THE SPATIAL DISTRIBUTION OF FRUIT VARIETIES IN THE FONTHILL AREA

A THESIS

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IAIN E. HAY

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INTRODUCTION

As the title indicates, the distribution of fruit in the Fonthill area will be examined and an explanation attempted in terms of the physical environment, economic condition and other criteria affecting the farmers' land-use decision.

The study area is located in central Pelham Township, above the Niagara Escarpment, about 6.5 miles south-west of St. Catharines and 4 miles north-west of Welland. (Fig. 1)

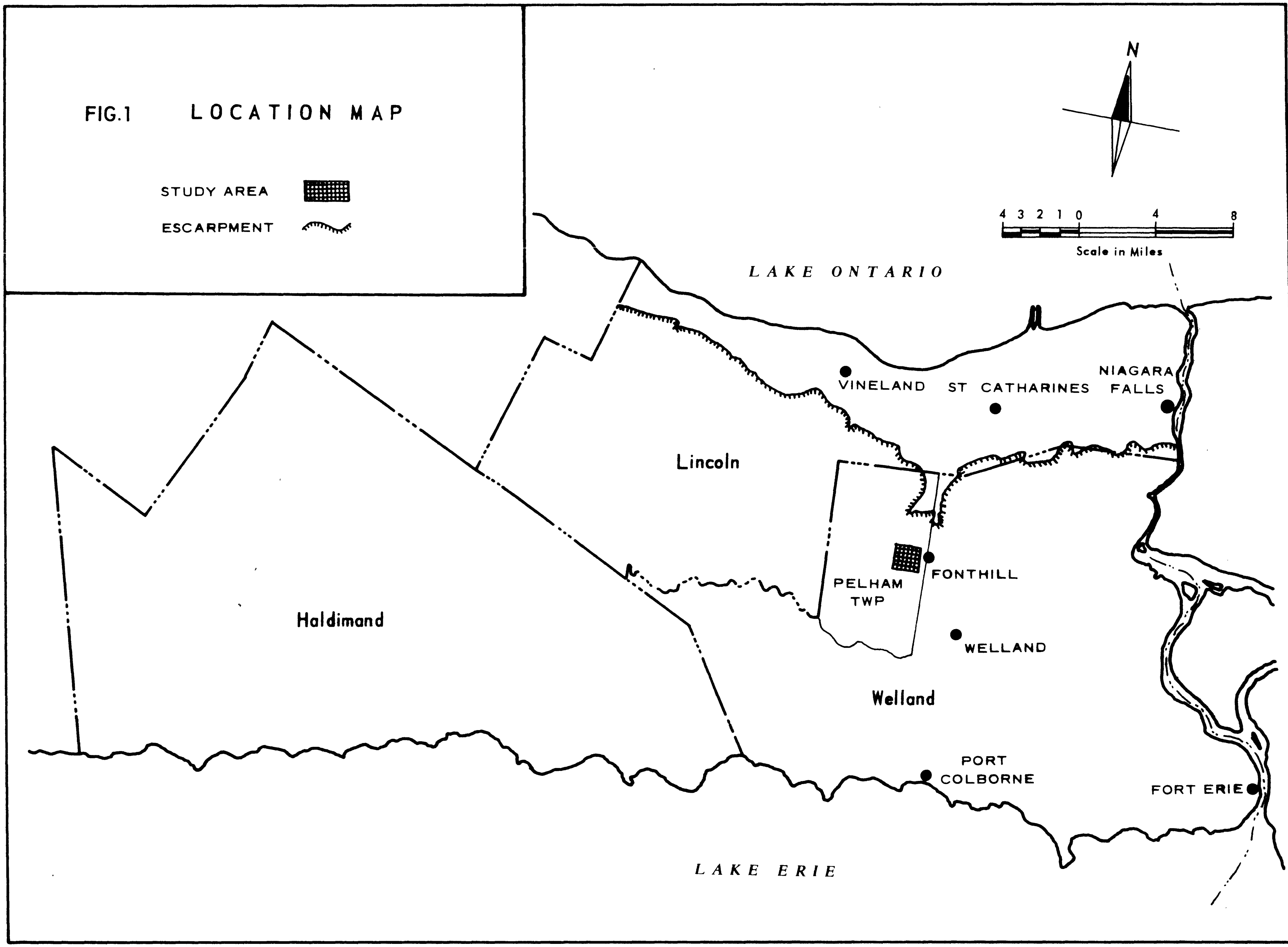
The study block is rectangular in shape, having an area of 4,400 acres or approximately seven square miles.

Most of the fruit grown in Pelham Township is found within the boundaries of the study area.

Chapter I deals with the research methods and procedures used to collect the necessary data. Chapter II consists of a discussion of the physical setting with emphasis on the comparative physical advantage the study area possesses for the production of fruit crops. The range of fruit crops grown and their respective acreages are discussed in Chapter III. In Chapter IV, the hypothesis, that soil texture and slope variations explain, in part, the spatial distribution of fruit, is tested. Within the general pattern of fruit distribution the distribution of the various individual fruit varieties are related to physical conditions of tree growth. A summary of the conclusions is presented in Chapter V.

Fieldwork for this thesis was carried out in August and September of 1966.

FIG.1 LOCATION MAP



CHAPTER I

RESEARCH METHODS AND PROCEDURES

The boundaries of the study area were selected on the basis that they enclose an area of almost continuous fruit production. Within the boundaries fruit growing is of prime importance to the farmer while without fruit growing is somewhat scattered and appears to be, in general, of secondary importance.

SOIL TEXTURE IDENTIFICATION

Soil texture was identified by mechanical analysis and by finger test. Soil samples were taken when noticeable differences in texture occurred; seventeen samples were taken in all. From laboratory analysis it was possible to construct a standard whereby other soil textures could be identified. The hydrometer method of mechanical analysis was used; the results of this analysis are given in table 1.

It is readily noticeable that all the samples have a high sand content. These readings were not corrected for "loss or ignition" and it is felt that this factor may have some bearing on the recorded high sand content. It was suggested by Dr. L. G. Reeds that these readings inferred a textural category one class too light. Correction of the readings involved the interpretation of the findings as being one textural class heavier than was actually measured.

Four textural types were identified: sand, loamy sand, sandy loam and loam.

TABLE 1

RESULTS OF MECHANICAL ANALYSIS

Sample	Percent Clay	Percent Salt	Percent Sand	Corrected Texture
1	16.5	12.5	71.0	Loam
2	11.0	13.0	76.0	Loam
3	6.0	4.0	90.0	Loamy Sand
4	9.0	9.0	82.0	Sandy Loam
5	11.0	9.0	80.0	Sandy Loam
6	6.0	4.0	90.0	Loamy Sand
7	5.0	5.0	90.0	Loamy Sand
8	6.0	10.0	84.0	Loamy Sand
9	6.0	6.0	88.0	Loamy Sand
10	10.0	6.0	84.0	Loamy Sand
11	6.0	2.0	92.0	Loamy Sand
12	3.0	13.0	84.0	Sandy Loam
13	8.0	11.0	81.0	Sandy Loam
14	7.0	4.0	89.0	Sandy Loam
15	6.0	4.0	90.0	Loamy Sand
16	15.0	7.0	78.0	Loam
17	14.0	7.0	79.0	Loam

SLOPE MEASUREMENT

The maximum slope of each field was measured by use of an Abney level (accurate to 0.5 degrees). To prevent a very small area of steep slope having undue influence, the measured slope had to be at least 100 feet in length.

FIELD MAPPING

Fieldwork consisted of a field by field examination of the study area; land-use, texture and maximum slope readings were recorded for each field. Air photos from a 1956 series at the scale of 1:1,350 were used in mapping field boundaries. Although land-use had changed considerably from the time these photos were taken, field boundaries showed very little change. From personal interviews it was possible to identify field boundary changes; at the same time, information regarding field and farm size was obtained.

Using fields as mapping units did entail certain problems. Some of the fields were too small to be accurately represented. In some cases it was doubtful whether or not an area should be classed as agricultural land since buildings and grounds took up a high percentage of the holding. Areas of this nature were not considered for the purpose of this paper. This accounts for the "special" area category in the land-use map. (See photos 1 and 2)

Also, the fields varied greatly in size affecting the accuracy of representing them with a single maximum shape reading and texture class. Much of this inherent inacurracy was overcome by classifying the slope readings (Table 2). If a field showed distinctive changes in soil texture it was subdivided and each section was examined separately.

TABLE 2

SLOPE CLASSIFICATION

Flat	0	-	1/2	Degrees
Gently Sloping	1/2	-	2-1/2	"
Moderately Sloping	2-1/2	-	6	"
Strongly Sloping	6	-	13	"
Moderately Steep	13	-	19	"
Steep	19	and above		"

THE LAND-USE, TEXTURE AND SLOPE MAPS

Using the Fonthill topographic map (30M/3C) at a scale of 1:25,000 a base map was constructed at a scale of 1:1,250. Details from the air photos were transferred to the base map using a sketch master.

A land-use map (figure 2), texture map (figure 3) and slope map (figure 4) were constructed using the above information. These maps are in the back-cover pocket.

Since the purpose of the thesis is to examine the distributions of the various fruit types, each fruit variety grown is represented on the land-use map. Other agricultural uses are represented in broad catagories. For example, no attempt was made to differentiate between types of pasture; hay and pasture are grouped together. Vegetables are separated from field crops. Vegetable are defined as those crops, other than fruit, which are grown for human consumption; field crops are defined as those crops which are produced for animal consumption.

Photo. 1. Example of the "Special area" category looking north from the corner of Camboro and Haist Roads.

Photo. 2. Example of the "Special area" category looking north-west from Centre Street. Note the large percentage of non-agricultural land.

No attempt was made to classify different urban uses.

CHAPTER II

THE PHYSICAL FRAMEWORK

The Niagara Fruit Belt, that narrow strip of land between the Niagara Escarpment and Lake Ontario running from Queenston to Hamilton, is acknowledged as the most favourable area in the province for the production of tender[1] and other fruit varieties. It is therefore advantageous to compare the study area with the Niagara Fruit Belt in terms of the prime physical prerequisite for the fruit growing industry.

CLIMATE

The amount of precipitation does not determine difference in distribution of fruit, either above or below the escarpment. Table 3 gives the monthly precipitation figures for St. Catharines below the Escarpment and for Welland[2] above the Escarpment.

Tables 4 and 5 indicate that the growing season is almost two weeks shorter at Fonthill than at St. Catharines. It should be noted that this reduction is in the fall ripening period rather than in the spring budding period. This has an important bearing in determining the type of fruit crop that can be grown.

The comparison of winter and spring temperatures normally expected above and below the Escarpment is of significance. It may be that winter and spring temperatures more than any other climatic parameters,

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1 Because of their delicate nature and exacting conditions for growth some fruit varieties are termed tender fruits. In the Niagara and Fonthill areas only peaches and sweet cherries may be termed tender fruits.

2 Welland is the nearest year-round weather station to Fonthill. Climatic data was not recorded at Fonthill until April 12th, 1962.

Photo. 3. Weather Station at Fonthill on the corner of Haist and Camboro Roads, opened April 12th, 1962.

Photo. 4. Orchard - hay boundary marks the division between Berrien Sandy Loam and Pelham Sandy Loam.

TABLE 3[3]

AVERAGE MONTHLY AND ANNUAL PRECIPITATION

STATION	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY
St. Catharines	2.3	1.8	2.1	2.4	2.1	2.5	2.4
Welland (Fonthill)	3.1	2.9	2.7	2.8	2.8	2.7	3.2

STATION	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
St. Catharines	2.5	2.6	2.2	2.1	2.0	27.0
Welland (Fonthill)	2.4	2.8	2.9	2.6	2.9	33.9

define possible fruit growing areas. Winter temperatures, if harsh enough, can kill or severely damage fruit trees. Spring temperatures if adverse, place limitations on the yield and quality of fruit that can be expected. Investment in orchards is high and it is reasonable to expect that fruit farming will be carried on only where the probability of unfavourable winter and spring temperatures are low.

R. G. Mercier and L. J. Chapman[4], in 1955, compared the peach climates of fruit growing areas in Ontario with that of the Niagara Fruit Belt in terms of certain critical winter and spring temperatures. It was postulated that a temperature of -20°F. was the critical temperature for dormant wood damage, -12°F. for dormant blossom bud damage and 26°F. after 60 to 100

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3 Source: R. E. Wickland and B. C. Matthews, Soil Survey of Lincoln County. (Research Branch, Canada, Department of Agriculture and the Ontario Agricultural College, Toronto, 1963. P. 14.)

4 R. G. Mercier and L. J. Chapman, "Peach Climate in Ontario" 1955-1956 Report of the Horticultural Experimental Station and Products Laboratory Vineland, (Ontario Department of Agriculture, Toronto, 1956).

TABLE 4[5]

FROST

STATION	SPRING FROST		
	EARLIEST LAST SPRING FROST	PROBABILITY 1 in 10 AFTER	LATEST LAST SPRING FROST
St. Catharines	April 14	May 21	May 27
Fonthill	April 12	May 22	May 29

STATION	FALL FROST		
	EARLIEST FIRST FALL FROST	PROBABILITY 1 in 10 AFTER	LATEST FIRST FALL FROST
St. Catharines	Sept. 22	Oct. 5	Nov. 11
Fonthill	Sept. 10	Sept. 29	Nov. 6

TABLE 5[6]

LENGTH OF FROST FREE PERIOD

STATION	SHORTEST FROST FREE PERIOD	90% PROBABILITY	LONGEST FROST FREE PERIOD	AVERAGE FROST FREE PERIOD
	DAYS	DAYS	DAYS	DAYS
St. Catharines	135	191	196	169
Fonthill	111	176	198	157

5 Source ibid P. 14.

6 Source op-cit P. 14.

degree-days[7] have accumulated for tender bud damage. Using the official weather records for the 30-year period 1925-1954, the probabilities of experiencing these temperatures or lower were calculated for each of the fruit growing areas. The results of these calculations are given in figures 5 and 6 and in table 6.

TABLE 6

LOW-TEMPERATURE INJURY TO BLOSSOM BUDS OF THE PEACH

WEATHER STATION	WINTERS IN * in 30 YEARS	SPRING IN ** in 30 YEARS	YEARS *** in 30 YEARS	RELATIVE RETURNS
Vineland	3	0.0	3.0	100
Harrow	4	1.2	5.0	93
Fonthill	6	0.0	6.0	89
Godrich	6	4.8	9.8	75
Forest	9	4.0	11.8	68
London	12	0.0	12.0	67
Port Dover	11	1.7	12.1	67
Simcoe	14	2.4	13.3	62

* Critical temperatures of -12°F.
** Critical temperatures of 26°F.
*** When estimating odds on a yearly basis the sum of winter and spring odds has to be corrected for the times both winter and spring injury occurs in the same year. This is done by subtracting from the sum a quantity equal to the product of the odds.

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7 A degree-day is defined in Merciers' Paper as any day experiencing a maximum temperature of 50°F. or over.

8 Mercier, op. cit. P. 15.

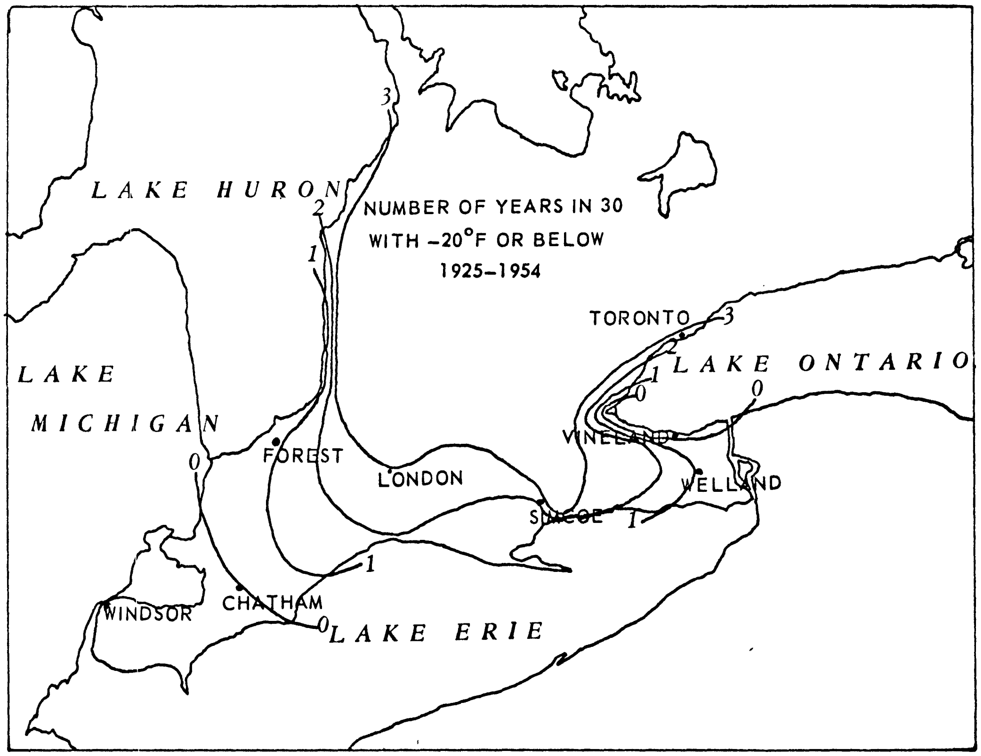

Fig.5 Variations in probable dormant wood damage in Southern Ontario. Isolines of odds of −20° F devide Southern Ontario into 5 general areas.

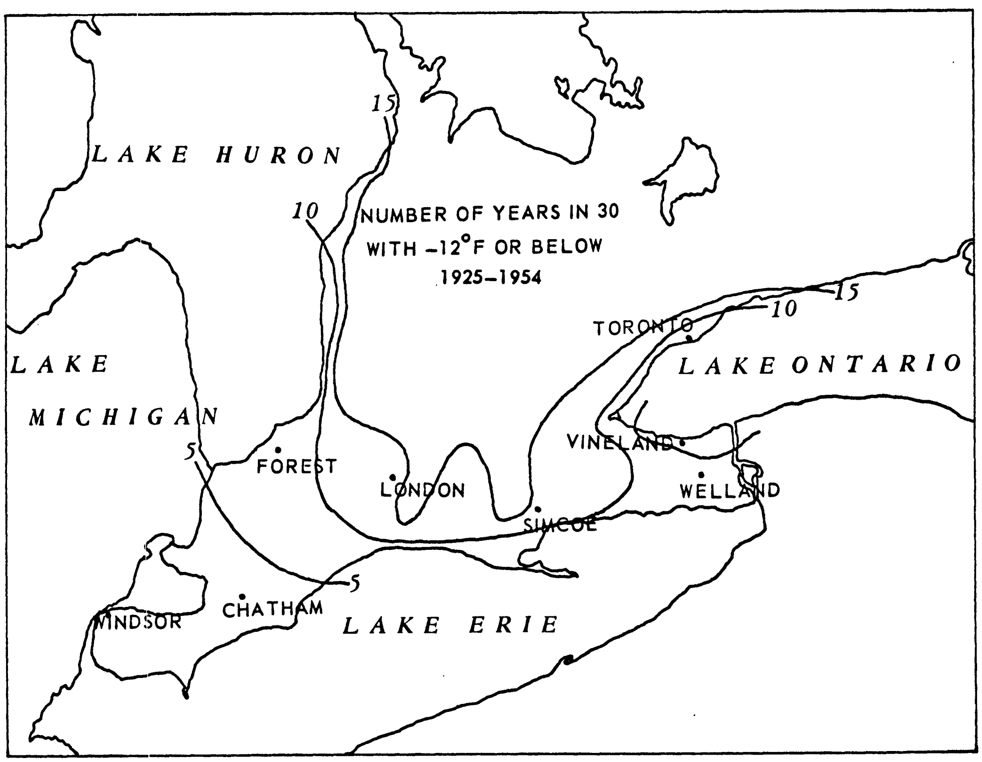

Fig.6 Variations in probable injury to dormant peach buds in Southern Ontario; isolines show the gradation from suitable to unsuitable climate.

Neither the critical temperatures suggested by Mercier nor the probability of frost damage can be accepted as such. No attempt was made to consider the wind chill factor, which is the resultant of wind velocity and surface moisture, the duration of "cold spells", or rapid changes in temperature all of which have bearing on frost damage. However, since the selection of the critical temperatures was based on the occurence of frost damage at certain stations we can accept the part that more frost damage occurs at Fonthill than at Vineland. The suggestion that there is a spring frost damage probability of zero in 30 years at Fonthill is complemented by the fall reduction rather than the spring reduction of the growing season. If this be true, then the growing of peaches is little inhibited climatically. Since the peach is the most frost-sensitive of the fruits grown in the Fonthill vicinity, the acceptance of the suitability of climate for the peach implies that the area is suitable for all other hardier varieties of fruit.

SOILS

While frost damage is the over-all limiting factor in the production of fruit crops, the soil factor further defines the limits of fruit production. Fruit crops are quite specific as to their soil requirements. The nutrient content of the soil can readily be changed, but most physical characteristics cannot be altered easily or economically.

All fruit varieties grown in Ontario, require a relatively deep sandy soil with a pervious well aerated subsoil; the water table should not be closer than four or five feet from the surface. If it is, root growth is restricted. This can result in insufficient moisture being transported from the soil to permit optimum fruit growth. Fruit quality and size may be affected to the extent that the crop cannot be marketed.

The soil types present in the study area belong to the Grey-Brown Podzolic Great Soil Group. All are dificient in organic matter, lime, phosphate, potash and to a lesser extent nitrogen.

All the soil types meet the drainage and well-areated permeable subsoil requirement. The depth of the glacio-fluvial deposits are in some cases over 300 feet[9]. Fonthill loam, Pelham loam, Pelham sandy loam are well drained, attested to by the absence of ditches along the concession roads and the lack of tile drainage. Berrien sandy loam[10] has a variable drainage ranging from good to poor depending upon site factors.

Mercier in his paper attempted to rank the soil types of Ontario with regard to their suitability for growing peaches (see table 7). Pelham sandy loam received a rating of very good, Berrien sand loam a rating of good, Fonthill loam a rating of fair[11], and Pelham loam a rating of marginal. However, some suspicion must fall on this ranking. It seems likely that suitable soils were defined as those soils already supporting peaches and that their relative rank was based upon the proportions of peaches growing on them. As was mentioned before, if conditions favour the growth of tender fruits then conditions must be suitable for the growth of more resistant varieties.

Figure 8[12] shows the distribution of tender fruit areas of the

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9 B. V. Sanford, Welland County Ontario - Two Prelimenary Maps Showing Drift Thickness and Bedrock Contours, (Geological Survey of Canada, Ottawa, 1956).

10 A glance at the soil map will indicate that Berrien sandy loam covers a very small part of the study area and as a result the variable drainage rating is of small importance.

11 Although Fonthill loam received a rating of only fair, it is precisely on this soil-type that most of the areas' peaches are grown.

12 The Niagara-Area Changing Land-Uses (Ontario Department of Municipal Affairs, Toronto, 1961, P.4).

TABLE 7[13]

SOIL RATING FOR PEACHES

1.	Very Good	Grimsby sandy Fox sandy loam Fox fine sandy loam Pelham sandy loam Harrow sandy loam Fonthill sandy loam
2.	Good	Vineland sandy loam Vineland fine sandy loam Vineland gravelly sandy loam Berrien sandy loam Berrien sand Beverley fine sandy loam Winona sandy loam
3.	Fair	Oshtemo sand Plainfield sand Burford gravelly loam Fox gravelly loam Fonthill loam
4.	Marginal	Ontario loam Virgil clay loam Virgil clay loam stony phase Parkhill loam Brookston clay loam (sand spot phase) Burford loam Beverley salt loam Miami loam Miami salt loam Brookston sandy loam Pelham loam Caistor loam

13 Mercier, op cit. P. 16.

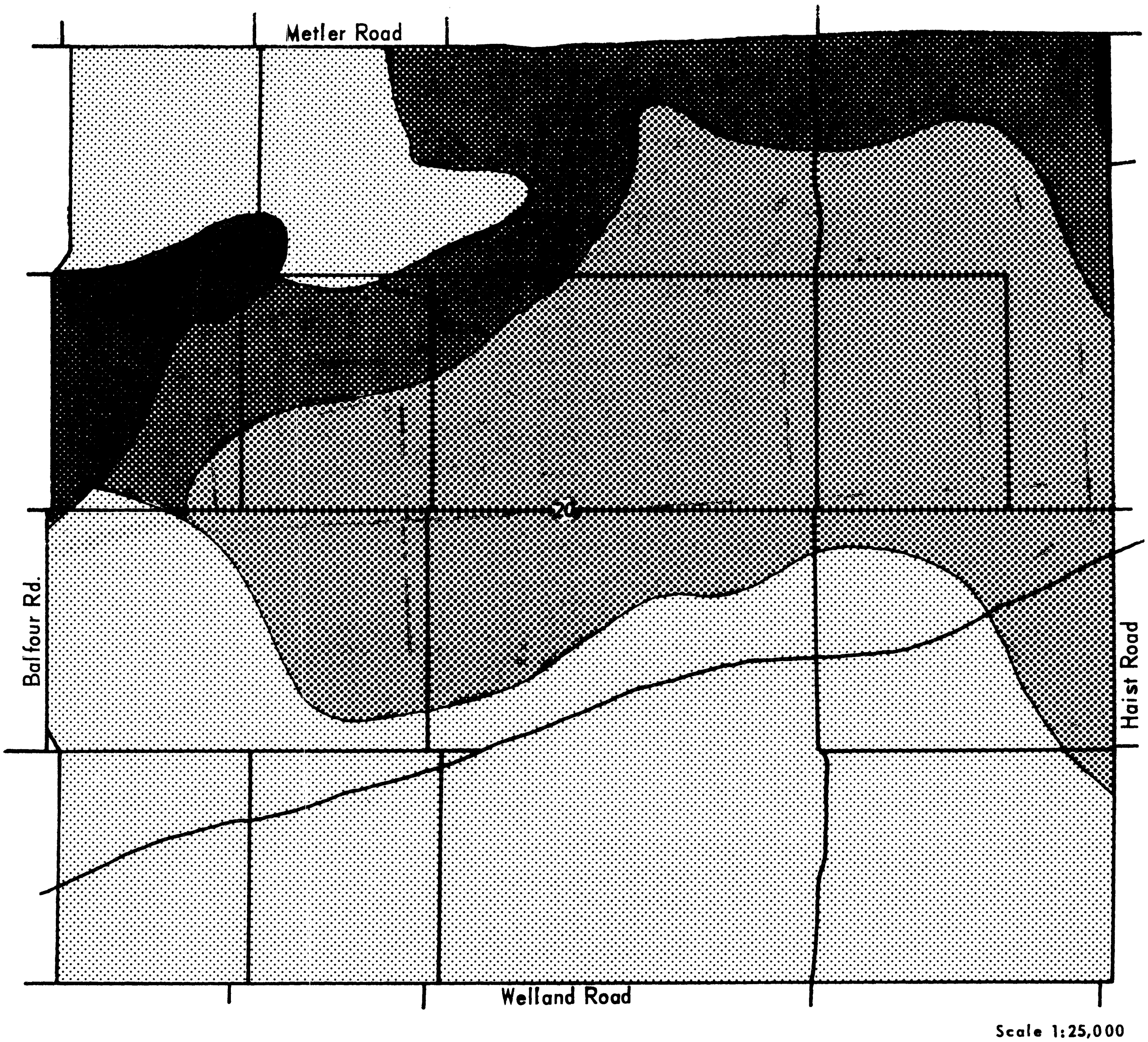
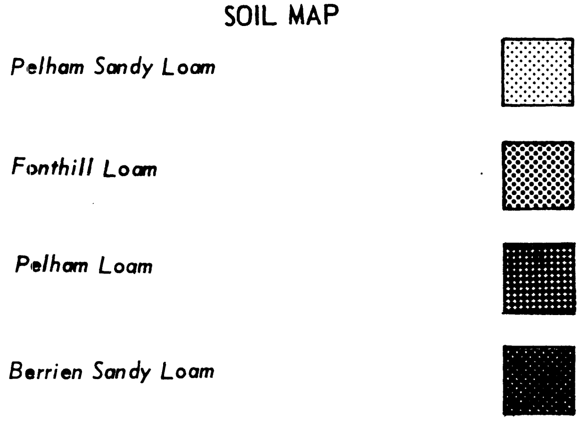


FIG. 7

SOIL MAP

Source: Soil Survey No. 5



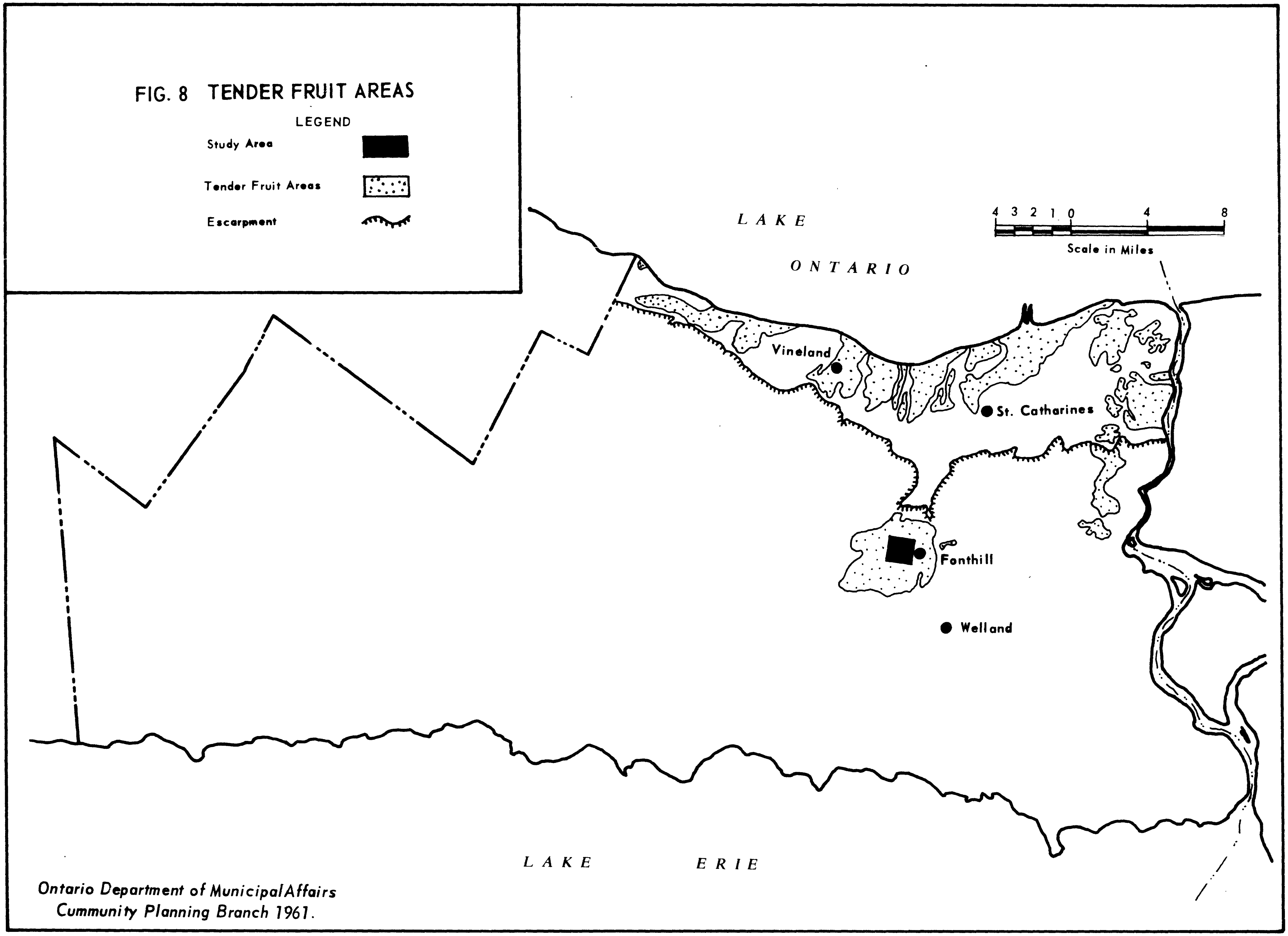


FIG. 8 TENDER FRUIT AREAS

Photo. 5. Pelham Sandy Loam developed on a fine sand parent. Note the compacted sub-soil.

Photo. 6. Fonthill Loam developed on deltaic material.

Photo. 7. Pelham Loam developed on Kame moraine. Note the stoney nature of the soil.

Photo. 8. Berrien Sandy Loam developed on till. Soil aggregates indicates the relatively high clay content.

Niagara Peninsula defined by climatic and soil requirements. It should be noted that the study area lies entirely within the Pelham tender fruit area.

Photo. 9.

Photo. 10. Moyer's sand and gravel pit. Note the depth and extent of the sand deposit.

CHAPTER III

FACTORS RELATING TO THE DISTRIBUTION OF FRUIT VARIETIES

Table 8 reveals the relative position of agricultural uses among the many other land-uses. Agricultural uses occupy over 50 percent of the total acreage. Table 9 illustrates the position of fruit crops among other agricultural uses. It should be noted that fruit crops occupy a large percentage of the agricultural land and that other agricultural uses are individually relatively minor. Table 10 indicates the relative importance of each fruit variety in terms of acreage and as a percentage of the total fruit land. Most noticeable are the relatively large acreages of peaches and sour cherries.

The physical and economic factors which tend to explain the heavy emphasis placed on peaches and sour cherries will be examined in this chapter.

Physical Elements

As was mentioned in Chapter II, the Fonthill area is more liable to frost damage than those areas below the escarpment. On this basis, we would expect a high representation of relatively hardy varieties. However, this is not the case, peaches are well represented although sweet cherries[16] are not. Still one would suspect that the high acreages of peaches and sour

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[16] Sweet cherry varieties are self-unfruitful, meaning that they will not bear consistently good crops unless pollinated with some other variety. Consequently sweet cherries are not planted in large blocks and usually occur in single or double rows. This manner of planting made the mapping and tabulation of sweet cherry acreages difficult. For this reason it is felt that this variety is under represented, although relative rank is correct.

TABLE 8 LAND-USE ACREAGES AND PERCENTAGES

USE	AREA IN ACRES		PERCENT 7th STUDY AREA	
Agricultural uses				
Fruit Crops	1420.5		32.3	
Vegetables	369.5		8.4	
Field Crops	207.5		4.7	
Hay and Pasture	159.5		3.6	
Planted Pine, Spruce and nursery stock	78.5		1.8	
		2235.0		50.8
Other uses				
Urban and special areas	497.0		11.3	
Extractive, Recreational, Roads	427.0		9.7	
		924.0		21.0
Bush and Scrub	639.0		14.5	
Idle	602.0		13.7	
		1241.0		28.2
		4400.0		100.0

TABLE 9 AGRICULTURAL USE AREAS AND PERCENTAGES

TYPE	AREA IN ACRES	PERCENT OF CROPLAND
Fruit Crops	1420.5	63.6
Vegetables	369.5	16.5
Field Crops	207.5	9.3
Hay and Pasture	159.5	7.1
Planted Pine, Spruce and Nursery Stock	78.0	3.5
Total:	2235.0	100.0

TABLE 10 FRUIT CROPS AREAS AND PERCENTAGES

FRUIT VARIETY	AREA IN ACRES	PERCENT OF FRUIT LAND
Peaches	470.0	33.1
Sour Cherries	403.0	28.4
Apples	176.0	12.4
Grapes	133.5	9.4
Pears	117.5	8.3
Sweet Cherries	61.5	4.3
Plums	36.0	2.5
Small Fruit	23.0	1.6
Total:	1420.5	100.0

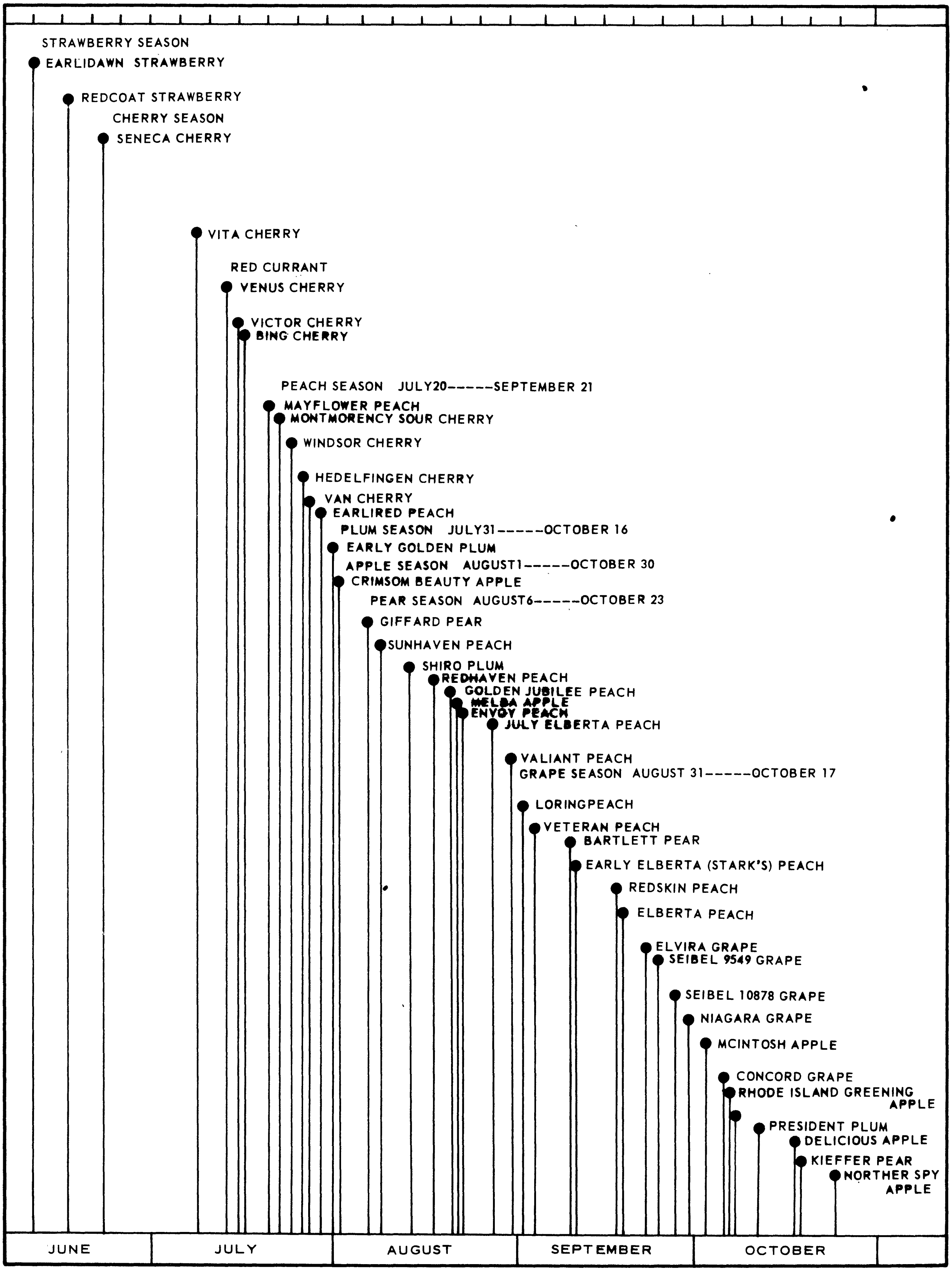
Photo. 11. Mature peaches in the background, young peaches in the foreground. View is from Tice Road looking south toward the glacial delta.

Photo. 12. Young to mature peaches. View is west from Effingham Road. Note the poor quality of the trees.

FIG. 9

PICKING DATES CHART

Horticultural Experiment Station....Vineland Station Ont.



cherries are related to environmental conditions.

The Fonthill area has a shorter growing season than areas below the Escarpment; it will be remembered that this reduction is in the autumn. Glancing at figure 9, we realize that fruit varieties most highly represented (i.e. peaches and sour cherries) are those harvested before mid-September, while those varieties that would appear to be under represented (i.e. apples, pears, plums, and grapes) are harvested after mid-September when the probability of frost is high. Grapes suffer a soil disadvantage as well. None of the soils found in the study area appear to be "grape" soils.

The high representative of peaches seems to bear out Mercier's contention that the probability of frost damage in the spring is low.

Economic Factors

The range of crops that can be grown , is generally defined by macro-environmental conditions. Out of this range of available crops, the farmer will tend to choose those which give him the highest sustained return for his investment. That is, crops yielding a high net return will be preferred to crops yielding a relatively lower net return. Table 11 compares the acreage of various fruit varieties with the corresponding net income per acre.

This comparison indicates that the respective acreage of fruit varieties are expressions of the net returns per acre. Peaches yield the highest average net returns per acre (excluding grapes) and also have

TABLE 11 [16]

NET INCOME PER ACRE FOR FRUIT VARIETIES

VARIETY	ACREAGE	NET INCOME PER ACRE Average	High
Peaches	470.0	89	271
Sour Cherries	403.0	71	353
Apples	176.0	12	99
Grapes	133.5	125	209
Pears	117.5	56	-
Sweet Cherries	61.5	-	-
Plums	36.0	-	-
Small Fruits	23.0	-	-

the highest acreage. Sour cherries has the second highest average net returns per acre, (excluding grapes), and has the second highest acreage. It may be that the similarity of total acreages of peaches and sour cherries is related to possible net returns. On the one hand, it is desirable to grow peaches since the average net returns are high. On the other hand, it is desirable to grow sour cherries because of the high possible net return. This also may explain the higher acreage of apples relative to pears.

Risk as a Stimulus to Diversity

Fruit farming involves a high degree of risk. Generally fruit

[16] Source. Farm Business Management Information for Extension Workers, (The Farm Economics Co-Operatives and Statistics Branch, Ontario Department of Agriculture and Food, 1966).

trees require at least five years before coming into production. The planting of an orchard involves a high investment and is expected to yield returns for at least twenty years. The grower, when planting, must attempt to forecast economic conditions which lie far in the future; he must also take into account the unpredictable nature of the weather. To reduce the risk factor, that is to maximize long-run profits, the farmer diversifies. Thus, eight varieties of fruit are grown, five of which are well represented, with a wide range of hardiness. The peach and sour cherry combination fits well into this scheme. If fruit varieties are ranked (see table 12) according to tenderness, peaches are most tender while sour cherries are sixth on the list.

TABLE 12

FRUIT VARIETIES RANKED ACCORDING TO TENDERNESS

(most tender)	Peaches
	Sweet Cherries
	Grapes
	Plums
	Pears
	Sour Cherries
	Small Fruit
(most hardy)	Apples

Of the seventy-one farms[17] in the study area only fourteen had

[17] For the purpose of this study, a farm is defined as a holding of land under single management being ten acres or more in extent, having less than fifty percent of its area idle or in nonagricultural uses.

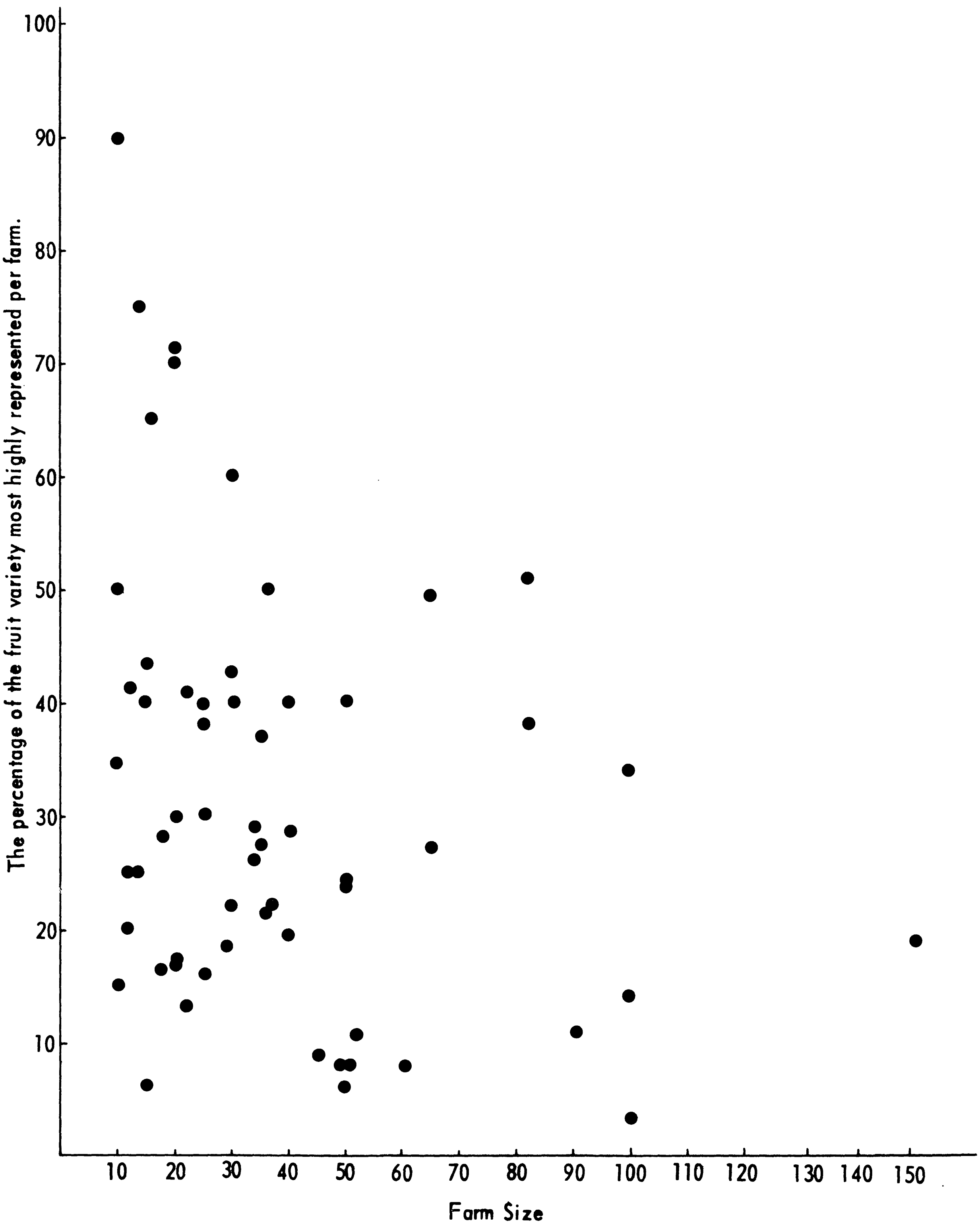
neither peaches nor sour cherries, seven had no sour cherries and nine lacked peaches.

It might be expected that there would be greater diversity with increasing farm size. Such a trend could represent an attempt by the farmer to spread the work load throughout the growing and harvesting season, and an attempt to minimize losses at a given time.

To test the diversity factor, the percentage of the fruit variety most highly represented per farm is plotted against farm size (Figure 10). If our expectations are correct, the smaller farms will have a high percent of one fruit crop, while larger farms will show progressively smaller percentages with increasing size. The existence of a relationship between the percentage of the fruit variety most highly represented per farm and farm size, is not verified by an examination of the scatter plot. Some small farms have a high percent of one variety indicating low diversity, and some large farms show a low percent of the most highly represented variety indicating a high degree of diversity. The range of points between, indicates that diversity is not related to farm size.

FIG. 10

RELATIONSHIP OF THE HIGHEST PERCENTAGE OF FRUIT GROWN TO FARM SIZE



CHAPTER 4

THE DISTRIBUTION OF FRUIT

The spatial distribution of fruit is the result of similar locational decisions made by many farmers. It is hypothesised that variations in texture and slope explain, in part, the spatial distribution of fruit in the Fonthill area.

TESTING THE HYPOTHESES

To test the hypotheses some method of comparing land-types[18] which characterize the study area with land-types utilized for fruit production had to be found. Such a comparison is effected by the use of simple land-type matrice. It will be remembered that four textural groups were recognized and that slope readings were grouped into six categories. There are, therefore, twenty-four possible combinations of soil texture and slope (i.e. land-types). A grid was constructed containing 24 spaces, 4 spaces in the vertical representing the 4 textural groups and 6 spaces in the horizontal representing the 6 slope categories. The spaces were numbered 1 to 4 and 1 to 6. Number 1 and number 4 in the vertical represent the highest and heaviest texture, respectively. Number 1 and number 6 in the horizontal represent the gentlest slope and the steepest slope respectively[19].

Figure 11 shows the spatial distribution of all land types found in the study area excluding land used for recreational and extractive purposes and roads[20]. Figure 12 shows the distribution of land-types utilized for

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18 For the purpose of this study land-type refers to an area with distinctive ranges of soil texture and slope.

19 It is to be noted that the land-types having a texture of 1 and a slope of 1 and a texture of 4 and a slope of 6 are nonexistent.

20 Thus, our total area is 3,973 acres instead of 4,400 acres.

FIG. 11

ALL LAND IN THE STUDY AREA EXCLUDING LAND USED FOR RECREATION AND EXTRACTIVE PURPOSES AND ROADS.

Heavier Texture ↓ / Increasing Slope →	1	2	3	4	5	6
1		18.5	58.5	109.5	89	15
2	153.5	325	434	707	320.5	81
3	99.5	344.5	348	509	375	1
4	74.5	45.5	117.5	69.5	16	

FIG. 12

ALL FRUIT LAND

Heavier Texture ↓ / Increasing Slope →	1	2	3	4	5	6
1		13.5	21.5	26.5	10	0
2	117.5	207.5	191.5	196	8.5	4
3	71.5	187	131	196.5	0	0
4	6	4.5	24	3.5	0	

fruit production.

A comparison of the two land-type distributions shows that the distribution of fruit is partially related to the amount of land found within each land-type and at the same time indicates a preferential choice of site. Thus, the land-type with number 2 category of soil texture and the number 4 slope category contains the largest area of land and also supports the largest acreage of fruit. At the same time, this land-type seems to be under-represented with respect to the proportion of fruit grown on other land-types.

If the presence of fruit on a given land-type is mainly a reflection of the frequency with which that type of land occurs, then we cannot say that the characteristics of that land-type influences the distribution of fruit. However, if the frequency with which fruit occurs on a particular land-type is not a reflection of the frequency of occurence of that land-type then we can argue that the different land-types possess characteristics which do influence the distribution of fruit. The X^2 test will be used to test the two possibilities.

The first step is to set up a null hypothesis. It is necessary to postulate that the spatial distribution of fruit is entirely random. It is the null hypothesis that is tested by .

The observed values (acreage of fruit), those that actually occur, are represented by O. The expected values (acreage of fruit), those values that would occur if the null hypothesis were true, are represented by E. The value is obtained by the formula:

$$X^2 = \sum \frac{(O - E)^2}{E}$$

$$= \frac{(O_1 - E_1)^2}{E_1} + \frac{(O_2 - E_2)^2}{E_2} + \cdot \quad \cdot \quad \cdot + \frac{(O_{24} - E_{24})^2}{E_{24}}$$

TABLE 13

OBSERVED AND EXPECTED FRUIT ACREAGES

LAND TYPE	TOTAL LAND in ACRES	O	E	O-E	(O-E)2	$\frac{(O-E)^2}{E}$
1	0	0	0	0	0	0
2	16.0	13.5	5.7	+ 7.8	60.84	10.7
3	58.5	21.5	20.9	+ 0.6	0.36	0.02
4	109.5	26.5	39.1	-12.6	158.76	4.1
5	89.0	10.0	31.7	-21.7	470.89	14.9
6	15.0	0	5.4	- 5.4	29.16	5.4
7	153.5	117.5	54.8	+62.7	3931.29	71.7
8	325.0	207.5	116.0	+91.5	8372.25	72.2
9	434.0	191.5	154.9	+36.6	1329.56	8.6
10	707.0	196.0	253.3	-57.3	3283.29	12.6
11	259.5	8.5	92.6	-84.1	7072.81	76.4
12	82.0	4.0	30.3	-26.3	691.69	22.8
13	99.5	71.5	35.5	+36.0	1296.0	36.5
14	344.5	187.0	122.9	+64.1	4108.81	33.4
15	348.0	131.0	124.2	+ 6.8	46.24	0.4
16	509.0	196.5	181.7	+14.8	219.04	1.2
17	37.5	0	13.4	-13.4	179.56	13.4
18	1.0	0	0.4	- 0.4	0.16	0.4
19	69.5	6.0	24.8	-18.8	353.44	14.3
20	45.5	4.5	16.2	-12.7	161.29	9.9
21	101.0	24.0	36.1	-12.1	146.41	4.1
22	69.5	3.5	24.8	-21.3	453.69	18.3
23	16.0	0	5.7	- 5.7	32.49	5.7
24	0	0	0	0	0	0

$$X^2 = \sum \frac{(O - E)^2}{E}$$

$$= 437.02$$

Degrees of Freedom N - 1 = 22 - 1 = 21.

Thus, for each land-type the amount by which the observed frequency differs from the expected frequency is squared and related to the expected frequency. When the figures for each category are summed these give the total sum of the squares of the differences between the observed and expected values. Each difference is divided by the appropriate value because the value from which the observed data deviate is different in each group[21].

Once the X^2 value is obtained it can be referred to the appropriate table and read off against degrees of freedom. This table gives the percentage probability that the null hypothesis is correct. By referring to Table 14 in "Tables for Statisticians" the value 437.02 with 21 degrees of freedom yields a probability value between 0.01 and 0.001. This means that there is less than one chance in 100 that the difference between the observed frequencies and expected frequencies could have arisen solely to chance. Thus, it is almost certain that the characteristics of the land-types do significantly affect the distribution of fruit.

THE DISTRIBUTION OF FRUIT VARIETIES

Figure 13 illustrates the distribution of fruit as the percentage area of each land-type. It can be seen that as soil becomes heavier and slope increases fruit production declines. Figure 14 shows which land-types are most attractive for fruit growing. It can be seen that fruit production has importance where the slope is not greater than 13° on a loamy sand or sandy loam. Since each variety of fruit has its own requirements for growth and cultivation, characteristics of the distribution of fruit may be thought of as the sum of the characteristics of all the fruit varieties. Figure 15 to 22 shows the percentage area occupied by each fruit variety in each land-

FIG. 13

PERCENTAGE OF EACH LAND-TYPE USED FOR FRUIT PRODUCTION

Increasing Slope →

Heavier Texture ↓

	1	2	3	4	5	6
1		73	36.8	24.2	11.2	0
2	76.5	63.8	44.1	27.7	2.7	4.9
3	71.9	54.3	37.6	38.6	0	0
4	8.1	9.9	20.4	5.0	0	

FIG. 14

LAND USE THAT HAS THE LARGEST AREA PERCENT IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓

	1	2	3	4	5	6
1		fruit	idle	other	scrub and bush	scrub and bush
2	fruit	fruit	fruit	fruit	scrub and bush	scrub and bush
3	fruit	fruit	fruit	fruit	scrub and bush	idle
4	hay and pasture	hay and pasture	scrub and bush	scrub and bush	field crops	

type. Figure 23 gives us an idea of the relative importance of each fruit variety in each land-type.

Peaches appear to be highly favoured on a sand with a slope less than $2\frac{1}{2}^{\circ}$. However, it should be noted that the slope range $\frac{1}{2}^{\circ}$ - $2\frac{1}{2}^{\circ}$ is preferred and within this slope range, peaches are favoured over three soil textures (i.e. sand, loamy sand, and sandy loam). Figure 18 illustrates the wide distribution of the peach as a favoured crop. Peaches are grown on the three aforementioned textures up to a slope to 19° [21].

Sour cherries are well represented on loamy sand and sandy loam, loamy sand being preferred. The area of concentration is defined by a maximum slope of $\frac{1}{2}^{\circ}$. Sour cherries have as wide a distribution as peaches; however, sour cherry production at its upper slope limits is defined by a slope of 13° rather than a slope of 19° as was the case with peaches. Also, it is only in the main area of concentration (i.e. on a loamy sand and sandy loam with a slope less than $\frac{1}{2}^{\circ}$) that the percentage area of sour cherries is greater than that of peaches.

Apples and pears both have wide ranges of production but have no marked areas of concentration and the percentage area per land-type is quite low. Relatively higher area percentages occur on those land-types which form the limits to peach and sour cherry production. In the case of pears, the percentage values are highest on loam-textured soils and in the case of apples on sand-textured soil. These fruit varieties are relatively important on two land-types each. From figure 23 it may be seen that these land-types have widely differing soil texture and slope characteristics.

Grapes, also, have a fairly wide range of cultivation. They are preferred on two land-types. These cover a sandy loam and loam textured soil

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21 It was found that cultivation stopped at a slope of 19°.

FIG.15

PERCENTAGE DISTRIBUTION OF PEACHES IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓

	1	2	3	4	5	6
1		43.2	6.8	15.9	4.5	0
2	12.7	25.7	17.1	7.6	2.6	0
3	13.6	22.2	7.8	15.9	0	0
4	0	0	0	0	0	

FIG. 16

PERCENTAGE DISTRIBUTION OF PEARS IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓

	1	2	3	4	5	6
1		0	3.4	0	2.2	0
2	1.3	5.7	3.7	2.6	0	4.9
3	0	3.5	5.3	1.7	0	0
4	4.0	6.6	7.6	0	0	

FIG. 17

PERCENTAGE DISTRIBUTION OF SWEET CHERRIES IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓

	1	2	3	4	5	6
1		0	1.7	0	0	0
2	2.3	2.3	1.8	2.3	0	0
3	0	0.7	2.2	2.6	0	0
4	0	0	0	2.9	0	

FIG. 18

PERCENTAGE DISTRIBUTION OF SOUR CHERRIES IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓

	1	2	3	4	5	6
1		10.7	9.4	4.6	2.2	0
2	46.3	21.2	11.3	7.6	0	0
3	38.7	16.8	2.7	6.8	0	0
4	0	0	4.3	0	0	

FIG. 19
PERCENTAGE DISTRIBUTION OF GRAPES IN EACH LAND-TYPE

Heavier Texture ↓ / Increasing Slope →	1	2	3	4	5	6
1		18.9	0	1.8	0	0
2	2.9	4.6	3.0	0.7	0.3	0
3	15.1	5.5	9.4	2.1	0	0
4	0	0	8.5	0	0	

FIG. 20
PERCENTAGE DISTRIBUTION OF SMALL FRUITS IN EACH LAND-TYPE

Heavier Texture ↓ / Increasing Slope →	1	2	3	4	5	6
1		0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	3.4	1.9	0	0
4	0	3.3	0	0	0	

FIG. 21

PERCENTAGE DISTRIBUTION OF PLUMS IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓	1	2	3	4	5	6
1		0	5.1	0	0	0
2		2.5	0.9	0.2	0	0
3	0	0.5	2.9	0	0	0
4	0	0	0	0	0	

FIG. 22

PERCENTAGE DISTRIBUTION OF APPLES IN EACH LAND-TYPE

Increasing Slope →

Heavier Texture ↓	1	2	3	4	5	6
1			0	1.9	2.2	0
2	5.9	1.8	6.3	6.7	0	0
3	4.5	5.1	3.0	7.7	0	0
4	4.1	0	0	2.1	0	

FIG. 23 HIGHEST PERCENT OF FRUIT IN EACH LAND-TYPE

	1	2	3	4	5	6
1		peaches	apples	peaches	peaches	0
2	sour cherries	peaches	peaches	peaches sour cherries and apples	peaches	pears
3	sour cherries	peaches	grapes	peaches	0	0
4	apples	pears	grapes	sweet cherries	0	

FIG. 24

RELATIONSHIP OF CERTAIN FRUIT VARIETIES TO LAND-TYPE

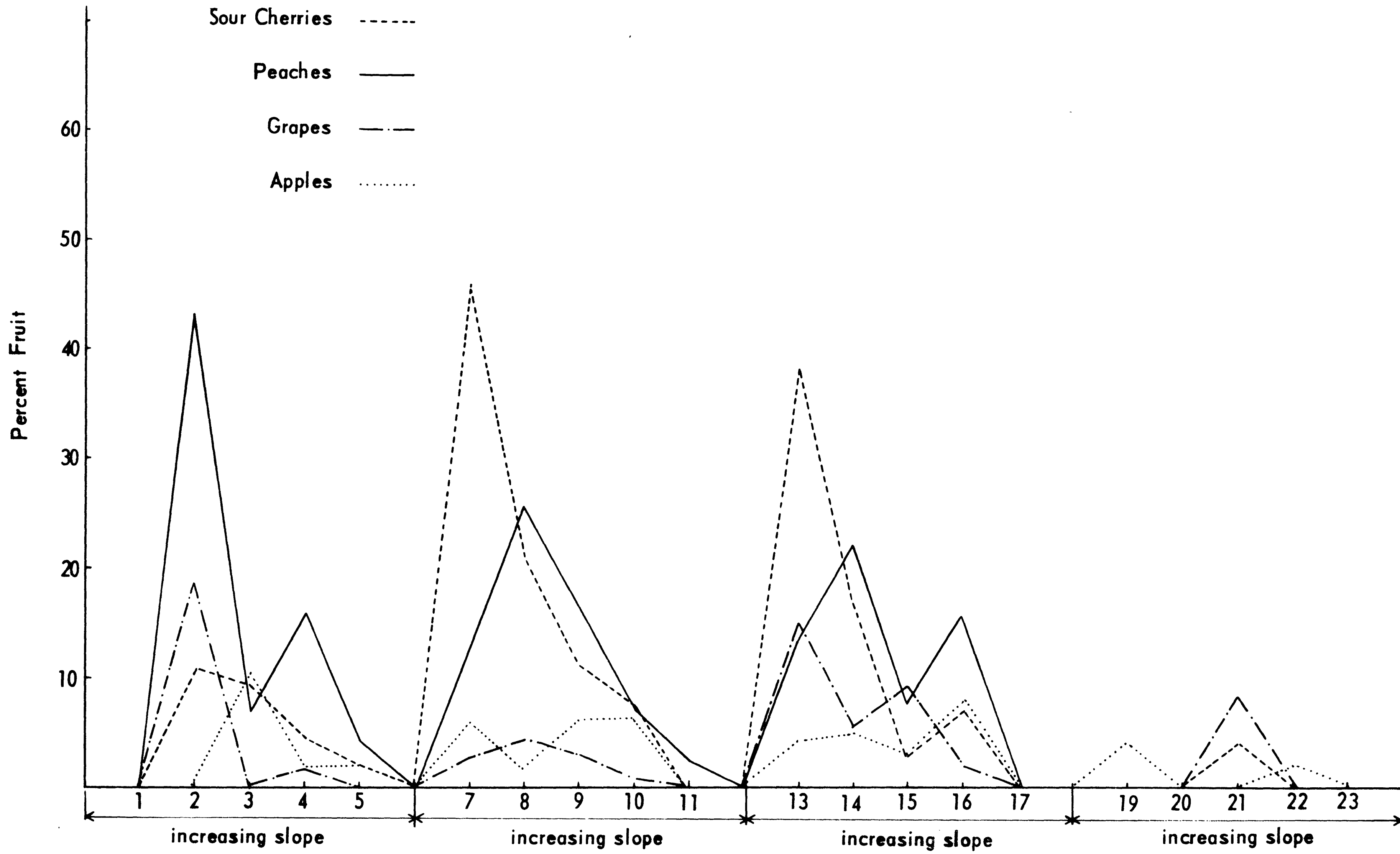
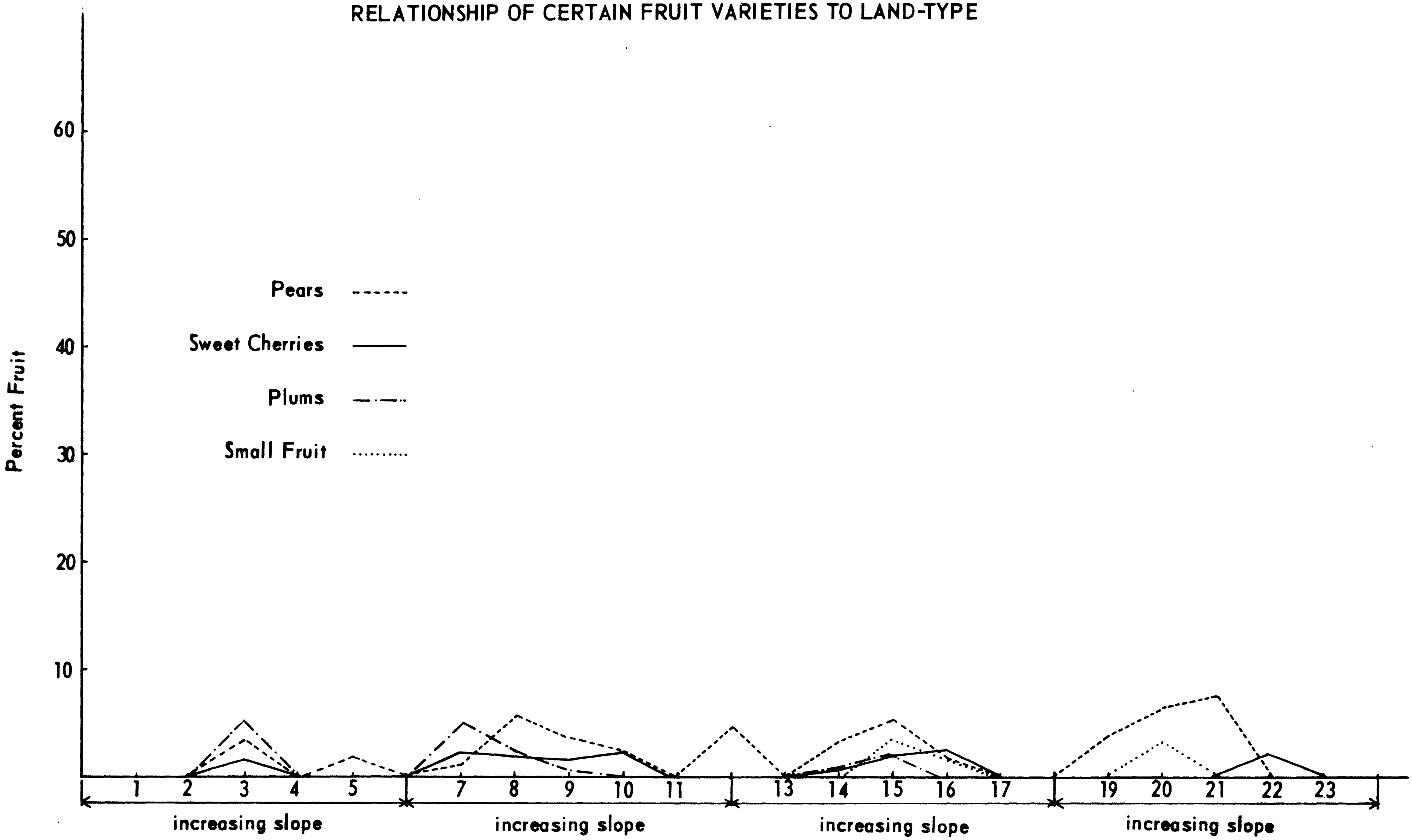


FIG. 25

RELATIONSHIP OF CERTAIN FRUIT VARIETIES TO LAND-TYPE



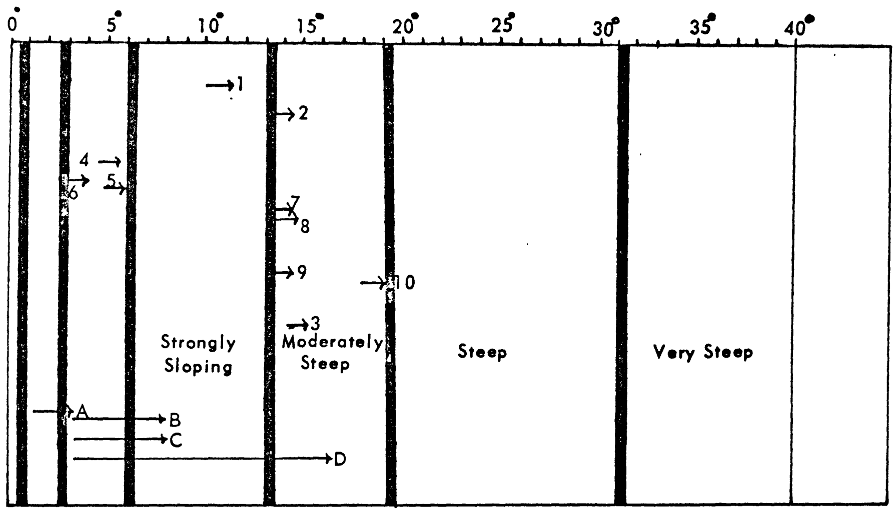


FIG. 26 Relationship between slope categories and use of farm implements.

1. *Rotary Cultivator*
2. *Tractor, standard wheels, multiple–share plough.*
3. *Standard tractor, multiple–share plough mounted.*
4. *Standard tractor–towed sowing and hoeing.*
5. *Standard tractor–mounted beet hoeing.*
6. *Standard tractor–mounted ridging.*
7. *Four–wheel–drive tractor/track–laying tractor, vineyard work.*
8. *Standard tractor, mounted reaper.*
9. *Rubber–tyred trailer transport.*
10. *Solid–tyred trailer transport.*

A. *No special difficulties.*
B. *Level–ground implements can generally be used.(*
C. *General limit of use of standard wheeled tractor.*
D. *General limit of use of tractor with four–wheel drive.*

Source: L. F. Curtis, The Discription Of Relief In Field Study Of Soils with a slope range of 6^{o} - 13^{o}.

Plums and sweet cherries both have small acreages. There is no area of concentration and the percentage area per land-type is small. Both varieties have the highest representation on loam. The slope limit of plums is 6^{o} while that of sweet cherries is 13^{o}.

Small fruits are barely represented at all and are present only on three land-types. The above discussion is illustrated graphically in figures 24 and 25.

EXPLANATION OF THE DISTRIBUTION OF FRUIT VARIETIES.

The characteristics of the distribution of fruit varieties have been discussed. An attempt will now be made to explain these characteristics in terms of the limitations of certain soil textures and slopes and in terms of competition for space.

The fruit varieties grown prefer a deep sandy soil which warms up rapidly in the spring and promotes vigorous root development. Even the grapes, mainly French hybrids, require a well-drained light soil. Since internal drainage is largely a function of texture, the extension use of loamy sand and sandy loam appears to be explained. The sand textured soils tend to be droughty; this explains the less intensive use of this soil for fruit cultivation. The loam textured soils tend to be relatively poorly drained explaining the complete absence of peaches on them.

The limitations of slope are illustrated in figure 26. From previous discussion, it will be remembered that the general limit to fruit cultivation was 13^{o}. Figure 26 shows that this is the general limit of the standard wheeled tractor working along maximum gradient. Fifteen degrees is the general limit for rubber-tired trailor transports working along the contour.

Photo. 17. Mature sweet cherry orchard west of Effingham Road on Fonthill Loam

Photo. 18. French hybrid grapes south of Highway 20 on the glacial delta.

This is significant since much tractor work is required in an orchard, especially during spraying and harvesting time. This would tend to explain why the bulk of fruit is grown on slope of less than 13^{o}.

Slope presents a further limit. During the spraying operation the farmer must run with the slope or across it with the effect that either one side or one end is higher than the other. This affects the spray coverage. During personal interviews, farmers were asked to point out slopes that gave them difficulty. It was found by measuring these slopes that any slope greater than 8^{o} presented a problem. If slopes of over 8^{o} are utilized, the angle of the nozzles on the sprayer unit must be adjusted after each run through the orchard, entailing much work. This would appear to explain the concentration of peaches and sour cherries on land-types with slopes less than 6^{o}.

It is to be expected that those crops which yield the highest net income will be priveleged among the fruit varieties in regard to their siting. Thus, peaches and sour cherries occupy the most favoured land-types. Their wide distribution over many land-types serves to illustrate their value and the tendency to plant them wherever possible. This explains the anomaly that sweet cherry acreages are highest on the heavier textured soils while they require a light well drained soil.

Peaches and sour cherries are planted on the most favoured sites to the extent that they virtually exclude all other varieties in their areas of concentration. Varieties such as apples, pears, and plums only increase in acreage on those land-types whose soil texture and slope characteristics are detrimental to the growth of peaches or sour cherries. These varieties are able to do so since they are able to grow satisfactorily over a relatively

Photo. 15. Young pears south of Tice Road on Berrien Sandy Loam.

Photo. 16. Old apple orchard north of Tice Road on Pelham Loam.

wide range of soil texture and slope conditions. Pears and plums are the least demanding of all the fruit varieties in their soil requirement. They can tolerate poorly drained soils although they yield much better crops on soils with better drainage conditions. Apples and pears can be grown under a sod system of management. This reduces the risk of erosion and cuts down on the amount of cultivation necessary in the orchard. These factors allow the production of apples and pears on the steeper slopes.

Referring to figues 24 and 25, it may be seen that the grape is the only fruit variety that competes with peaches on peach land-types. This may be explained by the fact that these grapes are French hybrids whose requirements are like those of the peach. The net income per acre for these grapes is higher than that for peaches; however, they were introduced in the late 50's and have as yet not gained in popularity explaining the relatively low acreage values.

From figure 24, it is also possible to see that land-types supporting a high percentage area of peaches do not suggest a high percentage area of sour cherries and vice-versa. The main difference in their choice of site appears to be slope. High percentage areas of sour cherries occurs where slope is less than $\frac{1}{2}^{\circ}$. Concentration of peaches occur where the slope range is $\frac{1}{2}^{\circ}$ - $2\frac{1}{2}^{\circ}$. It is suggested that almost level ground increase the danger of forst damage because there is no impetus for cold air drainage away from the trees. It is also suggested that the areas of flat ground are collecting sites for drainage waters from higher sites. Sour cherries being relatively hardy can survive these conditions while peaches cannot.

CHAPTER 5

A SUMMARY OF THE CONCLUSIONS

Because of the low probability of spring frost and the presence of deep, sandy, well-drained soils fruit production is favoured in the study area. The relatively high risk of frost in autumn has contributed to the preference for mid-summer ripening varieties (i.e. peaches and sour cherries) opposed to fall-ripening varieties (i.e. apples, pears and grapes).

Economic factors favour the cultivation of peaches and sour cherries. The per-acre net income derived from these two varieties is higher than that of any other fruit variety excluding grapes. Peaches and sour cherries have an extensive distribution and are grown wherever possible.

Concentrated areas of peach and sour cherry cultivation are quite stringently defined by slope and soil texture. Peaches are most highly favoured on land-types with a slope range of $\frac{1}{2}^{\circ}$ - $2\frac{1}{2}^{\circ}$ and with a sand, loamy sand, and sandy loam texture. Sour cherries are well represented on land-types with a maximum slope of $\frac{1}{2}^{\circ}$ and with a loamy sand or sandy loam texture. Other fruit varieties are virtually excluded from these land-types.

Fruit crops of secondary importance are apples, grapes and pears. These varieties show no marked areas of concentration and are relegated to those land-types whose characteristics of texture and slope are unfavourable for the cultivation of peaches and/or sour cherries.

It is concluded that the spatial distribution of fruit in this area is influenced significantly by variations in soil texture and slope.

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