LAND

CHAPTER A

GEOLOGY, PHYSIOGRAPHY AND CLIMATE

1. Bedrock Geology*

Although the bedrock is covered by a mantle of softer materials to a depth of 100 feet or more over much of the area, and as deep as 230 feet in some parts, it is important in a number of ways. First, it determines to a great extent the altitude and slope of the country. Second, the materials on which the soils have developed are derived mostly from the bedrock underlying the country. Third, the rock is exposed or is very near the surface in certain localities, as at St. Marys and at Ingersoll, and is quarried for various purposes. Lastly, the control of the river by engineering works requires, in some instances, solid foundations which can be found only on bedrock and, fortunately, this is possible in certain selected sites.

The backbone of the continent, the ancient pre-cambrian rocks, lies under 2,800 to 3,400 feet of sedimentary rocks, sandstone, shale and limestone. The pre-cambrian basement has an average dip of 28 feet a mile to the south-west. The sedimentary rocks have a surface with a slightly less dip. It is this rise from the south-west towards the dome in Dufferin and Grey Counties which predetermines the drainage pattern.

The sedimentary rocks underlying the soft materials are mostly shale and limestone. The soil materials are therefore clayey, derived from the shale, and are quite limy.

Along the valley bottoms the soft material is not so deep as in the surrounding countryside, and in building the Fanshawe Dam a rock base was available at 23 feet. Other proposed sites have bedrock at even less depths. Within the

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* Caley, J.F. Palaeozoic Geology of the London Area, Ontario. Geological Survey of Canada, Memoir 237, 1943; and Palaeozoic Geology of the Brantford Area, Ontario. Geological Survey of Canada, Memoir 226, 1941.

BEDROCK GEOLOGY

LEGEND

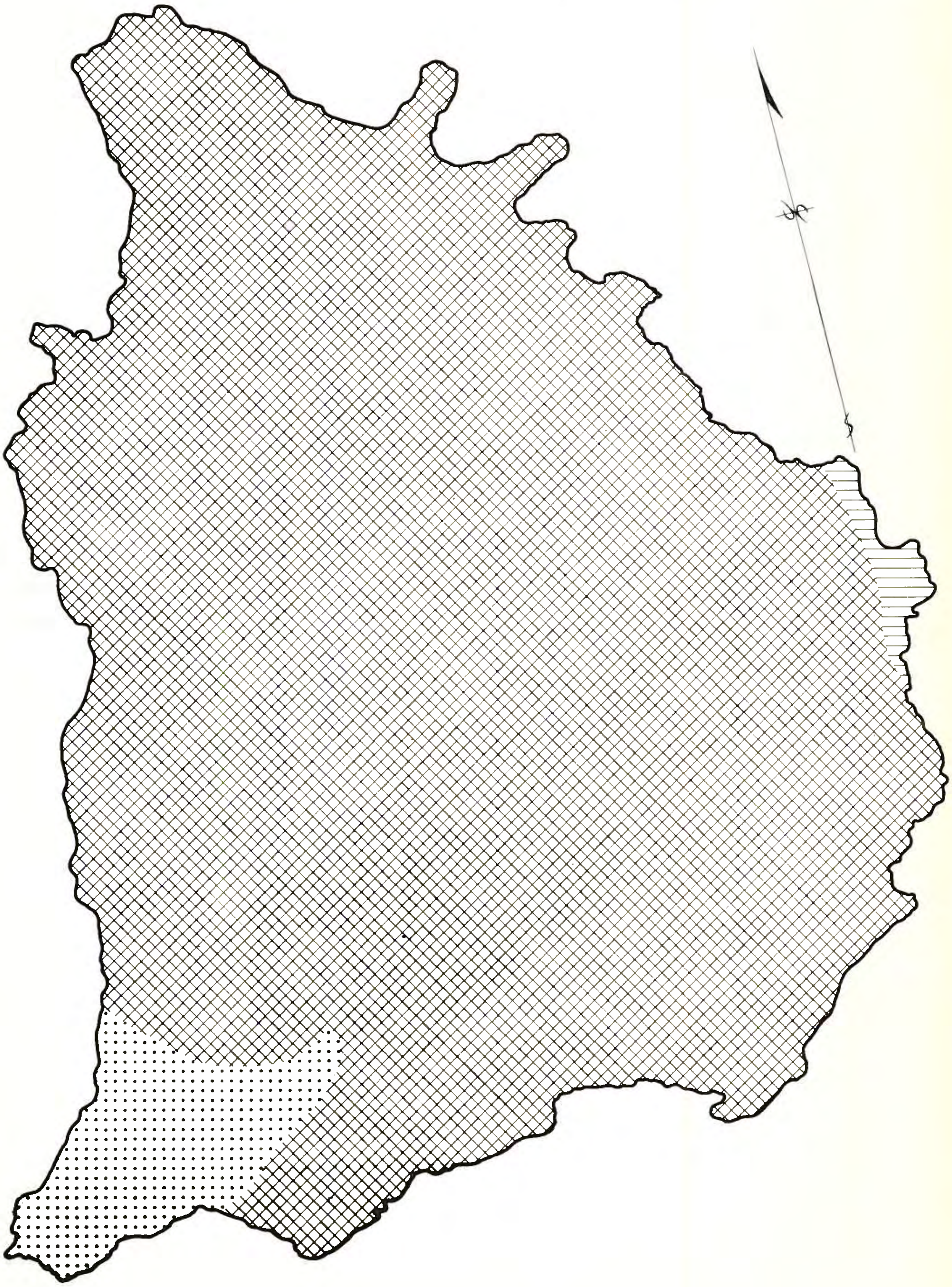
PALAEOZOIC

DEVONIAN

HAMILTON FORMATION	Soft blue and gray shale and gray limestone.
NORFOLK FORMATION	Gray and brown limestone and magnesium limestone, calcareous sandstone, chert, small quantities of gypsum.

SILURIAN

BERTIE AKRON SERIES	Buff and brown dolomitic limestone and dolomite.



underlying limestone, dolomite and shale and other deposits are levels containing water, gas, sulphur compounds and salt. Supplies of water from the rocks are not always of use because of these impurities.

The sedimentary rocks are among the oldest of this type of rock, called the Palaeozoic. The uppermost formations are of the Bertie-Akron of the Silurian system and the Norfolk and Hamilton of the Devonian system. The distribution of these formations is indicated in the accompanying maps.

2. Physiography

The soft material mentioned above as covering the bedrock is the result of the action of vast masses of ice, the Continental glaciation of 20 or 30 thousand years ago. The material, called "drift", was accumulated from the rock of the continent and deposited during at least three advances of the glacier. The kind of the lower deposits made by earlier glaciations, or by bodies of water between glaciations, determines to a great extent the nature of deep ground-water supplies, but little is known about them in detail. The last glaciation moulded the landscape as it is now seen and provided the material on which the soils developed. It is from the most recent deposits that shallow ground-water supplies are obtained.

The surface deposits were made by the advancing ice sheet, at its face or under its edge as the ice body decomposed or by streams and bodies of water created by melting ice. The surface has been eroded by the streams of the present river system, but in general the topography is more or less that which was moulded by the glacier and post-glacial waters. The present drainage system conforms pretty well to the relief rather than being the cause of it, as in unglaciated territory.

The upland called "Ontario Island" by Taylor* was the first part of Ontario freed of ice in the retreat of the Wisconsin glacier. The ice mass surrounding this "island"

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* Taylor, F.B. The Moraine Systems of Southwestern Ontario. Trans. C.I. 1913.

gradually assumed the form of two lobes that separated in their recession in the vicinity of London. Meltwater from the glacier poured onto the upland from the higher ice around it and found an escape in the crease to the south between the retreating lobes. There was built up in this way a number of drainage outlets or spillways which formed troughs in the till. These are occupied in part at the present time by the Thames River and its tributaries and are usually gravel-terraced valleys, much broader than would be warranted by existing drainage.

Another important glacial feature associated with the retreat of the ice lobes was the formation of terminal moraines which were flanked in some cases and separated in others by the drainage outlets. The moraines may be classified as either till or kame, depending on whether they were laid down on land or under water conditions.

The till moraines are composed chiefly of unsorted glacial materials and were formed at halts in the advances or retreats of the ice front. There are two more or less continuous till moraines, one in the south part and one extending irregularly across the north-west part of the watershed. The southern moraine lies immediately to the south of the Thames River between London and Ingersoll. At Ingersoll it swings away in a semicircle to the south-east and returns to the vicinity of the Thames River east of Woodstock. It is irregular in outline and broken in places by drainage channels. Its relief is usually between 25 and 50 feet above the adjacent land.

The northern till moraine enters the watershed from the west at Elginfield, extends in a north-easterly direction to St. Marys, turns almost due north as far as Fullarton and passes out of the watershed to the north-east, midway between Mitchell and Stratford. Taylor describes this moraine as "a slender lightly built moraine rather narrow but quite well defined, its relief being generally 20 to 30 feet, sometimes 50 feet".

There are two kame deposits of minor size within the watershed, one at Cobble Hill and the other a few miles east of St. Marys. A much larger kame moraine occurs east of Stratford but most of it lies outside the watershed.* Swampy areas in the hollows of the kame hills are the sources of the Avon and other tributaries of the Thames River. Gravel pits are often located in these hills because of the more or less sorted nature of their sands and gravels.

The moraines were formed by halts in the ice movement. The land form created under the ice while it was moving is called a till plain. Two types are found. In the south-easterly areas the till has been moulded into long oval hills called drumlins or whalebacks or into ridges and flutings. The drumlins and ridges run in a north-west to south-east direction. The till is made up of a medium-textured loamy material.

In the north-westerly half of the watershed the till plain has not the definite ridging of the drumlinized topography. Some of the till is of a heavier texture. These two characterisitcs, a "tumbled" or irregular topography and a heavier soil, restrict the drainage both overland and within the soil.

The land forms created by glaciation are shown on the accompanying map. In addition to the moraines, the two kinds of till plain, the meltwater channels (or spillways) and the kame moraines described in the preceding paragraphs, there are also recorded on the map eskers, sand plains and areas of muck.

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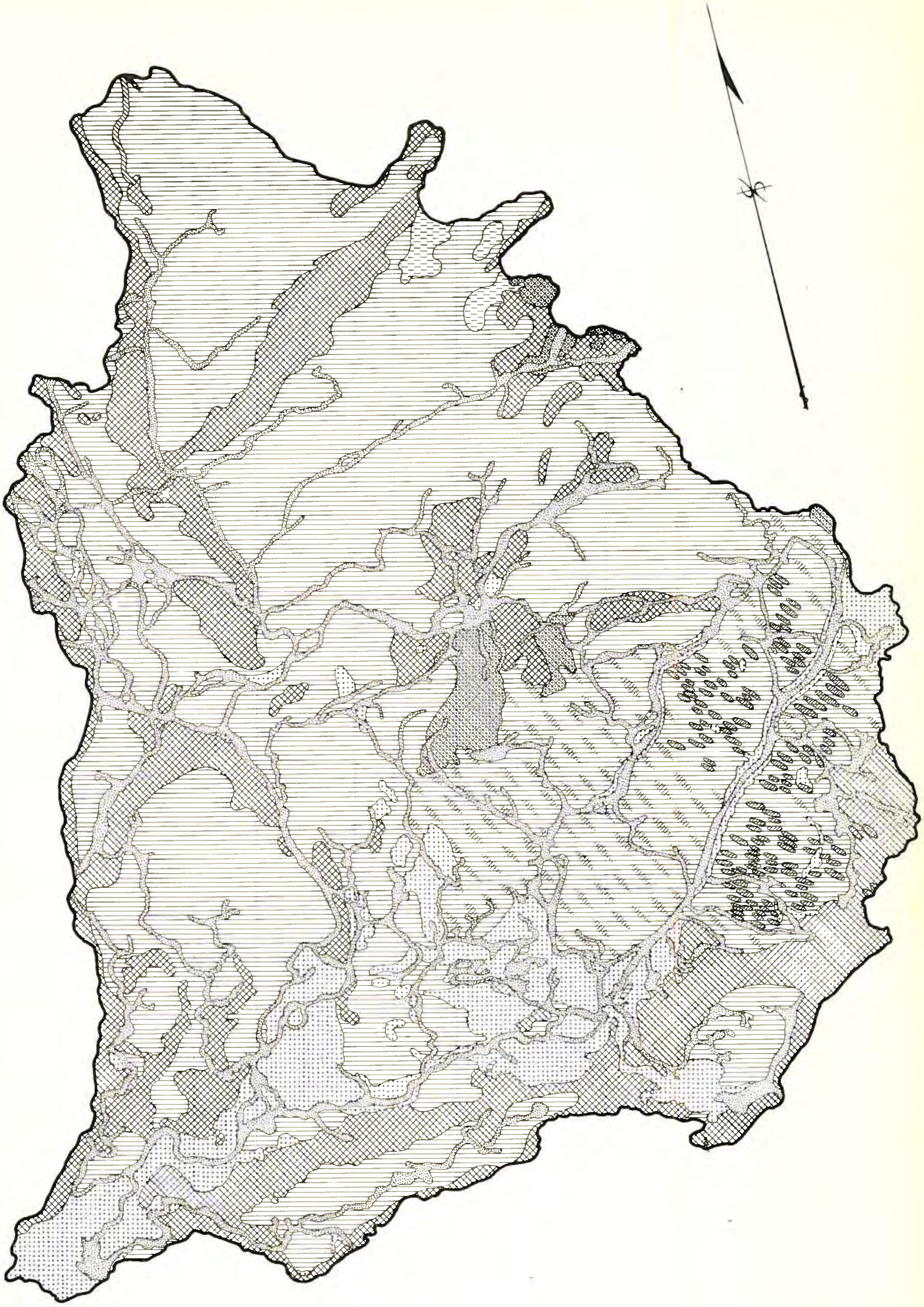
* Chapman, L.J. and Putnam, D.F. The Physiography of South-western Ontario. Scientific Agriculture, 24:3, 1943.



PHYSIOGRAPHY

LEGEND

- TILL PLAIN DRUMLINIZED
- TILL PLAIN UNDRUMLINIZED
- DRUMLINS
- SPILLWAYS
- SAND PLAINS AND DELTAS
- KAME MORAINES
- ESKERS
- TILL MORAINES
- MUCK

SCALE : MILES

0 1 2 3 4 5 6 7

The limestone bedrock which underlies the watershed determines the overall structure of the country and the nature of the soils. Quarry near Beachville.

The eastern portion of the watershed has many gentle ridges running north-west to south-east as in this scene south-east of Ingersoll.

Much of the watershed is flat but broken by irregularly hummocky slopes like this moraine south of London.

Eskers are ridges of gravel which cross the plains like rivers and are made up of roughly stratified sand and gravel like the kame moraines. Around London there are broad sand and gravel plains. These are the remains of deltas and off-shore sand deposits in post-glacial bodies of water. Muck deposits were formed in river valley bottoms and in upland areas of poor drainage by the accumulation of decayed vegetation.

3. Climate

The peninsular part of Southern Ontario is an upland which rises over 1,000 feet above the Great Lakes. The Upper Thames drains part of the south-western slope of that upland and its climate is affected by this position; particularly the rainfall and snowfall are above the average for Southern Ontario. On account of the special interest in floods and running water in this area, special stress will be given to these factors.

Three weather stations of long standing provide a reliable set of records on which to base a description of the local climate. They are at London, Stratford and Woodstock, strategically situated so far as the Upper Thames is concerned.

The winter temperatures on the Upper Thames are like those in the Toronto area or in Huron and Bruce Counties. In January, or in the three coldest months, Stratford is two degrees colder than London, which is a very definite difference. The snow blanket will be deeper at Stratford for this reason. In mid-summer the temperature spread is only slightly less. London and Woodstock have the same temperature in July as Kingston and Ottawa. The lowest temperatures officially recorded are -27°F. at London, -28°F. at Woodstock, -31°F. at Stratford and -32°F. at Lucan. Plant growth generally begins at London about the second week in April on the average, while the season is nearly a week later at Stratford. Killing frosts may be expected in five out of every ten years for a month later, that is, until May 13 at London and May 15 at Stratford, according to the figures.

The yearly precipitation averages 38 inches at London and Stratford, which is approximately 5 inches above the average for Southern Ontario. At least half of this is extra snow. Woodstock, with 33 inches in all and 58 inches of snow, is near the average for Southern Ontario. The rainfall of the summer six months is 19 inches at Stratford, 18 inches at London and 17.5 inches at Woodstock. London and Stratford are in line with the heavy snow belt that extends across the westerly slope south of Georgian Bay. In short, the Upper Thames Basin is in one of the wetter parts of the Province, comparable to the most easterly counties in the St. Lawrence and Ottawa lowland.

When considering floods or soil erosion the occurrence of unusual downpours or extended rains deserves special attention. It has been pointed out that run-off is at a maximum when the soil is saturated or the surface is glazed over with ice. Moreover, a heavy rain coinciding with a sudden warm spell in springtime adds meltwater from accumulated snow. For these reasons, the amount of rain needed to produce a flood cannot be stated definitely. The great flood of April 24 - 26, 1937, resulted from a widespread rain of four to over five inches in 48 hours falling on an icy surface, but no doubt serious floods are produced by lesser falls.

In order to get some figures on the frequency of heavy rains, the daily records taken at London, Stratford and Woodstock were examined for the last 25 years, that is, from 1921 to 1945. Disregarding rains of less than 1 inch during a 48-hour period, the accompanying table gives the number of 1 to 2, 2 to 3 and 3 to 4 inches or more at these three stations. Only the period of March 1 to October 31 was considered. Precipitation falling as snow was ruled out.

The first point of interest is that heavy rains are much less frequent during March and April than in the summer months. This is very fortunate; if the situation were reversed the spring floods would be much more frequent than they are now.

Judging by the past 25 years (1921 - 1945), falls of over three inches within 48 hours may be expected in one year out of five at London and Woodstock, and once every two or three years at Stratford. If several days of steady rain falling at a rate of less than three inches in 48 hours will produce bad floods on the Thames, then the totals just given do not represent all the flood-producers.

The question of whether the rains of the past 25 years can be taken as a measure of normal conditions may well be asked, because we are interested in predicting for the future. While it does not settle the question, the Stratford records for the period of 1896 to 1920 were examined for comparison with the succeeding 25-year period. The number of rains of over one inch in 48 hours was nearly the same in two periods - actually 156 in the earlier and 163 in the later period.

Westerly wind having a speed of seven to ten miles per hour is a typical trait of the climate in south-western Ontario and the London, Woodstock and Stratford stations all agree on this point. South-westerly or north-westerly winds are nearly as frequent as those which blow directly from the west. Sometimes strong winds and hail go together; such storms come along in about two years out of three. Twisters like the one that caused so much damage to buildings on the northern outskirts of Strathroy as recently as August 1944, fortunately, are only occasional visitors.

Bright sunshine for the area is recorded only at Woodstock. The sun shines approximately half the time possible during the growing season (April 1 - September 30), which is a little less than in drier parts of the Province.

THE FREQUENCY OF HEAVY RAINS (1921 - 1945)

Station	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1 - 1.99 inches in 48 hours									
LONDON	3	13	21	21	18	17	19	19	131
STRATFORD	7	16	14	20	16	19	12	18	122
WOODSTOCK	3	10	16	18	20	16	20	13	116
2 - 2.99 inches in 48 hours									
LONDON			5	4	4	6	4	5	28
STRATFORD			7	8	7	4	4		30
WOODSTOCK	1	1	5	3	6	1	5	1	22
3 - 3.99 inches in 48 hours									
LONDON			1	1	1	1			4
STRATFORD			2	1	1	3	3		10
WOODSTOCK		1		1	1				3
4 inches and over in 48 hours									
LONDON					1				1
STRATFORD				1			1		2
WOODSTOCK		1			1				2

THE FREQUENCY OF HEAVY RAINS
AT STRATFORD 1896 - 1920

Amount in 48 hours (inches)	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1 - 1.99	6	8	20	22	21	20	17	17	131
2 - 2.99	1	3	1	-	3	4	5	3	20
3 - 3.99	1								1
4 - up					2		1	1	4

CHAPTER 1

PURPOSE AND METHODS OF THE SURVEY

1. Statement of Purpose

The purpose of a soil conservation survey is fourfold; to make an inventory of the physical conditions; to make an inventory of land use; to appraise the capabilities of the soil and estimate the adjustment of use to capabilities; and to recommend that use of all the land which will sustain the resources of soil and moisture for all time.

2. Inventory of Soils

The first step in achieving the purpose of the survey is to identify, map and describe the soil types, to determine those features which limit the use and to measure the degree to which these features affect land use.

3. Inventory of Land Use

The use to which land is actually being put must be known. It is the best indication of the quality of the land. Present use indicates the type of agriculture being practised and the use must be known before a program can be drawn up which might cause changes in use.

4. Appraisal of Capabilities

A comparative rating of the capability of soil is indicated by the intensity of use of each kind of soil. Further consideration is given to the findings of tests and experiments made on the various soils or natural conditions. When all the land is divided according to capabilities and the present use is recorded on a map, direct comparison shows to what extent the various uses are adjusted to the capability; for example, how much of the land of highest capability is under intensive cultivation and how much of the land of lowest capability is retained under forest cover.

5. A Soil Conservation Program

To carry out a soil conservation program requires that each piece of land is used according to its capability. This means that the best land be used to the full extent of its ability to produce and the poorer land used only for that purpose which will yield consistently well without the land deteriorating in any way.

Further to making the actual type of use (cultivation, pasture and so on) fit the land, there must be special practices followed to make the best use of the land; either to take advantage of its fertility or moisture or to check destructive processes. These include soil-building practices, liming, fertilizing and crop rotations, erosion control measures such as contour cultivation, strip-cropping, grassed watercourses and diversion terraces and the improvement of wet lands with high fertility by artificial drainage.

A soil conservation program is not one which can be carried out in a short time or by a few people. It involves all those who own the land, and might take a generation to carry out. A plan or map of recommended use is really a guide to the adjustment of land use and management to the natural characteristics of the land.

6. Special Projects

Holding surface run-off in ponds for farm use is a conservation measure of special interest. To find out as much as possible about such ponds a survey was made of all existing ponds on the watershed.

A recognized method of getting a conservation program started is to set up a demonstration project. This is particularly suitable on the watershed of a small river when the results of conservation work can be seen in the behaviour of the stream. The drainage area, or watershed, of the Avon River above Stratford was studied in detail for the purpose of establishing a pilot project incorporating as many conservation practices as possible.

7. Survey Methods, Reconnaissance Mapping

The soils and land use of the watershed were mapped on a "reconnaissance" scale. That is, the area was travelled by car and visited on foot where vehicles could not drive. An area of 50 acres was set as the minimum of any soil type or condition which could be mapped. Land use was recorded, field by field, in a simple classification. Although aerial photographs with a scale of 5.28 inches to the mile were used to interpret the landscape, the mapping was done on the topographic sheets with a scale of one inch to the mile.

8. Existing Soil Maps and Other Information

While the area was being surveyed, use was made of all reports and maps already in existence. County soil maps were available for Middlesex and Oxford Counties and the soil mapping of Perth County was made available by the Ontario Soil Survey. Geologic maps of Western Ontario were used. Also, reference was made to maps of glacial geology made available by the Ontario Research Foundation.

A previous, detailed study made of erosion and land use capability in 1945 formed the basis of the classification used in the field. Conservation surveys on adjacent areas also contributed to a knowledge of the capabilities of soil types on the watershed.

9. Men and Equipment

The soil conservation survey field work was done by students and graduates in Agriculture and Geography from Ontario Universities. They travelled in pairs throughout the area in jeeps. Their equipment included tiling spades to open up the soil for examination, soil augers to bring up soil samples from depths of three and a half feet, and bottles of dilute hydrochloric acid for a simple chemical test to determine the depth of the soil.

10. Technical Equipment

Aerial photographs on the scale of 1,000 feet to the inch (5.28 inches to the mile) provide base maps on which are recorded all data found by field work. Interpretation of aerial photographs is a method of determining types of land and soil and particularly in establishing the extent and boundaries of any type recognized on the ground. They also provide an accurate map of forest cover, built-up areas and the shape and size of fields.

Abney hand levels are instruments for measuring slopes. These are used to determine the slope of land in estimating erosion conditions. This is an essential part of a conservation survey.

11. Preparation of Maps

The field observations are plotted on aerial photographs. These are traced onto sheets and photostated copies made on the scale of one inch to the mile. The mapping is then traced onto one map of the watershed on the one-inch scale. In printing for publication the scale is further reduced but the original accuracy and detail of the large scale is retained.

CHAPTER 2

SOILS OF THE WATERSHED

1. Definition of Soil

The most generally held idea of soil is that of the mantle of the surface of the earth in which seeds germinate and plants grow. The agricultural use of soil depends on the value of the soil as a medium in which seeds germinate and plants can grow, drawing moisture and nutrients from the soil.

Soil is a natural body formed from the mineral crust of the earth by living things on and within it by the action of air and water. The soil has its own characteristics which sum up the effects of its mineral and organic origin and the forces of weather and life which produce it.

Types of soil are recognized and defined by the various levels or horizons which are revealed in a vertical section or profile. There are three main horizons, the top-soil, the subsoil and the parent material. The topsoil is that which contains the organic matter, shows the greatest effect from weathering and the forces of decay and provides the best medium for plant growth. The subsoil has little or no organic content, but shows the results of the weathering action which has produced the soil. The parent material is entirely of mineral origin, shows little sign of weathering and no effect of life except where roots may have penetrated it.

2. The Great Soil Groups

The soils of the world differ chiefly in the effect of climate. Corresponding to climatic differences over the face of the earth there are major differences in soils. For example, the soils of Ontario, in a cool, moist climate, differ greatly from those of Western Canada with a cool dry climate and those of the Southern United States with a moist warm climate. Each of these areas is included in one of the "great soil groups". Most of the soils of Southern Ontario belong to the group known as the "gray-brown podzolic soils" or "gray-brown forest soils".

The chief weathering effects in the area of gray-brown podzolic soils are those of the surplus of moisture which falls during the greater part of the year, and the acid products of decomposition of trees, leaves and herbs.

Before the land was cleared for farming the natural cover was forest. The decay of leaves and wood produce a top layer of organic matter, or humus, with an acid reaction. The surplus water of rain and snowfall dissolved the acids and the solution percolated downwards through the soil. The acids leach certain minerals, particularly the calcium and iron compounds and the finest (colloidal) particles from the soil below. The iron compounds and colloids are redeposited at a lower level and free lime and magnesium carbonates at the lowest levels of the weathered material.

A vertical cross-section of the soil, or profile, reveals a number of levels or "horizons" with distinct characteristics. In the horizon at the surface the decayed plants are incorporated with mineral material to make a dark-coloured soil. Immediately below this is a very light-coloured horizon with no organic matter, quite powdery and loose. The surplus moisture of the rainfall and the acids from the top horizon have leached the light-coloured horizon. The dark and light-coloured horizons constitute the top soil. The subsoil is brown or reddish-brown in colour and has accumulated in it much of the materials leached out of the topsoil. Below the "subsoil" is the parent material. This is of entirely mineral composition and shows little or no effect of weathering.

The horizons, and their characteristics, of a typical gray-brown forest soil are illustrated in the accompanying illustration.

In an undisturbed virgin soil in a forest area the top horizon is of purely organic material, the result of decay of leaves, and often called "leaf mould". This horizon is labelled the Ao. In land which has been cultivated the Ao horizon has disappeared or mixed in with the lower Al horizon. The Al is the familiar dark, loamy topsoil of an uneroded soil. It is the Al horizon in a virgin soil or a cultivated soil kept in good tilth that offers the best medium for the germination of seeds and the growth of grasses, cereals, roots and many legumes. It is the Al horizon which most readily absorbs the rain and makes moisture available to plants. The chemical nature of the soil in this horizon and the activity of microscopic plants in it make plant food most readily available to crops. The loss of the topsoil by erosion or the loss of its tilth or fertility under mismanagement seriously reduces the value of the soil.

Underneath the dark-coloured topsoil is a light-coloured, dusty horizon. It is labelled the A2. From this horizon the lime, the iron and the fine clay and other colloidal particles have been leached. It is acid in reaction, has less plant nutrients and no well defined structure. In cultivated soils, some of this horizon becomes mixed with the Al. Usually, however, in an exposed vertical section of soil the light-coloured band shows up quite clearly.

The subsoil is called the B horizon. In it are accumulated some of the mineral nutrients, the fine particles and the iron compounds which have been washed from the topsoil. It is the presence of the iron compounds which gives the characteristic brown or reddish-brown colour to the subsoil. The accumulation of colloids makes the subsoil stickier than the topsoil. Movement of air and water, penetration by roots and the action of lime results in a "nut" structure, particularly in loamy and clay loam soils. Subsoil can retain quite a bit of moisture and, if roots can penetrate, the mineral nutrients are available in solution.

The C horizon consists of parent mineral material, gravel, sand, loam, silt or clay. On the watershed these materials are the products of glacial deposition. Their composition is determined largely by the underlying bedrock or rock in nearby areas. The type of material varies with the mode of deposition as described in the physiography section of this report.

3. Soil Classification

Within the soil group to which the Thames soils belong, the chief differences are due to physiographic origin. All soils formed on the same material belong to one "catena". Within one catena there are degrees of development of soils depending chiefly on the freedom of movement of water through them. These series of soils can be named individually or referred to as the excessively, well, imperfectly and poorly drained associates of the catena. In considering large areas like counties or watersheds, the catena and land form is the basis of land classification.

4. Soil Series and Types

A certain system of naming soils is followed by the Ontario Soil Survey, and is generally followed by those doing extension and research work. The basis of the system is the "soil series". Each series takes its name from the locality in which it was first identified. All the samples in a series have similar profiles.

The texture of the topsoil may vary within a series and adding the textural classification (e.g. clay, loam, silty loam, etc.) to the series name identifies a soil type. In fertility and crop response studies or farm planning the soil type is the basis of soil classification.

The soil types of the watershed may be listed as follows:

Soils developed on heavy-textured glacial till:

Well drained -

Huron clay loam		Huron silt loam

Imperfectly drained -

Perth clay loam		Perth silt loam

Poorly drained -

Brookston clay loam		Brookston silt loam

Soils developed on medium-textured glacial till:

Well drained -

Guelph loam

Imperfectly drained -

London loam

Poorly drained -

Parkhill loam

Soils developed on coarse-textured glacial till:

Well drained -

Dumfries loam
Dumfries sandy loam

Poorly drained -

Lyons loam

Soils developed on uniformly stratified sand:

Well drained -

Fox sandy loam

Imperfectly drained -

Brady sandy loam

Poorly drained -

Granby sand

Soils developed on stratified sands and gravels:

Well drained -

Burford gravelly loam

Imperfectly drained -

Brisbane loam

Poorly drained -

Gilford loam

Soils developed on stratified sand over clay :

Well drained -

Bockton sandy loam

Imperfectly drained -

Barrien sandy loam

Poorly drained -

Wauseon sandy loam

5. <u>The Huron Catena</u>

The watershed is dominated by soils of the Huron and Guelph catenas. Both contain soils of high inherent fertility. Possibly the Guelph is easier to handle and is located on more favourable topography.

Soils of the Huron series have about 9 inches of dark brown loamy A1 horizon over 5 to 10 inches of light grayish A2. The B horizon, about a foot in depth, is a rich brown colour, slightly reddish, and has a well developed nut structure. It clods into a hard mass if cultivated when wet. The parent material is a gray stony clay. There may be a few stones throughout the profile. At any one site the thicknesses of the horizon are fairly uniform.

Both clay loam and silt loam types are found within the series. It would seem that the silt loam is easier to work, but in the use of these soils there was not observed any significant difference between the silt loams and clay loams.

The Perth series has a little deeper and darker looking A1 but a less pronounced A2 horizon. The B horizon has a mottled gray and brown colouring and a more compact, sticky structure. This mottling is characteristic of inadequately drained soils. It signifies that the ground water saturates the subsoil for part or all of each year. The typical brown colour of the subsoils of well drained soils is due to the iron oxides. When soils are wet and, therefore, poorly aerated, the brown iron oxides are reduced to gray-coloured compounds. Generally speaking, the wetter the soil, the grayer and more pronounced the mottling in the subsoil.

Both silt loam and clay loam types are found. The silt loam is silty and almost entirely stone-free in the topsoil.

The slow drainage is due to the heavy nature of the material and poor external drainage or both. Unless steps are taken to improve the drainage, the Perth soils are usually unsuitable for winter grains and alfalfa although in favourable seasons may be quite suitable for spring grains and clovers.

Brookston clay is a typical poorly drained clay soil. There is a very dark, rich looking topsoil of 9 to 12 inches. It may be silty and under good management in good tilth. The subsoil consists of about 9 inches of very sticky, mottled clay. Both silt loam and clay types are found. The Brookston soils are, in many cases, the result of deposition of silt and clay by water in past ages. The silty soil is easier to work but the poor drainage in the subsoil and hazard of flood in spring restricts its use except where artificially drained. In the lower part of the watershed where the climate favours earlier working of the land, it may be used without artificial drainage for spring grain and corn. Up in Perth County the climate does not favour early planting and there is much less Brookston soil artificially drained.

6. Guelph Catena

Guelph loam is an easily worked, highly fertile soil which supports some very good farms. The profile is a good example of the type of soil which has developed in Southern Ontario. The topsoil varies in depth. There is about 6 to 8 inches of A1 and 6 to 18 inches of light grayish A2. Considerable variations in depth of A2 occur within a very small area.

Where soil is eroded or the A2 is shallow, the A1 and A2 get mixed in cultivation. It is convenient then to identify the topsoil as an "Ac" horizon.

The subsoil is a foot or more in depth and has a distinctive reddish-brown colour. It has a loose nut structure and is quite open.

The parent material is a gray stony loam. Pebbles, stones and boulders of rough, angular shape are present throughout the profile. In areas where the Guelph series predominates fieldstone houses and barn foundations are common, a feature lacking in areas of the Huron catena. The topography is gently rolling, often with regular smooth ridges. This physical landscape has favoured good farm layouts, but on the slopes, soil erosion is commonly seen.

The London series is the imperfectly drained associate of the Guelph. It is described as a brown loam (A1) over light grayish-brown loam (A2), grading into mottled reddish-brown and gray stony loam and clay loam. The A1 tends to be a little deeper and the B a little shallower than in the Guelph soils. The topsoil may be siltier.

This soil is naturally limited in its use by inadequate drainage. In years of favourable weather when early planting is possible there is considerable acreage of spring grains with apparently good yields. Large areas of the London loam type, however, do not appear to have the prosperous and established farms that are common on the Guelph soils.

The poorly drained associate of the Guelph and London series is the Parkhill. The profile is quite consistent, having a deep, dark-coloured loam topsoil and a grayish, mottled subsoil. The parent material and texture vary considerably. Sometimes the material is just the same as the Guelph and London. There may, however, be layers of silt or even clay. Because this soil is inherently fertile and has a deep topsoil but is limited in use by poor drainage, many acres have been drained artificially for growing cash crops such as beans and sugar beets. When not artificially drained its use is limited to hay and pasture.

7. The Dumfries Catena

Dumfries loam is a coarse-textured, stony soil. It is very pervious to water and may be quite droughty. Because water moves through it so freely, it has a comparatively deep profile. The A1 is a grayish-brown loam and the A2 has 6 to 15 inches of yellowish loam. The B horizon consists of about 10 inches of reddish-brown clay loam. The parent material is a gray loam with both round and angular stones and boulders.

The sandy loam may have as much as 2 feet of A2 horizon and the topsoil is much sandier. Both these types lack fertility and quickly lose organic content unless very well managed.

In areas with Dumfries catena the topography can be quite hilly. It is found along a ridge of hills running south-west from Harrington West to the Cobble Hills in Oxford County. In hollows where the water table is high and there is poor external drainage the poorly drained series, Lyons, is found. In the Guelph catena similar areas of London and Parkhill are drained by single lines of tile but with the Lyons the extra effort of digging through stony soil to improve land which has little natural fertility is not worth while.

8. Fox Catena

Considerable areas of the Fox sandy loam and its associated soils are found near the city of London. The profile of the Fox sandy loam is three feet deep or more. The topsoil consists of an A1 horizon which is a light brown sandy loam. The A2 is a yellow sand of variable depth as much as two feet. The B horizon is a reddish-brown loam with a fairly loose open structure. A parent material is a stratified stone-free sand, generally gray in colour and with a fair content of lime.

Because this soil is easy to work and warms up early in the spring, it is quite useful for cash crops, particularly tobacco and fruit. Because of its open structure and coarse texture, water moves through it very readily and it may become very dry in summer. Also, the original organic matter in the A1 horizon is soon worn out under cultivation. Where the usually flat relief associated with this soil is broken by steep stream valleys, the soil is subject to water erosion and, once the sand is exposed, to wind erosion.

Within the areas of Fox sand there are low spots with no effective surface drainage and a fluctuating high water table. In these areas are found the imperfectly drained associates called Brady sand, which has a deep A1, a shallower A2 which grades into the mottled gray and brown B horizon. Because of more favourable water relations, this soil may be considered to be a little better than the Fox, although it may be limited in its use by a late season due to water lying about in the fields.

The poorly drained series is called Granby. It has a topsoil which is normally quite deep but has a dark, nearly black colour. The subsoil is gray mottled sand. Because of its location this is often difficult to work due to water or wet conditions in the spring of the year. It is sometimes artificially drained, but this is not altogether to be recommended as in its natural state this soil can store quite a bit of water and when it is drained, it is subject to the same loss of fertility and organic material as its better drained associates, the Brady and Fox.

In some areas the sand deposits are quite shallow over clay. Usually the profile development is within the sand and the underlying clay is left unweathered. The impervious clay restricts the downward movement of water and the profile in the sand resembles that of the Brady soil. The soil series is here called the Berrien and is usually found as a sandy loam. The well drained series is called Bookton and the poorly drained is called Wauseon. The latter soil may be artificially underdrained. All these soils are quite intensively used, particularly for market gardening and fruit growing.

9. Burford Catena

Along the broad flat bottoms of many of the valleys, the meltwater channels and spillways described in the physiography of the watershed, and also in broad flat plains near Thamesford are deposits of gravel and silt uniformly stratified.

The well drained soil in this catena is called the Burford and may be two types, a loam and a gravelly loam. Although there is some disadvantage in its gravelly nature or the occurrence of cobblestones, it is quite a useful soil. On the valley bottoms, however, it is sometimes subject to annual flooding and possibly leaching of mineral nutrients by the downward movement of water.

The Burford loam is described as a light brown gravelly loam with 6 to 12 inches of yellowish-brown sand or gravelly loam and a subsoil of 8 to 10 inches of reddish-brown clayey or silty loam. Parent material is stratified, glay, calcarious gravel.

The imperfectly drained associate is the Brisbane series and the poorly drained the Gilford series. These have progressively deeper and darker coloured A1 horizons and grayish mottled subsoils. The natural limitation to the use of these soils is the hazard of flood and moist conditions early in the season, although because of their permeable nature they may become quite droughty in the summer.

10. Bottom Land and Muck

Along some river valleys there are soils which are built up from year to year by deposits of silt and they show no profile development. These soils are designated as bottom land.

In some low areas with no surface drainage there is an accumulation of 18 inches or more of decomposed organic matter. These soils are called muck. If the water table is permanently high, the organic matter does not decompose completely and the result is a peat.

The bottom land muck and peat soils are usually covered by pasture or woodland, although much could be done to improve the management for these two uses.

A cut to show the profile of Guelph loam. Under the dark loam of the topsoil is a light gray level. The reddish brown subsoil is beside the shaft of the spade.

Dumfries loam. A coarse-textured permeable soil with a deep leached horizon (light gray beside the handle of the spade).

Tobacco is grown on the light, sandy soils of the Fox series.

CHAPTER 3

CAPABILITY CLASSIFICATION

1. Definition of the Capability Classification[1]

Land classification according to its use capability is done so in terms of its physical characteristics. The classes are named according to the uses or systems of management that will give the best return from the land without deteriorating the land.

The classification described in this chapter is one developed by the Soil Conservation Service of the U.S. Department of Agriculture and adapted for use in this Province by the Conservation Branch of the Department of Planning and Development and by the farm planning group at the Ontario Agricultural College.

There are four main classes of land subdivided into eight use capability classes. They are summarized here.

A. Suitable for cultivation with:

- I - No special practices
- II - Simple practices
- III - Intensive practices

B. Suitable for occasional or limited cultivation with:

- IV - Limited use and intensive practices

C. Not suitable for cultivation but suitable for permanent vegetation with:

- V - No special restrictions or special practices
- VI - Moderate restrictions in use
- VII - Severe restrictions in use

D. Not suitable for cultivation, grazing or forestry:

- VIII - Land may be of value for wildlife

2. The Land Use Capability Classes

I - Land which is fertile, nearly level, not eroded, well drained, which can be farmed under ordinary good farm management without deteriorating.

II - Land whose inherent characteristics include some lack of fertility or organic matter, sloping and eroded or

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1. Classifying Land for Conservation Farming. Farmers' Bulletin No. 1853. U.S. Department of Agriculture.

subject to erosion, or is naturally inadequately drained, which may be brought into a high state of production by overcoming fertility or humus deficiency, by checking erosion with simple practices, such as extended rotations or contour tillage, or which can be improved by simple artificial drainage.

III - Land of lower capability which can be sustained in production if protected from erosion by intensive erosion control practices, such as contour strips, diversion terraces; inadequately drained land which may be brought into full production by under-drainage; or land which can be used to only a limited extent because of shallowness, droughtiness, boulders, and so on.

IV - Land of low capability subject to erosion, which is difficult to cultivate, is inadequately drained or which is suitable only for a limited use, on which intensive soil-building practices and restrictions in use are necessary to maintain it in production.

V - Land which cannot ordinarily carry cultivated crops or a crop rotation but which can be maintained under sod or tree cover indefinitely without any special practices or any restrictions in its use. It usually includes bottom land and muck areas which cannot be drained.

VI - Land which cannot be tilled regularly because it is rough or is subject to erosion and cannot be exposed by regular cultivation, but which may be used for permanent improved pasture or for forestry.

VII - Land which must be maintained under sod or forest cover and, if sod, grazing should be controlled; and if under tree cover, planting on the contour, or when lumbered special methods followed to avoid wheel tracks and skid marks which might induce gullying.

VIII - This class includes very wet places, bouldery areas or outcrops of bedrock and gravel beds which may carry enough vegetation to offer a shelter from wildlife.

Class I land on Perth silt loam that has been underdrained. This 1 per cent slope with no appreciable erosion has been seeded to a good mixture of grasses and legumes.

Class I land on well drained Huron silt loam: slope under 2 per cent with no appreciable erosion. The crop is Winter Wheat with fodder corn on the right.

Class II land, suitable for contour ploughing, is subject to erosion when ploughed up and down the slope in this manner.

Class III land. This field has been exposed to erosion until more than two-thirds of the topsoil has been washed to the flats. Shallow gullies have commenced in the furrows.

Class III land. On this 10 per cent slope sheet erosion is accompanied by shallow gullies. Only about 5 inches of the 18 inches of normal Huron topsoil found on adjacent fence lines remains, and accumulations at the foot of the hill have increased the depth of topsoil to 38 inches. The crop is Fall Wheat.

Class IV land. Rill erosion, forming gullies as a result of ploughing up and down the slope. Note accumulation of the topsoil in the hollow.

Class III and Class IV land on the slopes and Class V land on the bottom land of Trout Creek are typical.

Class III land on the slopes and Class V land on the flooded bottom. The slopes are between 10 and 15 per cent and have lost between one-third and two-thirds of their original topsoil.

Class V land at the headwaters of Trout Creek is covered by a woodlot.

Class VI land on slopes from 25 to 35 per cent. This land was still being cultivated up to the spring of 1945. Erosion has progressed to the extent that much of the subsoil had been lost, as well as the topsoil. In the spring of 1946 the owner planted this area with trees.

Class IV land. Unimproved Brookston clay loam is too poorly drained to be cropped in regular rotations and is best suited to hay and pasture.

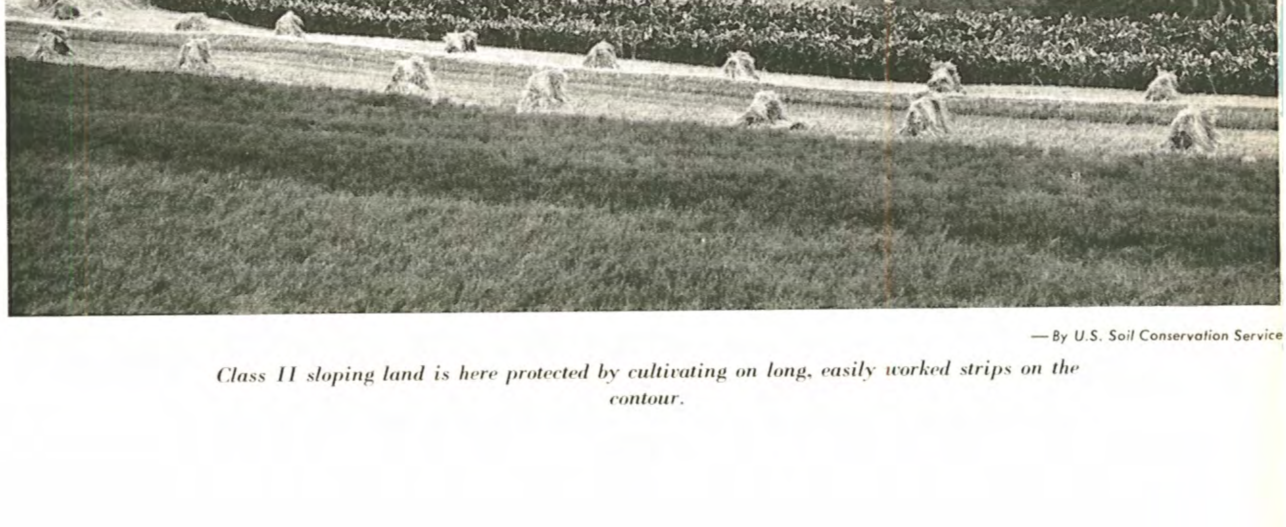
Class IV land on a 12 per cent Huron silt loam slope where sheet erosion has reduced the topsoil to almost nil and small gullies have become frequent. The field is still being ploughed up and down the slope.

Class VI land. Rough, hummocky eroded Dumfries loam with slopes ranging from 15 to 40 per cent. Present pasture is poor, having a low carrying capacity, and much of it is recommended for reforestation.

Class VI land. Present woodland on rough Dumfries soil has been reduced to 20 per cent.

— By U.S. Soil Conservation Service

Class II and Class III land on smooth slopes can be protected from erosion and fast run-off of water by planting on the contour alternate strips of close-growing, erosion-resisting crops and cultivated row crops.



— By U.S. Soil Conservation Service

Class II sloping land is here protected by cultivating on long, easily worked strips on the contour.

3. <u>The 1945 Conservation Survey of the North Branch Creek and Trout Creek of the Upper Thames Watershed</u>

In this survey conducted by the Conservation Branch, more than 58,000 acres were examined in detail. The soil type was identified, 11 slope classes were identified and 5 grades of estimated erosion. At the same time the land use of each field was identified as cultivated, permanent pasture, woodland or idle. From comparisons of slope, erosion, natural drainage and soil type, the capability classification was derived. Herewith is the summary of the findings of that survey. First, it was found that soils of the Huron and Perth series are either flat or, if sloping, little more than 6 per cent slopes were found. Soils of the Guelph series were also mostly either flat or with slopes under 6 per cent, but some areas of irregular slopes up to 15 per cent occur. Soils of the Dumfries series are commonly found on rough, irregular slopes of 15 per cent. The less well drained series, Brookston, London and Parkhill and the Burford series were generally on level land. The incidence of erosion is summarized in the following table.

ACREAGE AND PERCENTAGE OF EACH EROSION GROUP

Erosion Group	Combined Acres	Area %
No apparent erosion	38,582	66.2
Slight erosion	11,926	20.5
Moderate erosion	7,216	12.4
Severe erosion	487	0.8
Gravel pits	31	0.05
Ponds	49	0.1
Entire project	58,291	100.00

Land use on the area was found to be 70 per cent crop land, 20 per cent pasture, 9 per cent woodland and the remaining area idle, covered by water or urban development. The Huron, the Perth, the Guelph and the London series had more than 80 per cent in crop land, which is 10 per cent higher than the average for the area. The highest percentages of woodland were on the Brookston soils, where they did not have artificially drained land, on the Dumfries soils and on muck and bottom land.

A fairly high proportion of slight and moderate erosion were found on the Guelph and Dumfries soils, which is to be expected as those are the two soil types found on sloping ground. A direct relation was found by comparing estimated erosion to slope classes. On land which had slopes under 6 per cent, only slight erosion was found, but on slopes between 6 and 15 per cent most of it was moderately eroded and only about a quarter of it just slightly eroded. On slopes over 15 per cent about three-quarters is moderately eroded and the rest severely eroded. The degree of erosion is a little less on soils on rough, irregular slopes, presumably because these had been cultivated less than the smooth slopes. On crop land there was found to be no erosion on 64.7 per cent, slightly less than the "no apparent erosion" for the whole area. Slight and moderate erosion on crop land was found on a slightly larger proportion than on the whole area. On pasture land moderate erosion was found on 17 per cent of the area, which is considerably higher than the average, and on woodland only 4 per cent was moderately eroded. It would appear that enough of the woodland had remained from the original stand of trees to cut down the amount of erosion, but the high proportion of moderate erosion on pasture land would appear to indicate that much of this land had been relegated to pasture because of erosion that had taken place in the past.

Flat and uneroded land of the well drained series was grouped in Class I. Slopes under 7 per cent which, as was shown above, did not have a high degree of erosion, were put into Class II. Slopes over 7 per cent were put into Class III land, as were the Perth and London (imperfectly drained soils). Class IV land includes slopes up to 10 per cent if there was gullying, and up to 15 per cent if there were no gullies found. Bottom land and muck were allocated to Class V. Class VI land included slopes over 15 per cent if gullying or severe erosion were found, and on slopes over 20 per cent. Gravel pits, sandy ridges which might be reforested were allocated to Class VII, and ponds were considered as Class VIII land. A multitude of classes of soil types and conditions, when thus grouped into eight classes, gave the following proportions: Class I - 36.3 per cent; Class II - 34.3 per cent; Class III - 6.7 per cent; Class IV - 11.4 per cent; Class V - 7.5 per cent; Class VI - 3.7 per cent; and insignificant proportions of Classes VII and VIII.

When the present use of the land of the capability class is determined, two interesting features are apparent. First, the land of higher capability includes higher proportions of crop land and the land of low capability includes higher proportions of pasture and woodland, so that in general there is some adjustment of use to capability. The second feature is important in considering the future. There are still significant areas of land of low capability which are being used intensively for crop land. What is of further significance is that although much of the land of the low capability class, on account of drainage, is artificially drained, none of the land subject to erosion was being protected by any special tillage methods, and little of it being protected by any cropping systems designed to check erosion. The use of animal manure, limited use of green manure crops and a haphazard reliance on crop rotations were the only means of protection against erosion that were found.

4. <u>Results of the 1945 Survey</u>

Although some of the soil types found on the whole of the Upper Thames Watershed do not occur in the sample area done in 1945, a good deal was learned about soils of the Guelph, Huron, Dumfries and Burford catenas. The increasing incidence of erosion with increasing slope, the intensive use of the less sloping and less eroded soils, the degree to which the use of the inadequately drained soils depended on artificial drainage, gives a basis for assigning different types of land to the use capability class, and in the survey carried out in 1950 land was allocated to a capability class directly in the field without reference to the more specific slope and erosion class. In this way it was possible to do a reconnaissance survey of the entire watershed, having previously examined a smaller part of it in detail.

Similar work was done by the Conservation Branch on the watershed of the Ausable River in the summer of 1947, and soil types found on the Thames Watershed, particularly the Berrien and Fox series, were examined in detail and capability classes assigned to them. Further, the problem of neglected pasture and compaction of clayey soils of the Huron catenas was studied. The importance of pasture improvement in bringing these soils into a more productive state and making them less susceptible to erosion and accelerated run-off was studied so that again, on the reconnaissance survey, land could be allocated to a capability class from direct observation on the field.

CHAPTER 4

RECOMMENDED LAND USE ACCORDING TO USE CAPABILITY

1. Conditions Which Lower Use Capability

Certain conditions are generally recognized as lowering the use capability of soil - lack of fertility, inadequate drainage, droughtiness, stoniness and rough topography. Erosion, susceptibility to erosion, compaction, droughtiness resulting from erosion and lack of organic matter are not so generally recognized.

The capability classification described in the previous chapter is a "rating" of capability. The soils with lower ratings (II, III, IV and so on) have progressively poorer inherent capability or require more intensive practices (drainage, tillage methods for erosion control, extended rotations) to sustain them in production without deteriorating.

In this chapter there will be outlined a classification of "recommended" land use, according to use capability. In each class the recommended use is related to the condition which lowers its capability rating. This system avoids the numbering of classes and names them explicitly in terms of the recommended use.

2. Erosion, Run-off and Slope

The results of the detailed survey in 1945 showed how the degree of erosion increased with slope and how erosion affected land use. There is evidence of decreasing yields on eroded land which has lost its topsoil. Tests made on gently sloping plots of Huron soil near New Hamburg show how much soil and water is lost by erosion. These tests also show how much less is lost from land covered by sod or protected by contour tillage.

More serious, probably, than the loss of topsoil by erosion is the loss of water and the lower ability of eroded land to absorb and retain moisture. When land is

The spring thaw washed out this small gully on a 3 per cent slope near Stratford.

A heavy summer rain did this damage in less than one hour on a farm near Stratford.

Long smooth slopes like the one in the background on No. 7 Highway near Rannoch are very subject to erosion but can be controlled by contour methods of cultivation.

kept under cultivation, particularly where furrows and drill rows run up and down hill, topsoil is eroded. The soil that remains cannot absorb rainfall so readily, thus run-off is increased and both erosion and accelerated run-off are aggravated.

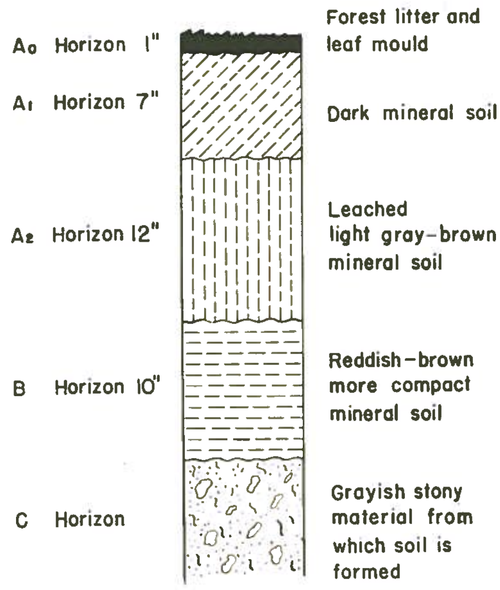
If water is held by contour cultivation and soil organic matter built up, the soil is improved with respect to moisture absorption. For example, there is much less erosion and water loss on a cornfield when corn follows a soil-building crop than from corn following corn or other tilled crops.

Even though examination of a soil on a slope does not reveal any serious erosion in the past, there is always the possibility of erosion if it is found on similar slopes. Any method of checking erosion on land susceptible to it should increase the moisture-absorbing and holding capability of the soil and cut down on the hazard of drought.

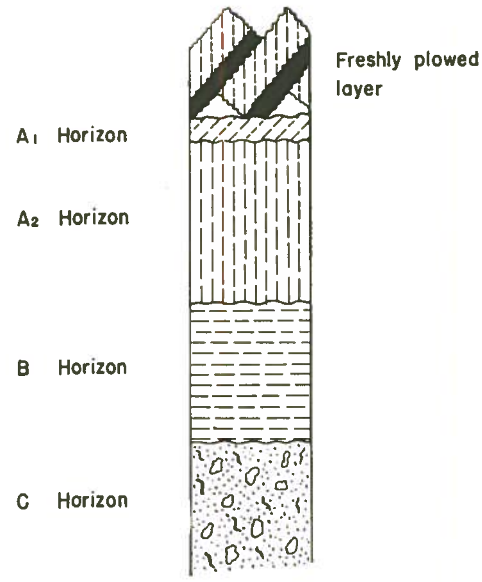
3. <u>Identifying and Estimating Erosion</u>

The most obvious evidence of erosion is gullying or, in the case of sand, blowouts. Deposition of soil at the bottom of a slope due to "soil wash" is also commonly seen and recognized. Rills, or small gullies, form in implement tracks, dead furrows or between rows of corn or other intertilled crops. These, however, are soon obscured by cultivation or crops.

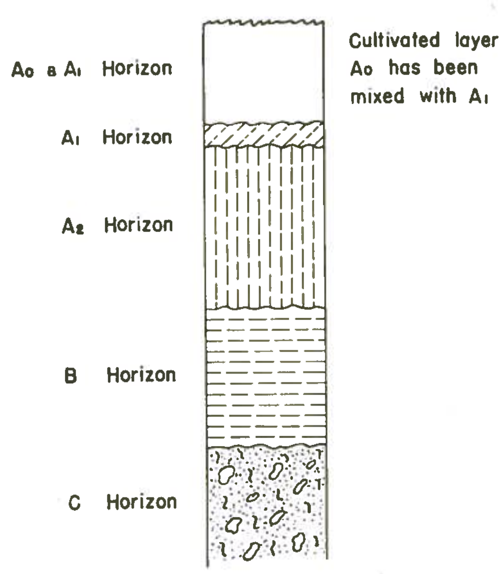
Less obvious evidence is the piling up of soil on the uphill side of a fence or the cutting away on the downhill side. In addition to all these surface clues to erosion there is an indirect clue. That is in crop response. When soil is eroded it is usually more droughty. On bald eroded slopes the growth may be quicker on dry soils in the wet early spring, but through most of the year the growth is poorer. Patchy crop response on slopes is a good way of detecting erosion.



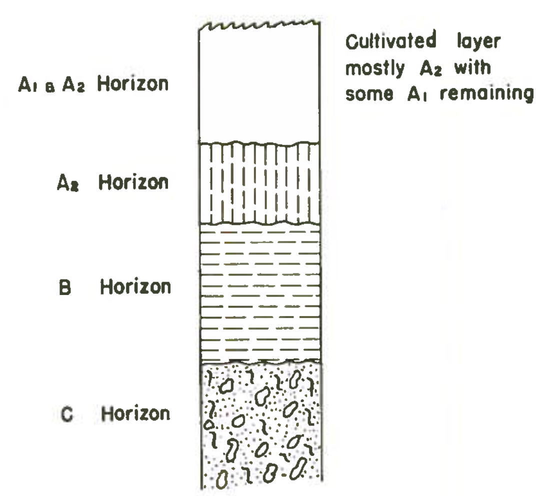
Virgin Profile
natural forest soil



Virgin Profile
after first plowing



Non-eroded
cultivated soil



Eroded cultivated soil
where ½ topsoil
has been lost

The above diagrams illustrate the various horizons found in the profile of Guelph loam, typical of the well drained soils of the region. The extent to which erosion has progressed may be ascertained by comparing the thickness of the present upper horizon with that of the same horizon in an undisturbed situation on similar slope.

There is one way of detecting and estimating erosion which is independent of seasonal changes or superficial evidence. This is examination of the soil profile.

Once a soil type has been identified at a location, an example of a good profile may be found in a woodlot or along a fence row on level or nearly level land.

In one example a full profile might show, say, 30 inches to the bottom of the subsoil (B horizon). This can be identified by using a dilute solution of Hydrochloric (or Muriatic) acid. The acid effervesces, or fizzes, on free carbonates which are not found within the A or B horizons. If, on the suspected erosion site, free carbonates are found at 20 inches then something like 10 inches of soil has been lost.

Of course the depth of profile may vary and the acid test may not be very definite, but if, by feel and sight, the horizons can be identified a good estimation of the degree of erosion can be made.

4. Inadequate Drainage

Removal of surplus water from the soil by natural means may be due to one or more of three factors. First, the ground-water table may be near the surface. This condition is found in low-lying areas and sometimes in upland regions. Second, the surface relief may be such as to check overland run-off of water to a stream course. The third factor is an impermeable soil, usually a clay, especially those which have been compacted when they were deposited.

The ill effects of inadequate drainage on agriculture are well known. Water lying on fields in spring delays cultivation and planting. Clay soils cannot be tilled in a wet condition. Winter killing and heaving are more likely in wet soils. Soils saturated with water are kept cool until later in the season so that germination and growth are delayed. Moisture in soils excludes air which is necessary to plants and to microscopic life within the soil.

Crops on poorly drained soils which dry out in summer are more subject to drought. This is because roots cannot penetrate so deeply during the actively growing season and if the weather is dry later, in July and August, the plants' roots are not down deep enough.

Poorly drained soils provide less storage capacity for moisture, partly because they may be saturated at the time surplus rain falls and partly because they do not have the open structure of well drained soils that lets water penetrate.

Where poor drainage is due merely to surface irregularities it can be remedied by ditches. High water tables and standing water in low spots can be remedied by single lines of tile.

Broad areas of poorly drained clay are artificially underdrained by using tile in grid or herring-bone patterns. The tile mains lead to outlet in streams and where streams are not well defined ditches are dug.

Inadequacy of drainage is often obvious from the evidence of standing water, wet spots or poor crop response Regardless of season the state of drainage can be identified by examination of the soil profile. Well drained soils have characteristically brown or reddish-brown subsoils. Imperfect-ly drained soils have mottled brown and gray subsoils and poorly drained, gray subsoils with some brown mottling. This condition can be examined no matter how dry it is at the time.

5. Compaction

Soil is compacted when its constituent particles come together and reduce the pore space, which holds air or water, between them. This may be a natural condition of the soil due to its mode of deposition under pressure of the ice or due to the physical properties of the clay, which may be quite massive, or it may be due to poor drainage. Compaction may be the result of its use. This may be due to the actual weight of implements or to the soil particles being broken into finer particles by cultivation and then puddled by water to make a massive clay. It may result from trampling by cattle. Further, it can be due to loss of organic matter which ordinarily helps to maintain soil structure when the soil more or less "collapses" when the organic matter is depleted.

This condition is found particularly on the Huron and Perth soils where these have been neglected and used for pasture without any improvement practices. In this condition the soils deteriorate, plants do not root as well, they are less absorptive to moisture, run-off is accelerated and, if it is sloping, so is erosion. Where these soils require breaking up mechanically to a greater depth than is usual in ploughing, it may be necessary to use deep ploughing or sub-surface tillage. Mechanical operations, however, will not entirely correct this condition as they have the tendency further to pulverize the soil and make it subject to compaction, particularly during heavy rains. The breaking up of these soils by deep-rooted legumes should improve the subsoils and the re-establishment of a good organic content in the topsoil should bring them into good tilth. This may be done by top dressings of manure on pasture or by growing green manure crops or bringing them into a crop rotation with an emphasis on soil-building crops, the grasses and legumes. The generally poor state of pastures and the obviously poor tilth of top soils is enough evidence to indicate this condition on soil types which are ordinarily quite productive.

6. Cover Crops

Ploughing under cover crops and maintaining vegetation on sloping fields over winter have two beneficial results. The first is to increase organic content of the soil by adding these crops to it. The second is to provide a mechanical check to the overland run-off of water, particularly in the late fall with its heavy rains and the early spring with the thaw. There is some evidence too that the maintenance of cover crops during the frost period has a beneficial effect on soil structure generally.

7. Pasture

Maintenance of improved pasture on land held under pasture for six or seven years or cultivation for a crop and then re-seeding to pasture are the greatest single erosion control measures with respect to the area on which they may be applied. Compared to the land subject to erosion which might be protected by contour tillage, the area which can be protected by wise use of cover crop and by the use of improved pasture is very great. Pasture, when seeded, fertilized and managed, gives far greater returns in beef or milk than pasture which is left to run wild indefinitely. Pasture improvement is, therefore, a good step to take from the farming point of view alone. It is also good to control erosion and accelerated run-off. Again, as with the cover crops, it tends to build up organic content of the soil and provides a mechanical check to overland run-off of water.

8. Contour Tillage

On smooth slopes whose only disadvantage is susceptibility to erosion and accelerated run-off, there are methods of tillage which check erosion mechanically. These methods include ploughing, cultivating and seeding on the contour, that is, along the level rather than up and down hill, and the establishment of strip-cropping on the contour. An example of this might be 20 acres of land all on one smooth slope. Supposing that a four-year rotation is normally carried out, then the field should be struck out into four strips of 5 acres each. Two might be seeded to grasses and legumes for hay, and the alternate strips seeded to grain and corn as they appear in the rotation. At the end of two years the sod of the meadow

A grassed waterway in a field of grain near Fullarton is good farming practice and good erosion control.

On smooth slopes alternate strips cultivated "on the level" save soil and water. This is on a farm near Byron.

Improved stands of grass and legumes constitute the most effective tool in building soil, saving moisture and resisting erosion. They produce good milk and beef, too. This splendid example is on a farm south-east of Ingersoll.

strips is ploughed under and made available to the crops while the strips which were cultivated for two years will be under grass. At the end of the four-year rotation each piece of land would have had its two years meadow and two years field crops and in any one year the sod of the meadow checks any run-off and soil washed from the cultivated strip.

9. Diversion and Grassed Waterways

Along with contour strips or as a measure by themselves diversion terraces or ditches can be struck out across the slopes. They are not absolutely on the level but are led slightly downhill towards a safe outlet. They may be constructed by ploughing or by using terracing equipment. Any water, with its burden of soil, that is washed down from the upper slope is caught in the diversion. The soil suspended in the water is deposited out as the flow is slowed down and the water is led slowly across the hill.

To dispose of the water from the diversion or merely to carry the water of the natural watercourses harmlessly across the field it is wise to have a grassed waterway. This may be achieved once the field is in sod by merely tripping the implements as they cross the watercourse and the stand of sod is retained along the path of the water. In some instances it is necessary to construct the watercourse by ploughing and grading and then establishing a good seed mixture which will establish sod within one season. Where there is a steep drop it might be necessary to lay sod cut from some other place. A bulletin on the construction of "Grassed Waterways"[1] is available from the Ontario Department of Agriculture.

10. Recommended Land Use According to Its Capabilities

The following are the seven classes of land indicated on the map which accompanies this report and a description of them.

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1. Grassed Waterways: Ontario Agricultural College Circular 81. 1950.

L - Cultivated Land

Included in this class are soils of the Huron, Guelph, Fox and Burford series which are fairly level and not subject to erosion.

There are no restrictions on the use of these soils nor any special practices over and above what is recognized as good farming to keep them in a cultivable and highly protective state indefinitely.

LR - Restricted Cultivation

Soils of the Dumfries series, even though level, and soils of the Guelph, Huron, Burford and Fox series, which have mild (that is less than 15 per cent) but irregular slopes which are subject to erosion and accelerated run-off but which do not lend themselves to mechanical methods of erosion control.

Erosion can be controlled from these soils by extending the rotation to include more soil-building crops and less grain and a minimum of intertilled crops, such as corn, beets, mangels and so on. Erosion in late fall and early spring can be checked by maintaining them under winter grain which may be in rotation or as a catch crop.

Diversion channels can sometimes be constructed to intercept the flow down these hills and in some cases single lines of tile are necessary to drain low-lying spots.

Soils of the Perth and London series are also included in this class if they are sloping, as they are also subject to erosion even though some provision has to be made to improve their drainage. If they are drained by tile, or left with dead furrows up and down hill during winter, it might be well to break the slope with strips of sod or diversion channels.

CF - Contour Cultivation

This class includes smooth slopes up to about 15 per cent on soils of the Huron, Perth, Guelph, Dumfries, Burford and Fox series that have been eroded or, because of their slope, are subject to erosion.

On slopes up to 4 or 5 per cent, regular cultivation and crop rotation may be maintained if the fields are struck out so that cultivation is along the contour, that is, "on the level" rather than up and down the slope. On steep slopes contour strip-cropping should be practised. If the slope is not long enough to allow for alternate strips of grassland and cultivated land a buffer strip of sod may be left across the slope or a diversion terrace established.

LD - Drainable Land

All the soils of the Perth and London series that are not subject to erosion, and much of the Brookston and Parkhill soils where suitable outlet can be found, can be brought into a high state of cultivation and made to conserve moisture if they are artificially drained.

Some of the Perth and London soils can be adequately drained with field ditches or merely striking out dead furrows to act as small ditches. Sometimes the small areas of these soils are found in depressions and can be adequately drained by single lines of tile. In some instances it may be worthwhile, particularly in the Parkhill and Brookston soils, to install thorough systems of tile underdrainage. Much of these soils has already been treated in this manner.

Although ditches are required to provide outlet for tile on these soils, much of the area is now adequately served in this respect and if further ditching is necessary some caution must be used in the safe construction of ditches and against digging where ditches are not necessary. There is a strong feeling that excessive ditching accelerates flow in the river system and contributes to flood, and evidence of this is easily seen, particularly in the location of the ditch itself. Moreover, once an outlet is established it should not be necessary to strike a ditch straight through to a natural outlet. Where this is done there is a tendency for a great deal of ice to pile up and when the ice jam breaks there is local flooding and a minor flood crest passes on down the river.

There is some question of the advisability of the intensive under-drainage on the soils of the Huron Catena in the north part of the watershed. Apart from any problem of drainage aggravating flood conditions, there is a question as to the actual economic value of drainage in that area. It is located towards the north limit of cash cropping of wheat and the growing of corn for husking. That is, even on well drained soils, there is not the intensive use that there is further south and down stream and the cost of under-drainage must be weighed against benefits. If wet soils are too late for corn for silage they can still be used successfully for grass and legume mixtures which are suitable for ensiling and much can be said of the advantage of this type of farming. Indeed, for either erosion control or optimum use of inadequately drained soils, grassland farming and the use of grass silage have many arguments to support them. Some poorly drained Perth, Huron and Brookston soils have not adequate outlets for artificial drainage and use is naturally restricted by poor drainage. Best use can be made of these soils by seeding them with species of grass and legumes that are tolerant of wet conditions. Timothy and red clover may last for some time, although orchard grass is more commonly found. Reed canary grass is recommended for these soils but is not commonly found. Unless well managed with rotational pasture or regular clipping it tends to become coarse and unpalatable. On similar conditions in New York State, Bird's Foot Trefoil has been found useful as it is tolerant of wet conditions and produces fodder which, though not as satisfactory as alfalfa, is much better than what is obtained by letting hay and pasture go wild on these soils.

ND - Not Drainable

Lyons loam, poorly drained associate of the Dumfries soil, is too stony and bouldery to lend itself to artificial drainage. The poorly drained associates of Burford found in the valley bottoms would not appear to be suitable for artificial drainage as they are so pervious as to become droughty and to lose fertility very easily. More study might be made of this problem but no examples were found on the watershed of intensive use of these soils.

The poorly drained sands are not recommended for drainage unless they have a very large organic soil overlying them and can be managed without danger of drought for special crops, particularly market gardening.

P - Improved Pasture

A good deal of land suitable only for pasture is already under grass, but with respect to area very little of it can be said to be well managed. Carrying capacity is not nearly as high as it might be. Weeds are common, especially wild carrot (or Queen Anne's Lace) and there is evidence of serious compaction. In upland regions pastures dry out in summer, probably because of the poor absorptive and retentive capacity of the soil for moisture.

Not only to improve production, but to improve the absorptive and holding capacity of these soils for the benefit of the whole watershed, these pastures could well be improved.

As was seen on the detailed study done in 1945, lands of steep slopes over 15 per cent are commonly seriously eroded and yet much of them are still under cultivation. It is not practicable to apply methods of contour cultivation on these soils, but they can be protected with improved stands of pasture which can yield nearly as well as pasture on better lands.

In the matter of pasture improvement reference may be made to publications on this subject by both the Ontario and Dominion Departments of Agriculture. Splendid examples of pasture improvement can be found on the farms co-operating with the Ontario Crop Improvement Association and the Department of Agriculture. The County of Middlesex has carried out some valuable studies on pasture renewal, renovation and management. The results of these studies and demonstrations can be applied to a great deal of the land which is indicated as recommended for improved pasture on the map which accompanies this report.

F - Woodlots and Reforestation

Much of the existing woodland on the watershed is to be found only in the very poorly drained areas. Small woodlots are found commonly on the backs of farms irrespective of soil types. Most of these could be improved in their management and this is discussed in the Forestry section of the report.

Steeply sloping land and land which has been gullied or wind-eroded should be put under forest cover by reforestation. Large areas for reforestation are indicated on the Forestry map accompanying this report, and areas which might be reforested by individuals are indicated on the Recommended Land Use map.

CHAPTER 5

PRESENT LAND USE

1. Present Land Use

An inventory of present land use is made for two reasons. First, to estimate the capability of the land, taking the present use as an indication of the experience of those who have been using the land for generations. Second is to estimate the degree to which use is adjusted to capability and the extent to which changes in use or management are required to bring all the land into its wisest use.

Present use of land over the whole area was mapped in six classes; in the order of the intensity of use and degree to which they expose land to soil erosion and water run-off they are as follows: idle (wasteland), forest, pasture, cultivated (in regular crop rotations), row crops and urban use.

2. Forest

Land which is covered by trees to at least 40 per cent of the area is considered woodland. It may or may not contain merchantable timber and may be only scrub growth. Much of it is pastured, but as it could become useful forest if ungrazed it is still classed as forest.

Some areas are not cultivated, grazed or supporting any tree growth and they are classed as idle.

3. Pasture

If land appears to have been under sod for longer than might be expected in any rotation it is considered to be pasture. This includes wasteland pasture, that is, land which has been cleared but has never been regularly cultivated. Some pastures have been established in the past by allowing formerly cultivated land to go to grass. Some were seeded to grasses years ago and have never been turned under since.

Pasture, hay and grain with a herd of beef animals, on Huron & Perth soils near Kinkora.

The milk herd is the backbone of agriculture. This mixed herd is grazing on improved pasture on a clay soil in Blanshard Township.

Under good management high yields of oats and other grains are obtained, like this field on London loam near Zorra Station.

4. <u>Cultivated</u>

Classed as cultivated is all that land which appears to be within a crop rotation of some sort and includes not only grain, clover and alfalfa but stands of hay or even of pasture when it is a recent seeding and appears likely to be turned under in due course in the rotation.

5. <u>Row Crops</u>

Included in this class are corn, roots, tobacco, beans and truck and fruit crops. These usually represent a more intensive use of land and they not only make heavier demands on the soil without returning anything to it but in their cultivation expose land to soil erosion if they are on slopes.

6. <u>Measuring Land Use</u>

The actual use of any particular piece of land is of little consequence except to the man who operates it. This survey is an inventory of soil and land use of the whole area and it is the relative proportions that are significant, not the use on any one field at any given time.

To determine the proportions of use only about one-third of the area was actually measured. This was done in this way. The mapping on the aerial photographs was traced on to large sheets of vellum, using an instrument known as the Abrams Sketchmaster. On the vellum a grid is drawn to indicate the roads at the scale of the photographs. An image of the mapping on the photo is projected on to the vellum and, by adjustment of the instrument, distortions and variations in scale are corrected.

The measuring of areas, or "planimetering", was done with a dotted template. This is a transparent sheet of "acetate" on which are printed dots which represent one acre of land on the scale of one inch to a thousand feet.

The area to be planimetered was chosen from regions scattered around the watershed which were considered representative of all the types of land and classes of land use that are found.

7. <u>Summary of Land Use</u>

Some 313,000 acres were analyzed. The following table shows the acreage and proportion of each use.

Use	Acres	Per Cent
Row Crops	21,597	6.9
Cultivated	195,983	62.6
Pasture	69,130	22.1
Forest	21,684	6.9
Idle & Urban	4,641	1.5
Total	313,031	100.0

Row crops and all other cultivated land together account for 69.5 or nearly 70 per cent of all the land. The figure of 6.9 or nearly 7 per cent of the land under forest cover is very close to that determined for the whole watershed in the survey of woodlots.

To summarize, present use is in roughly the following proportions:

Cultivated	70 per cent
Pastured	22 per cent
Wooded	7 per cent

Any program of soil conservation must take into account the demonstrated demand for regular cultivation on 70 per cent of the land of the watershed. If, for conservation purposes, more land is required to be under sod or trees, then the productivity of the cultivated land must be increased. The proportion of cultivable land will be shown in Chapter 7.

CHAPTER 6

TYPES OF FARMS

1. Basis of Classification

Although the watershed is favourable by reason of climate, soils and economic conditions to the growing of a considerable acreage and variety of cash crops, farming is still based on a mixture of crops and the production of beef, dairy products, pork and poultry. Except in rare instances, pigs and poultry are secondary to the production of beef and dairy products and are carried out usually in conjunction with the latter. The main difference in types of farms is, therefore, in the emphasis on beef animals or milch cows.

Each farm on the watershed was visited and recorded on a map as having either a beef herd or a dairy herd. Of course a few farms had dual-purpose cattle and many, although they were obviously devoted to milk production, carried a number of animals for slaughtering.

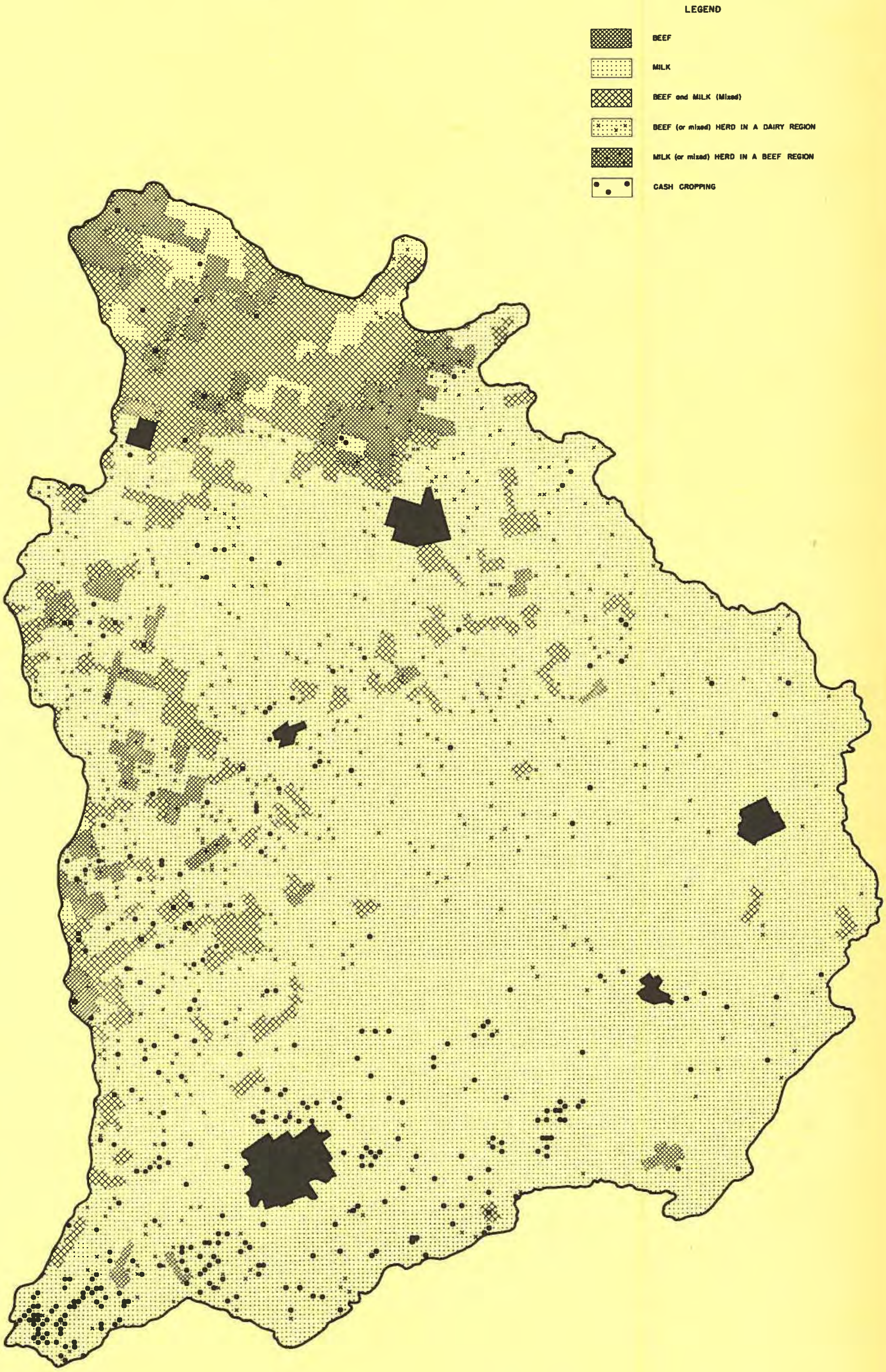
On the accompanying map, areas devoted entirely to beef production are shown with close cross-hatching, areas of milk production are dotted. Areas of mixed production are shown with an open cross-hatching. The occurrence of milk herds in a beef region is indicated by individual dots and the occurrence of beef herds in a dairy region by x's.

2. Incidence of Cash Cropping

No attempt was made to canvass every farmer to determine what fields were being cropped for cash or under contract rather than for consumption by animals on the farm, but observations were made of the more obvious instances of cash cropping, particularly of those crops which are ordinarily sold off the place such as flax, sugar beets, tobacco and truck crops. These are indicated on the map by heavy black dots. The distribution of these dots reveals a rather significant pattern and indicates the trends in land use on the watershed.

FARM TYPES

On the basis of types of herds with the incidence of cash cropping.



This mapping served two purposes. It helped to determine the farming regions on the watershed and it indicated somewhat the extent to which intensive land use is significant in soil conservation.

Apart from the returns to the farmer and the help that cash cropping can be to him in his own economy, there are two features of cash cropping that are important to consider in soil conservation, one good and one bad.

If soils and climate are suitable for cash cropping and it can be done without robbing the soil, the economic advantage can be a great benefit to a region. Some of the cash returns can be used in improving other phases of the farm operations such as purchase of better breeding stock, which in turn gives a higher return in the sale of young stock, which is an important part of a farm income. Profits may be used in the purchase of new equipment to handle the soil better, in purchasing fertilizer or in improving run-down pastures. Areas of favourable soils on which cash cropping and animal husbandry are combined often show a better economic stability and less problems of soil conservation than areas that have not this advantage.

Cash cropping becomes dangerous when it is so concentrated in an area that soil-building crops are not included in the crop rotations and there are few or no animals to assist in returning fertility to the soil. It is also dangerous when it is introduced to a soil which is susceptible to erosion by reason of slope. Intertilling of many cash crops seriously aggravates the erosion menace and persistent cash cropping may dangerously reduce the organic content of the soil. There is a tendency, however, for these crops to become established on lands unsuitable to them in regions where they are grown and especially during times of great demand and high prices. Granted that the movement may recede when times are less favourable, but once established they tend to persist until the soil is rendered quite unsuitable for them and after irreparable harm has been done to the soil by erosion.

3. Farm Regions

From the classification of farms on the basis of types of herds and the incidence of cash cropping, six regions may be separated out. Each of these has a fairly distinct set of physical features associated with it. In describing each the dominant types of land use, the physical characteristics and the conservation problems of each one will be noted.

4. The Perth County Region

A line joining Mitchell and Stratford separates to the north of it an area quite clearly dominated by beef production. This is the south-easterly lobe of a much larger area in Perth and Huron Counties that has this type of farming. The soils are largely of the Huron and Perth series. The land is flat to undulating with very little bold relief. Some soil erosion is found on the Huron soils on slopes, yet the land does not lend itself, over any large areas, to the practice of contour cultivation. Both the Huron and Perth soils show evidence of compaction with pastures that are more sparse and weed-ridden than should be on these inherently fertile soils. The Perth and Brookston soils are limited in their use by inadequate drainage, and despite the extensive ditching in the area the soils are still inadequately drained. Where dairy herds were found in the area they seemed to be associated with the ridges of better-drained soils, possibly because they could carry more alfalfa and grain. Cash cropping is for wheat and flax. Ponds are necessary for pasture and are commonly of the dug-out type.

The problems of erosion and soil compaction call for emphasis on pasture improvement and soil-building crops with extended rotations on the hummocky slopes to expose land to erosion for a minimum time. On the Perth and Brookston soils, if artificial drainage is neither practicable or economic, then use of grass and legume mixtures tolerant of these conditions is indicated.

5. The London Township Region

London Township is in the heart of a region which occupies the western edge of the watershed from Granton to London. As to land use, this is a very mixed region. Along the western divide there is a distinct region of beef production. This is the eastern edge of the west Middlesex and Lambton beef area. Most of the region is very mixed in type of herds. There is considerable cash cropping in the area, notably for sugar beets, wheat and barley.

The prevailing soil type is that of London loam which is imperfectly drained. Unless artificially drained this soil is of limited use and might be expected to carry beef animals as on other inadequately drained soils. Proximity to London gives an economic advantage to milk production. The Parkhill loam and the muck soils on the valley bottoms are artificially drained and used for cash crops, particularly sugar beets. The region looks as if it had not yet achieved stability and is likely to change in character. If it is to be anything but a beef region there will have to be more artificial drainage. It is drained by the Medway Creek and the North Branch of the Thames, and these are the streams which seem to contribute most to flood hazards in London and further drainage may be opposed by those who are concerned with flood control. In this connection it is remarkable that it is on the watershed with the flatter and less well drained land that the greatest flood peaks are built up.

The valleys in this region have broad smooth slopes and where they are not too steep they might be maintained under cultivation by using contour methods. Woodland is sparse and restricted to very wet and low spots. If artificial drainage is uot undertaken then better use can be made of the soils by adapting grass mixtures to the less well drained soils.

6. The Thamesford-London Plain

Between Thamesford and London there is considerable cash cropping along with the predominant dairy farming. This is because of the easily worked, warm, early soils of the Fox, Berrien and Burford series. As long as intertilled crops are kept off the erosible slopes and there is a prevalence of animal husbandry there should be no special soil problem. Truck crops and fruits are likely in the future to call for more irrigation and for water for spraying so that along with the construction of ponds there will be a greater concern for sustained flow in the streams. On rougher locations these light-textured soils might well be reforested to help conserve water.

7. The Oxford County Region

That part of Oxford County which is within the watershed is the heart of a region which contains small parts of Middlesex and Perth Counties. It is recognizable from the map of farm types as predominantly given over to dairy herds. It is the very heart of the old-established cheese region of Western Ontario.

The commonest soil type is the Guelph loam. There are inclusions of the less well drained associates, London and Parkhill, in the low-lying areas and soils of the Burford catena on the valley bottoms and terraces.

The south-eastern corner of the region has some well defined "drumlins" - long, oval hills or "whalebacks". The rest of the area is fluted and ridged so that the landscape seems to roll and swell as one traverses it. This is a very favourable type of topography for general farming. The easily worked and generally fertile Guelph soils usually support good farms wherever found.

Because of the sloping nature of the land considerable soil erosion is found. As the slopes are quite long and smooth they lend themselves to those types of erosion control that depend on contour tillage. One good example of contour tillage which has been established for some time in the area happens to be on the smooth slopes at the edge of the river valley at Beachville, but the same sort of thing might be practised on a good many of the slopes in the region.

Demand for winter feed for milk animals calls for a large proportion of this land to be cultivated for grain and legumes. To check soil erosion losses and consequent risk of drought the whole range of conservation farming practices has considerable scope in this region.

8. The Lakeside Region

From Tavistock through Lakeside to Cobble Hill the map of farm types shows a rather mixed region with more beef production than the country around it. This is associated with soils of the Dumfries series and rougher phases of the Guelph soils. There is a greater proportion of pasture on these lower capability soils and future use of the area will depend on good pasture management.

9. The Komoka Region

The high incidence of cash cropping down stream from London indicates the invasion of the watershed by tobacco. Fruit and truck gardening is also found. These uses are carried out on soils of the Fox and Berrien series.

Characteristic of the region is the sharp dissection of the land by many streams and ravines leading to the Thames. There is also considerable woodland on the rougher areas. There is serious danger of erosion on the steep slopes, also of water loss and soil organic content depletion.

10. Significance of the Regions

A soil conservation program is necessarily a local responsibility because it will be actually carried out by the people on the land. Any outside assistance, particularly from the Conservation Authority, should be planned with reference to the characteristics of the land in any one locality. It is suggested that any steps taken to promote soil conservation be done on a regional basis, using the regions here outlined in terms of types of farming and physical conditions.

CHAPTER 7

THE ADJUSTMENT OF LAND USE TO USE CAPABILITY

1. The Use Capability Classes

In the chapter on Land Use it was shown that 70 per cent of the land was under cultivation in regular crop rotations. This indicates the demand for cultivable land under the prevailing economic conditions and types of farming, which, as has been shown, is predominantly for milk production. Attention was also drawn, in the chapter summarizing the 1945 survey, to the fact that there was no organized effort to control erosion beyond the ordinary use of manure and crop rotations. Since 1945 a few demonstrations of conservation measures have been set up and considerable advance has been made in pasture development. The question remains, is there enough land of high capability which, under the proper management, will carry cropland on 70 per cent of the area? The following table gives the answer.

L	Cultivable land	2.8%
LR	Restricted cultivation	26.9%
CF	Contour cultivation	17.9%
LD	Drainable land	32.7%
Total		80.3%

The small percentage of land suitable for cultivation without special practices, (L) presents no problem. Supposing, on LR land, that rotations were extended from 4 to 5 years, the proportion of grain is only lowered 20 per cent. Land suitable for contour cultivation, (CF), can be retained in a 4-year rotation so that under proper management of erosion control there is no lessening of cultivated land. These three would then add up to 44.8 per cent which subtracted from 70 per cent leaves 25.2 per cent. This is only five-sixths of the land designated as drainable. Therefore, discounting that yields on sloping land subject to erosion should increase, and a

TABLE A

PER CENT OF CAPABILITY CLASSES IN EACH PRESENT USE

Use Capability	Present Use					Totals
	R	L	P	F	X	
L	3.6	3.3	1.4	1.3	0.2	2.5
LR	31.3	30.6	20.4	11.7	16.2	26.9
CF	29.0	21.2	9.7	7.5	3.8	17.9
LD	30.7	35.2	30.5	22.1	12.6	32.7
ND	0.1	0.2	0.6	0.5	0.6	0.3
P	2.4	2.8	7.5	3.3	3.1	3.9
F	2.9	6.6	29.9	53.5	63.5	15.5
Totals	100.0	100.0	100.0	100.0	100.0	100.0

TABLE B

PER CENT OF PRESENT USE IN EACH CAPABILITY CLASS

Use Capability	Present Use					Totals
	R	L	P	F	X	
L	6.5	77.6	12.1	3.7	0.1	100
LR	8.0	71.3	16.8	3.0	0.9	100
CF	11.1	73.8	11.9	2.9	0.3	100
LD	6.3	67.3	21.2	4.6	0.6	100
ND	2.4	33.2	48.5	12.7	3.2	100
P	4.4	45.9	42.6	5.9	1.2	100
F	1.3	26.2	42.6	23.8	6.1	100
Totals	6.9	62.6	22.1	6.9	1.5	100

sixth of the drainable land which might never be drained, there is still enough land suitable for cultivation to meet the demonstrated demands. This is a very encouraging answer. A further comparison of the present land use with the use capability should reveal the extent to which use is adjusted to capability and the extent to which use should be changed to conform to the natural characteristics of the soil. The two accompanying tables summarize these situations.

2. Extent to Which Use Is Adjusted

Referring to Table B, the present use of the land in each capability class can be compared to the average use for the area. The most extensive use capability class is that recommended for drainage. It represents (Table A) 32.7 per cent of the area. The proportion of it in each present use is very close to the average for the area. (Compare the percentages in line LD with those in the bottom line.) The next largest area is that recommended for cultivation with some restrictions in use, LR, 26.9 per cent. The proportions of it in row crops and under cultivation is considerably higher than the average for the area, 8.0 and 71.3 as compared to 6.9 and 62.6 per cent respectively.

Of the land recommended for pasture only 45.5 per cent is cultivated, compared to 62.6 for the whole area, whereas 42.6 is now pastured, which is far higher than the 22.1 per cent of the area which is now pastured.

Reading the table of percentages in this way it is easy to see that, in general, the lands of higher capability are used more intensively than the lands of lower capability. Again the answer is reassuring, but it is obvious that there is not a really close fit of use to capability.

3. Degree of Maladjustment

Twelve per cent of the land suitable for continued cultivation is under permanent sod and 3.7 per cent is wooded. Granted that these proportions are small compared to the use over the whole area analyzed, it still means that some land of high capability is relegated to a lower use. That this is so is partly due to the rectangular layout of farms and fields. Rectangular woodlots and fenced pastures sometimes include areas of land of better capability which should be in neighbouring fields. Re-adjusting fence lines according to natural soil boundaries in most cases will correct this.

Of the land suitable for cultivation with restrictions and the land on which contour tillage should be practised, very little is wooded and only a small proportion pastured. The high proportion of these classes that are tilled can be maintained, but a good deal more attention could be paid to erosion and water loss control. The land suitable for cultivation with restrictions (LR) carries 20 per cent of the total pasture and the drainable land (LD) carries 30 per cent (Table A). The land designated as suitable only for pasture (P) is only 3.9 per cent of the whole area and it is obvious that demands for pasture far exceed this proportion. Therefore it can be concluded that lands of higher capability will carry some pasture. The drainable land can continue to carry a good deal of it and any further drainage projects should be carried out with this in mind. The LR land can meet demands for pasture and at the same time serve good conservation purposes if it is seeded to pasture with occasional cultivation. This can be achieved by very long rotations or what the British call "ley" farming. Some tests should be run to determine the longevity of pasture and proper methods of management so that the most can be made of this type of land.

There is forest cover on only 6.9 per cent of the land, yet 15.5 per cent of the land is really suitable only for forest. Quite a bit of land now under pasture or even cultivated should have forest established on it, either by plantation or by natural regeneration. Further, existing woodland should have grazing excluded from it. This would increase the demand for production from the existing pasture. There is no doubt that, if all the land now used or potentially useful for pasture were brought up to the standards of production of the best managed pastures in the area, the carrying capacity of pasture on the watershed would be increased many times. It is hard to say exactly how much; some demonstration pastures carry as much as four times what unimproved pastures carry, so that it is not too much to expect that pastures could be made to produce, on the average, twice as much as they have been producing. Thus, any loss of area of pasture because of forestry can more than amply be made up by increased production on pasture.

4. Can Use Be Adjusted To Capability?

From the foregoing discussion the answer to this question would appear to be yes. The problem is how to do it. This will be discussed more fully in the next chapter. Briefly, the solution lies in two kinds of actions. First is the planning of individual farms to make each field, the crops on it and the system of management fit the natural conditions of the soil. This is "Farm Planning". The second may be called "Regional Planning" and will be effectuated not by individual operators but by public bodies and businesses which determine public policy of land use in any way.

CHAPTER 8

A RECOMMENDED CONSERVATION PROGRAM

1. Purpose

The aim of a conservation project has been repeatedly stated throughout this report to be the use and management of land according to its natural characteristics. The inventory of soil conditions given in the preceding chapters and in the accompanying map should be an adequate guide in formulating a plan. The inventory of land use and the descriptions of regions given in Chapter 6 provides a good enough picture of the present situation to indicate what changes, where necessary, are to be made. Enough is known of the ravages of soil erosion, fertility depletion and the methods of checking them to indicate the remedial measures necessary that need to be applied.

2. Demonstrations on Individual Farms

It is recognized that most of the work necessary to control erosion and water loss will be done by the farmers who occupy most of the land of the watershed. It is also recognized that the most effective way to introduce new ideas and methods is to demonstrate them on working units similar to other farms and right in the locality where farmers can see them. Therefore it is recommended that the Authority co-operate with existing agencies in establishing demonstration farms to show the application of farming methods designed specifically to control erosion and run-off.

Farms that have been planned for conservation now can be found on the watershed and the work on these farms is quite familiar to those who are interested in conservation and to a few others. It is now time to establish more of these farms so that every farmer on the watershed can see the same kind of operations.

It is recommended that demonstration farms be established according to the natural and economic regions outlined in Chapter 6 so that the farmers will see a demonstration on land which most nearly resembles their own with respect to soil conditions and type of farming.

3. Farm Planning and Conservation Practices

To operate a farm most efficiently and to incorporate all the necessary features of soil conservation into its management, a plan is necessary. A farm planning service is provided from the Soils Department of the Ontario Agricultural College through the Extension Service of the Department of Agriculture. This technical assistance is obtained by farmers by application through their county Agricultural Representative.

The first step in developing a farm plan is similar to the survey conducted on the whole watershed but is carried out in more detail. A map is prepared, using aerial photos as the base, of all the types and conditions of soil that are found on the farm. A map is also made of the present use of each field, the crop, its place in the rotation, wild pasture and so on. The capability of each natural division of the land is appraised according to what is known of each soil type, the extent of erosion and erosibility, determination of fertility and of any other natural limiting factors such as stoniness, droughtiness or lack of organic content.

A map of recommended use is drawn so that the existing fields, if necessary, are changed so that they conform to the natural conditions found on the farm. The use and the system of management of each field are indicated according to the natural classification. That is, for example, sloping land that is subject to erosion but on which erosion can be controlled by contour tillage and strip-cropping is marked out for cropping using those practices. Where seriously eroded land should be reforested, where gully control is necessary or where grassed waterways should be established are also indicated.

With the land that is available for cultivation under a drop rotation, particularly that on which strip-cropping is recommended, the system of rotation is worked out so that each year there is a constant acreage of grain and fodder to carry whatever herd it is found that the land can support.

The change from the present use to the recommended use may be quite radical and could not be brought into effect within a year and a change-over period is arranged. It may be necessary, in some cases, to change fence lines, particularly where long strips are necessary for strip-cropping. Arrangements are made to make these changes progressively as the change-over is brought about.

This type of plan is especially necessary where there is a lot of land of the type which in this report is indicated in class CF or where it is necessary to establish woodlots, grassed waterways and diversion channels. On farms where there is mostly that type of land which is susceptible to erosion but it is not controllable by contour cultivation, there is not necessarily any reason to move fence lines or rearrange fields. A conservation system of farming calls for rotations to be worked out which will expose the land as little as possible to erosion and maintain the emphasis on soil-building crops. There may, however, be scope for certain individual remedies such as grassed waterways, or diversion terraces and buffer strips to break up the slopes. There may also be individual cases of gully stopping, reforestation, improved woodland management or pasture improvement which can be carried out on fields and farms as they stand now without any radical change in the farm set-up. These can be proceeded with directly by the farmer;but where it involves practices and methods with which he is not familiar he should avail himself of whatever technical assistance there is.

Most of the things that are considered to be "conservation farming" can be done by the farmer with his own equipment. There are some things, however, which may require special equipment or heavy implements that every farmer does not possess. An example of this is the earth-moving or grading equipment necessary for some gully stopping, grading grassed waterways or constructing farm ponds. The Authority could serve a very useful function if it made equipment of this sort, and technical advice, available to co-operators. It might be convenient to enlist a group of co-operators in one district who have the same problems and concentrate on one or more features such as gully stopping or grassed water-courses. As one group of farmers become familiar with these practices they should be able to help out neighbors who have projects that can be handled with ordinary farm equipment.

There is some literature available on these subjects from the Provincial and Federal Departments of Agriculture. One particularly is recommended - Grassed Waterways (Ontario Department of Agriculture, 1950). Various bulletins issued by the U. S. Department of Agriculture describe conservation techniques in detail. There are a number of good textbooks available, notably those by Ayres, Gustafson and Bennett[1].

Actually new methods are better learned by demonstration, and technical advice is available from the extension service carried on from the Agricultural College. Many of the implement manufacturers have handy bulletins on contour cultivation, terracing and pond construction and should

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1. Ayres, Q. C. Soil Erosion and Its Control. McGraw-Hill. 1936.
   Gustafson, A. F. Conservation of the Soil. McGraw-Hill. 1937.
   Bennett, H. H. Elements of Soil Conservation. McGraw-Hill. 1947.

be able to demonstrate the use of their equipment as they do at Grassland and Wheatland Days or as was done on the Heber Down Farm at Brooklin, Ontario, in 1949. A conservation field day comparable to a Grassland Day might be arranged to show off some of these methods.

4. <u>Grassland</u>

Examination of the map of recommended land use according to use capability which accompanies this report will show how significant is the question of improved grassland. It might be said that this is the biggest single measure in soil conservation, whether it is considered from the point of view of area or of total production. The Grassland Day held at Woodstock in 1950 had as great significance to conservation as anything else that has ever been done.

Grass is both the biggest source of production of beef and milk and the surest way of building soil and resisting erosion. It might be said that if all the land on the watershed which is indicated as suitable for grassland, either in permanent pasture or in long rotations, were cultivated, fertilized and seeded to improved mixtures and were carefully managed with respect to clipping, fertilizing and grazing rotated, that there would be more grasses and legumes produced than could be used for grazing and for making hay. An answer to this question is the use of grass and legume silage. Those who are concerned with the technical problems of making and storing silage may not yet be convinced of its great value. Possibly some capable producers who pride themselves on their animal feeding may dispute its value. But those who have gone over to this type of farming, especially on land particularly suited to grass, are wholehearted in their support of the practice. To those who have considered the economic problems of setting up a farm these days, particularly the administrators of the Veterans Land Act, the idea of wintering a herd on grass silage is very attractive.

To all those who are advocating greater use of grass silage can be added those who are interested in soil and water conservation.

5. <u>Drainage</u>

Over 30 per cent of the soil on the watershed is inadequately drained naturally for the production of the full range of crops used, particularly alfalfa and winter grains. A higher proportion of these soils is cultivated than the average. Obviously, much of the area has been artificially drained to some extent to make this use possible. As land use becomes intensified, as it is likely to be with the growth in population of the Province, further artificial drainage can be expected.

In the conservation of water particularly there is some dispute as to the advisability of more drainage, and a Conservation Authority is especially concerned in the matter even though its powers may be limited in this respect.

Opposition to drainage is based, it would seem, more on ill advised, ill constructed and poorly managed drainage schemes than on any fault in drainage as an agricultural practice. In the procedure for carrying out drainage schemes there is no provision for even the advice of a soil expert or a trained agronomist. If proposed drainage schemes were reviewed from the point of view of whether the soil needed it or whether they were required for the cropping schemes on the land the decision to drain would be better supported.[1] The thousands of acres in Ontario which now carry willow scrub or poor wetland pasture with old but expensive drainage ditches going through them are mute evidence of the inadvisability of many drainage schemes. An anomaly in the

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1. Report of the Select Committee on Conservation. Ontario, The King's Printer, 1950.

administration of the drainage laws is often seen in awards on the basis of the land drained by the ditch regardless of whether the soil actually benefits from artificial drainage. Indeed, cases might be cited of the presumed beneficiary suffering from loss of water.

Many individuals are involved in the building of a drainage project, the petitioners, the municipal council, the engineer, the referee and whoever puts up the money for the job. Once a petition is accepted by council, work is proceeded with on the assumption that the project is a worth-while venture and there is little question of any other implications, what it does to the water relations of the area, stream flow and groundwater levels, or the ultimate total effect it will have on land use. Under present legislation the Conservation Authority is at least aware of what is proposed and can make it its business to study these other implications and use whatever influence and powers it has to inform and guide public policy in the matter.

The ill effects of drainage schemes are most noticeable locally and the accelerated run-off in a ditch may produce local flooding, especially where the ditch, being straight, has facilitated formation of an ice jam which, when it breaks, releases a flood peak. When a number of tributaries deliver their flood flows at the same time there may be flooding on a main stream.

It is ironic that areas which are drained artificially may suffer from drought in summer and even have a shortage of water supplies. If drainage were considered as "redistributing" water, and provision were made to hold part of the surplus flow for later use, rather than merely a process of "getting rid of the water", artificial drainage would appear in a better light.

Because a large proportion of the soils of the watershed require artificial drainage to improve agriculture and because further drainage works can be expected, it is recommended that the Authority, through a committee appointed for that purpose, watch closely, and influence where it can, policy and administration of drainage schemes.

6. Land Use Policy

Although the farmer is considered as the one who determines what use is made of the land and how it is to be managed, a little reflection will show that land use is actually controlled by many other people. The three main groups which influence land use are the agencies that extend credit to the farmer for his property, his improvements and his operations; the firms that supply him with his equipment, seed, fertilizer and materials; and the marketing agencies which buy his produce. A further control is in the governments which tax him and which, by systems of tax concessions and marketing aids, can induce him to apply his land to certain uses.

All these groups are as much interested, if not more, in sustaining not only the productivity of the land but the welfare of the whole community of which the farm is a part. It is conceivable, then, that without compulsion or control land use can be planned in such a way as to protect the soil and water, in short, to achieve the aims of conservation, "the wise use of all the land, for all people, for all time".

A few examples can illustrate this point. Take the case of cash cropping. The farmer may operate with short term credit or under contract from a processor who handles his product. If the farmer can clear himself of all debt and make a profit in a few years he has acted wisely. But if the land after a few years is no longer able to carry cash crops, and may be even too worn down or eroded to support mixed farming, the contractor or creditor has lost a customer in whoever occupies the land.

If the manufacturer who sells implements continues to sell tillage and harvest machinery to produce grain in an area which is susceptible to erosion, he may find himself eventually without customers (unless he changes to selling tree-planters). But if he studies the area and pushes the sale of implements for harvesting grass, a prosperous agriculture based on the natural capabilities of the soil is more likely to persist indefinitely.

Any marketing agency, private or co-operative, presumably expects to stay in business indefinitely and it is to its advantage to sustain the productivity of the land for all time. In addition to all the other technical services that such an agency may advance to its subscribers with respect to grading, packaging, fertilizing, spraying and so on, advice on the conservation of soil and water would be to the advantage of both the producer and the agent who distributes his goods.

For the most effective action in planning land use there must be some central agency whose interests cover all phases of land use to co-ordinate the gathering and dissemination of knowledge and the framing of policy. No body could perform this function better than a Conservation Authority and they now have the machinery for doing so in their Advisory Boards. It is therefore recommended that the Authority facilitate conferences of representatives of producers, financial houses, supply businesses and marketing agencies of agricultural produce within the watershed to discuss ways of shaping land use in accordance with conservation principles and what is known of the physical characteristics of soil and water resources.

7. Credit and Land Tenure

That the soil has been required to produce more than it can safely yield from year to year is not necessarily the fault of the farmer or of those who have been before him on the land. Whether owner or tenant, the operator has certain financial commitments to meet from year to year. To remain in possession and in operation he must meet these and he must use his land in such a way as to yield the necessary cash return. This is the reason for a good deal of the erosion and soil depletion which has gone on in the past. In the United States, where the problem of soil erosion and depletion and drought has been dealt with systematically for some years, this is recognized. Steps to correct it have been taken, not only by governmental bodies but by financial houses, in so far as their system of banking allows the extension of credit on land. The American attack on the problem merits close study. It need not be necessary to adopt their financial machinery nor revise our own to meet the situation. What is required is to study how our system of land tenure and financing can be accommodated to take into account conservation of our resources as much as they do prices, markets and all the other factors which influence the money market. It is recommended, therefore, that the Authority, through its Forestry and Land Use Advisory Boards, bring the inventory of resources that is given in this report and its maps to the attention of those who have a financial interest in the sustained productivity of the land.

Operating of farm land by leasehold tenants is generally looked on with disfavour as alien to the traditions of our country. In view of the rising cost of capital outlay to undertake operating a farm it is quite possible that tenancy may increase, that is, more people will be able to find enough money to equip and stock a farm, and rent it, than will be able to stock, equip and establish an equity in a farm. In older countries where farming has been carried on in this way for generations it has been common practice to write covenants into leases requiring certain specific land use practices to maintain the fertility and tilth of the soil. It is recommended, therefore, that the Authority explore, with competent legal advice, the possibilities of establishing soil conservation practices by using covenants in leases on farm properties.

With respect to cash cropping which may erode land and aggravate soil problems the only direct action the Authority can take is to acquire land for reforestation. The only other way in which harmful cash cropping, particularly tobacco, could be excluded from water-storage areas in swamps and from land susceptible to erosion is by passing zoning by-laws for areas to be protected. This need not conflict with the interests of producers, for there is ample land that is not vulnerable to satisfy foreseeable demands for special types of soil.

8. Forestry and Recreation

Acquisition by the Authority of land for these uses is described in other sections of the report. There is, however, a large acreage of land suitable for tree plantations or for woodland improvement remaining on farms. The Authority can assist farmers in reforestation and might enter into co-operative management of existing woodland, extending to the operator, not only technical assistance, but some material help in fencing and in arranging orderly and profitable marketing of his wood products.

CHAPTER 9

FARM PONDS

1. Inventory of Ponds

All the existing ponds were visited to find out as much as possible about building ponds on the watershed. On the basis of what was actually found and comparing this information with what is known of the types of land, a map of "Recommended Regions" was prepared. On this are indicated the regions most suitable for each type of pond.

Ponds that are actually being used on farms are of five types. These are: natural ponds, dug-out ponds, spring-fed ponds, by-pass ponds and ponds formed by dams. They had a variety of uses. Fire protection and stock watering are the main uses, but fishing, swimming and irrigation are not uncommon uses and some have been built for property beautification.

The existing ponds are in various states of repair and only a few can be considered to be properly managed. Ponds naturally silt in if not protected. They suffer most from trampling of cattle. A well managed pond should be fenced and a pipe or some other method used for drawing off water for stock.

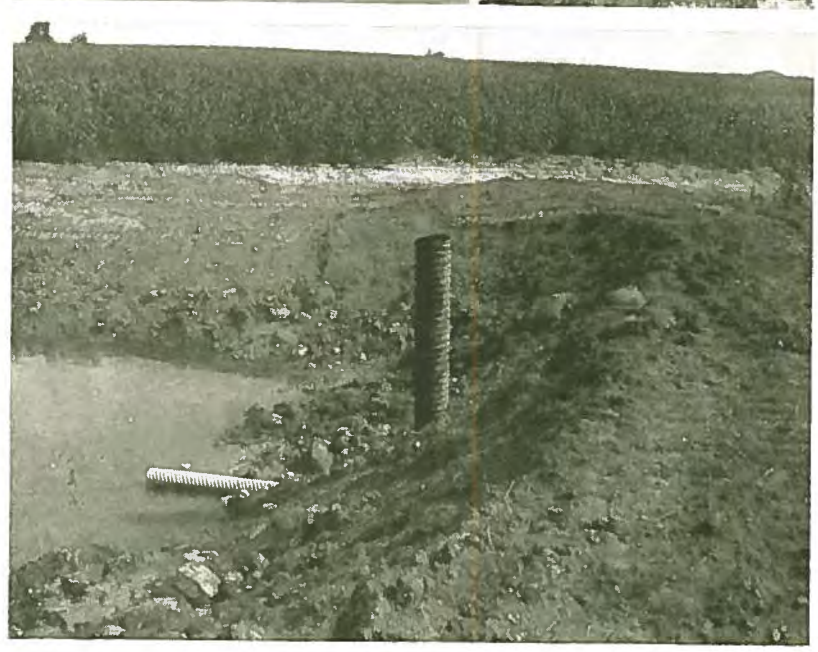
Of the 216 ponds examined on the watershed, 62 were natural ponds, 139 dug-outs, 8 spring-fed, 1 by-pass and 6 formed by dams. For the distribution of the different types according to land types see the accompanying map.

2. Relation Between Existing Ponds And Land Types

It is obvious that certain types of land are particularly well suited to ponds of certain kinds. Where ponds are lacking it is difficult to say whether it is because no need has been found for ponds or whether the land has not been suitable.

Dug-out ponds like this one near Elginfield are common in areas with ground water near the surface.

A well managed spring-fed pond north-east of Stratford.



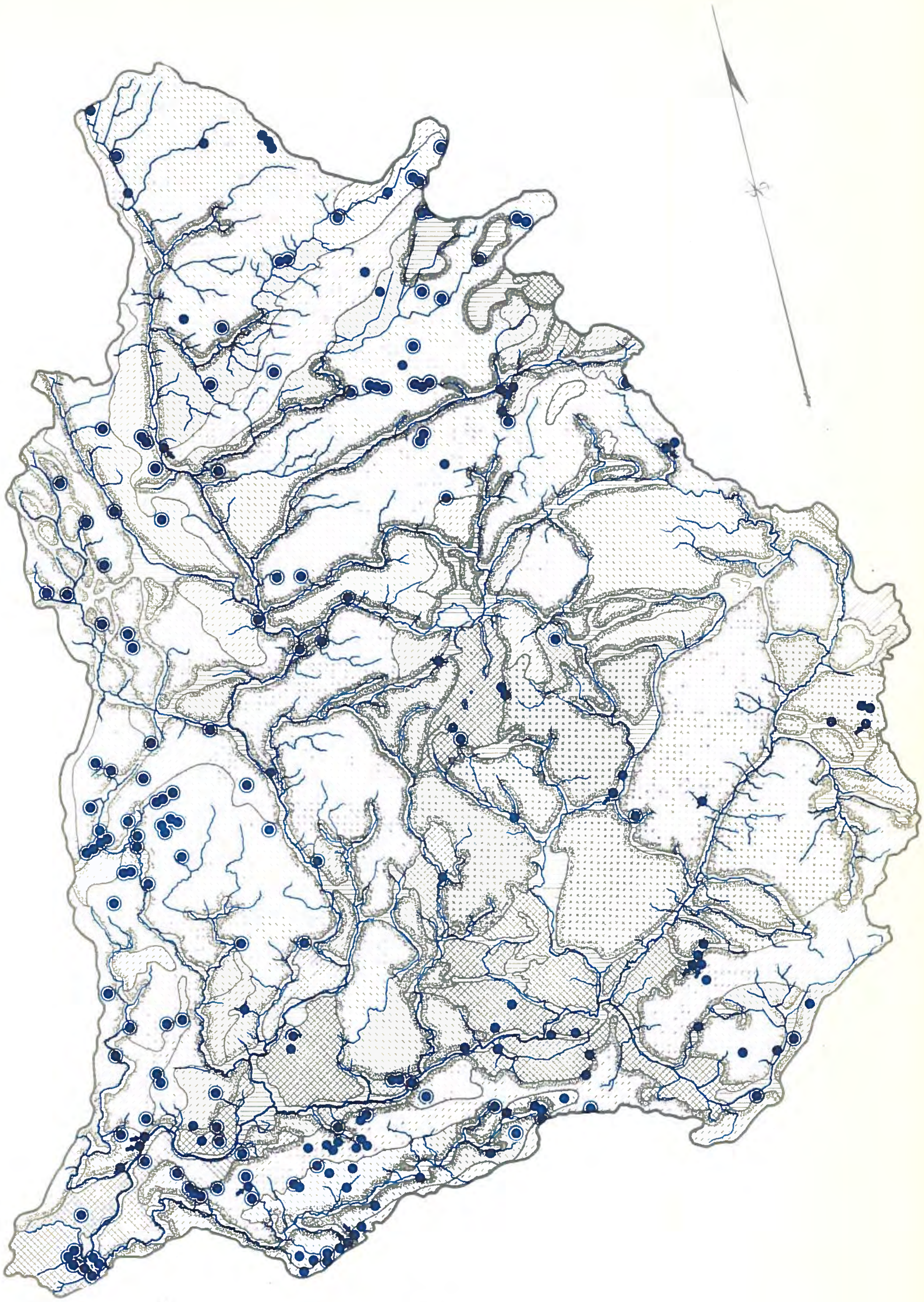
A run-off pond under construction north of Beachville. Note the clay dam to the right, emergency spillway in the background and drop inlet discharge pipe in the middle.

The commonest type of pond is the simple dug-out, and these are found especially on two types of land. First, the wetter locations on the undrumlinized till plain. It is characteristic of this land type to have a poorly established natural drainage system and on the low spots the water table reaches the surface. The same condition is found on the clay moraines which have irregular topography and numerous wet hollows. Natural ponds are found in the same locations and also on the flat valley bottoms or spillways where water lies in pools or can be found easily by simple excavation.

Ponds that require definite construction only totalled fifteen, and only one was found on the drumlinized till plain. This is remarkable because it is on this type of land that the most prosperous agriculture is to be found. It would appear that up to the present no particular need for ponds has been felt, but it would seem that this type of land would lend itself particularly to pond building by damming watercourses. The soil on this land type is fairly permeable and in the past farmers may have found that ponds do not readily hold water, but on similar situations on other watersheds, possibly where people are more "pond conscious", ponds have been found.

The commonest type of artificial pond is that which is fed from springs. These are not found on the kame moraines, probably because the soils are too permeable, and only one was found in a spillway. These permeable soils often have springs along the margin, between them and the less permeable soils.

A very useful type of pond, because it is so simple to build and has such a small risk of being washed out or silted in, is the by-pass pond, but only one of these was found. There are six ponds formed by damming, mostly on permanent streams, although they can be built on intermittent water-courses where they are certain to be filled during the spring run-off and on many occasions may be re-filled during summer storms



FARM PONDS

EXISTING FARM PONDS

- DUG-OUT
- DAM ON PERMANENT STREAM
- SPRING-FED
- BY-PASS
- NATURAL

RECOMMENDED REGIONS

- TILL PLAIN-DRUMLINIZED Suitable for all types
- TILL PLAIN-UNDRUMLINIZED Suitable for all types especially dug-out.
- TILL MORAINE Suitable for all types especially runoff.
- KAME MORAINE and SAND PLAINS Less suitable permeable soil.
- SPILLWAYS Less suitable-May have by-pass ponds or permanent dams where bottoms are impermeable.
- ESPECIALLY Suitable for spring-fed ponds on edges of kame moraines and spillways.

3. Recommended Regions

The accompanying map shows both the existing farm ponds and the regions that are recommended as particularly suitable for certain types. It is recommended that as demonstrations are set up this regional distribution be followed so that farmers will see examples of the type that they will most likely build themselves. Providing a suitable impermeable bottom can be found, the drumlinized till plain should be able to carry any type, according to the available supply of water. The type of pond called the "run-off", which is not listed here, but which is commonly referred to in literature on ponds, might be established by putting earth dams across intermittent water-courses which drain sufficient land to give the necessary run-off. In New York State, where the climate is not unlike that of south-western Ontario, this type of pond is commonly built, even though it is only filled by meltwater in the spring of the year.

On the undrumlinized till plain in the north-western part of the watershed, the commonest type is the dug-out pond; and although other types might be built, and there is no question regarding permeability of the soil, the dug-out type should be the commonest.

In the regions of till moraine all types might be built but special attention might be paid to the run-off types as the country is generally rolling and provides many suitable small watersheds to feed ponds by surface run-off.

The kame moraines and sand plains are considered less suitable for ponds because soil is so permeable that the pond may not hold water, nor an earth dam be entirely reliable.

On the flat valley bottoms and plains indicated as spillways on the physiographic map, ponds are less certain of success. This is because the gravelly and silty soils are so permeable to water. Small streams might be drained or excavations at the side may be made for by-pass streams, but if this is contemplated investigation must be made to establish that there is an impermeable clay bottom on which the pond may be sited. For this purpose an extendible soil auger which will bring up samples from ten feet can be used. It will be seen that the map of recommended pond regions closely resembles the physiographic map given in the introductory general section of this report. There is one addition, that is the shading of areas which mark the boundary between permeable (sandy and gravelly) soils and impermeable soils. Springs are common in these zones, and if the pond can be sited on the impermeable soil, then these are very likely spots for building.

4. Building Farm Ponds

A farm pond might be defined as a surface reservoir of water with a natural supply to be used for farm purposes and to cost no more than what a farmer would be prepared to pay for either a main or supplementary (or emergency) supply of water.

Farm ponds have two purposes - first is to serve the farmer on whose property they are built. The second purpose is only achieved if a great many ponds are built. That is, it is believed that a multitude of small ponds will help to conserve moisture in the soil,and in the case of ponds formed by dams, help, each in their small way, to control the flow in the streams.

A bulletin describing the main features of pond building is available from the Conservation Authority. This is only a guide and does not presume to give specific instructions for each individual pond. This pamphlet, along with the information given with this report and map, should be helpful in a general way by actually selecting the site, and constructing the pond should be undertaken only under the direction of a person competent to make the decision. As pond building becomes more common, farmers and contractors should become more familiar with the details of constructing ponds in each locality.

Because ponds are of value to the whole watershed as well as to the individual farmers, it seems only right that a program of pond building should have the support of the Conservation Authority and the program is getting that support in provision of some technical help in constructing ponds. It is recommended that the Authority continue to carry out this project.