8	2.74	2.77	1.67	1.13	4.38
10	3.43	3.43	2.07	1.45	5.56
12	4.12	4.09	2.47	1.76	6.97
14	4.82	4.75	2.88	2.08	8.26
(..........	....	Estimated Average Yield/Acre	....	....	..........)
700 lbs.	20.2 bu.	21.2 bu.	34.7 bu.	44.2 bu.	10.8 bu.

TABLE 53. Attitude of Surveyed Farmers Toward Gross Income Required to Grow Sunflowers Compared to Small Grains, Flax, and Row Crops, by Type of Grower, North Dakota, 1975

Type of Grower and Crop	Gross Income From Sunflowers		
	Less Than	Equal To	Greater Than
	(............%...........)		
Growers of Sunflowers			
Wheat	48	32	20
Barley	37	36	27
Flax	36	28	36
Corn Grain	66	22	12
Soybeans	52	42	6
Pinto Beans	46	31	23
Nongrowers of Sunflowers			
Wheat	20	24	56
Barley	7	30	63
Flax	6	31	63
Corn Grain	20	41	39
Soybeans	19	43	38
Pinto Beans	12	69	19
All Growers			
Wheat	28	27	45
Barley	17	32	51
Flax	16	30	54
Corn Grain	36	34	30
Soybeans	31	43	26
Pinto Beans	32	35	33

reduced 10 cents to $7.80/cwt., sunflower acreage would begin to be replaced by barley. The sunflower price would have to increase to $8.50/cwt. before there would be an increase in sunflower acreage with the other prices remaining the same. At $7.90/cwt., sunflowers will compete on a per bushel basis with wheat at $3.16, corn at $1.90, flax at $6.29, and soybeans at $4.19.

Herman analyzed the optimum farm organization on three sizes of farms in southeastern North Dakota (40). Herman also used two price levels. The first series used was the same as the long-term prices employed in the East Central supply response model (Table 56) except that $7.27/cwt. was used instead of $7.90 for sunflowers. Sunflowers and wheat were the most profitable crops included in the optimum solution for all three farm sizes. Sunflowers entered at the maximum level (20% of the

TABLE 54. Attitude of Surveyed Farmers Toward Gross Income Received From Sunflowers Compared With Wheat and Barley, by Type of Grower, North Dakota, 1975

Type of Grower and Crop	Gross Income From Sunflowers		
	Better	Same	Worse
	(............%...........)		
Growers of Sunflowers			
Wheat	49	30	21
Barley	69	18	13
Nongrowers of Sunflowers			
Wheat	34	34	32
Barley	43	39	18
All Growers			
Wheat	41	32	27
Barley	52	32	16

TABLE 55. Yield Trials of Oil Sunflowers at Seven Locations in North Dakota, 1975[1]

Hybrid or Variety	Location							
	Casselton[2]	Carrington Dryland	Carrington Irrigated	Mayville[2]	Langdon[2]	Minot[2]	Williston[2]	Average
	(.................... pounds per acre ....)							
Hybrid 894	2,240	1,461	2,521	2,073	1,926	972	1,404	1,799
Hybrid 204	1,893	1,438	2,287	2,422	1,866	1,020	1,206	1,733
Hybrid 903	2,169	1,630	2,083	1,907	1,940	884	1,464	1,725
Hybrid 893	2,113	1,561	2,247	2,147	1,691	782	1,236	1,682
Hybrid 896	2,349	1,581	2,364	1,865	1,807	646	908	1,646
Hybrid 891	1,847	1,458	2,149	2,331	1,610	809	1,271	1,639
Hybrid 212	1,760	1,313	2,113	1,979	2,069	945	1,200	1,626
Peredovik	1,988	1,146	1,907	1,786	1,443	802	1,160	1,462

[1]Tests at Casselton, Carrington, Langdon, Minot, and Williston were conducted by the North Dakota Agricultural Experiment Station in cooperation with the U.S. Department of Agriculture. Tests at Mayville were conducted by Cargill, Inc., Glyndon, Minnesota.
[2]Dryland.

SOURCE: (39, p. 12).

TABLE 56. Prices of Selected Crops Employed in Sunflower Supply Response Models, North Dakota

Crop	Price Series		Herman's Study	
	Long-Term	Current	Long-Term	Current
	(........	.... $/bu.	....	........)
Sunflowers ($/cwt.)	7.90	10.50	7.27	13.00
Wheat	2.70	4.36	2.70	4.50
Durum	2.70	5.69	2.70	6.00
Barley	1.50	2.42	1.50	3.25
Oats	.95	1.35	.95	1.50
Flax	4.70	6.79	4.70	9.00
Corn	1.75		1.75	
Soybeans	4.55		4.55	

total cropland) allowed by the model. The sunflower price would have to fall from $7.27 to $6.35/cwt. before the acreage would be reduced in the small farm, to $7.18 in the medium farm, and to $6.99 in the large farm. Wheat replaced sunflowers on all farm sizes when the price of wheat increased to $2.95. Wheat did not entirely replace sunflowers due to spring seeding labor limitations. Barley replaced sunflowers on the small farm when the price reached $2.10/bushel, but only partially replaced sunflowers on the medium and large farms because of spring labor limitations.

Results from the current prices employed by Herman were as follows: Sunflowers entered at the maximum level allowed by the small farm model. If the price of sunflowers fell from its programmed level of $13.00 to $11.95/cwt., the sunflower enterprise would be completely replaced in the optimum solution. The medium farm size solution showed sunflowers to be the second most profitable crop, but they did not come in at the maximum level. If the price was reduced to $11.49, the acreage would only be about half of what it was at the $13.00 level. If the price increased to $13.86, the acreage would increase about a third over its acreage at $13.00. The large size farm model showed that sunflowers at $13.00 came in at about half of the maximum acreage allowed. The price would have to increase to $13.62 before the maximum acreage allowed would come in. If the price fell to $11.21, only about 7% of the cropland acreage would be in sunflowers.

The results of this study showed that sunflowers have a definite profit potential for up to 20% of the cropland acreage under both short- or long-term price relationships. In addition, sunflowers have a great potential to take pressure off the critical small grain spring seeding and harvesting labor periods.

Schaffner and others studied the economic benefits from one and two additional inches of growing season rainfall and made a supply response study in four areas of the state (41). Only in the Eastern Central and Red River Valley areas were sunflowers used as a crop choice. Sunflowers came in at the maximum level in both areas.

Northwest Central Area

Five crops were used in the supply response model for the Northwest Central area. The crops were wheat, durum, barley, and sunflowers on continuous and summer fallow land and flax and oats on continuous land. The supply response model reflects the general practices of the Northwest Central area that will return the greatest profit to the resources used with the prices assumed. Results of the supply response model using long-term price relationships indicated that 16% of the cropland would be sunflowers. This is the maximum acreage permitted in the model to ensure proper rotation with sunflowers. Sunflowers were grown first in the rotation after summer fallow. The price of sunflowers could decrease from $7.90/cwt. to $3.41/cwt. before a decrease in acreage would occur. Acreage devoted to sunflowers at $7.90 would not be displaced until the price of wheat was above $2.76, barley above $1.88, durum above $2.64, flax above $4.44, and oats above $1.52. Acreage devoted to sunflowers at $10.50 would not be displaced until the price of wheat was above $5.86, durum above $4.24, barley above $3.82, flax above $10.72, and oats above $2.98.

Potential Production Related to Processing Requirements

A major consideration when establishing a processing plant is the raw product supply. The harvested acres by county for North Dakota and Minnesota that might contribute production to a processing plant are given in Tables 57 and 58. Acreage harvested during the 1970-1975 period varied from a low of 121,000 acres to a high of 498,000 acres in North Dakota. A similar variation has occurred in Minnesota. The acreages shown include both oil and non-oil sunflowers. The 498,000 harvested acres in North Dakota in 1975 were an all-time high, while in Minnesota the high was in 1972 at 259,800 acres.

The supply area used for this study was composed of counties from North Dakota, South Dakota, and Minnesota. Thirty-five eastern counties in North Dakota (Figure 37), 23 western counties in Minnesota (Figure 36), and eight counties in northeastern South Dakota made up the potential supply area.

Processing plant supply requirements were related to three estimates of sunflower production from the

TABLE 57. Harvested Acreage of All Sunflowers by Counties, North Dakota, 1970-1975

County	Year					
	1970	1971	1972	1973	1974	1975[1]
Pembina	5,500	17,500	22,500	16,000	4,000	8,900
Walsh	2,000	4,000	9,000	11,000	8,000	16,700
Grand Forks	22,000	51,500	64,500	64,000	47,500	58,800
Traill	18,500	43,500	60,000	44,500	19,500	15,700
Cass	36,500	44,000	114,000	99,000	83,500	71,800
Richland	17,000	33,000	51,000	42,000	43,000	51,100
Dickey				1,000	5,000	8,800
Sargent			2,000	4,000	7,000	28,800
LaMoure			4,000	9,000	15,000	22,000
Ransom	2,500	2,500	4,000	9,000	15,000	26,100
Stutsman	500	5,000	6,000	7,000	9,500	12,800
Barnes	4,000	11,000	23,500	38,000	45,000	71,400
Steele	3,500	5,000	14,000	17,000	11,000	19,600
Griggs	500	2,000	3,000	6,000	8,000	10,900
Foster	5,500	12,500	15,000	24,000	27,000	33,700
Eddy			2,000	3,000	5,500	17,200
Wells			3,000	2,000		4,900
Cavalier			2,000	1,000		
Nelson			2,000	6,000	4,500	8,700
Benson			1,000	3,000	1,500	1,900
Sheridan					1,500	3,400
Adams					1,000	
Other Counties	3,000	5,500	4,500	4,500	5,000	4,800
Total Acres	121,000	237,000	407,000	411,000	367,000	498,000
Oil Sunflower Acres	38,000	93,000	267,000	300,000	188,000	349,000

[1]Preliminary.

SOURCE: (42).

three-state area: (1) 1975 actual production, (2) farmer survey projections, and (3) total maximum potential for the entire state of North Dakota. In 1975, 615,000 acres of oil sunflowers were harvested in the three-state area for an estimated production of 279,000 tons (Table 59). Assuming that processors could attract 100% of the supply, a 500 ton/day plant would utilize 54% of the 1975 production (Table 60). A 1,000 ton/day plant could operate at 93% capacity; a 1,500 ton/day plant could operate at 62% capacity; and a 2,000 ton/day plant at only 47% capacity.

This illustrates the large tonnage needed to support processing plants of various sizes. Attraction of 100% of total production is unrealistic for a plant located in North Dakota. There is excess capacity in existing plants processing flax and other oil crops that will compete for the sunflower production. The majority of oilseed sunflowers today are sold on the export market as whole seed. This market will also compete for the sunflowers produced. If, for illustration purposes, a processing plant attracted 50% of the 1975 production in the supply area, a 1,000 ton/day plant could operate at only 54% of capacity.

Projected Acreage

The projected sunflower acreage was based on what farmers in a North Dakota survey indicated they would plant if a sunflower processing plant was located in their area and the returns from sunflowers were equal to or better than their second best cash crop. The projected acreage in Minnesota and South Dakota was based on production trends as given in Table 49, p. 58.

The study of farmers' attitudes for growing sunflowers indicated that 69% of the farmers in the sample would support a plant if the net returns from sunflowers would be equal to or greater than their second best crop (38). The most support for a processing plant would be in the present sunflower production areas of the Red River Valley and Southeast Central North Dakota where farmers have had experience growing sunflowers. Based on the farmer survey, the proportion of cropland acreage devoted to sunflowers would average 7% in the eastern two-thirds of North Dakota (Figure 37, p. 62). This proportion varied by area and ranged from 5% in areas where sunflowers are not commonly grown to 13% where they are grown extensively.

TABLE 58. Harvested Acreage of All Sunflowers by Counties, Minnesota, 1970-1975

County	Year					
	1970	1971	1972	1973	1974	1975[1]
Kittson	700	1,300	4,100	4,200	2,200	4,100
Roseau	200	300	100	100		
Marshall	1,700	3,000	5,700	5,900	5,700	6,200
Pennington	4,100	7,800	6,900	7,100	3,100	2,000
Red Lake	3,400	6,200	3,500	3,200		
Polk	10,000	17,300	27,600	22,900	13,300	11,800
Clearwater	1,000	1,700	200	200		
Norman	31,300	59,100	42,000	39,200	17,500	15,200
Mahnomen	400	800	2,000	1,900		
Clay	7,300	11,600	23,500	19,500	23,500	10,900
Becker	300	500	8,000	7,000	4,100	1,800
Wilkin	14,400	24,100	63,400	69,500	37,400	30,000
Otter Tail	600	1,200	8,300	8,200	8,000	6,500
Grant	2,000	4,200	32,900	32,400	20,800	24,000
Traverse	4,500	8,700	22,700	25,000	25,100	40,000
Big Stone		200	3,100	2,500	7,200	19,500
Stevens		200	1,800	1,500	2,800	3,600
Pope		200	800	700		
Swift		500	500	300		
Chippewa		400	1,700	900		
Lac Qui Parle			700	400		
Yellow Medicine			200	100		
Douglas		200	100			
Total Acres	81,900	149,500	259,800	252,700	170,700	175,600
Estimated Oil Acres[2]	33,200	63,400	205,700	184,100	114,369	142,236

[1]Preliminary.
[2]Estimated using the same ratio of total acres in the above counties to Minnesota total acreage.

SOURCE: (43).

If these data were used to project sunflower production in the 35 North Dakota counties, it is estimated that about 1,069,000 acres might be grown (Table 59). Also, there has been a substantial increase in acreage in South Dakota since 1972. If one assumed thê eight counties in northern South Dakota would be part of the supply area and the estimated 1975 acreage was doubled, this would add another 176,000 acres. There is also another potential supply area in western Minnesota. The acreage in this area has not increased since 1972; so if it was held at the 1975 level, there would be another 158,000 acres for a plant to draw raw material from (Table 59).

Projected yields were held at the 1975 level because production would expand westward where rainfall is lower. Higher yielding hybrids are expected to offset the lower rainfall effect.

There would be sufficient production using the farmers' projected acreages (Table 59) to operate a plant of up to 2,000 tons/day at full capacity (Table 60) assuming the plant was able to attract 94% of the total supply. A 1,000 ton/day plant operating at 100% of capacity would require about 47% of the projected production.

A maximum sunflower acreage projection of 3,334 million acres was made for the three-state supply area. This maximum acreage projection was made to illustrate supply and utilization relationships that may exist if the crop was grown to the maximum extent in North Dakota. This projection was derived by deleting the acreage in summer fallow, sugarbeets, and potatoes from total cropland and dividing the residual by six. This computation assumes that sunflowers would be grown once in a six-year rotation. An extended rotation was used to account for land on which sunflowers may not be grown. Using these assumptions, a maximum of 3 million acres of sunflowers could be grown in North Dakota. The same acreage for Minnesota and South Dakota used in the farmer survey projection was employed in this maximum potential sunflower production (Table 59). Under the maximum acreage projection, all of the model processing plants would have sufficient raw material to operate at full capacity with only the largest 2,000-ton/day plant coming close to requiring 50% of the entire production or 43%.

Production Problems

There are some production problems that discourage farmers from growing sunflowers. The survey of grower attitudes for sunflowers showed that 44% of the farmers do not own row crop equipment and felt the investment at this time was too high (38). The proportion of farmers having no row crop equipment varied from a low of 13% in the South Red River Valley area to a high of 75% in the Northeast Central area.

Farmers were asked to rate sunflowers with small grain when grown on comparable land and given the same management (38). Sunflowers were rated better than small grains on only one item, drought resistance, by both the growers and nongrowers of sunflowers (Table 61). In general, sunflowers in the past have performed better under growing conditions with moisture stress than have the other longer growing season crops, such as corn. Growers of sunflowers rated them worse than small grains on five items — harvest, drying, disease, insects, and birds. Nongrowers of sunflowers rated them worse than small grains on four items — market outlet, harvest, drying, and birds (Table 61). Twenty-

TABLE 59. Estimated Sunflower Production for 1975, Farmers' Projections and Maximum Potential for North Dakota, South Dakota, and Minnesota

Projections by State	Planted Acres	Production in Tons
1975 Production		
North Dakota	369,000	173,000
South Dakota	88,000	29,000
Minnesota	158,000	77,000
Total	615,000	279,000
Farmers' Projected Production		
North Dakota	1,069,000	500,000
South Dakota	176,000	58,000
Minnesota	158,000	77,000
Total	1,403,000	635,000
Maximum Potential Production		
North Dakota	3,000,000	1,275,000
South Dakota	176,000	58,000
Minnesota	158,000	77,000
Total	3,334,000	1,410,000

TABLE 60. Total Oilseed Sunflower Requirements of Specified Plant Sizes and Utilization Levels Assuming 1975 Production, Farmers' Projected Production, and Maximum Potential Production Projection for North Dakota, South Dakota, and Minnesota

Plant Size and Percent Utilization	Annual Tons of Sunflowers Processed	1975 Production[1]		Projected Acreage[2]		Max. Projected Acreage[3]	
		Acres Required	Percent of Total Supply	Acres Required	Percent of Total Supply	Acres Required	Percent of Total Supply
	(000)	(000)		(000)		(000)	
500 Tons							
100%	150	331	54	331	24	355	11
75%	112	247	40	247	18	265	8
50%	75	165	27	166	12	177	5
1,000 Tons							
100%	300	661	108	663	47	709	21
75%	225	496	81	497	35	532	16
50%	150	331	54	331	24	355	11
1,500 Tons							
100%	450	992	161	994	71	1,064	32
75%	337	743	121	745	53	797	24
50%	225	496	81	497	35	532	16
2,000 Tons							
100%	600	1,322	215	1,326	94	1,419	43
75%	450	992	161	994	71	1,064	32
50%	300	661	108	663	47	709	21

[1]Based on 907 lbs./acre average yield and 615,000 acres.
[2]Based on 905 lbs./acre average yield and 1,403,000 acres.
[3]Based on 846 lbs./acre average yield and 3,334,000 acres.

seven percent of the farmers listed blackbirds as a problem in sunflower production, 17% mentioned late harvest and late maturing, 13% mentioned equipment costs, 10% disease, 9% marketing and obtaining current price reports, and 8% insect problems.

If good management practices are followed, the losses due to disease and insects may be kept to a minimum. Increased sunflower acreage has been accompanied by an increase in the prevalence of insects and disease (44). Management practices are known and chemicals are available to control some of these problems. New approved chemicals, new varieties, and other technological advances are taking place which can improve yields and reduce risks.

There are 30 or more known diseases of sunflowers (44, p. 22). Of these only downy mildew, rust, Sclerotinia stalk and head rot, Verticillium wilt, Phoma black stem, and Alternaria leaf and stem spot threaten yield of sunflowers. The growing of resistant varieties and using pest management practices are the most economical ways to minimize losses.

The number of insects of potential economic importance is higher than the number associated with other crops of the area (44, p. 37). There are about a dozen species of insects that are of current economic importance. If good management practices are not followed, several of these species may cause moderate to severe yield reductions.

More educational work is needed and answers found for some of the problems farmers encounter in the growing of the crop to help overcome some of the resistance of farmers not now growing sunflowers to become interested in the crop. Also, as long as there is no limit on the acreage of wheat and feed grains that can be grown and prices remain relatively high, the acreage of sunflowers may not expand as fast as might be expected.

Dollar returns compared to other crops and convenient market outlet are the primary factors which guide farmers in their decision to grow or not to grow sunflowers. Dollar returns are closely related to the yields obtained. The newer hybrids are increasing the potential yields that can be obtained and, thereby, placing sunflowers in a better competitive position with other crops.

TABLE 61. Attitude of Growers and Nongrowers of Sunflowers Surveyed in North Dakota Toward Sunflowers Compared With Small Grain for Specified Production Aspects, 1975

Type of Grower and Production Item	Sunflowers Compared With Small Grain		
	Better	Same	Worse
	(............ % ....)		
Growers of Sunflowers			
Market Outlet	7	77	16
Harvest	9	44	47
Drying	5	32	63
Disease	3	36	61
Insect	3	24	73
Birds	0	12	88
Fieldwork Conflicts	28	54	18
Weed Control	41	46	13
Drought Resistance	84	15	1
Risk	32	49	19
Contract Problems	22	47	31
Nongrowers of Sunflowers			
Market Outlet	3	32	65
Harvest	4	21	75
Drying	3	17	80
Disease	9	46	45
Insect	7	47	46
Birds	2	8	90
Fieldwork Conflicts	34	44	22
Weed Control	35	45	20
Drought Resistance	71	22	7
Risk	12	56	32
Contract Problems	15	59	26
All Growers			
Market Outlet	5	46	49
Harvest	5	29	66
Drying	4	22	74
Disease	7	42	51
Insect	5	39	56
Birds	1	10	89
Fieldwork Conflicts	32	47	21
Weed Control	37	45	18
Drought Resistance	76	19	5
Risk	18	54	28
Contract Problems	17	55	28

Chapter 6

TRANSPORTATION ANALYSIS OF THE SUNFLOWER INDUSTRY

The feasibility of locating a sunflower processing facility in North Dakota depends on its comparative advantage relative to other locations in obtaining the raw product and in supplying the final demand for oil and meal. An important element in determining the competitive position of a processing facility located in North Dakota is the transportation cost of marketing sunflowers from producer to final consumer.

A transportation cost analysis of sunflower processing facilities in three North Dakota locations was undertaken to determine the competitive position of each facility relative to existing processing plants. Analyses based on an estimate of 1975 sunflower production and two alternative projections of sunflower production were undertaken. One projection was based on information obtained from a survey of growers in North Dakota and the other projection was based on a maximum potential sunflower production estimate for North Dakota. Neither projection was intended to reflect anticipated production levels for a specific year in the future. The projections were developed for the purpose of analyzing the effect on the industry of higher levels of sunflower production.

For the purpose of the transportation analysis, three commodity movements associated with the distribution of oil-type sunflowers were identified, and the transportation costs associated with each movement were analyzed. The commodity movements included the shipment of sunflowers from grower to processor and export points, the shipment of crude sun oil from processor to refiner and export points, and the shipment of sun meal from processor to final demand.

A transshipment model employing a linear programming algorithm was used to carry out the analysis. A transshipment model provides a framework for taking into account intermediate processing stages in the flow of a commodity from raw to finished product (45, p. 195). Through this procedure, an optimum system of routing shipments from sources to destinations can be determined in such a manner as to minimize total transportation cost within the constraints imposed by source capacities and destination requirements. The linear programming model is designed with the assumption that all costs other than transportation costs are equal at all origins and processing points and that all product movement decisions are made on the basis of least cost only.

Industry Structure

An underlying assumption of the transportation analysis is that the markets for sunflower products will expand in the U.S. and so will sunflower production. The commodity flows to processing and final demand points identified in this analysis should be viewed as one possible set of configurations that may develop with the growth of the sunflower industry. They should be viewed as a simplification of both the existing market structure and what may occur in the future.

Sunflower Production Regions

Sunflower production in the U.S. has been concentrated in the states of North Dakota, Minnesota, and South Dakota. In 1975, a relatively large number of acres were planted to sunflowers in Texas. It was assumed for the purpose of the transportation analysis that sunflower production in Texas would continue to expand.

Sunflower production was assumed to occur in six producing regions and a central shipping point was selected in each producing region (Figure 38). All outbound shipments of sunflowers from a given production area were assumed to originate at the central shipping point for that area. The shipping points and the production estimates used in the transportation analysis are provided in Table 62. It should be noted that sunflowers have been grown in areas of the U.S. that are not included in the production regions identified in this study. However, production in those areas has been limited (less than 1% of total production in recent years) and widely dispersed and for these reasons they were not included in the analysis.

The 1975 production estimates were based on estimates published by the Statistical Reporting Service of the U.S. Department of Agriculture, a survey of growers in North Dakota, and information obtained from industry sources. The production estimate based on projected acreage by farmers in North Dakota included changes in the level of production in other states. Sunflower production was assumed to double in South Dakota, triple in Texas as a result of increased acreage and yield, and remain at the 1975 level in Minnesota.

The production estimate based on maximum potential sunflower production in North Dakota was made in an attempt to examine the effect of a high level of production on the sunflower processing industry. It was assumed that the maximum acreage devoted to sunflowers in North Dakota would be 3 million acres, while the acreage and production in other regions would remain at levels identified in the preceding paragraph. Under this production estimate, the North Dakota yield was lower than under the other production estimates — reflecting the fact that less productive land in the western part of the state would have to be brought into production to attain the acreage estimate.

Sunflower Processors

Historically, the quantity of sunflowers crushed in the U.S. has been small relative to domestic sunflower production and other oilseed commodities. This has been the result of a relatively strong export demand for whole seed sunflowers and the fact that domestic markets for sun oil and meal have not yet been firmly established. Because of the available supply of sunflowers and existing crush capacity, most of the sunflowers crushed in the U.S. have been crushed by processors in the Minneapolis-St. Paul area. It is anticipated, based on conversations with individuals in the industry, that processors in the Minneapolis-St. Paul area will maintain and possibly increase their sunflower crushing operations. It is also anticipated that cottonseed processors in Texas will utilize their facilities to crush sunflowers in addition to cottonseed.

Two products, oil and meal, were assumed to be produced and marketed by sunflower processors. The yields of the oil and meal used in the transportation analysis are those given on p. 28. Sunflower hulls, potentially a third product resulting from processing sunflowers, were not considered in the transportation analysis because of their low value relative to oil and meal.

For the purpose of the transportation analysis, two

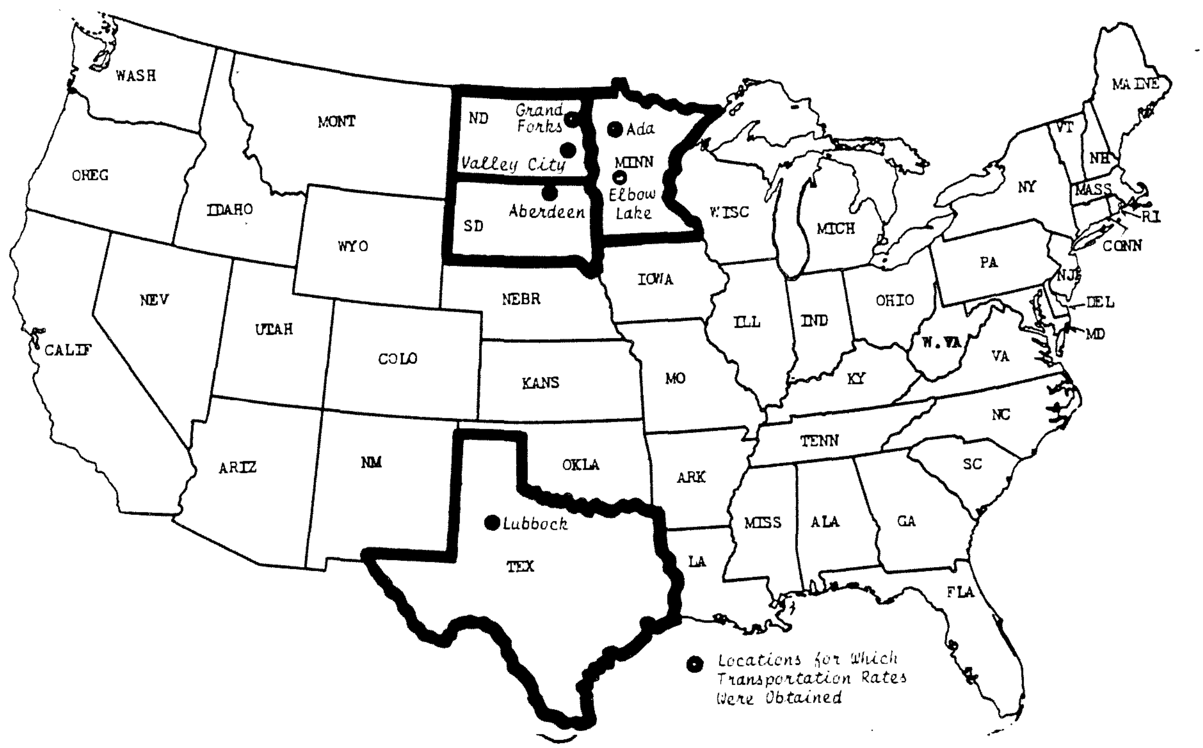


Figure 38. Sunflower Producing Regions Used in Transportation Analysis

TABLE 62. Estimated Oilseed Sunflower Production for Selected U.S. Regions for 1975 and for Alternative Production Projections

Region	Central Shipping Point	Estimated Production (1,000 Tons)	% of Total Production	Acreage (1,000 Acres)
	1975			
Northeastern North Dakota	Grand Forks, ND	35.0	7.6	74.0
Southeastern North Dakota	Valley City, ND	138.0	30.1	295.0
Northwestern Minnesota	Ada, MN	29.0	6.3	64.5
West Central Minnesota	Elbow Lake, MN	48.0	10.5	93.5
South Dakota	Aberdeen, SD	29.0	6.3	88.0
Texas	Lubbock, TX	180.0	39.2	300.0
Total		459.0	100.0	915.0
	Farmers' Projected Acreage			
Northeastern North Dakota	Grand Forks, ND	150.0	12.8	321.0
Southeastern North Dakota	Valley City, ND	350.0	29.8	748.0
Northwestern Minnesota	Ada, MN	29.0	2.5	64.5
West Central Minnesota	Elbow Lake, MN	48.0	4.1	93.5
South Dakota	Aberdeen, SD	58.0	4.9	176.0
Texas	Lubbock, TX	540.0	45.9	600.0
Total		1,175.0	100.0	2,003.0
	Maximum Potential North Dakota Production			
Northeastern North Dakota	Grand Forks, ND	472.0	24.2	1,110.0
Southeastern North Dakota	Valley City, ND	803.0	41.2	1,890.0
Northwestern Minnesota	Ada, MN	29.0	1.5	64.5
West Central Minnesota	Elbow Lake, MN	48.0	2.5	93.5
South Dakota	Aberdeen, SD	58.0	3.0	176.0
Texas	Lubbock, TX	540.0	27.6	600.0
Total		1,950.0	100.0	3,934.0

locations in the U.S. (Minneapolis-St. Paul and Lubbock, Texas) were identified as locations in which sunflower processing facilities are presently located (Figure 39).* Estimates of the crush capacity at each location that could be used for crushing sunflowers were made using information provided by industry sources. A long-run adjustment was made in the crush capacity at both locations to allow for a possible increase in the quantity of sunflowers crushed, but recognizing that other oilseed crops will also be processed at existing facilities. The crush capacity estimates are provided in Table 63.

Three locations in North Dakota were selected for illustrative purposes as a possible site for a sunflower processing facility. Those sites represent the Northeast, East Central, and Southeast areas of the state (which also represent the areas of greatest sunflower production in the state). To determine the maximum quantity of sunflowers that would move into each North Dakota location, the crush capacity of each location was assumed to be unlimited. Each North Dakota location was analyzed separately to determine the effect on the overall flow of sunflowers, oil, and meal to processing and final demand points specified in the study.

*Generally, oilseed processing facilities can be used to crush different oilseed crops, and it is possible that small quantities of sunflowers are crushed at other locations. However, it was assumed that the level of sunflower crush at these locations is small and would not increase appreciably unless oilseed sunflower production increased in those areas.

Sunflower Exports

Most of the oil sunflower crop produced in the U.S. in recent years has been exported. According to industry sources, approximately three-fourths of the 1975 crop will be exported; and it was assumed that the proportion of the U.S. sunflower crop exported would remain at that level. This assumption was modified in analyzing one of the potential plant locations in North Dakota to determine the effect on the industry of a substantial increase in the domestic crush. The assumption was modified so that only 25% of the sunflower crop was exported for the production estimate in which maximum sunflower production in North Dakota was assumed. Estimates of sunflower exports are provided in Table 67, p. 74.

Duluth-Superior and New Orleans were selected as export points. Most of the sunflowers exported from the U.S. have moved through the Duluth-Superior port. However, New Orleans, as well as other gulf ports, may become an important export point for sunflowers as the production of sunflowers in the South increases. Each export point was assumed to have unlimited capacity in handling sunflowers.

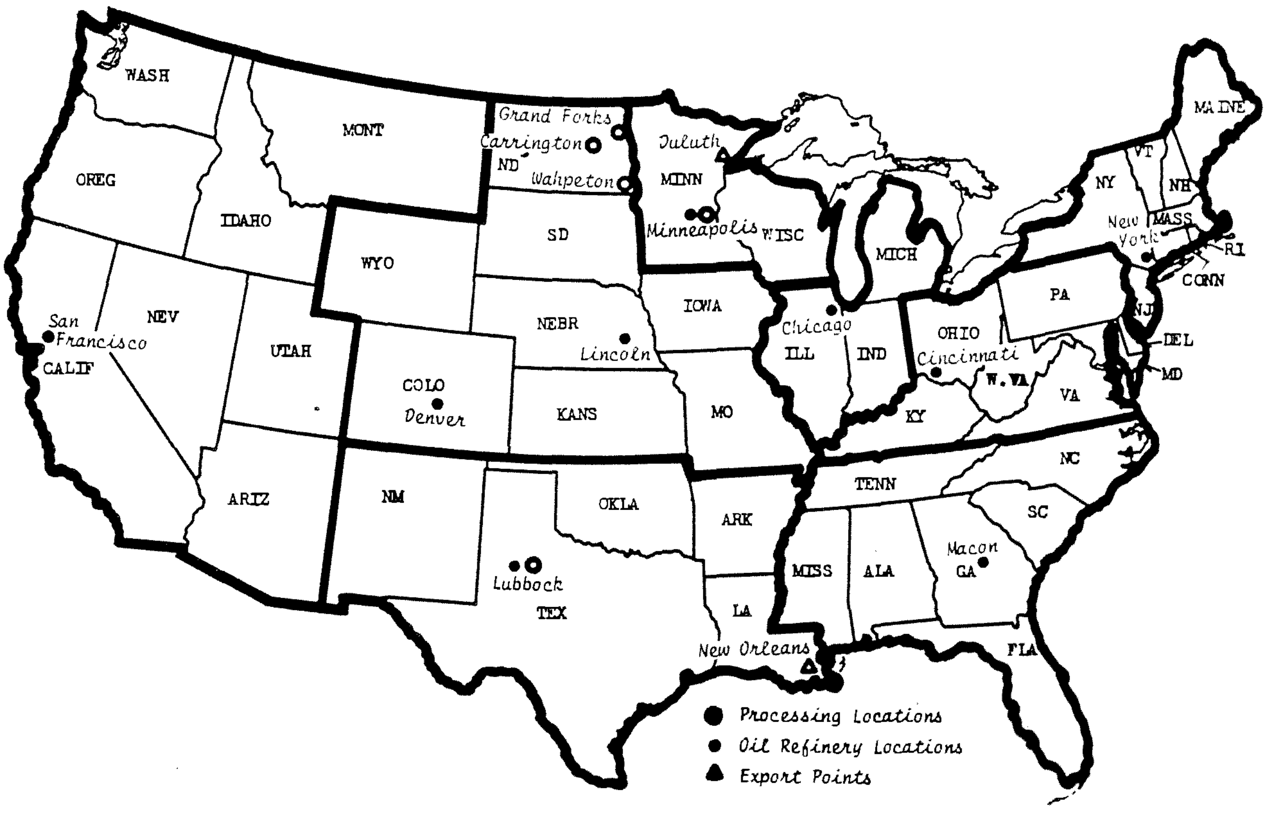


Figure 39. Regional Processing and Oil Refinery Locations and Export Points Used in Transportation Analysis

Oil Refineries

The use of sun oil in the U.S. has been quite limited and, as a result, relatively little oil has been refined domestically. In addition, very little sun oil has been exported from the U.S. either in raw or refined form because of the ad valorem import taxes the EEC has levied on vegetable oil. For these reasons, it is particularly difficult to establish estimates of sun oil production and disposition. Accordingly, the estimates of oil production and disposition presented in this study should be viewed in their proper perspective as not representing predictions, but one possible set of alternative estimates that could be made.

Historically, domestic use of sun oil has accounted for less than 1.0% of the annual total edible vegetable oil consumption in the U.S. However, significant increases in domestic consumption of sun oil occurred in 1973 and 1974, and it is assumed that this trend will continue in the future.

Eight groups of states were selected as regional refining centers of crude sun oil. Within each of those eight regions, a central point was identified through which crude oil shipments from processors for domestic use were assumed to move (Figure 39).

The refinery locations were selected on the basis of industry publications that identified the location of vegetable oil refineries (46, 47) and on the basis of the following assumptions:

(1) refiners that are presently processing crude sun oil will continue to do so;

(2) given an increase in the domestic demand for sun oil, the oil will be refined at regional locations satisfying regional demands; and

(3) there are no technological or capacity limitations that would prevent refiners of edible fats and oils from refining sun oil.

It was assumed that 80% of the sun oil produced was refined domestically and the balance was exported for each sunflower production estimate. The estimates of the quantity of sun oil refined in the U.S. and crude oil exported that were used in the transportation analysis are provided in Table 64.

The quantity of oil refined in each region was determined using the proportion of projected U.S. population accounted for by each region (Table 65). The 1985 population projections were used in determining the regional disposition of oil under both estimates of increased sunflower production. It should be noted that this procedure does not and is not intended to take into account interregional differences in the consumption of products for which refined sun oil may be used as a primary input. The assumption of no capacity limitations on refiners seems realistic since the industry has operated at an estimated two-thirds of the maximum annual capacity (48, p. 24).

Exports of sun oil have varied considerably in recent years. Almost 90% of the oil produced in the U.S. was exported in 1972, while in 1974 approximately 10% was exported (34, November, 1974, pp. 27-36). For the purpose of this study, 20% of U.S. sun oil production was assumed to be exported. Duluth-Superior and New Orleans were selected as possible export points for sun oil. According to industry sources, most of the oil that has been exported has moved through the Duluth-Superior port. However, this could change in the future with more oil moving through gulf ports.

Sun Meal Use

The use of sun meal as a feed ingredient has been quite limited. Most of the meal produced has been used in the same geographic area in which it was produced. According to industry sources, most of the sun meal produced in the Minneapolis-St. Paul area is shipped to southern Minnesota and western Wisconsin.

Nine meal consumption regions within the U.S. were identified for the purpose of this study (Figure 40). The regions were delineated on the basis of (1) the present demand for sun meal, (2) the fact that feed manufacturers in the western and southwestern parts of the U.S.

TABLE 63. Annual Regional Sunflower Crush Capacity Employed in Transportation Analysis

Location	Short-Run Annual Capacity	Long-Run Annual Capacity
	(1,000 tons)	(1,000 tons)
Minneapolis-St. Paul	117	300
Lubbock, Texas	100	200
North Dakota	Unlimited	Unlimited

TABLE 64. Produced, Refined, and Exported Sun Oil Used in the Transportation Analysis for Alternative Sunflower Production Estimates

Sunflower Production Estimate	Sun Oil Refined in U.S.	Sun Oil Exports	Total U.S. Sun Oil Production
	(.................. 1,000 tons	..................)	
1975	35.4	8.9	44.3
Farmers' Projected Acreage	90.6	22.6	113.2
Maximum Potential North Dakota Sunflower Production	150.0	37.9	187.9

obtain supplies of oilseed meal from Midwest and Southern suppliers, and (3) the assumption that there would be a greater number of potential outlets for meal located closer to a sunflower processing plant than farther away.

Analysis of oilseed meal prices in different producing and consumption areas in the U.S. suggest that most of the sun meal produced in the Upper Midwest would be sold in that area and in western markets. Shipments of meal farther east and south into major supply areas would not seem likely and, in fact, would move against the geographic price structure. To provide an illustration

TABLE 65. Population Projections[1] and Regional Sun Oil Consumption Estimates Used in the Transportation Analysis for Alternative Sunflower Production Estimates

		1975			Farmers' Projected Acreage			Maximum Potential North Dakota Sunflower Production
Region	Central Receiving Point	Population of Region	% of U.S. Population in Region	Sun Oil Consumption	Population of Region[2]	% of U.S. Population in Region[2]	Sun Oil Consumption[2]	Sun Oil Consumption[2]
		(millions)		(1,000 tons)	(millions)		(1,000 tons)	(1,000 tons)
1	New York, NY	37,634	17.7	6.3	41,430	17.7	16.0	26.6
2	Cincinnati, OH	38,145	17.9	6.3	41,898	17.9	16.2	26.9
3	Macon, GA	31,700	14.9	5.3	34,876	14.9	13.5	22.4
4	Chicago, IL	25,613	12.0	4.3	28,088	12.0	10.9	18.0
5	Minneapolis, MN	8,533	4.0	1.4	9,363	4.0	3.6	6.0
6	Lincoln, NB	15,672	7.3	2.6	17,087	7.3	6.6	10.9
7	Lubbock, TX	22,003	10.3	3.6	24,109	10.3	9.3	15.4
8	San Francisco, CA	33,824	15.9	5.6	37,217	15.9	14.4	23.8
	Total	213,124	100.0	35.4	234,068	100.0	90.5	150.0

[1]SOURCE: (49).

[2]1985 population projections were used to estimate regional sun oil consumption for both long-run sunflower production estimates. This is not meant to imply, however, that either production estimate will be attained by 1985. It was assumed that the percent of U.S. population in each region was the same for both short-run and long-run estimates.

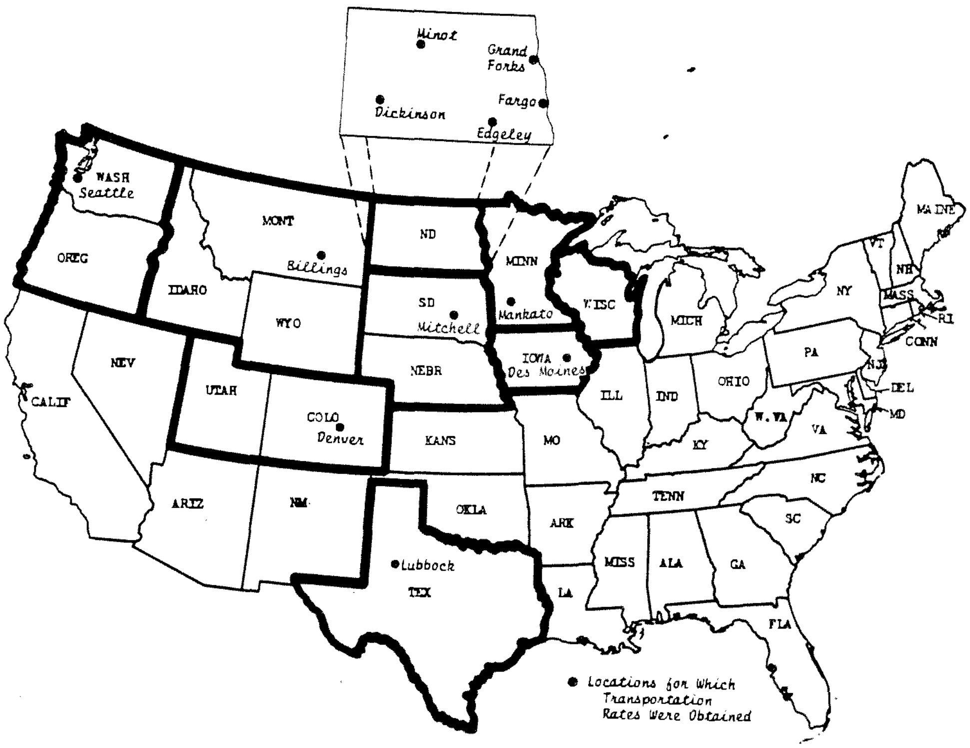


Figure 40. Regional Sun Meal Consumption Regions Employed in Transportation Analysis

of the geographic price structure of oilseed meals, the price of soybean meal at various locations in the U.S. and the cost of shipping meal to these locations are compared with the price at Decatur, Illinois (a major supply point for soybean meal) (Table 66).

The prices for soybean meal at the different locations in relation to the price at Decatur reflect the influence of local supplies, as well as transportation costs. For example, the differences in the price of soybean meal between Decatur and Kansas City and Minneapolis are relatively small and reflect the influence of local supplies. The difference in price between Decatur and Chicago reflects transportation costs, while the differences in price between Decatur and western points also reflect the transportation cost of importing soybean meal from a surplus producing region.

Examination of the soybean meal geographic price differentials and transportation rates suggests in which markets oilseed meal produced at a North Dakota location could compete. In addition to satisfying the demand in local markets, meal produced at the North Dakota location could compete in western markets with meal produced in other areas. Eastern markets, such as Buffalo, would have limited potential as possible markets for meal produced at a location in North Dakota because of the transportation rate structure.

TABLE 66. Price Differences and Transportation Rates for Soybean Meal Between Selected Locations and a Major Supply Point,[1] 1975

Location	Soybean Meal Price[2]	Price Above Major Supply Point	Transportation Rate from Major Supply Point[3]	Transportation Rate from East Central North Dakota Location[3]
	(........	....	$/ton	........)
Portland, OR	157.35	32.89	41.50	36.30
Los Angeles, CA	157.51	33.05	41.50	33.00
San Francisco, CA	157.58	33.12	41.50	33.00
Chicago, IL	132.98	8.52	8.90	27.40
Kansas City, MO	127.39	2.93	11.00	21.60
Minneapolis, MN	126.82	2.36	20.10	17.90
Buffalo, NY	138.89	14.40	24.00	52.80
Decatur, IL	124.46	0.00	—	28.80

[1]Major supply point: Decatur, Illinois.
[2]Average annual price of soybean meal, 44% solvent.
[3]Rail rates were used for all transportation rates.

TABLE 67. Summary of Production and Distribution of Sunflower Seed, Oil, and Meal Employed in Transportation Analysis

Item	1975	Farmers' Survey Projection	Maximum Potential North Dakota Sunflower Production
	(........	1,000 tons	........)
Production	459.0	1,175.0	1,950.0
Disposition of Sunflowers			
Crush (1,000 Tons)	115.0	294.0	488.0
Exports (1,000 Tons)	344.0	881.0	1,462.0
Disposition of Crush			
Meal (1,000 Tons)	64.4	164.6	273.3
Oil			
Domestic Utilization	35.4	90.6	150.0
Exports of Oil or Meal	8.9	22.6	37.9
Total	44.3	113.2	187.9

Central points for receiving shipments of meal were specified within the nine meal consumption regions (Table 68). For each region, the quantity of sun meal that could be used was assumed to be 30% of total oilseed meal used by feed manufacturers in 1975. This assumption seems reasonable based on the quantity of feed produced for ruminant animals in the nine meal consumption regions (33, pp. 8-15) and the fact that most sun meal is fed to ruminants. The utilization of oilseed meal was estimated using 1975 U.S. oilseed meal production estimates and estimates of the quantity of meal used by feed manufacturers (50, p. 20).

Transportation Structure of the Sunflower Industry

Truck, rail, and barge were considered for shipping sunflowers, oil, and meal. According to industry sources:

(1) both truck and rail are used to ship sunflowers from producing areas to processing and export points;

(2) most of the sun oil is shipped by rail in 60,000 pound jumbo tank cars;

TABLE 68. Regional Sun Meal Use Employed in Transportation Analysis

Region	Regional Center	Maximum Annual Use[1]
		(.....1,000 tons.....)
1	Seattle, WA	43.0
2	Billings, MT	26.0
3	Denver, CO	43.0
4a	Minot, ND	10.0
4b	Dickinson, ND	10.0
4c	Grand Forks, ND	6.0
4d	Fargo, ND	12.0
4e	Edgeley, ND	12.0
5	Mitchell, SD	173.0
6	Mankato, MN	130.0
7	Eau Claire, WI	130.0
8	Des Moines, IA	432.0
9	Lubbock, TX	346.0

[1]Based on the assumption that sun meal could account for 30% of total oilseed meal used by feed manufacturers in 1975.

(3) most of the sun meal is shipped by truck, but would probably be shipped by rail if the distance were greater than 400 miles;

(4) if sunflowers grown in the Upper Midwest were exported through New Orleans, they could be shipped by barge from Minneapolis-St. Paul down the Mississippi River.

The mode of transportation used to ship sunflowers and sun meal was selected on the basis of least cost transportation rates. Truck, rail, and barge rates that reflected current rates were collected from industry sources and compared to determine the least cost mode of transportation (Tables 69 and 70). All sun oil shipments were assumed to move by rail with the exception of shipments from Minneapolis to New Orleans which would move by barge (Table 71) during the shipping season. Oil produced at Minneapolis for export through New Orleans would require storage during the winter when the river is frozen. However, a storage cost was not considered in the analysis.

Estimates of the cost of transporting sunflowers by truck had to be made since sunflowers are an unregulated commodity. Truck rates were obtained from private trucking firms and the Upper Great Plains Transportation Institute at North Dakota State University. An average cost estimate provided by representatives of the Transportation Institute was used because of the variability in rates quoted by the trucking firms. The truck rates used for the shipment of sunflowers were based on an estimated average cost of 41.2 cents/mile to transport a cargo of 45,000 pounds and assumed a backhaul.*

Analysis of Industry Marketing Patterns for the 1975 Sunflower Production Estimate

The first stage of the transportation analysis was to analyze industry marketing patterns using the 1975 estimates of sunflower production and meal and oil production. Two separate analyses were undertaken. In the first situation, no North Dakota processing plant was introduced into the analysis so that a basis would exist for analyzing the effect on industry marketing patterns for each North Dakota plant. In the second situation, a North Dakota plant was introduced into the model to compete with existing facilities. The procedure was repeated for each North Dakota plant so that comparisons between the three North Dakota locations could be made.

The least-cost sunflower and sun oil shipments with no North Dakota plant allowed to enter the solution are presented in Tables 72 and 73. Given the geographic dispersion of production and processing locations, both processing locations entered the solution with 15 thousand tons of sunflowers crushed at the Minneapolis location and 100 thousand tons at the Lubbock location. In the least-cost solution, 8.4 thousand tons of meal were produced at the Minneapolis location and shipped to the Mankato region, while 56 thousand tons of meal were produced and used at the Lubbock location.

A comparison between these product flows and what would be expected given actual industry conditions is not entirely possible. As indicated earlier, the final demand locations for the oil and meal represent one possible set of spatial configurations that could develop. In addition, oilseed processors in the southern part of the U.S. have not crushed large quantities of sunflowers in the past. Some observations can be made, however, with respect to the product flows indicated by the model.

*If a backhaul were not assumed, the average cost/mile would be 82.4 cents. This would not change the results of the transportation analysis, however, because all costs to ship sunflowers would increase by the same amount.

TABLE 69. Least-Cost Transportation Rates for Shipping Sunflowers From Production Areas to Processing and Export Destinations[1] (In Cents/Ton and Cents /Cwt.)[2]

FROM Sunflower Production Locations / TO Sunflower Processing Locations	Grand Forks, ND	Carrington, ND	Wahpeton, ND	Minneapolis, MN	Duluth, MN	Lubbock, TX	New Orleans, LA
Grand Forks, ND	—	540 T (27)	440 T (22)	1,020 R (51)	920 T (46)	3,940 R (197)	1,640 TB (82)
Valley City, ND	440 T (22)	320 T (16)	320 T (16)	1,100 T (55)	1,040 T (52)	3,920 R (196)	1,720 TB (86)
Ada, MN	260 T (13)	540 T (27)	320 T (16)	920 T (46)	860 T (43)	3,940 R (197)	1,540 TB (77)
Elbow Lake, MN	540 T (27)	760 T (38)	220 T (11)	540 T (27)	800 T (40)	3,720 R (186)	1,160 TB (58)
Aberdeen, SD	920 T (46)	540 T (27)	480 T (24)	980 T (49)	1,440 R (72)	3,720 R (186)	1,600 TB (80)
Lubbock, TX	3,940 R (197)	3,920 R (196)	3,740 R (187)	3,700 R (185)	3,920 R (196)	—	2,820 R (141)

[1]Where the central point of production and processing regions coincided, the transportation rate was assumed to be zero. In reality, there would be a transportation cost, but it would be small relative to the cost of interregional shipments.
[2]The rates in cents/cwt. are in parentheses.
R — Rail Rate.
T — Truck Rate.
TB — Truck and Barge Rate.

TABLE 70. Least-Cost Transportation Rates for Shipping Sun Meal From Processors to Feed Manufacturing Destinations (In Cents/Ton)[1]

FROM Sunflower Processing Locations / TO Meal Consumption Locations	1 Seattle, WA	2 Billings, MT	3 Denver, CO	4a Minot, ND	4b Dickinson, ND	4c Grand Forks, ND	4d Fargo, ND	4e Edgeley, ND	5 Mitchell, SD	6 Mankato, MN	7 Eau Claire, WI	8 Des Moines, IA	9 Lubbock, TX
Grand Forks, ND	3,620 R	2,235 T	2,790 R	830 R	1,070 R	—	500 R	780 R	1,640 R	1,400 T	1,325 T	1,810 R	3,860 R
Carrington, ND	3,620 R	1,690 T	2,730 R	590 R	900 R	780 R	680 R	590 R	1,075 T	1,570 T	1,525 T	1,810 R	3,860 R
Wahpeton, ND	3,620 R	2,235 T	2,650 R	920 R	1,010 R	590 R	450 R	590 R	955 T	1,040 T	955 T	1,520 R	3,860 R
Minneapolis, MN	3,620 R	2,870 T	2,270 R	1,725 T	1,920 T	1,130 T	925 T	1,130 T	1,180 T	545 T	545 T	955	5,140 R
Lubbock, TX	4,430 R	4,345 T	1,630 T	4,420 R	5,490 R	3,860 R	3,730 R	3,860 R	2,750 R	2,810 R	5,405 T	2,420 R	—

R — Rail Rate.
T — Truck Rate.
[1]The rail rates reflect the rates in effect on June 6, 1975. The truck rates reflect the rates in effect on November 3, 1974.

TABLE 71. Least-Cost Transportation Rates for Shipping Crude Sun Oil From Processors to Refinery and Export Destinations[1] (In Cents/Ton and Cents/Cwt.)[2]

FROM Sunflower Processing Locations \ TO Oil Refinery and Export Locations	1 New York, NY	2 Cincinnati, OH	3 Macon, GA	4 Chicago, IL	5 Minneapolis, MN	6 Lincoln, NE	7 Lubbock, TX	8 San Francisco, CA	E Duluth, MN	E New Orleans, LA
Grand Forks, ND	3,460 R (173)	2,420 R (121)	3,180 R (159)	2,080 R (121)	1,340 R (67)	1,900 R (95)	3,600 R (180)	3,560 R (178)	1,260 R (63)	3,640 R (182)
Carrington, ND	3,600 R (180)	2,540 R (127)	3,220 R (161)	2,280 R (127)	1,560 R (78)	1,820 R (91)	3,600 R (180)	3,560 R (178)	1,560 R (78)	3,660 R (183)
Wahpeton, ND	3,380 R (169)	2,400 R (120)	3,000 R (150)	1,940 R (97)	1,100 R (55)	1,740 R (87)	3,440 R (172)	3,560 R (178)	1,140 R (57)	3,550 R (175)
Minneapolis, MN	2,820 R (141)	2,020 R (101)	2,580 R (129)	1,540 R (77)	—	1,560 R (78)	3,280 R (164)	3,560 R (178)	980 R (49)	750 R (37.5)
Lubbock, TX	3,660 R (183)	2,780 R (139)	3,280 R (164)	3,180 R (159)	3,060 R (153)	2,120 R (106)	—	3,800 R (190)	X	2,420 R (121)

[1]The rail rates reflect the rates in effect on June 6, 1975. The barge rate reflects an average rate during the spring of 1976.

[2]The rates in cents/hundredweight are in parentheses.

R — Rail rate.
B — Barge rate.
X — Dummy rate inserted.
E — Export location.

TABLE 72. Least-Cost Sunflower Flows for 1975 Production Estimates Without Any North Dakota Processing Plants

FROM Sunflower Production Locations \ TO Sunflower Processing and Export Locations	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	Total
	(……….	1,000	tons	……….)	
Grand Forks, ND			35.0		35.0
Valley City, ND			138.0		138.0
Ada, MN			29.0		29.0
Elbow Lake, MN			48.0		48.0
Aberdeen, SD	15.0		14.0		29.0
Lubbock, TX		100.0		80.0	180.0
Total	15.0	100.0	264.0	80.0	459.0

First, 77% of the sunflowers moving to export would move through the Duluth-Superior port. In the past almost all of the sunflower exports have moved through that port, but with a substantial increase in sunflower production in Texas, export from gulf ports becomes important.

Second, the quantity of sunflowers crushed at the Minneapolis location was less than what has been crushed at that location in recent years. Third, sun oil exports moved through the New Orleans port reflecting the relatively low cost of transporting oil by barge from Minneapolis to New Orleans. Sun oil exports in the past have moved almost exclusively through the Duluth-Superior port.

The least-cost product flows of sunflowers, oil, and meal under the 1975 sunflower production estimate with each North Dakota plant analyzed separately are presented in Tables 74, 75, and 76. In each instance, the North Dakota plant entered the solution and in each instance the level of processing activity at the Minneapolis location declined significantly. When the plant in southeastern North Dakota entered the solution, processing activity at the Minneapolis location declined to zero. Comparisons of the level of processing activity of each North Dakota plant with existing plants for each sunflower production estimate are presented in Table 77.

The following observations can be made in comparing the competitive position of the three North Dakota processing facilities as each was allowed to compete with existing facilities:

(1) Two of the North Dakota plants would produce approximately one-half of the oil required for export, and one of those plants would also serve the entire oil market of Consumption Region 5. The third North Dakota plant would serve the entire oil market of Consumption Region 4.

(2) The meal produced at each North Dakota plant would be shipped to North Dakota markets, reflecting close proximity to each plant.

TABLE 73. Least-Cost Sun Oil Flows for 1975 Production Estimate Without Any North Dakota Processing Plants

TO Oil Refinery and Export Locations / FROM Sunflower Processing Locations	1 New York, NY	2 Cincinnati, OH	3 Macon, GA	4 Chicago, IL	5 Minneapolis, MN	6 Lincoln, NB	7 Lubbock, TX	8 San Francisco, CA	E Duluth, MN	E New Orleans, LA	Total
	(1,000 tons)										
Minneapolis, MN					1.4					4.4	5.8
Lubbock, TX	6.3	6.3	5.3	4.3		2.6	3.6	5.6		4.5	38.5
Total	6.3	6.3	5.3	4.3	1.4	2.6	3.6	5.6		8.9	44.3

E — Export.

TABLE 74. Least-Cost Sunflower Flows for 1975 Production Estimate, Three North Dakota Processing Plant Locations Considered Separately

TO / FROM Sunflower Production Locations	Sunflower Processing and Export Locations Including Northeastern, ND					Sunflower Processing and Export Locations Including East Central, ND					Sunflower Processing and Export Locations Including Southeastern, ND					Total Sunflower Production	Sunflower Production Locations
	Northeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	East Central, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	Southeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA		
	(1,000 tons)																
Grand Forks, ND	11.3			23.7		11.3			35.0					35.0		35.0	Grand Forks, ND
Valley City, ND				138.0					138.0					138.0		138.0	Valley City, ND
Ada, MN				29.0					29.0					29.0		29.0	Ada, MN
Elbow Lake, MN				48.0					48.0					48.0		48.0	Elbow Lake, MN
Aberdeen, SD		3.7		25.3			3.7		14.0		15.0			14.0		29.0	Aberdeen, SD
Lubbock, TX			100.0		80.0			100.0		80.0			100.0		80.0	180.0	Lubbock, TX
Total	11.3	3.7	100.0	264.0	80.0	11.3	3.7	100.0	264.0	80.0	15.0		100.0	264.0	80.0	459.0	Total

TABLE 75. Least-Cost Sun Oil Flows for 1975 Production Estimate, Three North Dakota Processing Plant Locations Considered Separately

FROM Sunflower Processing Locations / To Oil Refinery and Export Locations	1 New York, NY	2 Cincinnati, OH	3 Macon, GA	4 Chicago, IL	5 Minneapolis, MN	6 Lincoln, NB	7 Lubbock, TX	8 San Francisco, CA	E Duluth, MN	E New Orleans, LA	Total
	(1,000 tons)										
Northeastern, ND									4.4		4.4
Minneapolis, MN					1.4						1.4
Lubbock, TX	6.3	6.3	5.3	4.3		2.6	3.6	5.6		4.5	38.5
Total	6.3	6.3	5.3	4.3	1.4	2.6	3.6	5.6	4.4	4.5	44.3
East Central, ND				4.3					0.1		4.4
Minneapolis, MN					1.4						1.4
Lubbock, TX	6.3	6.3	5.3			2.6	3.6	5.6		8.8	38.5
Total	6.3	6.3	5.3	4.3	1.4	2.6	3.6	5.6	0.1	8.8	44.3
Southeastern, ND					1.4				4.4		5.8
Minneapolis, MN											
Lubbock, TX	6.3	6.3	5.3	4.3		2.6	3.6	5.6		4.5	38.5
Total	6.3	6.3	5.3	4.3	1.4	2.6	3.6	5.6	4.4	4.5	44.3

E — Export location.

TABLE 76. Least-Cost Sun Meal Flows for 1975 Production Estimate, Three North Dakota Processing Plant Locations Considered Separately

FROM Sunflower Processing Locations / TO Meal Consumption Locations	1 Seattle, WA	2 Billings, MT	3 Denver, CO	4a Minot, ND	4b Dickinson, ND	4c Grand Forks, ND	4d Fargo, ND	4e Edgeley, ND	5 Mitchell, SD	6 Mankato, MN	7 Eau Claire, WI	8 Des Moines, IA	9 Lubbock, TX	Total
	(1,000 tons)													
Northeastern, ND						6.0	0.3							6.3
Minneapolis, MN										2.1				2.1
Lubbock, TX													56.0	56.0
Total						6.0	0.3			2.1			56.0	64.4
East Central, ND								6.3						6.3
Minneapolis, MN										2.1				2.1
Lubbock, TX													56.0	56.0
Total								6.3		2.1			56.0	64.4
Southeastern, ND							8.4							8.4
Minneapolis, MN														
Lubbock, TX													56.0	56.0
Total							8.4						56.0	64.4

TABLE 77. Sunflower Crush at Each Processing Location for Each Production Estimate

Processing Location	Production Estimate: 1975 Tons/Yr.	1975 Tons/Day[1]	Farmers Projected Acreage Tons/Yr.	Farmers Projected Acreage Tons/Day[1]	Maximum North Dakota Potential Sunflower Production Tons/Yr.	Maximum North Dakota Potential Sunflower Production Tons/Day[1]
Northeastern, ND	11,300	38	71,400	238	214,900	716
Minneapolis, MN	3,700	12	22,600	75	73,100	244
Lubbock, TX	100,000	333	200,000	667	200,000	667
Total	115,000		294,000		488,000	
East Central, ND	11,300	38	60,700	202	182,000	607
Minneapolis, MN	3,700	12	33,300	111	106,000	353
Lubbock, TX	100,000	333	200,000	667	200,000	667
Total	115,000		294,000		488,000	
Southeastern, ND	15,000	50	84,600	282	272,400	908
Minneapolis, MN	—	—	9,400	31	15,600	52
Lubbock, TX	100,000	333	200,000	667	200,000	667
Total	115,000		294,000		488,000	

[1]Operating capacity is based on 24 hours/day, 300 days/year.

Sensitivity of Sunflower and Sun Oil Shipments to Transportation Rate Changes — 1975 Sunflower Production Estimate

Sensitivity analysis was employed in this study to analyze the effects of changes in transportation rates on the least-cost solution of the linear programming model. It indicated the range over which selected transportation rates could vary, while all other rates were held constant, and still maintain the level of shipments attained in the least-cost solution. Sensitivity analysis was used in this study to study the effect of changes in the rate structure on the least-cost product flows of sunflowers and oil.

The sensitivity of the rate structure of shipments of sunflowers from sunflower production regions in North Dakota, Minnesota, and South Dakota to each processing plant location in North Dakota was analyzed. In those instances where no shipment of sunflowers occurred in the least-cost solution, sensitivity analysis provided an indication of the rate decrease required to stimulate such a flow and the volume that would be shipped. Sensitivity analysis provided an indication of the magnitude of the rate increase required before each flow would be reduced or leave the solution for sunflower shipments occurring in the least-cost solution. It also provided an indication of the rate decrease required to increase the flow of sunflowers and the increase in volume to be expected.

The results of the sensitivity analysis of sunflowers under the 1975 production estimate are provided in Table 78. The results indicated that relatively large changes in rates would be required before the least-cost solution would change. Rate increases in excess of 18% for sunflower flows to North Dakota processing locations would be required before any of the flows would leave the solution. In all instances, substantial rate reductions would be required before the solution would change.

To illustrate the use of sensitivity analysis, consider the flow of sunflowers from the Aberdeen, South Dakota, production region to a processing plant in east central North Dakota. Under the least-cost solution, 11.3 thousand tons of sunflowers flowed from South Dakota to the North Dakota plant (Table 74). The transportation rate was $5.40/ton. The rate would have had to drop to $3.60/ton in order to increase sunflower shipments from the South Dakota production region to the North Dakota plant. At that rate, an additional 3.7 thousand tons of sunflowers would have been shipped to the processing facility. On the other hand, if the rate were to increase above $6.40/ton, the quantity of sunflowers shipped to the North Dakota plant would have declined.

Two types of markets were identified in analyzing the oil shipments from North Dakota processing facilities to refinery locations and export points. Active markets were those oil markets that a North Dakota plant served under the least-cost solution. Inactive markets were those that were not served by a North Dakota plant under the least-cost solution.

The results of the sensitivity analysis of the optimum oil flows for each North Dakota plant are presented in Table 79. The rate ranges show considerable stability for the inactive markets, while the rate ranges for the active markets show less stability. In considering the rate ranges for the inactive markets, a North Dakota plant in some instances could gain at least a share of certain inac-

TABLE 78. Effect of Changes in Transportation Rates on Sunflower Shipments to North Dakota Processing Locations for 1975 Production Estimate

Sunflower Production Location	Destination	Present Rate	Required Rate to Increase Shipment (anything less than)	Volume to be Gained	Upper Limit on Rate in Order to Continue to Supply Sunflowers
		(¢/ton)	(¢/ton)	(1,000 tons)	(¢/ton)
Grand Forks, ND	Northeastern, ND	—	0	3.7	280
	East Central, ND	540	20	11.3	[1]
	Southeastern, ND	440	0[2]	15.0	[1]
Valley City, ND	Northeastern, ND	440	120	11.3	[1]
	East Central, ND	320	140	11.3	[1]
	Southeastern, ND	320	80	15.0	[1]
Ada, MN	Northeastern, ND	260	0[2]	11.3	[1]
	East Central, ND	540	0[2]	11.3	[1]
	Southeastern, ND	320	0[2]	15.0	[1]
Elbow Lake, MN	Northeastern, ND	540	0[2]	11.3	[1]
	East Central, ND	760	0[2]	11.3	[1]
	Southeastern, ND	220	0[2]	11.3	[1]
Aberdeen, SD	Northeastern, ND	920	520	11.3	[1]
	East Central, ND	540	360	3.7	640
	Southeastern, ND	480	0[2]	6.4	600

[1]No shipments occur in the least-cost solution.
[2]The rate required to stimulate shipments is less than zero.

tive markets given the appropriate rate decrease, but at the same time it would lose all or part of an active market that it serves. This would occur in those instances where the advantage of the rate reduction on oil shipments was more than offset by the additional costs incurred in shipping sunflowers into the plant for processing.

Analysis of Industry Marketing Patterns for Alternative Estimates of Increased Sunflower Production

Two estimates of increased levels of sunflower production were made. One was based on sunflower acreage estimates obtained in a survey of farmers in North Dakota and the other was based on the assumption of maximum potential sunflower production in North Dakota (pp. 65-66). Under the estimate of the maximum potential sunflower production, it was assumed that three million acres of sunflowers would be grown in North Dakota, and that the proportion of production shipped from each producing region would be the same as that indicated in the farm survey. The sunflower production estimate and the resulting crush using the maximum potential North Dakota production estimate was 66% higher than the production estimate based on the survey of North Dakota farmers.

The production estimate based on maximum potential sunflower production in North Dakota was also used to determine the impact on marketing and processing activities if sunflower exports were reduced from 75% to 25%. The southeastern North Dakota plant location was used for this purpose.

An adjustment was made in the crush capacity at existing locations to reflect long-run adjustments. As in the short-run, each North Dakota plant was assumed to have unlimited capacity in the long-run (Table 63, p. 72).

The same procedure was used in analyzing each of the North Dakota locations as was discussed in the previous section. That is, in no instance was more than one North Dakota location introduced into the model to compete with existing plants.

Farmers' Projected Acreage

The least-cost product flows of sunflowers, oil, and meal under the production estimate based on the survey of North Dakota farmers with each North Dakota plant analyzed separately are presented in Tables 80, 81, and 82. The sunflower crush at each processing location is given in Table 77. Each of the existing processing locations entered the solution as does each North Dakota

TABLE 79. Effect of Changes in Transportation Rates on Sun Oil Shipments to All Markets From North Dakota Processing Locations for 1975 Production Estimate

North Dakota Sunflower Processing Location	Market	Destination	Present Rate	Required Rate to Increase Shipment (anything less than)	Volume to be Gained	Upper Limit on Rate in Order to Keep Present Market
			(¢/ton)	(¢/ton)	(1,000 tons)	(¢/ton)
Northeastern, ND	1	New York, NY	3,460	2,500	4.4	[1]
	2	Cincinnati, OH	2,420	1,620	4.4	[1]
	3	Macon, GA	3,180	1,940	4.4	[1]
	4	Chicago, IL	2,080	2,020	4.3	[1]
	5	Minneapolis, MN	1,340	1,260	1.4	[1]
	6	Lincoln, NB	1,900	960	2.6	[1]
	7	Lubbock, TX	3,600	0[2]	3.6	[1]
	8	San Francisco, CA	3,560	2,640	4.4	[1]
	E	Duluth, MN	1,260	400	28.3	1,320
	E	New Orleans, LA	3,640	1,260	4.4	[1]
East Central, ND	1	New York, NY	3,600	2,800	[3]	[1]
	2	Cincinnati, OH	2,540	1,920	[3]	[1]
	3	Macon, GA	3,220	2,240	[3]	[1]
	4	Chicago, IL	2,280	[4]	[4]	2,320
	5	Minneapolis, MN	1,560	1,080	1.4	[1]
	6	Lincoln, NB	1,820	1,260	[3]	[1]
	7	Lubbock, TX	3,600	0[2]	[3]	[1]
	8	San Francisco, CA	3,560	2,940	[3]	[1]
	E	Duluth, MN	1,560	1,520	4.3	1,820
	E	New Orleans, LA	3,660	1,560	[3]	[1]
Southeastern, ND	1	New York, NY	3,380	2,380	4.4	[1]
	2	Cincinnati, OH	2,400	1,500	4.4	[1]
	3	Macon, GA	3,000	1,820	4.4	[1]
	4	Chicago, IL	1,940	1,900	4.3	[1]
	5	Minneapolis, MN	1,100	[4]	[4]	1,440
	6	Lincoln, NB	1,740	840	2.6	[1]
	7	Lubbock, TX	3,440	0[2]	3.6	[1]
	8	San Francisco, CA	3,560	2,520	4.4	[1]
	E	Duluth, MN	1,140	240	28.3	1,180
	E	New Orleans, LA	3,500	1,140	4.4	[1]

[1]Inactive market.
[2]The rate required to stimulate shipments is less than zero.
[3]Less than 1,000 tons.
[4]The North Dakota plant has the entire market. No increase is possible even with reduced rates.

plant. As in the analysis of the three North Dakota plants, using the 1975 sunflower production estimate, the plant in southeastern North Dakota competed the strongest with the Minneapolis location. The southeastern North Dakota plant crushed 282 tons of sunflowers per day compared to 31 tons per day at the Minneapolis location.

In considering the least-cost flows of sunflowers, oil, and meal, the following observations can be made with respect to comparing the three North Dakota locations:

(1) The plant in northeastern North Dakota would receive shipments of sunflowers for processing from the northern production region in North Dakota. The east central and southeastern plants would receive shipments from production regions in both North Dakota and South Dakota.

(2) The northeastern location would ship oil to one domestic market and produce all of the oil moving to export. The east central location would provide all of the oil required in Consumption Region 4 and produce over one-half of the oil needed to meet export requirements. The plant in southeastern North Dakota would capture virtually all of the oil market in Consumption Region 4 and produce all of the oil moving to export.

(3) The sun meal produced at each North Dakota location would be shipped to North Dakota markets. The

TABLE 80. Least-Cost Sunflower Flows for Sunflower Production Estimate Based on Survey of North Dakota Farmers, Three North Dakota Processing Plant Locations Considered Separately

FROM Sunflower Production Locations \ TO	Sunflower Processing and Export Locations Including Northeastern, ND					Sunflower Processing and Export Locations Including East Central, ND					Sunflower Processing and Export Locations Including Southeastern, ND					Total Sunflower Production	Sunflower Production Locations
	Northeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	East Central, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	Southeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA		
	(1,000 tons)																
Grand Forks, ND	71.4			78.6					150.0					150.0		150.0	Grand Forks, ND
Valley City, ND				350.0		36.0			314.0		26.6			324.4		350.0	Valley City, ND
Ada, MN				29.0					29.0					29.0		29.0	Ada, MN
Elbow Lake, MN				48.0					48.0			9.4		38.6		48.0	Elbow Lake, MN
Aberdeen, SD		22.6		35.4		23.3	33.3				58.0					58.0	Aberdeen, SD
Lubbock, TX			200.0		340.0			200.0		340.0			200.0		340.0	540.0	Lubbock, TX
Total	71.4	22.6	200.0	541.0	340.0	60.7	33.3	200.0	541.0	340.0	84.6	9.4	200.0	541.0	340.0	1,175.0	Total

TABLE 81. Least-Cost Sun Oil Flows for Sunflower Production Estimate Based on Survey of North Dakota Farmers, Three North Dakota Processing Plant Locations Considered Separately

FROM Sunflower Processing Locations \ TO Oil Refinery and Export Locations	1	2	3	4	5	6	7	8	E	E	
	New York, NY	Cincinnati, OH	Macon, GA	Chicago, IL	Minneapolis, MN	Lincoln, NB	Lubbock, TX	San Francisco, CA	Duluth, MN	New Orleans, LA	Total
	(1,000 tons)										
<u>Northeastern, ND</u>				4.9					22.6		27.5
Minneapolis, MN				5.1	3.6						8.7
Lubbock, TX	16.0	16.2	13.5	0.9		6.6	9.3	14.4			76.9
Total	16.0	16.2	13.5	10.9	3.6	6.6	9.3	14.4	22.6		113.1
<u>East Central, ND</u>				10.9					12.5		23.4
Minneaplis, MN					3.6					9.2	12.8
Lubbock, TX	16.0	16.2	13.5			6.6	9.3	14.4		0.9	76.9
Total	16.0	16.2	13.5	10.9	3.6	6.6	9.3	14.4	12.5	10.1	113.1
<u>Southeastern, ND</u>				10.0					22.6		32.6
Minneapolis, MN					3.6						3.6
Lubbock, TX	16.0	16.2	13.5	0.9		6.6	9.3	14.4			76.9
Total	16.0	16.2	13.5	10.9	3.6	6.6	9.3	14.4	22.6		113.2

E — Export location.

TABLE 82. Least-Cost Sun Meal Flows for Sunflower Production Estimate Based on Survey of North Dakota Farmers, Three North Dakota Processing Plant Locations Considered Separately

TO Meal Consumption Locations / FROM Sunflower Processing Locations	1 Seattle, WA	2 Rillings, MT	3 Denver, CO	4a Minot, ND	4b Dickinson, ND	4c Grand Forks, ND	4d Fargo, ND	4e Edgeley, ND	5 Mitchell, SD	6 Mankato, MN	7 Eau Claire, WI	8 Des Moines, IA	9 Lubbock, TX	Total
	(1,000 tons)													
Northeastern, ND				10.00		6.0	12.0	12.0						40.0
Minneapolis, MN											12.6			12.6
Lubbock, TX													112.0	112.0
Total				10.00		6.0	12.0	12.0			12.6		112.0	164.6
East Central, ND				10.00			12.0	12.0						34.0
Minneapolis, MN											18.6			18.6
Lubbock, TX													112.0	112.0
Total				10.00			12.0	12.0			18.6		112.0	164.6
Southeastern, ND				10.00		6.0	12.0	12.0	7.4					47.4
Minneapolis, MN											5.3			5.3
Lubbock, TX													112.0	112.0
Total				10.00		6.0	12.0	12.0	7.4		5.3		112.0	164.7

plant in southeastern North Dakota would also ship a small quantity of meal to South Dakota.

Maximum Potential North Dakota Sunflower Production

The least-cost flows of sunflowers, oil, and meal and the crush at each processing location under the maximum potential North Dakota sunflower production estimate are presented in Tables 83, 84, and 85 and also in 77. Again, each North Dakota processing location entered the solution and the southeastern North Dakota plant crushed the largest quantity of sunflowers of the three North Dakota locations. Under this production estimate, each North Dakota plant crushed a relatively large quantity of sunflowers because of the high production level assumed for the state.

The quantity of oil and meal shipped from each North Dakota location with the increased level of processing was greater than under the previous estimate of sunflower production. More oil and meal markets were served by each North Dakota location. With respect to meal flows, substantial quantities of meal would be shipped to Wisconsin in addition to serving North Dakota markets from both the northeastern and southeastern locations, while the east central location would ship meal to South Dakota. While these flows contradicted the flows suggested by the geographic price structure of oilseed meal, they occurred because of the nature of the transportation model which was designed to minimize the total transportation bill of shipping sunflowers, oil, and meal.

The assumption that 75% of the sunflower production is exported was modified to 25% and combined with the maximum North Dakota production estimate. The product flows of sunflowers, oil, and meal for the southeastern North Dakota processing location are presented in Tables 86, 87, and 88.

At the North Dakota location, 1,156 thousand tons of sunflowers were crushed annually (3,853 tons/day); and at the Minneapolis location, 106 thousand tons (353 tons/day) were crushed annually. The Texas processing facility operated at the upper limit of its long-run crush capacity. Sunflowers would be shipped from three of the five production locations in the northern three-state production area to the North Dakota processing plant.

The North Dakota plant would serve six of the eight domestic oil markets and produce all of the sun oil that is exported in considering the least-cost flows of oil and meal. The meal produced at the North Dakota plant would be shipped to all meal consumption locations in North Dakota, as well as to out-of-state locations to the south and east of the plant. No meal would be shipped to western locations outside of North Dakota. As indicated earlier, some of these meal flows would seem to contradict the geographic price structure of meal. The nature of the transportation model caused these flows to occur, however.

Sensitivity of Sunflower and Sun Oil Shipments to Transportation Rate Changes — Maximum Potential North Dakota Sunflower Production Estimate

Rate sensitivity analysis was used to analyze the stability of the sunflower and oil flows in the least-cost solution under the maximum potential North Dakota

TABLE 83. Least-Cost Sunflower Flows Assuming Maximum Potential North Dakota Sunflower Production Estimate, Three North Dakota Processing Plant Locations Considered Separately

From: Sunflower Production Locations \ To	Sunflower Processing and Export Locations Including Northeastern, ND					Sunflower Processing and Export Locations Including East Central, ND					Sunflower Processing and Export Locations Including Southeastern, ND					Total Sunflower Production	Sunflower Production Locations
	Northeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	East Central, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	Southeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA		
	(1,000 tons)																
Grand Forks, ND	214.9			257.1					472.0					472.0		472.0	Grand Forks, ND
Valley City, ND				803.0		182.0			621.0		214.4			588.6		803.0	Valley City, ND
Ada, MN				29.0					29.0					29.0		29.0	Ada, MN
Elbow Lake, MN		15.1		32.9			48.0					15.6		32.4		48.0	Elbow Lake, MN
Aberdeen, SD		58.0					58.0				58.0					58.0	Aberdeen, SD
Lubbock, TX			200.0		340.0			200.0		340.0			200.0		340.0	540.0	Lubbock, TX
Total	214.9	73.1	200.0	1,122.0	340.0	182.0	106.0	200.0	1,122.0	340.0	272.4	15.6	200.0	1,122.0	340.0	1,950.0	Total

TABLE 84. Least-Cost Sun Oil Flows Assuming Maximum Potential North Dakota Sunflower Production Estimate, Three North Dakota Processing Plant Locations Considered Separately

FROM: Sunflower Processing Locations \ TO: Oil Refinery and Export Locations	1	2	3	4	5	6	7	8	E	E	
	New York, NY	Cincinnati, OH	Macon, GA	Chicago, IL	Minneapolis, MN	Lincoln, NB	Lubbock, TX	San Francisco, CA	Duluth, MN	New Orleans, LA	Total
	(1,000 tons)										
Northeastern, ND		26.8		18.0					37.9		82.7
Minneapolis, MN	22.2				6.0						28.2
Lubbock, TX	4.4		22.3			11.0	15.4	23.9			77.0
Total	26.6	26.8	22.3	18.0	6.0	11.0	15.4	23.9	37.9		187.9
East Central, ND		14.2		18.0		11.0		23.9	3.1		70.2
Minneapolis, MN					6.0					34.8	40.8
Lubbock, TX	26.6	12.6	22.3				15.4				76.9
Total	26.6	26.8	22.3	18.0	6.0	11.0	15.4	23.9	3.1	34.8	187.9
Southeastern, ND	11.2	26.8		18.0		11.0			37.9		104.9
Minneapolis, MN					6.0						6.0
Lubbock, TX	15.4		22.3				15.4	23.9			77.0
Total	26.6	26.8	22.3	18.0	6.0	11.0	15.4	23.9	37.9		187.9

E — Export location.

TABLE 85. Least-Cost Sun Meal Flows Assuming Maximum Potential North Dakota Sunflower Production Estimate, Three North Dakota Processing Plant Locations Considered Separately

TO Meal Consumption Locations / FROM Sunflower Processing Locations	1 Seattle, WA	2 Billings, MT	3 Denver, CO	4a Minot, ND	4b Dickinson, ND	4c Grand Forks, ND	4d Fargo, ND	4e Edgeley, ND	5 Mitchell, SD	6 Mankato, MN	7 Eau Claire, WI	8 Des Moines, IA	9 Lubbock, TX	Total
	(1,000 tons)													
Northeastern, ND				10.0	10.0	6.0	12.0	12.0			70.3			120.3
Minneapolis, MN											40.9			40.9
Lubbock, TX													112.0	112.0
Total				10.0	10.0	6.0	12.0	12.0			111.2		112.0	273.2
East Central, ND				10.0	10.0	6.0	12.0	12.0	51.9					101.9
Minneapolis, MN											59.4			59.4
Lubbock, TX													112.0	112.0
Total				10.0	10.0	6.0	12.0	12.0	51.9		59.4		112.0	273.3
Southeastern, ND				10.0		6.0	12.0	12.0			112.6			152.6
Minneapolis, MN											8.7			8.7
Lubbock, TX													112.0	112.0
Total				10.0		6.0	12.0	12.0			121.3		112.0	273.3

TABLE 86. Least-Cost Sunflower Flows Using Maximum Production With a Reduced Level of Sunflower Exports[1]

TO / FROM Sunflower Production Locations	Sunflower Processing and Export Locations: Southeastern, ND	Minneapolis, MN	Lubbock, TX	Duluth, MN	New Orleans, LA	Total
	(1,000 tons)					
Grand Forks, ND	324.0			148.0		472.0
Valley City, ND	803.0					803.0
Ada, MN	29.0					29.0
Elbow Lake, MN		48.0				48.0
Aberdeen, SD		58.0				58.0
Lubbock, TX			200.0		340.0	540.0
Total	1,156.0	106.0	200.0	148.0	340.0	1,950.0

[1]A 25% level of exports of whole seed sunflowers assumed.

sunflower production estimate. The results are presented in Tables 89 and 90. The sensitivity analysis showed the solution to be somewhat unstable for both the sunflower flows and oil flows.

The sensitivity analysis showed the solution to be unstable for sunflower flows from the Valley City and Aberdeen production regions to the southeastern North Dakota processing location. In each instance a rate increase of less than 10% would reduce the quantity of sunflowers shipped to that processing location. The solution was stable for sunflower flows from the Valley City region to the east central processing location and from the Grand Forks region to the northeastern processing location. Substantial rate increases would have had to occur before sunflower shipments would be reduced in each of those situations. In most instances, substantial rate reductions would be required before additional sunflower shipments to North Dakota processing locations would occur.

The rate sensitivity relationships for the oil flows from North Dakota processing locations showed most of the relationships to be unstable. In most instances rate increases of less than 10% would reduce the quantity of oil shipped from North Dakota processing locations. Relatively small rate reductions would be required to stimulate oil shipments from North Dakota processing locations to Consumption Regions 1, 2, 6, and 8.

TABLE 87. Least-Cost Sun Oil Flows Assuming Maximum Potential North Dakota Sunflower Production Estimate and Reduced Level of Sunflower Exports

TO Oil Refinery and Export Locations / FROM Sunflower Processing Locations	1 New York, NY	2 Cincinnati, OH	3 Macon, GA	4 Chicago, IL	5 Minneapolis, MN	6 Lincoln, NB	7 Lubbock, TX	8 San Francisco, CA	E Duluth, MN	E New Orleans, LA	Total
	(……… 1,000 tons	………)									
Southeastern, ND	56.8	80.6	36.4	54.0		32.9		71.5	112.9		445.1
Minneapolis, MN	22.8				18.0						40.8
Lubbock, TX			30.6				46.4				77.0
Total	79.6	80.6	67.0	54.0	18.0	32.9	46.4	71.5	112.9		562.9

E — Export location.

TABLE 88. Least-Cost Sun Meal Flows Assuming Maximum Potential North Dakota Sunflower Production Estimate and Reduced Level of Sunflower Exports

TO Meal Consumption Locations / FROM Sunflower Processing Locations	1 Seattle, WA	2 Billings, MT	3 Denver, CO	4a Minot, ND	4b Dickinson, ND	4c Grand Forks, ND	4d Fargo, ND	4e Edgeley, ND	5 Mitchell, SD	6 Mankato, MN	7 Eau Claire, WI	8 Des Moines, IA	9 Lubbock, TX	Total
	(……… 1,000 tons	………)												
Southeastern, ND				10.0	10.0	6.0	12.0	12.0	173.0	130.0	130.0	164.3		647.3
Minneapolis, MN												59.4		59.4
Lubbock, TX													112.0	112.0
Total				10.0	10.0	6.0	12.0	12.0	173.0	130.0	130.0	223.7	112.0	818.7

TABLE 89. Effect of Changes in Transportation Rates on Sunflower Shipments to North Dakota Processing Locations for Maximum Potential North Dakota Sunflower Production Estimate

Sunflower Production Location	Destination	Present Rate	Required Rate to Increase Shipment (anything less than)	Volume to be Gained	Upper Limit on Rate in Order to Continue to Supply Sunflowers
		(¢/ton)	(¢/ton)	(1,000 tons)	(¢/ton)
Grand Forks, ND	Northeastern, ND	—	0[1]	15.1	20
	East Central, ND	540	200	182.0	[2]
	Southeastern, ND	440	200	214.4	[2]
Valley City, ND	Northeastern, ND	440	120	214.9	[2]
	East Central, ND	320	180	48.0	500
	Southeastern, ND	320	280	15.6	340
Ada, MN	Northeastern, ND	260	0[1]	29.0	[2]
	East Central, ND	540	140	29.0	[2]
	Southeastern, ND	320	140	29.0	[2]
Elbow Lake, MN	Northeastern, ND	540	0[1]	32.9	[2]
	East Central, ND	760	0[1]	48.0	[2]
	Southeastern, ND	220	80	32.4	[2]
Aberdeen, SD	Northeastern, ND	920	320	32.9	[2]
	East Central, ND	540	380	58.0	[2]
	Southeastern, ND	480	[3]	[3]	520

[1]The rate required to stimulate shipments is less than zero.
[2]No shipments occur in the least-cost solution.
[3]All of the sunflower production is shipped to the North Dakota processing location. No increase is possible even with reduced rates.

TABLE 90. Effect of Changes in Transportation Rates on Sun Oil Shipments to All Markets From North Dakota Processing Locations for Maximum Potential North Dakota Sunflower Production Estimate

North Dakota Sunflower Processing Location	Market	Destination	Present Rate	Required Rate to Increase Shipment (anything less than)	Volume to be Gained	Upper Limit on Rate in Order to Keep Present Market
			(¢/ton)	(¢/ton)	(1,000 tons)	(¢/ton)
Northeastern, ND	1	New York, NY	3,460	3,400	5.8	[1]
	2	Cincinnati, OH	2,420	[2]	[2]	2,520
	3	Macon, GA	3,180	2,840	5.8	[1]
	4	Chicago, IL	2,080	[2]	[2]	2,120
	5	Minneapolis, MN	1,340	580	5.8	[1]
	6	Lincoln, NB	1,900	1,860	5.8	[1]
	7	Lubbock, TX	3,600	0[3]	5.8	[1]
	8	San Francisco, CA	3,560	3,540	5.8	[1]
	E	Duluth, MN	1,260	[2]	[2]	1,320
	E	New Orleans, LA	3,640	1,260	37.9	[1]
East Central, ND	1	New York, NY	3,600	3,420	14.2	[1]
	2	Cincinnati, OH	2,540	2,520	12.7	2,720
	3	Macon, GA	3,220	2,860	14.2	[1]
	4	Chicago, IL	2,280	[2]	[2]	2,360
	5	Minneapolis, MN	1,560	820	3.1	[1]
	6	Lincoln, NB	1,820	[2]	[2]	1,880
	7	Lubbock, TX	3,600	0[3]	14.2	[1]
	8	San Francisco, CA	3,560	[2]	[2]	3,560
	E	Duluth, MN	1,560	1,500	18.0	2,000
	E	New Orleans, LA	3,660	1,560	3.1	[1]
Southeastern, ND	1	New York, NY	3,380	3,280	11.0	3,420
	2	Cincinnati, OH	2,400	[2]	[2]	2,500
	3	Macon, GA	3,000	2,820	11.2	[1]
	4	Chicago, IL	1,940	[2]	[2]	2,140
	5	Minneapolis, MN	1,100	600	6.0	[1]
	6	Lincoln, NB	1,740	[2]	[2]	1,840
	7	Lubbock, TX	3,440	0[3]	11.2	[1]
	8	San Francisco, CA	3,560	3,520	11.2	[1]
	E	Duluth, MN	1,140	[2]	[2]	1,340
	E	New Orleans, LA	3,500	1,140	37.9	[1]

[1]Inactive market.
[2]The North Dakota plant has the entire market. No increase is possible even with reduced rates.
[3]The rate required to stimulate shipments is less than zero.

Chapter 7

ECONOMIC IMPACT OF SUNFLOWER PROCESSING PLANTS IN NORTH DAKOTA

Description of the Model

An input-output model for North Dakota was used to estimate the economic impacts of a sunflower processing plant in the state. The model, which includes 13 sectors (Table 91), has been used to predict gross business volume at both the state and state planning region level. North Dakota is divided into eight state planning regions (Figure 41), which generally coincide with the trade areas of the eight major trade centers in the state. The state regions considered for possible plant locations were SR4, SR5, and SR6.

An input-output model involves three basic tables. The three types of tables are:

(1) transactions table,

(2) technical input-output coefficients table, and

(3) interdependence coefficients (multipliers) table.

The transactions table shows the purchases and sales by each of the industrial sectors to the other sectors in the region's economy. The table is arranged so the columns show the purchases from (and payments to) each column sector and the rows indicate the sales of that row sector to the other column sectors.

The technical input-output coefficients table is derived from the transactions table. It is the transactions table expressed as decimal fractions of column totals in the transactions table. Thus, each coefficient in that table indicates the fraction of total input of the column sector that is obtained from the row sector. In other words, each coefficient indicates the direct requirenent (per dollar of output) that the column sector obtains from the row sector.

The interdependence coefficients (multipliers) table is derived from the technical input-output coefficients table. It shows the total input requirement (direct and indirect) that must be obtained from each row sector per dollar of output for final demand by the column sector. The column totals of this table are the total output requirements from all row sectors in the economy per dollar of output for final demand by the column sector. The interdependence coefficients, or multipliers, are shown in Table 92. An example of how the multipliers are used can be illustrated for the household sector (the sector that consists principally of wages, salaries, and profits). The money paid for wages, salaries, and profits (household sector) will generate gross business volumes for all 13 sectors of the economy. Each dollar paid to the household sector will generate \$.0674 to the agriculture, livestock sector; \$.0268 to the agriculture, crops sector; \$.0056 to the mining sector; and so forth for the remaining 10 sectors. The wages, salaries, and profits (household sector) will generate \$1.5516 to the household sector (the \$1 originally paid to households plus an additional \$.5516 of wages, salaries, and profits induced via the multiplier process). The gross receipts multiplier is the total gross business volume that \$1 of output for final demand will generate in gross business volume in all other sectors. The gross receipts multiplier is the sum of the 13 sector multipliers. For example, the 3.0759 gross receipts multiplier for households means that \$1 received by the household sector will end up generating a gross business volume in all sectors of \$3.0759. Sales by any of the other sectors will follow the same procedure; but each sector has a different set of multipliers (and a different column total, which is called the gross receipts multiplier).

Assumptions and Results

The economic impact of a sunflower processing plant was broken down into two phases, construction and operation. The construction impact refers to the "one time" total gross business volume generated in the area as a result of the construction of a sunflower processing plant. The operational impact is an annually occurring impact. The gross business volume generated from the operation of a sunflower processing plant will take place each year the plant is in operation. The gross business volume generated each year the plant is in operation is assumed to be the same, disregarding inflation.

Economic Impact Resulting from Construction Phase

The possible locations considered for the plant were State Planning Regions 4, 5, and 6. Much of the actual processing equipment and building materials are to be purchased out of state, so the multiplier effect will not apply in North Dakota for these expenditures. The cost of labor for plant construction (except for technical equipment installation) was assumed to be paid to local contractors within the region in which the plant is located. The pre-erection phase of construction of the processing buildings was assumed to be subcontracted to a construction firm in the locating region. One-half of the service/auxiliary equipment was presumed to be purchased from firms located in Fargo (SR5), so the multiplier effect for these expenditures would occur in SR5. Service/auxiliary buildings were assumed to be purchased in the local region. Expenditures for land were assumed to remain in the locating region and 80% of the cost of a railroad spur-line installation would be spent locally. The analysis was made mainly for the region in which a sunflower processing plant will locate since most of the economic impact will occur in this region.

Expenditures for construction are made to three sec-

TABLE 91. Industrial Sectors Used in the North Dakota Input-Output Model

Sector Number	Description of Economic Unit	SIC[1] Code Number
1	Agriculture, Livestock	Group 013
2	Agriculture, Crops	Groups 011, 012, 014 and 019
3	Mining	Division B
4	Construction	Division C
5	Transportaion	Division E (except Major groups 48 and 49)
6	Communication and Utilities	Major Groups 48 and 49
7	Wholesale and Agricultural Processing	Group 505
8	Retail	Major Groups 52, 53, 54, 55, 56, 57, 58, and 59
9	Finance — Insurance — Real Estate	Division G
10	Business and Personal Services	Major Groups 70, 72, 73 75, 76, 78, and 79
11	Professional and Social Services	Major Groups 80, 81, 82, 84, 86, and 89
12	Households	All Households
13	Government	Division I

[1]SIC = Standard Industrial Code.
SOURCE: (51).

tors of the economy: construction, retail trade, and households. The expenditures to the construction sector consist of sublet construction made prior to the processing building and equipment installation and service/auxiliary building construction. Rail trackage installation costs are spent in the locating region primarily through the household sector (wages), although a very small amount will be spent in the retail sector. Payments for land, wages, and salaries constitute household sector expenditures. The estimated expenditures to these sectors in the locating state region were $200,280 to construction; $7,500 to retail trade; and $241,005 to the household sector for a 500-ton/day plant (Table 93). In addition to this, $141,900 would be spent to the retail sector of

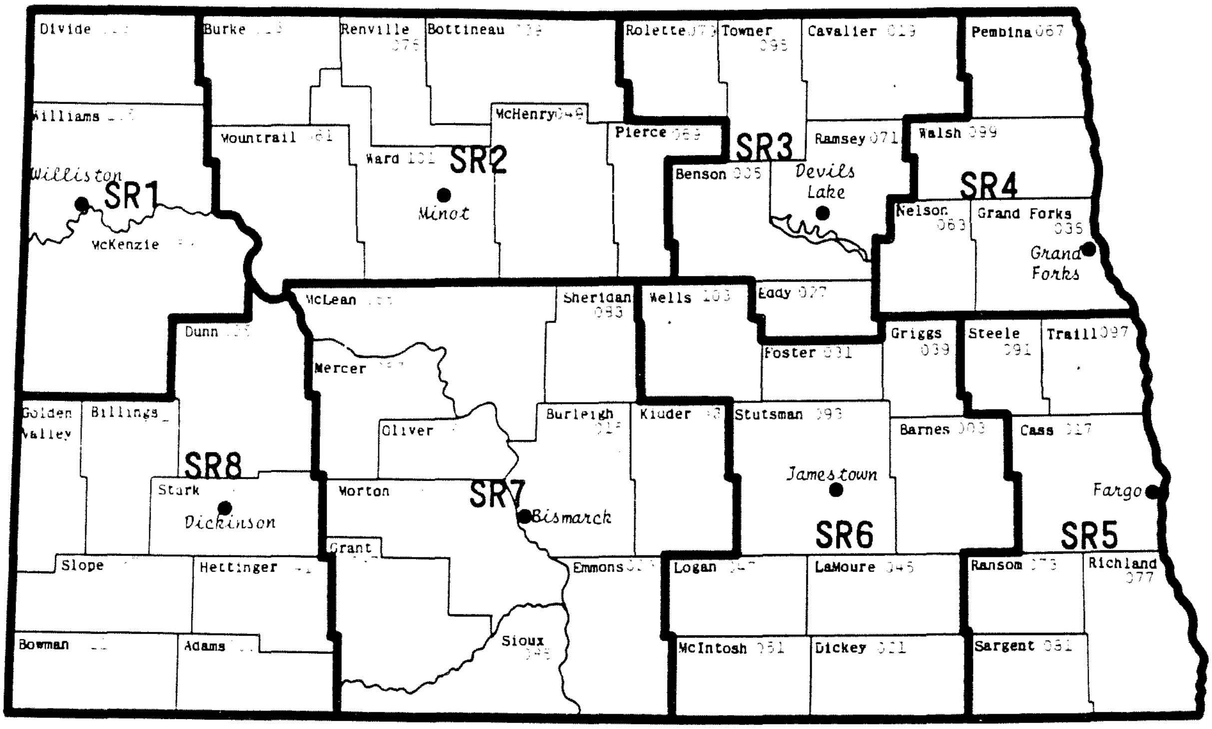


Figure 41. North Dakota State Planning Regions and Major Trade Centers • Major Trade Centers

SR5 (Fargo) for service/auxiliary equipment. The estimated expenditure for a 1,000-; 1,500-; and 2,000-ton/day plant is also included in Table 93.

The expenditures will generate gross business volumes to all sectors of the region's economy; but the principal impact will be on the construction, retail trade, and household sectors. The total impact on the economy is the sum of the changes for these and the other individual sectors. The impact to the individual sectors is the amount spent to each sector times the multipliers that apply to that sector. For example, the $200,280 spent to the construction sector for a 500-ton/day plant will generate a gross business volume of $488,000. This occurs as follows: $200,280 to the construction sector is multiplied by each of the 13 sector multipliers to get $488,000.

200,280 X 1.0494 (construction sector multiplier) = 210,000*

200,280 X 0.4098 (retail multiplier) = 82,000*

200,280 X 0.6086 (household multiplier) = 122,000*

200,280 X each remaining multiplier and then added** = 74,000*

Adding the above gross business volumes generated by expenditures to the construction sector will provide the $488,000 worth of new business volume that results (Table 94). The $7,500 spent in the retail sector is handled the same way except the expenditures are taken times the retail multipliers to arrive at $16,000 new business volume generated from the retail sector. The $241,005 expenditures to the household sector will generate $741,000 new business volume from that sector. The total economic impact to the locating region is the sum of the gross business volumes generated from the construction, retail trade, and household sectors, or $488,000 + $16,000 + $741,000 = $1,245,000. Thus, the total economic impact for a region with a 500-ton/day capacity sunflower processing plant locating there is $1,245,000 (Table 94). The $141,900 spent to the retail sector for equipment in Fargo (SR5) will generate a gross business volume of $296,174 in that region during the construction period.

The procedures for determining the economic impacts of a larger capacity sunflower processing plant are the same as for the 500-ton/day plant. If a 1,000-ton/day capacity plant were constructed, the expenditures to the sectors (Table 93) should be taken times the multipliers (Table 91) for each respective sector to obtain total impact. The expenditures to the construction sector will generate $732,000; the retail sector will generate $16,000; and the household sector will generate $946,000 for a total gross business volume of $1,694,000 for a 1,000-ton/day processing plant (Table 94). The $154,300 spent to retail trade in Fargo (SR5) will generate a gross business volume of $322,055 in that region if the 1,000-ton/day plant is constructed.

The economic impact resulting from the construction phase of a 1,500-ton/day and 2,000-ton/day plant is $2,398,000 and $2,988,000, respectively. A detailed breakdown of sector effects is provided in Table 94. Pur-

*Rounded to nearest thousand.

**The same procedure is carried out for the remaining 10 sectors, but they are grouped together because of their smallness and called "other."

TABLE 92. Input-Output Interdependence Coefficients, North Dakota Economy

Sector \ Sector	Agricultural Livestock	Agricultural crops	Mining	Construction	Transportation	Communication and Utilities
1. Agr., Livestock	1.2082	0.0777	0.0445	0.0343	0.0455	0.0379
2. Agr., Crops	0.3973	1.0931	0.0176	0.0135	0.0180	0.0152
3. Mining	0.0083	0.0067	1.0395	0.0302	0.0092	0.0043
4. Construction	0.0714	0.0784	0.0512	1.0494	0.0488	0.0645
5. Transportation	0.0152	0.0113	0.0284	0.0105	1.0079	0.0135
6. Comm. and Util.	0.0923	0.0835	0.1556	0.0603	0.0839	1.1005
7. Whls. and Agr. Proc.	0.5821	0.1637	0.0276	0.0210	0.0281	0.0242
8. Retail	0.7098	0.8134	0.5229	0.4098	0.5472	0.4313
9. Fin., Ins., and R. E.	0.1531	0.1677	0.1138	0.0837	0.1204	0.1128
10. Bus. and Pers. Serv.	0.0564	0.0684	0.0430	0.0287	0.0461	0.0374
11. Prof. and Soc. Serv.	0.0712	0.0644	0.0559	0.0402	0.0519	0.0526
12. Households	1.0490	0.9646	0.8419	0.6086	0.7872	0.7946
13. Government	0.0991	0.0957	0.0852	0.0519	0.2583	0.0999
Gross Receipts Multiplier	4.5134	3.6886	3.0271	2.4421	3.0525	2.7887

Sector \ Sector	Wholesaling and Agricultural Processing	Retail	Finance Ins., and Real Estate	Business and Personal (Non-Professional) Services	Professional and Social Services	Households	Government
1. Agr., Livestock	0.1941	0.0889	0.0617	0.0384	0.0571	0.0674	0.0
2. Agr., Crops	0.6591	0.0320	0.0372	0.0153	0.0231	0.0268	0.0
3. Mining	0.0063	0.0024	0.0049	0.0043	0.0050	0.0056	0.0
4. Construction	0.0620	0.0343	0.0728	0.0538	0.0776	0.0886	0.0
5. Transportation	0.0131	0.0104	0.0120	0.0118	0.0100	0.0093	0.0
6. Comm. and Util.	0.0777	0.0528	0.1321	0.1103	0.1191	0.1054	0.0
7. Whls. and Agr. Proc.	1.7678	0.0459	0.0714	0.0241	0.0368	0.0423	0.0
8. Retail	0.6206	1.2733	0.6761	0.4522	0.6665	0.7442	0.0
9. Fin., Ins., and R. E.	0.1341	0.0577	1.1423	0.1084	0.1400	0.1680	0.0
10. Bus. and Pers. Serv.	0.0521	0.0194	0.0766	1.0509	0.0455	0.0605	0.0
11. Prof. and Soc. Serv.	0.0539	0.0276	0.0816	0.0497	1.1026	0.0982	0.0
12. Households	0.7977	0.4032	1.2013	0.7157	1.0432	1.5516	0.0
13. Government	0.0808	0.0393	0.1071	0.0774	0.0881	0.1080	1.0000
Gross Receipts Multipliers	4.5193	2.0872	3.6771	2.7123	3.4146	3.0759	1.0000

TABLE 93. Local Expenditures, by Economic Sector, Resulting From Construction of Four Model Sunflower Processing Plants, 1975

Sector	Plant Capacity (tons per day) 500	1,000	1,500	2,000
Construction	$200,280	$299,880	$435,020	$566,420
Retail	7,500	7,500	7,500	7,500
Households	241,005	307,405	429,155	416,755

chases of $185,400 (retail sector) in Fargo (SR5) for a 1,500-ton/day plant will generate a gross business volume of $386,967 in that region over the construction phase of the plant. The economic impact as a result of expenditures for the 2,000-ton/day plant of $193,650 to retail trade in Fargo (SR5) is $404,186 over the construction period.

The total economic impact during the construction phase of a sunflower processing plant varied from $1.3 million to $3.0 million, depending upon the plant size. It should be recalled that this impact is nonrecurring and results over the entire construction period, regardless of the length of time for completion.

Economic Impact Resulting from Operational Phase

The operational phase of a sunflower processing plant will also have an impact on the economy of the region in

TABLE 94. Additional Gross Business Volumes of Economic Sectors, Resulting From Construction of Four Model Sunflower Processing Plants, 1975

Resulting Increase in Gross Business Volume by Sector	Sector to Which Expenditure Is Made ($000) Construction	($000) Retail	($000) Household	($000) Total
		500-Ton Per Day Plant		
Construction	210	—	21	231
Retail	82	10	179	271
Households	122	3	374	499
Other[1]	74	3	167	244
Total	488	16	741	1,245
		1,000-Ton Per Day Plant		
Construction	314	—	27	341
Retail	123	10	229	362
Households	183	3	477	663
Other[1]	112	3	213	328
Total	732	16	946	1,694
		1,500-Ton Per Day Plant		
Construction	456	—	38	494
Retail	178	10	319	507
Households	265	3	666	934
Other[1]	163	3	297	463
Total	1,062	16	1,320	2,398
		2,000-Ton Per Day Plant		
Construction	594	—	46	640
Retail	232	10	385	627
Households	345	3	802	1,150
Other[1]	212	3	356	571
Total	1,383	16	1,589	2,988

[1]Includes agriculture (livestock and crops), mining, transportation, communications and utilities, wholesale and agricultural processing, finance — insurance — real estate service, professional business and personal and social service, and government.

which the plant is located. Operational impacts differ from construction in that operational impacts occur annually and continue to take place as long as the plant is in operation, while construction impacts occur only once. During the operational phase the plant is assumed to derive one-half of its financing within North Dakota, 30% coming from the state region where the plant locates and 10% coming from each of the other two regions wherein the plant could possibly locate. Fuel and solvent for the plant will come from out of state as will the working capital, thus not having a multiplier effect on the economy of the local region. Brokerage fees are assumed to remain in the locating region. State taxes, licenses, and social insurance fees will move out of the locating region to the state capitol. Multipliers were not applied to these expenditures because the multiplier for the government sector has been assumed to be 1.0000, meaning this sector will generate no additional business volume. The remainder of the operational costs are assumed to stay within the locating region.

Expenditures during the operational phase are made to five sectors of the economy — construction (maintenance construction), communications and utilities (electricity and water), finance — insurance — real estate (interest and insurance), business and personal service (brokerage fees), and households (wages and salaries). A 500-ton/day capacity plant would have annual expenditures of $257,890 to the construction sector; $346,730 to the communications and utilities sector; $110,674 to the finance — insurance — real estate sector; $18,750 to the business and personal service sector; and $496,910 to the household sector (Table 95). In addition, $20,528 would be paid to the finance — insurance — real estate sector of the other two possible locating regions, and $194,090 would be paid to the government sector of the North Dakota economy. The expenditures for the other three plant sizes are presented in Table 95. In addition, expenditures to the finance — insurance — real estate sector of the other two regions are $29,325; $36,444; and $43,563 for the 1,000-; 1,500-; and 2,000-ton/day plant sizes, respectively. Expenditures to the government sector are $257,480; $320,320; and $385,100 for the three plant sizes, respectively.

The economic impact from the operation of a sunflower processing plant is determined by taking the annual expenditures to each sector times their respective multipliers to obtain the annual gross business volume generated. For a 500-ton/day plant, the annual expenditures to the construction sector of $257,890 times the multipliers generate an annual gross business volume of $630,000; while the communications and utilities sector generates $967,000; the finance — insurance — real estate sector generates $407,000; the business and personal service sector generates $51,000; and the household sector generates $1,529,000 for a total annual impact of $3,584,000 during the operational phase in the locating region (Table 96). The annual expenditures to the finance — insurance — real estate sector of the other two regions generate $75,484 in each region annually.

The economic impact resulting annually from the operation of a 1,000-; 1,500-; and 2,000-ton/day plant is $5,365,000; $7,023,000; $8,705,000, respectively. A detailed breakdown of sector effects is provided in Table 96. The annual impact to each of the other two regions for expenditures to the finance — insurance — real estate sector was $107,830 for a 1,000-ton/day plant; $134,008 for the 1,500-ton/day plant; and $160,186 for the 2,000-ton/day plant.

The economic impacts during the operational phase of a sunflower processing plant would range from $3.6 million to $8.7 million annually in the locating region depending on the size of plant. The economic impacts of a processing plant were greater during the operational phase than during the construction phase because of the greater number of dollars staying in the locating region during operation of the plant.

TABLE 95. Local Expenditures, by Economic Sector, Resulting From the Operation of Four Model Sunflower Processing Plants, 1975

	Plant Capacity (tons per day)			
Sector	500	1,000	1,500	2,000
Construction	$ 257,890	$ 386,790	$ 449,420	$ 532,400
Communications and Utilities	346,730	665,760	969,300	1,237,140
Finance — Insurance — Real Estate	110,674	174,705	236,432	296,299
Business and Personal Service	18,750	39,000	60,750	87,000
Households	496,910	604,300	711,380	802,450
Total	$1,230,954	$1,870,555	$2,427,282	$2,955,289

TABLE 96. Additional Gross Business Volumes of Economic Sectors Resulting From the Operation of Four Model Sunflower Processing Plants, 1975

Resulting Increase In Gross Business Volume by Sector	Sector to Which Expenditure is Made					
	($000) Construction	($000) Communications and Utilities	($000) Finance Insurance Real Estate	($000) Business and Personal Service	($000) Households	($000) Total
			500-Ton Per Day Plant			
Construction	271	22	8	1	44	346
Communications and Utilities	16	382	15	2	52	467
Retail	106	150	75	8	370	709
Finance — Insurance — Real Estate	22	39	126	2	84	273
Households	157	276	133	13	772	1,351
Other[1]	58	98	50	25	207	438
Total	630	967	407	51	1,529	3,584
			1,000-Ton Per Day Plant			
Construction	387	43	13	2	54	499
Communications and Utilities	22	733	23	4	64	846
Retail	151	287	119	18	450	1,024
Finance — Insurance — Real Estate	31	75	200	4	102	412
Households	224	529	210	28	938	1,929
Other[1]	86	190	78	50	251	655
Total	901	1,857	642	106	1,859	5,365
			1,500-Ton Per Day Plant			
Construction	471	63	17	3	63	617
Communications and Utilities	27	1,067	31	6	75	1,206
Retail	184	418	160	28	529	1,319
Finance — Insurance — Real Estate	38	109	270	7	120	544
Households	274	770	284	44	1,104	2,476
Other[1]	104	276	107	77	297	861
Total	1,098	2,703	869	165	2,188	7,023
			2,000-Ton Per Day Plant			
Construction	559	82	22	7	71	741
Communications and Utilities	32	1,401	39	10	85	1,567
Retail	218	549	200	58	597	1,622
Finance — Insurance — Real Estate	45	144	339	12	135	675
Households	324	1,012	356	91	1,245	3,028
Other[1]	122	362	134	119	335	1,072
Total	1,300	3,550	1,090	297	2,468	8,705

[1]Includes agriculture (livestock and crops), mining, transportation, wholesale and agricultural processing, business and personal service, professional and social service, and government.

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