ECONOMIC RELATIONSHIPS IN THE OIL OF PEPPERMINT AND OIL OF SPEARMINT INDUSTRIES

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Gail L. Cramer

1964


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ECONOMIC RELATIONSHIPS IN THE OIL OF PEPPERMINT AND OIL OF SPEARMINT INDUSTRIES

by

Gail L. Cramer

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
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ABSTRACT

ECONOMIC RELATIONSHIPS IN THE OIL OF PEPPERMINT AND OIL OF SPEARMINT INDUSTRIES

by Gail L. Cramer

Few statistics are compiled on mint oil production, distribution, or consumption. Neither the basic functions nor the structure of the industry have been described or analyzed. For that reason, the problem lies in describing the economic relationships in the industry to provide vital knowledge to improve managerial decision making at all stages in the production and marketing processes.

The specific objectives of this research were to explore the shifts in production centers, to determine foreign production and international trade, to determine foreign and domestic utilization and to examine the market structure and various indications of market performance.

Basic data used to determine the factors influencing the shifts in production areas were obtained from previous production cost studies in the Midwest and West Coast production centers. Other data on foreign production, utilization and market structure were obtained from industry buyers and the foreign service.

The results of the production studies proved the profitability of mint oil production in the Pacific Northwest. The steady decline of the industry in the Midwest has been partly caused by verticillum wilt and buyer pricing practices.

Due to the rigid climatic conditions needed to produce quality mint oil, the United States produces about 90 percent of the world's supply of peppermint oil and the majority of spearmint oil. Other countries that produce mint oil are dispersed through Europe.

The United States exported about 51 percent of the United States production of peppermint oil and 40 percent of the spearmint crop in 1962. The largest importer is the United Kingdom followed by other countries located in Europe.

The mint oil industry in the United States is composed of about 1,200 producers, 4 buyers and 6 major users. While a competitive structure dominates the producer level a bilateral oligopoly exists at the wholesale marketing stages. Although more research is needed to determine the conduct and performance of the industry, price differentials do prevail that are greater than regional transportation and quality differences.

The major buyer in the industry handles 50 percent of the U.S. production while the remaining three buyers handle an estimated 30, 15 and 5 percent.

A statistical model was formulated to determine the demand and supply of peppermint and spearmint oil. The model contains four stochastic equations that are solved simultaneously using a two stage least squares estimation procedure.

It was discovered that the price-quantity relationships in both demand equations were obscured by unknown quantities of stock at the buyer and user levels and the oligopsonistic nature of the industry.

With this inherent weakness, the demand for peppermint oil was inelastic and the demand for spearmint oil was slightly elastic (computed at the mean values of other variables).

Both the supply equations for peppermint and spearmint oil were inelastic, but the sign on the peppermint equation was negative indicating an identification problem.

Alternative formulations of the demand equations using two other estimation procedures proved less fruitful and violated the basic assumptions suggested by an oligopsonistic industry.

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CHAPTER I

INTRODUCTION

The United States is the world's supplier of choice mint oil, producing approximately 80 percent of the world supply. Of the 2,979,000 pounds of mint oil produced in the United States in 1963, peppermint oil accounted for over three-fourths of the total amount and spearmint nearly one-fourth.

The mint industry is the largest commercial perennial herb industry in the United States covering 55,000 planted acres and amounting to a gross return to growers of 12,936,000 dollars in 1963. Although the mint industry is relatively small compared to major agricultural crops, it is very complex, requiring specialized equipment and much technical knowledge.

This oil is produced commercially in two regions. The oldest region is the Midwest region consisting of the states of Indiana, Wisconsin and Michigan. The youngest, but largest, region is the Pacific Northwest which includes

the states of Oregon and Washington.

In 1963, the Pacific Northwest planted 74.6 percent of the United States' peppermint plants and produced 83.8 percent of the peppermint oil supply. The state of Washington produces the majority of spearmint oil grown in the United States.

The major use of peppermint oil is as a flavoring material in chewing gum, toothpaste, medicines, perfumes, and beverages. Spearmint oil has a more limited use deriving its demand primarily from the production of chewing gum and toothpaste.

Peppermint oil is produced from one variety, Mitcham; however, many different qualities of the oil exist depending on the producing area's climatic conditions and the amount and kinds of weeds distilled in the oil.

Spearmint oil is of two varieties. One variety is called Scotch and the other Native. They differ in their individual qualities and monetary value, but are usually blended when used. This is especially true for spearmint used in the chewing gum industry.

Mint production requires a large fixed investment in plant and equipment, but not any larger than some other types of agricultural enterprises. A distillery unit alone may cost from 8,000 to 10,000 dollars. Much of the farm equipment is complementary with other farm enterprises. Mint culture is unique among agricultural crops because of the distillation process and the rigid climatic conditions

necessary in order to attain high grade oil.

Four buyers, or brokerage firms, purchase mint oil directly from the producers. In some areas, the buyers purchase oil at harvest time, but usually the larger buyers use forward contracts. The amount of oil a buyer purchases is dependent upon orders from final users plus extra inventories for noncontract sales to minor users during the marketing year.

Oil of peppermint and oil of spearmint are classified by the United States Department of Agriculture as "essential oils"; however, most producers in the industry refer to the two groups of volatile oil in the aggregate as "mint oil".

Mint oil is the main product derived from commercial plantings of mint, although an infinitesimal amount of mint is used in leaf form in various foods and beverages.

The Problem Setting

Only statistics from commercial producing areas, including acreage, yield, production, and average prices received by farmers are collected. The United States Department of Agriculture does not collect data on carryover stocks at the farm, buyer, or user level as the industry is unwilling to cooperate in compiling these statistics. Also, few statistics on foreign production and utilization are compiled.

At present, most of the final users and producers know little about the industry as a whole or about the pricing mechanism that exists. Specifically, more descriptive research is needed on the mint industry in the United States, foreign production of mint oil, international trade, and the economic relationships that exist in the industry.

The Objectives

The general objective is to describe the mint industry. There is a need for factual information to determine basic economic relationships before detailed economic analysis is possible.

The mint oil industry has not been under public controls, except for a short period during World War II. Therefore, this study will attempt to determine the market structure and suggest some indications of market performance.

Specific objectives are as follows:

1. To describe the industry practices with regard to production, marketing, consumption and the interrelationships between growers, buyers, and users.
2. To determine the cause of shifts in production areas.
3. To determine the relationship between quality of oil and average farm prices received by farmers.

4. To determine foreign production, utilization, and international trade.
5. To explain the peppermint and spearmint pricing mechanism.

Approach to the Study

The approach to the study will primarily be historical, as out of the past we form the future. Using historical data, one can project the future using economic theory and statistical procedures if the structure of the industry remains intact and a set of homogenous factors operates throughout the time period concerned.

Chapter II provides the historical description of the industry, such as acreage, yield, and production trends, and the regional movements of the industry due to changes in absolute advantage.

Chapter III deals with foreign production areas and international trade.

Chapter IV deals with production cost analysis.

Chapters V and VI attempt to examine pricing practices, marketing channels, and the demand and supply of mint oil. The demand and supply of oil will be analyzed using a two-stage least squares estimation procedure.

The final chapter includes the summary and conclusions of the study and suggestions for future studies.

Definitions

Certain words are used throughout this study that are unique to the mint oil industry. For this reason, and to insure a better understanding of the material, the following definitions are inserted.

Oil of Peppermint: Oil derived from Mentha piperita L.

Oil of Spearmint: Oil derived from Mentha spicata L. (Although the scientific names of both Oil of Peppermint and Oil of Spearmint are not technically correct, they are the ones most widely used in research papers.)

Mint Oil: Refers exclusively to peppermint and spearmint oil.

Major constituents: esters, menthol, menthone, menthofuran — the chemical compounds important to mint quality.

Menthofuran: an unstable chemical which is overly sweet and has an aromatic character. It is found mainly in the blossoms of the mint plant.

Cornmint or Mentha arvensis: an oil with a very high menthol content. Many times referred to in foreign countries as peppermint oil, but the oil characteristics are markedly different than oil from Mentha piperita.

CHAPTER II

THE MINT INDUSTRY IN THE UNITED STATES

The mint industry in the United States does not cover a geographically extensive area, but it has grown in importance with the popularity of peppermint and spearmint oil as flavoring agents. Before discussing the historical background, production areas, and diseases of the mint industry, it is imperative to know the cultural requirements that affect its historical development in the United States.

Cultural Requirements

Peppermint and spearmint by nature are plants that require the long summer days of the Northern latitudes. Research has established that quality peppermint oil can only be produced above 40 degrees latitude. Luxuriant growth of peppermint can be attained in lower latitudes in states such as California, but the high menthofuran content of the oil makes it unsuitable for the manufacturing of certain products such as chewing gum and toothpaste.

A high menthofuran content is attributed to the high luminosity prevailing in dry atmosphere.

Besides the 140 day growing season, peppermint needs an abundant supply of fresh water. In the early days, mint

was found growing along river banks with its roots extended into the water. Spearmint requires similar conditions, but it is less restricted to areas, by the length of day, than peppermint. Although this is true, spearmint normally follows peppermint due to the complementary equipment needed for both enterprises.

Both peppermint and spearmint are grown on highly organic soils in the Midwest. These soils are commonly referred to as "muck soils". Mint does well on this loosely textured soil especially when supplemental irrigation is used.

In the Pacific Northwest, the majority of the mint is grown on mineral soils classified as "sandy loam". Much of the mint in the Pacific Northwest is rill irrigated from federal irrigation projects, however, overhead sprinklers are used west of the Cascade Mountains. Supplemental irrigation is needed. None of the producing areas provide the 50 to 60 inches of annual precipitation required for mint.

Since the cultural requirements of these two crops are so strenuous, these two regions produce most of the world's supply of peppermint and spearmint oil. Even though the United States is almost the sole producer of mint, production has not remained constant from year to year because the mint industry has been plagued by diseases. This has caused a fugitive industry. The history of mint culture will further explain the movement and the development of the fugitive industry.

History of Mint Culture[1,2]

Commercial plantings of peppermint in the United States began in Ashfield, Massachusetts about 1812. The plants were gathered and distilled, and the oil was peddled in New York.

As peppermint became more popular, the mint industry developed in Wayne County, New York. This was about 1816. New York production is believed to have reached a maximum of about 4,000 acres, but diminished rapidly to become almost extinct by the early 1900's.

The decline in acreage in New York was due to competition from the Midwest producing areas and from insects and diseases existing in the New York producing area.

In 1835, the peppermint industry moved westward to Northern Ohio and Southern Michigan. The first plantings in Michigan were on White Pigeon Prairie in St. Joseph County. Plantings were also set in Northern Indiana. By 1911, Michigan and Indiana were the world's largest suppliers of mint oil.

Diseases and new outlets for mint oil kept dealers and producers seeking new areas for mint production. The

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[1]Nelson, Ray. Verticillium Wilt of Peppermint, Michigan Agricultural Experiment Station, Technical Bulletin 221, June 1950.

[2]Liebie, Lester N. Peppermint Oil - An Economic Study, Washington State Agricultural Experiment Station, Popular Bulletin 199, August 1950.

industry was introduced into the Pacific Northwest in 1903 with rootstock imported from England. The new plantings were concentrated in Oregon and slowly expanded into California and the lower Columbia River area in the state of Washington.

Because of the increasing need for menthol during World War II, peppermint acreage boomed in Oregon in the 1940's. Unlike Oregon, Washington's expansion in acreage came in the 1950's due to the verticillum wilt problems in the Midwest. This caused new areas to open in Washington especially in the ditch irrigated areas of Yakima, Benton, and Franklin Counties.

Today, Washington and Oregon produce 83.8 percent of the peppermint oil and Washington produces 72.6 percent of the spearmint. Oregon, at this time, has only 25 experimental acres of spearmint under cultivation.[3]

The industry keeps spreading. In recent years, peppermint has been cultivated commercially in Wisconsin. Although the Crop Reporting Service, U.S.D.A. only publishes estimates of acreage in commercial production areas, the 1959 Census of Agriculture indicates that small acreages of peppermint are grown in Idaho, Montana, Nevada, and

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[3]Guenther, Ernest. "The Spearmint Oil Industry in Washington State," Perfumery and Perfumery and Essential Oil Record. London, England, November 1961, pp. 696-696.

Minnesota. So far, however, production in these areas is minor.

The reason the industry keeps moving is attributed to verticillium wilt, which reduces yields by stunting the plants, and to cultural practices. Reduced yields affect returns per acre. As a result, industry pricing practices are a major factor in changing the regional absolute advantage of mint production.

Mint Oil Production in Michigan[4]

Michigan has a long history in the production of medicinal herbs. In an account by Henry Kraemer, the peppermint industry was introduced by Calvin Sawyer in St. Joseph County in 1835. The roots were brought in from Ohio and Sawyer established the first peppermint plantation on Pigeon Prairie in the township of White Pigeon. In the spring of 1836, other farmers made plantings from roots obtained from Sawyer.

Much of the first oil produced was purchased by village merchants who exchanged it in New York City for merchandise needed in their trade. As the crop gained favor, many of the merchants acted as brokers for Eastern dealers. The eastern dealers mainly exported it to Europe, principally to Liverpool, England.

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[4]Kraemer, Henry. "Michigan - An Important Source of Raw Vegetable Products," Michigan Academy of Science Report, 21:187-199, 1919.

An important phase of the Michigan peppermint industry came in about 1844 when a New York firm monopolized the trade of mint oil. The firm accomplished the monopoly by first sending an agent to Europe to determine the amount of oil needed in the Liverpool market. It was estimated to be around 12,000 pounds per year. The firm also sent an agent west into the producing regions to determine annual production. Farms in New York did not produce enough mint oil and those in Ohio too much, but production in Michigan was the quantity desired to supply the Liverpool Market. Therefore, the New York firm contracted with New York and Ohio producers to plow up their mint fields, to destroy the roots, and not to plant any more mint for a period of five years. They paid the growers $1.50 per acre for doing this. Next, they contracted with growers in St. Joseph County to pay them $2.50 per pound for their mint oil delivered to this agency for a period of five years. The growers were bound under heavy penalties not to sell roots, not to expand production, and to deliver every ounce of mint oil grown.

During the three years that the contracts lasted, the agency gained a considerable fortune and ceased to enforce the contracts. Many of the growers made small fortunes also and retired from business. One thing gained by the monopoly was that Michigan established the reputation of producing the highest quality oil desired by most users of mint oil.

The first plantings were in burr oak soil, but later peppermint was planted in muck soils that were high in organic matter and easily penetrated by the fibrous roots of peppermint. Peppermint grown on muck soil in St.Joseph County flourished and the largest peppermint farm in the world was established by A.M. Todd.

In 1892, A.M. Todd moved this business from Nottawa to Kalamazoo. As the popularity of Michigan oil grew, A.M. Todd found it necessary to engage more in marketing than in production. A.M. Todd became known as the "Peppermint King of the World". He was the founder of the A.M.Todd Company, the largest handlers of mint oil in the world. The company at present is operated by relatives, John and Winship Todd, and is located in Kalamazoo, Michigan.

As diseases and insects plagued production in St. Joseph and Van Buren Counties, production spread to other counties, particularly to Clinton and Shiawassee. In 1940, these two counties comprised the majority of mint acreage in Michigan.

Mint production has not been extensive throughout the state, rather it has been limited to small pockets of muck soil in the Southwestern and Southcentral portions of the state.

In 1940, there were 1,034 growers reporting 18,800 acres of mint as compared with 169 growers reporting 6,241 acres in 1959. The major reason for the decline in the

industry has been the competition from the Pacific Northwest and the wilt disease which has reduced yields so producers can no longer cover production costs or receive an adequate return on investment. Most producers are turning to alternative crops including sugar beets, sod for urban lawns, corn, and vegetables; however some growers have moved to new producing regions such as Wisconsin and the West Coast.

Diseases

Many diseases and insects affect peppermint and spearmint, but most of them can be controlled. The most serious disease affecting the American mint industry is caused by a fungus Verticillum alboatrum. The disease manifests itself by wilting and stunting the mint plant and curling the upper leaves. These leaves turn yellow-brown and in severe cases drop off.

Gradually the wilt spreads, forming distinct brown and dead patches in mint fields. Wilt fungus is taken into the plant through the root system. The nutrient conducting vessels of the plant are penetrated by the fungus, preventing the normal uptake of water and soil nutrients.

Under a continuous mint rotation, the fungus develops rapidly in the soil. In the absence of peppermint and spearmint production, the fungus remains in the soil for an estimated ten years.

Wilt disease is very serious in Michigan and Indiana and it has been spreading at an alarming rate since 1944 in Willamette Valley, Oregon and since 1946 in Yakima Valley, Washington.

In 1960, about 8,000 acres in Oregon were infected by wilt disease and about 4,000 acres in Washington.[5]

The disease was first isolated in 1924, but years of research at land grant universities and by the A.M. Todd Company have not brought the fungus under control nor have acceptable disease resistant varieties been propagated.

Rust, another fungus disease, can be controlled by the mint producers. This disease was a real problem a few years ago but has been brought under control by sanitary cultural practices and by spraying the plants with chemical compounds. Rust reproduces itself by spores and has a reproductive cycle of about two weeks.

Current Research on Verticillum Wilt

Wilt disease spread rapidly in Michigan from 1935 to 1947. A survey in 1939 showed that only one field of 20 acres was free from the disease and it was new mint on "new soil".[6]

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[5]Guenther, Ernest. "The Peppermint Oil Industry in Oregon and Washington States," Perfumery and Essential Oil Record, London, England, October 1961, pp. 632-642.

[6]Nelson, Ray. op. cit., p. 29.

Although a quantitative measure is not available to represent the loss from the disease, Nelson thinks it represents a sum totalling millions of dollars both from reduced oil yields and the loss of the mint industry to the Midwest.[7]

Currently, three universities and the U.S.D.A. are working on the disease. They have, so far, suggested three alternatives. One is deep plowing; the second, fumigation; and the third is breeding disease resistant varieties.

Deep Plowing:[8]

In the deep muckland soils of Indiana, it is recommended that the grower plow fields to 30 inches. Deep plowing buries the fungus and the roots of mint are not affected since the root system of the plant is quite shallow. Research at Purdue University has shown that deep plowing reduces wilt considerably and that the soil 30 inches below could support the growth of peppermint.

Disadvantages of deep plowing are:

1. some soils are too shallow
2. most fields are small and irregular so they are hard to plow
3. relatively high cost machinery would be required
4. increased labor costs would be involved.

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[7] Ibid.

[8] Green, Ralph J. "Deep Plowing as a Control for Mint Wilt."

More research is being done on deep plowing to determine its overall effectiveness.

Soil Fumigation:[9]

Tests with soil fumigates have been carried on at both Purdue University and Oregon State University. So far, a chemical called Vorlex distributed by Morton Chemical Company seems promising.

The following test shows the effectiveness of Vorlex.

Table 1. Results of Vorlex Tests at Purdue University.

Treatment	Gallons per acre	Wilt Index	Pounds of Peppermint Oil per acre
Telone (Dow Chemical)	40	6.3	34.6
"	80	5.8	33.0
Telone - Chloropincrin	40	3.1	37.0
"	80	1.9	53.0
Vorlex (Morton Chemical)	50	.1	62.0
Check Plot	--	9.1	21.3

Wilt Index = 0-10

Trials have been run since 1961 and the .1 wilt index shows that vorlex will control the disease, but not

[9] Green, Ralph J. "Summary - Control of Mint Diseases - 1963".

eliminate the disease completely. The annual cost of vorlex is $300 per acre. Although on a volume scale, most think the price could probably be reduced to about $75 per acre, which would increase the profitability of the crop in the Midwest if yields increase 20 to 30 pounds per acre.

Both deep plowing and fumigation increase costs far beyond profitable means for mint producers at the present time.

Disease Resistant Varieties:[10]

The most inexpensive alternative seems to be the development of resistant varieties. Many problems arise in plant breeding to replace Mitcham peppermint because it is necessary to use a spearmint-type parent (mentha crispa) as the resistant parent in the cross. As a consequence, the oil is highly variable.

Other problems encountered in producing hybrids have been that Mentha piperita M. seldom produces seed. To obtain seeds from peppermint, one must thresh the flower spikes at least three times, each time in smaller seives. Then one must take the chaft and left over seeds and pick out the seeds with a microscope and a dissecting needle.

Another problem has been the synchronization of flowering of the parent varieties. Other problems involve

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[10] Nelson, Ray. Op. cit.

the reluctance and conservatism of major users of mint oil. Mint users do not want a perceptible difference in the taste of their product.

Oil with a very distinct "off odor" is easily detected by anyone. However, hybrid mint oil that is close to the standard blend of oil is much harder if not impossible to detect by the average tester.

Recently, Dr. Nelson informed me that he had developed a hybrid mint plant that he thinks will be acceptable to the trade.[11] To date, it has been accepted by candy manufacturers. Also, the cost of the rootstock is comparable to that presently paid for Mitcham peppermint rootstock.

Poor cultural practices can be directly responsible for the spreading of rust and wilt diseases. Declining acreage in the Midwest, has been partially caused by continuous cropping of mint without rotation. Even after producers realize they have wilt disease, some are late in taking corrective action.

The state of Oregon is the first state to put forth any effort to stop the sale of diseased rootstock. They have established a rootstock certification board at Oregon State University to inspect all rootstock sold. This board was established in 1963.

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[11] Nelson, Ray. Personal Correspondence, July 1964.

The only other effort put forth before this time was a state quarantine law which prohibited the sale of diseased rootstock in Madras, Oregon. However, it is hard to keep the area disease free when there is the interchange of farm machinery and cars, trucks, etc. between producing areas.

Verticillum wilt is especially hard to control in the Pacific Northwest due to the gravity flow irrigation system.

Oregon growers are determined to find a control for the disease. Most growers are taking an active part through their grower organization and donate to a research fund at the rate of one cent per pound of oil produced.

Unique Characteristics of Mint

Peppermint and spearmint are propagated vegetatively using stolens or young plants from previous plantings. Crops planted from stolens are expected to produce a good crop the first year.

One acre of mint on Midwest organic soil should produce enough stolens to plant between 7 and 15 acres. On mineral soils in Washington and Oregon, one acre of mint will normally provide planting stock forabout 4 to 7 acres. If contracts stipulate a "good price," extra acreage can be planted using "plants" as rootstock. Normally, however, the yield is poorer than that from plants grown from stolens.

First year mint is set in single rows and is called "row mint." Second year mint is termed "meadow mint" because after the harvest of first year mint the land is tilled and this allows the stolons to grow throughout the field.

Row mint is easier to cultivate and keep clear of weeds. If weeds are distilled in the mint oil, the oil will have an "off odor" which makes the oil of little use.

After the plants are bedded in early spring, fieldmen from the major users and from buyers visit many of the farms to make suggestions. These fieldmen are particularly interested in keeping the fields free from weeds.

Weeds are controlled using various chemicals, however, in the Pacific Northwest, some growers use geese. Geese are purchased in the spring and are left in the fields to eat weeds. These geese will not eat the mint plants. The geese are then sold in the fall because usually by the second year, the geese acquire a taste for the mint plant itself.

Although chemical weed control is popular, some growers also use mechanical means and hand labor.

Mint oil quality originates on the farm. Once mint oil has been produced, little can be done to improve it.

During the growing season, the farm activities include weeding, disease control, and supplemental irrigation.

When the mint plant reaches flowering stage, it is mowed much like alfalfa. The hay is left in the field to dry for about two days during which time the moisture content decreases to approximately 35 percent. If the mint hay is left to dry in the field too long, the leaves will shatter which will reduce yields.

The oil is primarily concentrated in the leaves so swathing is generally a morning activity when the mint stems are tougher. Next, a chopper picks up the hay and puts it in distilling tubs mounted on a truck or tractor. The truck moves from the field to the farm distillation plant where the mint hay goes through a simple distillation process.

The distillation procedure consists of shooting steam into the portable tubs. This steam under pressure ruptures the membrane around the oil particle and vaporizes the oil. The steam and oil vapors are then transmitted through a condenser unit to reduce the mixture to water and oil. The water and oil are collected in an oil receiver. The oil floats to the top of the water and the oil is then drained off into 55 gallon barrels provided by the buyers. This distillation process requires from 45 minutes to 2 hours depending on the type of distillery unit.

Much improvement has taken place in distillery units, but the distillation process remains unchanged.

At the end of harvest, the grower takes his oil to the buyer's pick up stations located in the producing area.

After the mint oil is collected at pick up stations, it is sent by rail to the buyer's plant where it is reweighed, checked for water content, and sampled for quality.

The major quality test is performed using gas chromatography. This process registers on a chart the presence and ratio of major constituents that affect quality and flavor characteristics. Someone who has worked around mint for any length of time can readily identify quality by the mint odor.

About two thirds of all oils sold are redistilled prior to use. By combining regional purchases into uniform blends, buyers can smooth out minor regional differences in quality of mint so that final products remain fairly consistent in flavor year after year.

Types of Peppermint and Spearmint Oil

There are two major types of peppermint oil produced from Mentha piperita L. One type is referred to as Prime Oil of Peppermint. Prime Oil of Peppermint is characterized by a high degree of flavor stability, a clean sharp flavor, and a low quantity of the ingredient known as menthofuran.

The second type of peppermint oil is normally called Kennewick Oil of Peppermint, although some refer to it as Yakima Oil of Peppermint. These two names are derived from the areas in the state of Washington in which they are produced. This oil is distinguished from Prime Oil by a more

aromatic flavor character, a lower degree of flavor stability, and a higher menthofuran content.

Oil produced in Central Washington may contain as much as 10 to 16 percent menthofuran compared to 3 to 4 percent in Western Washington, Oregon, and the Midwest produced oil. Kennewick oil receives its aromatic character from the high light intensity, high summer temperatures, and low humidity.

In the United States, the chewing gum and toothpaste manufacturers limit their purchases to Prime Oil and exclude the Kennewick type completely. The candy industry, however, uses some of the Kennewick oil not only because of the cost advantage, but also because it appears to give a stronger flavor burst. This seems necessary in products which are sweet or are coated with chocolate.

Exports consist mainly of Kennewick Oil, primarily because it can be purchased at a lower price. Foreign markets are not as concerned with quality, per se, as they are in receiving a consistent flavor year after year.

There are two varieties of spearmint grown. One variety is Native and the other, which comprises the majority of the spearmint produced, is Scotch. Scotch variety is more widely used because of its mellow flavor. Native variety has much more strength, therefore, in chewing gum a mixture of the two varieties is used. The Native variety is less common and brings a premium price. Native Oil is

never used alone. It is always used as a blend with the Scotch variety.

Peppermint: Acreage, Yield, and Production

Two regions in the United States produce peppermint oil commercially. The Pacific Northwest region (Washington and Oregon) is one region and the other is the Midwest region (Indiana, Michigan, and Wisconsin).

Acreage planted to peppermint has been relatively stable since 1929. In 1947, growers maintained 47,700 acres. In 1963, the United States handled 41,800 acres which is only 12 percent less than the 1947 acreage.

Although acreage has remained relatively constant, there has been a shift in producing regions. In 1947, the Pacific Northwest had about 32.3 percent of the acreage while the Midwest accounted for the remaining 67.7 percent. The Pacific Northwest continued to expand acreage as wilt disease increased in the Midwest and as the export demand increased. In 1963, the West accounted for 75.4 percent of the United States' total acreage.

These drastic, but steady shifts in acreage are shown in figure 1, page 27. The increase on the West Coast came in Oregon in the 1940's and in the Yakima Valley in the 1950's.

Midwest acreage has fluctuated widely, but it is steadily declining. As shown by the graph, the West surpassed the Midwest in acreage in about 1952.

As shown by figure 2, page 28, yield per acre of peppermint varies considerably from state to state. In Michigan and Indiana, the older mint producing area, mint yields are quite low compared to Washington and Oregon. Much of this variation is again due to wilt disease prevalent in the Midwest coupled with better growing and climatic conditions in the Western area.

Wisconsin, a relatively new peppermint producing area, produces yields which are relatively stable, ranging from 31 pounds per acre in 1950 to 43 pounds per acre in 1962.

When peppermint was introduced into the rill irrigated sections of central Washington in 1941 and 1942, yields of Washington oil increased profusely. This was also true in Oregon when acreage was expanded to the Madras and other areas east of the Cascade Mountains. Even though these areas are well adapted to mint production, other factors also influenced yields. These other factors include improved farming practices such as chemical weed control, more effective use of fertilizers, the elimination of rust, and better stills.

Fertilizers are important on most farm crops, but on mint there is no evidence of a relationship between total growth of hay and the yield of oil. Also, no one element is extremely important for increasing production of

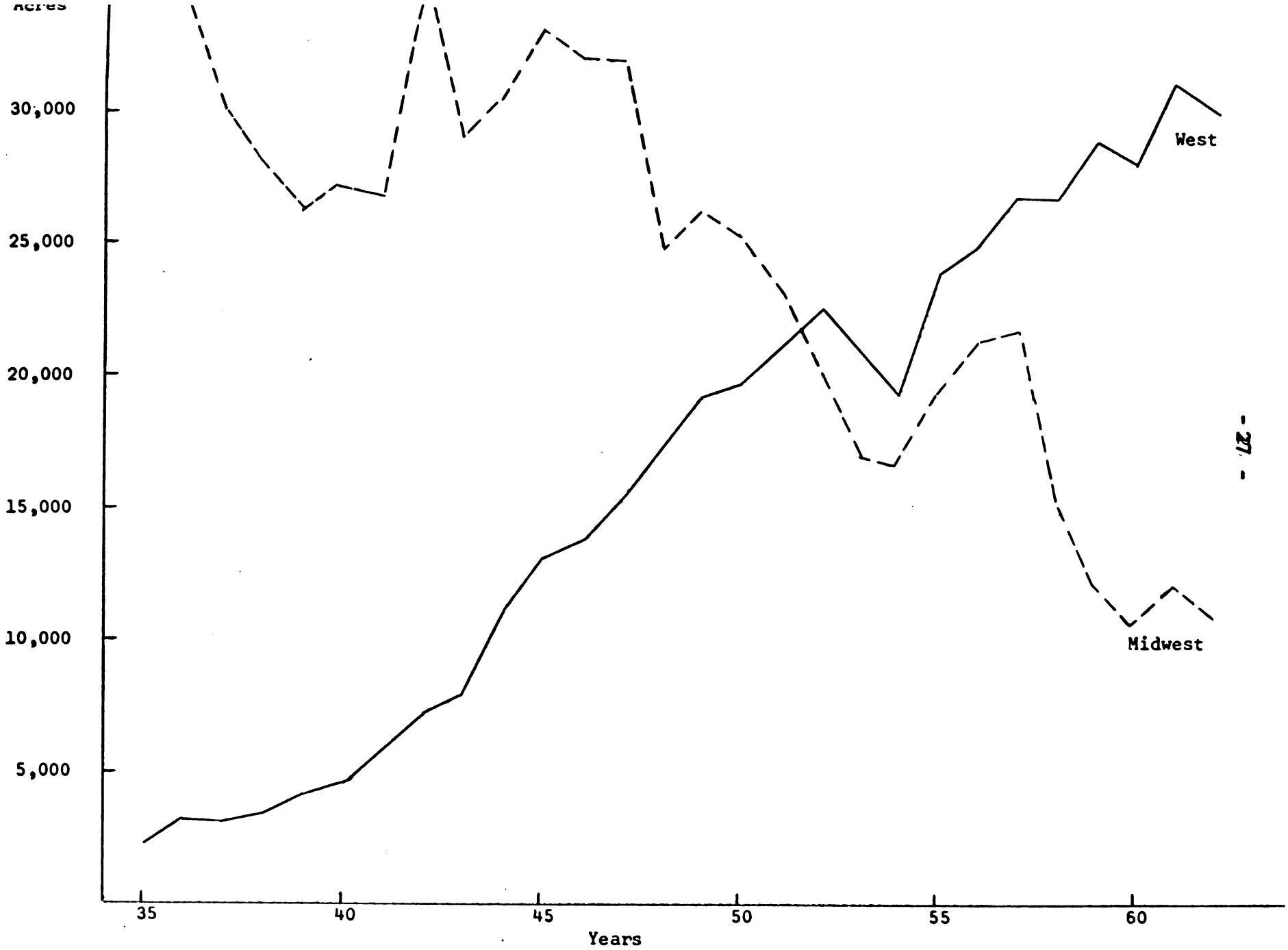

Figure 1: United States acreage of peppermint by region, 1935-63

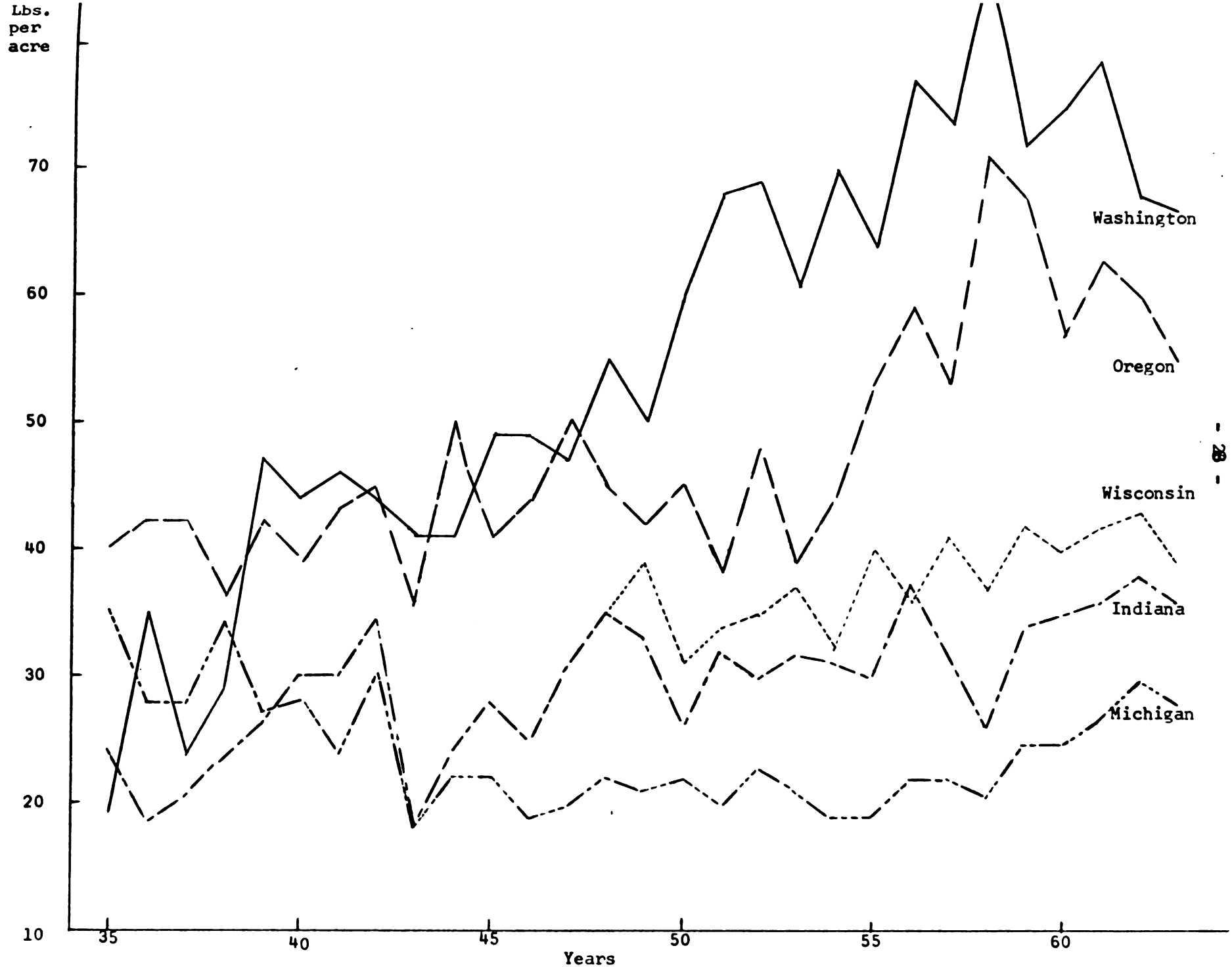

Figure 2: United States yield of peppermint oil per acre by state, 1935-63

oil.[12,13] Soil scientists know that a certain amount of fertilizer is needed to maintain normal growth, but as yet little is known about the exact application to get optimum results. It is known, however, that the fertilized fields do get the better yields.

In recent years, yields of Washington peppermint ranged between 60 and 87 pounds per acre, but fluctuated widely depending on the area and specific growing conditions. Yields of Oregon plants have ranged between 39 and 71 pounds per acre since 1953 and the trend is upward.

Because acreage has remained relatively stable and there have been increases in yields on the West Coast, United States production has increased 252 percent from 1947. (See figure 3, page 30.) Production in the West has grown tremendously while Midwest mint oil production has been slowly diminishing.

Spearmint: Acreage, Yield, and Production

Spearmint is produced commercially in Michigan, Indiana, and Washington.

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[12] Ellis, N.K. "Peppermint and Spearmint Production," Economic Botany, Vol. 14, No. 4: 280-285, October-December, 1960.

[13] Davis, J.F. "Progress Report for Peppermint Research for Years 1949-1952," Michigan State University, Unpublished, undated.

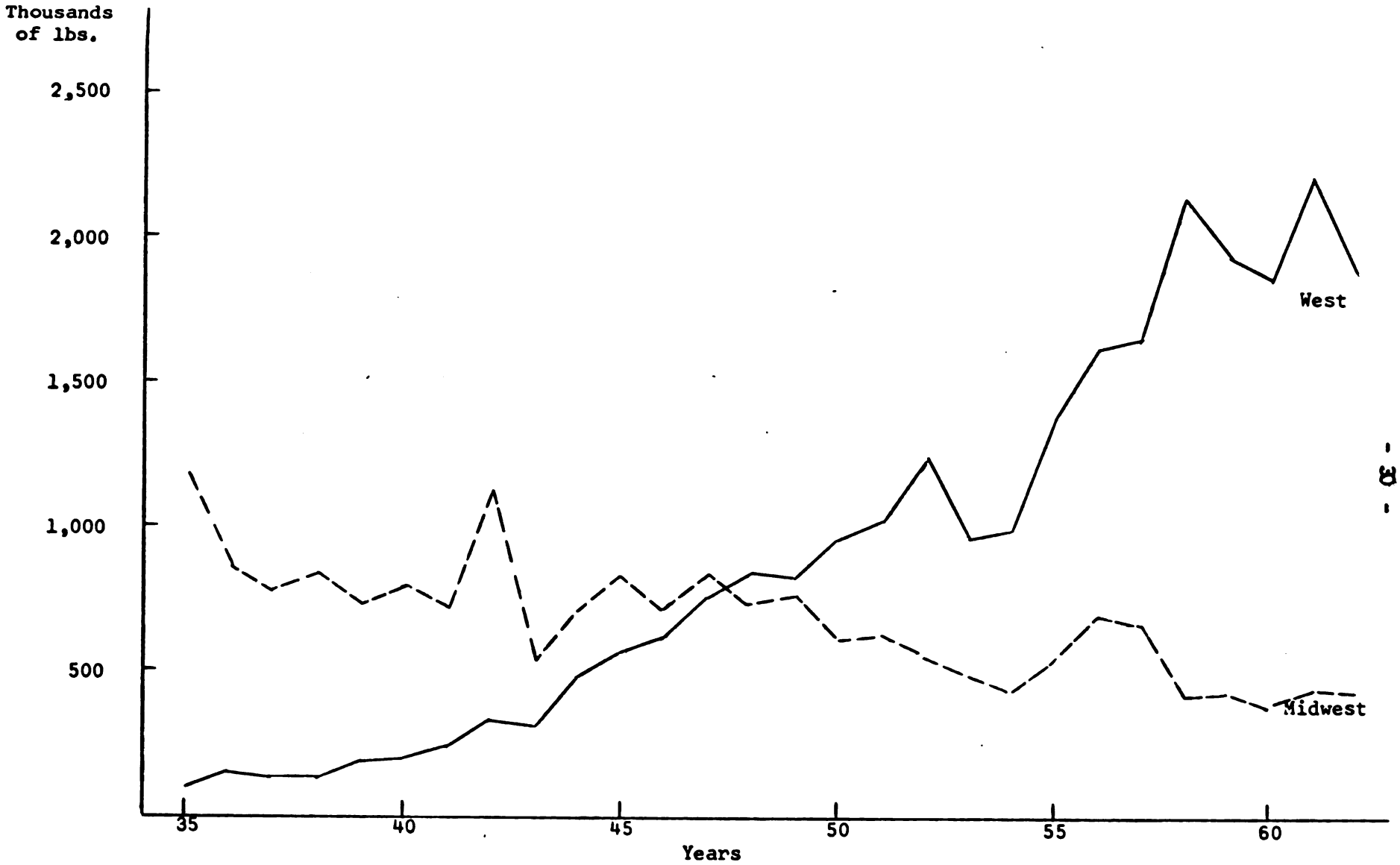

Figure 3: United States production of peppermint oil by region, 1935-63

Before World War II, all spearmint was grown in the Midwest, but now Scotish spearmint is cultivated extensively in Washington, particularly in the Yakima Valley.

Since 1935, total acreage of spearmint has fluctuated more than peppermint acreage. There were 14,300 acres harvested in 1947 compared with 21,100 acres in 1962. A big drop in acreage came between 1962 and 1963 when United States acreage declined 42.2 percent to 12,200 acres. This was due to declining prices received by growers which, in turn, resulted from large inventories existing since 1960.

As shown by figure 4, page 32, acreage of spearmint has varied greatly in all three producing states. The Midwest accounted for all 22,200 acres of spearmint in 1948, but in 1963, because of its introduction in Washington, the Midwest supported only 6,200 acres or a little over 50 percent of the total spearmint acreage.

Yield per acre of spearmint oil is also much lower in the Midwest thanon the West Coast. Since 1952, the yield per acre in the Midwest ranged between 24 and 40 pounds per acre, similar to peppermint yields. Spearmint yields in Washington have ranged between 70 and 100 pounds per acre, much above peppermint yields. (See figure 5, page 33.) Lower average peppermint yields in the older area along the Columbia River caused the difference in Washington's average yields per acre of peppermint and spearmint oils.

Because of the high yields per acre in Washington, Washington growers produced 72.6 percent of the United

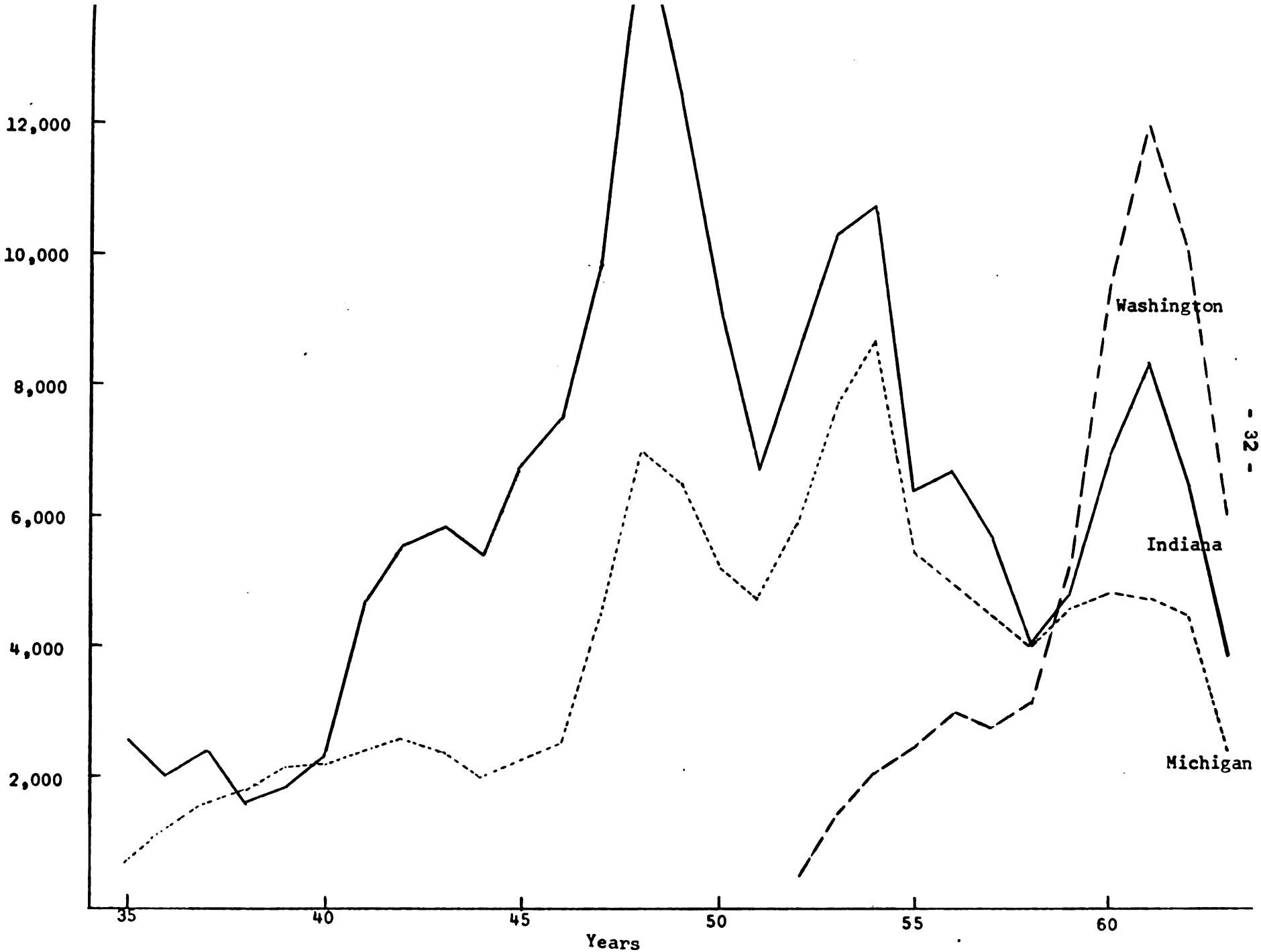

Figure 4: United States acreage of spearmint oil by state, 1935-63

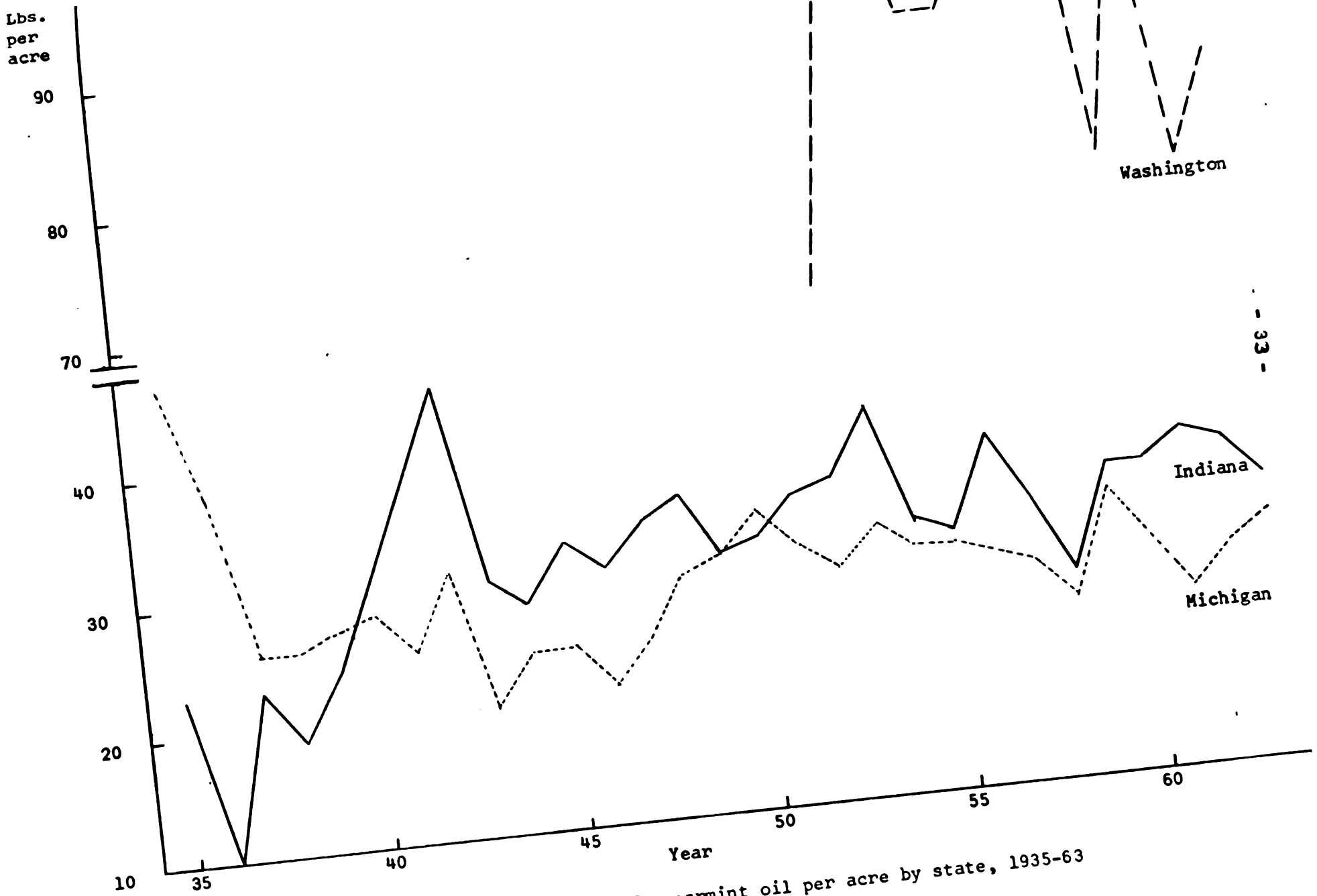

Figure 5: United States yield of spearmint oil per acre by state, 1935-63

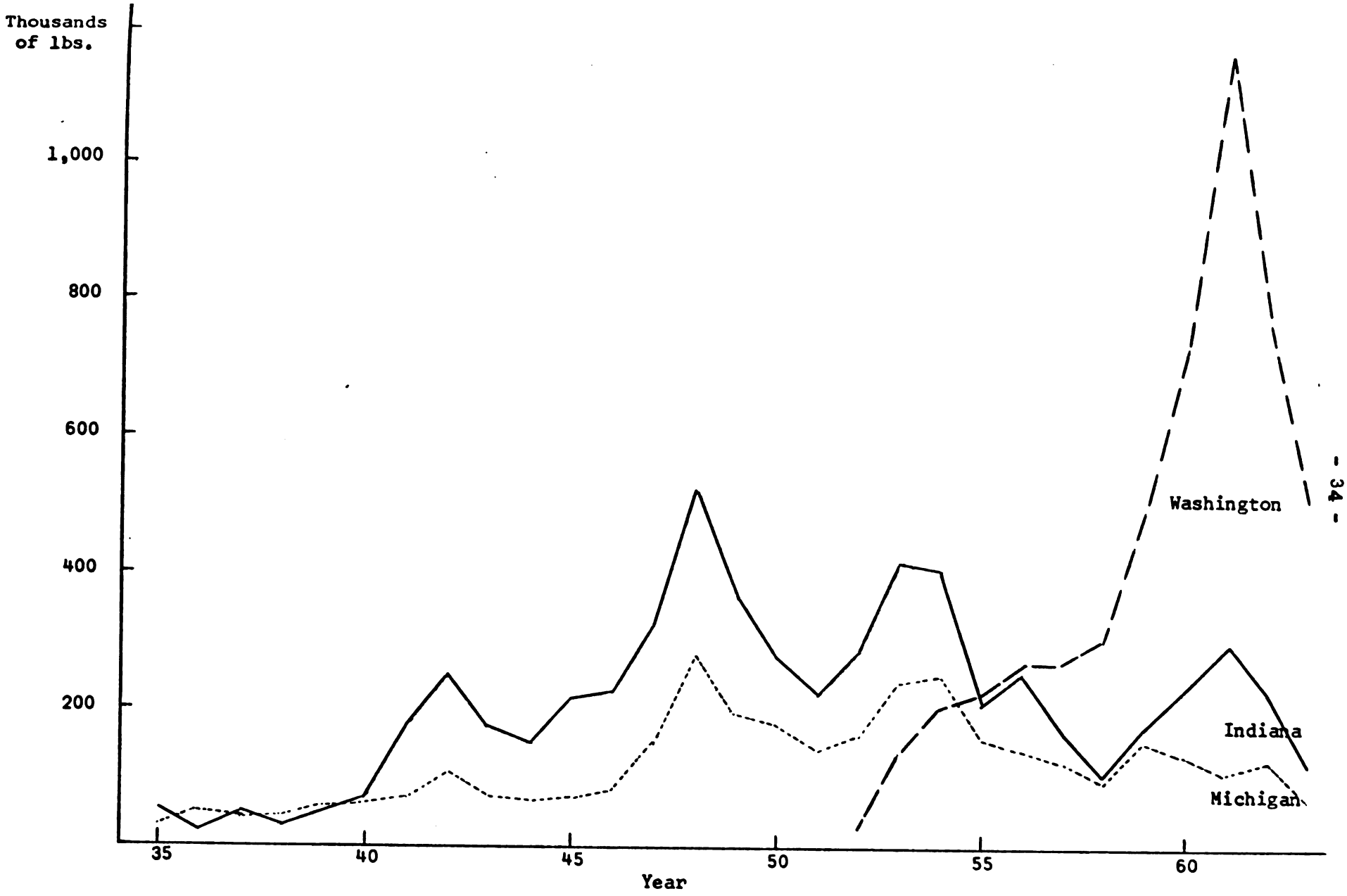

Figure 6: United States production of spearmint oil by states, 1935-63

States supply of spearmint oil in 1963. This percentage has remained relatively constant in the last 3 to 4 years. (See figure 6, page 34.)

Scotish variety yields more pounds per acre than the Native variety. According to a survey in 1960, 90 percent of the spearmint grown in the Yakima Valley is of Scotish variety.[14] Due to the low yield per acre of Native oil, a premium from $.50 to $1.00 per pound is paid for this variety at the farm level.

Roughly 30 percent of Indiana's acreage is Native spearmint and in Michigan, approximately 85 percent is Native oil. The reason for the greater amount of Native oil produced in the Midwest area is that it is more wilt disease resistant than either peppermint or Scotish spearmint.

Prediction Equations for Production

One of the many uses of historical data is that of predicting the future. Many producers probably already use a technique based on historical data to estimate production. The buyers of mint oil must also have a technique to determine anticipated production.

Using a statistical procedure called "multiple regression," relevant economic variables can be taken into account to predict future production. In interpreting the results of the equations which follow, one must remember that

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[14] Guenther, Ernest. "The Spearmint Oil Industry in Washington State," Perfumery and Essential Oil Record, November 1961.

the results are only as relevant as the model. If the structure of the industry changes in the future, these equations can be very misleading. This is especially true when trend variables are included in estimating equations.

In equation 1, 89 percent of the annual variation in United States production of peppermint oil is explained by changes in trend, annual acreage, and the three year moving average of peppermint oil farm prices.

The values obtained from a multiple regression analysis applied to the annual data from 1947 to 1963 indicate that an increase of one acre of peppermint in the United States will result in 57.7 pounds increase in total production holding other variables constant. For a 1964 prediction, the estimated pounds of oil may be attained by inserting the number 18 for X_2, the estimated acreage, as prepared by the Statistical Reporting Service, U.S.D.A., for X_3, and the three year moving average of the U.S. average farm price as X_4. The three year moving average price to be used in the 1964 prediction is calculated with the 1964 price as the last in the series of the three years. Since these figures are not available until late in the year the contract price could be used as a close approximation. Although this measure of farm price may not be precise, it is some indication of the amount of future production. Then the multiplication, addition, and subtraction, as indicated below, should be performed.

Equation 1:

$$X_1 = 35.67 + 57.09X_2 + .0577X_3 - 184.35X_4$$
$$(-.043) \quad (3.43) \quad (4.59) \quad (-1.667)^*$$

*numbers in parentheses are t-values

Where: X_1 = United States production of peppermint oil in thousands of pounds

X_2 = Trend 1947 = 1, 1948 = 2, etc.

X_3 = Acreage of peppermint in the United States

X_4 = Three year moving average of the annual United States farm price (use prediction year as the last year in the moving average)

$\bar{R}^2$ = .85: Multiply by 100, to obtain the percentage of total variation in production explained by the equation

Degrees of freedom = 13

Standard error of the estimate = 164.55

All variables are statistically significant at the 95% level using the two tailed t-test, except the three year moving average of the farm price of peppermint oil.

The trend variable is very important in this equation and takes into account the movement of the peppermint industry to the West Coast, where wilt disease is not prevalent, where there are better growing conditions, and where new technology both in distillation and cultural practices exist.

Since carryover stocks are not published, the use of a three year moving average farm price is an attempt to average out their influence on prices.

This equation is for the United States production as a whole. Many variables cannot be measured and are assumed to be random. Production equations could be set up for a state or a grower, but again it would be less accurate than for the entire industry due to varying degrees of wilt disease, climatic conditions, and other variables excluded from this simplified model.

The equation for estimating production of spearmint has a high correlation coefficient, $\bar{R}^2 = .96$. Although the sign between production and average farm price of spearmint is negative, the price variable is statistically significant only at the 50% significant level using the two tail t-test with 13 degrees of freedom.

Equation 2:

$$X_5 = 335.45 + 28.52X_2 + .058X_6 - 34.66X_7$$
$$(-1.73) \quad (4.96) \quad (10.15) \quad (-.82)^*$$

*the numbers in parentheses are t values

Where: X_5 = United States production of spearmint oil in thousands of pounds

X_2 = Trend 1947 = 1, 1948 = 2, etc.

X_6 = Acreage of spearmint in the United States

X_7 = Three year moving average of the annual United States farm price of

spearmint oil. (use prediction year as the last year in the moving average)

$\bar{R}^2$ = .92: Multiply by 100, to obtain the percentage of total variation in production explained by this equation.

Degrees of freedom = 13

Standard error of the estimate = 85.33

The high coefficient of determination does not imply that the variables explain the supply of spearmint nor does it imply the significance of structural coefficients. The high R^2 does, however, indicate that the past predictive value of the equation is good.

Chapter III

World Production, Trade, and Movement of Peppermint and Spearmint Oil

Little information has been published on the world production of peppermint and less is known about spearmint. Available references are out of date, although some information was gathered from private correspondence with dealers in mint oil.

A.M. Todd Company estimated that the 1962 United States mint oil crop was between 65 and 80 percent of the world production, excluding Mentha arvensis or cornmint. They believe the figure to be closer to 80 percent than 65 percent.

Cornmint, a term used in the United States for Mentha arvensis, has a high menthol content. Outside of the United States it is indiscriminately called peppermint. But it is an oil with very different flavor characteristics.

According to foreign service dispatches from agricultural attaches, the latest figures available on foreign production of peppermint oil are as follows:[15]

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[15]Compiled by Barber, L.A., Chemical and Rubber Division, United States Department of Commerce, Foreign Services Dispatches. 1964.

1939 - U.S.S.R. = 300,000 pounds

1941 - Argentina = 4,234 pounds

1944 - Canada = 4,000 pounds

1941 - Bulgaria = 29,938 pounds

1950 - France and Morocco = 77,175 pounds

1951 - Italy = between 22,680 and 45,360 pounds

1954 - Spain = 2,268 pounds

These figures, today, can be very misleading. Recent correspondence with Ernest Guenther indicated that Bulgarian peppermint oil production runs between 100 and 150 tons a year.[16] Their production in 1963 was about 240,000 pounds. The foreign service reported a production of 29,938 pounds. This shows over a 800 percent increase in production over a span of twenty-two years.

More information is known about producing areas. According to past records in the Perfumery and Essential Oil Record, peppermint has been planted at one time or another in many countries in the world. Because of the cultural requirements of the crop, peppermint in significant amounts is only grown in certain parts of Europe including Italy, Spain, Ukraine, Hungary, Bulgaria, England, France, Austria, and Rumania and in the United States. Other countries producing peppermint oil are India, Morocco, Australia, Argentina, and Canada.

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[16]Guenther, Ernest. Personal Correspondence, 1964.

The only exporters of peppermint oil of any real importance in international trade are the United States, Italy, Morocco, and in past years, Russia. Russia in recent years has had little excess oil because of poor crops and a large demand for the oil within their country. Other countries do export small amounts, but they are not competitors in the world market.

Exports originating from Italy and Morocco combined amounted to about 10.8 percent of the United States exports in 1961.

Table 2. United Kingdom Imports (In Pounds).

Country of Origin	1959	1960	1961
France	91,955	66,603	37,650
Italy	40,508	35,965	44,213
United States	280,253	300,021	304,152
Other foreign countries	7,146	15,270	20,349
Total	419,862	417,859	406,964

Source: "The Trade of the United Kingdom," Customs and Excise Department, London, England. Personal Correspondence, 1964.

These import figures, can also be misleading because much cornmint is counted as Mentha piperita in foreign figures. Also, much Mentha piperita is adulterated outside the United States. Oils are adulterated with various oils such as cornmint, but in the United States this practice is forbidden by law.

Italian peppermint oil obtains a premium price in the United Kingdom market because it is of better quality than the Kennewick Oil that is exported from the United States.

Table 3. Range of Prices of Peppermint Oil in the United Kingdom (Shillings per pound).

Country of Origin	1959	1960	1961
United States	24-34	31-36	29-39
Italy	42.6-49	48-53	60-65
Morocco	38-44	38-42	40-42

Source: Perfumery and Essential Oil Record Supplement, published monthly. London, England.

Spearmint oil is produced in many European countries. Germany, Italy, Yugoslavia, and Japan and Russia grow spearmint, but the major areas of production are the United States and China.

The United States is the only exporter of a sizeable amount of spearmint oil. China in past years has exported oil to England, but in 1953 to 1960, shipments became erratic and ceased altogether in 1960.[17]

United States Exports of Peppermint

In 1962, the United States exported 50.7 percent of its total peppermint oil crop to 53 countries. There may

[17] Orr, Elizabeth and Pope, R. "The Market for Peppermint, Arvensis, and Spearmint Oils and Menthol," Tropical Science, 1962, pages 38-47.

be more than 53 countries using United States produced peppermint oil, however, since the United Kingdom re-exports some of the oil it imports. Statistics on re-exports are not available. Oil of peppermint continues to be popular and the foreign demand for the flavor is growing rapidly. No country outside the United States, however, is reported as being self-sufficient in the production of peppermint oil.

In 1936, the United States exported 386,000 pounds of peppermint oil which established a record. The United Kingdom, the largest consumer, took 59 percent of the exports. Five countries demanding 33 percent of these exports were Germany, Canada, Australia, Netherlands, and France.[18]

Comparing United States exports in 1936 to exports in 1962, suggests that the composition of importing countries has changed only slightly. In 1962, the largest consumer was again the United Kingdom which purchased 27.2 percent of the exports followed by France, West Germany, Mexico, Japan, Netherlands, Canada, and Australia.

Mexico and Japan have greatly increased imports and the flavor is gaining popularity in the African countries. (See figure 7, page 45.) Figure 7 shows the United States exports of peppermint oil summarized by continents.

With the increasing popularity of the peppermint flavor, United States exports increased 265 percent between

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[18] Perfumery and Essential Oil Record, May 1937, p. 158.

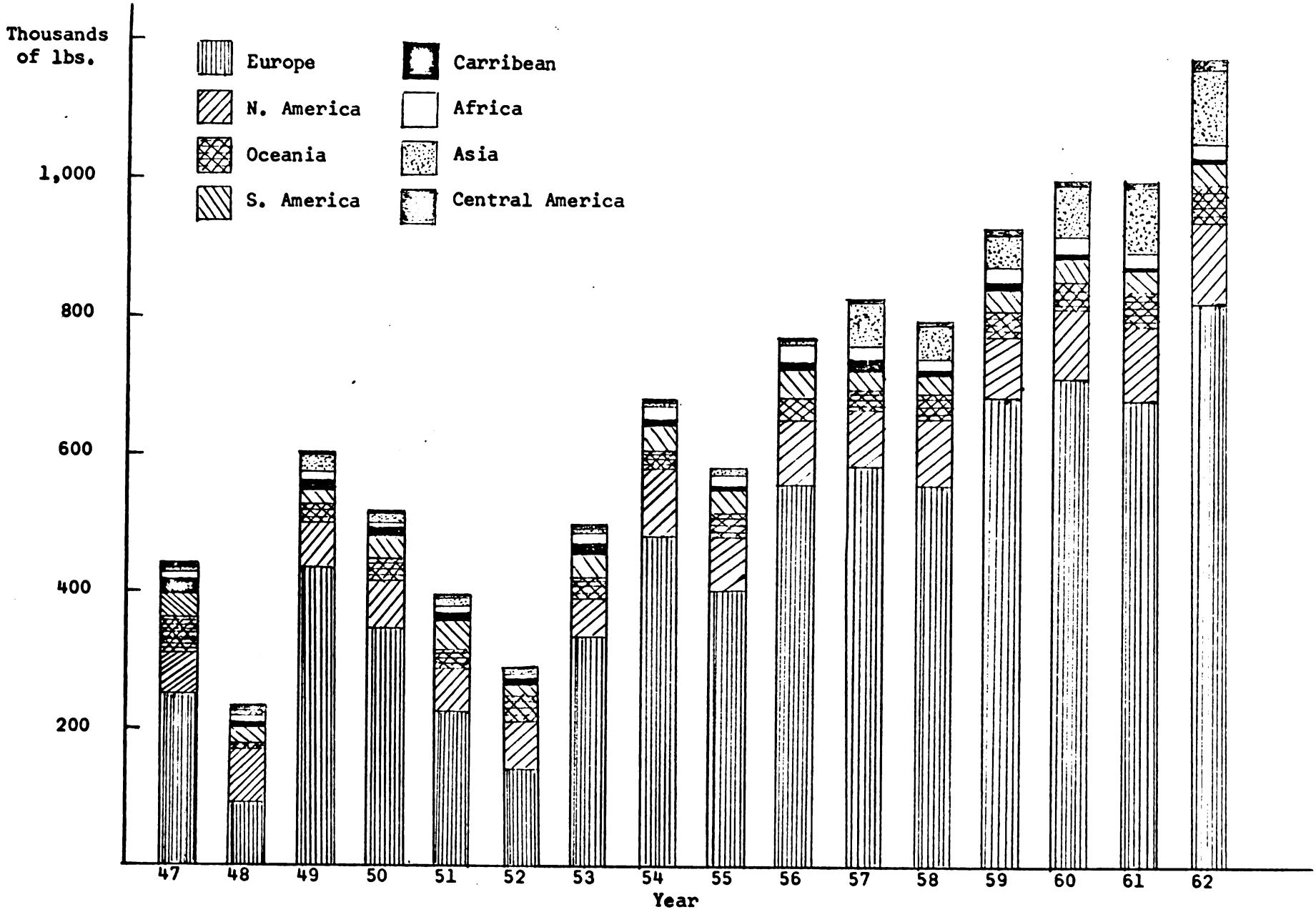

Figure 7: United States exports of peppermint oil by continent, 1947-62

1947 and 1962. If this export trend continues, which most dealers believe it will, acreage of mint will expand in the near future. This is possible in both Washington and Oregon as there are thousands of irrigated acres of land that is free of wilt disease on which to expand production. These acres are now planted to other cash row crops.

The two major exporting companies in the United States are I.P. Callisons and Sons, Inc. of Chehalis, Washington and the A.M. Todd Company of Kalamazoo, Michigan. These companies have offices and representatives in all major importing countries. These representatives find customers and get a 2 to 5 percent commission on sales. Buyers export the oil directly to the customer. Most of the mint oil is exported from New York, since the time advantage is apparently worth the expense in shipping the oil in condensed form across the United States from the Pacific Northwest. Both the Port of Seatle and the Port of Portland are used, but many times it takes two or three weeks longer to get to the importing country due to the smaller volume of other goods shipped from these ports.

Mint oil is normally shipped F.O.B. at the port of departure. Foreign prices of mint oil include price of the drum, freight, and clearing the shipment which normally costs about 10 cents per pound.

United States Exports of Spearmint Oil

Spearmint use is relatively new compared to peppermint. World demand for spearmint oil was slow in developing. At present, however, exports of spearmint oil are growing rapidly. In 1962, the United States exported 446,000 pounds compared with 59,600 pounds in 1947. A small amount of other mint oil (probably Mentha arvensis) may be included in the reported spearmint oil exports.

The year 1962 was the largest year for spearmint exports. (See figure 8, page 48) The United States shipped 154,198 pounds to the United Kingdom; 38,139 pounds to France; 30,059 pounds to Canada; and 27,448 pounds to Mexico. This can be compared to 1947 exports when the United Kingdom purchased 5,225 pounds, France 2,731 pounds, Australia 9,107 pounds, Canada 29,835 pounds, and Mexico 5,397 pounds. As one can see, tastes and preferences have changed radically in Europe with the introduction of spearmint flavored chewing gum and toothpaste.

In 1958, exports of spearmint oil amounted to 53.6 percent of the United States crop compared with 39.7 percent of the crop in 1962. Although the percentage of the crop exported in 1962 is smaller in percentage terms than that exported in 1958, in absolute terms, exports increased 172,000 pounds from 1958 to 1962.

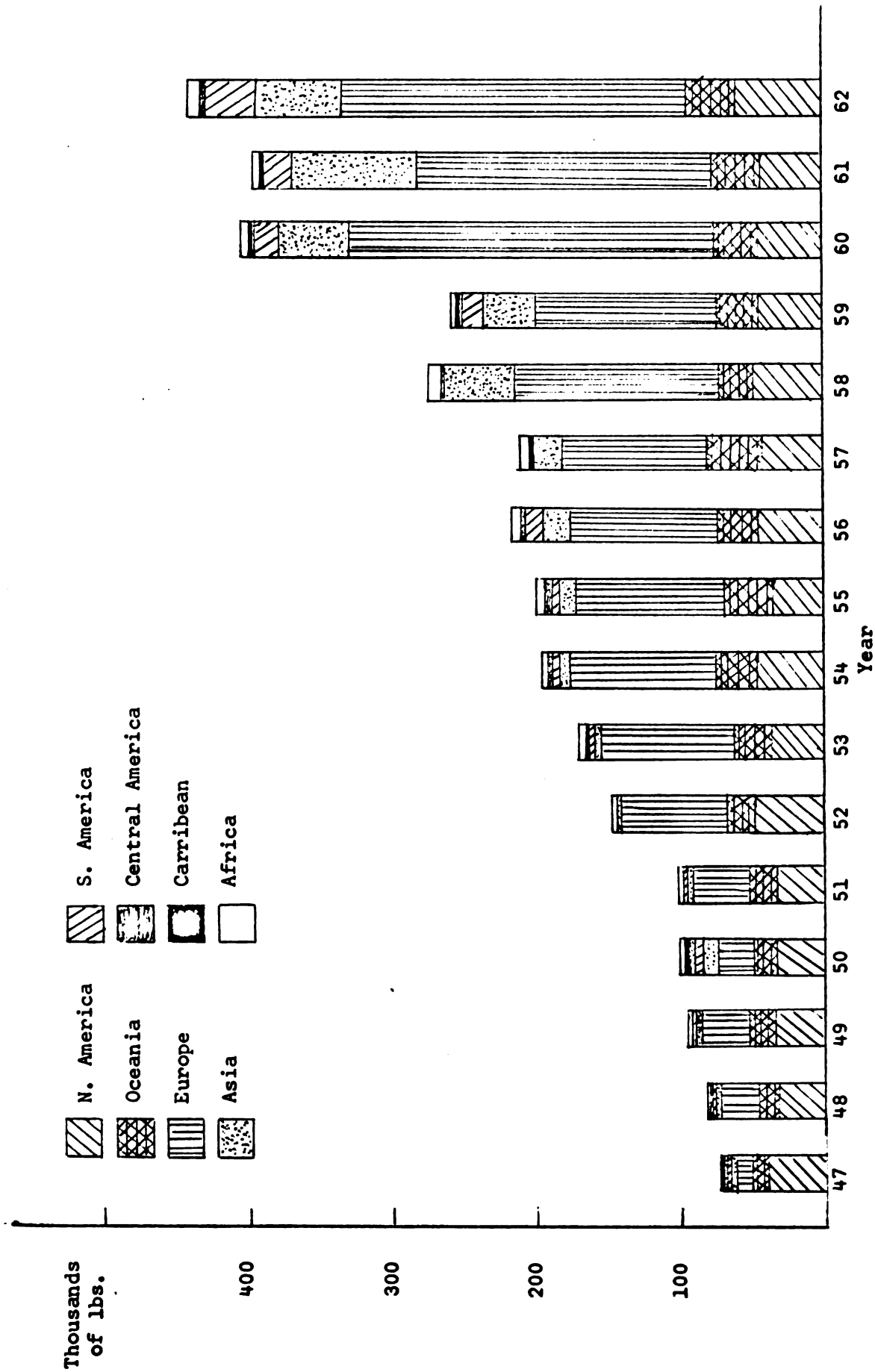

Figure 8: United States exports of spearmint oil by continent, 1947-62

Analysis of Exports

Economic theory is an important tool in analyzing the exports of mint oil. Since two qualities of peppermint oil exist, one mainly for domestic consumption and the other for foreign consumption (with an exception being in the candy industry), buyers can practice price discrimination to increase their total revenue. This is possible because the two markets can be separated.

The demand for peppermint oil on the domestic market is hypothesized to be very inelastic, for reasons to be discussed in the next chapter, and the demand for exports to be more elastic due to the price consciousness of foreign importers.

If the above analysis holds, one could expect the following relationship to exist:

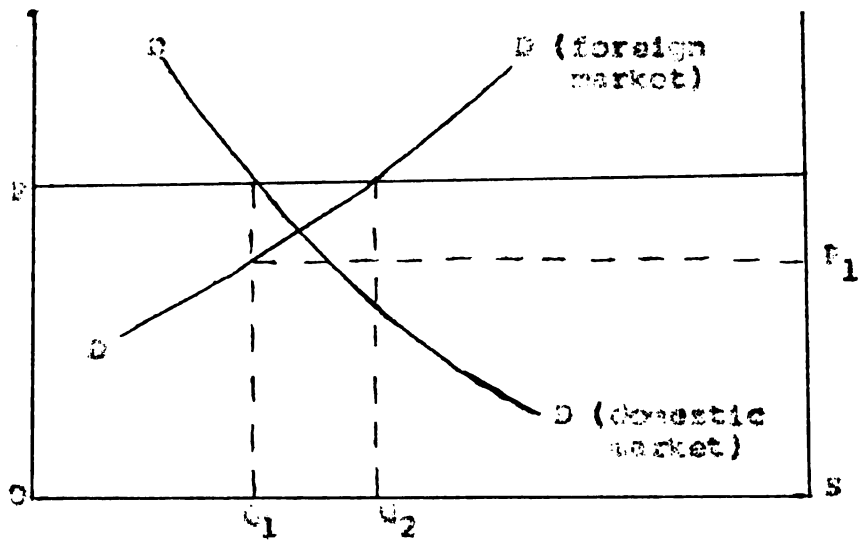

Figure 9: Profit maximization in two markets.

The figure is made by superimposing the demand in the export market on the demand in the domestic market after turning the demand curve for exports by 180 degrees.

Total quantity of mint oil available for sale during the marketing year is OS. At price OP, the quantity taken in the domestic market is OQ_1 and the quantity taken in the foreign market is SQ_2 leaving a surplus of mint oil amounting to Q_1Q_2. If the buyers discriminated, which they do with Kennewick peppermint oil, the buyer could sell OQ_1 on the domestic market at a price of OP and sell Q_1S in the export market at a price of SP_1, thereby clearing the market and increasing total revenues. The price OP and SP_1 is set by equalizing the marginal revenue in both markets.

This discrimination will work as long as the price in the export market is not lower than the domestic price by an amount sufficient to cover transportation charges and import duties of 25% on goods imported back into the United States. Another condition is that the price elasticity of demand in the export market must be more elastic. This is what one would expect with several countries selling on the world market.

Imports of Peppermint Oil into the United States

Imports of peppermint oil into the United States have been small. In 1945, imports were 150 pounds most of it being imported from the United Kingdom. Imports in 1962

totaled 901 pounds, most of it originating in Austria. Since there is a 25 percent duty on imports, few essential oils are imported. Some of the imports are shipped to mint oil dealers for analysis, but most firms use United States Oil.

As shown in figure 10, page 52, imports from Argentina from 1957-1959 ranged between 11,023 and 794 pounds. This oil was Mentha arvensis and not Mentha piperita; however, this must not have been labeled correctly when imported into the United States.[19]

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[19]Todd, W.A. Personal Correspondence, June 1964.

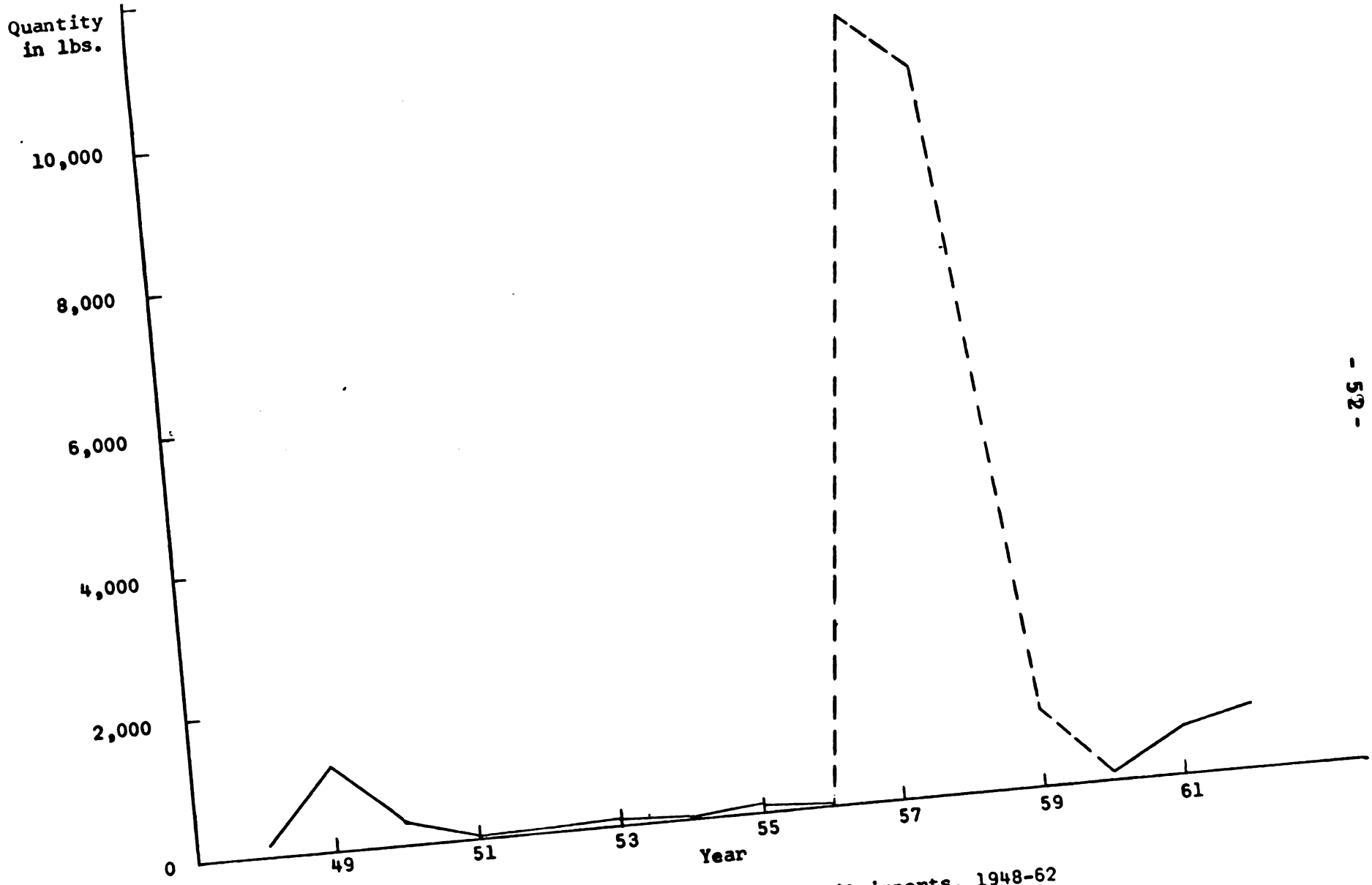

Figure 10: United States peppermint oil imports, 1948-62

CHAPTER IV

Analysis of Mint Oil Production Costs

Major investment in mint oil production include plant and equipment. The capital needed to purchase the necessary distilling plant, trucks, tractors, tanks, and other equipment for a modern, efficient business can amount to $20,000 to $30,000 in Southwestern Washington, depending on the size of operation.[20] This cost can be reduced if second hand equipment is purchased. In the Midwest where many growers are leaving the industry, parts of distilleries can be purchased at great savings. However, new equipment to modernize a typical stationary two-tub still in Indiana at 1962 prices costs from $5,500 to $6,500.[21]

Production studies show costs vary greatly between farms in the same area and between farms in the Western and Midwestern regions.

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[20] Walker, A.L. Peppermint Oil Production in South Central Washington, Washington State Agricultural Experiment Station Circular 253, May 1954, page 11.

[21] Green, Ralph J. Mint Farming, Agricultural Research Service, U.S.D.A. in cooperation with Purdue University Agricultural Experiment Station, Agriculture Information Bulletin No. 212, page 29.

Labor accounts for the largest cost. This is especially so for weeding which represents the largest portion of the labor needed to assure good quality mint.

The following production cost studies give some indication of production costs and returns to management in both regions.

Table 4. Cost of Mint Production Midwest Region, Indiana, 1963.

	Cost per acre
Labor and Machinery	$ 90 to $100
Land and Improvements	25 to 30
Fertilizer	30 to 40
Stolons or plants	15 to 20
Chemicals	10 to 12
Miscellaneous Overhead	6 to 10
Total cost per acre first year	$176 to $212
Minus stolons or plants	15 to 20
Total cost for succeeding years	$161 to $192

Source: Green, Ralph J. Mint Farming, op. cit.

A similar study in 1961 estimated Indiana costs per acre between $175 and $225 including the cost of land, stolons, fertilizers, pesticides, labor, and equipment costs required to plant, cultivate, weed, harvest, and distill the crop.[22]

[22] Green, Ralph J. Mint Farming, op. cit.

Pacific Northwest Region

Table 5. Cost of Mint Production Columbia Basin, Washington, 1955.

	1st yr.	2nd to 5th yr.
Land preparation:		
Plow	$ 4.00	$ -0-
Disc and harrow	1.00	-0-
Ditching	6.00	-0-
Fertilizer: N-160 pounds	30.00	30.00
Application	4.00	4.00
Roots:	50.00	-0-
Planting:	12.50	-0-
Irrigation:		
Labor	6.25	6.25
Water and electricity	7.21	7.21
Cultivation	18.00	24.00
Weed Control	20.00	25.00
Insect and disease control	-0-	4.70
Harvesting costs	51.00	68.00
Land*	30.00	30.00
Total Cost per Acre	$239.96	$199.16

Source: Federal Cooperative Extension Service, Pullman, Washington.

*Estimated at $600 per acre, capitalized at 5 percent.

Average total cost per acre in the Pacific Northwest is between $224 and $240 per acre for first year mint and between $183 and $199 for 2 to 5 year mint; as compared with $175 and $225 for row mint in the Midwest and between $161 and $182 for meadow mint 2 to 5 years old.

As an example of returns to operators for peppermint oil, the average yield for the Midwest for the period 1957

Table 6. Cost of Mint Production Jefferson County, Oregon, 1959*.

	1st yr.	2nd to 5th yr.
Land Preparation:		
Plow, Disc, Harrow	$ 6.45	$ -0-
Fertilizer: N-130 pounds	23.00	23.00
Application	2.00	2.00
Roots	25.00	-0-
Planting	12.50	-0-
Irrigation:		
Labor	20.50	20.50
Water and electricity	5.00	5.00
Cultivation	6.20	9.80
Weed Control	28.00	28.00
Harvesting Costs	60.00	60.00
Land**	30.00	30.00
Total Cost per Acre	$223.65	$183.30

Source: Federal Cooperative Extension Service, Jefferson County, Oregon.

* Costs based on custom rates.
** Estimated at $600 per acre, capitalized at 5 percent.

to 1961 was 32 pounds per acre and the average price per pound was $6.20 over the same period. Multiplying yield times the price per pound gave a gross return to Midwest growers of $198.40. With production costs between $161 and $192, this leaves a return to the operator of between $6.40 and $37.40 per acre.

Making similar calculations for West Coast peppermint growers with an average yield of 69 pounds per acre and an average price of $3.87 per pound, the average gross return per acre is $267.03. Since production costs average between $183.30 and $199.15, the average net return per acre was

from $67.87 to $83.73.

A 1953 study suggested that growers must have from $50 to $75 net return for management to make peppermint farming a sound venture.[23] In the long run under perfect competition, no excess profits exist, therefore this return is for management, and risk and uncertainty. The net return is much larger on the West Coast thus explaining, in part, the reason for the rapid increase in acreage in the Pacific Northwest and the slow decline in acreage in the Midwest. Another cause of the slow decline in acreage in the Midwest has been the high fixed to variable costs in mint oil production. The fixed assets in mint production have a low salvage value which keeps growers in the industry at seemingly unprofitable levels.

Another indication of returns to growers is shown by figure 11, page 53. Gross returns per acre have been larger on the West Coast than they have been in the Midwest, but the gap is closing. The larger yield per acre on the West Coast has been the primary reason for the larger gross returns per acre than in the Midwest.

In the Midwest, spearmint oil net returns are less per acre than peppermint net returns. This is due to lower yields and a lower price per pound. Production costs,

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[23] Green, Ralph. Mint Farming, Agriculture Information Bulletin No. 212, Agricultural Research Service, U.S.D.A., page 20, 1964.

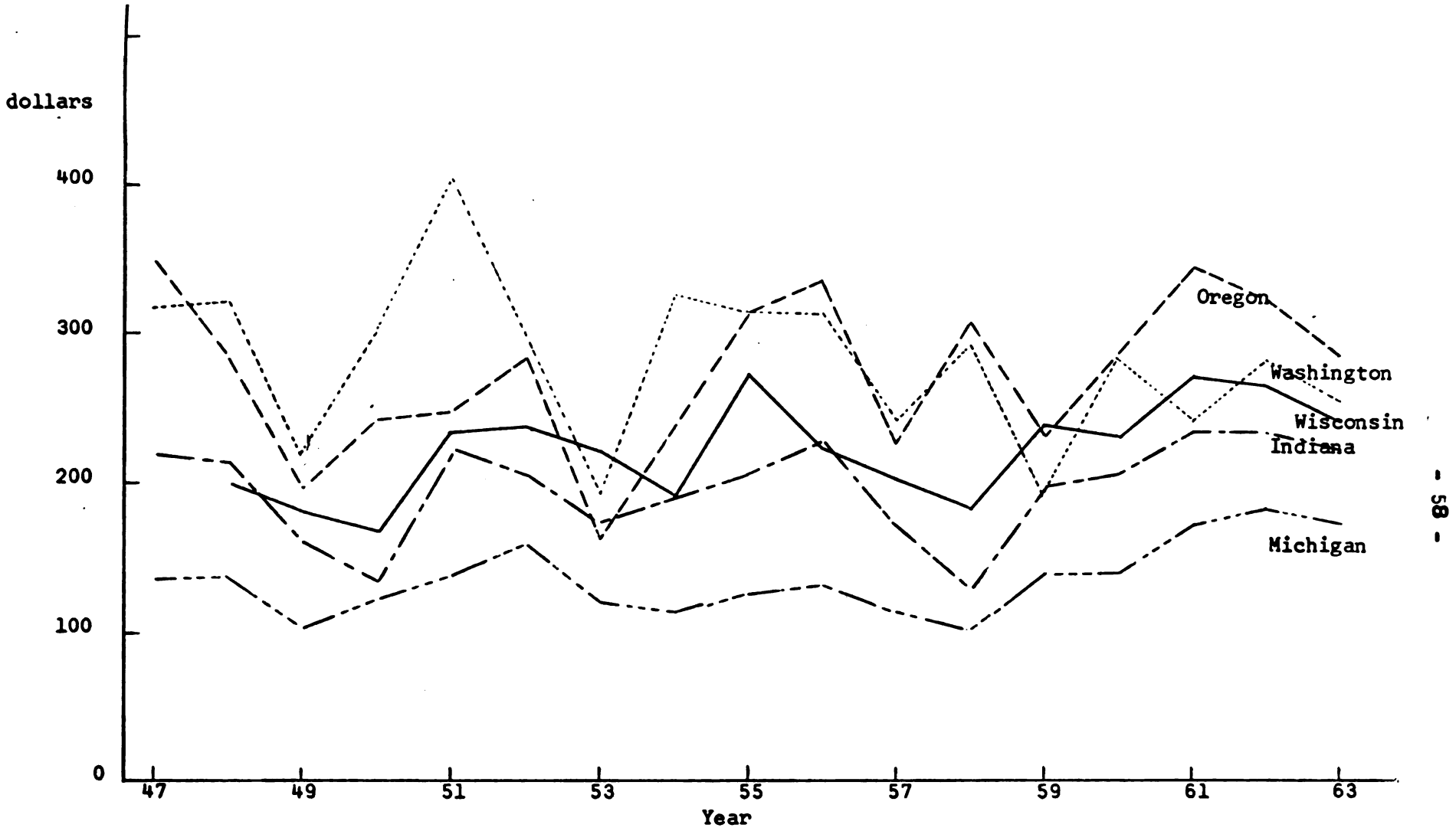


Figure 11: Gross returns per acre from peppermint oil by state, 1947-63

however, are similar to production costs of peppermint except that disease free rootstock is not necessary.

Spearmint oil production in Washington shows an average gross return per acre of $317.13 calculating the same way as for peppermint. Using the production cost figures for the West Coast of between $183.30 and $199.16, this gives a net return of $117.97 to $133.83 per acre. This return to management explains the large increases in spearmint in Washington since 1952.

Although these returns seem large at the present, figure 12, page 60, shows that gross returns per acre have been moving downward since the plantings in Washington were first established.

The profitability of mint in the Midwest implies that only the more efficient producers will remain in the industry while the "average" producer is forced to find alternative crops. At present, the buyers are using price incentives to keep part of the Midwest oil in user blends. But, they are slowly being forced to use more Oregon oil. There is little doubt that users will be forced to use almost all Western oil if present prices and production costs continue and present yield relationships hold.

Implications of High Fixed Costs

Why do Midwest growers remain in mint production even though they are not making a profitable return on their

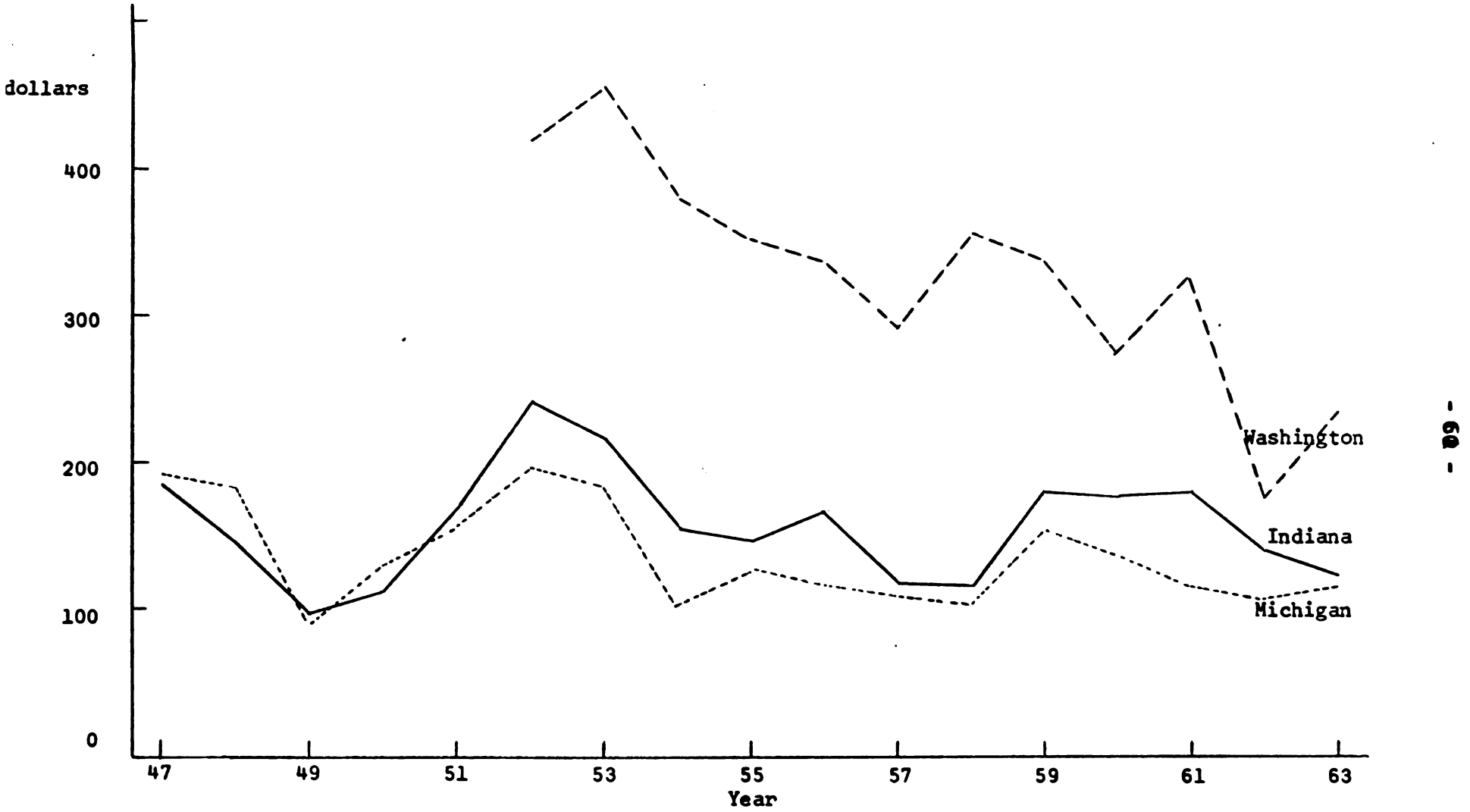


Figure 12: Gross returns per acre from spearmint oil by state, 1947-63

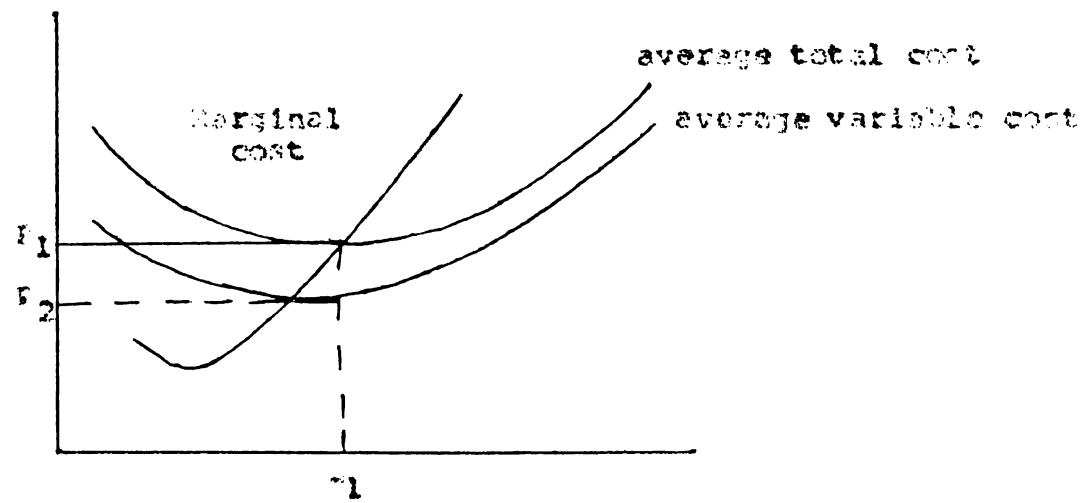
investment? To answer this question, one can use economic theory. In analyzing the question, there is a need to again build up a background of the industry.

As mentioned before, the industry has heavy fixed costs in distilling equipment. This equipment is a fixed asset as the marginal value product is greater than the salvage price, but lower than the acquisition price. Therefore, the grower keeps his distillery unit.

In the short run, a producer must cover his average variable costs or out-of-pocket costs or stop production. The logic behind this statement is that the grower has fixed costs whether he produces mint or not. In the long run, a producer must cover both fixed and variable costs.

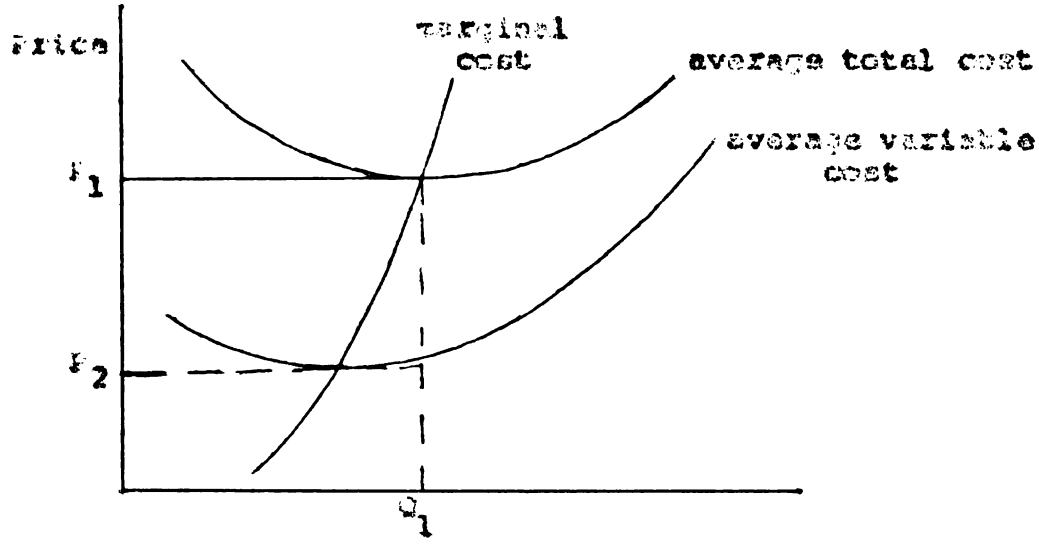
Midwest growers remain in the industry because they have few variable costs to cover and their investment is a fixed asset. As an example of this situation, the following cases will illustrate the problem using normal cost curves which one would expect to exist in a competitive case.

Figure 13. Case IV High variable to fixed costs



In case one, the firm is in equilibrium at price P_1, and at quantity Q_1. In the short run, the price can only fall a short distance to P_2 and that is the lowest price the firm will take before it will close its business.

Figure 14. Case 2: High fixed to variable costs that are relevant for the mint industry.



In case two, the firm is in equilibrium where marginal cost is equal to marginal revenue at price P_1 and quantity Q_1. The grower will continue his operation in the short run if he covers his average variable costs. Notice, in figure 14, that the mint grower will remain in business at a much lower price than would the same entrepreneur in an industry characterized by high variable to fixed costs. This phenomenon shows that if prices are low over an extended period, or the long run, growing mint will not be profitable.

Many industries, such as coal and railroads, which have large fixed to variable costs want federal legislation to insure themselves of covering all costs in the long run. Of course, federal legislation has been talked about by Midwest mint producers, too.

Firms that are burdened with heavy fixed costs also lose flexibility. Farmers increase output along their long run marginal cost curve as mint prices rise, but as mint prices fall, growers want to decrease output as much as possible so as to reduce total cost as much as possible. Due to few variable costs, few production costs can be avoided and growers cannot reduce output as much as if all costs were variable.

In summary, high fixed to variable costs have a tendency to hold entry and exit of growers to a minimum, which implies the relative stability of acreage in mint from year to year.

Chapter V

Market Structure, Pricing Practices and Domestic and Foreign Consumption

There were 1200 growers of mint oil in the United States in 1962. They produce the mint and distill it on the farm or have it custom distilled by a neighbor at $.80 to $1.00 per pound.

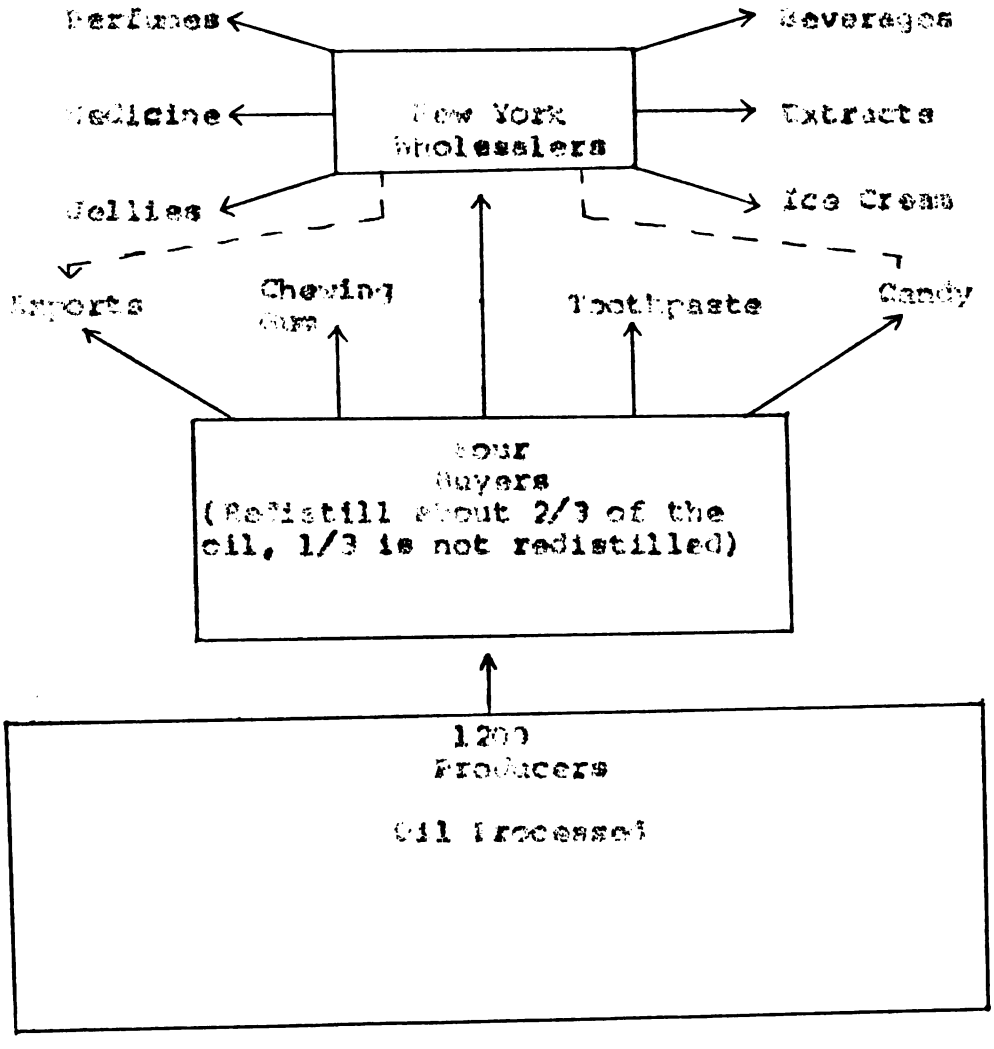
After the oil is distilled, vertical integration in the industry has limited the sale of mint oil to four purchasers. The buyers are located in the producing areas, although Midwest buyers do purchase mint oil on the West Coast. One buyer is located at Chehalis, Washington; another in Kalamazoo, Michigan; and two in South Bend, Indiana.

The largest buyer in the industry handles about 50 percent of the annual production; deals heavily with major chewing gum, toothpaste, and candy manufacturers; and has a sizeable trade in the export market. The second largest buyer handles an estimated 30 percent of the annual production and has the largest export business. This buyer also has some portion of the large toothpaste and chewing gum accounts. Both of these two buyers handle other products. The largest buyer handles orange and lime juices and the second largest buyer handles botanical drugs. Two smaller buyers purchase the residual 20 percent of the mint oil market.

These two buyers have some export accounts and sell to New York wholesalers and to the candy industry, but do only a small business with chewing gum firms.

Movement of mint oil through the market channels is shown by the flow diagram below:

Figure 15. Major movement in Oil of Peppermint and Oil of Spearmint.



——— dominant flow of mint oil
– – – – some small amounts of mint oil

Market structure in the mint oil industry can be analyzed by the degree of buyer and seller concentration, the degree of product differentiation, and the conditions of entry and exit into the market.

Since four major buyers purchase the majority of the raw oil from growers, the four buyers form a theoretical oligopsony. Three major chewing gum manufacturers and three major toothpaste manufacturers contract oil directly from buyers, forming a bilateral oligopoly in the wholesale marketing stages.

Buyers can blend any quality of oil a user desires so product differentiation is not a barrier to a new buyer entering the market. Product differentiation, however, does exist to the extent that users prefer oil from specific buyers. Users prefer oil from certain buyers because of buyer services and the availability of a reliable supply of oil meeting their specific needs.

Entry barriers in the buying phase of the mint industry include capital and user loyalty. Buyers provide (1) galvanized 55 gallon drums for all growers, (2) pick up stations in all major producing areas, (3) a field staff providing information on mint production, (4) short term credit to growers, (5) redistillation equipment and blending facilities to blend oil for user specifications, and (6) storage facilities for large accounts. All of these items require a capital outlay on the part of any new buyer attempting to enter the market.

In oligopsonistic industries, it is important to realize the interdependence of buyers. Buyers realize that tacit agreements are necessary to avoid price wars and other agressive tactics. Therefore, in oligopsonistic industries, most product promotion is limited to non-price competition in the form of user services, personal contacts, and trade journal advertising.

Price leadership is also common in oligopsonies. Dominant firm price leadership and barometric firm price leadership are prevalent in many oligopsonistic industries. Price leadership should not receive a bad connotation because price leadership may not exploit firms or individuals. Price leadership only means that other firms recognize a firm for its superior market information and pricing ability. But if imperfect knowledge about alternative uses of factors exists, then oligopsonistic industries have the potential power of exploiting a producer by paying the factor less than its marginal value product.

The largest buyer in the industry obtains a continuous record of production statistics, planted acreage, and farm carryover from its fieldmen operating the receiving stations in all of the producing areas.

During the winter months and early growing season, the buyers meet with their large accounts and discuss the price the accounts are willing to pay for the quantity of oil that they will need. Then the buyer subtracts his fee of 50¢ per pound or 10 percent, whichever is greater, for

his services and re-distillation charges of 10 to 12 cents per pound and releases contracts to growers. The time that contracts are released depends upon the amount of acreage expansion or contraction needed.

If growers feel that the contract price is too low, they will bargain back and forth with the buyer. Then the buyer must try to re-negotiate with the users. If farmers have over planted and stocks exist at the farm, buyer, and user levels, users will offer a lower price and stock oil. Most users stock oil for more than a year to hedge against high mint oil prices, although most users buy some oil every year.

Most of the oil produced in Michigan, Wisconsin, Indiana, and Oregon is produced by growers under contract to buyers with user commitments known by buyers. Central Washington oil is purchased after harvest depending upon the export demand and the demand for oil by candy manufacturers.

When mint oil is in short supply and buyers want new production regions opened, buyers hold the price high in the area for a few years such as was the case in the Madras area in Oregon. Peppermint culture was first introduced in the Madras area on a commercial basis in 1954 when a group of seventeen producers, encouraged by the A.M. Todd Company, planted 651 acres.[24] The A.M. Todd Company does research to

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[24] Brown, Robert C. The Agricultural Geography of Peppermint in the Pacific Northwest, unpublished master thesis, Oregon State University, 1962.

find land capable of producing mint to insure a consistent supply for its accounts.

Because of the large investment in distillation equipment, it is believed that entry comes from acreage expansion during periods of rising prices rather than from new producers coming into the industry, except when wilt diseases forces production to new areas. New growers can have mint custom distilled, but usually the person doing the custom distilling has to use the distillery at the same time the new producer would need it. Mint hay must be distilled at full bloom to get quality oil.

The proper time of distillation depends on the relationship of the major constituents of the oil. Major constituents of the peppermint oil include esters, menthol, and menthofuran. These increase in the plants throughout the growing season. Menthone, another major constituent, decreases in the plant throughout the growing season. Early distillation results in a less mature oil with a lower content of esters, menthofuran, and menthol and a higher menthone content.[25] So, the time of distillation is important in controlling quality to meet U.S.P. standards for the chemical composition of oil. In addition, buyers and users impose odor and quality standards.

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[25]Tornow, Paul. "Production of Quality Peppermint Oil," paper presented to members of the Oregon Essential Oil Growers League in 1962.

According to some growers in Michigan and some informed sources from the West Coast, in most years the same stipulated contract price is offered all growers for comparable quality oil produced in the same area. Since the buyers perform the same services and offer the same price for oil, growers should be indifferent as to which buyer contracts his oil. However, most growers do business with the same buyer year after year because of the lack of contract price differentials.

Buyers, therefore, perform an intermediary function of a processing or a blending agency and a wholesale firm that must keep both the growers and users content in order to remain in business. Most of the buyers have been in the business for many years and have established reputations for quality oil and grower service.

Growers' organizations have been formed in Michigan, Oregon, and Washington, but most of them have not tried bargaining with buyers on a price basis. Most of these grower organizations are service organizations where growers discuss common problems and bring in speakers on various phases of the industry.

The Oregon Essential Oil Grower League has about 150 members and is strong in both Washington and Oregon. An extension economist from Oregon State University is an adviser to the group and each year at the annual meeting, normally about January 1, he gives a market outlook report

based on U.S.D.A. statistics. This gives the growers some insight into price conditions in the year ahead.

In years when prices are low, some growers keep part of their oil, but according to one buyer, banks are unwilling to finance the grower with stocks on hand because if the oil is not handled and stored properly, it will deteriorate rapidly. Also, the risk may be large as users stock mint supplies in low price years. The buyers have been willing to make production loans to growers if needed. This also helps bind the grower and buyer together, forming a type of vertical coordination in the mint industry.

One grower, the author was told, sold his mint directly to a foreign importer, but this is a rare situation in the industry.

Consumption of Peppermint Oil in Domestic and Foreign Markets

It has been recently estimated that about 43 percent of peppermint oil is processed in chewing gum, 16 percent in toothpaste and 23 percent in exports, while the other 8 percent ends up primarily in candy with small amounts going into a variety of goods such as ice cream, jellies, medicine, beverages, etc.[26] Spearmint oil has about the same breakdown in percentage terms as does peppermint oil in

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[26]Estimated from buyer sales in recent years, personal correspondence, 1964.

utilization. That is, between chewing gum, toothpaste and exports.

The remarkable popularity of mint as flavor is shown by the fact that in 1962, Americans consumed over six billion packages of chewing gum, one hundred million pounds of toothpaste and over three billion pounds of candy.[27] Mint oil was used in two thirds of the gum, in over half the toothpaste and in a large portion of the candy.[28]

Utilization of peppermint oil in foreign countries is comparable to its uses in the United States, but it has a different distribution among manufacturers. According to a 1954 Foreign Service dispatch from Turin, Italy the main users of peppermint oil are manufacturers of liquors, confectionery, cosmetics and toothpaste.[29] Most apothecaries utilize imported menthol instead of local peppermint oil.

The following figures compare the distribution in Italy and in the United States.

The Italians are large light wine drinkers, and, as expected, much more peppermint oil is consumed in alcoholic beverages in Italy than in the United States. Some United States oil is used for liquors, but it is an infinitesimal amount.

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[27]Todd, W.A. "The Mint Industry in the United States", paper presented in Japan, 1962.

[28]Ibid.

[29]Barber, L.A. Chemical and Rubber Division, U.S. Department of Commerce, personal correspondence, 1964.

Table 7. Italian utilization of peppermint oil in 1954.

Industries	Consumption Percent
Liquor	10
Confectionary	25
Cosmetics	10
Toothpaste	40
Pharmaceuticals	5
Other	10

Source: Barber, L.A. Chemical and Rubber Division, U.S. Department of Commerce, personal correspondence, 1964.

Table 8. Utilization of United States peppermint oil 1947.

Industries	Consumption Percent
Exports	32.0
Extracts	.5
Chewing gum	50.0
Candy	8.0
Toothpaste	5.0
Mint Jelly	1.5
Medicine	3.0

Source: Liebel, Lester N. Op. Cit., page 18.

Also, most of the European countries use much American peppermint oil in confectioneries. During the Second World War, the 40,000,000 persons in Great Britain ate an average of two ounces of mint flavored candy and other peppermint oil products weekly.[30] The British used

the oil for peppermint drops (much like lemon drops) to help maintain national morale during the war. It seems that peppermint drops made the people more content.

The above tables also indicate that Italy uses more oil in cosmetics and toothpaste than does the United States, as a percentage of each country's total production of peppermint oil.

Special World War II Conditions

In 1942, the United States exported only 13.3 percent of the United States' crop, the lowest amount recorded since 1929. Only 191,000 pounds were exported from the United States because of the short crop of only 826,000 pounds in the United States. Exports were small because of the high domestic demand for peppermint oil not only for manufacturing consumer products, but also for a supply of menthol since Japan was the major source of Mentha arvensis or cornmint. Mentha arvensis has a very high content of menthol and may be as high as 75 to 85 percent. This was before the large development of the Mentha arvensis industry in Brazil, our most important source of menthol today.

Since peppermint oil has about a 45 to 55 percent menthol content, it was processed for menthol during the war years, but this is not normal. This shortage of peppermint

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[30] The Perfumery and Essential Oil Record, April 1943, page 96.

oil available for export caused a verbal battle between the British and the United States. The British asked for 200,000 pounds of peppermint oil, but the War Food Administration forced the British to reduce their requirement to 125,000 pounds.[31]

The "peppermint crisis" during this period forced the War Food Administration to regulate the use of peppermint oil in 1943. The restriction on the use of peppermint oil was as follows: No person in any calendar quarter could use more than the following percentages in any particular class use during the corresponding calendar quarter in 1941.[32]

Table 9. Restrictions on use of peppermint oil.

Class of Use	Permitted Percentages of 1941 Use
Manufacture of chewing gum	70
Manufacture of confectionery	70
Manufacture of pharmaceutical preparations	100
Manufacture of dentifrices	75
Manufacture of miscellaneous articles	70

The Office of Price Administration also regulated prices paid to producers and listed prices for dealers selling

[31]Liebel, Lester N. Op. Cit., page 19.

[32]Federal Register, Wednesday, January 5, 1944, War Food Order No. 81 as Amended.

in 400-pound drums.[33] The war period, however, was the only time during which public regulation has been needed in the industry.

Prices

Monthly wholesale prices of peppermint oil are collected by the United States Bureau of Labor Statistics. These prices concern mainly low quality oil sold to New York wholesalers. Wholesale prices of peppermint oil were relatively high after World War II when firms tried to adjust to normal domestic production. Prices remained high from 1947 to 1953, but have steadily declined to the present, as shown by Table 10, page 77.

As firms adjusted from public controls during the war, previous products were brought back on the market plus new innovations in toothpaste and an ever-increasing popularity overseas which caused mint oil prices to rise greatly. Even though the amount of oil used per item is small, in total it takes large amounts of mint oil to flavor all the toothpaste, candy and chewing gum sold in just about every grocery store, and drug store, across the United States.

Farm prices of peppermint oil vary between regions and even within states and producing areas depending on the

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[33] Ibid.

Table 10. Monthly Wholesale Prices of Peppermint Oil 1/

(Dollars per pound)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average 2/
1963	4.20	4.20	4.65	4.80	4.80	4.80	4.75	4.75	4.50				4.606
1962	3.50	3.50	3.50	3.40	3.40	4.30	4.00	4.00	4.00	5.25	5.25	5.25	4.113
1961	4.90	4.90	4.90	4.40	4.40	4.00	4.00	4.00	4.00	4.00	3.50	3.50	4.208
1960	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.25	4.90	5.00	5.00	4.263
1959	3.90	3.75	3.75	3.70	3.70	3.70	3.65	3.45	3.35	3.15	3.15	4.00	3.604
1958	3.60	3.60	3.60	3.60	3.60	4.10	4.50	4.50	4.25	4.25	4.25	3.90	3.979
1957	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.50	4.50	4.25	4.25	4.625
1956	5.60	5.60	5.75	5.85	5.60	5.60	5.60	5.25	5.05	7.50	7.75	7.75	6.113
1955	7.75	7.75	7.75	7.75	7.50	7.25	7.25	7.15	6.25	6.25	6.25	5.80	7.058
1954	5.60	5.60	5.60	5.40	5.75	5.75	6.25	6.25	6.25	4.75	4.75	4.75	5.558
1953	5.75	5.50	5.50	5.50	5.50	5.50	5.00	4.65	4.50	4.50	4.50	5.60	5.167
1952	7.00	7.00	7.00	7.25	7.25	7.25	6.80	6.80	6.25	6.10	5.60	5.50	6.650
1951	6.95	7.29	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.20	7.00	7.203
1950	5.81	6.19	6.25	6.25	6.25	6.15	6.11	5.90	6.07	6.25	6.36	6.63	6.185
1949	6.90	6.90	6.60	5.98	5.75	5.50	5.50	5.50	4.97	4.88	4.99	5.50	5.748
1948	7.58	7.55	7.55	7.51	7.50	7.50	7.50	7.50	7.30	7.10	7.00	6.94	7.378
1947	7.75	7.75	7.55	7.58	7.92	7.85	7.70	7.70	7.70	8.14	7.85	7.80	7.774

1/ Peppermint Oil - natural drums, producer to first buyer, F.O.B. New York, Friday price.

2/ Nine-month average price.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

quality of oil produced, availability and the demand for the oil. As an example, in 1962, the Midwest producers received an average price of approximately $6.50 per pound; Western Washington, Western Oregon and Madras growers received $3.50 or less per pound and Ontario, Hermistron (Oregon) and other producing areas received between $3.00 and $5.50 per pound.[34]

Since the annual average price received by growers varies considerably due to regional and local quality variations, the annual price may not reflect actual shifts in demand, but may reflect only shifts in quality of the oil and the location of production and the amount of mint stocks held by growers, buyers and users.

As shown by Figure 16, page 79, the farm prices of peppermint oil have fluctuated widely, but since 1951 the general trend has been toward lower prices. Prices in all producing states have moved in the same direction year after year which indicates the same factors influence all states' prices. This common factor is that all buyers purchase oil in all producing areas. All firms in oligopsonies must pay exactly the contract price offered by other buyers, so contract prices are equal for comparable quality oil.

This general trend had exceptions in 1959 and 1961. In 1959, prices were maintained at a relatively high level

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[34]Paul Tornow, op. cit.

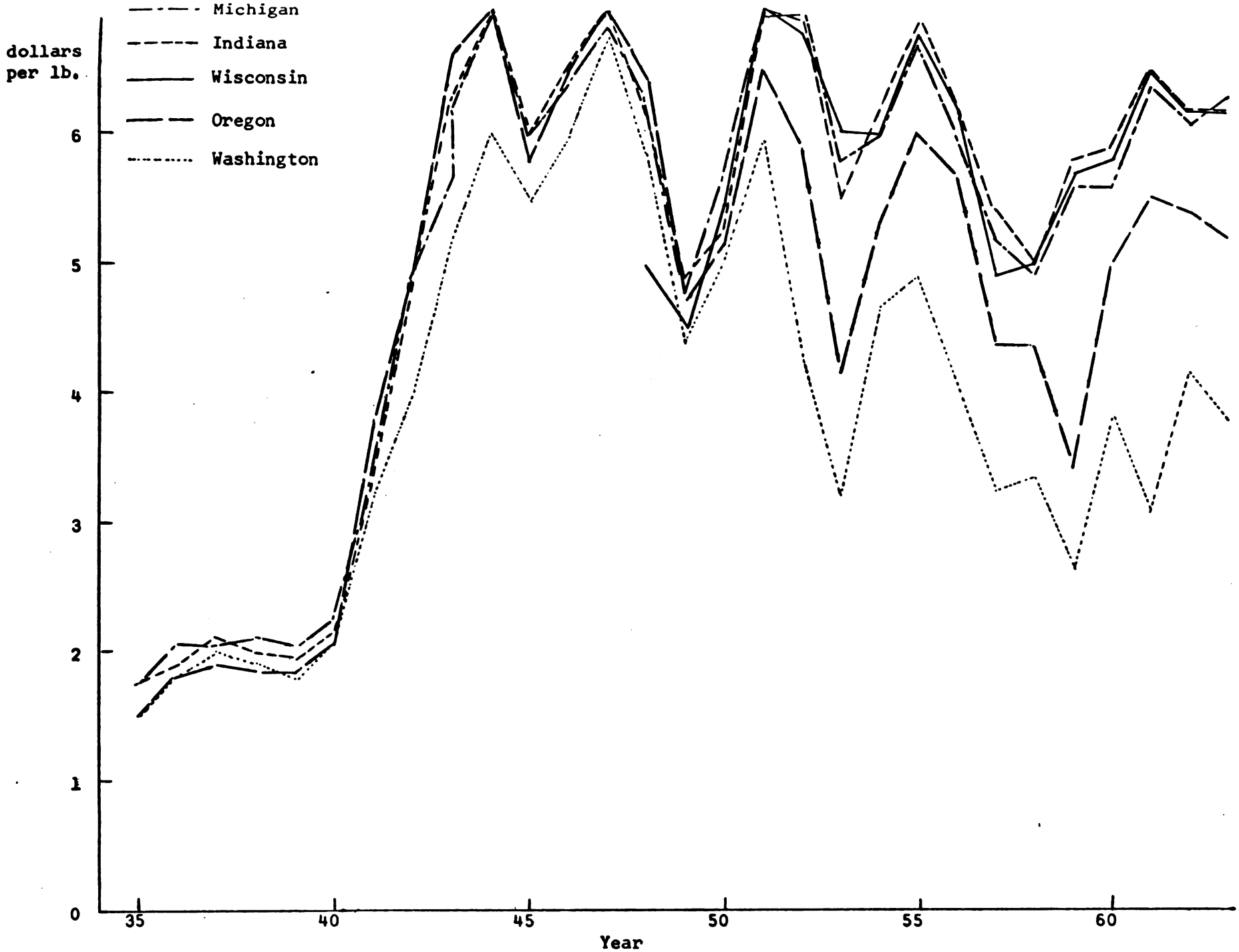

Figure 16: United States annual farm price of peppermint oil received by farmers, 1935-63

in the Midwest to encourage expansion of acreage in order to obtain enough oil to keep the user blends fairly consistent.

According to one buyer, the inconsistency in the Washington price movement in 1961 was due to the attempt to expand acreage in Oregon by holding the price relatively high. Central Washington growers that do not contract their oil assured that a price of $1.00 less per pound than Oregon prices would be paid as had been done in past years. They increased acreage by 2,200 acres so buyers offered them an even lower price than the customary price differential would have indicated.

Spearmint oil prices have fluctuated more widely than have peppermint prices. However, again the price of the two varieties of spearmint oil are averaged together in the annual average state price received by farmers. The price of spearmint oil is normally below that of peppermint oil. But, the price movements of both oils seem to move simultaneously in the same direction (except for the period since 1957).

Spearmint prices in Michigan and Indiana almost coincide every year with Michigan prices, in recent years, below Indiana prices. (As shown in Figure 17, page 81) As mentioned before, buyers say that Native variety brings a premium from $.50 to $1.00 per pound over Scotish oil. Michigan produces much more Native variety than Indiana,

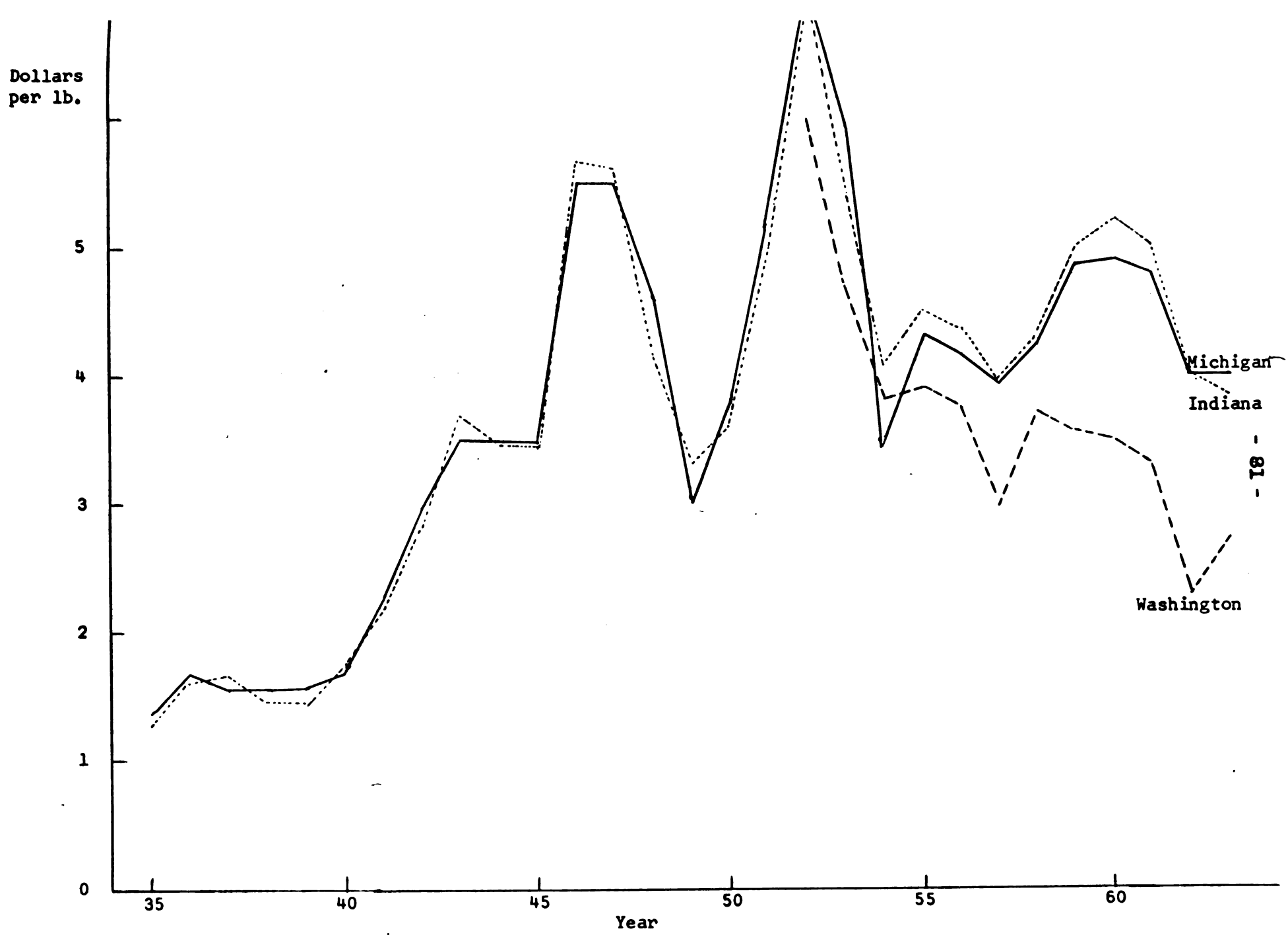

Figure 17: United States annual farm prices of spearmint oil received by farmers, 1935-63

but average prices received by farmers do not reflect this difference.

All spearmint oil is homogenous within the same variety. However, all oil prices in Michigan and Indiana have experienced a slight upward trend since 1934, while spearmint oil prices in Washington have continued to decline since the first commercial plantings in 1932. Washington grows more of the lower price Scotch spearmint than Indiana or Michigan, but the $1.30 to $1.70 price differential between prices received by growers in Washington and the Midwest in recent years is greater than variety differences and transportation cost. This price differential more than likely reflects the market structure in the industry.

These price differentials do not indicate a perfect market but an attempt at diversification for buyers.

Prices are only one aspect of the profitability of an industry to growers. Production cost studies (Chapter IV) indicated the absolute advantage of the industry to the Pacific Northwest, in spite of the low prices received by growers.

Chapter VI

Demand and Supply of Mint Oil

Uses for peppermint oil and spearmint oil are very limited. Consequently, by the oils' nature as flavoring agents, they should follow Alfred Marshall's four principles governing the derived elasticity of demand. Marshall's principles state that the derived demand for any factor of production will be more inelastic, (1) the more essential the factor, (2) the more inelastic the demand curve for the final product, (3) the smaller the fraction of the total cost that goes into the factor and (4) the more inelastic the supply curve of the other factors.[35]

In the domestic market there is no important substitute for quality mint oil at a relevant range of market prices. There are both synthetic peppermint and spearmint oils but they are of no practical importance because of their inferior quality. The poor quality of synthetic mint oil makes it impossible for use in flavoring chewing gum or toothpaste.[36]

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[35] Marshall, Alfred. Principles of Economics. Eighth Edition, the Macmillan Company, New York, 1948, pages 385 and 386.

[36] Todd, W.A., personal correspondence, 1964.

Mentha arvensis and Menthol are substitutes for peppermint oil, to some degree, outside the United States. This can be observed during periods of high prices, such as during the second World War (even though price controls existed), when much Mentha piperita was adulterated with these substitutes.

Mint oil represents a very small portion of the cost of the final product. One pound of peppermint oil will flavor 100 pounds of chewing gum base, 400 pounds of toothpaste or about 800 to 1600 pounds of finished candy.

To give an idea of the amount of peppermint oil used, one pound of oil will flavor 100 pounds of gum base and this will produce 15,000 sticks of gum of the regular size. Therefore, one stick of chewing gum contains approximately sixty-six millionths of a pound of oil.[37] When the farm price of peppermint oil is $3.00 per pound, the farm value of the flavoring agent in a stick of gum is .04 cents.

The supply of many of the ingredients of both chewing gum and toothpaste is expected to be inelastic because of the nature of the ingredients. Take for example, chewing gum which is made of the following five basic constituents: chewing gum base, sugar, corn syrup, softeners and a flavoring agent.

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[37] Hutson, R., E. Jones and E. Benne. "Use of DDT in the Control of the Mint Flea Beetle," Reprint from Michigan Agricultural Experiment Station Quarterly Bulletin, Vol. 29, No. 4, May 1947, page 235.

Chewing gum base is a blend of chicle, which is a tropical latex product tapped from several species of trees found primarily in Central America, and resin obtained by tapping pine trees. One would expect the supply of such an ingredient to be very inelastic in the short run. The same would be true of the other ingredients.

Since Marshall's principles hold for mint oil, one would hypothesize that the demand for oil as a factor of production is quite inelastic and more inelastic than the demand for the final product.

The next section reports an application of statistical procedures to the economic and commodity relationships in the mint oil industry. Most published research is of a descriptive nature. With larger computers and improved econometric techniques, it is now feasible to apply adequate statistical procedures.

The Statistical Model

The statistical model contains four stochastic equations that are solved simultaneously using two stage least squares. This procedure is used rather than ordinary least squares because it is believed that the quantity of peppermint and spearmint oil and prices of peppermint and spearmint oils are determined simultaneously. Using two stage least squares, the correlation of endogenous variables and the disturbance term are considered producing better structural coefficients.

In the first stage of two-stage least squares analysis the endogenous variables that will be used as independent variables in the second stage are estimated as a function of all the predetermined variables in the system by applying ordinary least squares. Then, these estimated values of the endogenous variables from the first stage are plugged back into the original equations which are then solved by ordinary least squares as the second stage.

Assumptions of two-stage least squares include serial independence, finite and constant variance and identification which implies estimates of structural coefficients that are asymptoticly efficient, and consistent.[33] This procedure also assumes that the model is correctly specified and that the variables are measured without error.

Public controls on peppermint oil ended August 22, 1946. The marketing system for mint oil was back to normal by 1947. Most companies that had government contracts for their products during the war were producing for the domestic market again by 1947. Since all mint oil products produced before the war were on the market by 1947, this insures a rather homogenous set of factors operating during the period chosen for analysis, 1947 to 1962. The major changes in the industry from 1947 to 1962 have been product

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[33] Henderscheid, L.V. "Assumptions Regarding Disturbances and Properties of Estimators", Class notes, Agricultural Economics 831, Spring 1964, Michigan State University.

innovation and the movement of mint production to the West Coast.

In any statistical analysis some of the variables are chosen at the discretion of the investigator. There are major variables anyone would include and minor variables anyone would exclude but there are many variables that are indeterminate. The largest problem confronted was in choosing significant demand and supply shifters. The most relevant demand and supply shifters are presented below in the economic model.

The Economic Model

$$Y_{1t} = A_{01} + B_1Y_{2t} + B_2Y_{4t} + B_3X_{1t} + B_4X_{3t} + B_5X_{3t} + U_{1t}$$

$$Y_{2t} = A_{02} + C_1Y_{1t} + C_2Y_{4t} + C_3X_{5t} + C_4X_{6t} + C_5X_{7t} + U_{2t}$$

$$Y_{3t} = A_{03} + D_1Y_{4t} + D_2Y_{2t} + D_3X_{4t} + D_4X_{2t} + D_5X_{3t} + U_{3t}$$

$$Y_{4t} = A_{04} + E_1Y_{3t} + E_2Y_{2t} + E_3X_{5t} + E_4X_{3t} + E_5X_{7t} + U_{4t}$$

Where:[39]

Y = endogenous variables

X = independent variables

Y_1 = average annual farm price of peppermint oil in dollars per pound

Y_2 = annual production of peppermint oil in thousands of pounds

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[39]All statistical data used are presented in the appendix.

Y_3 = average annual farm price of spearmint oil in dollars per pound

Y_4 = annual production of spearmint oil in thousands of pounds

X_1 = annual exports of peppermint oil from the United States in thousands of pounds

X_2 = population of the United States between the ages 15-34

X_3 = disposable income per capita

X_4 = annual exports of spearmint oil from the United States in thousands of pounds

X_5 = trend 1947 = 1; 1948 = 2; etc.

X_6 = annual acreage of peppermint (measured in acres)

X_7 = index of prices received by farmers for truck crops (1910-1914 = 100)

X_8 = annual acreage of spearmint (measured in acres)

U = random disturbance term.

Estimated Demand Equations

$$Y_1 = -15.15 - .00041\hat{Y}_2 - .00047\hat{Y}_4 - .0022X_1 + .00054X_2 - .0010X_3$$

$$(.0012) \quad (.0019) \quad (.0017) \quad (.00039) \quad (.0021)$$

(values in parentheses are standard errors of regression coefficients)

$R^2 = .57$[40]

Standard error of the estimate ($S_{y.x}$) = .781

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[40]Calculated from actual data using $\hat{Y}_2$ and $\hat{Y}_4$. Rerunning the above equation deflating the data by the Consumer Price Index did not affect the statistical significance of the variables. It did, however, increase the correlation coefficient slightly.

Durbin-Watson test:[41] inconclusive

$$Y_3 = 22.01 - .00042\hat{Y}_4 - .00093\hat{Y}_2 + .00024X_4 - .00033X_2 + .0010X_3$$

(.0016) (.0015) (.010) (.00051) (.0033)

(values in parentheses are standard errors of regression coefficients)

$R^2 = .29$

$S_{y.x} = 1.04$

Durbin-Watson test: no serial correlation

The economic model was specified such that the farm price of peppermint and spearmint oil is a function of the estimated quantities of peppermint and spearmint oil produced, exports, population characteristics and personal disposable income per capita.

In the peppermint oil price equation, all variables are statistically insignificant at the 10 percent level except exports of peppermint oil and population characteristics.

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[41] The Durbin-Watson test is a method to test whether or not the unexplained residuals from an equation, fitted by least squares, are correlated with successive values. This phenomena is called serial correlation or auto-correlation. The test statistic is as follows:

$$d' = \frac{\sum_{t=2}^{N} (d_t - d_{t-1})^2}{\sum_{t=1}^{N} d_t^2}$$

Tables are available to determine the amount of serial correlation in Joan Freidman and Richard J. Foote, Computational Methods for Handling Simultaneous Equations, Agricultural Handbook No. 94, (ARS) USDA, Revised May 1957.

Also, the negative sign on income was not expected, suggesting that peppermint oil is an inferior good. However, the variable is statistically insignificant using the two-tailed t-test with 10 degrees of freedom at the 10 percent significance level.

Again, in the spearmint oil price equation, quantity of peppermint and spearmint oil are insignificant in explaining variations in the price of spearmint oil. Exports of spearmint oil and income are also insignificant. The sign of the coefficient of exports would not be expected to be positive nor would one expect a negative sign on population characteristics.

Economic theory states that there should be an inverse relationship between price and quantity. In the mint oil industry the price and quantity of mint oils are inversely related but the coefficients are insignificant.

Due to other unmeasurable variables such as stocks, prices and quantities of flavoring agents and the oligopsonistic nature of the industry, the price-quantity relationship is obscured.

In both price equations that the quantity of the other mint oil explains more of the variation in that mint oil's farm price, according to the partial correlation coefficients. Even though the oils are complements, one would not expect this relationship to exist.

An inelastic demand for peppermint oil was hypothesized. Point elasticity computed at the mean values of the

variables was -.63, confirming this belief.[42] The point elasticity of demand for spearmint oil was slightly elastic, -1.37.

Estimated Supply Equations

$$Y_2 = 1851.33 - 200.48\hat{Y}_1 + .414\hat{Y}_4 + 46.55X_5 + .006X_6 + 7.03X_7$$
$$\qquad\qquad (30.72) \quad (.25) \quad (15.9) \quad (.011) \quad (2.50)$$

(values in parentheses are standard errors of regression coefficients)

$R^2 = .95$

$S_{y.x} = 123.7$

Durbin-Watson test: no serial correlation

$$\hat{Y}_4 = -1097.72 + 42.22\hat{Y}_3 + .397\hat{Y}_2 + 3.03X_5 + .065X_3 - 1.09X_7$$
$$\qquad\qquad (23.73) \quad (.395) \quad (3.43) \quad (.004) \quad (1.05)$$

(values in parentheses are standard errors of regression coefficients)

$R^2 = .93$

$S_{y.x} = 57.13$

Durbin-Watson test: no serial correlation

As a whole, the supply equations are statistically much more reliable than the demand equations. Much of this reliability can be attributed to the inclusion of acreage

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[42] Point demand elasticity was calculated as follows:

$$\eta = \frac{1}{b_1} \cdot \frac{\bar{Y}}{\bar{X}}$$

as a predetermined variable. This is justified because acreage must be planted prior to year of harvest and harvested acreage is essentially equal to planted acreage.

Variables used to explain the variations in the quantity of peppermint and spearmint oil produced include estimated farm prices, acreage harvested, trend and prices of alternative crops. These variables are all highly significant in the supply of peppermint oil equations and explained 99 percent of the variation in the quantity of peppermint oil produced.

This system of equations explained 93 percent of the variation in the quantity of spearmint oil produced, although trend was not a useful variable in the equation. Also, one would not expect the negative sign between quantity of peppermint and the prices of truck crops.

Another statistically significant relationship is the positive sign between the quantity of spearmint oil produced and the price of spearmint oil.

The point elasticity of supply of spearmint oil is .244 calculated at the mean values of the variables and the point elasticity of the supply of peppermint is -.694. Therefore, both supply equations are inelastic which is expected with any perennial type crop when analyzing year to year quantity change.

Alternative Formulations of Demand Equations

Two alternative models were formulated before choosing the model presented in this chapter. The first alternative model was also a simultaneous equation model applying two-stage least squares to both peppermint and spearmint oil separately. And the second alternative model was a single equation model using ordinary least squares.

First Alternative Model

This model contained two stochastic equations that were solved by two-stage least squares procedure using time series data (1947-1962). The same assumptions and conditions are necessary in this model that applied to the previous simultaneous equation model.

$$Y_1 = a + B_1Y_2 + B_2X_1 + B_3X_2 + U$$

Where:[43]

Y_1 = annual average United States peppermint oil price received by growers (in dollars), excluding the State of Washington.

Y_2 = domestic supply of peppermint oil in thousands of pounds.

X_1 = annual average farm price of spearmint oil in dollars.

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[43]Only the demand equation is presented as this is the equation that needs improvement.

X_2 = United States personal disposable income per capita in dollars.

The predetermined variables in the system of equations include farm price of spearmint oil, disposable income per capita, trend and acreage of peppermint. The results of the demand equation for peppermint oil are presented below:

$$Y_1 = 5.64 + 6.42Y_2 + .240X_1 - 11.96X_2$$
$$\qquad\qquad (11.32) \quad (.23) \quad (10.01)$$

(values in parentheses are standard errors of regression coefficients)

$R^2 = .30$

$S_{y.x} = .79$

All coefficients are insignificant at the 20 percent significance level using the two-tailed t-test with 12 degrees of freedom.

Another distinguishing feature of the equation is the positive relationship between the farm price of peppermint oil and the quantity of peppermint oil. This condition is an exception to the "law of demand" and does not reflect the rationality of manufacturers, although the trend effect is probably very important.

Also, the negative sign between farm price of peppermint oil and income per capita is not expected.

The following demand equation for spearmint oil was formulated under the same assumptions as the demand equation for peppermint oil.

$$Y_1 = a + B_1Y_2 + B_2X_1 + B_3X_2 + U$$

Where:

Y_1 = annual average United States farm price of spearmint oil in dollars.

Y_2 = domestic supply of spearmint oil in thousands of pounds.

X_1 = annual average farm price of peppermint oil in dollars per pound, excluding the State of Washington.

X_2 = United States personal disposable income per capita.

The predetermined variables in the system of equations are farm price of peppermint oil, disposable income per capita, trend and acreage of spearmint. The results of the demand equation are presented below:

$$Y_1 = 3.02 - 11.69\hat{Y}_2 + .482X_1 - .050X_2$$
$$\qquad\qquad (11.82) \quad (.32) \quad (.11)$$

(values in parentheses are standard errors of regression coefficients)

$r^2 = .32$

$S_{y.x} = .933$

Only the farm price of peppermint oil is statistically significant at the 20 percent level using the two-tailed t-test with 12 degrees of freedom. Also, note the negative relationship of income and price.

The more complete simultaneous model was chosen over this alternative model because of better structural coefficients in explaining supply and demand. The four equation model explains more of the variation in production and the price of peppermint oil, but does not explain much of the variation in the price of spearmint oil.

Second Alternative Model

The second alternative model is a single equation model using ordinary least squares as an estimation procedure. In ordinary least squares analysis the assumptions include serial independence, only one endogenous dependent variable and finite and constant variance which permits the application of the Markov Theorem.[44] The Markov Theorem states that ordinary least squares gives the best linear, unbiased, consistent estimates of both the estimates and the beta parameters.

This economic model misrepresents the hypothesis that the price of mint oil and the quantity of mint oil produced are determined simultaneously. The ordinary least squares estimation procedure used on both economic models formulated as the farm price of peppermint and spearmint oil, separately, as a function of the quantity of peppermint and spearmint oil produced, lagged one year, plus other demand

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[44] Wanderscheid, L.V. Op. Cit., page 1.

shifters. Other demand shifters were disposable income per capita and the farm price of the mint oil not used as the dependent variable.

None of the regression coefficients were significant at the 20 percent significance level except disposable income per capita in the peppermint oil equation which was negative. The coefficient of determination for peppermint oil was .69 and for spearmint oil .49.

Other demand shifters were formulated in equations in the first phases of this study. These independent variables are the price of toothpaste and the price of menthol. The price of toothpaste was deleted from the equations because of the high intercorrelation with disposable income per capita and the price of peppermint oil in the spearmint demand equation. Menthol price also had a high correlation with income and was deleted as an explanatory variable since it is not a substitute within the United States.

Chapter VII

SUMMARY AND CONCLUSIONS

The United States produces about 80 percent of the world's supply of Mitcham peppermint oil while about 10 percent is produced in Southern France, Italy, Spain, Morocco, and North Africa. Another 10 percent is produced in Bulgaria, Rumania, and Russia.

Shifts in production centers within the United States have been caused by wilt disease and have been encouraged by major buyers in the industry. To illustrate these shifts, note the history of production centers. The first commercial peppermint oil production in the United States was started in Ashfield, Massachusetts in 1812. Later, the industry moved to Wayne County, New York then to the Midwest and presently the major producing centers are in the states of Oregon and Washington.

Cultural requirements of peppermint are quite rigid. Peppermint requires the long summer days of the northern latitudes and an abundant supply of fresh water.

Spearmint oil production normally follows after wilt disease results in peppermint production being no longer profitable because spearmint is more wilt resistant. Some

growers however, produce both mint oils to allow complementary use of farm equipment. Spearmint also requires similar soil and climatic conditions. Complementary items on mint farms are the distillation equipment, farm machinery and farm enterprise organization.

Quality mint oil originates on the farm. Although some minor regional differences can be blended into user specification, off odor mint oil is of little value.

Two kinds of peppermint oil exist. One is Prime Oil used exclusively in the manufacturing of chewing gum and toothpaste. The second is Kennewick Oil which is used in candy and in the export market due to the high menthofuran content of the oil. This high menofuran content gives the oil an aromatic character with unstable flavor characteristics.

Spearmint oil is of two varieties. The first is the Scotish variety and the second is Native variety. The flavor characteristics differ markedly. Scotish oil is mild, while Native oil is stronger. This stronger oil is needed to give "punch" to chewing gum. Both varieties are blended when used.

There are 1,200 growers, four buyers, and six major domestic users in the industry. The two major buyers have receiving stations in all producing areas. They do research in various areas to test for land suitable for mint production and to encourage farmers to produce oil. Buyers contract

the oil from growers on orders from major users, thus acting as a brokerage firm. However, both buyers and users stock oil. Users stock more than a year's supply of oil to hedge against high prices. Buyers also stock oil to sell to minor users throughout the marketing year.

The United States is also the major exporter of peppermint oil. In 1962, the United States exported 50.7 percent of the total crop to 53 countries. United States exports have increased 265 percent between 1947 and 1962. Other exporters are Italy and France.

Europe is the largest importer of United States mint. In 1962, the United Kingdom imported the largest percentage of the United States' exports (27.2%) followed by France, West Germany, Mexico, Japan, Netherlands, Canada, and Australia.

The United States also produces the majority of the world's spearmint oil. Exports amounted to 59,000 pounds in 1947 and 446,000 pounds in 1962. Major importing countries are the United Kingdom, France, Canada, and Mexico. Spearmint flavor is relatively new in most countries, but is gaining much popularity in Europe.

The major domestic movement of mint after the oil is collected by the buyers is as follows: (1) 48 percent is processed into chewing gum, (2) 28 percent is exported, (3) 16 percent is manufactured in toothpaste, and (4) 8 percent is used by candy manufacturers and by New York wholesalers.

Mint production competes with other heavily intensive types of agriculture. The major reason for the shifts in the mint oil industry to the Pacific Northwest has been the wilt disease which lowers yields to make mint oil production unprofitable at current prices in the Midwest.

In recent years, average net returns per acre to peppermint growers have been between $6.40 and $37.40 in the Midwest and between $67.87 and $33.73 in the Pacific Northwest for meadow peppermint. Average net returns to spearmint growers in the Pacific Northwest have been between $117.90 and $133.83 per acre, while average net returns per acre in the Midwest have been even lower than those for peppermint.

Producing mint oil is more or less a long run situation because of the technical knowledge, the large investment, and the skill needed to produce quality oil. In the Midwest, many growers remain in the industry at low returns because of fixed assets, which have a low opportunity cost. Therefore, the large investment in equipment acts as a barrier to entry and exit of growers.

The demand for peppermint oil is inelastic, while the demand for spearmint oil is slightly elastic. The supply of both peppermint and spearmint oil is inelastic. More research is needed to determine the relationships of other flavors as complements and/or substitutes.

Because of the stocks held by buyers and users and the oligopsonistic nature of the industry, price equations are

not reliable for predictive purposes. However, after farm prices of peppermint and spearmint were corrected by other predetermined variables, they were statistically significant but one sign was negative in the supply equations.

The future of the industry in the Midwest as well as on the West Coast will be determined by the following things:

1. Research to control wilt disease or to eliminate the wilt disease.
2. Demand in the export markets.
3. Pricing practices of major buyers.

It is expected that the United States consumption of mint oil per capita will remain relatively stable due to mint's limited use. However, new uses are being discovered.

More research is needed to determine the conduct and performance of the industry. It is known that price differentials exist that do not reflect a perfect market. Also imperfect knowledge on production, carryover stocks, and market structure of few buyers and few sellers in the wholesale marketing stages distinguish this industry from the classical economists' competitive norm.

Since the majority of the mint oil is produced in the Pacific Northwest, effective price bargaining could be established through existing institutions. The Oregon Essential Oil Grower League has control of much of the mint oil supply through their 160 members in both Washington and Oregon.

As shown in the price analysis chapter, the demand for peppermint oil is inelastic. Although the demand for spearmint is slightly elastic, the author suggests that the insignificant regression coefficients are not reliable.

Because the demand for mint oil is inelastic and the cost of mint oil is a small portion of the total cost, and with few, if any, substitutes, price bargaining has a potential. For example, if a bargaining association could control the supply of oil, they could double the farm price of oil from $6.00 a pound to $12.00 a pound and only increase the price of mint oil in a stick of gum from .04 cents to .08 cents.

An alternative to a growers organization might be a grower-buyer bargaining organization. This would probably be a stronger organization to bargain with final users.

If the buyers were unwilling to cooperate, however, existing institutional arrangements exist to bypass them. An association could purchase its own facilities for redistillation and distribution. All major users at present have mint oil purchasing staffs and export agents have their own private businesses. So if buyers did not want to participate in such bargaining activities, present outlets could be established without much expense.

Also the Midwest producing states could possibly form an association or belong to an industry wide association. An industry wide association is more desirable than a regional organization. An industry wide association could

regulate supply so that nonmembers would not increase production as prices increase. Also, since one region's peppermint and spearmint oil is a perfect substitute for another region's mint oil one would expect the price elasticity to be greater for a region than for the industry as a whole.

For a bargaining association to be a success it must meet the following requirements:

1. The negotiated price must be realistic with supply and demand for mint oil.
2. The organization must be fortified with economic literature.
3. All officers and growers must understand bargaining and how to evaluate people.
4. It must have a competent manager that commands respect of users and must hold the growers together.
5. The manager must be able to speak for a significant volume of product.

Bargaining associations can be of value to some agricultural crops, but the failure rate is high. However, price bargaining does offer a way to combat the bilateral oligopoly in the wholesale marketing stages.

In combating an oligopsony, bargaining associations are not exempt from restraint of trade and other monopoloid practices under the Sherman Antitrust Act or the Clayton Act.

Another alternative grower association may be a federal marketing order. These orders provide a legal framework in which to operate with government regulation to enable "orderly marketing".

In concluding this study, the author hopes that this information will provide, to both producers, buyers and users, more knowledge of the current situation that exists in the mint oil industry and methods of analysis that may be applicable to managerial decision making.

Table 11. Peppermint Acreage by States 1935-1963.

Year	Washington	Oregon	California	Total Far West
1935	420	1,500	350	2,270
1936	610	2,100	350	3,060
1937	700	2,000	350	3,050
1938	820	2,300	340	3,460
1939	960	2,500	550	4,010
1940	1,200	2,800	570	4,570
1941	1,800	3,100	750	5,800
1942	2,700	3,600	770	7,065
1943	3,500	3,800	690	7,990
1944	3,900	6,000	1,120	11,020
1945	4,400	8,000	650	13,050
1946	4,400	9,000	600	13,800
1947	4,700	11,000	---	15,400
1948	5,200	12,600	---	17,400
1949	5,300	14,500	---	19,270
1950	5,700	14,600	---	19,700
1951	7,100	14,000	---	21,100
1952	7,500	15,000	---	22,500
1953	7,000	13,500	---	21,000
1954	7,300	11,500	---	19,300
1955	11,000	13,000	---	24,000
1956	11,000	14,000	---	25,000
1957	12,300	14,800	---	26,900
1958	12,800	14,600	---	26,900
1959	13,300	15,600	---	28,900
1960	13,800	14,300	---	28,100
1961	16,000	15,300	---	31,300
1962	13,700	16,500	---	30,200
1963	14,700	16,800	---	31,500

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 12. Peppermint Acreage by States 1935-1963.

Year	Indiana	Michigan	Wisconsin	Ohio	Total Mid West
1935	14,200	23,300	---	450	37,950
1936	11,500	22,800	---	600	34,900
1937	8,400	20,900	---	700	30,000
1938	7,400	19,900	---	400	27,700
1939	8,200	18,900	---	240	26,940
1940	9,700	17,500	---	90	27,290
1941	12,200	13,900	---	140	26,240
1942	17,500	17,400	---	130	35,030
1943	15,900	13,000	---	120	29,020
1944	16,400	14,000	---	160	30,560
1945	18,000	15,000	---	240	33,240
1946	18,000	14,000	---	---	32,000
1947	18,500	13,500	---	---	32,000
1948	14,800	10,000	100	---	24,900
1949	15,700	9,500	500	---	26,200
1950	14,500	10,000	1,300	---	25,400
1951	11,300	10,000	1,800	---	23,100
1952	9,100	9,000	2,000	---	20,100
1953	7,600	7,400	2,000	---	17,000
1954	7,800	6,400	2,500	---	16,700
1955	9,600	6,800	3,200	---	19,600
1956	12,500	6,000	2,900	---	21,300
1957	11,900	5,800	3,900	---	21,600
1958	7,100	4,000	4,200	---	15,300
1959	4,900	2,000	4,400	---	12,000
1960	4,600	2,000	4,300	---	10,900
1961	5,600	1,900	4,500	---	12,000
1962	4,800	1,700	4,300	---	10,800
1963	4,500	1,800	4,000	---	10,300

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 13. Peppermint Production by States 1935-1963
(In Thousand Pounds)

Year	Washington	Oregon	California	Total Far West
1935	19	60	18	97
1936	35	88	18	141
1937	24	84	18	126
1938	29	83	17	129
1939	45	105	24	174
1940	53	109	28	190
1941	83	133	20	236
1942	119	162	31	312
1943	144	133	25	302
1944	160	300	29	489
1945	216	328	24	568
1946	216	396	16	618
1947	221	550	—	759
1948	286	567	—	831
1949	265	609	—	844
1950	342	657	—	963
1951	483	532	—	1015
1952	518	720	—	1238
1953	427	526	—	959
1954	511	506	—	993
1955	704	689	—	1393
1956	847	826	—	1633
1957	910	784	—	1694
1958	1114	1037	—	2134
1959	994	1061	—	1925
1960	1035	815	—	1850
1961	1264	964	—	2228
1962	932	990	—	1380
1963	985	924	—	1909

Source: Vegetables-Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 14. Peppermint Production by States 1935-1963
(In Thousands Pounds)

Year	Indiana	Michigan	Wisconsin	Ohio	Total Mid West
1935	344	806	---	18	1169
1936	210	627	---	13	850
1937	172	587	---	20	779
1938	158	669	---	8	843
1939	213	510	---	8	731
1940	291	490	---	3	784
1941	386	334	---	4	722
1942	595	522	---	6	1123
1943	286	234	---	4	524
1944	394	308	---	4	706
1945	504	330	---	8	842
1946	450	266	---	---	716
1947	574	270	---	---	844
1948	518	220	4	---	739
1949	513	200	20	---	751
1950	377	220	40	---	637
1951	362	200	61	---	623
1952	273	207	70	---	550
1953	243	155	74	---	487
1954	242	122	80	---	449
1955	288	129	128	---	545
1956	462	132	101	---	695
1957	381	128	160	---	669
1958	195	84	155	---	434
1959	167	65	185	---	423
1960	161	50	172	---	383
1961	202	51	189	---	442
1962	192	51	185	---	419
1963	162	50	156	---	368

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 15. Domestic Supply of Peppermint Oil 1929-1963

Year	U.S. Production 1,000 lbs.	U.S. Exports Less Imports 1,000 lbs.	U.S. Exports	Domestic Supply	U.S. Exports as a % of Production
1929	968	221	221	747	22.8
1930	992	232	233	760	23.5
1931	628	228	230	400	36.6
1932	440	254	252	186	57.5
1933	642	235	235	407	36.6
1934	920	238	238	682	25.9
1935	1,368	337	338	1,031	24.7
1936	1,067	384	386	683	36.2
1937	1,012	348	349	664	34.5
1938	1,064	366	372	698	35.0
1939	905	344	396	561	43.3
1940	974	249	315	725	32.4
1941	940	164	287	776	30.5
1942	1,435	184	191	1,251	13.3
1943	826	200	225	626	27.2
1944	1,195	244	280	951	23.4
1945	1,410	284	316	1,126	22.4
1946	1,344	326	370	1,018	27.5
1947	1,615	435	447	1,180	27.7
1948	1,505	220	228	1,366	14.4
1949	1,612	594	600	1,018	37.2
1950	1,636	504	504	1,132	30.8
1951	1,639	388	390	1,250	24.4
1952	1,788	282	282	1,506	15.8
1953	1,425	492	492	933	34.5
1954	1,461	674	674	787	46.1
1955	1,933	570	570	1,363	29.4
1956	2,368	757	757	1,611	32.0
1957	2,363	827	833	1,536	35.5
1958	2,575	789	799	1,736	31.0
1959	2,472	951	952	1,521	38.5
1960	2,233	1,004	1,004	1,229	45.0
1961	2,670	1,001	1,002	1,669	37.5
1962	2,340	1,185	1,186	1,155	50.7
1963	2,277				

Source: Crop Reporting Board, Statistical Reporting Service, U.S.D.A. and U.S. Department of Commerce, personal correspondence.

Table 16. Peppermint for Oil, Commercial Crop United States 1929-1963

Year	Acres for harvest	Yield per acre lbs.	Production 1,000 lbs.	Price per lb. dollars	Farm Value $1,000.
1929	55,530	17	968	3.17	3,[illegible]4
1930	56,220	18	992	1.90	1,[illegible]
1931	44,320	14	628	1.20	756
1932	31,540	14	440	1.42	6[illegible]
1933	33,220	19	642	1.73	1,102
1934	33,390	28	920	2.40	2,21[illegible]
1935	43,700	31	1,368	1.70	2,33[illegible]
1936	41,330	26	1,067	1.96	2,[illegible]1
1937	37,280	27	1,012	2.00	2,025
1938	34,840	31	1,064	2.01	2,141
1939	31,350	29	905	2.00	1,812
1940	31,800	31	974	2.22	2,15[illegible]
1941	31,890	29	940	3.44	3,2[illegible]
1942	42,100	34	1,435	4.85	6,9[illegible]
1943	37,010	22	826	5.93	4,9[illegible]
1944	41,530	29	1,195	6.85	8,1[illegible]
1945	40,200	30	1,410	5.87	8,274
1946	46,000	29	1,344	6.36	8,54[illegible]
1947	47,700	34	1,615	6.94	11,209
1948	42,700	37	1,595	6.20	9,[illegible]5
1949	45,500	35	1,612	4.72	7,61[illegible]
1950	46,100	35	1,636	5.31	8,6[illegible]4
1951	44,200	37	1,638	6.52	10,683
1952	42,600	42	1,788	5.75	10,274
1953	37,500	38	1,425	4.37	6,22[illegible]
1954	35,500	41	1,461	5.32	7,770
1955	43,600	44	1,938	5.83	11,30[illegible]
1956	46,300	51	2,368	5.23	12,379
1957	48,700	49	2,363	4.19	9,875
1958	42,700	60	2,575	4.02	10,3[illegible]
1959	41,300	60	2,472	3.49	8,62[illegible]
1960	39,000	57	2,233	4.53	10,2[illegible]
1961	43,300	62	2,670	4.50	12,024
1962	41,000	57	2,340	5.04	11,[illegible]0
1963	41,800	54	2,277	4.76	10,834

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, Washington, D.C.

Table 17. Spearmint Acreage by States 1935-1963.

Year	Washington	California	Total Far West
1935	---	340	340
1936	---	230	230
1937	---	230	230
[illegible]	---	290	290
1939	---	240	240
[illegible]	---	240	240
1941	---	150	150
1942	---	160	160
1943	---	30	30
1944	---	---	---
1945	---	---	---
1946	---	---	---
1947	---	---	---
1948	---	---	---
1949	---	---	---
1950	---	---	---
1951	---	---	---
1952	450	---	450
1953	1,450	---	1,450
1954	2,100	---	2,100
1955	2,500	---	2,500
1956	3,000	---	3,000
1957	2,800	---	2,800
1958	3,200	---	3,200
1959	5,300	---	5,300
1960	9,300	---	9,500
1961	12,000	---	12,000
1962	10,000	---	10,000
1963	6,000	---	6,000

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 18. Spearmint Acreage by States 1935-1963.

Year	Indiana	Michigan	Total Mid West
1935	2,500	700	3,200
1936	2,000	1,200	3,200
1937	2,400	1,600	4,000
1938	1,600	1,800	3,400
1939	1,800	2,100	3,900
1940	2,300	2,200	4,500
1941	4,600	2,400	7,000
1942	5,500	2,600	8,100
1943	5,800	2,400	8,200
1944	5,400	2,000	7,400
1945	6,800	2,200	9,000
1946	7,500	2,500	10,000
1947	9,800	4,500	14,300
1948	15,200	7,000	22,200
1949	12,400	6,500	18,900
1950	9,100	5,200	14,300
1951	6,800	4,700	11,500
1952	8,400	5,900	14,300
1953	10,400	7,800	18,200
1954	10,700	8,700	19,400
1955	6,400	5,400	11,800
1956	6,700	5,000	11,700
1957	5,600	4,500	10,100
1958	4,000	4,000	8,000
1959	4,800	4,600	9,400
1960	6,900	4,800	11,700
1961	8,300	4,700	13,000
1962	6,600	4,500	11,100
1963	3,800	2,400	6,200

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 19. Spearmint Production by States 1935-1953
(Thousands of Pounds)

Year	Washington	California	Total Far West
1935	---	12	12
1936	---	10	10
1937	---	10	10
1938	---	13	13
1939	---	10	10
1940	---	12	12
1941	---	4	4
1942	---	5	5
1943	---	2	2
1944	---	---	---
1945	---	---	---
1946	---	---	---
1947	---	---	---
1948	---	---	---
1949	---	---	---
1950	---	---	---
1951	---	---	---
1952	32	---	32
1953	141	---	141
1954	210	---	210
1955	225	---	225
1956	270	---	270
1957	272	---	272
1958	307	---	307
1959	504	---	504
1960	741	---	741
1961	1,176	---	1,176
1962	770	---	770
1963	510	---	510

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 20. Spearmint Production by States 1935-1963
(Thousands of Pounds)

Year	Indiana	Michigan	Total Mid West
1935	58	33	91
1936	20	46	66
1937	55	42	97
1938	30	47	77
1939	43	61	104
1940	69	62	131
1941	175	72	247
1942	248	104	352
1943	174	79	253
1944	151	70	221
1945	218	77	295
1946	225	82	307
1947	323	158	481
1948	532	280	812
1949	372	195	567
1950	282	177	459
1951	231	141	372
1952	294	165	459
1953	416	242	658
1954	407	252	659
1955	211	157	368
1956	255	140	395
1957	168	122	290
1958	108	96	204
1959	173	147	320
1960	235	134	369
1961	299	113	412
1962	231	122	353
1963	122	70	192

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, U.S.D.A.

Table 21. Domestic Supply of Spearmint Oil 1935-1963.

Year	U.S. Production 1,000 lbs.	Imports 1,000 lbs. 1/ & 2/	Domestic Supply 1,000 lbs.	Imports as % of Production
1935	103	25	78	24.3
1936	76	31	45	40.8
1937	107	29	78	27.1
1938	90	30	60	33.3
1939	114	38	76	33.3
1940	143	33	110	23.1
1941	251	42	209	16.7
1942	357	23	334	6.4
1943	255	27	228	10.6
1944	221	37	184	16.7
1945	295	19	276	6.4
1946	307	56	251	18.2
1947	481	60	421	12.5
1948	812	78	734	9.6
1949	567	93	474	16.4
1950	459	98	361	21.4
1951	372	100	272	26.9
1952	491	145	346	29.5
1953	799	167	632	20.9
1954	869	101	678	22.0
1955	593	197	396	33.2
1956	665	220	445	33.1
1957	562	214	348	38.1
1958	511	274	237	53.6
1959	824	254	570	30.8
1960	1,110	407	703	36.7
1961	1,598	394	1,194	24.8
1962	1,123	446	680	39.7
1963	702			

1/ Imports, if any, in basket category.
2/ Other mint oils.

Source: Crop Reporting Service, Statistical Reporting Service, U.S.D.A. and U.S. Department of Commerce, personal correspondence.

Table 22. Spearmint for Oil, Commercial Crop 1935-1963
United States

Year	Acres for harvest	Yield per acre lbs.	Production 1,000 lbs.	Price per lb. dollars	Farm Value 1,000 $
1935	3,540	29	103	1.30	134
1936	3,430	22	76	1.61	122
1937	4,230	25	107	1.60	171
1938	3,680	24	90	1.52	134
1939	4,140	28	114	1.53	174
1940	4,740	30	143	1.77	253
1941	7,150	35	251	2.22	556
1942	8,260	42	357	2.83	1,029
1943	8,230	31	255	3.64	927
1944	7,400	30	221	3.50	773
1945	9,000	33	295	3.50	1,033
1946	10,000	31	307	5.61	1,722
1947	14,300	34	481	5.57	2,673
1948	22,200	37	812	4.31	3,496
1949	18,900	30	567	3.20	1,813
1950	14,300	32	459	3.68	1,688
1951	11,500	32	372	5.08	1,888
1952	14,750	33	491	6.88	3,376
1953	19,650	41	799	5.43	4,337
1954	21,500	40	869	3.85	3,349
1955	14,300	41	593	4.22	2,503
1956	14,700	45	665	4.06	2,702
1957	12,900	44	562	3.49	1,962
1958	11,200	46	511	3.93	2,009
1959	14,700	56	824	4.09	3,367
1960	21,200	52	1,110	4.03	4,473
1961	25,000	64	1,598	3.73	5,910
1962	21,100	53	1,123	2.83	3,183
1963	12,200	58	702	3.07	2,152

Sources Vegetables - Fresh Market, Crop Reporting Service, Statistical Reporting Service, U.S.D.A.

Table 23. United States Exports and Imports of Mint Oils 1929-1962

Calendar Year	Spearmint Oil				Peppermint and Other Mint Oil	
	Exports		Imports		Exports	
	1,000 Pounds	1,000 dollars	1,000 Pounds	1,000 dollars	1,000 Pounds	1,000 dollars
1929	221	795	.4	2	Not shown separately	
1930	233	700	.6	3	" "	"
1931	230	438	1.8	3	" "	"
1932	262	455	7.6	5	19.2	25
1933	235	567	.1	.5	25.9	30
1934	233	670	.05	.5	30.1	37
1935	338	865	.6	4	25.4	44
1936	386	874	1.9	5	30.9	56
1937	349	895	1.0	7	20.4	56
1938	372	870	5.5	12	30.3	57
1939	386	994	51.5	81	37.7	75
1940	316	837	67.1	110	32.9	72
1941	237	980	123.2	231	41.8	105
1942	191	944	6.7	10	22.5	67
1943	225	997	25.1	90	27.4	91
1944	280	2,018	36.2	158	37.2	114
1945	316	2,497	32.2	36	19.2	73
1946	370	2,739	43.5	41	56.4	201
1947	447	3,534	11.5	30	58.6	407
1948	229	1,735	.2	6	77.7	511
1949	600	3,721	6.1	30	93.1	470
1950	504	3,057	---	---	97.6	391
1951	399	2,900	10.7	35	99.6	589
1952	282	2,042	.1	1	145.0	1,000
1953	492	2,781	.1	2	167.0	1,100
1954	674	4,023	.05	1	190.5	997
1955	570	3,865	.1	2	197.0	1,003
1956	757	4,427	.05	1	219.5	1,149
1957	838	4,362	11.1	36	213.7	1,137
1958	799	3,643	10.3	31	274.0	1,342
1959	952	4,011	1.2	6	254.0	1,306
1960	1,004	4,640	.1	2	407.0	2,351
1961	1,002	4,834	.6	5	384.0	1,930
1962	1,186	5,703	1.0	4	446.0	1,914

1/ Imports, if any, in basket category.

Source: U.S. Department of Commerce, personal correspondence.

Table 24. United States Exports of Peppermint by Continent 1947-1962.

Continent	1947	1948	1949	1950	1951	1952	1953	1954	1955
North America	61,670	71,373	70,603	76,165	71,239	74,242	71,909	100,447	74,334
Central America	1,167	1,296	1,496	2,213	1,774	296	1,054	1,519	455
Caribbean	23,340	7,743	3,724	9,453	8,939	9,173	8,704	6,391	7,599
South America	43,681	30,854	40,194	26,395	47,403	14,333	29,373	42,910	23,136
Europe	350,506	95,193	437,704	343,404	229,225	145,293	340,173	478,100	404,723
Asia	8,906	5,643	15,033	19,640	6,510	4,883	2,696	4,144	13,272
Oceania	51,273	3,772	17,005	22,999	24,364	20,972	22,713	27,855	22,734
Africa	3,451	12,073	9,252	6,444	3,325	12,013	13,440	14,370	17,017
Countries under $1000	---	---	---	---	568	833	770	---	---
TOTAL	543,993	228,047	600,110	503,613	393,975	282,998	492,337	675,813	570,130

Table 24. United States Exports of Peppermint by Continent 1947-1962 (In Pounds).

Continent	1956	1957	1958	1959	1960	1961	1962
North America	96,303	88,617	113,368	93,434	114,651	102,834	135,640
Central America	1,261	1,111	2,160	970	2,437	1,764	3,841
Caribbean	9,033	10,884	7,306	11,049	9,633	905	2,815
South America	31,645	27,981	24,129	25,940	37,493	33,749	41,967
Europe	554,479	530,094	555,828	681,786	714,469	674,310	913,153
Asia	15,318	79,410	42,070	54,224	57,484	117,855	111,655
Oceania	27,155	29,194	34,388	44,044	43,851	49,363	60,118
Africa	21,611	20,701	18,925	21,882	23,742	20,724	16,362
Countries under $1000	—	—	—	—	—	—	—
TOTAL	756,360	837,992	798,674	932,359	1,003,765	1,001,504	1,185,551

Source: FT-410, United States Exports of Domestic and Foreign Merchandise, Annual 1947-62.

Table 25. United States Exports of Spearmint by Continent 1947-1955 (and other mint oils in pounds).

Continent	1947	1948	1949	1950	1951	1952	1953	1954	1955
North America	24,214	20,939	34,531	35,933	30,745	33,555	33,759	43,579	33,557
Central America	50	47	130	109	---	---	---	50	---
Caribbean	45	50	---	747	---	553	[illegible]	600	330
South America	75	150	[illegible]	1,357	654	[illegible]94	[illegible]	2,019	2,810
Europe	[illegible],719	30,115	37,540	26,203	44,800	77,[illegible]77	[illegible]	135,410	122,340
Asia	[illegible],410	5,770	2,335	13,[illegible]33	2,754	2,275	1,[illegible]00	4,293	7,065
Jamaica	---	---	---	---	---	---	[illegible],[illegible]00	---	---
Africa	---	724	732	642	1,031	3,735	[illegible],[illegible]00	3,081	2,150
Oceania	[illegible]3,[illegible]72	[illegible]3,[illegible]00	17,672	21,512	[illegible]3,[illegible]40	[illegible]3,375	[illegible],[illegible]37	[illegible]3,640	34,176
Countries under $100	---	---	---	---	[illegible]37	[illegible]07	[illegible]24	---	---
TOTAL	[illegible]7,[illegible]36	77,700	93,997	97,393	[illegible]0,[illegible]20	145,[illegible]18	[illegible]47,[illegible]00	[illegible]93,[illegible]03	137,037

Table 25. United States Exports of Spearmint by Continent 1947-1962 (and other mint oils (Cont'd) in pounds).

Continent	1956	1957	1958	1959	1960	1961	1962
North America	37,253	36,997	48,444	39,620	41,488	40,469	57,587
Central America	---	500	---	550	140	926	1,764
Caribbean	220	---	830	66	457	50	100
South America	6,448	12,617	18,419	12,076	20,170	21,355	35,521
Europe	127,280	110,334	131,315	128,185	256,452	197,788	234,691
Asia	15,228	13,358	47,693	41,110	57,665	93,116	67,082
Oceania	29,926	37,757	24,183	31,467	27,079	36,523	33,464
Sample	---	---	---	---	---	---	---
Africa	3,046	2,096	3,280	1,250	3,915	3,973	10,960
Countries under $1000	---	---	---	---	---	---	---
TOTAL	219,521	213,659	274,164	254,324	407,366	394,205	445,069

Source: FT-410, United States Exports of Domestic and Foreign Merchandise, Annual 1947-1962.

Table 26. Population Characteristics of the United States as of July 1 (in numbers), 1947-1962.

Year	Ages 15-19	Ages 20 - 24	Ages 25 - 29	Ages 30 - 34	Totals
1947	10,772	11,358	11,759	11,053	44,942
1948	10,717	11,315	11,865	11,158	45,055
1949	10,454	11,156	11,962	11,281	44,853
1950*	10,617	11,482	12,242	11,517	45,858
1951	10,483	11,962	12,122	11,686	46,253
1952	10,501	10,508	12,007	11,898	44,914
1953	10,679	10,240	11,842	12,084	44,845
1954	10,906	10,033	11,704	12,271	44,914
1955	11,020	10,167	11,575	12,349	45,111
1956	11,255	10,141	11,494	12,351	45,291
1957	11,653	10,157	11,289	12,267	45,377
1958	12,355	10,336	11,077	12,129	45,897
1959	12,824	10,509	10,870	11,981	46,274
1960*	13,147	10,727	10,804	11,981	46,659
1961	13,724	11,144	10,750	11,714	47,333
1962	14,825	11,593	10,732	11,509	48,659

* Figures stated as of April 1.

Source: Current Population Reports, Population Estimates, Series P-25, No. 265, U.S. Department of Commerce, Bureau of Census.

Table 27. United States Imports of Peppermint Oil by Country 1943-1962. (Quantity in pounds)

Country	1962	1961	1960	1959	1958	1957	1956	1955	1954	1953	1952	1951
United Kingdom	85	85	90	240	145	55	55	110	55	115	64	13
West Germany		2										
Hungary		441										
Italy	66	66	44	128	205							
Japan		100									2	
Austria	750											
Argentina				794	9,920	11,023						
Canada										3		
TOTAL	901	694	134	1,162	10,270	11,078	55	110	55	118	66	13

Country	1950	1949	1948
United Kingdom	14	33	143
France	2		
Belgian Congo	273		
Canada		952	
China		50	7
Netherlands		166	
TOTAL	289	1,201	150

Source: Foreign Trade Report No. 110, United States Imports by Commodity and Country of Origin.

Table 28. Gross Returns Per Acre for Mint Oil by State, 1947-1963.

Year	Peppermint Oil (in dollars)					Spearmint Oil (in dollars)		
	Ind.	Mich.	Misc.	Wash.	Ore.	Ind.	Mich.	Wash.
1947	217	137	—	317	350	185	193	—
1948	215	133	200	322	288	145	134	—
1949	162	101	180	220	197	90	90	—
1950	136	124	169	303	241	112	123	—
1951	224	139	237	405	247	170	156	—
1952	207	160	238	297	283	242	196	420
1953	176	121	222	195	162	216	193	456
1954	192	114	192	325	233	156	101	380
1955	207	127	272	314	319	148	125	351
1956	229	132	224	312	333	166	116	337
1957	173	115	201	240	230	119	107	291
1958	130	103	195	292	309	116	102	355
1959	193	140	240	191	231	180	155	333
1960	207	140	232	285	285	177	137	273
1961	234	172	273	241	347	180	115	323
1962	235	193	267	282	324	140	108	177
1963	223	175	242	255	286	124	117	234

Source: Vegetables - Fresh Market, Crop Reporting Board, Statistical Reporting Service, United States Department of Agriculture.

BIBLIOGRAPHY

Ballinger, L. E. "The Analysis of Peppermint Oil," Reprint from Analytical Edition Industrial and Engineering Chemistry, Vol. 14, Page 13, January 15, 1942.

Barbour, L. A. Chemical and Rubber Division, U. S. Department of Commerce.

Brown, Robert C. The Agricultural Geography of Peppermint in the Pacific Northwest, unpublished Master's thesis, Oregon State University, 1952.

Davis, J. F., Lucas, E. E., and Shepherd, L. C. "Mint Grown on Organic Soils", Reprint from Better Crops with Plant Food Magazine, 1957.

Davis, J. F. Progress Report for Peppermint Research for Years 1949-1952, Muck Experimental Farm, Michigan State University.

Ellis, N. K. and Wilcox, E. M. "A Machine for Collecting Fallen Peppermint Leaves," Reprint from Agricultural Engineering, Vol. 24, No. 7, Pages 237-239, July 1943.

Ellis, N. K., Fawcett, H. L., Gaylord, F. C., and Ballinger, L. E. A Study of Some Factors Affecting the Yield and Market Value of Peppermint Oil, Purdue University Agricultural Experiment Station Bulletin No. 451, June 1941.

Ellis, N. K. Mint Culture in Northern Indiana, Purdue University Agricultural Experiment Station Circular No. 227, February 1937.

Ellis, N. K. "Peppermint and Spearmint Production", Reprinted from Economic Geography, Vol. 14, No. 4: 330-335, October-December, 1938.

Ellis, N. K. Proceedings of the National Mint Research Conference, Purdue University, 1947-1948.

Foote, Richard J. Analytical Tools for Studying Country and Irrigation Structures, Agriculture Handbook No. 157, U.S. Dept. Agriculture, Soil Conservation Service, August 1958.

Friedman, Joan and Foote, Richard J. Computational Methods for Handling Systems of Simultaneous Equations, Agricultural Handbook No. 94, (ARS) USDA, Revised May 1957.

Green, Ralph J. "A Review of Research on Mint Wilt at Purdue University From 1948-1953," undated.

Green, Ralph J. "Deep Plowing as a Control for Mint Wilt", Purdue University, Undated.

Green, Ralph J. Mint Farming, Agriculture Information Bulletin No. 212, Washington, D.C., February 1963.

Green, Ralph J. Talk at Michigan State University 1963, "Summary of Mint Diseases - 1963".

Guenther, Ernest. "The Peppermint Oil Industry in Oregon and Washington States", Perfumery and Essential Oil Record, October 1961, pages 632-642.

Guenther, Ernest. "The Spearmint Oil Industry in Washington State", Perfumery and Essential Oil Record, November 1961, pages 695 and 696.

Horner, C.E. Control Peppermint Diseases, Oregon Agricultural Experiment Station Bulletin 547, February 1955, Oregon State University, Corvallis, Oregon.

Hughes, A.D. Improvements in the Field Distillation of Peppermint Oil, Oregon Agricultural Experiment Station Bulletin 525, August 1952, Oregon State University, Corvallis, Oregon.

Hutons, R., Jones, E.L., and Benne, E.J. "Use of DDT in the Control of the Mint Flea Beetle", Reprint from Michigan Experiment Station Quarterly Bulletin, Vol. 29, No. 4, pages 233-234, May 1947.

Kohl, W.H., Hall, C.W., Shepard, L.E., Jerrim, D.M. "An Investigation of some Factors Affecting the Distillation of Peppermint Oil", Reprinted from the Quarterly Bulletin of the Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, Vol. 32, No. 4, pages 570-579, May 1950.

Kraemer, Henry. "Michigan - An Important Source of Raw Vegetable Products", Michigan Academy of Science Report, 21:167-199, 1919.

Landing, J.E. Analysis of the Decline of the Commercial Mint Industry in Indiana since World War II, unpublished Master's thesis, Geography Department, Pennsylvania State University.

Landing, J.E. Paper for Geography 601, available upon request at Western Reserve Library, Cleveland, Ohio.

Laughlin, Winston M. "A Study of the Physical and Chemical Properties of Michigan Peppermint Oil", Reprint from Quarterly Bulletin of the Michigan Experiment Station, Michigan State University, East Lansing, Michigan, Vol. 42, No. 4, pages 787-793, May 1960.

Liebel, Lester. Peppermint Oil - An Economic Study, Pullman 1950, Washington Institute of Agricultural Science, Popular Bulletin 199.

Lucas, R.E. "Fertilizer Recommendations on Organic Soils", Reprinted from Better Crops with Plant Food Magazine, Magazine of the American Potash Institute, January 10, 1962.

Lucas, R.E. Talk on Mint Oil Production, Michigan State University, 1953.

Manderscheid, L.V. Class notes, Agricultural Economics 821, Michigan State University, Spring 1964.

Marshall, Alfred. Principles of Economics, Eighth Edition, The MacMillan Company, New York, 1948.

Nelson, Ray. Verticillum Wilt of Peppermint, East Lansing, 1950. Michigan Agricultural Experiment Station Bulletin 221.

Orr, Elizabeth and Pope, R. "The Market for Peppermint, Arvensis, and Spearmint Oils and Menthol", Tropical Science, 1962, p. 39-47.

Solinter, William, Mint Distillation, Summary of a talk given February 1953, Michigan State University.

St. John, J.L. and Watson, V.K. "Peppermint Oil - Relation of Maturity and Curing of Peppermint Hay to Yield and Composition of Oil", Reprint from Agricultural and Food Chemistry, Vol. 3, No. 12, page 1033, December 1955.

Todd, Winship A. The Mint Industry in the United States, paper presented in Japan in 1962, available upon request.

Tornow, Paul. "Production of Quality Peppermint Oil", paper presented to members of Oregon Essential Oil Growers League in 1963.

Walker, A.L. Peppermint Oil Production in South Central Washington, 1953. Washington Agricultural Experiment Station Circular 253, May 1954, 15 pages.

Current Population Reports, Population Estimates, Series P-25, No. 265, U.S. Department of Commerce, Bureau of Census.

"Facts About Chewing Gum and the Wm. Wrigley Jr. Company", available upon request.

Federal Extension Service, Cost Data for Peppermint Production in Columbia Basin, Washington and Jefferson County, Oregon.

Federal Register, Wednesday, Jan. 5, 1944, War Food Order No. 81 as amended.

I.P. Callisons and Son, Inc., Essential Oil, Botanical Drugs, Information pamphlet available at their office in Lloyd Building, Seattle 1, Washington.

Oregon Essential Oil Growers League Proceedings, 2nd - 11th, Annual Meetings, 1951-1960, Corvallis, Oregon.

Perfumery and Essential Oil Record, 1919-1963, Diana House, 33-34 Chiswell Street, London, England.

United States Exports of Domestic and Foreign Merchandise, FT-410, annual 1947-1962.

United States Imports by Commodity and Country of Origin, FT-110, annual 1947-1962.