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DESCRIPTION OF THE U.S. AND MICHIGAN SOYBEAN INDUSTRY AND THE POTENTIAL FOR SOYBEAN PROCESSING

John N. (Jake) Ferris
Department of Agricultural Economics
Michigan State University

Historians have identified that soybeans were cultivated in ancient China, Manchuria and in neighboring countries. While introduced into the United States from the Orient in the early 1800's, their economic importance was not recognized until a century later (4). Soybeans were first processed for oil and meal in the United States about 1910 by an oil mill on the West Coast. Commercially successful processing of U.S. soybeans began in 1922.

The U.S. Department of Agriculture began estimating soybean acreage, yield and production in 1924. In that year, total U.S. acreage planted was 1,567 thousand acres and harvested for beans only 448 thousand acres, indicating that early on, soybeans were primarily a forage crop. Production in Michigan started in the early 1900's, and by 1930, 1,000 acres were grown, yielding about 10 bushels per acre, with total production as only a minuscule part of the total U.S. output.

In 1994, U.S. soybean acreage reached and exceeded 60,000 thousand acres with yields over 40 bushels per acre. This generated peak production at about 2.5 billion bushels with over $13 billion in cash receipts. The value of soybean production in U.S. agriculture is second only to corn among crops and represents about one-sixth of the value of all crops.

Harvested area of soybeans in Michigan has increased to an average of 1,473 thousand acres in 1992-94, with average yields of 36.3 bushels in this period. This combination of area and yields generated production averaging 53.6 million bushels in 1992-94. Based on this three-year average, Michigan is close to breaking into the top 10 states. In 1992-94, gross sales of

soybeans from Michigan farms averaged $314 million, and like the U.S. soybean sales, are second only to corn among crops and represent nearly 10 percent of receipts from marketings of all crops and livestock.

Description of Soybeans

The soybean is a plant which belongs to the pea family and is classified as a legume. Being a legume, it has the capacity to fix nitrogen and therefore does not require nitrogen fertilizer. This feature has two important implications to the environment: (1) it's cultivation has a much more benign effect as compared to corn, potatoes, vegetables and similar crops; and (2) it's role in the rotation with other crops reduces the extent to which nitrogen fertilizer is required on those other crops.

Few farmers specialize in soybean production except in the Delta region of the U.S. Most of the production and harvesting equipment for corn and wheat can also be used for soybeans, which contributes to its importance as a rotation crop. In the South and mid South, double-cropping has been of significance, but the practice has declined in recent years.

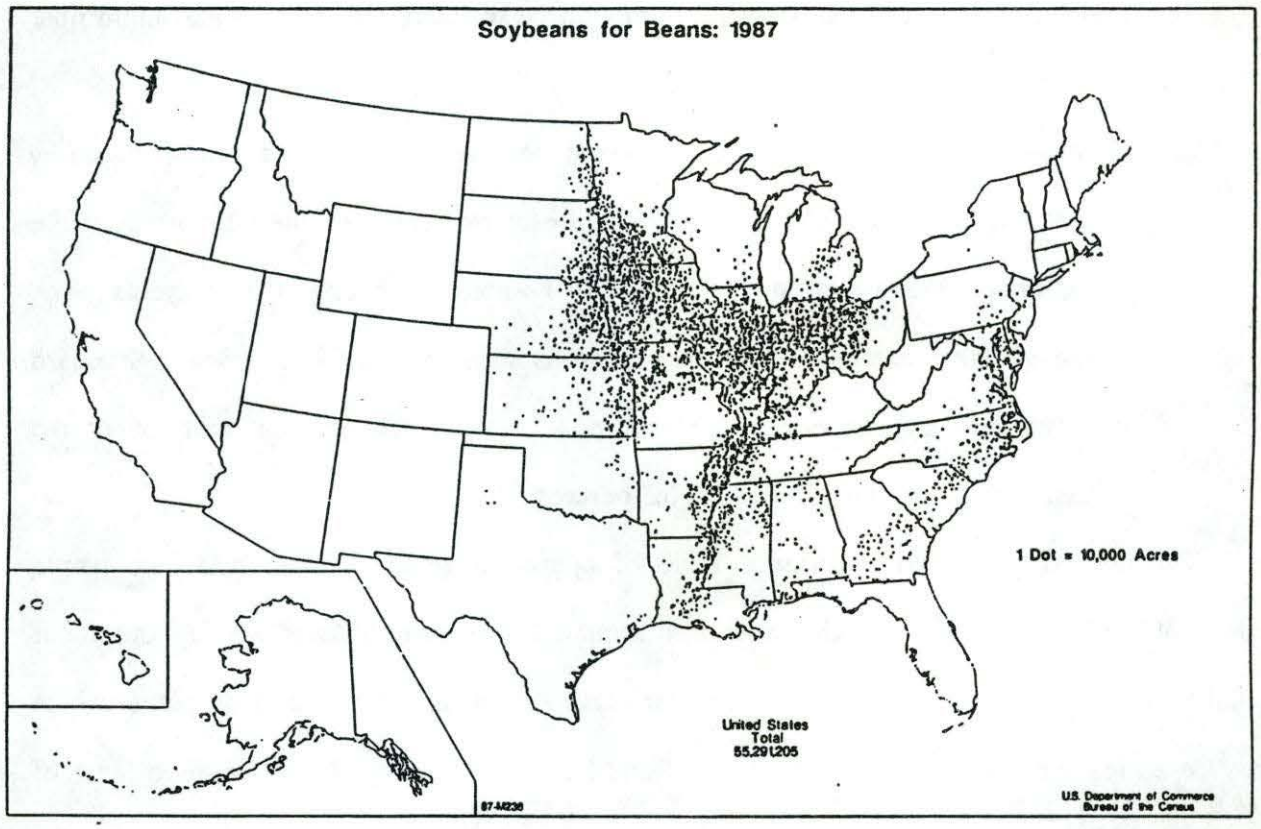
The major producing areas tend to be in the same area that corn is predominant except in the mid South along the Mississippi River (Figure 1).

Soybean Oil

Early in the history of soybean cultivation in the U.S., it was mostly a forage crop. When processing began in the 1920's, its value was mostly from the output of oil. A bushel of soybeans (60 pounds) normally yields around 11 pounds of oil. More recently, however, the value of soybean meal has overtaken the value of the oil.

Soybean oil comprises almost three-fourths of the total fats and oils used in edible oil products. Nearly half of the domestic edible use of soybean oil is in salad and cooking oils, followed by baking and frying fats and margarine. A small proportion goes into inedible uses, which includes paint or varnish, fatty acids, resins, plastics, inks and fuel.

Figure 1



Soybean Meal

About 47 pounds of meal are produced from a bushel of soybeans. Soybean meal is a primary source of protein supplement in U.S. livestock rations. Soybean meal has recently represented about 80 percent of all protein feeds fed to U.S. livestock and over 50 percent of all processed feeds in these rations.

As described by the National Oilseed Processors Association (NOPA), soybean meal is being produced and marketed in two forms (1):

1. "Soybean flakes and 44 percent protein soybean meal are produced by cracking, heating and flaking soybeans and reducing the oil content of the conditioned product by the use of hexane or homologous hydrocarbon solvents. The extracted flakes are

cooked and marketed as such or ground into meal. Standard specifications are: minimum protein of 44.0 percent; minimum fat of 0.5 percent; and a maximum fiber of 7.0 percent."

2. "Soybean flakes and high protein or solvent extracted soybean meal are produced by cracking, heating and flaking de-hulled soybeans and reducing the oil content of the conditioned flakes by the use of hexane or homologous hydrocarbon solvents. The extracted flakes are cooked and marketed as such or ground into meal. Standard specifications are: minimum protein of 47.5-49.0 percent; minimum fat of 0.5 percent; and maximum fiber of 3.3-3.5 percent."

The solvent-type plant requires a scale of operation which, at the minimum, would process 400-500 tons per day, which amounts to around 15 thousand bushels per day and about 5 million bushels per year. On a much smaller scale are extruder/expeller type plants which produce a meal with about 46.5 percent protein and 5.5 percent fat. The relative importance of extruder/expeller processing is quite low, nationally.

Production of "high protein meal," typically at 48-49 percent protein, has increased rapidly, and by 1990, represented two-thirds of all soybean meal production. This has been due mainly to the expansion in poultry production. Broilers and turkeys require this higher protein content. Hogs also require meal with high protein and low fiber.

High protein soybean meal usually commands about an 7-8 percent premium over 44 percent meal. Because of the higher fat content, extruder/expeller meal may be priced 10-15 percent over 44 percent meal at the elevator level.

Expeller/extruder technology allows soybeans to be processed on a small scale. An elevator in northwest Ohio is marketing meal from this process in Michigan. A couple of such operations have been present in Michigan. Total amounts of meal involved have been relatively small.

Roasting soybeans on individual dairy farms is also an alternative being practiced in some cases in Michigan. This provides a feed with both a fat and protein source and is economical, however, only when soybean prices are low relative to corn.

Food Use of Soybeans

Human consumption of soy foods has been traditional in the Orient, and in the past couple of decades, has become more common in the U.S. Among the more important soy foods are soy sauce, tofu, soy milk and soy milk products, tempeh, etc. Soybeans grown in Michigan, Ohio and Indiana tend to have a lower oil content than those grown in other parts of the Midwest. This characteristic is desirable in soy foods, providing opportunities for some growers to contract such beans at a premium. A substantial export market in the Pacific Rim has been tapped as a result.

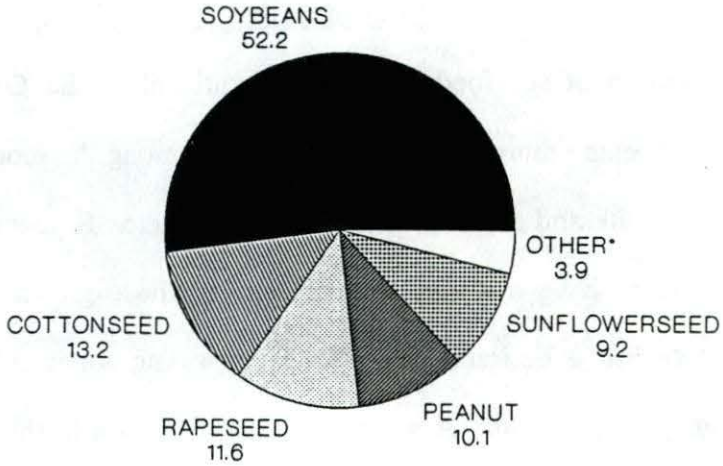
Food use accounts for nearly one-third of total soybean consumption in Asia (3). Currently, import demand for food use beans in Asia is around 1.5 million MT. In Japan where consumption of tofu accounts for nearly half of food use of soybeans, the U.S. is the principal supplier. However, the U.S. is facing increased competition from other nations in the food use market in Japan and other Asian nations. Because of the size and potential of the food use market, and the premium paid for food quality beans, this market deserves increased attention.

Soybeans in a Global and U.S. Perspective

Soybeans are, by far, the most important oilseed in the world. As indicated in Figure 2, soybeans comprise over half of the total production of oilseeds around the globe, followed by the close competitors of cottonseed, rapeseed (which includes canola), peanut, sunflowerseed, copra and palm kernel. Because oilseed prices have traditionally been determined more by market fundamentals of supply and demand than by government price supports, soybean prices, along with soybean meal and soybean oil, are closely linked to the total global oilseed, meal and oil markets. This is not to say that government programs haven't influenced the oilseed market, however.

Figure 2

World Production of Oilseeds by Type,
1992-94, in Percent



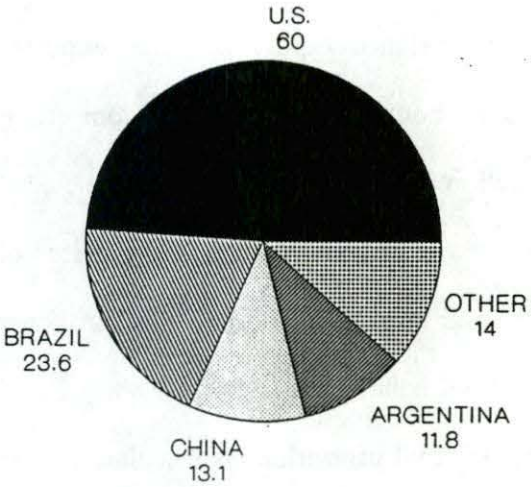
* INCLUDES COPRA AND PALM KERNEL

Because soybeans are processed more for the meal than the oil, soybean meal represents over 60 percent of the world output of protein meals, but only about 30 percent of the output of fats and oils. These percentages can be compared with the 52 percent soybean seeds represent of total world oilseed production (Figure 2).

The United States produces about half of the world's soybeans followed by Brazil at about 20 percent (Figure 3). China and Argentina are other major producers. The U.S. produces nearly 70 million metric tons (MT) of oilseed, of which soybeans represent about 60 million MT, or about 85 percent of the total (Figure 4). This total oilseed output in the U.S. in 1992-94 was about 30 percent of the total world oilseed production. Other major oilseed producers include China, Brazil, India, Argentina, the European Union (E.U.) and the Former Soviet Union (FSU).

Figure 3

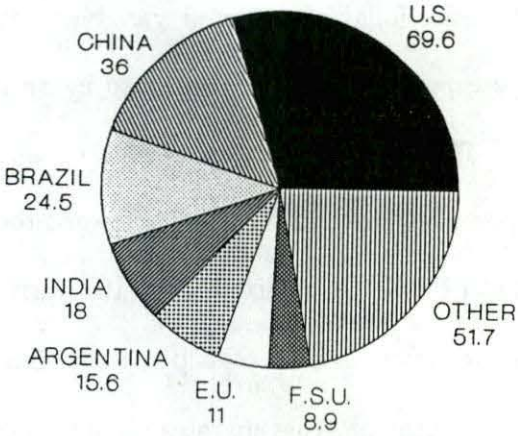
World Production of Soybeans by Major Nations, 1992-94, in Mil. MT



WORLD PRODUCTION • 122.5 MIL. MT

Figure 4

World Production of Oilseeds by Major Nations, 1992-94, in Mil. MT



WORLD TOTAL • 235.3 MIL. MT

Trends and projections for the U.S. soybean industry are presented in Table 1. Production reached a record 2.6 billion bushel crop in 1994, following a relatively small 1993 crop which was damaged by Midwestern floods. Generally, about two-thirds of the crop is processed domestically and the balance exported. The importance of the export market, however, is much greater in that about 20 percent of the domestic meal output is exported and 10-12 percent of the oil production is exported.

The farm price of soybeans is directly related to the prices of the by-products. Soybean meal is somewhat tied to the total market for oilseed meal in general, but more specifically to corn prices and the supply-demand balance on soybeans. A key indicator of that balance is the ratio of ending soybean stocks to total utilization, as calculated in Table 1. This ratio generally ranges between 10 and 15 percent of utilization. When over 20 percent, as forecast for 1994-95, prices come under downward pressure.

The soybean oil price is more related to the international vegetable oil market. A significant portion of U.S. soybean oil exports are government-assisted by both concessional and commercial export programs. Under the provisions of the Uruguay Round of the GATT negotiations, the U.S. will reduce subsidized exports. However, expanding world demand will eventually raise prices to levels higher than would have been the case without GATT.

In Table 1 are annual projections for selected variables related to the U.S. soybean industry to the year 2000. These projections were generated by an econometric model of U.S. agriculture called "AGMOD." The model forecasts a slow expansion for the U.S. soybean industry in this period with exports beginning to accelerate toward the end of the decade. Most of the gains attributable to GATT will be realized after the turn of the century. Soybean producers respond to gross margins over variable costs per acre. Since corn is a close substitute in production, that response is in terms of gross margins on soybeans relative to gross margins on corn.

Table 1

Trends and Projections of Variables Related to U.S. Soybeans

ITEM	UNIT	YEARS										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
PRODUCTION	Mil Bu	1926	1987	2190	1871	2558	2089	2141	2229	2304	2362	2458
CRUSHINGS	Mil Bu	1187	1254	1279	1272	1360	1317	1323	1343	1382	1423	1459
EXPORTS	Mil Bu	557	684	770	589	790	757	739	814	873	909	917
ENDING STOCKS	Mil Bu	329	278	292	209	510	425	403	376	325	255	237
ENDING STOCKS/ UTILIZATION	Ratio	0.179	0.136	0.134	0.107	0.225	0.195	0.186	0.166	0.138	0.105	0.096
FARM PRICE	$/Bu	5.74	5.58	5.56	6.40	5.35	6.00	5.89	6.24	6.56	7.15	7.52
GROSS MARGIN OVER VARIABLE COSTS												
NOMINAL	$/A	126	118	136	135	148	137	133	146	158	180	193
1982-84 $	$/A	96	87	97	94	100	89	85	91	97	108	113
SOY MEAL PRICE*	$/T	170	176	181	180	155	175	185	196	206	226	237
SOY OIL PRICE*	CENTS/Lb	21.0	19.1	21.4	27.1	27.0	24.9	18.8	19.1	19.5	19.9	20.4

*AT DECATUR, IL.

Soybean producers have received government supports, most recently in the form of a "marketing loan." In 1991-95, this rate has been at $5.02 and $4.92 per bushel. However, the farm price of soybeans in the past has seldom been as low as the support rate. Under the 1990 farm legislation, farmers participating in the program have been allowed to plant soybeans on "optional flex acres" which can be as much as 10 percent of the program base. Overall, however, outside of concessional export sales of soybean oil, and in recent years soybean meal, government programs have not had much direct effect on the soybean market.

Federal legislation does provide for check-off programs which are administered by the United Soybean Board. Dollars received from the check-off are applied to marketing, production and utilization research and to information programs. Continuation of these programs is subject to farmer votes.

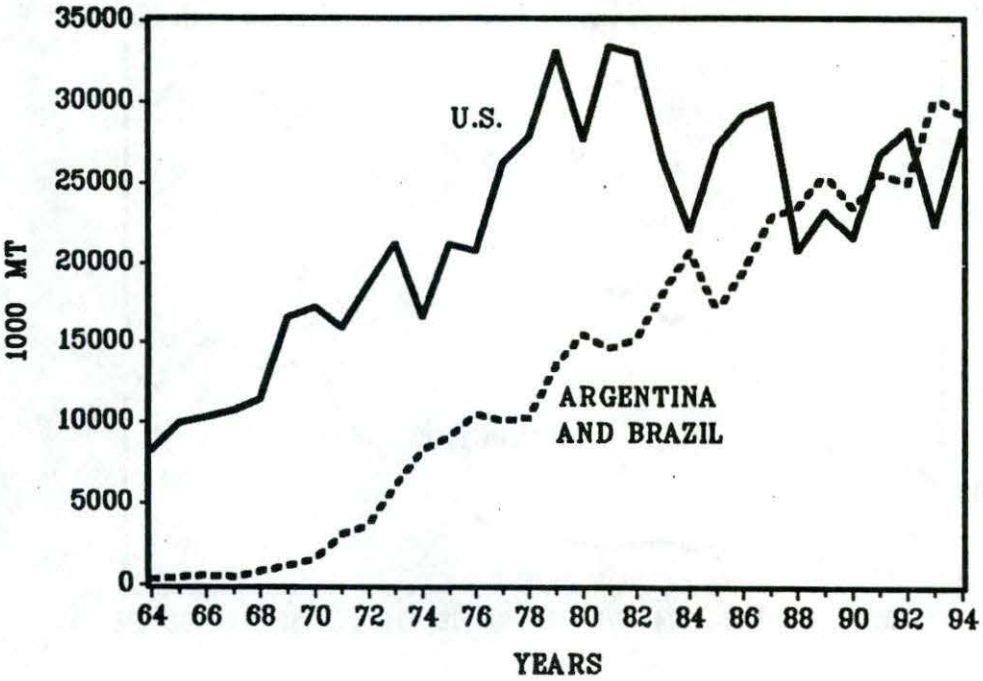
As can be seen in Figure 5, the U.S. soybean industry has been somewhat hampered by increased competition in export markets by South America. Since the early 1980's, U.S. soybean exports (including soybean equivalents in meal exports) have even trended downward while exports of both soybeans and soybean products from South America have continued to expand.

While the European Union remains on a net import basis on oilseeds, their Common Agricultural Policy (CAP) in the past has heavily subsidized oilseed production. They made a mistake early in the CAP formulation by not bringing oilseeds and other by-product feeds under the "Variable Levy" which has provided high price supports for grains. As a result, imported by-product feeds entered livestock ratios as energy sources, as well as protein sources, replacing some grain in rations and compounding a grain surplus problem.

To address this dilemma, the CAP provided income transfer to oilseed producers (through processors) and encouraged an increase in oilseed production in order to reduce oilseed imports and to shift grain land to oilseeds.

Figure 5

Exports of Soybeans and Soybean Equivalents in Meal
From the U.S. and From Argentina and Brazil

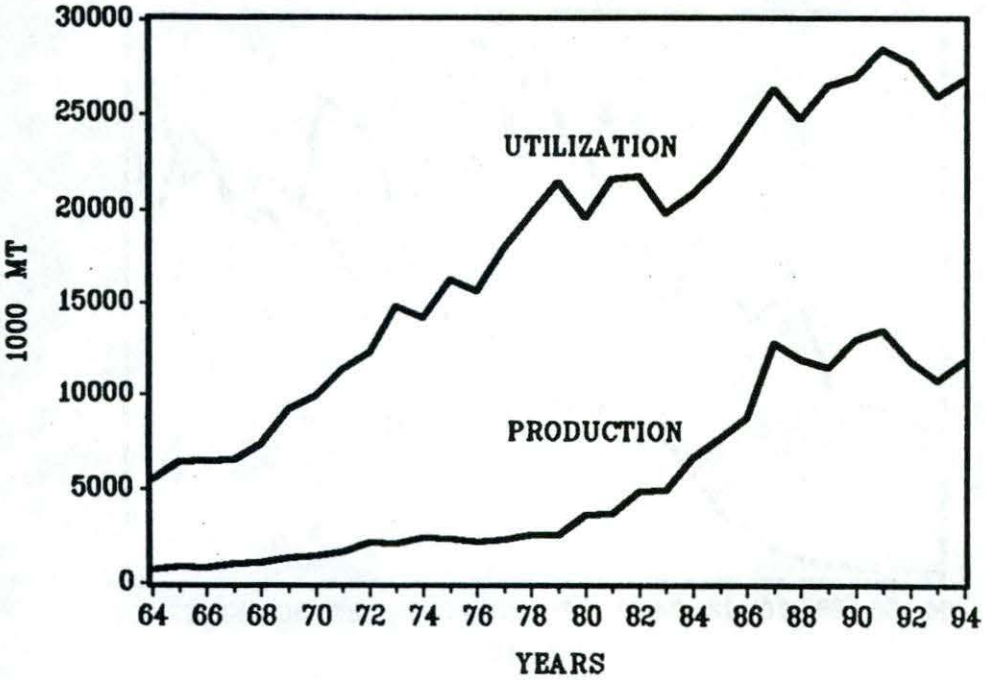


The escalation in production in the 1980's can be traced in Figure 6. The increase in oilseed production outpaced utilization, denying oilseed exporters access to the European market. The U.S. soybean industry filed complaints with GATT, and with CAP reform some concessions have been made and production has leveled off. With the conclusion of the Uruguay Round of GATT, further reductions in subsidies are scheduled.

Not included in the utilization of oilseeds in Figure 6 are corn gluten feeds and meal. Importation of these feedstuffs from the U.S. increased sharply during the 1980's as U.S. ethanol production expanded. In recent years, these feeds, converted to a soybean meal equivalent (corn gluten feed is around 26 percent protein), represented about 5 percent of protein meal fed in the E.U. At issue is the status of these imports under GATT since ethanol is produced under a subsidy.

Figure 6

Production and Domestic Utilization of Oilseeds
in the European Union (EC-12)



The key to expansion of the U.S. soybean industry will be the pace of economic development around the world. Growth in the domestic market for soybean meal and oil will be relatively slow. Continued expansion in poultry consumption relative to red meat should be a plus for soybean meal demand. However, total meat consumption per capita will likely be leveling off over the next 20 years. On the other hand, the potential for expanded consumption of animal protein in the developing world is very substantial. Their capacity to provide feed grains and protein feed for expanding livestock numbers is limited and they will likely require increased imports of these products.

Michigan

Soybean production has been a growth industry in Michigan, especially since the mid 1970's. As can be seen in Figure 7, acreage expanded at a more rapid pace into the early 1980's, leveled off and then moved consistently upward into the 1990's. Some of this expansion in acreage was at the expense of dry beans. Yields fluctuated between 20 and 25 bushels per acre from 1960-75, and then registered a remarkable rising trend for the next 20 years (Figure 8).

The result of the accelerated upward movement in both acreage and yields was a five-fold increase in production in the 1975-94 period (Figure 9). From a project of the Michigan Agricultural Experiment Station in 1990-92, called the "Status and Potential of Michigan Agriculture" (SAPMA), evaluations were made on the future of agricultural enterprises including soybeans (6). As shown in Figure 9, continued expansion was forecast. Actual production since the conclusion of SAPMA has headed strongly toward the projection for the year 2000.

Another clue concerning the strength and viability of the soybean industry in Michigan is whether production has gained on the rest of the nation. Figure 10 tallies the percent that Michigan soybean production represented of total U.S. output over 1960-1994. The sharp expansion after the mid 1970's is apparent. After registering output at around 1 percent of U.S. totals for several years, Michigan climbed to 2.5 percent by the early 1990's.

Production has increased in all the districts in the southern Lower Peninsula (Figure 11). Most notable has been in the expansion in the South Central District, followed by the Southeast District. (See Figure 12 for a map of the districts.)

The market for soybean meal has also been expanding (Figure 13). Based upon livestock numbers and representative feeding rates for high protein concentrates (including soybean meal), presumed utilization of such feeds can be calculated by counties and districts.

Figure 7

Acres Harvested for Soybeans in Michigan

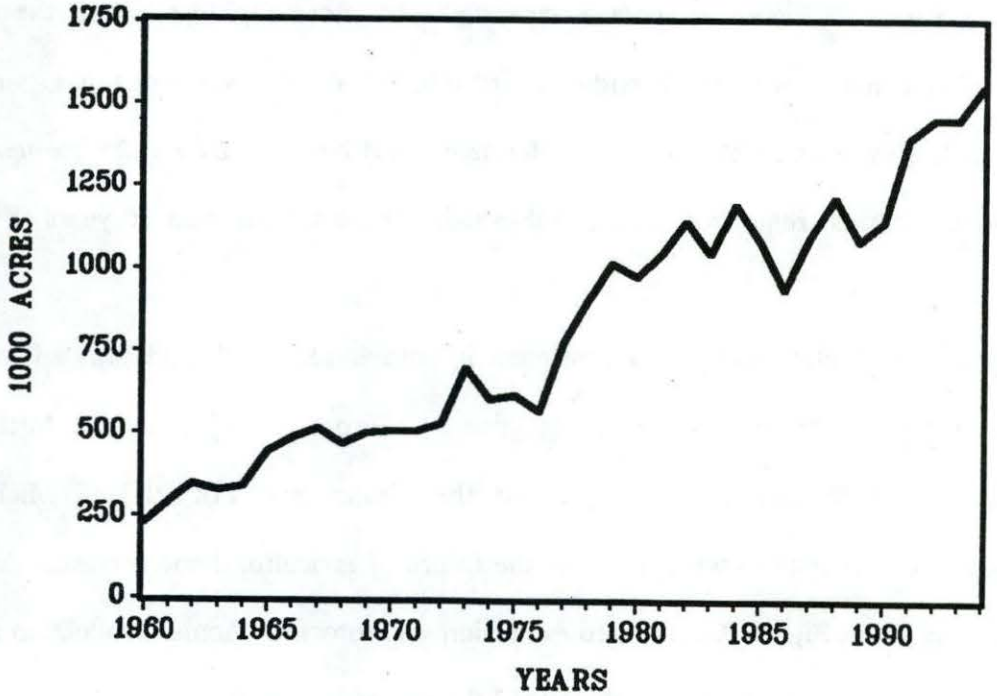


Figure 8

Yield of Soybeans in Michigan

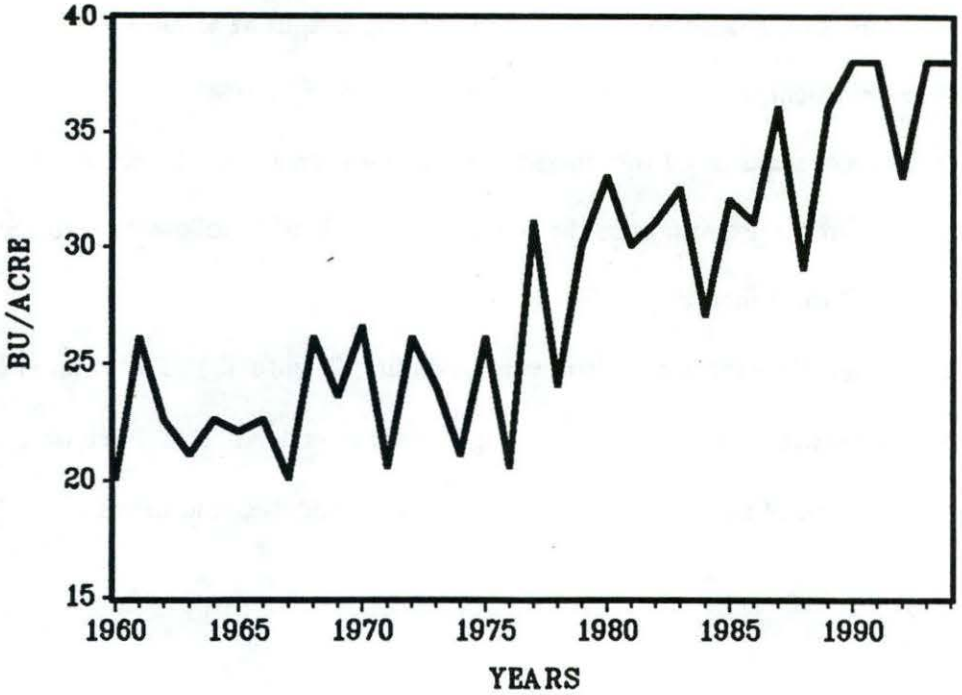
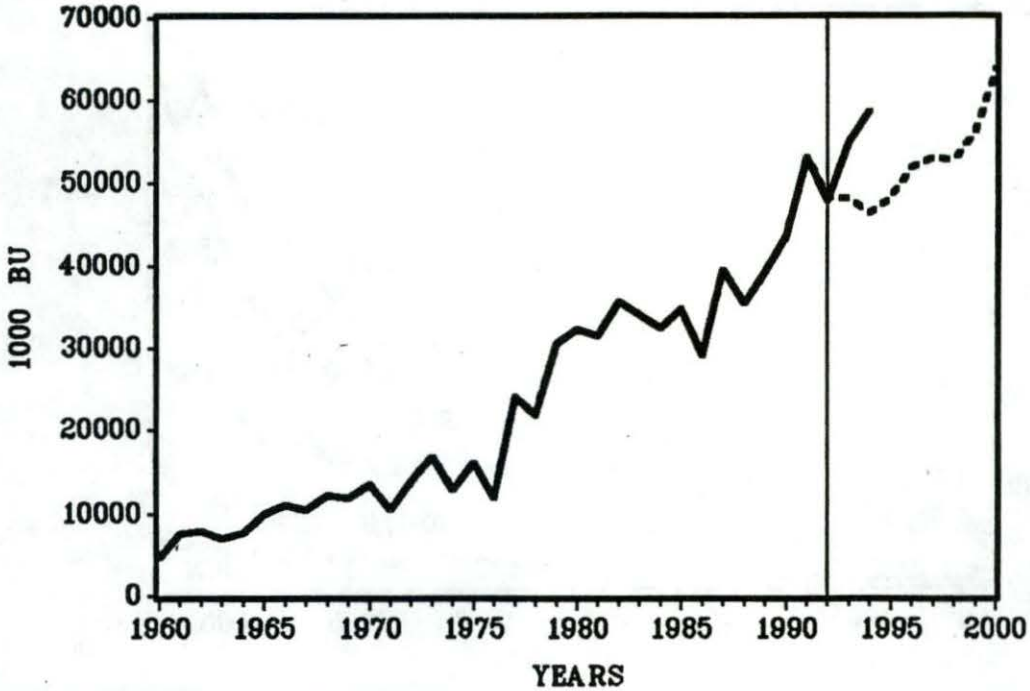


Figure 9

Trends in Soybean Production in Michigan
and Forecasts from the "SAPMA" Project*



* "SAPMA" stands for "Status and Potential of Michigan Agriculture"

—— ACTUAL ---- FORECAST

Figure 10

Michigan's Share of U.S. Soybean Production

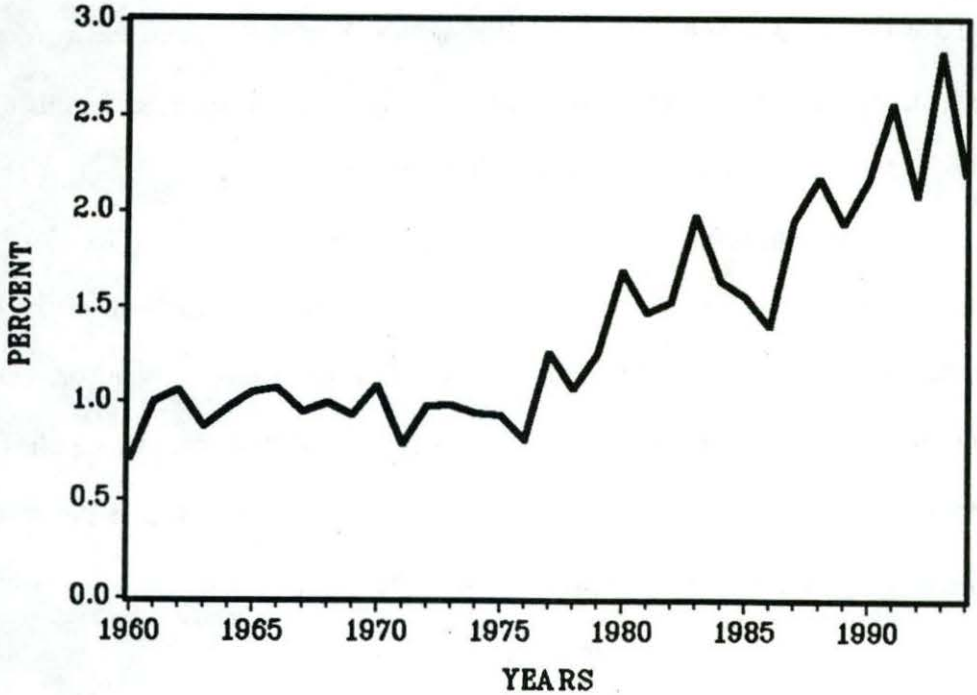
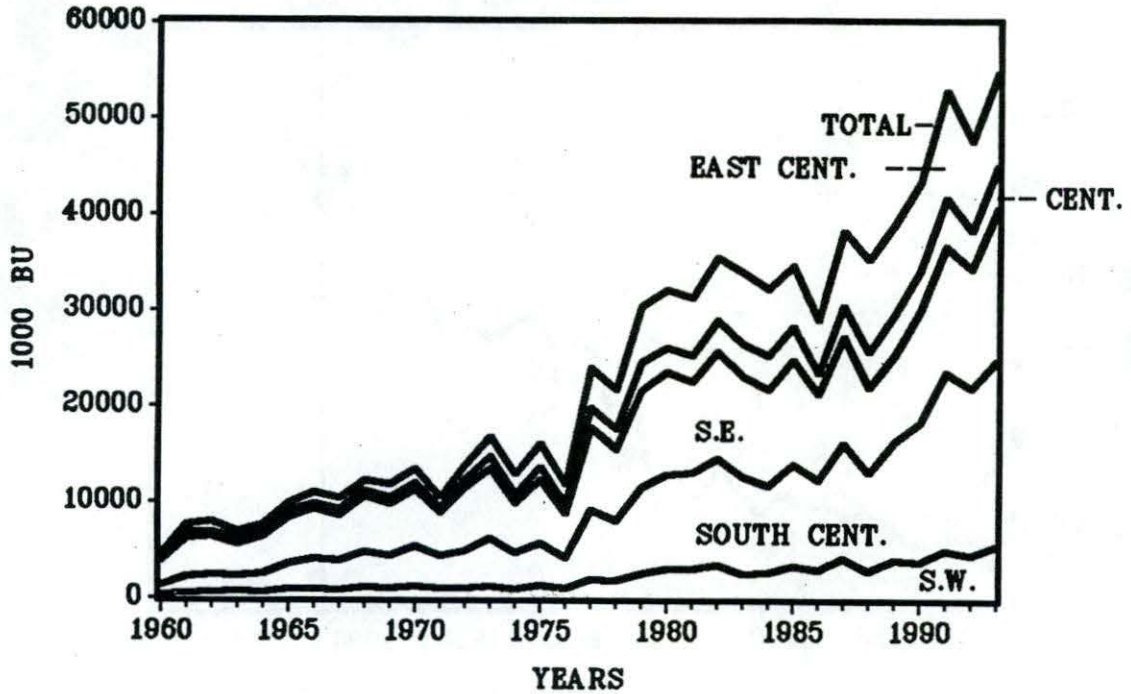


Figure 11

Production of Soybeans by District in Michigan's Southern Lower Peninsula*



* Production in the West Central District has been too small to be represented in this chart. Production in the early 1990's has been about 150 thousand bushels.

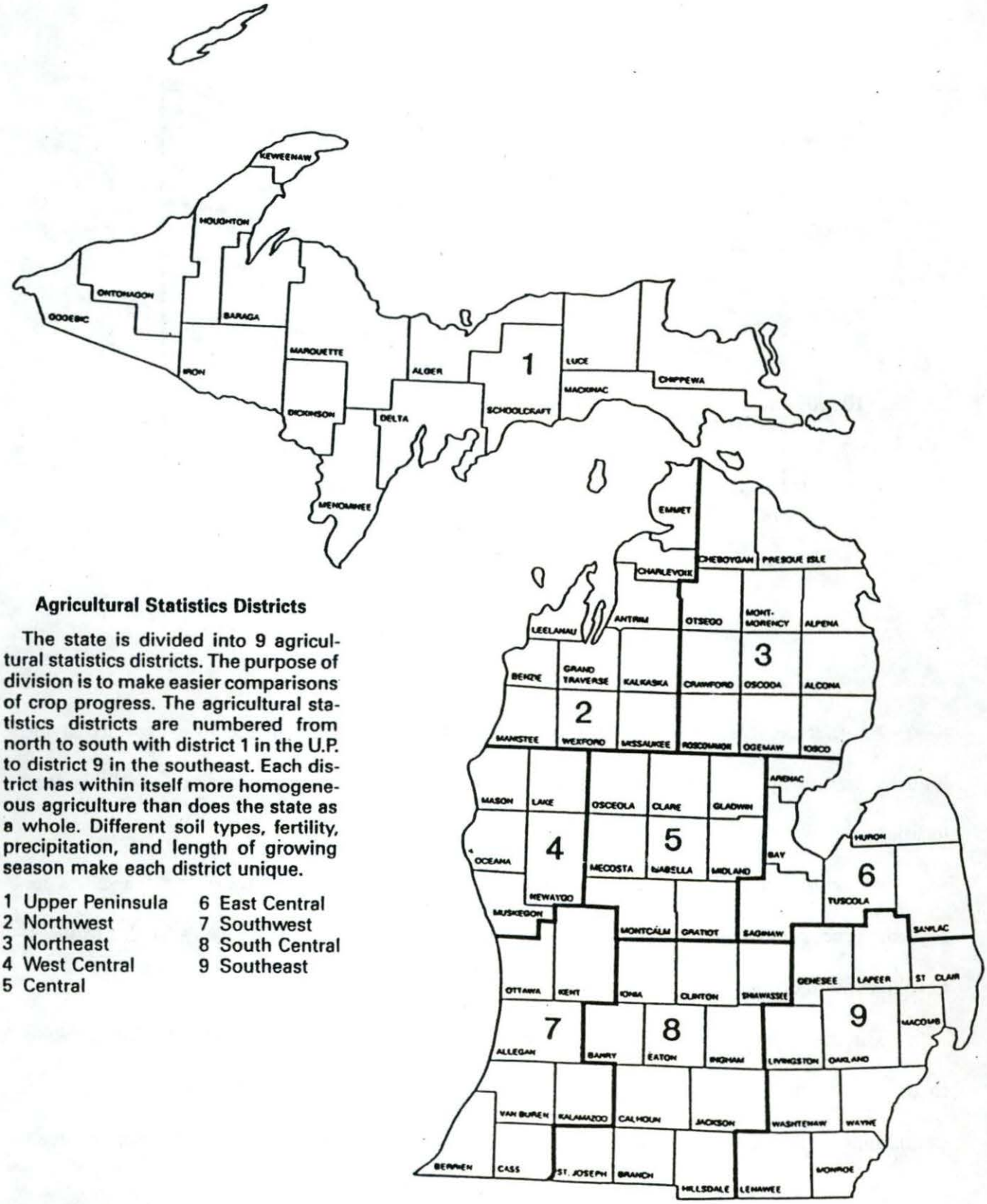
Total utilization of high protein feeds is approaching 500 thousand tons according to this analysis--compared with 300 thousand in the mid 1970's. Much of the gain in this market has been in southwest Michigan. This can be attributed to a doubling of hog numbers in this district during 1975-94 and a phenomenal eight-fold increase in turkey production.

Potential for Soybean Processing in Michigan

Very little of Michigan's soybeans are processed within the state. Nearly all of the beans are trucked to processors in northern Indiana and Ohio, with some going to Windsor, Ontario, Canada, and some to Illinois. Studies in the early 1980's concluded that soybean supplies were adequate to support a solvent-type processing operation, but that markets within the state for the meal would be limiting. Outside markets would have to be developed.

Figure 12

State of Michigan and the Agricultural Statistics Districts



Agricultural Statistics Districts

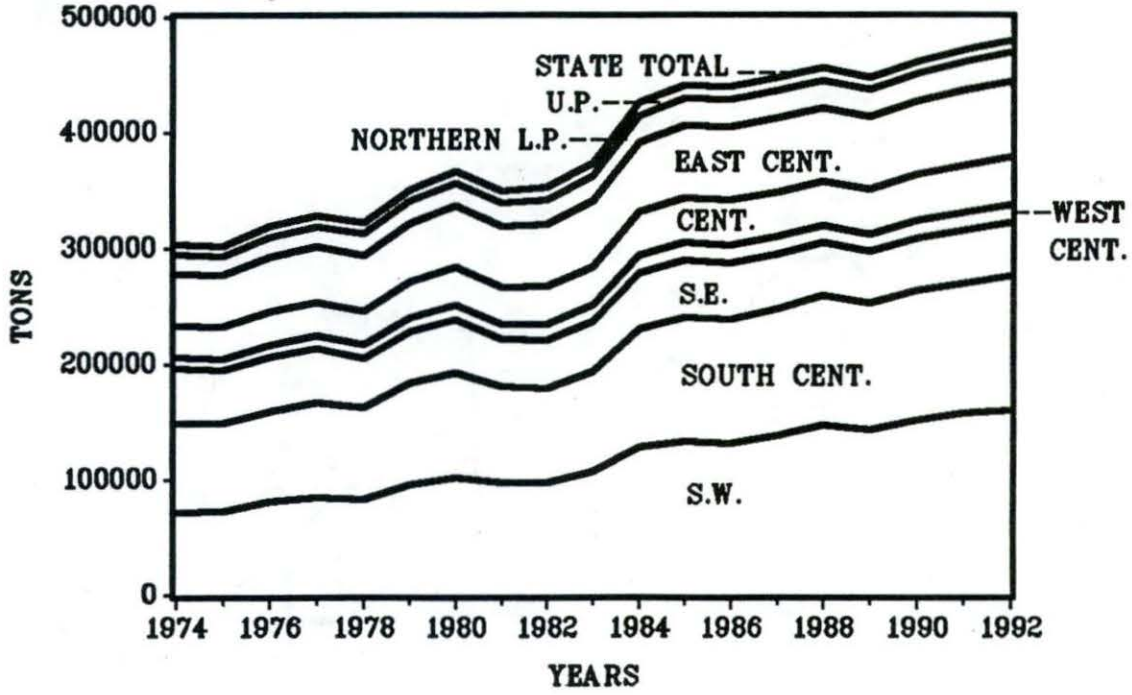
The state is divided into 9 agricultural statistics districts. The purpose of division is to make easier comparisons of crop progress. The agricultural statistics districts are numbered from north to south with district 1 in the U.P. to district 9 in the southeast. Each district has within itself more homogeneous agriculture than does the state as a whole. Different soil types, fertility, precipitation, and length of growing season make each district unique.

1 Upper Peninsula
2 Northwest
3 Northeast
4 West Central
5 Central
6 East Central
7 Southwest
8 South Central
9 Southeast

Source: Michigan Agricultural Statistics Service.

Figure 13

Estimates of the Feeding of High Protein Feed to Livestock in Michigan by Districts, 1974-92



Another deterrent to soybean processing in the state has been the over-capacity in the industry nationally. Processors have been reluctant to launch major capital efforts in new locations.

As both soybean production and meal markets expand in the state, the feasibility for soybean processing is augmented. Also, the plants existing in the early 1980's in the Midwest have become more obsolete since then.

The major rationale for a plant in the state is to save on transportation costs for soybeans to be moved out of the state and for soybean meal to be shipped back into Michigan. An evaluation of the savings could be made by measuring the trucking or rail costs involved.

Another approach is to examine soybean prices at various points in Michigan relative to prices at the major processors outside the state. Secondly, prices paid by farmers for soybean meal in the state could be compared with prices at the processors.

Looking at both transportation costs and observed basis, a processing plant in Michigan could add as much as 20 cents per bushel to soybean prices and lower meal costs by $10-15 per ton in an area north of the southern two tiers of counties. Such a plant would likely also draw beans from the southern two tiers of counties and also capture a portion of the meal market there, but the total impact would be less because these counties are closer to existing mills south of Michigan.

The map in Figure 14 displays the annual average soybean production by counties in the central and southern sections of the Lower Peninsula, and by districts for the northern Lower Peninsula and for the Upper Peninsula for 1991-93 (2). Production in the seven tiers of the central and southern Lower Peninsula counties are also tabulated. Total production north of the lowest two tiers of counties amounts to 31.0 million bushels, compared with the state total of 51.7 million bushels.

The map in Figure 15 indicates the location of the market for high protein meal. As indicated, the total market in the state adds up to 480 thousand tons, of which 324 thousand tons are in Tiers 3-7 and an additional 36 thousand tons are in the northern Lower Peninsula and the Upper Peninsula.

These figures do not represent the utilization of just soybean meal, but a combination of high protein feeds, of which soybean meal is a major portion. Data are not available on what proportion is soybean meal, but in total, soybean meal represented 87.5 percent of the high protein feed in U.S. livestock rations in 1992-94.

Figure 14

Average Annual Soybean Production by Counties in the Central and Southern Sections of the Lower Peninsula and by Districts in the Northern Lower Peninsula and the Upper Peninsula of Michigan, 1991-93, in 1,000 Bushels

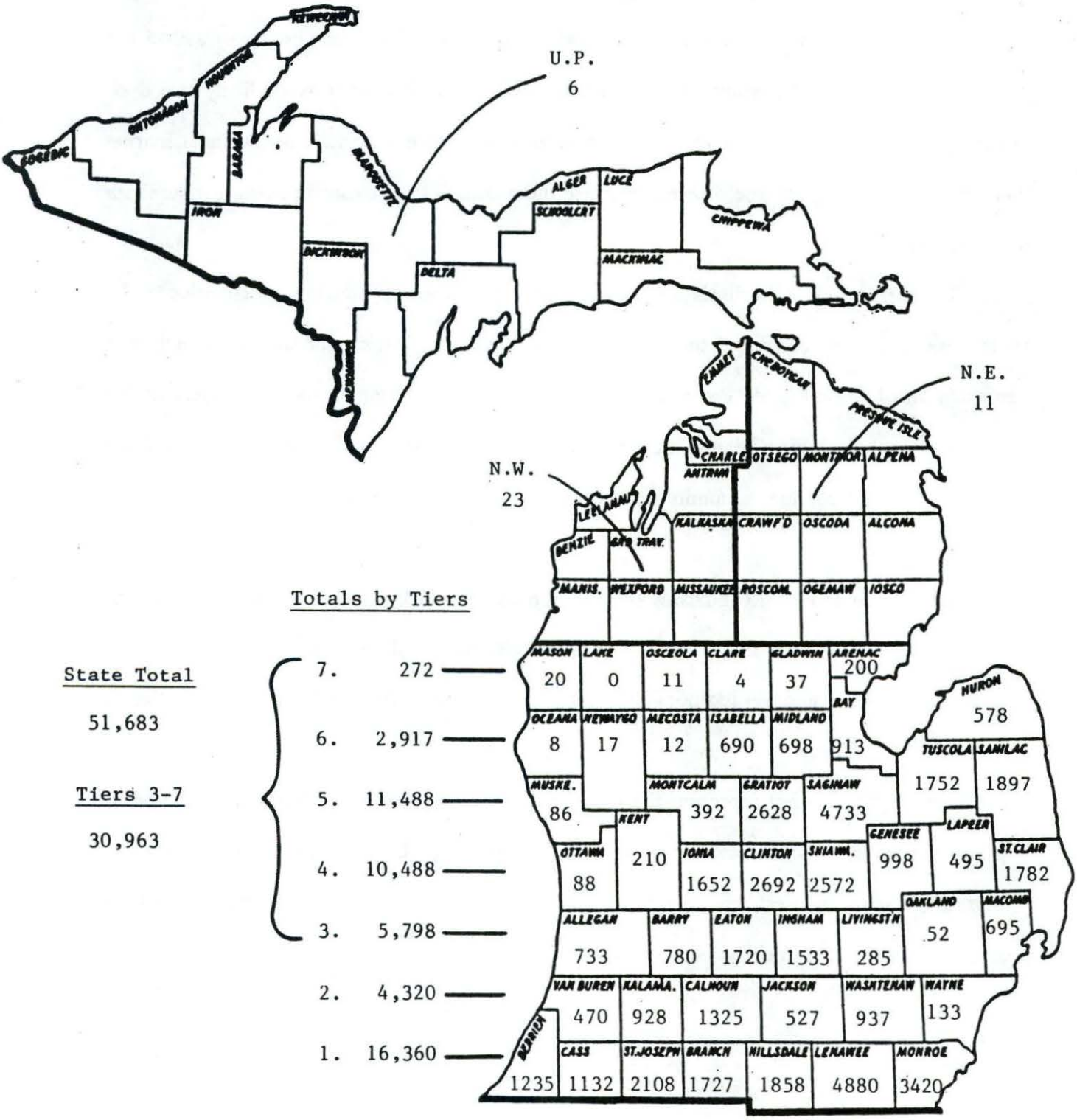
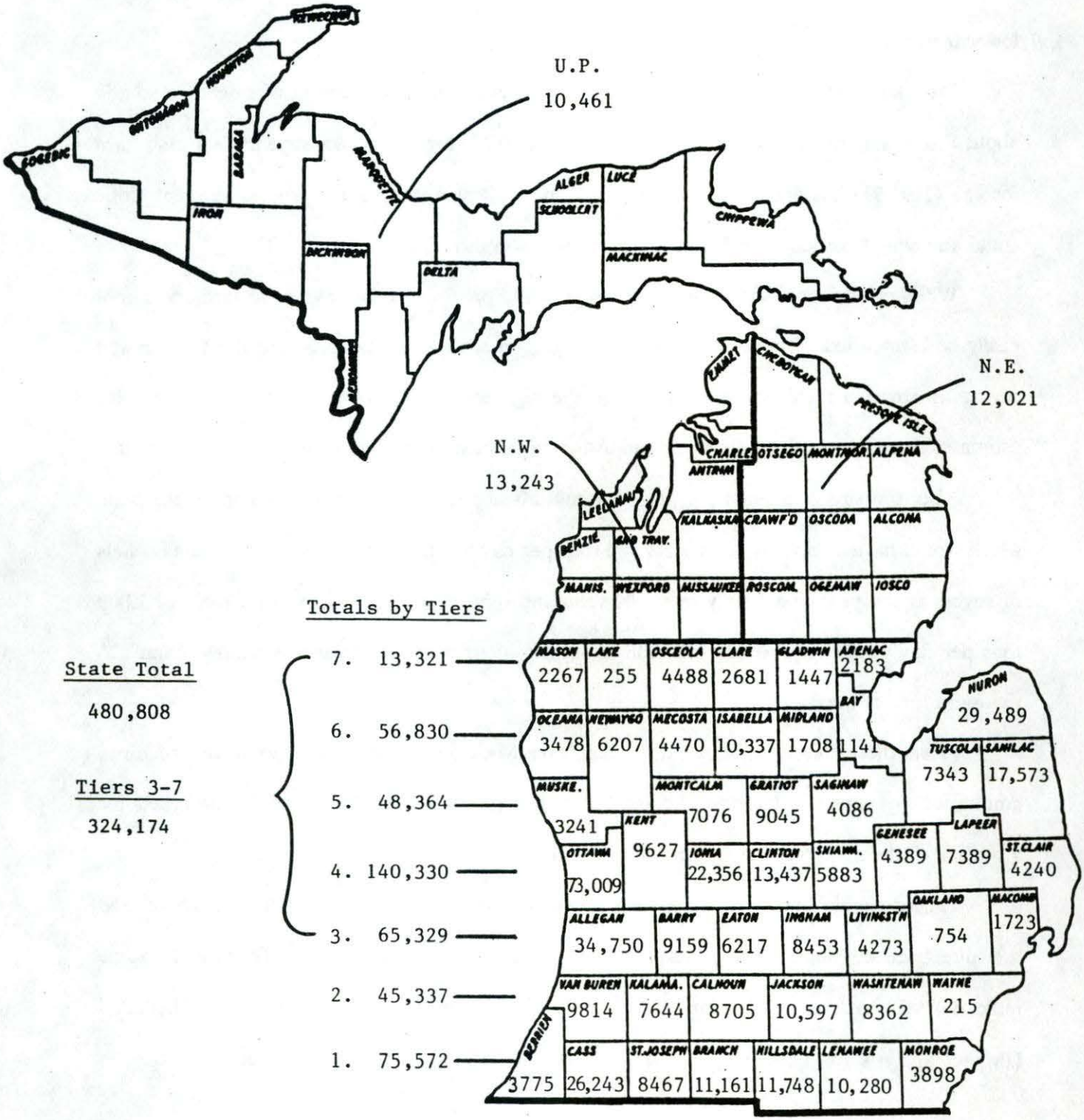


Figure 15

Estimated Amounts of High Protein Concentrates Fed to Livestock in Michigan by Counties in Central and Southern Lower Peninsula and by Districts in the Upper Peninsula and Northwest and Northeast Lower Peninsula, 1992, in Tons



If we restrict the analysis to the portion of Michigan above the lowest two tiers of counties, a strengthening of 20 cents per bushel in this area would have amounted to about $6.2 million. A lowering of soybean meal prices by, say, $10 per ton over 360 thousand tons in the area above the lowest two tiers of counties would amount to another $3-4 million annually in lower feed costs.

With these assumptions, the location of a soybean processing plant in Michigan could add about $10 million annually to net cash farm income in Michigan. In recent years, net cash farm income (1991-93) has averaged $910 million. This indicates that such a processing plant alone could add over 1 percent to Michigan farmers' net cash farm income.

Whether the construction of a new plant would pass on all the savings to farmers cannot easily be established. The 20 cent per bushel gain in soybean price basis and the $10 per ton savings in soybean meal prices are likely on the high end of the ranges. If more conservative estimates seem appropriate, downward adjustments in these stated estimates can be factored in.

Also, the size of a plant (or plants) would affect the extent of gain. Plants on the scale which would have a capacity to process 400 tons per day would require about 4.4 million bushels of soybeans per year and supply over 100 thousand tons of meal. A plant on a scale of 2,000 tons per day would require over 22 million bushels of soybeans per year and supply about 525 thousand tons of meal.

From these numbers, it is fairly clear that Michigan could easily supply the required amount of soybeans to a large-scale plant, but such an operation would need to find markets for a portion of the meal production outside the state.

The economic impact of a soybean processing plant on Michigan extends much beyond the direct effects indicated by output, total income and employment. To provide some indication of what the broader implications might be, multipliers were obtained from IMPLAN (IMpact analysis for PLANning). IMPLAN was developed by the USDA Forest Service, in

cooperation with the Federal Management Agency and the USDI Bureau of Land Management (5).

IMPLAN estimates two sources of the extended effects of an industry. One is labeled "indirect." Indirect effects are production changes in backward linked industries caused by the establishment of the plant. The second effect is labeled "induced." Induced effects are changes in regional household spending caused by changes in household income (generated by the establishment of the plant and its indirect effects).

Table 2 presents the estimation of IMPLAN of these effects for a soybean processing plant in Michigan. The resulting numbers include direct, indirect and induced effects of the soybean processing plant. The employment figure may seem a bit high, but can probably be traced to the high degree of automation in modern soybean processing plants.

Another effect of a soybean processing plant would be to encourage an expansion of soybean production. A 20 cent per bushel gain in price would translate to about $8 per acre in increased gross receipts. In recent years, Michigan soybean producers have realized gross margins over direct costs on soybeans of about $125 per acre. An $8 per acre gain would add about 6 percent to gross margins.

Table 2

Multipliers for Indirect and Induced Effects of
a Soybean Processing Plant in Michigan

Item	Indirect	Induced	Total
Output	1.8337	.2434	2.0771
Total Income	5.0951	2.7832	7.8783
Employment	10.2789	5.8861	16.1605

Source: IMPLAN.

Lowering soybean meal prices by $10 per ton would have a positive influence on livestock production. While such savings may amount to only about 1 percent of the gross sales on livestock, gross margins over direct costs are typically about 20-25 percent of gross. This means a savings of 1 percent of sales translates to 4-5 percent of gross margins over cash costs.

An expansion in both soybean production and livestock production would have secondary and tertiary effects on the rest of the economy. The extent of these effects depends on what resources are diverted to these enterprises. For example, if soybean acreage increases at the expense of corn acreage, the impact of increased soybean production may not be a net gain.

In evaluating the total economic impact on Michigan agriculture of a soybean processing plant, a comprehensive model would be needed to trace through the changes over time. Shifting from corn to soybeans can be accomplished very quickly. Because of the lag structure in livestock production, the full impact of a soybean processing plant on livestock may not be registered for several years. The effects on net returns to soybean and livestock production, however, would be registered immediately as would the direct and indirect impacts of the plant itself on the local economy.

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