USE OF AIRPHOTOS IN LAND SYSTEM MAPPING: WYNYARD, SASK.

THE USE OF AIRPHOTOS IN LAND SYSTEM MAPPING AND FIELD PATTERN ANALYSIS IN THE WYNYARD AREA, SASKATCHEWAN

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THE USE OF AIRPHOTOS IN LAND SYSTEM MAPPING AND FIELD PATTERN ANALYSIS IN THE WYNYARD AREA, SASKATCHEWAN

by

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Abstract

In this study a land classification scheme based on pedologic and geomorphic parameters with an alpha-numeric coding system was applied in the Wynyard Area, Saskatchewan, and a land system map was prepared using small scale vertical black and white airphotographs.

Field characteristics such as the number of fields per section, field size, field shape and shape ratio, the percentage of cultivated land, and physical interruptions (sloughs and drainageways) were examined using airphoto interpretation methods. Land values and farm sizes were obtained from Rural Municipal Maps. The relationships between these characteristics and the land systems, as well as the interrelationships between the various field characteristics were investigated.

Results reveal that many field characteristics vary from land system to land system, however, the interrelationships between field characteristics are not direct, reflecting the combined effect of the very regular land subdivision in the prairies and the various factors of the physical environment.

Department of Geography M.Sc.

L'utilisation de la photo aérienne pour la cartographie des systèmes écologiques et l'analyse de l'arrangement spatial des terres dans la région de Wynyard, Saskatchewan

par

Sanda Win

RESUME

Dans cette étude, une démarche de classification des terres fondée sur des paramètres pédologiques et gémorphologiques et avec un système de codage alpha-numérique fut appliquée dans la région de Wynyard, en Saskatchewan, et une carte des systèmes écologiques fut dressée à partir de photos aériennes à petite échelle en noir et blanc.

Plusieurs caractéristiques du terrain, telles que le nombre de champs par unité cadastrale, leur dimension, leur forme et leurs rapports morphologiques, le pourcentage de terre cultivée et les interruptions de surface (fossés et canaux de drainage) furent observées par photo-interprétation. La valeur des terres et la superficie des fermes furent obtenues à partir des cartes des municipalités rurales. Les relations entre ces caractéristiques et les systèmes écologiques furent étudiées de même qu'entre les caractéristiques de terrain elles-mêmes.

Les résultats révèlent que plusieurs caractères du terrain varient d'un système écologique à l'autre; cependant, les corrélations entre les caractéristiques du terrain elles-mêmes ne sont pas directes et reflètent plutôt l'effet combiné du cadastre très régulier des prairies avec divers facteurs de l'environnement.

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TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER | Page

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

CHAPTER 1

INTRODUCTION

The classification of land according to its inherent properties is of great importance because the surface characteristics not only exert a direct influence on the productivity of the area, but also reflect the combined effect of the factors of the physical environment and the economic activities of a region. A knowledge of the geographical distribution, magnitude, and limitations of the physical land characteristics is essential for a variety of planning purposes.

General surveys are required to determine the range of development possibilities of an area, and land classification or land system mapping fills this requirement because it provides a broad framework for assessing all types of projects that depend on the physical factors. Subsequently, more intensive surveys can be carried out in smaller areas as the need arises. Where the land has been previously surveyed, a reassessment of the use of the land can also be made.

The choice of attributes for land system mapping is largely determined by the use for which the land systems are being considered. For agricultural use, it is necessary to assess the land according to factors such as climate, topography and soil, that are relevant to crop production and farm management.

The basic purpose of this study is to devise and apply a land classification system suitable for use in the cereal belt of Western Canada. It aims at demonstrating how a land system map based on pedology and geomorphic parameters, can be prepared using airphoto interpretation methods and how the physical characteristics of the land system can be classified and collated.

The secondary purpose is to use the land systems as a framework for investigating other features of the agricultural landscape such as field characteristics, land value and farm size, in order to discover the extent to which they are related to the physical controls of the land system. Such evaluation is useful because it contributes to the improvement of existing methods of cultivation and where necessary, adjustments can be made so that the land systems are utilized for maximum production.

The area examined is the Wynyard map area in southern Saskatchewan. The area provides a good test site for examining the application of land system mapping, firstly, because the area includes the two major soil zones of the region—the Dark Brown Soils and the Black Soils with a smaller occurrence of Gray Luvisols. Soils of the Dark Brown and the Black Soil Zones are developed under grassland but moisture efficiency is greater in the latter. The moisture supply is usually reliable in the Gray Luvisols, however, the forest soils have a low humus content, therefore lacking the high fertility of the grassland soils.

Equally significant is the fact that the area lies in a transition zone between grain farming (wheat, barley, some oats and flax) and mixed farming (wheat, coarse grains, forage crops and livestock) (Mitchell et al., 1962, p. 27).

GENERAL BACKGROUND TO THE WYNYARD AREA

During the exploration of the prairies, a route selected by fur trader Henry Kelsey in 1690-91, passed through the Wynyard area. Routes selected during the scientific explorations by Captain John Palliser in 1857-58, and John Macoun in 1879 and 1880 also crossed the area (McConnell and Turner, 1969, p. 8).

The earliest settlement was at Fort Touchwood Hills at a junction of trails to Fort Qu'Appelle in the southeast, Fort Pelly in the northeast and Batoche and Fort Carlton in the northwest. Between 1849-1909 Fort Touchwood Hills was a trading post of the Hudson Bay Company.

By 1911, the Wynyard area was settled mainly by people of English, Scottish, Austrian, German and Scandinavian origins, followed by the French and the Irish. Although the English and Scottish are found spread over the Wynyard area, people of German origin are concentrated around Last Mountain Lake, the Scandinavians around the Quill Lakes and the Austrians on the Touchwood Hills.

Settlements today, are mainly along the railroads and highways which form an extensive network. The earliest railroad built around 1889-1890 in the southwestern part of the Wynyard area, connects Saskatoon to Regina and passes through Davidson, Girvin and Craik. Major railroads traversing the area are the northwest-southeast line from Saskatoon to Melville and two north-south lines: one from Prince Albert to Regina and the other from Humboldt to Regina. Other lines connect Colonsay with Young and Leroy with Lanigan.

Roads are numerous and within the Wynyard area are sections of north-south highways numbers 2, 6 and 20, and east-west highways numbers 14 and 15, which more or less follow the railroads serving the Wynyard area.

The Wynyard area has an agricultural economy. In the western portion of the area, small grains such as wheat, barley, oats, rye, flax, and mustard are important. Wheat is dominant on the heavier drought resistant soils and on gentler topography. The more rolling lands are used for grazing or a combination of grazing and grain farming. For example, in the Rural Municipality of Arm River in the southwest, a large cattle farm has been established in the vicinity of Squaw Creek.

On some of the poorer soils, particularly where salinity is a problem, the land is used as community pastures such as those in the Rural Municipalities of McCraney (No. 282), Prairie Rose (No. 309) and Usborne (No. 310).

Northwards and eastwards in the parkland prairie, where the climatic conditions are favourable for the satisfactory growth of coarse grains and forage crops in most years, mixed farming becomes more important. This type of farming is also significant in areas of transitional soils and on higher elevations, where frost hazards and a cooler, more humid growing season tend to limit the production of wheat, whereas coarse grains and forage crops thrive well.

In addition to agricultural activities, potash mining is also important. Potash is mined in the northern part of the area in an east-west zone from Colonsay to Wynyard, and the larger plants include Noranda Potash Mine southeast of Colonsay, and Alwinsal Potash, south of Guernsey. Magnesium sulphate is also extracted near Watrous and the town of Wynyard.

Since agriculture is the major occupation in the area, the land system approach has to be based on appropriate parameters. The methodology, application and analysis of land systems in the Wynyard area are considered in the following chapters. In Chapter 2 there is a review of the physical environment of the area—climate, geology, soils and vegetation. The third chapter presents the scheme of land systems and the mapping codes used, and there is discussion of the significance of the selected parameters and their relevance to agriculture. In the fourth chapter there is an examination of the application of the scheme, a review of field work and airphoto analysis, and an explanation of the derivation of land systems and the resulting map. The fifth chapter gives a resumé of the different land systems and their agricultural characteristics, and in Chapter 6 there is an examination of the relationships between land systems, field characteristics, land values and farm sizes. These relationships are illustrated in a series of graphs and scatter plots. A chapter summarizing the results of the land system mapping and the analysis of the various parameters concludes the study.

CHAPTER 2

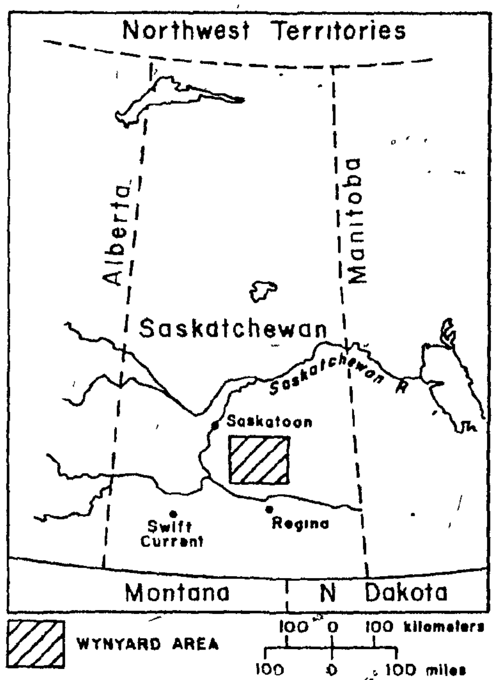
PHYSIOGRAPHY OF THE WYNYARD AREA

INTRODUCTION

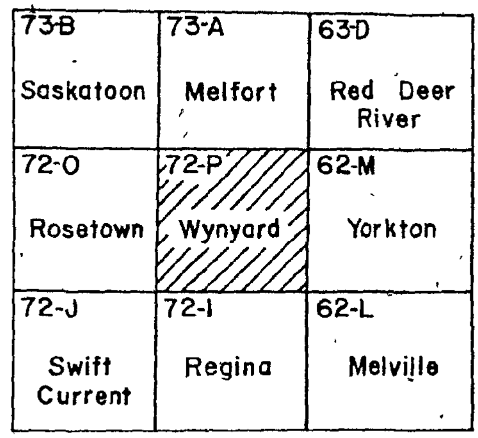
Wynyard is in mid-Saskatchewan and the map sheet area (N.T.S. 72-P) is bounded by the meridians 104° and 106° west and the parallels 51° and 52° north as shown in Fig. 2.1a. The area was subdivided into township and range in the late 19th century. The western limit of the area is range 29 and the eastern limit, range 15. The area includes all of townships 24 to 34 with parts of 23 and 35 on the edges (Fig. 2.1c). The total area is approximately 5900 square miles.

GEOLOGY AND TOPOGRAPHY

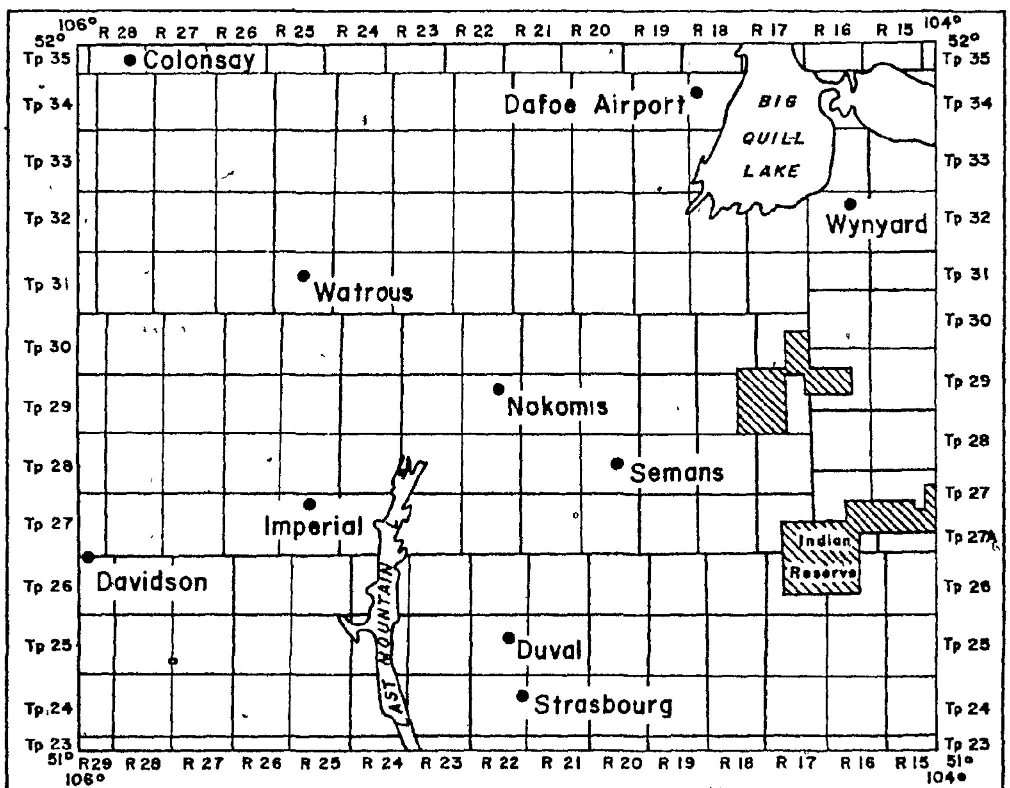
The bedrock geology of the Wynyard area is very simple: a series of Upper Cretaceous sands, clays and shales of regionally flat to very gently dipping structure. The total relief of the bedrock surface is about 259 meters (850 feet); the highest being 579 meters (1900 feet) in the Allan Hills east of Davidson (Fig. 2.2) and the lowest point—320 meters (1050 feet) in the Regina Valley. Bedrock is exposed only along parts of the Lewis Creek and the Arm River.



(a) Location of the Wynyard area.

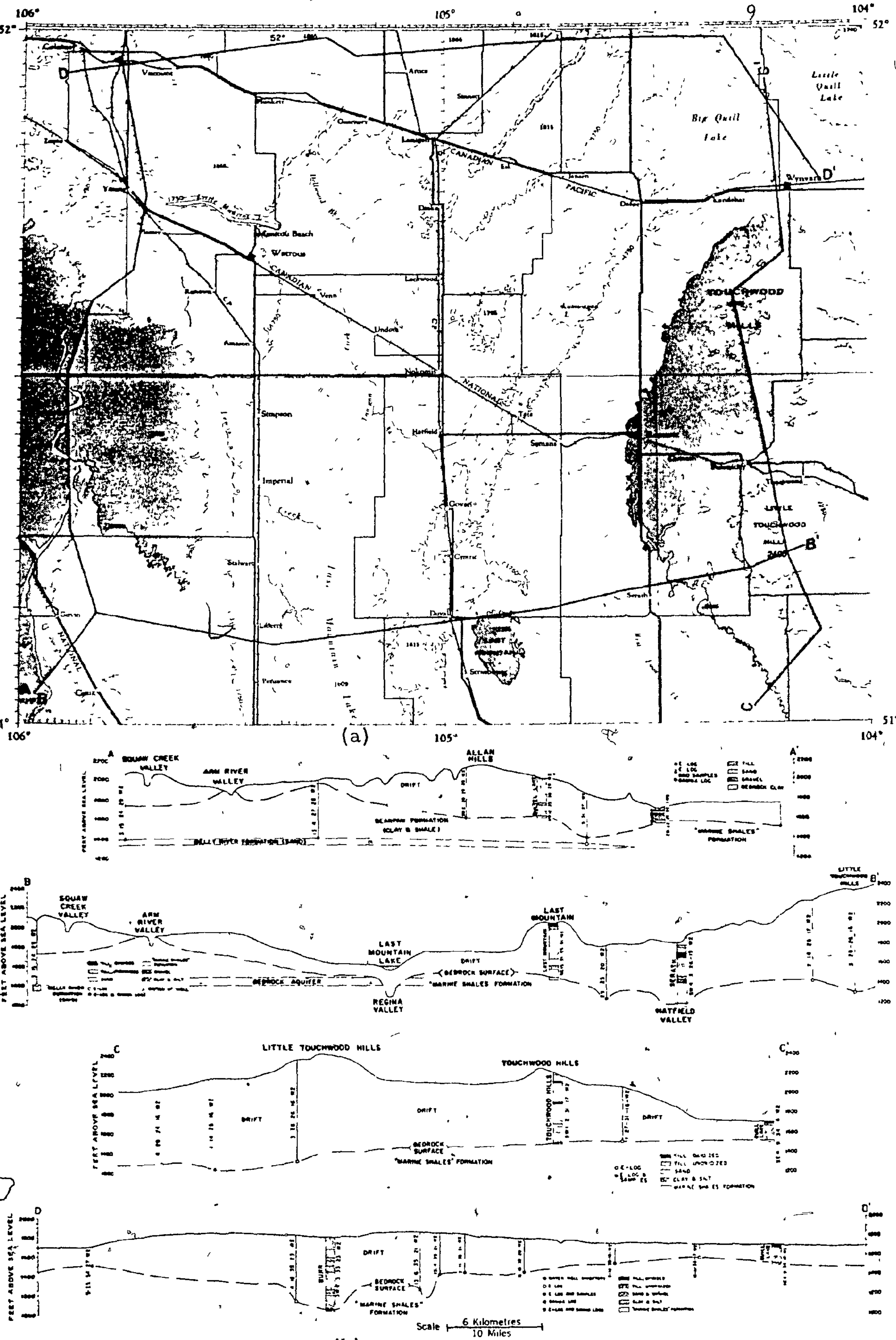


(b) The Wynyard area and areas surrounding it.



(c) Township and range locations of the Wynyard area.

Fig. 2.1 The location of the Wynyard area.



*From Geology and Groundwater Resources of the Wynyard Area

Fig. 2.2 Geological cross sections and their locations in the Wynyard Area

Upper Cretaceous Series

Within this series three formations are present in the Wynyard Area: Lea Park Formation, Belly River Formation and Bearpaw Formation (Table 2.1).

The Lea Park Formation underlies the Belly River Formation in the southwestern part of the Wynyard area and eastwards as shown in Fig. 2.3, the Lea Park Formation merges into the "Marine Shales" Formation.

The Belly River Formation is a thin unit of sand also occurring in the southwestern portion of the map area. It is composed of non-calcareous, fine to medium grained sand and is 12 to 21 meters thick. Where the Belly River Formation ends, is considered to be the boundary between the Bearpaw and the "Marine Shales" Formation.

The Bearpaw Formation overlying the Belly River Formation forms the bedrock of the western section of the Wynyard area, whereas, the "Marine Shales" Formation is the bedrock in the eastern part (Fig. 2.3). The "Marine Shales" Formation is equivalent to the Bearpaw and Belly River Formations. Only two areas of bedrock exposure are found in the Wynyard area.

Fig. 2.2a gives the locations of some transects across the Wynyard area and the geological cross sections (Fig. 2.2b) illustrates that the relationship between bedrock geology and topography is very weak to non-existent. The elevation of the bedrock surface ranges from 320 to 580 meters

TABLE 2 1

GEOLOGICAL FORMATIONS IN SASKATCHEWAN

Era	Period Time Estimate Years	Epoch	Formations in Saskatchewan	Thickness, feet	Materials and Remarks
	2,000,000	Pleistocene		0-400−	Glacial deposits· lake clays, boulder clay, etc.
CENOZOIC	Tertiary 58,000,000	Pliocene			Erosion.
		Miocene	Wood Mountain	50+	Gravels, conglomerates, sandstones, etc.
		Oligocene	Cypress Hills	125+	Gravels, conglomerates, sands, etc.
		Eocene	Swift Current	50+	Gravels, conglomerates, sands, etc. Erosion, Larimide Revolution.—
		Paleocene	Ravenscrag	800+−	Buff, grey, etc., sands, shales clays, coal.
MESOZOIC	Cretaceous 65,000,000	Upper Cretaceous	Frenchman	20-190	Grey, etc., sands, shales, clays.
			Whitemud	12-75	White, grey, etc., sandy clays, clays, etc., partly refractory.
			Eastend	20-100	Yellow, very fine sands, silts, etc. (mostly marine) *
			Bearpaw	700+−	Dark shales (marine).
			Belly River	0-890	Sands, shales, coal (mostly non-marine).
			Lea Park	810-1,140	Light and dark gray shales (marine).
			Alberta	580-1,300	Dark gray shale (marine).
		Lower Cretaceous		270-630	Gray sands, shales, coal (marine and non-marine).
	Jurassic 32,000,000			0-440+−	Gray shales, some limestone (marine and non-marine).
	Triassic 28,000,000				Erosion.
PALAEOZOIC	Permian 38,000,000				Erosion.
	Carboniferous 86,000,000	Present under	lying the Southwest		Limestones, shales, etc. (marine).
	Devonian 45,000,000			1,200	Gray, red shales, limestones, dolomites, gypsum (marine, possibly some non-marine).
	Silurian 27,000,000			?	Limestones, gypsum, salt.
	Ordovician 67,000,000			?	Not reached in wells, outcrops of limestone in north.
	Cambrian 105,000,000				Erosion.
	Pre Cambrian 1,450,000,000+−				Granites, sedimentary gneisses and schists, etc.

*All formations above the Eastend are non-marine.

Source : Mitchell et al (1962)

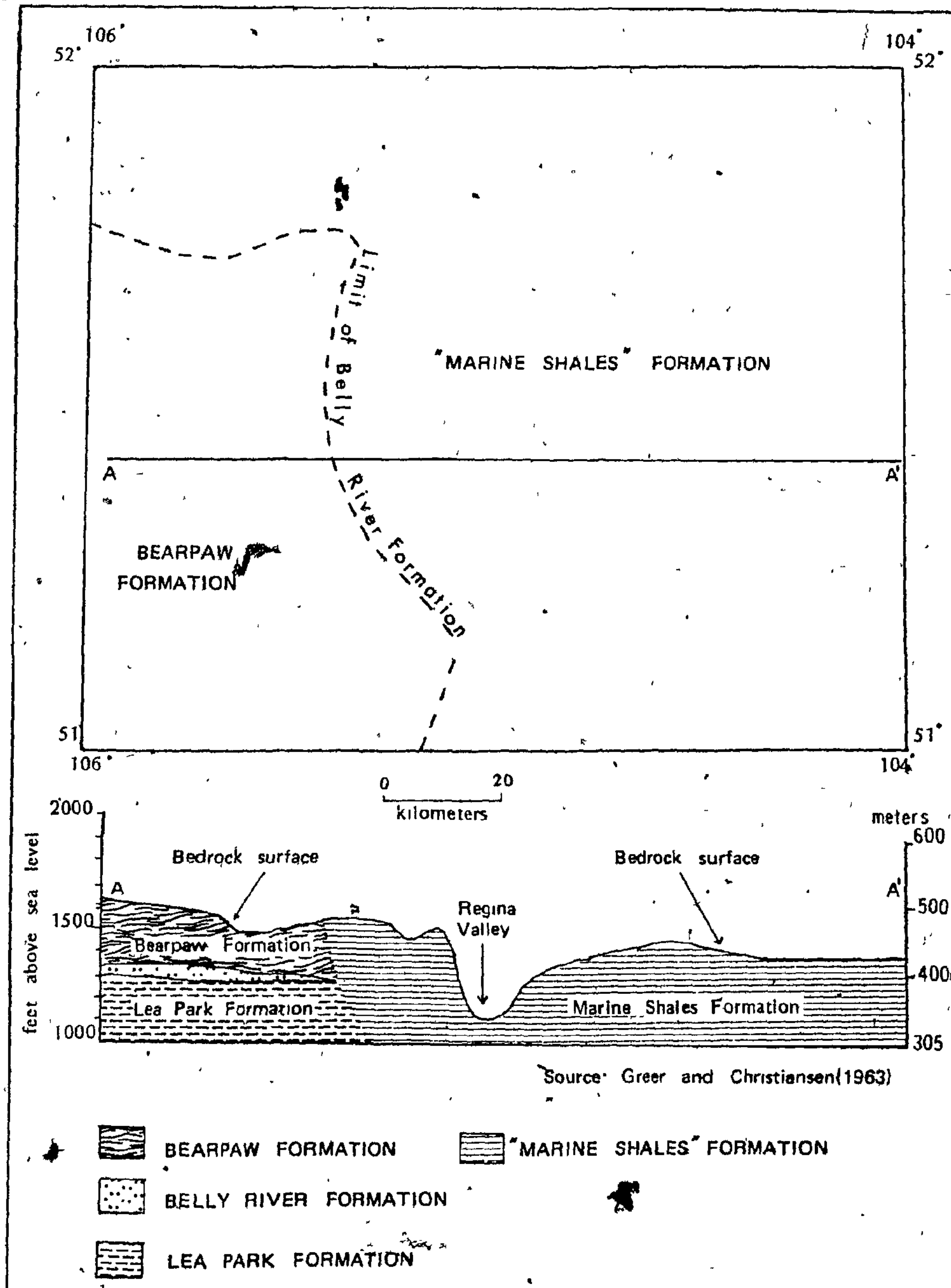


Fig. 2.3 Bedrock geology of the Wynyard Area

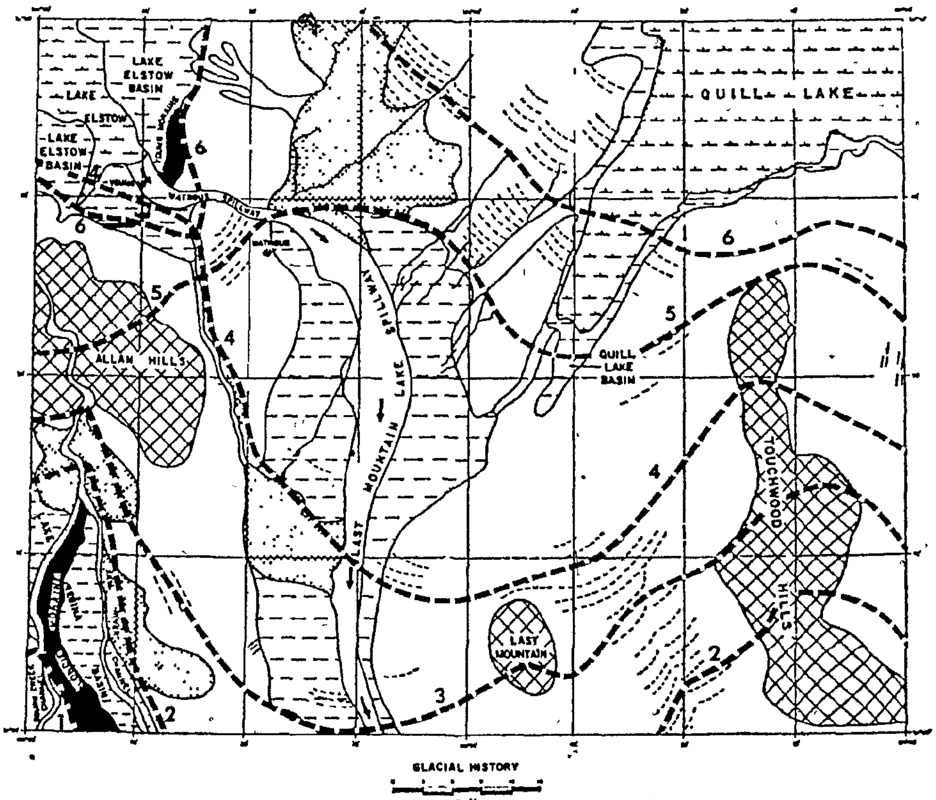
(1050 to 1900 feet) along the transects and for the greater part, glacial drift is very thick.

Pleistocene Events

During the Pleistocene, the Wynyard area was overridden by continental ice and remained ice covered until the final deglaciation. According to Greer and Christiansen (1963) the area was overridden by the Condiean Glacier and there were seven significant stages in the deglaciation of the Wynyard area as shown in Fig. 2.4.

The first portion of the area to be deglaciated was the Squaw Creek section in the southwest. There was then fairly rapid ice retreat until the ice front occupied a position northeast of the Arm River Channel with meltwater draining southeast and cutting the Arm River Terrace. Ridged moraines in this area, as well as ice frontal positions in the adjacent Regina area to the south and the Melville area to the southeast, suggest that an interlobate re-entrant was present in this sector.

During the succeeding phase, a major lobe occupied the Last Mountain Lowland between the Touchwood and the Allan Hills, and the meltwaters were discharged through the Arm River, the Loon and the Jumping Deer Creek Channels. Last Mountain Lake began to develop as an ice marginal channel during the next stage with meltwater from Lake Elstow in the northeast draining into it by the Lewis Spillway. Last



Source Greer and Christiansen (1963)

LEGEND

- Ground moraine
- End moraine
- Hummocky moraine
- Ridged moraine trend
- Flutings
- Esker
- Direction of meltwater flow
- Meltwater channel
- Glacial lake
- Glacial lake basin
- Glacial lake strandline
- Fluvio-lacustrine plain
- Ice frontal positions at various stages of deglaciation

Fig. 2.4 Ice frontal positions during deglaciation and glacial features of the Wynyard Area after the final retreat of the ice

Mountain and the southern part of the Touchwood Hills Uplands were deglaciated about that time.

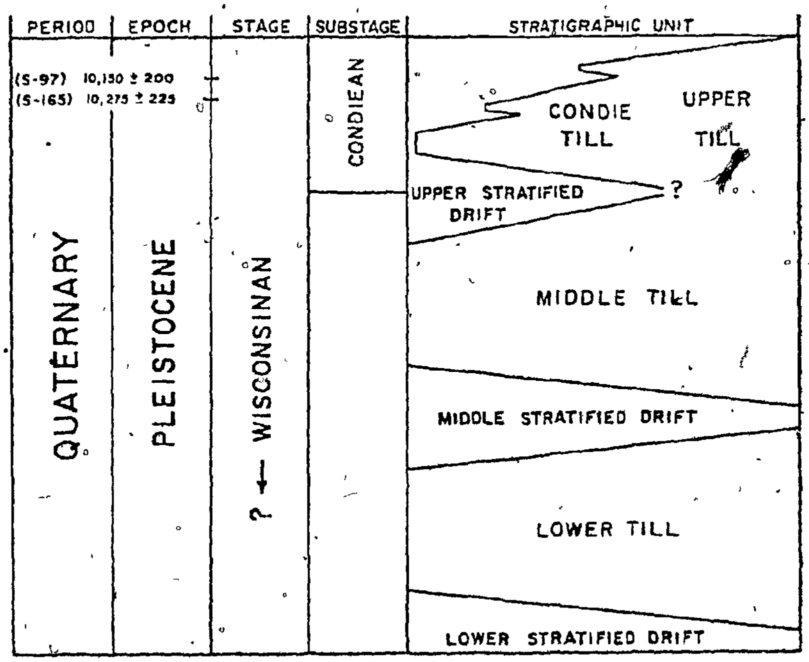
In the succeeding episode, a major re-entrant of the ice occupied the area around Watrous, and to the east a major outwash fan delta was being formed by meltwater. With farther retreat of the ice front the meltwater from Quill Lake in the northeast was carried by the Peter Lake and the Lockwood Spillways into Last Mountain Lake. Meltwater from the northwest was discharged into Last Mountain Lake through the Watrous Spillway and the Plunkett Channel south of Plunkett. During that period Last Mountain Lake extended across the entire north-south length of the Wynyard area.

In the final episode of deglaciation the ice margin stood north of the Wynyard area and there was meltwater drainage via the Quill Lakes depression to Last Mountain Lake.

Glacial Deposits

These consist of a sequence of oxidized zones, Condie Till and stratified units between the till (Greer and Christiansen, 1963) as shown in Fig. 2.5.

The oldest deposit in the sequence is the Lower Stratified Drift which contains mainly sand and occurs in the central lowland of the Wynyard area. The deposits are extensive and thick, varying from 6 to 92 meters. Overlying this is the Lower Till which occurs in the Touchwood Hills



Source: Greer and Christiansen (1963)

Fig. 2. 5 Summary of Pleistocene stratigraphy in the Wynyard Area

area. At the top is an oxidized zone and in some areas, the base is in contact with bedrock.

The Middle Stratified Drift found only in the Allan Hills is composed of 55 meters of gravel, silt and clay. The Middle Till which overlies this layer of stratified drift is calcareous with a texture from a sandy loam to a clay loam and occurs in the Touchwood Hills and the Allan Hills.

Lying between the Middle Till and the Upper Till, the Upper Stratified Drift composed mainly of sand with a thickness of 9 to 46 meters, is well developed in the Western section. The Upper Till lies above the Upper Stratified Drift and is calcareous with a texture from sandy loam to clay loam.

Drift thickness in the Wynyard area varies from a few meters in the southern portion of the Allan Hills to over 305 meters in the Little Touchwood Hills (Greer and Christiansen, 1963). As seen in Fig. 2.2, the drift in the valleys ranges from 152 to 229 meters in thickness.

In areas where moraines occur, surficial materials are mainly till with small amounts of silt, sand and gravel. In the ground moraine belt, sand and gravel are present in lenses and small outwash plains, whereas, in the hummocky moraine they are in the form of lenses and kames.

The main sources of sand and gravel in the Wynyard area are eskers and outwash plains while minor amounts of sand and gravel are found on eroded till plains and meltwater channels. Silt and clay are mainly found in the swales within glacial lake basins or in depressions, although there are areas where the clay collapsed during the final melting of the ice. In such areas there is an absence of till over the lacustrine materials. The topography of the area is hummocky and there is a lack of preferred orientation of structural features.

Within valleys and spillways there is an assortment of till, sand, gravel, alluvium and colluvium, and on eroded till plains, cobbles and boulder lags are present in addition to silt, sand and gravel.

Topography

Glaciation has moulded the topography of the Wynyard area and provided some of the major relief features. Where the ice front remained stationary for long periods, end moraines were formed. They are linear belts of low hills and two major end moraines—the Condie and the Young Moraines as shown in Fig. 2.4—are present in the area.

The Condie Moraine (Christiansen, 1961) lies to the east of the Squaw Creek in the southwestern portion of the Wynyard area. Rising about 8 to 15 meters above the ~~plains~~ area, it is 0.62 to 3 km. wide and up to 19 km. long in the Wynyard area. In the northwestern part of the area the Young Moraine forms a prominent ridge about 15 meters high to the south of the town of Young.

Hummocky moraines are often found in the indentations between large active ice lobes. Hummocky moraine is found in the Allan Hills Upland, the Last Mountain Upland and the Touchwood Hills Upland. The topography is rolling to strongly rolling and local relief is 6 to 31 meters. Till knobs, kames, kettles and small depressions are characteristic features of the hummocky morainal landscape.

In places where the ice experienced slow recession or readvance, ridged moraine occurs. Such ridged moraines are found in many parts of the Wynyard area, particularly in the southeast near Last Mountain, in the northwest near Watrous and in the north central part of the central plains.

Eskers and associated kames are very common in the Wynyard area. The most prominent eskers are found to the northeast of Drake (Tp. 32; R. 21), northwest of Lockwood (Tp. 31; R. 22), northwest of Bank Lake (Tp. 21; R. 23), within township 32—range 24 west of Delwood Brook, and east of Kutawagan Lake (Tp. 30; R. 20). In general, eskers are sinuous ridges composed of sand and gravel. Those in the Quill Lake basin are three to six meters high and about 30 meters wide (Greer and Christiansen, 1963).

Ground moraine covers large sections of the lowland area of Wynyard. With an undulating to gently rolling topography and relief from 2 to 9 meters, the ground moraine is traversed by meltwater channels, eskers and morainal ridges. In the lowland area there are also extensive lacustrine basins and eroded till plains with associated deltaic forms and drainageways.

There are three major glacial lake basins in the Wynyard area: the Elstow Lake Basin, the Last Mountain Lake Basin and the Quill Lake Basin. The first of these, situated in the northwest portion of the Wynyard area, was named by Edmunds (1962). The topography is undulating to rolling with a local relief of up to 12 meters. However, there are no well-defined shoreline features. Last Mountain Lake occupies the central portion of the Last Mountain Lake basin. The basin floor is flat to undulating with a relief of about 2 to 9 meters. Eskers rising up to 9 meters are prominent topographic features. The Quill Lake Basin in the northeast is predominantly a bevelled till plain with eskers rising up to 6 meters above the flat to undulating surface. The lowest areas are occupied at the present day by the Big and Little Quill Lakes.

The general direction of drainage from the glacial lakes was south and the drainage trace is discernible as a series of major spillways. Lake Elstow stood between 564 and 549 meters with the Lewis Spillway serving as an outlet to the Last Mountain Lake basin. The Lewis Channel is about 31 meters deep and 610 meters wide. With retreat of the ice front and lowering water levels, the Watrous-Last Mountain Lake Spillway came into being. Little Manitou Lake and Last Mountain Lake now occupy the floors of these spillways.

Little Manitou Lake about 6.8 km. long and 0.3 km. wide lies in a deep valley north of the town of Watrous. Last Mountain Lake is 34 km. long and 0.5 to 1.9 km. wide with a maximum depth of 30 meters (Greer and Christiansen, 1963).

Physiographic subdivisions

The Wynyard area is located in the Great Plains region of Canada, in the Saskatchewan Plain Area of the Second Prairie Level which has an average elevation of 610 meters (2000 feet) above sea level and is for the most part an area of gentle relief. The landscapes are generally low morainal hills or undulating till plains with flat lacustrine basins. Such a landscape is present in the Wynyard Area as shown in Fig. 2.6: morainal hills in the Allan Hills, Touchwood Hills and Last Mountain Uplands are separated by an extensive till plain. The remainder of the surface of the Wynyard area is for the most part, composed of glacial drift that is very thick, and streams rarely expose the underlying rock. Numerous lakes occupy shallow depressions and the largest of these are the Quill Lakes.

Acton et al. (1960) have divided the Wynyard area into the following physiographic subdivisions: the Saskatchewan Rivers Plain, the Quill Lake Plain, the Assiniboine River Plain, the Allan Hills Upland, the Touchwood Hills Upland and the Last Mountain Upland as shown in Fig. 2.7.

The Saskatchewan Rivers Plain in the northern portion

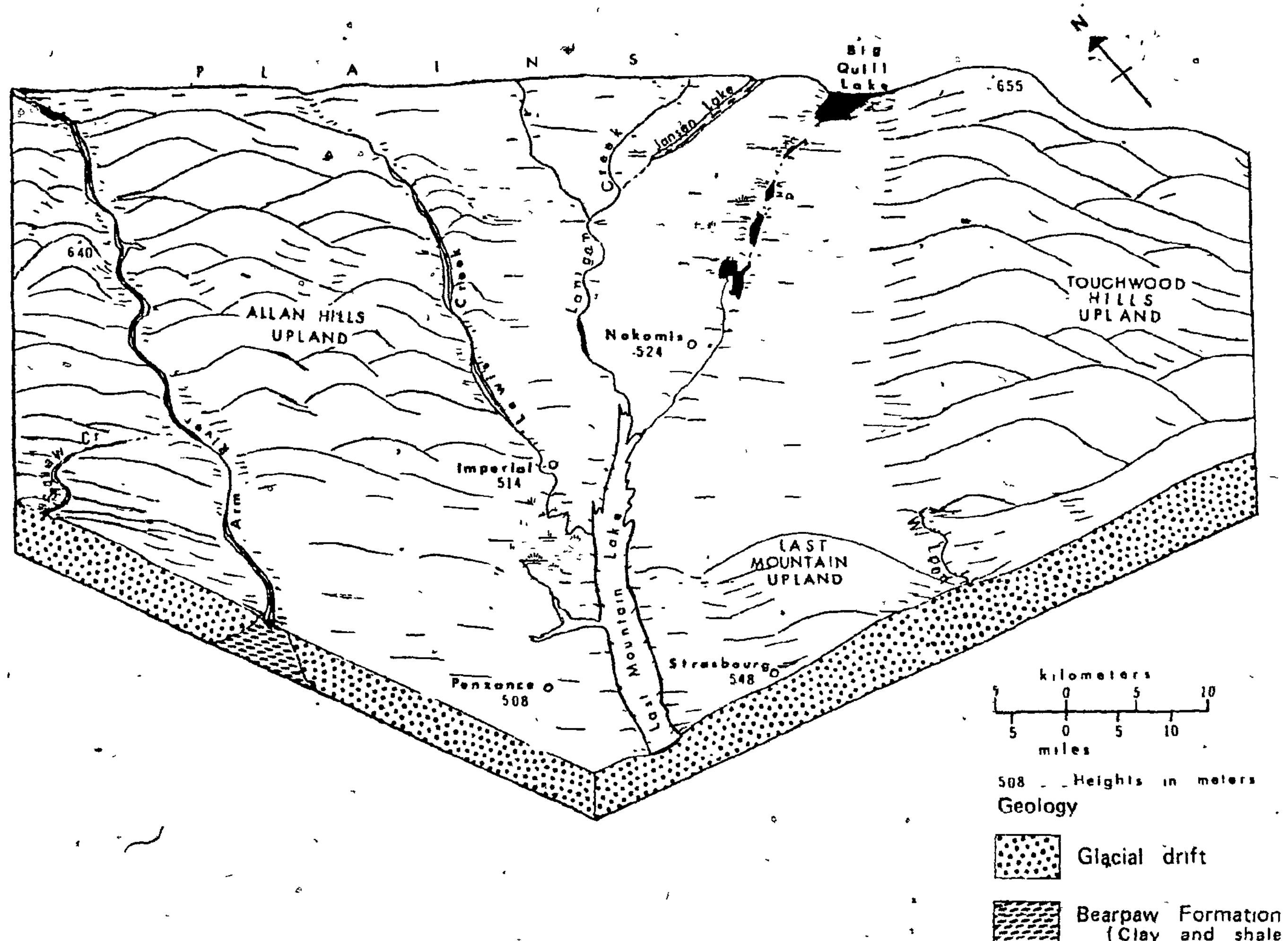
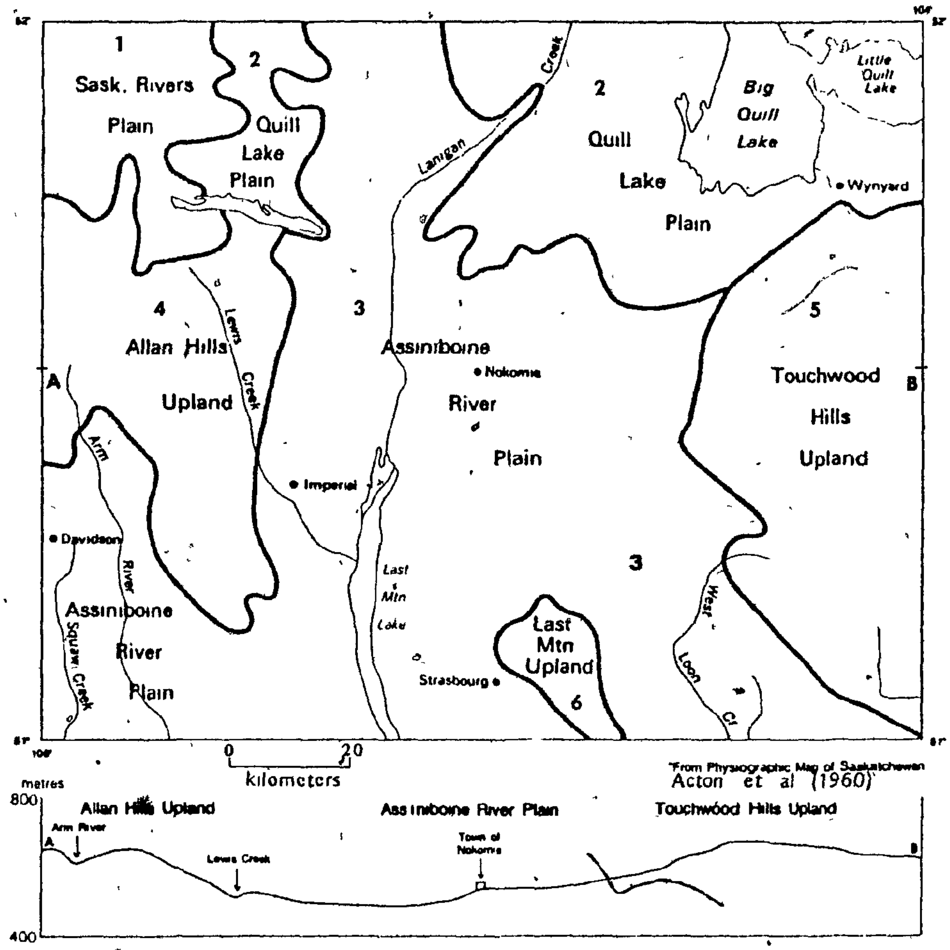


Fig. 2.6 Physiography of the Wynyard Area



REF.NO.	PHYSIOGRAPHIC SUBDIVISION	ELEVATION (above sea level)	TOPOGRAPHY
1	Saskatchewan Rivers Plain	518–549 meters (1700–1800 feet)	Gently undulating
2	Quill Lake Plain	534–595 meters (1750–1950 feet)	Gently undulating
3	Assiniboine River Plain	488–595 meters (1600–1950 feet)	Gently undulating
4	Allan Hills Upland	610–655 meters (2000–2150 feet)	Gently to strongly rolling
5	Touchwood Hills Upland	595–732 meters (1950–2400 feet)	Gently to strongly rolling
6	Last Mountain Upland	595–678 meters (1950–2225 feet)	Gently to strongly rolling

Fig. 2.7 Physiographic subdivisions of the Wynyard Area.

of the map area is gently undulating with elevations ranging between 518 to 549 meters. It occupies approximately 13 per cent of the Wynyard map area. The Quill Lake Plain lying to the east of the Saskatchewan Rivers Plain and separated into two sections by the Assiniboine River Plain, ranges in elevations between 534 and 595 meters and comprises about 20 per cent of the total area. Occupying the central and the southwestern sections of the map area, the Assiniboine River Plain is the largest plain region with an area occupance of 60 per cent of the total map sheet.

In the western section of the area, the Allan Hills Upland with an elevation of 610 to 655 meters rises 180 meters above the plain. It has a north-south trend and is undulating to strongly rolling.

In the eastern portion of the map area is the Touchwood Hills Upland which trends north-south paralleling the central plain. The upland area includes the Touchwood Hills in the northern section and the Little Touchwood Hills in the south. The two upland areas rise approximately 245 meters and 305 meters respectively above the central plains.

To the west of the Touchwood Hills and standing dominantly above the surrounding plains, is the Last Mountain Upland, a striking feature in the landscape with extremely rugged topography rising some 650 meters above the plains.

Drainage

A large portion of the plains area is occupied by water bodies such as the Big Quill (260 sq. km.), Last Mountain (229 sq. km.) and Little Manitou (21 sq. km.) Lakes. All of these are very shallow: mean depths are 4.9 meters for Big Quill Lake, 7.6 meters for Last Mountain Lake and 2.4 meters for Little Manitou Lake (Whiting, 1974). The Quill Lakes form a basin of internal drainage with various creeks supplying water from the surrounding upland areas--Quill Creek from the north, and Dafoe Brooke, the Rushville Brook, the Magnusson Creek and the Jolly Creek from the south. The Quill Lakes Drainage Basin has no outlet below about 527 meters (Greer and Christiansen, 1963) the minimum level of the former glacial Quill Lake.

Drainage in the southern portion of the central lowland is into Last Mountain Lake which occupies a former meltwater channel. This is an open drainage system with an outlet to the Qu'Appelle River in the south. However the drainage net is not particularly dense or well integrated and large portions of the Wynyard area have internal drainage with large kettles and sloughs providing the local base level.

CLIMATE

The Wynyard area lying in the heart of the Canadian prairies has a severe climate with extremes of temperature and low precipitation. In the Köppen system the area is classified as a Db climatic type.

Temperature

The mean temperature for the coldest month is below -3°C and that of the warmest month is above 10°C. There are extremes of temperature during both the summer and the winter seasons as a result of the mid-continental position of the area. The monthly average temperatures for the meteorological stations in the area are shown in Fig. 2.8. January is the coldest month for all the stations, the lowest figures being reported at Dafoe Airport in the northeast with a mean of only -19.4°C. Duval with -17.2°C has the warmest January temperature. July is the hottest month with mean temperatures ranging from 18.1°C at Dafoe Airport to 18.6°C at Imperial. Temperatures drop rapidly during the months of October and November and there is a rapid rise after February. In both winter and summer the colder temperatures are experienced in the northeast part of the area as shown in Fig. 2.9 and Fig. 2.10.

Frost

Frost may occur in any month and the occurrences in late spring and early fall are critical for crop growth. Available frost data for some locations in the Wynyard area are given in Table 2.2. Isolines showing the mean dates of the last occurrence of spring frost are shown in Fig. 2.11. At

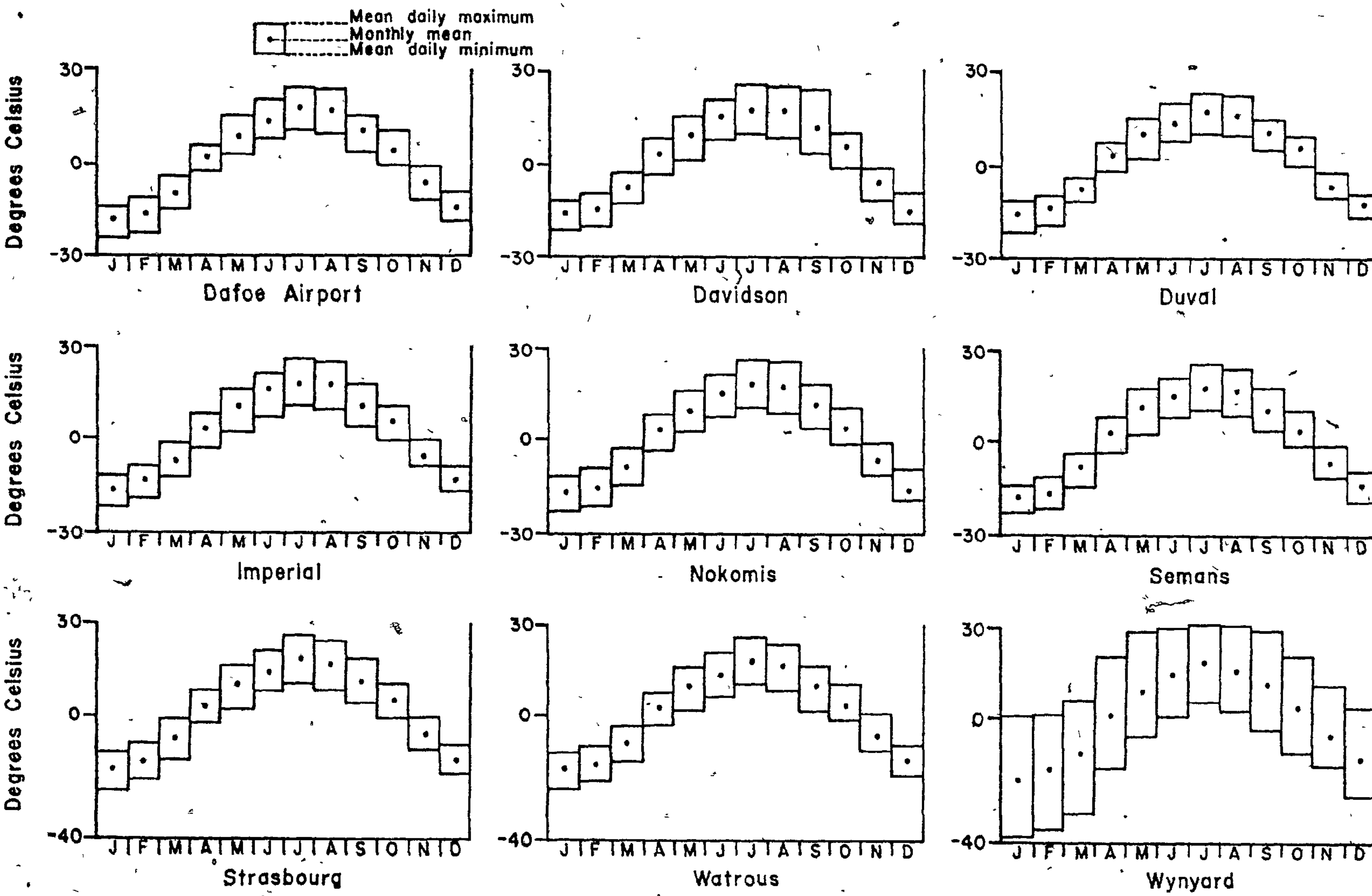


Fig. 2.8 The monthly averages of daily minimum, mean and maximum temperatures for selected stations. (Data Source: Climatic Summaries, Temperature and Precipitation, vol. 5, Environment Canada, with metric conversion.)

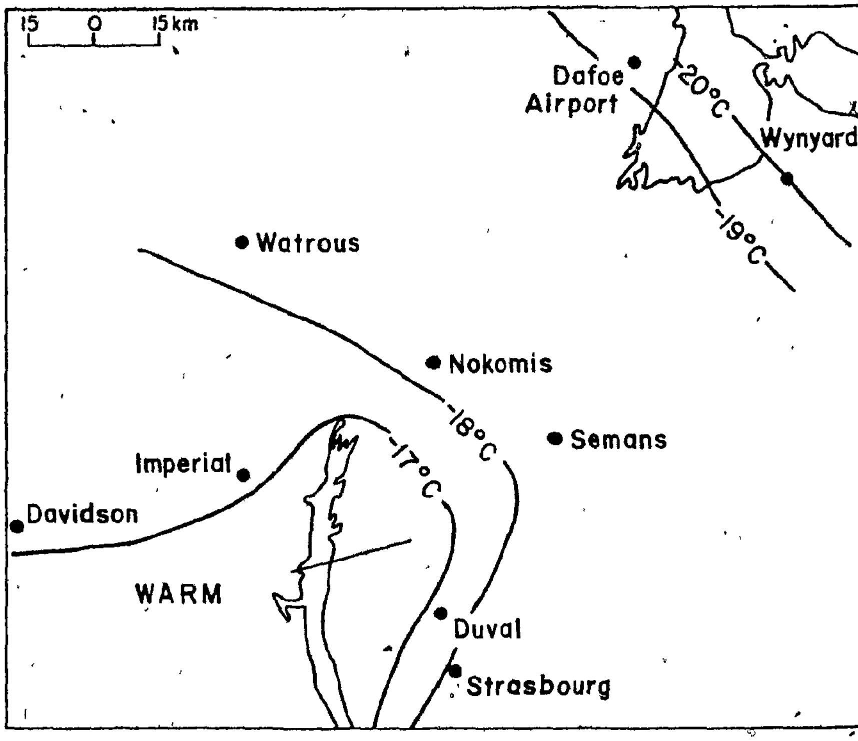


Fig. 2.9 Generalized isolines illustrating mean January temperatures of the Wynyard area. (Data Source: Temperature and Precipitation, vol. 5, Environment Canada, with metric conversion.)

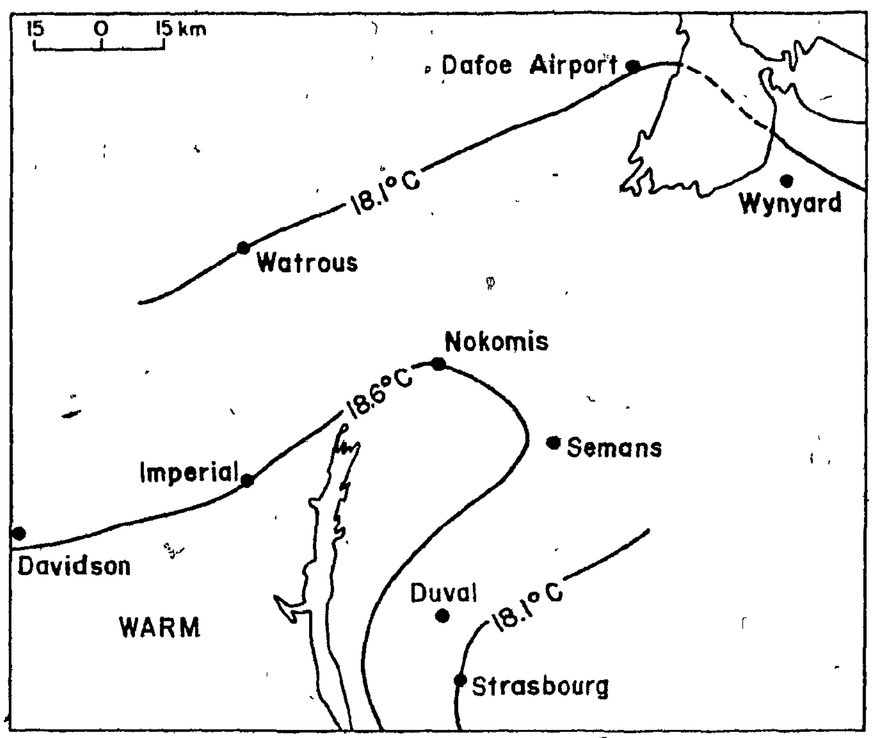


Fig. 2.10 Generalized isolines illustrating mean July temperatures of the Wynyard area. (Data Source: Temperature and Precipitation, vol. 5, Environment Canada, with metric conversion.)

TABLE 2.2

FROST DATA FOR SELECTED STATIONS IN WYNYARD AREA

Station	No. of Years	Height Above Mean Sea Level (Meters)	Average Frost-free Period (Days)	Last Frost (Spring)			First Frost (Fall)			Frost Free Season Extremes on Record (Days)	
				Average	Earliest	Latest	Average	Earliest	Latest	Long-est	Short-est
Dafoe Airport	6	540	103	May 29	May 15	June 10	Sept 9	Aug 17	Sept 26	112	71
Davidson	23	619	112	May 24	May 6	June 13	Sept 13	Aug 17	Oct 14	152	71
Imperial	15	515	93	June 2	May 7	July 7	Sept 3	July 25	Sept 25	133	21
Nokomis	23	524	108	May 26	May 2	June 20	Sept 11	Aug 17	Oct 14	139	71
Semans	22	563	97	May 31	May 7	July 5	Sept 5	July 31	Sept 22	137	44
Strasbourg	30	549	110	May 24	Apr 29	June 23	Sept 11	Aug 22	Oct 2	156	77

Source: Meteorological Division, Dept. of Transport, Climatic Summaries.

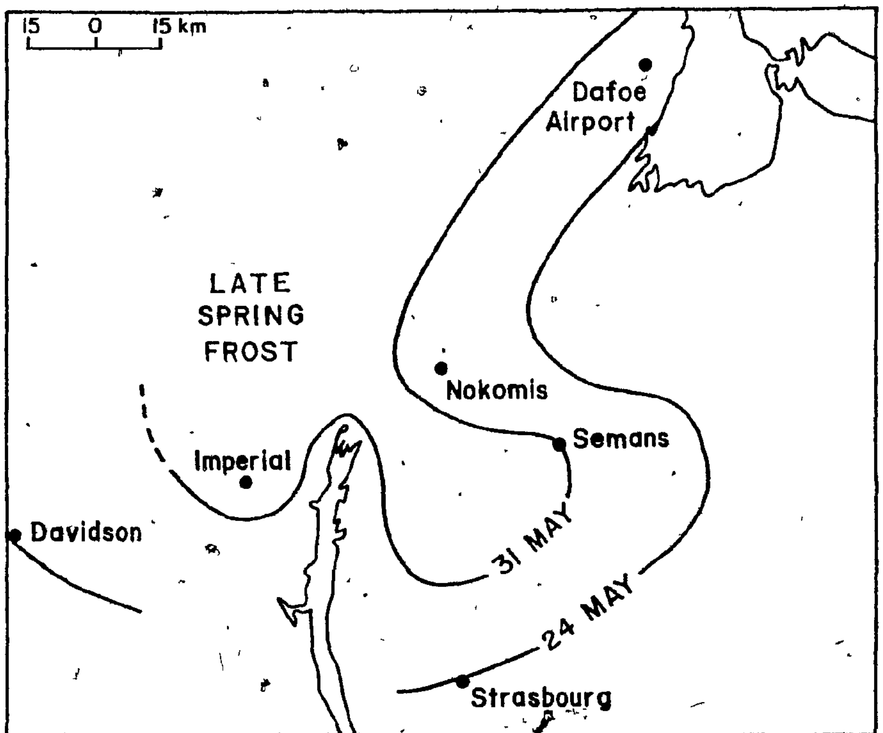


Fig. 2.11 Isolines illustrating the mean dates of occurrences of late spring frost. (Data Source: Boughner et al., 1956)

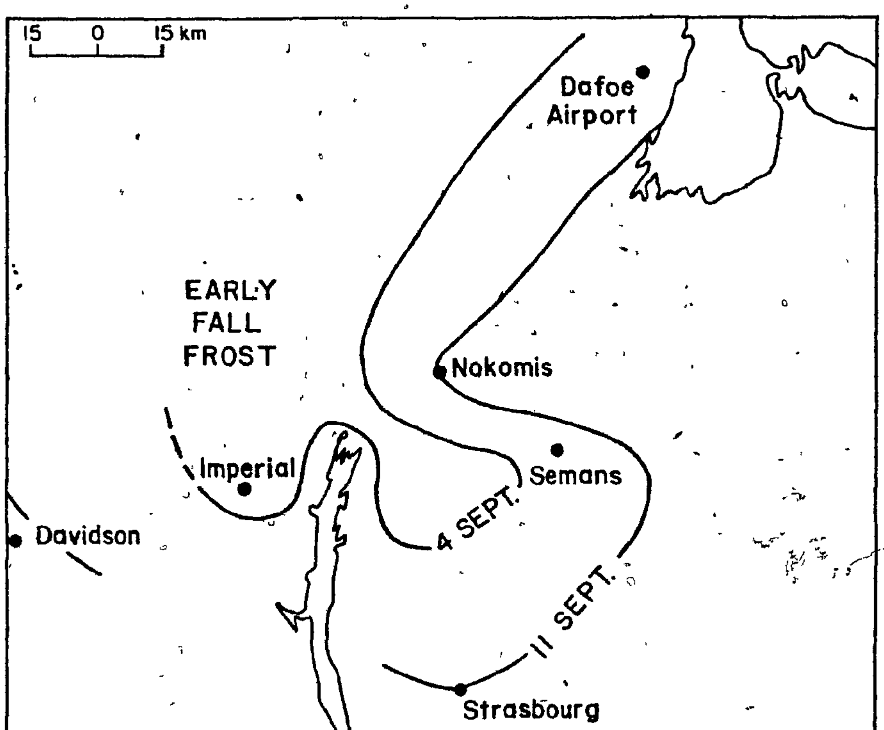


Fig. 2.12 Isolines illustrating the mean dates of occurrences of early fall frost. (Data Source: Boughner et al., 1956)

Strasbourg on the southern foot slopes of Last Mountain Upland, the last spring frost occurs on May 24, whereas, at Imperial on the central plains there are frost occurrences till June 2. The mean dates of early fall frost are shown in Fig. 2.12. When Strasbourg and Imperial are compared, it can be seen that the frost free period is about 20 days longer at the former location. Due to the inavailability of frost data for the Allan Hills Upland, isolines could not be drawn but it is probable that the isolines would curve north at the foothills. Frost occurrences in the northwestern lowlands are in general later in the spring and earlier in the fall than the neighbouring uplands due to unrestricted drainage of cold air from the north and the uplands, and also the absence of large modifying bodies of water. The frost-free season shown in Fig. 2.13 becomes shorter away from Last Mountain Lake and Quill Lakes. The average frost-free period ranges from 93 days at Imperial situated on the lowland plain to 112 days at Davidson which is sheltered from cold northerly air by the Allan Hills.

Precipitation

The mean monthly and annual precipitation of selected stations are shown in Fig. 2.14. During winter the precipitation is mainly in the form of snow and the area with the greatest amount of precipitation in January is towards the north. Strasbourg at the foot of Last Mountain Upland in

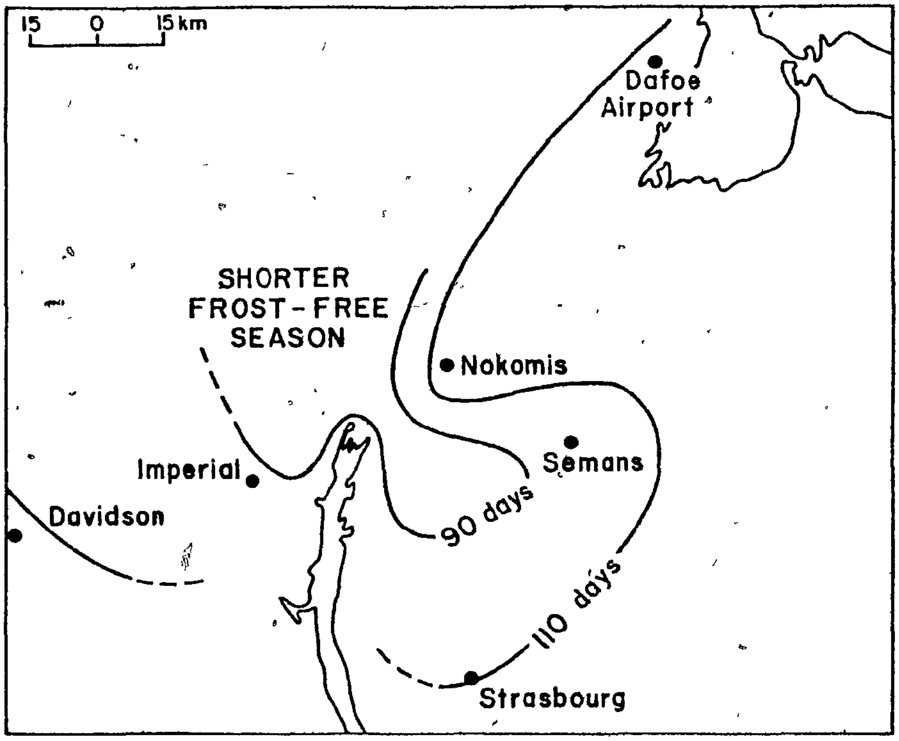


Fig. 2.13 Isolines showing the number of frost free days for certain locations in the Wynyard area. (Data Source: Boughner et al., 1956)

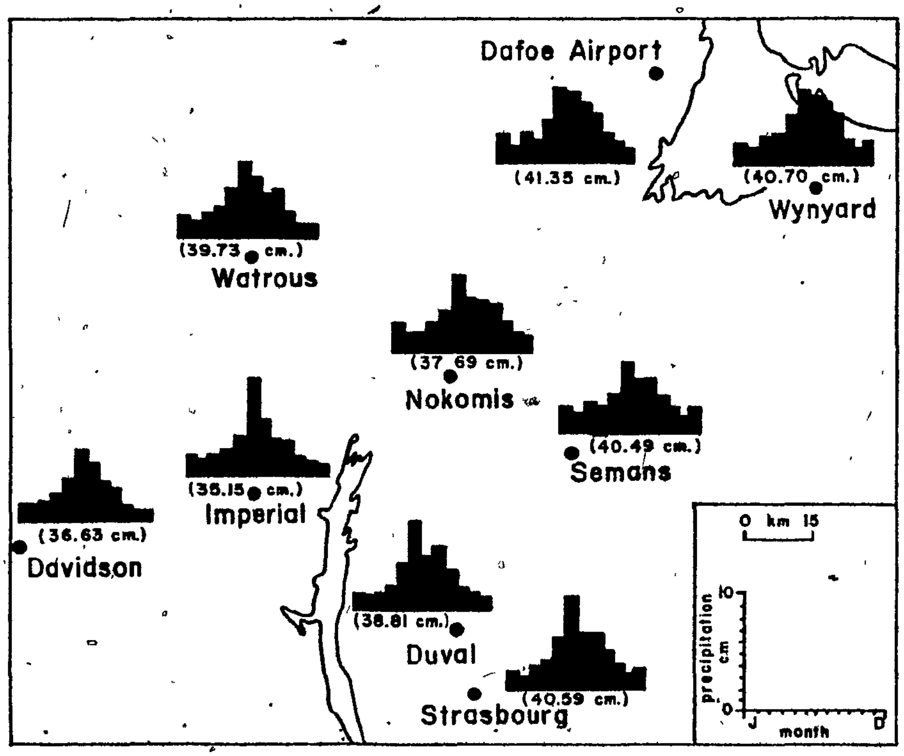


Fig. 2.14 Mean monthly and annual precipitation for selected stations. (Data Source: Environment Canada)

the south has 17 mm. The drier area is in the southwest (Fig. 2.15). The area with more than 76 mm. during June as shown in Fig. 2.16, lies in the Last Mountain Lake area between the Allan Hills Upland and the Last Mountain Upland and the amount decreases towards the north. The Wynyard area has an average annual precipitation of about 33 cm. to 43 cm. of which 65 per cent occurs during the month of May, June, July, August and September with the highest amount—totalling about 20 per cent of the annual precipitation—in June (Fig. 2.14).

NATURAL VEGETATION

Native vegetation within the Wynyard area has been radically changed by cultivation and intensive grazing. Where the land has not been put to the plough, two types of vegetative cover remain: grassland and woodland.

The natural grasslands remain only in the southwestern portion of the area. The most common species include common spear grass (*Stipa comata*), porcupine grass (*Stipa spartea var. curtiseta*), northern wheat grass (*Agropyron dasystachyum*), rough fescue (*Festuca scabrella*), bromeweed (*Gutierrezia diversifolia*), and moss phlox (*Phlox hoodii*) while cat-tails (*Typha latifolia*) and bulrushes (*Scirpus validus*) thrive in meadows and marshes. In the saline areas the vegetation is somewhat different and consists of salt tolerant shrubs such as salt wort (*Salicornia rubra*) and salt grass (*Distichlis stricta*).

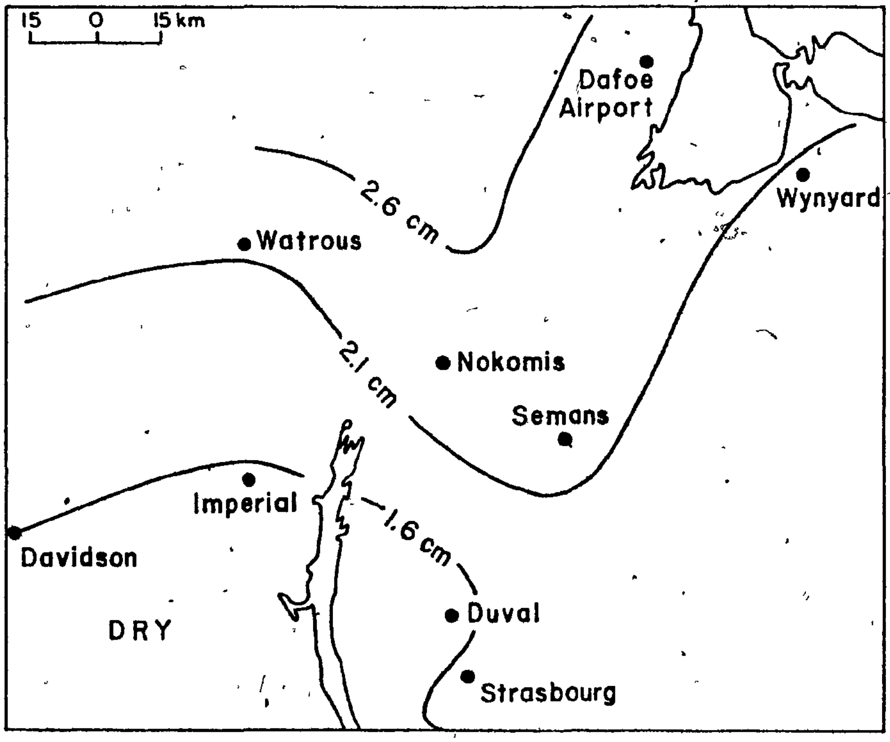


Fig. 2.15 Generalized isolines showing the distribution of precipitation in the Wynyard area during January. (Data Source: Temperature and Precipitation, vol. 5, Environment Canada, with metric conversion.)

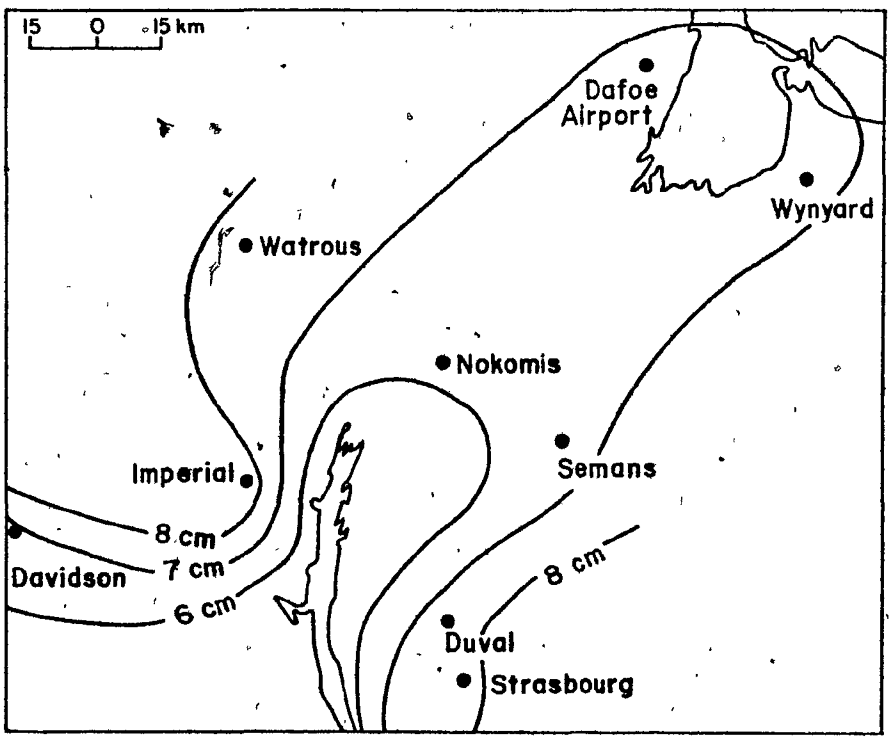


Fig. 2.16 Generalized isolines showing the distribution of precipitation in the Wynyard area during June. (Data Source: Temperature and Precipitation, vol. 5, Environment Canada, with metric conversion.)

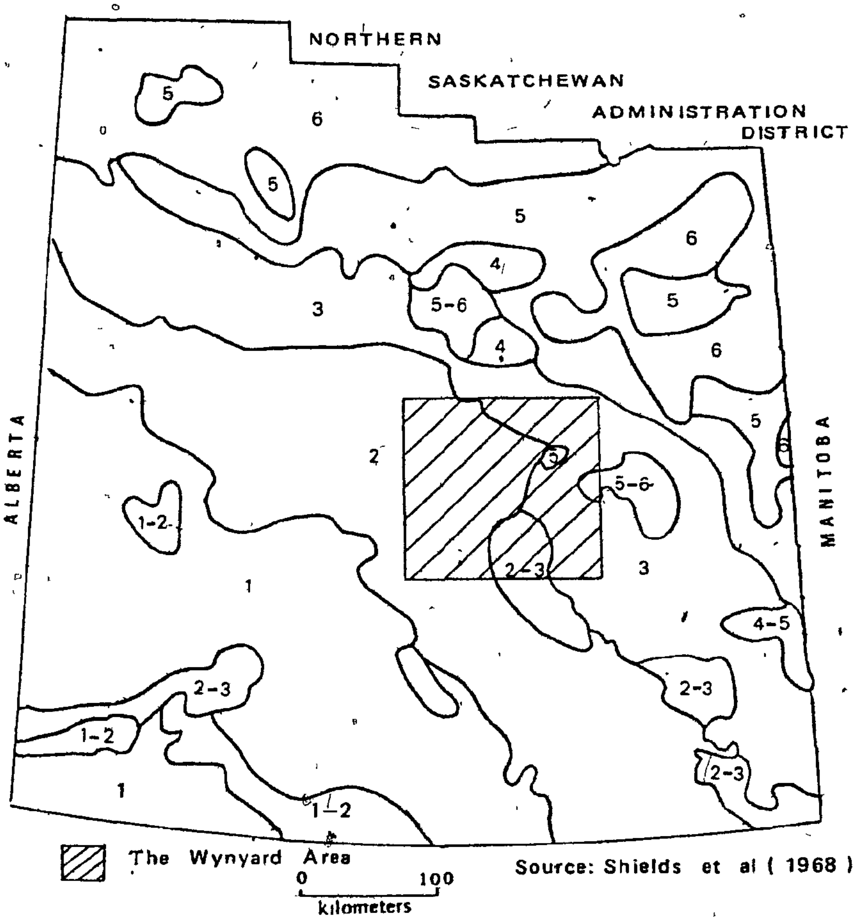
The woodland areas are very restricted. In the valleys and moist sloughs of the grassland, aspen groves occur as narrow strips following the outline of the wetter sites. In the Touchwood Hills a more extensive tree cover occurs due to the greater precipitation effectiveness. Aspen (*Populus tremuloides*) and poplar (*Populus balsamifera*) predominate on these uplands, forming a light tree cover.

SOILS

Within the Wynyard area the soils fall into two major groups: the Chernozemic and the Luvisolic. The Chernozemic soils are associated with the grassland vegetation of the area. Two soil zones are identifiable—the Dark Brown Soil Zone and the Black Soil Zone (Fig. 2.17). The first of these occurs in the driest part of the area. Eastward and north-eastward as moisture conditions become more favourable, the amount of organic matter in the soil increases and soil colour changes from brown to very dark brown and black.

The Gray Luvisol soils (formerly Gray Wooded) occur in the Touchwood Hills Upland. Unlike the Chernozemic soils of the Dark Brown and Black Soil Zones, the Gray Luvisols are wooded soils formed under trees with a lower content of organic matter and the surface horizons are gray in colour, hence the term Gray Luvisol.

Highly complex soil patterns occur in Saskatchewan and because of the difficulty of limiting units to single Series,



LEGEND

1. Brown Soils
2. Dark Brown Soils
3. Black Soils (Thin Black)
4. Thick Black Soils
5. Dark Gray and Dark Gray Luvisol Soils
6. Gray Luvisol and Peat Bog Soils

Fig. 2.17 Soil zones of Saskatchewan

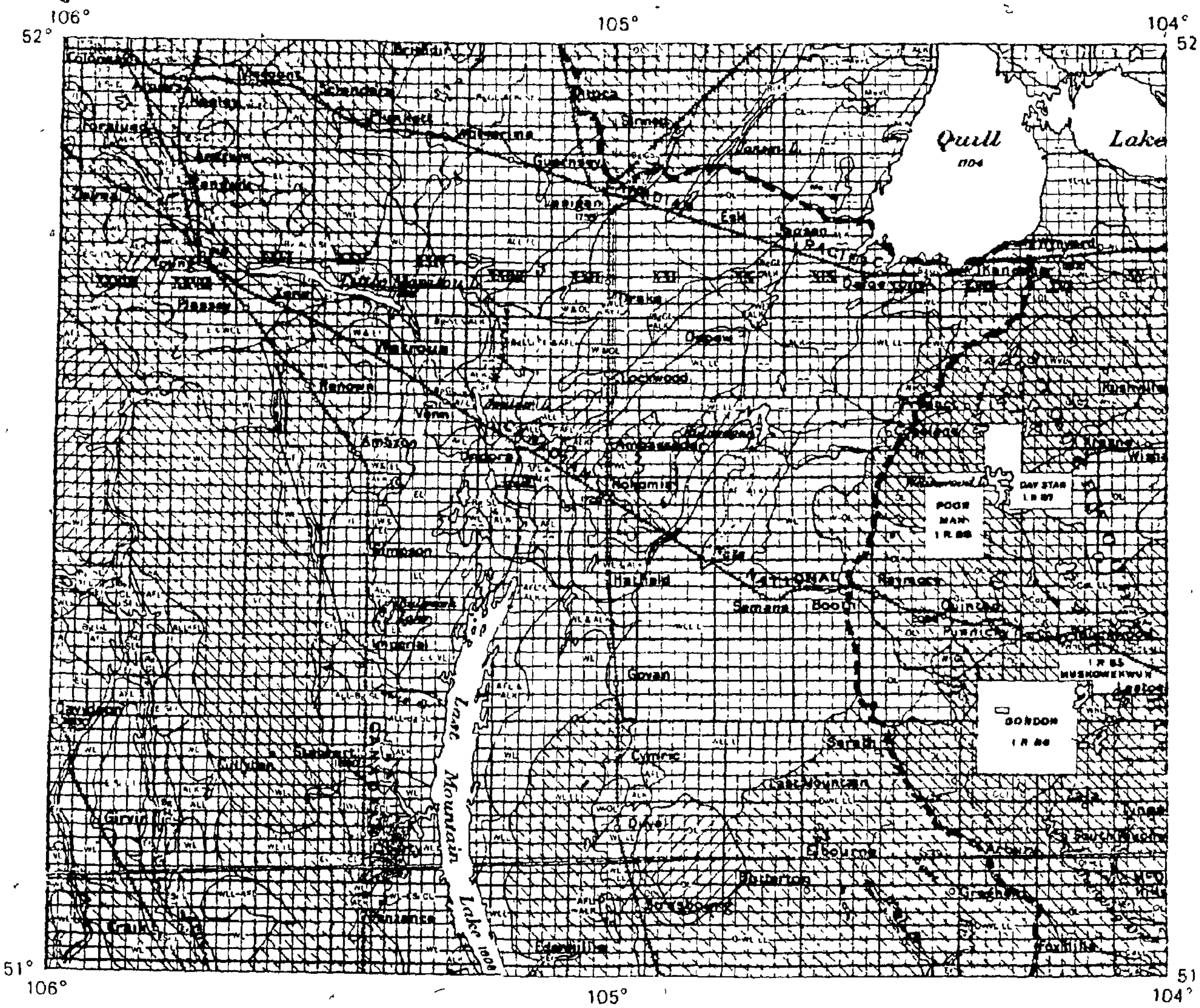
the Soil Association has been used for mapping combinations or complexes of several Soil Series on a given landform. The Soil Association is composed of a group of associated soil profiles (Series or Members) developed on similar parent materials and under similar climatic conditions.

The major Soil Associations of the different soil zones in the Wynyard area are shown in Fig. 2.18.

Dark Brown Soil Associations

In the Wynyard area there are six Dark Brown Soil Associations—Weyburn, Elstow, Asquith, Biggar, Bradwell and Wyandotte. A summary of these associations is given in Table 2.3.

Weyburn Association. The soils of the Weyburn Association are developed on glacial till and are widely distributed in the Wynyard area. They occur in all topographic situations whenever the underlying till is exposed. They are frequently associated with Biggar, Elstow, Asquith, Bradwell and Wyandotte Associations in the Dark Brown Soils and with Black Oxbow soils along the zonal boundary. Weyburn soils are dark brown with limy knolls and have medium textures ranging from light loam, loam, sandy clay loam to clay loam. Loam is the most common texture. The chief problems of the Weyburn soils are hazards of drought, wind erosion (particularly on the light loams) and water erosion on rolling topography. Stones are present in the soil, requiring removal before cultivation.



Scale 36 Km / 6 Miles

*From Saskatchewan Soil Survey Report Nº12, 1944

LEGEND

SOIL TEXTURES

C	Clay
Si C	Silty Clay
Si CL	Silty Clay Loam
CL	Clay Loam
Si L	Silty Loam
S CL	Sandy Clay Loam
L	Loam
LL	Light Loam
VL	Very Fine Sandy Loam
FL	Fine Sandy Loam
GL	Gravelly Loam
G-SL	Mixed Gravelly Loam and Sandy Loam
SL	Sandy Loam
S	Sand
G	Gravel
C & CL	Example of mixed textures Clay and Clay Loams

SOIL PHASES (Topographic)

- Flat to depressional land, with slow to impeded drainage.
- Gently to moderately undulating.
- Mixed undulating and rolling areas, also used for very gently rolling.
- Gently to moderately rolling.
- Strongly rolling, (some mixed moderately and strongly rolling)
- Dune topography

SOIL PHASES (Stony, gravelly, eroded)

(St)	Stony phase - very stony soil.
(C)	Gravelly phase - frequent gravel subsoils.
●	Eroded phase of solonetz soils (frequent "burn-out" or blow-out" pits)

OTHER FEATURES

	Soil Zone Boundary
	Railway Line and Station.
O-W L.	Example of mixed soil area Oxbow and Weyburn Loams.

DARK BROWN SOILS

Association	Description
W Weyburn	Medium textured soils on undifferentiated glacial till (boulder clay) deposits.
Bg Biggar	Coarse textured soils on glacial outwash or stream-eroded till.
A Asquith	Light textured soils on sandy glacial lake-alluvial deposits.
E Elstow	Medium to heavy textured soils on silty glacial lake deposits.

BLACK SOILS

Association	Description
O Oxbow	Medium textured soils on undifferentiated glacial till (boulder clay) deposits.
Y Yorkton	Medium textured deep black high lime soils on resorted glacial till.
Ws Whitesand	Coarse textured soils on glacial outwash or stream-eroded till.
Me Meota	Light textured soils on sandy glacial lake-alluvial deposits.
B Blaine Lake	Medium to heavy textured soils on silty glacial lake deposits.
Cd Cudworth	Medium textured high lime soils on silty glacial lake deposits.
Ca Canora	Medium textured deep black high lime soils on silty glacial lake deposits.

TRANSITION (DEGRADED BLACK) SOILS

Association	Description
Wh Whitewood	Medium textured soils on undifferentiated glacial till (boulder clay) deposits.

GRAY WOODED SOILS

Association	Description
Wv Waitville	Medium textured soils on undifferentiated glacial till (boulder clay) deposits.

MISCELLANEOUS SOILS

(Immature soils and other groups not classified with existing soil associations)

	Name	Description
Av	Alluvium	Variable textured soils of river flats and upland depressions, with poorly drained subsoils, but not excessively saline.
ALK	Alkali	Variable textured saline (alkali) soils.
MK	Muskeg	Bog or Peat soils.
DS	Dune Sand	Undifferentiated dune sands.
S	Sand	Undifferentiated sand deposits.
G	Gravel	Undifferentiated gravel deposits.
Er	Eroded	Eroded soils of valley slopes and escarpments, with variable textures and thin (truncated) profiles.

Fig. 2. 1 8 Soils of the Wynyard Area

TABLE 2.3

SUMMARY OF SOIL ASSOCIATIONS OF THE DARK BROWN SOIL Z

SOIL ASSOCIATION	PARENT MATERIAL	SOIL TEXTURE	SOIL COLOUR: Horizon and depth	SOIL COLOUR: Dry soil	SOIL COLOUR: Moist soil	DOMINANT PROFILE	CAPABILITY CLASS FOR AGRICULTURE	MAJ MAJ
Weyburn	Glacial till (undifferentiated)	Medium to moderately fine loam*, light loam, clay loam, sandy clay loam	Ap (0–4")	10YR 4/1 Dark grayish brown	10YR 3/2 Very dark grayish brown	Orthic Dark Brown	fair arable land (Class 3) to poor land unsuitable for cultivation (Class 5)	grain
Elstow	Glacio–lacustrine deposits	Medium to fine: clay, silty clay, silty clay loam, clay loam, silt loam.	Ap(0–4")	10YR 4/2 Dark grayish brown	10YR 3/2 Very dark grayish brown to 10YR 2/2 Very dark brown	Orthic Dark Brown and Calcareous Dark Brown	fair arable land (Class 3)	grain
Asquith	Sandy glacio–lacustrine deposits	Moderately coarse: fine sandy loam*, light loam.	Ap(0–7")	10YR 4/2 Dark grayish brown to 10YR 3/2 Very dark grayish brown	10YR 3/1 Very dark gray	Orthic Dark Brown	poor arable land (Class 4) to unsuitable for sustained cultivation (Class 5)	grain forag whe bro swe livest
Biggar	Glacio–fluvial and stream eroded till	Coarse to moderately coarse gravelly loam, light loam, sandy loam*, mixed gravelly loam and sandy loam, stony stony gravel	Ah(0–5")	10YR 4/2 Dark grayish brown	10YR 3/2 Very dark grayish brown	Orthic Dark Brown	poor arable land (Class 4) to unsuitable for cultivation (Class 5 or 6)	grain forag clc cre Also, arabl
Bradwell	Sandy glacio–lacustrine deposits	Medium to moderately fine. very fine sandy loam to loam	Ap(0–5")	10YR 4/2 Dark grayish brown	10YR 2/2 Very dark brown	Orthic Dark Brown	fair arable land (Class 3)	grain
Wyandotte	Clayey modified glacial till	Moderately fine to fine: clay loam*	Apk(0–3")	10YR 4/2 Dark grayish brown	10YR 3/2 Very dark brown	Rego Dark Brown and Calcareous Dark Brown	fair arable land (Class 3)	grain

\+ only those present in the Wynyard Area

SOURCE ; Mitchell et al (1950 and 1962)
Ellis et al (1965 and 1970)

* dominant

TABLE 2.3

IY OF SOIL ASSOCIATIONS OF THE DARK BROWN SOIL ZONE+

SOIL COLOUR Dry soil	Moist soil	DOMINANT PROFILE	CAPABILITY CLASS FOR AGRICULTURE	MAJOR LAND USE AND MAJOR CROPS	TOPOGRAPHY	HAZARDS	AREA OCCUPANCE (%)
10YR 4/1 Dark grayish brown	10YR 3/2 Very dark grayish brown	Orthic Dark Brown	fair arable land (Class 3) to poor land unsuitable for cultivation (Class 5)	grain : wheat	wavy relief of knolls,slopes and depressions	1.limited moisture storage 2.many cultural interruptions 3 presence of surface stones 4 shallow soils on knolls are susceptible to water and wind erosion.	40.0
10YR 4/2 Dark grayish brown	10YR 3/2 Very dark grayish brown to 10YR 2/2 Very dark brown	Orthic Dark Brown and Calcareous Dark Brown	fair arable land (Class 3)	grain · wheat	undulating	1.limited moisture storage 2.susceptible to water and wind erosion .	12.0
10YR 4/2 Dark grayish brown to 10YR 3/2 Very dark grayish brown	10YR 3/1 Very dark gray	Orthic Dark Brown	poor arable land (Class 4) to unsuitable for sustained cultivation (Class 5)	grain . wheat forage ; crested wheat grass, brome grass, sweet clover livestock production	very gently undulating	1.very sandy surface soil 2.local gravelly subsoils in fine sandy loams 3.low moisture storage 4.low drought resistance 5.tendency to drift	7.0
10YR 4/2 Dark grayish brown	10YR 3/2 Very dark grayish brown	Orthic Dark Brown	poor arable land (Class 4) to unsuitable for cultivation (Class 5 or 6)	grain · rye*,wheat forage . sweet clover,brome and crested wheat grass Also, areas of non-arable land present	undulating, rolling to hilly	1.gravelly loam and light loam areas are very stony 2.frequent deposits of coarse sand gravel or cobbles 3.low moisture storage 4.low drought resistance 5.low fertility 6.susceptible to wind erosion	5.0
10YR 4/2 Dark grayish brown	10YR 2/2 Very dark brown	Orthic Dark Brown	fair arable land (Class 3)	grain : wheat	gentle to roughly undulating	1.low moisture storage 2.tendency to drift	0.2
10YR 4/2 Dark grayish brown	10YR 3/2 Very dark brown	Rego Dark Brown and Calcareous Dark Brown	fair arable land (Class 3)	grain : wheat	gentle to strongly rolling	1.shallow soils on knolls are subject to water and wind erosion	0.2

Elstow Association. The soils of the Elstow Association were developed on silty glacial lake deposits. Elstow soils occur extensively around Colonsay, Zelma and Plassey; in a zone from Watrous to Penzance and in a north-south zone bordering Arm River to the east of Davidson. In many places, the lacustrine deposits are comparatively thin and underlain by glacial till with the result that Biggar soils or Asquith soils occur mixed with the Elstow Association. In other areas Elstow soils are underlain by Weyburn, Biggar, Asquith and Meota soils. Elstow soils range in texture from clay to light loam, the dominant textures being loam, clay loam and silty clay loam. The heavier soils are highly drought resistant but silt loams and loams are not and so they are more susceptible to drifting. Elstow soils have a dark grayish brown colour in cultivated fields and there are few stones where the lacustrine cover is thick.

Asquith Association. The soils of the Asquith Association were developed on glacial lake and alluvial deposits. They occur mainly in the area between Last Mountain Lake and the town of Stalwart, and also in the Watrous—Last Mountain Spillway. In addition, small areas are also found northwest of Last Mountain, near Govan, northwest of Tate and around the section of Arm River to the northwest of Davidson. Asquith soils frequently occur in association with Weyburn, Biggar, Elstow, Meota and Oxbow soils. The textures of Asquith soils vary from fine sandy loam to light loam, and local gravel subsoils are common in fine sandy loam areas particularly where Asquith soils are mixed with Biggar soils. The Asquith soils have a low moisture holding capacity with a tendency to drift. There is decreased fertility after years of cultivation.

Biggar Association. The soils of the Biggar Association are developed on coarse to moderately coarse textured fluvio-glacial materials in outwash plains and on the margins of former glacial lake beds. Extensive occurrences are found along the Arm River east of Davidson and within the Watrous-Last Mountain Spillway between Lake Manitou and Last Mountain Lake. Biggar soils are also found in mixed soil areas with Weyburn, Asquith and Whitesand soils. The textures of Biggar soils vary from gravelly loam to sandy loam. The Biggar light loams and gravelly loams are the better soils within the association and are used for rye, forage crops and some wheat, whereas Biggar sandy loams are less drought resistant and more subject to wind erosion. Sandy textured Biggar soils are practically stone free whereas the gravelly loams and light loams are very stony. Biggar soils in comparison with other soils associations of the Wynyard area are very poor agricultural soils and have low drought resistance.

Bradwell Association. Soils of Bradwell Association were developed on glacio-fluvial as well as lacustrine materials. In the Wynyard area small areas occur north and northeast of Davidson, and southwest of Guernsey. Bradwell soils also occur with Meota soils south of Guernsey. Textures of Bradwell soils in the Wynyard area vary from very fine sandy loam to loam.

Wyandotte Association. The final soil association of the Dark Brown Soil group is the Wyandotte Association. These soils were developed on clayey modified glacial till and occur in the Allan Hills Upland. The Wyandotte soils occur mainly on morainal landscapes and the surface textures are dominantly clay loam. In areas where Wyandotte soils occur, there is a lower frequency of knolls and depressions and also stones are less numerous than in soils of the Weyburn Association.

Black Soil Associations

In the Black Soil Zone there are seven soil associations —the Oxbow, Whitesand, Yorkton, Cudworth, Meota, Canora and Blaine Lake Associations and a summary of these is presented in Table 2.4.

Oxbow Association. The soils of the Oxbow Association are black chernozemic developed on glacial till. They occur extensively in the Wynyard area and are often found in mixed association with Cudworth, Whitewood, Biggar, Yorkton, Canora and Paddockwood soils. The Oxbow soils are generally light loams, loams and clay loams with loam being the most common texture. There are local patches of gravelly subsoils and stones and boulders are common. The profile is generally

TABLE 2. 4

SUMMARY OF SOIL ASSOCIATIONS OF THE BLACK SOIL ZONE+

SOIL ASSOCIATION	PARENT MATERIAL	SOIL TEXTURE	SOIL COLOUR Horizon and depth	Dry soil	Moist soil	DOMINANT PROFILE	CAPABILITY CLASS FOR AGRICULTURE	MAJOR LA[illegible] AND MAJOR [illegible]
Oxbow	Glacial till (undifferentiated)	Medium loam*, light loam and clay loam	Ap(0–6")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic Black	good arable land (Class 2) to fair arable land (Class 3)	grain wheat coarse grain forage an livestock farming
Whitesand	Glacial outwash and stream eroded till	Coarse :sandy to gravelly	Ah(0–2")	10YR 3/1 Very dark gray	10YR 2/1 Black	Orthic Black	fair arable land (Class 3) to poor arable land (Class 4)	grain wh rye, forage sweet clov mixed farr dairying.
Yorkton	Glacial till (modified)	Medium loam * and light loam	Ap(0–8")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic Black	good arable land (Class 2)	grain wh barley forage : clover an
Cudworth	Silty glacial lake deposits	Medium: silt loam*, loam, light loam	Ap(0–4")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Rego Black and Calcareous Black	good arable land (Class 2)	grain w undulating coarse gr livestock land
Meota	Sandy glacial lake and alluvial deposits	Light : fine sandy loam* , very fine sandy loam and light loam	Ap(0–5")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic and Calcareous	fair arable land (Class 3)	mixed fa
Canora	Silty glacial lake deposits	Medium : silt loam; light loam	Ap(0–8)	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Rego Black	very good arable land (Class 1)	grain :w on undu land
Blaine Lake	Silty glacial lake deposits	Medium to fine. clay,silty clay loam*, clay loam* silty loam*,light loam	Ap(0–6")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic Black	good arable land (Class 2)	grain w coarse [illegible]

\+ only those present in the Wynyard Area

SOURCE: Mitchell et al(1950 and 1962)
Ellis et al (1965 and 1970)

* dominant

TABLE 2. 4

SUMMARY OF SOIL ASSOCIATIONS OF THE BLACK SOIL ZONE+

SOIL ...oh d ...th	COLOUR Dry soil	 Moist soil	DOMINANT PROFILE	CAPABILITY CLASS FOR AGRICULTURE	MAJOR LAND USE AND MAJOR CROPS	TOPOGRAPHY	HAZARDS	AREA OCCUPANCE (%)
6")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic Black	good arable land (Class 2) to fair arable land (Class 3)	grain :wheat, coarse grains, forage and livestock farming	Wavy type, knoll, slope and depression	1.numerous glacial stones 2.local patches of gravelly subsoils 3.many cultural interruptions 4.irregular fields 5.water and wind erosion on knolls	20.8
2")	10YR 3/1 Very dark gray	10YR 2/1 Black	Orthic Black	fair arable land (Class 3) to poor arable land (Class 4)	grain :wheat, rye, forage: sweet clover, mixed farming dairying.	undulating to very gently rolling	1.very stony 2.low drought resistance 3.severe wind erosion, in sandy loam soils	2.0
-8")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic Black	good arable land (Class 2)	grain :wheat,oats barley forage : sweet clover and brome	very gently undulating with frequent depressions	1.numerous glacial stones 2.local coarse sandy-gravelly subsoils 3 large areas of wet non-arable(saline)land 4.irregular fields 5.severe water erosion	1.0
-4")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Rego Black and Calcareous Black	good arable land (Class 2)	grain : wheat on undulating land, coarse grains and livestock on rolling land	undulating and rolling	1.severe water and wind	0.6
-5")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic and Calcareous	fair arable land (Class 3)	mixed farming	smoothly undulating	1.low drought resistance 2.tendency to drift	0.2
-8)	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Rego Black	very good arable land (Class 1)	grain :wheat* on undulating land	nearly level	1.slight to moderately severe water erosion 2.poorly drained areas	0.2
-6")	10YR 3/2 Very dark grayish brown	10YR 2/1 Black	Orthic Black	good arable land (Class 2)	grain: wheat*, coarse grains	undulating to smoothly rolling	1.frequent alkali lakes 2.water and wind erosion	0.2

thin and on rolling phases, water erosion is a serious problem. Weeds such as wild oats and thistles are particularly troublesome.

Whitesand Association. The soils of the Whitesand Association are developed on glacio-fluvial deposits and are similar to the soils of the Biggar Association of the Dark Brown Soil Zone although somewhat darker in colour as a result of their higher organic content. These soils occur mainly around Wolverine, Guernsey, Lanigan, Quill Lakes and in a few other comparatively small areas. They also occur in association with Oxbow, Yorkton and Meota soils. Textures range from mixed gravelly sandy loam to light loam, the most common being gravelly loam. The Whitesand soils have low drought resistance and are very poor agricultural soils. The sandy loams are liable to wind erosion which has become a serious problem on these soils.

Yorkton Association. The Yorkton Association is also developed on glacial till and in the Wynyard area the largest occurrences are around the Quill Lakes. Yorkton soils often occur with a number of other soil associations such as the Canora, Oxbow and Whitesand. Textures range from loam to light loam and when well-drained, they are fertile. The moisture conditions are favourable for the growth of tall grasses, numerous groves of aspen, poplar and willow. Drainage conditions are generally poor and weeds such as wild oats and thistle are a problem. In common with other glacial soils, stones are frequently encountered.

Cudworth Association. The soils of the Cudworth Association are developed on glacio-lacustrine deposits and occur on the Touchwood Hills in association with the Oxbow soils. The most extensive occurrence is around Punnichy. Textures range from loam to light loam, with loams being the most common. The soils are affected by water as well as wind erosion as a result of their upland position.

Meota Association. The soils of the Meota Association were developed on glacial lake and alluvial deposits and in the Wynyard area; soils of this type occur around Wolverine, Guernsey, Drake and to the west of Big Quill Lake. Meota soils are also found with soils of the Yorkton and Whitesand Associations, and along the zonal boundary, with Weyburn, Elstow, Asquith, Bradwell and Biggar soils. The predominant texture is fine sandy loam with variations including sandy loam, light loam and very fine sandy loam. The Meota soils are shallow with low drought resistance and a great tendency to drift.

Canora Association. The soils of the Canora Association were developed on glacial lake deposits and within the Wynyard area, they occur west of the Big Quill Lake. Canora soils also occur in association with soils of the Yorkton, the Meota and the Oxbow Associations. The textures of the Canora soils within the Wynyard area range from light loam to silt loam. Typical Canora soils have few stones. However, where they occur in association with soils developed on glacial tills, stones are more frequent. The Canora soils are very fertile but wind erosion is a problem particularly with the light loam textures.

Blaine Lake Association. The soils of the Blaine Lake Association are also developed on lacustrine deposits. The main occurrences are northeast of Drake and west of the Quill Lakes. The soils are mainly loams and clay loams with fair to good drought resistance, high fertility, an absence of stones and a gentle undulating topography. The Blaine Lake Association provides very good agricultural soils. There is some water and wind erosion, and weeds and poor drainage in depressions provide some problems.

Transition Soil Associations

These soils are transitional in character; and are found interspersed with Black and Gray Luvisol soils. Dark Gray Luvisols (Degraded Black soils) occur chiefly between the black grassland soils and the Gray Luvisol soils or as islands in the forest region. They were developed under a grass cover but due to favourable moisture conditions and a subsequent forest cover, their profiles have been changed by trees. They are associated with both black and gray soils and occur in various stages of transition between the true Black and the true Luvisolic soils.

Whitewood Association. Within the Wynyard area Dark

Gray Luvisol soils occur as the Whitewood Association, occupying the Gordon and the Muskowekwan Indian Reserves. The soils of this association are developed on glacial till. The surface colour has a dark grayish tinge and the most common texture is loam. The Whitewood soils are similar to the Oxbow Association and are generally fertile where they are not strongly degraded. However, much of the area has remained in bush or forest cover requiring clearing before cultivation is possible.

Other transition soils occurring in the Wynyard area are represented in the Calcareous Dark Gray soils. These soils do not show indications of development under a grass cover. They are lower in organic matter than comparable black soils and are formed on calcareous deposits under a wooded or peat vegetation. The high lime content and the poor drainage and the relatively recent age of the soils may have combined to prevent the full development of a leached Gray Luvisol profile.

<u>Paddockwood Association</u>. The soils of the Paddockwood Association are also developed on glacial till. They occur in a small area north of the Day Star Indian Reserve in association with Oxbow soils. The textures are loam and clay loam and although they bear some resemblance to the Yorkton soils, the Paddockwood soils are lower in organic matter, have a more pronounced platy structure and are lighter in colour. The topography of these soil

areas is nearly level to gently undulating. These soils are used chiefly for grain production. Glacial stones, the necessity of clearing trees before cultivation, the presence of poorly drained areas and frost hazards, provide problems in crop production.

Table 2.5 gives a summary of the transition soils and the Gray Luvisol soils.

The Gray Luvisol Soil Associations

The Gray Luvisol soils of the Wynyard area occur on the upland area under well developed stands of trees. They are lower in organic matter, nitrogen, phosphorus and sulphur (Mitchell et al., 1962) and therefore lower in fertility than the Black or Degraded Black soils. There are two soil associations present--the Waitville and the Kelvington.

Waitville Association. The soils of the Waitville Association were developed on glacial till deposits and occur on the Touchwood Hills around the Day Star and Muskowekwan Indian Reserves. The textures include clay loam, loam and light loam with loam being the most extensive. Although the surface soils are soft and loose structured, they tend to run or flow when wet, and bake dry forming a hard compact surface crust. Clearing of stones and trees, which is costly, is required for cultivation of the Waitville soils which also require careful management.

TABLE 2.5

SUMMARY OF SOIL ASSOCIATIONS OF TRANSITION SOILS AND GRAY LUVISO

	SOIL ASSOCIATION	PARENT MATERIAL	SOIL TEXTURE	SOIL Horizon and depth	COLOUR Dry soil	COLOUR Moist soil	DOMINANT PROFILE	CAPABILITY CLASS FOR AGRICULTURE	MAJOR / MAJOR
TRANSITION SOILS	Whitewood (Dark-gray Chernozemic-Luvisolic)	Glacial till (undifferentiated)	Medium, light loam,clay,clay loam*	Ah(0–2")	10YR 3/1 Very dark gray	10YR 2/2 Very dark brown	Orthic	good arable land (Class 2)	grain :wh barley forage :s clover an grass
TRANSITION SOILS	Paddockwood (Calcareous Dark gray)	Glacial till (undifferentiated)	Medium:loam*, clayloam,light loam loam	Ap(0–6")	10YR 4/1 Dark gray	10YR 2/1 Black	Calcareous	good arable land (Class 2) to fair arable land (Class 3)	grain wh barley forage :s clover,bro
GRAY LUVISOL SOILS	Waitville	Glacial till (undifferentiated)	Medium : loam*, clay loam and light loam	Ap(0–5")	10YR 6/1 Light gray	10YR 4/1 Dark gray	Orthic	fair arable land (Class 3)	grain .bar wheat others :a
GRAY LUVISOL SOILS	Kelvington	Clay (Glacial lake deposits ?)	Heavy : heavy clay* and clay	Ap(0– 4")	10YR 6/1 Light gray	10YR 4/1 Dark gray	Orthic	fair arable land (Class 3)	grain: ba wheat others: a

+ only those present in the Wynyard Area

SOURCE : Mitchell et al (1950 and 1962)
Ellis et al (1965 and 1970)

* dominant

TABLE 2.5

F SOIL ASSOCIATIONS OF TRANSITION SOILS AND GRAY LUVISOL SOILS+

OIL on d th	COLOUR Dry soil	Moist soil	DOMINANT PROFILE	CAPABILITY CLASS FOR AGRICULTURE	MAJOR LAND USE AND MAJOR CROPS	TOPOGRAPHY	HAZARDS	AREA OCCUPANCE (%)
-2")	10YR 3/1 Very dark gray	10YR 2/2 Very dark brown	Orthic	good arable land (Class 2)	grain :wheat,oats barley forage :sweet clover and brome grass	knoll and depression, mixed undulating-rolling and rolling	1.glacial stones and boulders 2.slight to moderately severe water erosion 3.tree clearing required	0.8
-6")	10YR 4/1 Dark gray	10YR 2/1 Black	Calcareous	good arable land (Class 2) to fair arable land (Class 3)	grain: wheat,oats barley forage :sweet clover,brome, grass	gently undulating to depressional	1.glacial stones 2.tree clearing required 3.areas of poorly drained land 4.slight water erosion	0.2
-5")	10YR 6/1 Light gray	10YR 4/1 Dark gray	Orthic	fair arable land (Class 3)	grain :barley, oats wheat others :alfalfa seed	gently undulating to strongly rolling	1.Glacial stones 2.adverse soil structure of plow layer 3.low inherent fertility 4.tree clearing required 5.frost hazard	0.6
- 4")	10YR 6/1 Light gray	10YR 4/1 Dark gray	Orthic	fair arable land (Class 3)	grain: barley,oats wheat others: alfalfa	gentle to moderately rolling	1.very heavy texture 2.rolling topography 3.heavy tree clearing required. 4.adverse soil structure of plow layer	0.4

Kelvington Association. The soils of the Kelvington Association were developed on glacio-lacustrine deposits. They are very dark gray, heavy clays and occur chiefly on the uplands. They are present near the Day Star and Poor Man Indian Reserves and their textures vary from heavy clay to clay, with heavy clay being predominant. Poor internal drainage, rolling topography and a tree cover limit agricultural use.

Miscellaneous Soils

These soils are present in all soil zones and are "composed of complexes of Chernozemic, Solonetzic, Regosolic and Gleysolic series developed on a variety of deposits. They do not have the specific characteristics used to define a Soil Association and are better referred to as Soil Complexes" (Ellis et al., 1970).

Within the Wynyard area, there are three main Soil Complexes: the Alluvium Complex, the Hillwash Complex and the Runway Complex as summarized in Table 2.6.

Alluvium Complex. The Alluvium Complex is developed on recent alluvial deposits and colluvial sediments transported by water. Because the parent materials are derived from a variety of sources, the alluvial soils vary widely in physical and chemical properties. They are generally stone free and occur on stream flood plains and in upland depressions. The surface drainage is generally moderate to poor and most

TABLE 2.6

SUMMARY OF MISCELLANEOUS SOILS

SOIL COMPLEX	PARENT MATERIAL	SOIL TEXTURE	SOIL COLOUR	CAPABILITY CLASS FOR AGRICULTURE	MAJOR LAND USE AND MAJOR CROPS	TOPOG
Alluvium (includes Chernozemic, Solonetzic, Regosolic & Gleysolic)	Recent alluvial deposits and colluvial sediments of variable origin	variable : sand to clay	variable	better–drained land ; fair to poor arable (Class 3 & 4), generally pasture. (Class 5 & 6)	mostly uncultivated	upland areas,str plains gently
Hillwash (Regosolic Chernozemic)	Colluvial and eroded deposits of variable origin on slopes of valleys and escarpments glacial and recent	variable	variable	unsuitable for cultivation (Class 5 or 6)	pasture	dissecte undulat steeply
Runway (Chernozemic, Regosolic & Gleysolic)	alluvial and eroded deposits of glacial and recent drainage channels	variable	variable	unsuitable for cultivation (Class 5 and 6)	native pasture	dissecte modera sloping depressi

SOURCE: Mitchell et al (1950 and 1962)
Ellis et al (1965 and 1970)

TABLE 2.6

SUMMARY OF MISCELLANEOUS SOILS

LOUR	CAPABILITY CLASS FOR AGRICULTURE	MAJOR LAND USE AND MAJOR CROPS	TOPOGRAPHY	HAZARDS	AREA OCCUPANCE. (%)
	better–drained land: fair to poor arable (Class 3 & 4); generally pasture (Class 5 & 6)	mostly uncultivated	upland depressinal areas,stream-flooded plains – flat to gently undulating,	1.presence of salts 2.impeded drainage	4.0
	unsuitable for cultivation (Class 5 or 6)	pasture	dissected,roughly undulating and steeply sloping	1.steep slopes 2.exposure of soil could induce erosion	1.6
	unsuitable for cultivation (Class 5 and 6)	native pasture	dissected and moderately sloping to depressional	1.bottom–lands poorly drained 2.very small areas of good soils 3.sometimes stony 4.thin weakly developed soils	3.0

alluvial soils show indications of gleying. The textures range from sand to clay and although some areas fall within capability class 3 and 4 (fair to poor arable land), most of the Alluvium Complex is Class 5 and 6 land and is uncultivated.

The Hillwash Complex. The soils of this complex are developed on colluvial and eroded deposits on the slopes of valleys and escarpments. As in the Alluvium Complex, the soils of the Hillwash Complex are derived from a variety of deposits and therefore their texture, colour and composition among other properties, vary widely. The landscape is dissected, roughly undulating to steeply sloping and most of the soils falling within capability class 5 and 6 remain uncultivated.

The Runway Complex. This complex occurring mainly in eroded channels of dissected plains also developed on alluvial and eroded glacial till and the soils are variable in texture and composition. The land often poorly drained and generally unsuitable for cultivation, is utilized as unimproved pasture.

Gleysolic Soils

Gleysolic soils (poorly drained) are widely distributed throughout the area. They are chiefly meadow soils occupying flat to depressional areas and are of little agricultural use unless drained.

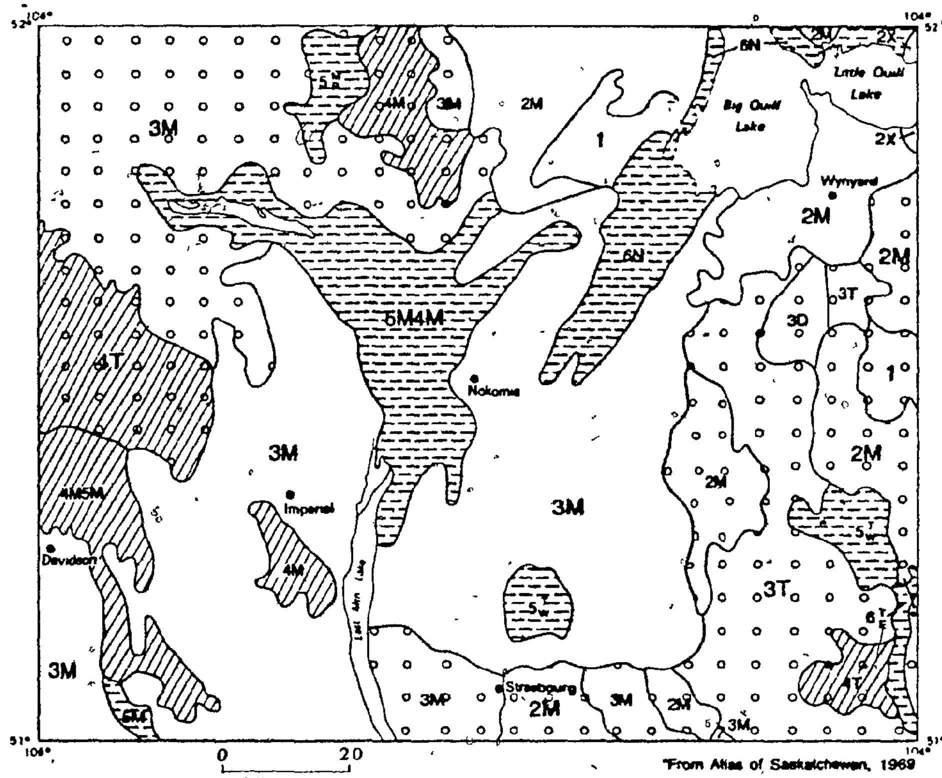
After drainage they are similar to Chernozemic soils. In drier seasons, the gleysolic soils are used for hay production or for grazing.

SOIL CAPABILITY FOR AGRICULTURE

Soil capability classes are separated according to the degree of the limitations, and the subclass provides information on the kind of limitation. Subclasses are shown for all classes except Class I. A general description of the seven classes and ten subclasses are given in the legend of Fig. 2.19 which shows the soil capability of the Wynyard area.

Large portions of the Wynyard area are good to fair arable land. The best land (Class 1) has no significant limitations and occurs west of the Big Quill Lake and in the extreme eastern portion of the area. Requiring only slight conservation practices, this land type is suitable for the growth of annual field crops and has a high productivity rating for a wide range of crops. The average long term wheat yield on this soil type in Saskatchewan is 1798 to 2248 litres per hectare (Shields and Rostad, 1969).

The lower slopes of the Touchwood Hills and the area around the Quill Lakes are good arable land (Class 2) and the degree of limitations is moderate. Annual field crops can be grown and the yield is high for a fairly wide range of crops. On Class 3 land, however, although annual field crops can be grown, special conservation practices are



From Atlas of Saskatchewan, 1969
p.106,107

Legend

Examples:

4T — This represents an area of Class 4 land in which topography is the significant limitation.

5 T/W — This represents an area of Class 5 land because of adverse topography in combination with wet sloughs and potholes.

o o o — This overprint represents land in which 20 to 30% of the area is occupied by sloughs and potholes. Such areas are generally recognized as Class 5 land.

CAPABILITY CLASSES

1. Soils with no significant limitations affecting their use for crops.
2. Soils with moderate limitations which may restrict the range of crops or require some (moderate) conservation practices.
3. Soils with moderately severe limitations which may restrict the range of crops or require special conservation practices.
4. Soils with severe limitations which restrict the range of crops,or necessitate special conservation practices,or both.
5. Soils with very severe limitations which are best suited to the production of perennial forage crops;improvement practices are feasible.
6. Soils with extremely severe limitations which are capable only of producing native perennial forage crops,improvement practices are not feasible.
7. Soils with no capability for arable farming or permanent pasture

SUBCLASS LIMITATIONS

C – Climate (low temperatures,inadequate or poor distribution of rainfall during growing season,or a combination of these.)
T – Topography(Excessive slope or other topographic limitation).
E – Erosion (Damage by water or wind erosion)
P – Excessive stoniness.
I – Innudation (Soils subjected to flooding due to overflow of stream.)
W – Water(Applied to soils where excess water,not due to inundation, limits their use for agriculture.)
M – Moisture retention(Insufficient water holding capacity.)
D – Soil Structure(Poor structure and/or permeability.)
N – Salinity (Excessive soil salinity)
X – Cumulative(Moderate limitations due to the cumulative effect of minor adverse characteristics which singly are not serious enough to affect the class rating.)

Fig. 2.19 Generalized soil capability of the Wynyard Area.

required. This class occupies a large portion of the Wynyard area particularly the plains area and the footslopes of the Touchwood Hills.

The range of crops that can be grown becomes more restricted on Class 4 land where severe limitations occur and the land requires extremely careful management to produce annual field crops. The rolling topography of the Allan Hills and the Touchwood Hills falls within this class.

Class 5 land is very limited occurring mainly in the central plain around Nokomis, in the southeast Touchwood Hills and Last Mountain Upland. Improvement practices are necessary and the land is best suited to the cultivation of forage crops. On the other hand, Class 6 land with its main occurrence southwest of Big Quill Lake is capable of being utilized only for native pasture.

The major types of limitations in soils of the Wynyard area are low moisture retention, unfavourable topography, erosion and to a lesser extent, stoniness. With the exception of the Allan Hills, the Touchwood Hills and Last Mountain Upland, the soils of the Wynyard area have low moisture storing capacity. Although the upland areas have a higher capacity for moisture storage, irregular topography and prolonged cooler temperatures limit cultivation to a certain extent.

CHAPTER 3

LAND SYSTEMS

INTRODUCTION

For many research and practical purposes, it is useful to be able to identify regions of homogeneous character and to subdivide them according to various criteria. In a paper on the contribution of air photo interpretation to problems of land division according to natural units, Schneider (1966) has illustrated the growing importance of the concept of land classification and the practical value of identifying and delimiting homogeneous land units in various applied fields.

Grigg (1965, p. 466) defines classification as "the grouping of objects into classes on the basis of properties or relationships that are common". He demonstrated that the most important purpose of classification systems is to permit inductive generalizations to be made about the objects studied. In land classification, it is possible to define and describe common characters and relate similar features although they may be geographically separate (Mabbutt, 1968).

The land systems approach was used as early as 1933 by Veatch who was concerned with classifying the agricultural land of Michigan. He also recognized that the economic significance of a land type will vary in accordance with changes in economic conditions, scientific discoveries and advances in agriculture. Within a land system there is usually a recurring pattern of topography, soils and vegetation (Christian and Stewart, 1952). A land system according to Stewart and Perry (1953, p. 55) is "a scientific classification of country based on topography, soils and vegetation correlated with geology, geomorphology and climate".

In Canada, land systems have been mapped as an integral part of the Biophysical Land Classification (Lacate, 1969). The classification was developed primarily for the reconnaissance mapping of unsettled areas of forest and associated wildlands, and to date, most biophysical mapping has been carried out in non-agricultural areas.

A procedure for the reconnaissance mapping of land attributes within the agriculturally settled portion of the Prairies has been proposed by J.A. Shields (1974, personal communication) and adopted for use in the Wynyard study area (72-P). The scheme is composed of two levels of regionalization: soil-climatic subzones of relatively large size with areas ranging from 221 sq. kilometers (85 square miles) to 7,685 sq. km. (2,951 square miles) and land systems approximately 3 sq. km. (1.3 square miles) to 352 square km. (135 square miles) in size as seen in Fig. 4.1. The highest level (soil-climatic subzones) is derived by superimposing agroclimatic subregional boundaries on a map of soil zones (Shields and Ferguson, 1975). Within this broad framework of soil-climatic subzones, specific parameters such as topography, landform, parent material and its texture as well as the phases of eroded and saline soils, are used to achieve local subdivision into land systems (Fig. 3.1). These land systems can be defined as physical land areas which exhibit a recurring pattern of topography, landform, parent materials, soil texture and soil phase, within a soil-climatic subzone.

The association of similar features into regions is synthetic regionalization (Unstead, 1933) and there are many different types of regions. Some are simple single-parameter delineations and others highly complex. The land systems of Wynyard are delimited on the basis of a combination of parameters as shown in Fig. 3.1 and are multiple-feature regions. Wherever they occur, they exhibit the same association of multiple features. Land systems of the same type may recur within a soil-climatic subzone, or they may occur in adjacent soil-climatic subzones. Such occurrences, although varying in size, always retain the general characteristics of their type. Beckett and Webster (1965) used the term "reproducibility" to convey this idea meaning that the same land type would have the same assemblage of characteristics or recurring pattern wherever it occurred.

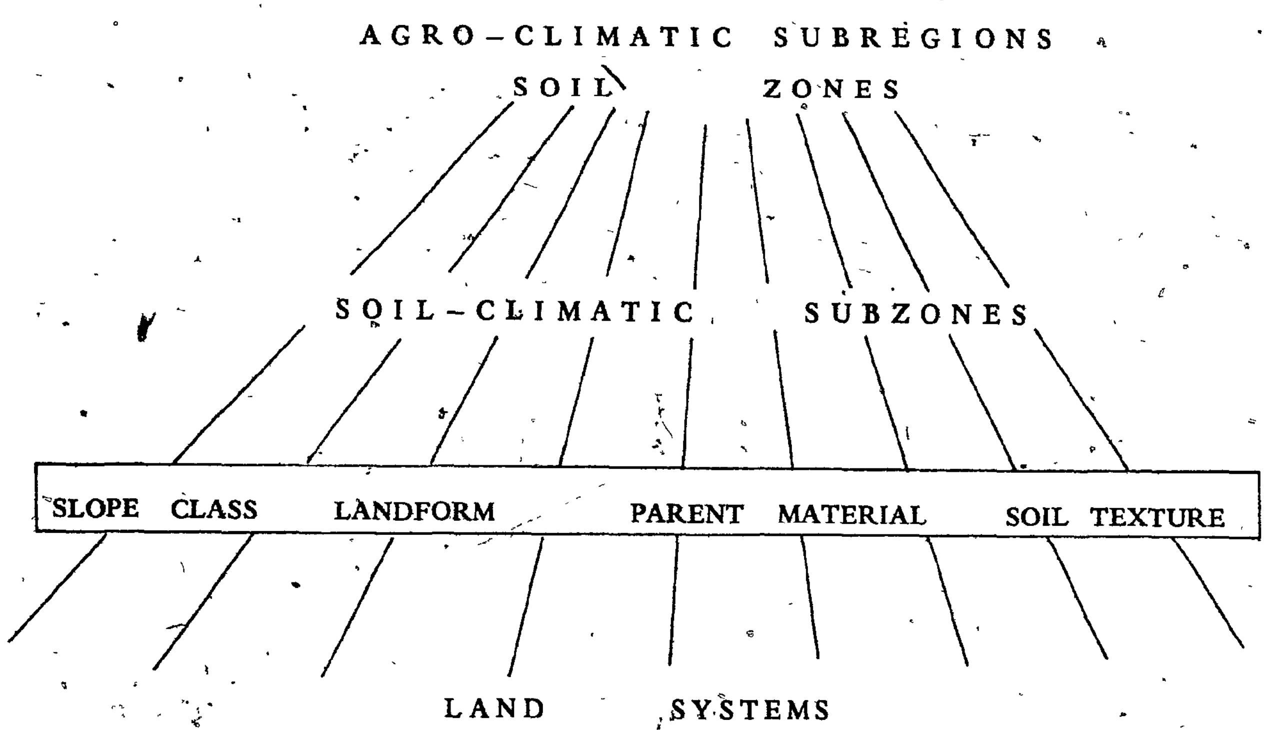


Fig. 3.1 Hierarchy of land division in the Wynyard Area

LAND SYSTEMS FOR AGRICULTURE

Land systems are areas where the climate, parent materials, topography, soil and vegetation are uniform within the limits significant for a particular form of land use (Gibbons and Downes, 1964). The characteristics or factors used in the identification and delimitation of land systems for agricultural purposes can be grouped into various subsets —climatic, morphological and pedological.

The fundamental components in classifying land for agricultural uses are climate and soil, and to a lesser extent, topography, landform, parent material and its texture. According to many soil scientists, land classification is basically the grouping of soils in a manner that is relevant for people such as farmers who are using the soil in a practical way. Many soil scientists believe that a good land classification system has to be based on a soil classification (Vink, 1960). On the other hand, agronomists tend to argue that soil and land are different; soils being defined in terms of physical-chemical properties and use, whereas land is considered in terms of features and relationships that are relevant to its use by economic enterprises in terms of its value as property (Kellogg, 1951). Soil is only one attribute of land.[1] It is a three-dimensional body occupying

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[1]More recently a tract of land has been defined geographically as "a specific area on the earth's surface: its characteristics embrace all reasonably stable, or predictably

the uppermost part of the earth's crust and having properties differing from the underlying rock material as a result of the interactions between climate, living organisms, parent material and relief (Brinkman and Symth, 1972). It is not an independent attribute but a long term resultant of bio-climatic processes (Jenny, 1941).

Therefore, it seems fairly clear that a land classification system in an agricultural area must take into account a complex of surface and near-surface factors that are associated with soil and that these must be assessed in terms of their significance for agricultural activities.

LAND SYSTEM PARAMETERS

The significant parameters used for classifying land systems include climate and zonal soils which were combined to form soil-climatic subzones. These subzones in turn form a broad framework within which land systems, based on topographic slope, landform, soil material and texture, were derived.

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cylic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of land by man (Brinkman and Smyth, 1972, p. 63).

Climate

Climate has a unique place in any discussion of soil and plant growth. It is not only a major factor in soil formation, but it also affects vegetation, parent material, topography, drainage and man's activities.

Under dry land conditions as in the Canadian prairie region, climate is considered a prime component in the analysis of land for agricultural purposes. Many factors influencing the growth of plants are determined by climatic conditions, and even in an area that has been long settled and farmed, climate plays an important role. Temperature, insolation and precipitation are the most important factors affecting the selection of crop types and their distribution.

Climatic control is exerted by the duration and intensity of sunlight and the length of the growing season or period with temperatures above the minimum for plant transpiration and other life processes. The duration and total amount of sunlight is important for seed production in certain species and varieties, and also for the manufacture of chlorophyll—an essential substance in plant food production.

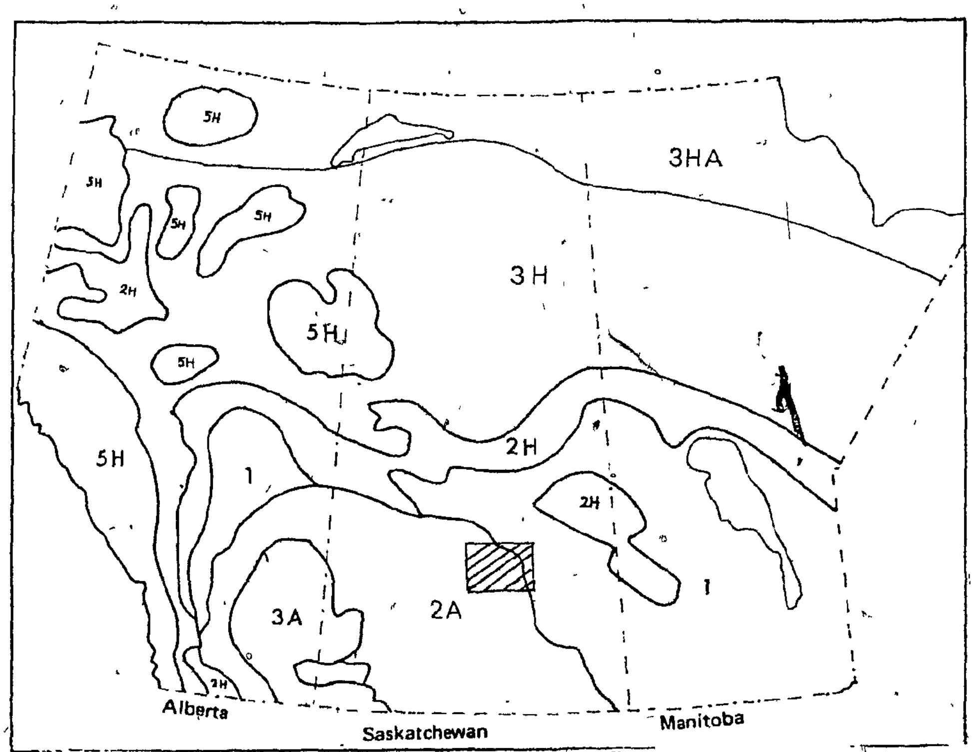
The length of the growing season is controlled by both maximum and minimum temperatures. At low temperatures, plant growth proceeds slowly, and above a certain maximum the rate of growth declines. During periods of freezing temperatures, crops are in danger of frost injury. Extreme cold results in severe crop damage; roots or stems are injured and growth is terminated. Stunted growth may also result from excessively high temperatures. The limits of maximum and minimum growth temperatures vary considerably among different crop species and varieties.

In addition to heat and light, water is essential to plant growth, and the water available to plants depends upon the precipitation and the soil moisture conditions. Actively growing plants are composed of 75 to 90 per cent water (Hildreth et al., 1941) and during the growth period there is a continuous movement of water carrying mineral and nutrients to the plant tissues. Water is essential to ensure high crop yields. A long period of severe dry weather causes a soil moisture deficiency and consequently, crop failures and reduction of fodder for livestock. The risk of wind erosion and grasshopper damage to crops is increased. On the other hand, excess water may cause flooding and serious soil erosion resulting in crop failure.

In addition to its direct importance to crop growth, climate largely determines the seasonal and regional incidence of crop diseases. In general, the occurrences of infection, the length of the incubation period and the degree of plant injury are related to temperature. For example, wheat stem rust develops in approximately 90 days at a temperature of 32° F (0° C), in 22 days at 40° F (4.4° C) and only 5 days at 75° F (23.9° C) (Valli, 1968). Precipitation and atmospheric humidity encourage fungal diseases as the fungi spores require free water to germinate. Mildew and wilt diseases are caused by the low intensity of light, whereas high intensity favours cereal rust diseases.

Besides influencing crop growth and yield, climate also has an effect on agricultural practices. In areas with repeated exposure to drought, summerfallowing, grain-forage rotation and other moisture conservation methods are practised. Regional variations in precipitation, evapotranspiration and frost incidence have a direct effect on the crop calendar because of their control on critical periods such as seeding, germination, ripening and harvest. Generally prolonged cool temperatures in springtime results in late seeding with decreased yields particularly in districts with early fall frost hazards.

The importance of regional and subregional climate for land classification within an agricultural context, is further demonstrated by its role in soil capability classification of the Canada Land Inventory. Limitations due to climatic deficiencies were established to account for the degree of moisture deficiency resulting from insufficient precipitation and on the basis of heat deficiency. The prairie provinces are separated into three agro-climatic subregions on the basis of increasing aridity and three on the basis of frost incidence or heat deficiency. These subregions of Saskatchewan within the Canada Land Inventory boundary, are shown in Fig. 3.2.



The Wynyard Area

Source: Shields and Ferguson(1975).

LEGEND

	Agro-climatic subregions	Mean Annual Precipitation (cm)	Average Frost-free Period (days)	Degree days above 5.5 °C	General description
Wynyard	1	40–45	> 90	1225–1670	Climate is suitable to permit the growth of all dryland crops that are typical to the prairie region.
Wynyard	2A	30–40	> 90	1330–1670	Areas where the amount of precipitation in approximately 50% of the years has been a limiting factor to crop growth.
	3A	27–35	90–120	1330–1670	Areas where the amount of rain has usually been a severe limiting factor to crop growth: a 2-year rotation is practised to the virtual exclusion of all other rotations.
	2H	40–50	75–90	1060–1225	Areas where the amount of precipitation is usually adequate but where wheat has suffered some frost damage in approximately 30% of the years.
	3H	27–35	< 75	1000–1112	Areas where the amount of precipitation has usually been adequate but where it is not considered practical to grow wheat because of damaging frost.
	5H	27–35	< 60	< 950	Areas where the amount of precipitaion has usually been adequate, but where the average frost free period has been so short that it is not practical to grow cereal crops. Only hay crops are recommended.

Fig. 3.2 Agro–climatic subregions of the prairie provinces

Zonal soils

The effect of climate and vegetation on soil formation is shown by the changes that take place in the original geological parent material. Where moisture, temperature and sunshine permit plant growth, organic matter and soil organisms appear in the mineral matter. The action of water causes changes in the chemical composition of the mineral matter and also transfers chemical substances either downward or upward in the soil. The intensity of these changes depends upon the type of climate, native vegetation, kind of parent material and the time factor. These changes eventually produce layers or horizons which make up the profile of zonal soils.

In the Prairie region, the major types of vegetation reflect broad differences in climate, and the combined influence of these two factors is shown by the occurrence of several major soil belts or zones. In Saskatchewan a combination of relatively low precipitation, high summer temperatures and warm westerly winds results in a relatively short, sparse grass vegetation. The surface layer of the soil developed under this short grass prairie is a light brown to brown, reflecting the lower organic matter of the soil and this more arid portion of southwestern Saskatchewan falls within the Brown Soil Zone. Towards the east and north of this soil zone the climate is less arid and the native vegetation taller. Consequently, the surface layer of soils becomes progressively darker and thicker in the Dark Brown and Black Soil Zones, due to a corresponding increase in the accumulation of organic matter in the soil. In the more moist and cooler locations in these soil zones, patches of wooded vegetation occur. Forest replaces grassland in the more humid and cooler north and northeast, resulting in a grayish coloured surface soil layer.

Fig. 2.17 shows that the Wynyard area falls within the Dark Brown and the Black Soil Zones. However, high relief modifies temperatures and even in the continental interior, highland areas are appreciably cooler than surrounding low-relief areas during the summer months. In addition, the amount of precipitation is largely determined by relief, and the greater amount on higher ground results in a denser vegetative cover and this, together with the more moist conditions results in differences of soil type. Therefore in addition to broad belts of zonal soils, smaller areas occur. For example, in the Wynyard area, the higher elevation of the northern slopes of the Touchwood Hills with lower potential evapotranspiration has resulted in a tree cover which has contributed to the formation of an "island" of Gray Luvisol Soils surrounded by the Black Soils of the plains.

The significance of zonal soils can be seen in Table 3.1 which shows the organic matter levels of soils in the different soil zones.

TABLE 3.1

ORGANIC MATTER LEVELS OF CULTIVATED SOILS
FROM THE MAJOR SOIL ZONES
IN SASKATCHEWAN

Soil Zone	% Organic Matter
Brown	3.7
Dark Brown	4.3
Black	5.5
Dark Gray	6.0
Gray Luvisol	2.4

Source: Rennie et al. (1976).

Soil-climatic subzones

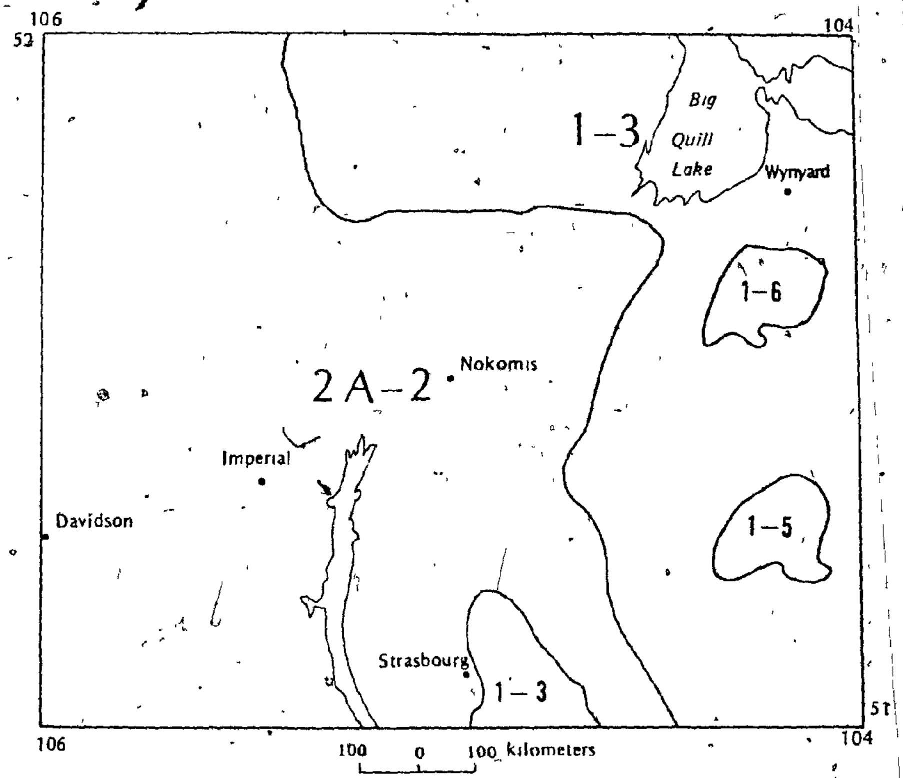
These subzones shown in Fig. 3.3, are derived from a combination of agro-climatic subregions (Fig. 3.2) and soil zones (Fig. 2.17). They correspond closely to the soil zones and provide a broad base for the delimitation of land systems.

Topographic slope

Surface relief is the simplest criterion for distinguishing between land systems whether the boundaries are drawn in the field or from aerial photographs (Bawden, 1967). Slope is a basic parameter in the system. It is used in the identification of landform type which permits the inclusion of geomorphological information in the description together with an appreciation of the main surface elements—the flats and slopes or facets which characterize the regions.

Slope is defined as the generalized gradient of the surface and expressed in terms of percentage grade (Soil Survey Staff, 1951). It is very relevant for agricultural activities because it is the intermediary between climate and soil.

The slope angle has an effect on the intensity of solar radiation which is greatest on southward facing slopes that are normal or near-normal to the sun's rays. An extreme but important effect of slope angle gives rise to the anomalous occurrence of zonal soils in the Saskatoon map area (73-B) bordering the Wynyard area on the west. Within this area of



LEGEND

2A–2	Moderate moisture deficiency (2A) in the Dark Brown Soil Zone(2)
1–3	No significant moisture or heat deficiencies (1) in the Black Soil Zone (3)
1–5	No significant moisture or heat deficiencies in the Dark Gray Luvisol Soil Zone (5)
1–6	No significant moisture or heat deficiencies in the Gray Luvisol Soil Zone (6)

Fig. 3.3 Soil–climatic subzones of the Wynyard Area

Black Chernozemic soils, an island of Gray Luvisol soils occurs on a high north-facing slope. The cooler temperature of the northerly aspect as well as a higher precipitation, may have resulted in a forest vegetation which in time contributed to the formation of Gray Luvisol soils. In contrast, the other slopes were dominated by tall grass vegetation resulting in the formation of Black Chernozemic soils. North facing slopes have the worst aspect situation and this has a marked effect on the growth characteristics of crops. Easterly slopes receive maximum insolation in the morning and west facing slopes in the evening, and landforms, characterized by complex slope orientations result in considerable variability in crop growth and maturity, which in turn influence management practices and economic inputs in relation to yield.

The steepness, the length and the shape of slope have a pronounced effect on agricultural activities particularly with regard to soil erosion which in turn affects crop yields. Slopes have different runoff rates depending on steepness, and in general terms, erosion per unit area increases 2.5 times as the angle of slope is doubled (Kohnke and Bertrand, 1959). The risk of erosion is greatest on bare slopes as seen in Plate 1a. The lower parts of bare long slopes are particularly susceptible because of the concentration of runoff and the greater velocity of the water (Plate 1b).

Measurements of soil erosion on different textures in relation to slope length, were carried out by the United States Soil Conservation Service. Fig. 3.4 illustrates that in general, soil losses increase with increasing slope length (Bennett, 1939). The rates of erosion also vary according to the different soil textures and losses increase with an increase in silt content (Fig. 3.4). Precipitation falling on a sloping surface is disposed of by infiltration and run-off. Infiltration is greatest in coarse textured soils, whereas, runoff is greatest in fine textured soils. In Fig. 3.5 it can be seen that the runoff rates shown as percentages of the precipitation are appreciably higher on the silt loams compared with the coarser textured fine sandy loams.

The water that runs off a slope collects at the foot of the slopes therefore depressional areas tend to be poorly drained, whereas, the knolls are droughty. Thus the availability of moisture for plant growth is extremely variable and has a direct effect on the crop yield. This is illustrated in Fig. 3.6 by sample data for wheat yields from the Edenwold area (50° 38′ N and 104° 15′ W) in Saskatchewan. In contrast to either the knoll or depression, the yield per hectare is higher on the mid-slopes where the soil moisture is most favourable for plant growth. The soils of the knoll are deficient in moisture and organic matter content; the depression is subject to impeded drainage and periodic flooding. The effect of slope differences on crop yields in a broader regional context is very well illustrated by

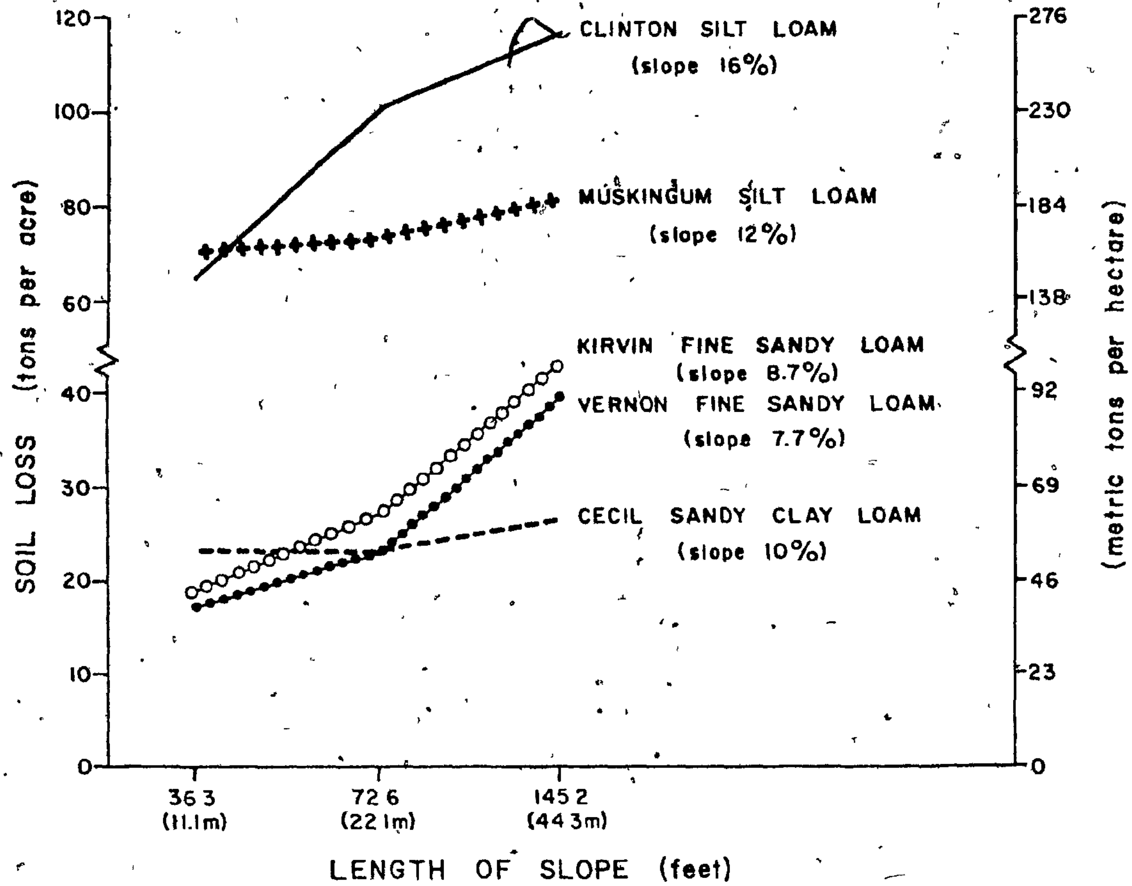


Fig. 3.4 The relationship between the length of the slope and the amount of soil loss. (Data Source: Bennett, 1939, p. 150)

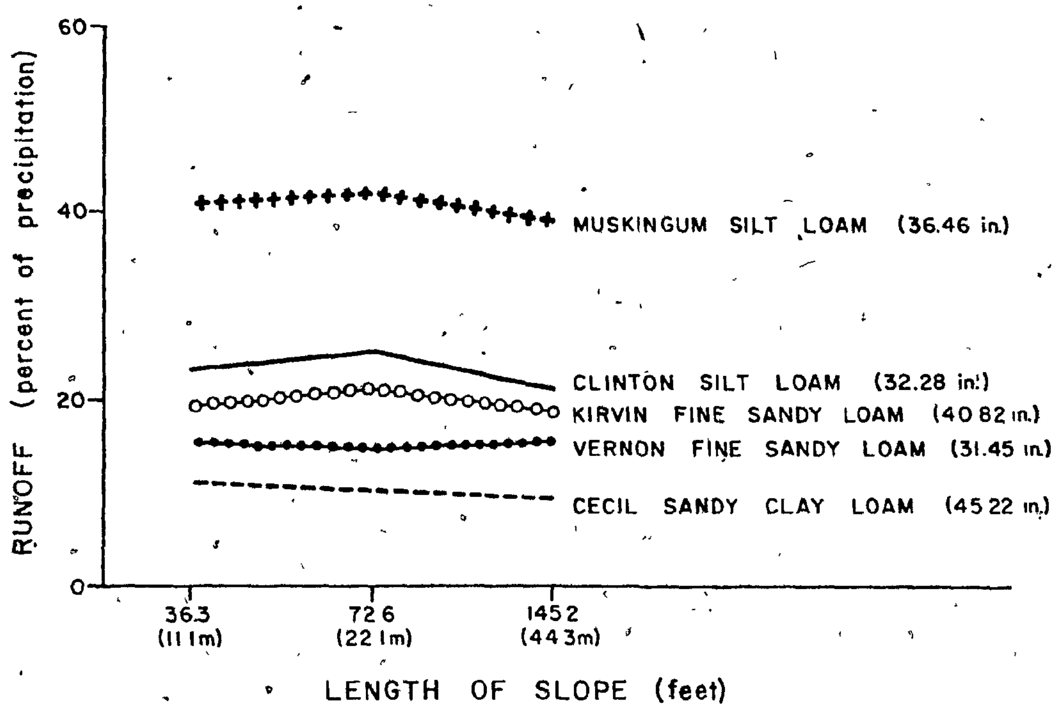


Fig. 3.5 The relationship between the length of slope and runoff on soils of different textures. (Rainfall in inches is given within brackets.) (Data Source: Bennett, 1939, p. 150)

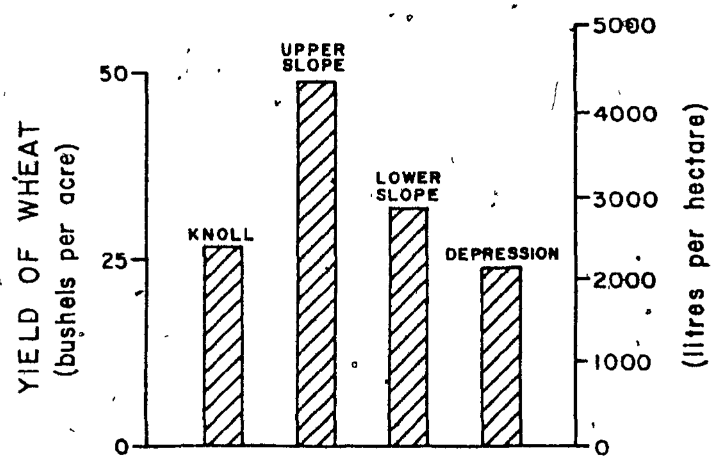


Fig. 3.6 The yield of wheat within one field (Edenwold area, 1960). (Data Source: Guide to Farm Practice in Saskatchewan, 1972, p. 86)

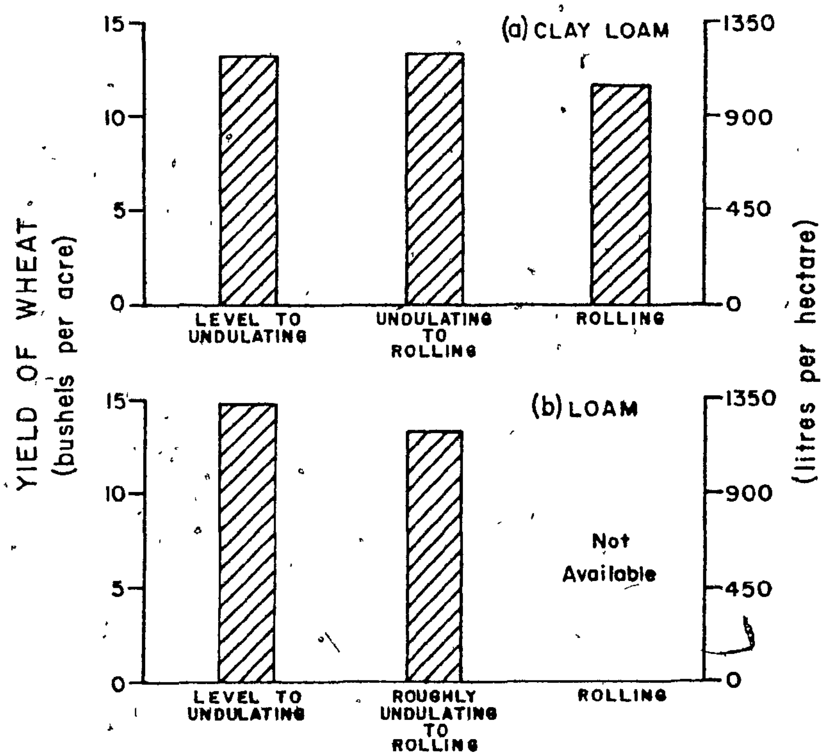


Fig. 3.7 The yield of wheat in relation to topography. (Data Source: Moss, 1962, p. 10)

wheat yields from Saskatchewan over a twenty-seven year period 1932-1959 (Fig. 3.7). On clay loam soil with gentle slopes the average yield was 117.8 litres per hectare as compared to 106.1 litres on rolling slopes of the same soil type (Moss, 1962, p. 10, with metric conversion).

The most important feature of surface slope is the direct effect on agricultural practice. On steep slopes, cultivation is limited either because of the difficulty of using farm machinery or because of the erosion hazards. On undulating land of less than five per cent slope (Class 1) weeding and seeding machinery can be used without difficulty. However, on steep slopes (Map classes 2 and 3) the safe and satisfactory use of farm implements, particularly heavy agricultural machinery, becomes restricted and careful management practices are required.

On strongly sloping land, tractors with more power are required for pulling farm machinery. As more power is required, more fuel is used and this factor as well as the longer time required on hilly land contributes to higher operating costs. In addition, on very steep slopes, cultivated fields tend to be small and irregular thus interfering with the efficient use of large machinery. On slopes of 30 per cent (Class 3) or more, only light agricultural machinery can be used, therefore tractor selection with regard to size, type of engine and the amount of traction, is dependent on the type of land over which it will be used.

Sloping land can be reshaped by cutting the high spots and filling the low spots (Smith and Coyle, 1960) but the complexity of slopes in areas of hummocky ground moraine would make such operations very costly and in many places impossible.

The cultivation of steep slopes greatly increases the risk of erosion. To check the downhill flow of water, contour strip and field strip cropping or terracing, or a combination of these methods is essential--the width of a strip in part depending on the slope of the land. In experiments on slopes of 5, 10, 15 and 20 per cent at Auburn Experimental Station (U.S.A.), soil losses were appreciably less from strip-cropped areas and the steepest slopes benefitted the most from intertillage practices (Bennett, 1939, p. 349).

Slope classification for the Wynyard area. Four slope classes were recognized in this study and these are shown in Table 3.2.

Landform

The characteristics of the land surface and its suitability for supporting mankind vary in a number of ways. The need for some kind of areal subdivision and categorization to enable problems of land use planning and economic assessment to be approached systematically is obvious. Landforms can be readily interpreted from the stereoscopic photo images and is the second parameter in defining land systems. Landforms not only provide a basis for mapping land types

TABLE 3.2

SLOPE CLASSES

Map Class	Type of Topography	% Slope
1	Nearly level to undulating	0 - 5
2	Gently rolling	5 - 10
3	Strongly rolling or steeply sloping	10 - 30
4	Hilly	30 - 60

but they also provide important information about the parent material and to a lesser extent, soil genesis. The present surface form is a record of the operation and interaction of the geomorphic processes in the recent geological past that have moulded the land surface and therefore determined the basic character of the land system.

The assemblage of landforms in a given area is very relevant for agriculture. For example, in Saskatchewan the occurrence of large sloughs results in a pattern of subdivision of small fields with irregular shapes. Deep sloughs which have water throughout the growing season and depressions in which clumps of trees and bushes grow, reduce the land available for cultivation. Shallow sloughs are often cultivated but late drying in the spring leads to delayed cultivation, seeding, swathing and harvesting. Plate 2 shows a seeded slough which is still green and will not be ready for swathing until some time after the rest of the field. When working land around sloughs, many turnings have to be made. Likewise working within a dried-up slough requires many turnings, which is not only difficult with large machinery but also increases the time and energy inputs per unit area. Consequently, field efficiency is reduced particularly where a large number of sloughs occur within cropped fields.

Sloughs can be reclaimed for cultivation by drainage but such operations are costly and the drained water collecting in a new location simply results in a larger scale wet land problem. Similarly, in a series of wet years, dried-up sloughs revert to grass sod and reclamation is time consuming and costly.

Another example of the significance of landforms in agricultural practice is provided by rills and gullies. Small rills can be ploughed in, but due to the difficulty and the impracticability of taking farm machinery across the major gullies, these are not cultivated resulting in a lower percentage of arable land per unit area than in land systems which are not gullied. The land between gullies has to be worked as separate fields and so the farmer has to drive round the gullies to reach the next field thus increasing the time involved in each operation. In addition, gully control methods have to be practised to prevent further loss of arable land.

Landform classification for the Wynyard area. In developing a national system of landform classification for soil mapping, the Canada Soil Survey Committee (1978) integrated the system of the Saskatchewan Soil Survey with aspects utilized by the Geological Survey of Canada (Fulton, 1972) and those utilized for terrain mapping in British Columbia (E.L.U.C., 1976). In the recently developed national system, emphasis is placed on two basic attributes: materials and surface expression (or form), which are recognized in terms of their inherent properties rather than on inferred genesis.

Howard and Spock (1940) defined a landform as "any element of the landscape characterized by a distinctive surface expression, which may be associated with a definite internal structure and/or composition, and sufficiently conspicuous to be included in a physiographic description".[1] In this context, landform is considered to be a recurring pattern of form (or an assemblage of slopes) associated with a surficial deposit. Emphasis is placed on the description of surface expression but genetic origin is also inferred.

Landforms are recognized as being directly relevant for soil classification and interpretation (USDA Soil Survey Staff, 1951) thus providing a key factor in the total land system classification. The landforms considered in this context belong to the third and fourth orders in the scheme devised by von Engeln (1942).

In the Wynyard area we are concerned essentially with glacial and glacio-fluvial landscapes and ten landform types were identified and mapped as indicated in Table 3.3. To facilitate mapping a simple alphabetical system[2] was used and block diagrams of these landform assemblages are presented in Fig. 3.8.

The type B landform is hummocky with random knolls,

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[1]As given in Acton (1972), page 24.

[2]The scheme devised by the Canada Soil Survey Committee, has not been used because it was not finalized at the beginning of this study.

TABLE 3.3

Landform Types

Map Code*	Description
B	Hummocky pattern characterized by random knolls, short ridges and swales.
D	Low relief characterized by a general pattern of dissection providing external drainage for the area.
G	Pattern characterized by general dissection providing external drainage for the area. Random knolls and swales occur between the drainage lines.
H	Drainage channels characterized by hillwash and eroded valley sides with slopes greater than 5%.
J	Pattern of low relief (< 5% slopes) in which shallow sloughs occupy more than 15% of the area.
K	Hummocky pattern characterized by knolls and kettles each of which occupies more than 15% of the area with kettles providing internal drainage for the area.
R	Pattern characterized by a series of linear ridges and swales.
S	Pattern characterized by large shallow depressions.
U	Unpatterned, nearly level areas.
Y	Runways with slopes generally less than 5%.

*The letter code used is not a regular ABC sequence because certain letters are used for soil classification.

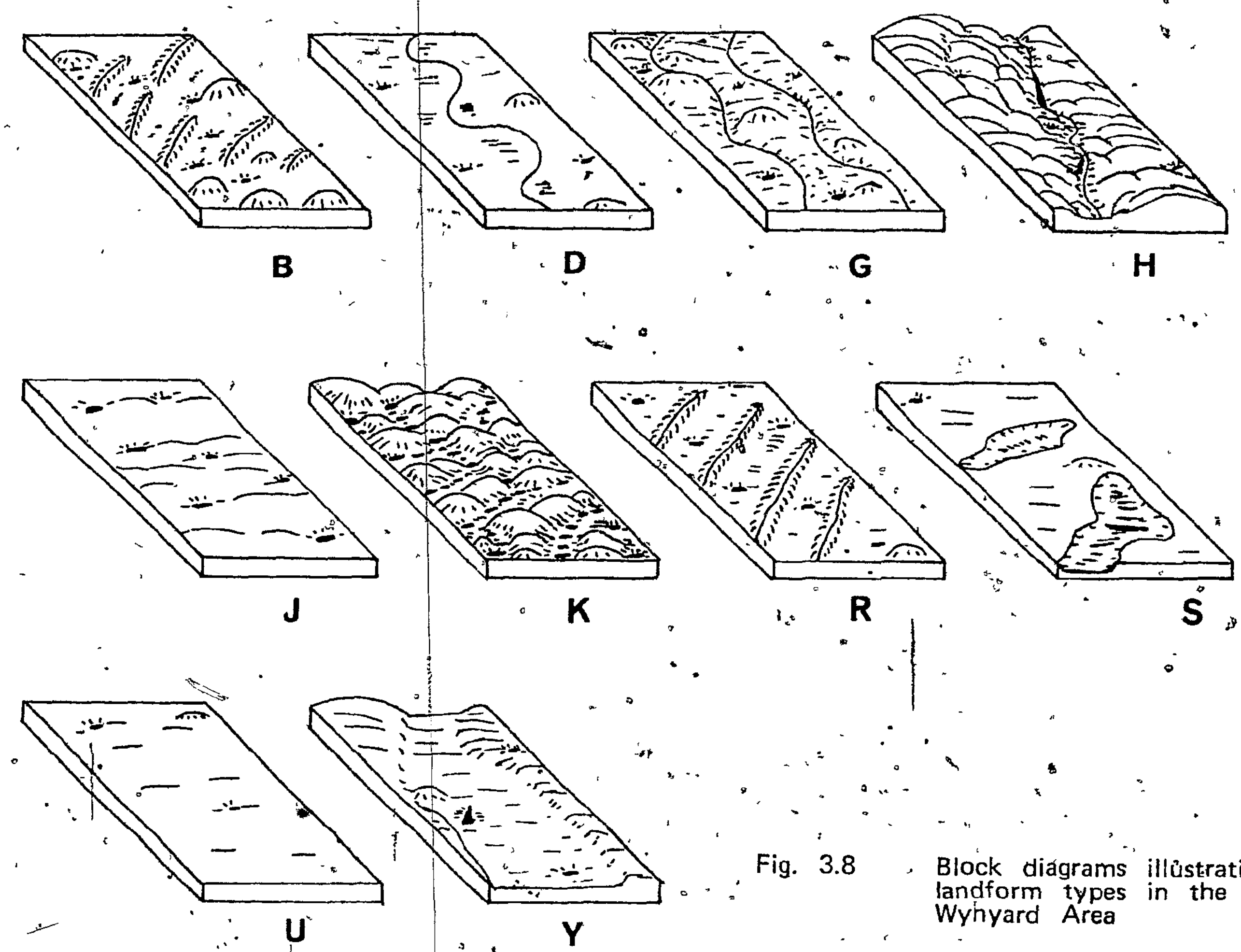


Fig. 3.8 Block diagrams illustrating landform types in the Wyhyard Area

short ridges and swales. The land is drained externally by streams and also internally by kettles, However, these are less frequent in occurrence than in the other glacial landscapes of the area.

The type D areas have landforms of low relief with comparatively few knolls, ridges or kettles. The extremely long gentle slopes of less than 5 per cent grade which characterize this landscape are the result of glacio-lacustrine conditions and there has been subsequent dissection of the deposits by streams which now drain the area.

The type G landform also has a stream-dissected pattern, however, between the drainage channels there are infrequent random knolls and swales. Few kettles are present but for the most part, drainage is externally through the numerous streams.

The type H landform is dominated by channel landforms of the meltwater or spillway type. Depressions in the channels are currently occupied by sloughs or lakes, and the eroded valley sides are generally a striking feature of the landscape with slopes exceeding 5 per cent.

Landform type J is one of low relief with very subdued features.. Slopes are less than 5 per cent and the surface is undulating with shallow sloughs occupying more than 15 per cent of the area. Former outwash plains, till plains and lake basins are included in this category.

Landform type K is dominated by hummocky landforms with numerous knolls and kettles. Both knoll and kettle forms occupy more than 15 per cent of the area. The kettles provide internal drainage for the area and in contrast to landform type G, there are few external drainage outlets. This is a morainal landscape with varying slopes but few isolated ridges.

Landform type R is another morainal type, however this is dominated by ridge and swale topography. The linear ridges are in marked contrast to those of the B type landform because they are long and very pronounced. There are more frequent kettles than in the B landscape and the general effect is one of more pronounced topography.

A landform type with large shallow depression has been designated as type S. The depressions are generally flat-bottomed although some have minor ridges within them.

Landform type U (unpatterned) is also subdued with less than 5 per cent slopes. The basic landforms in this type are outwash plains, till plains or lake basins and the surface is relatively smooth with few knolls or sloughs.

Landform type Y has less than 5 per cent slopes and it is found to occur along valley bottoms of glacial spillways or as weakly developed drainage channels.

Parent material

The third parameter in the definition of land systems--the type of parent material, is very significant for soil development. It is important because it largely determines the original supply of soil mineral nutrients required by plants. It may also contribute to undesirable soil conditions such as excessive quantities of soluble salts, or extreme acidity or alkalinity. Knowledge of the nature of the parent material provides a direct guide to the soil texture. In addition, the depth of the soil and the rates of erosion are modified by the erodibility of the parent material.

The last major geological event affecting the Prairie Provinces was that of glaciation. The loose earthy mineral matter deposited by glaciation together with some more recent deposits formed by present day streams, by the action of wind and by the development of peat bogs, form the present Prairie surface. The surficial materials forming the parent materials of Saskatchewan soils (Moss, 1965, pp. 7) are summarized in Table 3.4.

<u>Parent material classification for the Wynyard area</u>. Most parent materials in the Wynyard area have resulted from transportation by water, wind, ice or gravity transfer or their combined action. Fluvial materials deposited by flowing water are coarse textured, whereas lacustrine deposits formed within lakes, are generally fine textured and fertile. Wind blown materials are either silty or sandy and generally infertile. Materials of glacial origin on the other hand, exhibit various textures and their fertility is variable. In addition to varying amounts of sand and gravel, glacial

TABLE 3.4

SURFICIAL GEOLOGICAL DEPOSITS FORMING THE PARENT MATERIAL OF SASKATCHEWAN SOILS

Residual (or Pre-glacial)	- Material deposited before the ice age
Exposed bedrock	- Residual deposits exposed by erosion or occurring in non-glaciated areas
Modified bedrock	- Residual deposits partly mixed with glacial deposits by the action of glacial ice or water
Glacial till (or morainal)	- Mixed materials deposited by ice
Fluvial and Lacustrine	- Materials sorted and deposited by water flowing from the melting ice
Fluvial	- Chiefly coarse sandy and gravelly materials deposited on land
Lacustrine	- Fine sandy, silty, and clayey materials deposited in standing water in glacial lakes
Aeolian	- Material sorted and deposited by wind
Wind-blown sands	- Chiefly sand dunes
Loess	- Wind deposits composed chiefly of silt-sized particles
Recent	- Materials deposited or formed after the final disappearance of the glacial ice, up to and including the present
Alluvium	- Material deposited on river flood plains by present streams
Colluvium	- Material deposited by gravity
Organic deposits	- Peat (plant) material developed on the surface of mineral deposits

Source: Moss, 1965, p. 7.

tills also contain cobbles and boulders which can cause damage to farm machines and hinder their operation. Stone-picking is therefore necessary before cultivation and it is both time consuming and costly.

The types of material encountered in the Wynyard area are listed in Table 3.5. The residual materials resulting from weathering of the bedrock are very limited in extent and so have not been shown on the map. There are three types of materials which are widespread throughout the area—glacial till, lacustrine and fluvial and three types which are more limited: alluvial, colluvial and eolian. However, colluvial and eolian materials are too restricted for mapping.

Materials of fluvial origin found along the stream and creek flood plains, are either reworked older materials or freshly deposited materials of colluvial origin. The textures of the deposits are variable and when they occur near permanent water bodies, poor drainage is typical. The most important fluvial deposits originated as glacio-fluvial materials having been carried, sorted by the melted ice and deposited as outwash. These deposits generally consist of coarse sands and gravels and near moraines they may occur in the form of kames, eskers and crevasse-fills.

The lacustrine deposits found on old lake bottoms in the Wynyard area are proglacial in origin. For this reason they tend to be coarse grained near former ice front positions ranging through fine silts and clays at greater

TABLE 3.5

TYPES OF MATERIALS

Map Code	Type of Material
A	Alluvial
F	Fluvial
L	Lacustrine
M	Glacial till

distances from the ice margin where deep water conditions prevailed.

The other material in the classification is glacial till. This has been deposited by the ice with little or no transportation by water. It is generally in the form of ground moraine: an unstratified, unconsolidated, heterogeneous mixture of clay, silt, sand, gravel and sometimes boulders. The texture of morainal material varies widely as does the chemical composition and the degree of weathering.

Soil texture

Soil texture is important to land system mapping because of its relationship to many other soil properties such as water storing capacity, water flow and drainage, cation exchange capacity, erosion susceptibility and salinity among others. It is, therefore, a very important soil characteristic and one that is relatively permanent.

The finer the texture of the soil the greater is its moisture holding capacity. Moisture retention studies on sub-surface horizons of Saskatchewan soils by de Jong (1967) indicate that the per cent moisture by weight retained by a sandy loam soil at the wilting point was only one-half that of a clay loam (13 per cent) and one-quarter that of a heavy clay soil. The ratios were nearly similar at field capacity where the clay loam soil retained 26 per cent moisture. Fig. 3.9 illustrates that moisture reserves of loam, clay loam

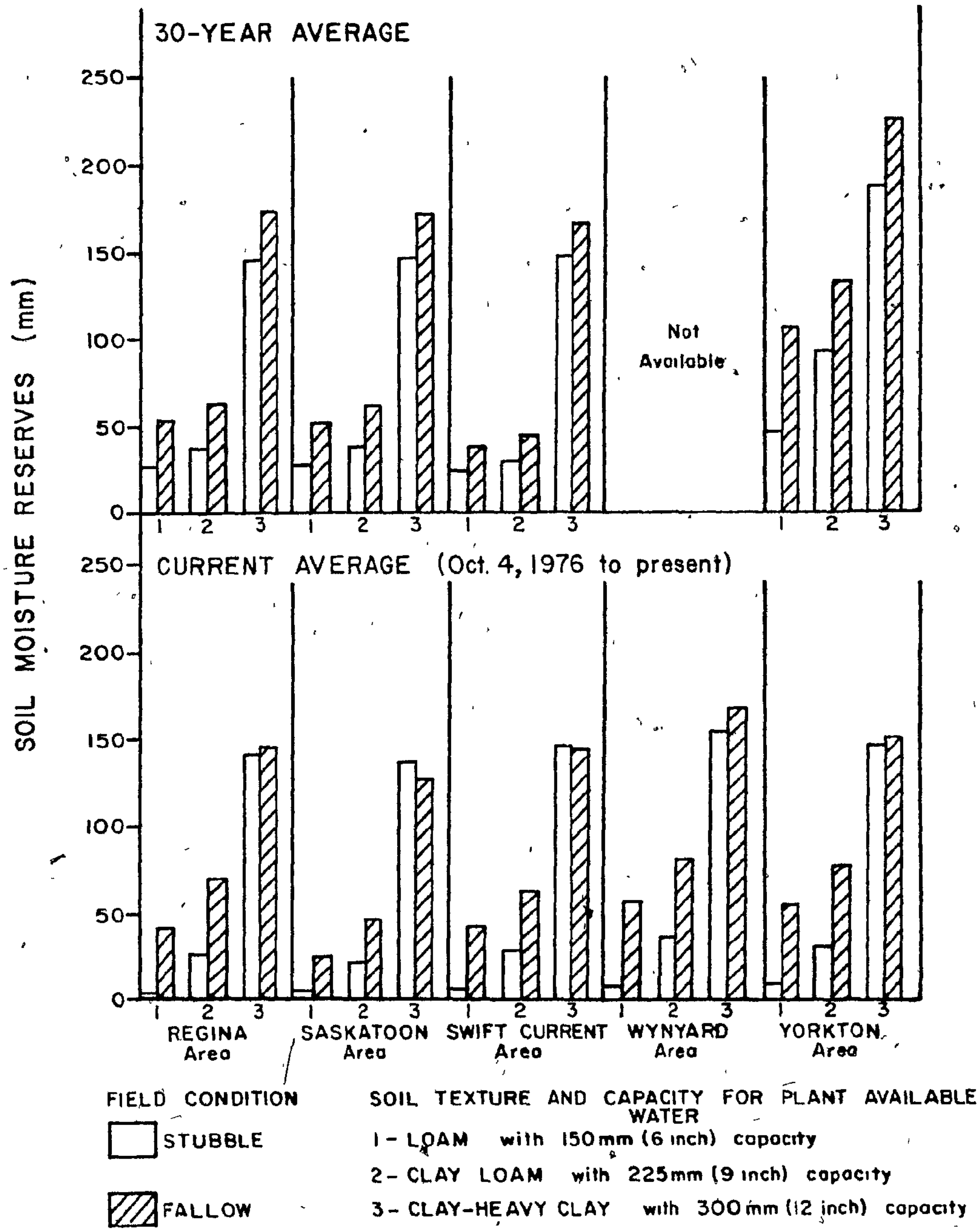


Fig. 3.9 The moisture reserves of different textured soils under stubble and fallow for some areas in southern Saskatchewan. (Data Source: Soil Moisture Evaluation Project Report no. 19, 1976)

and clay-heavy clay soils on stubble and fallow field conditions increase with increasing clay content, with fallowed soils retaining more moisture.

Soil moisture retained at field capacity minus that at permanent wilting is termed plant available water. When expressed on a weight basis, moisture available to plants was 7 per cent for sandy loam, 13 per cent for clay loam and 22 per cent for clay soils, and on a volume basis the average water available to plants in the upper 1.2 meters (four feet)of sandy loam , clay loam and heavy clay soils was 12.5, 22.5 and 32.5 cm. respectively (de Jong, 1967). Plant available water for the soils in Fig. 3.9 is 150 mm. for loam, 225 mm. for clay loam and 300 mm. for clay-heavy clay. Similarly, plant available moisture at various depths generally shows a decrease from clay soils to sandy loam soils (Lehane and Staple, 1965) as seen in Fig. 3.10.

Further work by de Jong (1967) established that soil moisture retention in the surface horizon was related to the organic matter content as well as the texture. For example, the per cent available water in a loam soil with less than 3.5 per cent organic matter was 10 per cent as compared to 15 per cent in a loam soil with more than 7 per cent organic matter. A loam soil with intermediate level of organic matter had 12 per cent plant available water. This relationship also serves to illustrate the importance of the differing organic matter levels of zonal soils (Table 3.1).

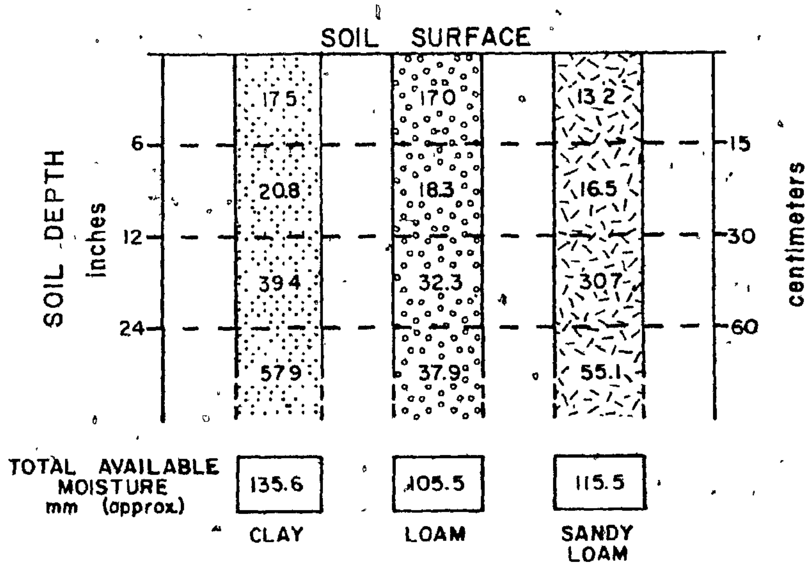


Fig. 3.10 Available soil moisture at various depths for different textured soils in southwestern Saskatchewan. (Data Source: Lehane and Staple, 1965, p. 210, with metric conversion.)

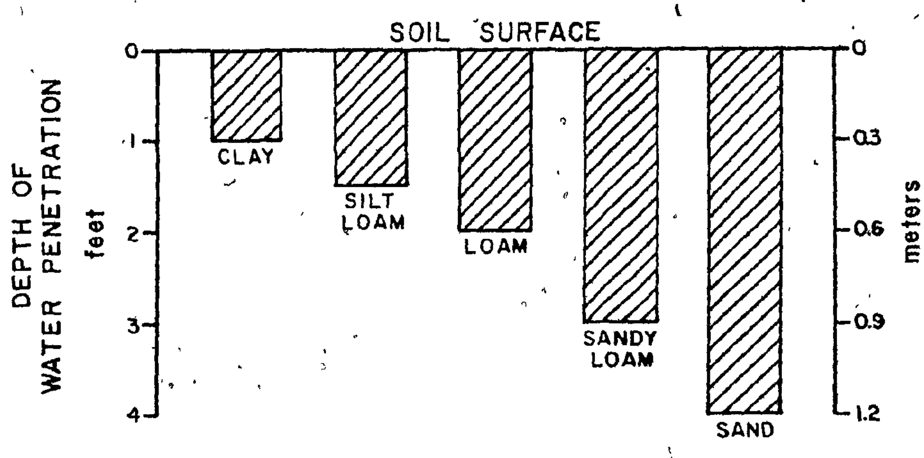


Fig. 3.11 The approximate depth of soil to which 76 mm (3 inches) of water infiltrates. (Data Source: Donahue, 1965, p. 257)

The texture of the soil also influences the conductivity or flow of water through the soil. At saturation, coarse soils have the highest conductivity, whereas, fine textured soils are the best conductors under unsaturated conditions. Fine textured soils with their smaller pores are generally the slowest to become moist. In Fig. 3.11 the different soil depths to which water penetrates are shown for different soil textures, and it can be seen that 76 mm. (three inches) of water wets a clay soil to a depth of 31 cm. (one foot), a loam soil to 62 cm. (two feet) and a sandy soil to 124 cm. (four feet) (Donahue, 1965, page 257).

When fine textured subsurface layers are present the drainage from the overlying soil is limited. Besides the slow permeability resulting in impeded drainage, textural stratification of fine textured soils also restricts deep root penetration. Impeded drainage in fine textured soils may also result in the soils becoming saline and artificial drainage is often necessary for the removal of excess salts.

The soil texture has a direct effect on drainage practice. Heavy soils are generally drained by open ditches, whereas, coarse textured soils are tile-drained. Open ditches reduce arable land and are obstacles to farm machinery and where feasible, tile drains are used. The depth of the tile below the surface of the land and the interval between the tiles vary with the texture of the soil. It is common for the tiles to be at a depth of 1 to 1.2 meters in sandy or saline soils. The intervals between the tile drains vary from 9 to 21 meters for clay and clay loams, to 31-93 meters for sandy loams as shown in Table 3.6.

Plant growth is affected by the amount of nutrients which the plants take in through their roots. The nutrients from the soil solution are absorbed by plants in the form of ions. The surfaces of clay minerals and humus control the level of cationic exchange in a soil with the result that this varies with soil texture. The relationship between soil texture and cationic exchange capacity can be seen in Fig. 3.12. In general, sands have a lower cation exchange capacity than the heavier soils; the more clay there is in a soil, the higher the cation exchange capacity, and therefore the higher the nutrient supply.

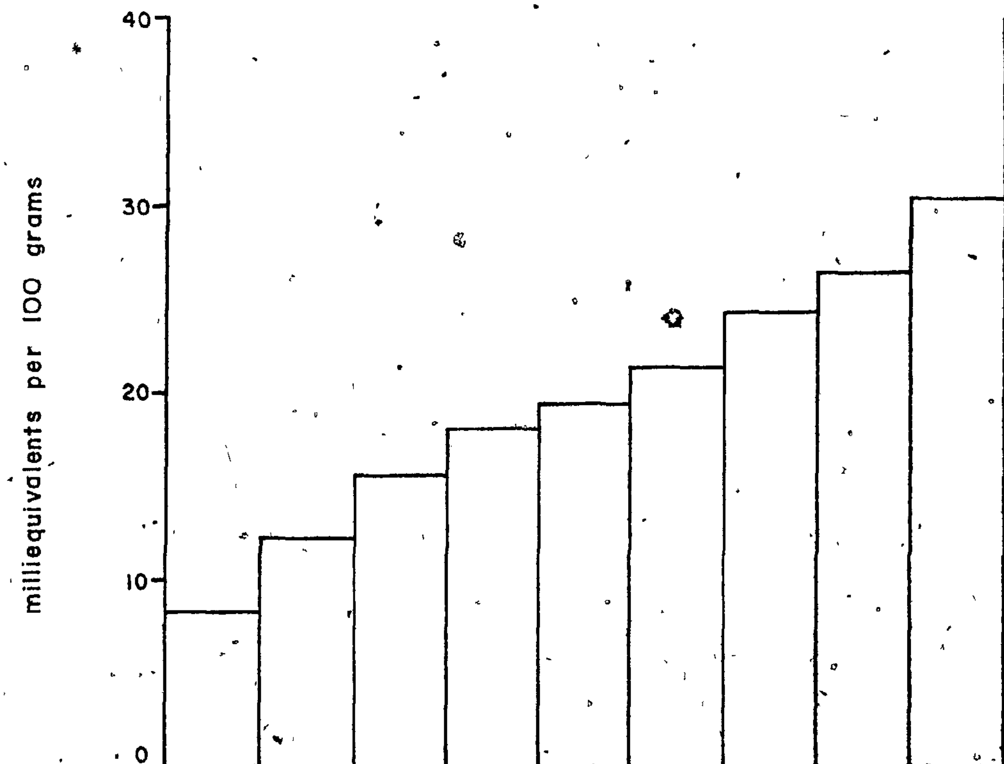
The texture of a soil is very relevant to erosion. Fine sands and silts are most readily eroded by raindrops, whereas, due to their greater size and weight, coarse particles are more likely to remain in place. Cohesive soils such as clay and clay loam on the other hand, are not generally affected by raindrop impact. Sandy soils are more susceptible to wind erosion. Unless there is a heavier textured subsoil the bare sandy soils conserve a very small amount of moisture and the risk of soil drifting is very great. Sandy and light loamy soils can drift even when cultivated. Soils with a clay content such as loams, sandy clay loams, sandy clays, silt loams, clay loams and silty clay loams, on the other hand, are not

TABLE 3.6

INTERVALS OF TILE DRAINS FOR VARIOUS SOIL TEXTURES

Soil	Permeability	Spacing (Meters)	Spacing (Feet)
Clay and clay loam	Very slow	9 - 21	30 - 70
Silt and silty clay loam	Slow to moderately slow	18 - 31	60 - 100
Sandy loam	Moderately slow to rapid	31 - 93	100 - 300
Mucks and peats		15 - 61	50 - 200

Source: K.H. Beauchamp (1955), page 513 with metric conversion.



SOIL TEXTURE	LOAMY SAND			SANDY LOAM		VERY FINE SANDY LOAM	LOAM		SILTY CLAY LOAM
CLAY CONTENT (%)	7.9	9.	6.7	18.3	18.6	17.8	18.6	26.3	32.4
SOIL ASSOCIATION	Asquith		Biggar	Weyburn	Bradwell		Elstow	Weyburn	Elstow
HORIZON	Ap	Ap	Ah	Ap	Ap	Ap	Ap	Ah	Ap
THICKNESS OF HORIZON	0-6	0-7	0-5	0-4	0-5	0-5	0-6	0-6	0-3

Fig. 3.12 The relationship between cation exchange capacity and soil texture. (Data Source: Ellis et al., 1965 and 1970)

as easily eroded. Strip cropping is often practiced to reduce wind erosion. The most effective width of a strip in part depends on soil texture. Anderson et al. (1966) have suggested strip widths as shown in Fig. 3.13 for soils farmed in a 2-year rotation; sandy soils and the fine clays, more susceptible to drifting, have narrower strips than the intermediate textures.

Differences in soil texture are often reflected by differences in crop yields. Moss (1962) has noted that high yields of wheat in Saskatchewan are often associated with relatively high clay content of the soil (Fig. 3.14). The figure shows that sandy soils have the lowest yield at 980 litres per hectare (10.9 bushels per acre) whereas the heavier clay soils have the highest yield at 1717 litres per hectare (19.1 bushels per acre).

Soil texture has an important effect on the choice of farm machinery. For example, in soft, wet or loose soils it is better to use a 4-wheel drive tractor with its increasing drawbar pull for a given wheel slip than it is to use a 2-wheel drive vehicle. Clay soils are often a problem for farm machinery because of tractor slippage and rolling resistance. In heavy soils, shallow-concavity discs operate more satisfactorily, whereas, a greater disc angle penetrates better in hard sandy soils. For the same reason a blade cultivator is not suitable for clay soils, whereas, it is the best implement for sandy soils.

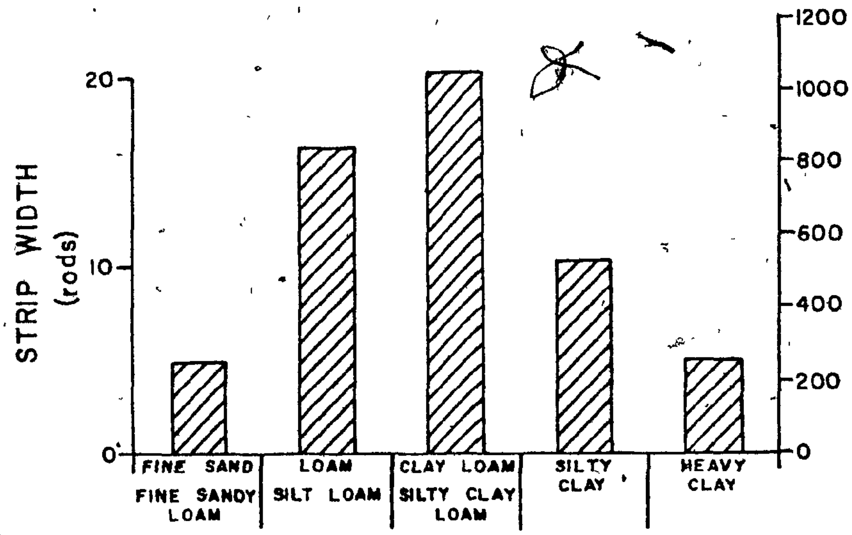


Fig. 3.13 The relationship between the width of field strips and soil téxtures. (Data Source: Anderson et al., 1966, p. 17)

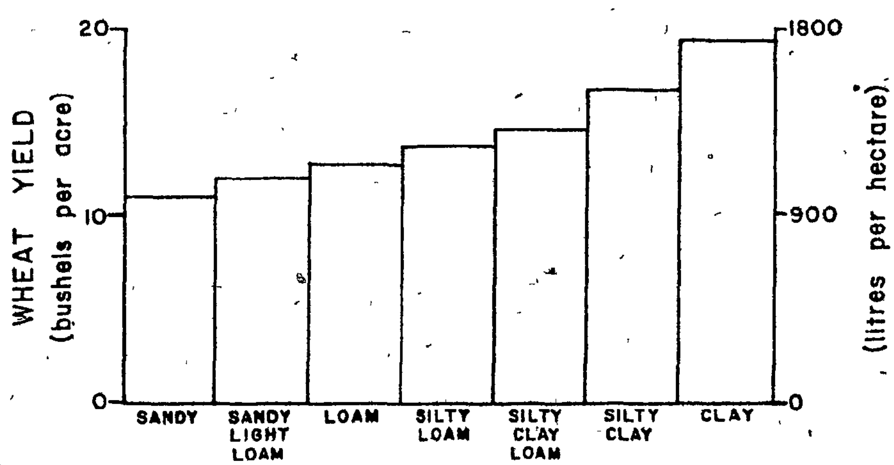


Fig. 3.14 The relationship between the yield of wheat and soil textures. (Data Source: Moss, 1962, p. 9)

Fine textured soils if plowed when they are too wet may puddle and dry into hard clods that are difficult to break down for seedbed preparation, and very heavy soils often have compact crusts which prevent seedlings from emerging. Plowing and cultivating fine textured soils, improve the air-moisture relations for better plant growth. On the other hand, coarse-textured soils do not improve much with tillage and because of their relatively low capacity for moisture retention, it is best to have them seeded as early in the spring as possible.

Soil texture classification for the Wynyard area. The soil textures of the Wynyard area are divided into four groups—sandy loam, loam, clay loam and clay. Table 3.7 shows the modal texture and the range of textures included within each group. The percentages of sand, silt and clay-sized particles of each textural group as determined by the Saskatchewan Institute of Pedology, is given in Fig. 3.15.

Soil phase

In dealing with land systems some consideration must be given to the effects of present day processes such as runoff, wind erosion, and salinity in the upper soil horizons. Soil erosion is frequently a serious problem in a cultivated landscape. Removal of topsoil often results in impoverished solum, low crop yields or unsuccessful crop production. This may lead to hardship and farm abandonment. It is therefore

TABLE 3.7 . SOIL TEXTURAL GROUPS FOR SURFACE HORIZON .

Map class	Characteristic texture	Range of textures included
5*	Loamy sand	sand, loamy sand .
6	Sandy loam	gravelly loam · sandy loam ; fine sandy loam .
7	Loam	very fine sandy loam; light loam ; silty loam .
8	Clay loam	very fine clay loam; clay loam; silty clay loam .
9	Clay	silty clay; clay; heavy clay .

* not present in the Wynyard Area .

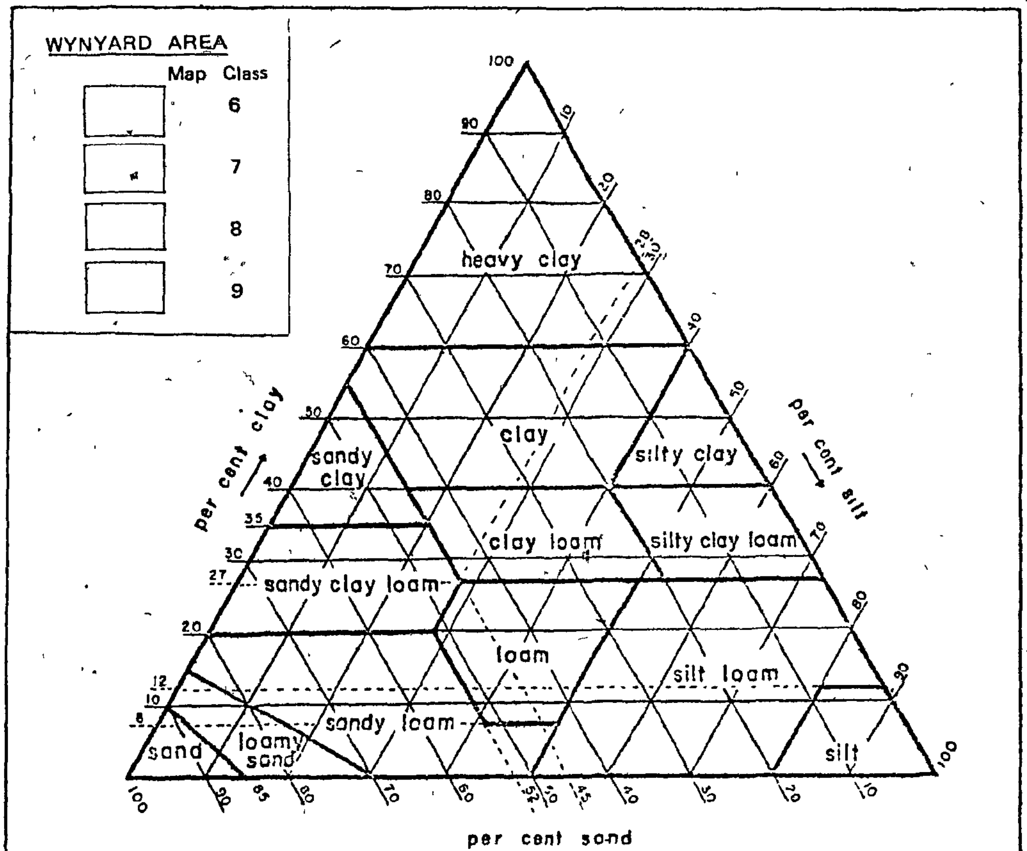


Fig. 3.15 Percentages of sand, silt, and clay-particles for the determination of soil textural classes in Saskatchewan . (Source: Moss,1967,p.33)

important for land to be classified with regard to erosion and salinity hazards, in order that proper use and management practices are carried out.

A soil phase is not in itself a category of the soil classification system but is a subdivision of any level within the classification system. The basis of the subdivision may be any soil characteristic or a combination of soil characteristics which are potentially significant to man's use or management of the land. They generally include the degree of erosion, salinity or stoniness.

Types of erosion vary from one region to another according to the rainfall intensity and the soil characteristics. Occurrences of drought are followed by crop failure, consequent soil exposure and erosion. Soil exposed through plowing is particularly susceptible to erosion. Available and potential plant nutrients are lost and often the entire topsoil is removed with inevitable reduction in crop yield inspite of applications of fertilizers, manure and crop rotation.

Water erosion. Soil erosion by water is caused by the splash of raindrops or rainwater and snowmelt in channelized flow. A very heavy torrential rain such as a prairie rainstorm is capable of splashing away as much as 250 metric tons of soil per hectare (Buckman and Brady, 1969, with metric conversion). The lack of a vegetative cover or the cultivation of the soil with soil-exposing crops tends to accelerate erosion. The rates of soil erosion are determined by the amount of rainfall, the erodibility of the soil, the length of the slope, the slope gradient and crop management practices.

The soil may be removed by flowing water in the form of sheet erosion, rill erosion or gully erosion. Rills and gullies are often initiated by cattle tracks, wheel ruts or poorly maintained drainage ditches. Plate 3 shows rill erosion on fallowed land which if left unchecked will develop into gullies. Soil damage is increased and farming becomes more difficult.

On long slopes, field strip cropping perpendicular to the slopes, reduces the velocity of water and the amount of runoff and consequently, soil loss is reduced.

For the land system mapping of the Wynyard area, the severity of water erosion has been divided into three classes as shown in Table 3.8 with mapping codes W-, W and W+, the plus or minus sign denoting the degree of erosion. The soils within this group are thin and droughty on the top of knolls and have been subjected to water and to a lesser extent, wind erosion. The W- class refers to an area where moderate sheet erosion has taken place and about one-third to half of the productive topsoil has been removed from 15 to 30 per cent of the land. There are a few rills but these soils do not require significantly different management practices from the uneroded soils. In contrast, the W phase has more than half of its

TABLE 3.8

SEVERITY OF WATER EROSION

Map Class	Description
W-	Moderately eroded land where 1/3 - 1/2 of the productive topsoil has been removed from 15 - 30% of the land.
W	Severely eroded land where more than 1/2 of the productive topsoil has been removed from 15 - 30% of the land.
W+	Severely eroded land where more than 1/2 of the productive topsoil has been removed from more than 30% of the land.
W++*	Very severely eroded land where at least 20% of the land has an intricate pattern of moderately deep or deep gullies. The soil profiles have been destroyed except in small areas between the gullies.

*Does not occur in the Wynyard area.

topsoil removed from about 15 to 30 per cent of the area and shallow gullies may be present. The W+ class is severely eroded with both sheet and gully effects and more than half of its topsoil has been lost from over 30 per cent of the land.

Wind erosion. Erosion by wind—another factor in the classification—is a problem in dry regions where strong winds occur frequently and where the soil moisture and the texture conditions favour drifting. Soil particles lying loose and set in motion by the wind strike the soil surface and detach more soil particles. A rough soil surface aids in trapping the drifted particles and thus reduces erosion. Bare land plowed into ridges also minimize drifting. Plants and their residue retard ~~wind~~ velocity and prevent the soil particles from being blown off. The detachment and erosion of soils by the wind is greater on a large field where there are no obstructions. In an area where wind erosion is a hazard, fields are kept as narrow as possible and strip cropping is practised.

Soil erosion depletes fertility and leads to changes in soil texture. Due to sandblasting of the stems and the leaves, plants may be infected by disease organisms thus lowering the crop yield. A reduced yield may also result from root exposure and increased moisture stress. The erosion of a soil lowers its productivity and it is therefore of great importance to control wind erosion by reducing the area of the exposed soil with trash cover or crop cover; by practising strip-cropping and crop rotation and by establishing shelterbelts.

The wind eroded land of the Wynyard area has been classed according to its severity. The degree of wind erosion ranges from moderately eroded land "E-", through severely eroded land "E" to blow-out land "E+" as shown in Table 3.9. In the E- class, the wind has eroded part of the A horizon and in certain areas the removal may be complete, exposing lower horizons. The E class has all of the A horizon removed with partial removal of the B horizon and there may be an occasional blow-out area. In the case of E+, most of the soil profile has been removed and extensive reclamation is required for agriculture. Blow-out areas are numerous and an accumulation of the drifted soil is found in blow-out areas. In Plate 4 the grass growing along a fence has trapped drifted soil and the fence is deeply buried by the soil.

Salinity. The accumulation of salts in the field is a serious problem for agriculture. A high salt content around the roots of plants greatly reduces their osmotic processes. The effects of salinity can be seen in the appearance of the plant—dwarfed or stunted habit, and dull or blue green rather than green colouration. In many field crops, severe salinity is indicated by barren spots where individual plants or groups of plants have wilted and died. Plate 5 shows a field of ripening wheat within which a barren spot is present.

TABLE 3.9

SEVERITY OF WIND EROSION

Map Class	Description
E-	Moderately eroded land. The wind has removed some of the A horizon.
E	Severely eroded land. The wind has removed all of the A horizon and part of the B or other lower horizons. The plow layer consists mainly of the original horizons below the A although some patches of the original A horizon remain in the area.
E+	Blow-out land. The wind has removed most of the soil profile and the area is classified as a miscellaneous land type. Blow-out holes are numerous and deeply carved into the lower soil or parent material.

The occurrence of salinity is often indicated by variations in crop vigour. A very high level of salt is toxic to plants —the toxic effect increasing with the salt content.

The sensitivity of plants to salinity varies. Forage crops such as saltgrass, Canada wildrye, Western wheat grass, barley and others have a high tolerance, whereas, clovers and cereals such as white sweetclover, yellow sweetclover, rye and oats have only a moderate tolerance (Richards, 1954).

Salinity classes for the Wynyard area are given in Table 3.10. N- indicates moderately saline land which can be cropped although the yields may be low. N is moderate to strongly saline land where grains will give poor yields and field crops such as barley and rape are better adapted. Strongly saline land N+ is generally too saline for cultivation and is left in its natural state: generally unimproved grassland.

Some other surface characteristics such as stoniness, internal drainage and soil structure also influence the growth of crops. However, they were not included in the study because the emphasis is on those attributes which are readily visible in the landscape and visible on aerial photography.

LAND SYSTEM MAPPING CODE

All of the attributes described in the preceding paragraphs are incorporated in the description of the land system. The attributes are combined in a numerator/denominator format

TABLE 3.10

SEVERITY OF SALINITY

Map Class	Description
N-	Moderately saline land.
N	Moderate to strongly saline land.
N+	Strongly saline land.

as indicated in Fig. 3.16. The system has the merit of being relatively simple and therefore easily applied. It is alpha-numeric and therefore amenable to computer analysis. The system can be illustrated by reference to some particular examples of land systems from the study area:

$\frac{2K7M}{W}$ This combination indicates that the topography is gently rolling (2), the landforms are glacial knob and kettle (K), the dominant soil texture is loam (7), and the parent material is glacial till (M). Many limy knolls are present and there has been severe erosion by water (W).

$\frac{1J6L}{EN}$ This land system has a nearly level to undulating topography (1), low relief landforms with more than 15 per cent of the area occupied by shallow sloughs (J), a dominant soil texture of sandy loam (6), and a lacustrine (L) parent material. There has been severe erosion by wind (E) and the land is moderate to strongly saline (N).

1U7M This combination refers to a land system with a nearly level to undulating topography (1), an unpatterned low relief landform (U), a loamy soil texture (7) and a glacial till parent material (M).

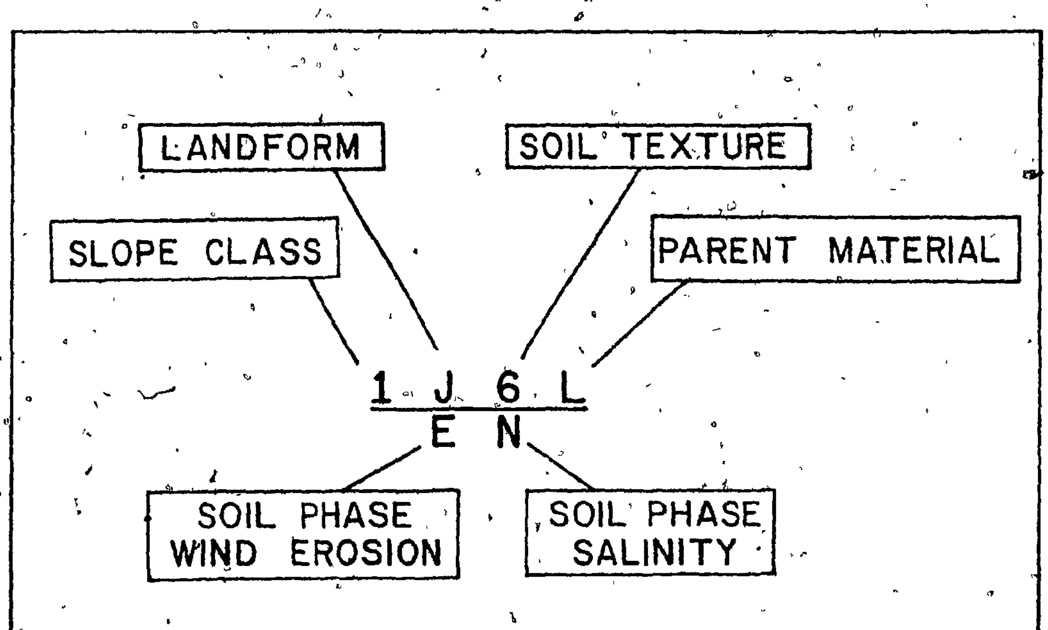


Fig. 3.16 Interpretation of the Alpha- numeric code used in mapping land systems.

CHAPTER 4

THE APPLICATION OF LAND SYSTEM MAPPING TO THE WYNYARD AREA

INTRODUCTION

Aerial photographs have been used extensively for land system analyses by various organizations including groups concerned with engineering and military applications such as MEXE (Military Engineering Experimental Establishment) in the United Kingdom; resource survey groups such as CSIRO (Commonwealth Scientific Industrial Resource Organization) and regional planning groups such as the Tennessee Valley Authority. Thus the methodology of land unit differentiation on airphoto is well established.

The major physiographic boundaries are easily identifiable by the obvious pattern contrasts between the different terrain and soil units. Pattern analysis relies on the study of the gross landforms (Benninghoff, 1953) which are the most conspicuous feature in the airphoto (Verstappen, 1966) and small scale aerial photography is ideal for the delineation of broad regional patterns (Colwell, 1960; Stone, 1956). For the land system classification of Wynyard, black and white vertical air photographs with the normal 60 per cent stereo-overlap and 20 per cent sidelap were used. The photographs were taken with a 3.5 inch focal length camera at an altitude varying between 25,100 feet to 25,600 feet to give nominal scales ranging from 1:73,000 to 1:82,000. The date of photography was July 1970: this being the latest coverage of the area at the start of the study. A spring coverage was deliberately chosen because the sloughs are clearly visible at this time of year and soil differences are more marked than later in the season when the surface has dried and the crops cover much of the ground surface.

FIELD WORK

The initial field work included the identification of the landforms along traverses and relating them to the patterns on the air photographs. The intent was to provide specific ground truth information as a base for photo interpretation work. Features such as ridges, knolls, kettles, drainageways amd depressions as defined in each landform description were taken into account. Slope class estimates were recorded on the airphotographs at every 0.8 km. (1/2 mile) with frequent checks made with an Abney Level. Distance was gauged by the speedometer mileage, which was used in combination with the sectional grid roads to pinpoint locations on the air photographs and the topographic maps.

The presence of gravel pits was helpful in locating fluvial materials. It was noted that these sandy or gravelly materials often support bush, native grass or a poor crop. Morainal materials were recognized by the presence of numerous surface stones in the soil. Fresh road cuts were also useful for checking the various types of parent materials.

Checks for erosional phases were made by noting changes in soil colour, water flow, the presence of rills or gullies and the plant cover. The occurrence of wind erosion is apparent from the accumulation of soil from cultivated land in "blow ridges" along fence rows and the exposure of subsoil in "blow out" pits.

The presence of salt accumulation can be detected by variation in crop vigour, barren spots in the crop cover or the actual occurrence of precipitate crusts in the soil profile. Salt crystals give the soil a grayish tone and in excessive amounts, the soil becomes light gray or white.

AIRPHOTO INTERPRETATION EQUIPMENT

The airphoto interpretation equipment used included the ODSS III (Old Delft Scanning Stereoscope), the Abrams Model CB-1 Stereoscope and the K & E (Keuffel and Esser) Vertical Sketchmaster. The ODSS III is a mirror stereoscope with magnifications of 1.5 to 4.5 and viewing of 9"x9" and 9"x18" photographs, as well as scanning them, is possible without shifting them during the operation. The Abrams CB-1 Stereoscope is a lens stereoscope with two to four power magnification. These stereoscopes were used for interpretation and the K & E Sketchmaster was used for the transfer of mapping details from the air photographs to the base map.

AIR PHOTO ANALYSIS

Following the initial field work the airphoto interpretation was carried out systematically for the whole Wynyard area using the Old Delft Scanning Mirror Stereoscope and the Abrams CB-1 pocket stereoscope. Delineations were made on alternate photographs.

Soil-climatic subzones

As these subzones provide a broad framework for subdivision of smaller units which are more or less homogeneous in terms of terrain factors such as landform type and soil texture, generalized soil-climatic subzonal boundaries were delimited before any other parameter, as illustrated in Plate 6.

Slope

Through careful stereoscopic viewing and with field observations as guides, boundary lines were drawn between areas with different slope classes. Slope can also be inferred from the photographic tone since variations in tone are often the result of slope differences. Slopes with direct illumination are generally lighter, whereas, reverse slopes are usually darker. These tonal contrasts are greater in areas with steeper slopes. In general, the coarseness of the photographic texture also increases with increasing topographic irregularity. However, this is not solely the effect of topography. It is also due to the landform pattern, the type of parent material, the texture of the soil and the soil phase, among other factors.

Landform

Stereoscopic study of the airphoto stereopairs for the identification of the landform pattern was the next step in the interpretation. The landscape which had been divided into areas with similar slope classes was further divided according to repetitive landform patterns. In this study the term landform refers to the surface expression of a recurring pattern of slope assemblages. The identification of the landforms was based on the pattern of the landform types described in Table 3.3, according to their relative relief, slope and the photographic texture. The boundaries of the landform patterns and the slope classes as well as their respective mapping codes were recorded on each stereopair.

Parent material and soil texture

Factors influencing photographic tones include soil colour, soil texture, moisture content, parent material, vegetation, shadows, freshly tilled fields, cultivation and exposure of subsoil among others and it is not possible to determine the type of parent materials and soil texture by airphoto interpretation only. Therefore preliminary boundaries for parent materials and soil textures were transferred from published soil maps of Rural Municipalities (Shields and Clayton, 1966) to overlays on the airphotograph. Separate overlays were made for parent material and soil texture and township and range grids were used as guides in the transfer. The transferred boundaries were then refined by reviewing them with slope and landform delineations, and common boundaries drawn where appropriate.

Changes in landform patterns, vegetation patterns, tone, drainage and other micro-features help in the identification of soil materials (Belcher, 1955; Benninghoff, 1953; Colwell, 1960). However, some micro-features under normal terrain and weather conditions do not show tone contrasts in the soils (Colwell, 1960, p. 639). Generally the photographic tone of outwash materials is light gray (Colwell, 1960) but identification of granular deposits is not always possible by tonal patterns alone (Mollard and Dishaw, 1958). Alluvial soils and lacustrine soils are generally dark toned and have smooth photographic textures where these soils are deep. The identification of lacustrine materials is also aided by the long length of the slopes. Air photo images of lacustrine veneer over morainal deposits showed slight variations in tone and the photographic texture is coarser than in the deeper lacustrine soils. Morainal materials or till generally have a mottled appearance.

Fine textured soils because of their greater water retention capacity, in general photograph darker than the coarser textured soils. Light photographic tones can be interpreted as the result of aridity, stronger slope or greater erosion.

Soil Phase

Photo interpretation was carried out for soil erosion and salinity for all the stereopairs.

Soil erosion. Areas of eroded soil were seen on the airphoto as lighter tones. This results from the removal of the upper soil horizons and the exposure of the sub-soil which has a lower organic content and thus is generally higher in colour. In contrast, the lower slopes are locally darker due to the accumulation of organic materials and the higher moisture content. The erosional characteristics were marked on the stereopairs as symbols in the denominator of the mapping code.

Soil salinity. The salinity phase of the soil is also shown as part of the denominator in the coding system. Bare saline soil surface areas appear as light spots when dry due to a surface crust of white salts which remain after the water evaporates. Areas of salt accumulation vary in size from a few square meters to 260 hectares within cultivated areas. However, in the low relief, high water table areas there are extensive spreads of salt precipitation. For example, areas as large as 5200 ha (20 square miles) occur around the Quill Lakes in the northeastern part of the Wynyard area. Crops are also a good indicator of soil salinity but on black and white air photographs it is not always possible to detect plant response to salinity because of the limited tonal contrast between the plants and their background. Salinity can also be inferred from the absence of cultivation, changes in the appearance of the vegetation and the topographic position of the area in the landscape. The vegetation is often left in its natural state and this shows up as a dark gray toned expanse of land with no distinct pattern. Around lakes and depressions the accumulation of salt produces a white ringed pattern. According to the airphoto interpretation the area affected by salts in the Wynyard map sheet is approximately 1419 sq. km. (141870 ha. or c. 550 square miles). When salinity occurred, the mapping code N was recorded on the stereopairs.

DERIVATION OF LAND SYSTEMS

This was carried out in four phases: incorporation of soil and landform data, preparation of the base map, field verification and preparation of the final map.

Methodology

As the airphoto interpretation for landform types, slope classes and soil phases was completed, the mapping codes were marked on the air photograph to which soil-climatic subzones were previously demarcated as shown in Plate 6. Land systems were derived within each subzone by superimposing the soil texture and the parent material map overlays onto the above airphotograph map base. Some minor adjustments of land component boundaries were required to form coincident land system boundaries and thereby eliminate areas too small to be shown on the final map. In some cases these small areas represented real landscape entities. However, in the majority of cases these minor discrepancies resulted because land component boundaries were derived from different data sources. Each delineated land system with its characteristic landform, slope, soil texture, parent material and soil phase, was distinct from adjoining areas. An example of the procedure is presented in Plate 6. In this particular area six land systems have been delineated within the Black and the Gray Luvisol (Wooded) Soil Zones.

Base Map

The same procedure was carried out on all the stereopairs of the Wynyard area. The boundary lines of the land systems were then transferred onto a base map at a scale of 1:80,000 which had been enlarged from the 1:250,000 National

Topographic Sheet of the Wynyard area. This large base map consisted of four sheets of stable matte film.

The transfer of the boundaries of the land systems was made from the transparent overlay with the airphotograph taped to it for proper registration. A Keuffel and Esser Vertical Sketchmaster which utilizes the camera-lucida principle was used in transferring data from the photograph to the base map. The photograph and an overlay on which the land system boundaries had been delineated, was placed on the platen and the image on the photograph was brought into registration with the topographic feature or road shown on the base map. Corrections for tilt and scale were carried out by adjusting the leg heights of the sketchmaster. The near correspondence between the nominal scale of the air photograph and the scale of the base map greatly facilitated the transfer of the boundaries.

Field verification

The final phase of the field work was to check the land system boundary lines, the landform patterns, the slope classes, the parent material types, the soil textural groups and the soil phases as derived from the airphoto interpretation. In addition checks were made of the details provided in geological and soil reports as well as the field observations made during the preliminary field work.

Land system map

The four sheets of the base map were photographically reduced and assembled into a single map sheet at a scale of 1:250,000 and the resulting original was edited and printed as a land system map of the area (Fig. 4.1).

CHAPTER 5

ANALYSIS OF THE LAND SYSTEMS OF THE WYNYARD AREA

AREA OCCUPANCE

The procedures for land system mapping are very sensitive to differences in landscape since they take into account all the important land parameters. This results in a very detailed compartmentation as shown on the land system map (Fig. 4.1). The areas occupied by the different land systems vary appreciably. Likewise the areas of each slope class, landform type, parent material type and soil textural group show a wide variation.

Land systems

Seventy-seven distinct land systems were recognized in the Wynyard area and several of these are represented by numerous individual occurrences of the same type. For example, land system $\frac{2K7M}{W}$, which accounts for 19 per cent of the total area, has 33 individual occurrences; land system $\frac{3K7M}{W+}$, covering 11 per cent of the total land area, occurs in 17 separate areas; land system $\frac{1K7M}{W-}$, with ten per cent of the area, has 17 occurrences; 1J7M, with an area equivalent to seven per cent of the total, recurs 22 times, and $\frac{1G7M}{W-}$, with five per cent of the area, occurs in four locations.

Each of the remaining land systems occupies less than five per cent of the total area. Land system 1B7M with a single occurrence has the smallest area accounting for only 0.02 per cent of the total. Fig. 5.1a shows the relative significance of the various land systems—most of them occupying very small areas.

Slope class

The Wynyard area is generally flat with slopes of 0 to 5 per cent occupying 52 per cent of the area. The distribution of slopes is shown in Fig. 5.2, and it can be seen that the level areas are predominantly in the central plain in a zone stretching from Davidson in the southwest to the Quill Lake Basin in the northeast.

Class 2 slopes occupy about 32 per cent of the area and occur to the east of Last Mountain Lake extending northeast to the Day Star Indian Reserve in the Touchwood Hills. On the west side of the map area, Class 2 slopes occur in the area west of Stalwart in a north-south zone, which is interrupted by many areas of Class 1 and Class 3 slopes.

Areas with Class 3 slopes occur in the Allan Hills Upland and in the southeast portion of the Wynyard area. This zone stretches from the Poor Man Indian Reserves southwards to the edge of the Wynyard area. Class 4 slopes occur only locally in the dissected parts of the Allan Hills.

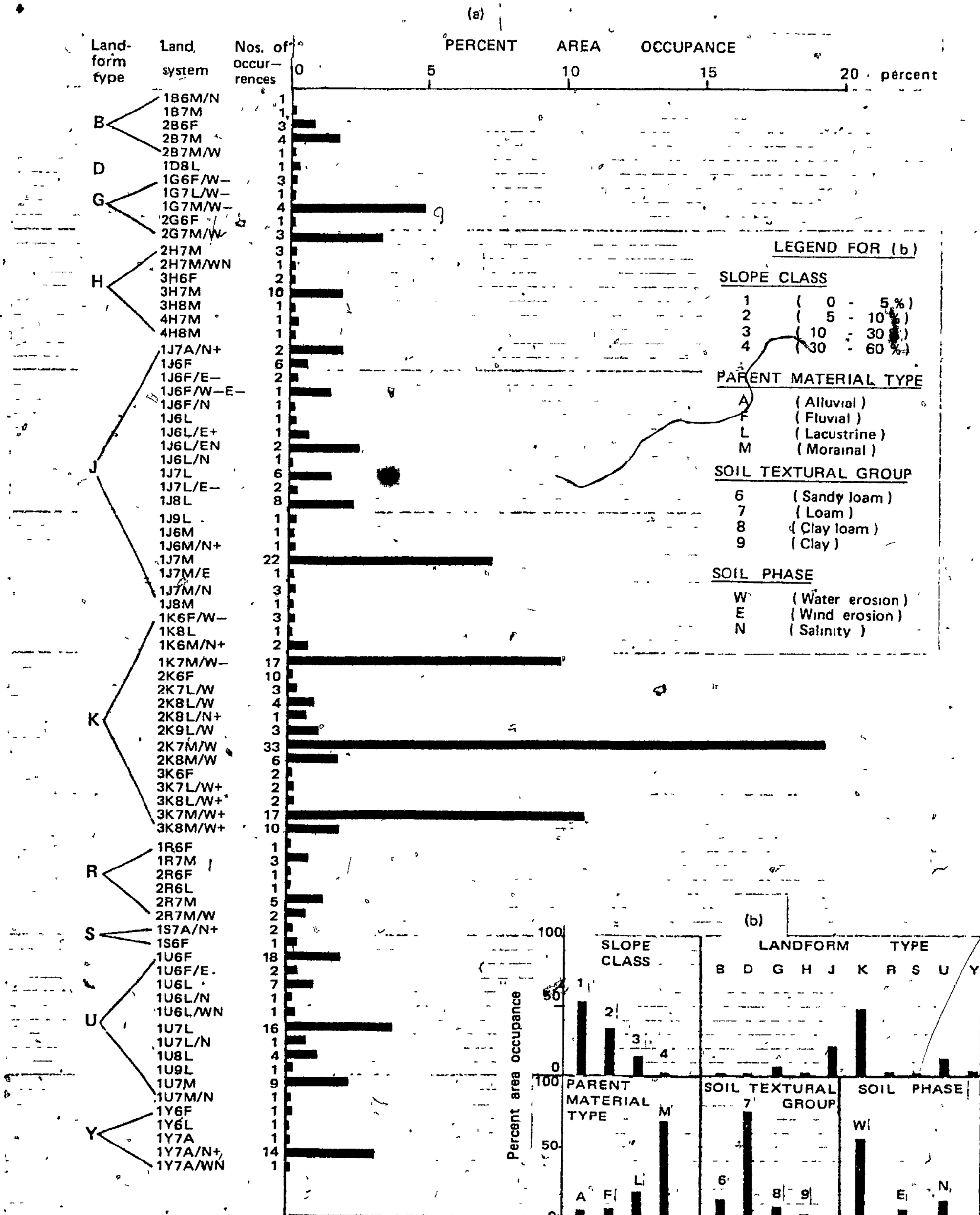


Fig. 5.1 The percent area occupied by each land system (a) and the various parameters of slope, landform type, parent material type, soil textural group and soil phase (b).

TABLE 5.1

AREA OCCUPANCE - SLOPE CLASS

Slope Class	Approximate Area		
	Quarter Sections	km.^{2}	Per Cent
1 (0 - 5%)	11,848	7,714	52.19
2 (5 - 10%)	7,353	4,787	32.39
3 (10 - 30%)	3,415	2,223	15.05
4 (30 - 60%)	85	55	0.37

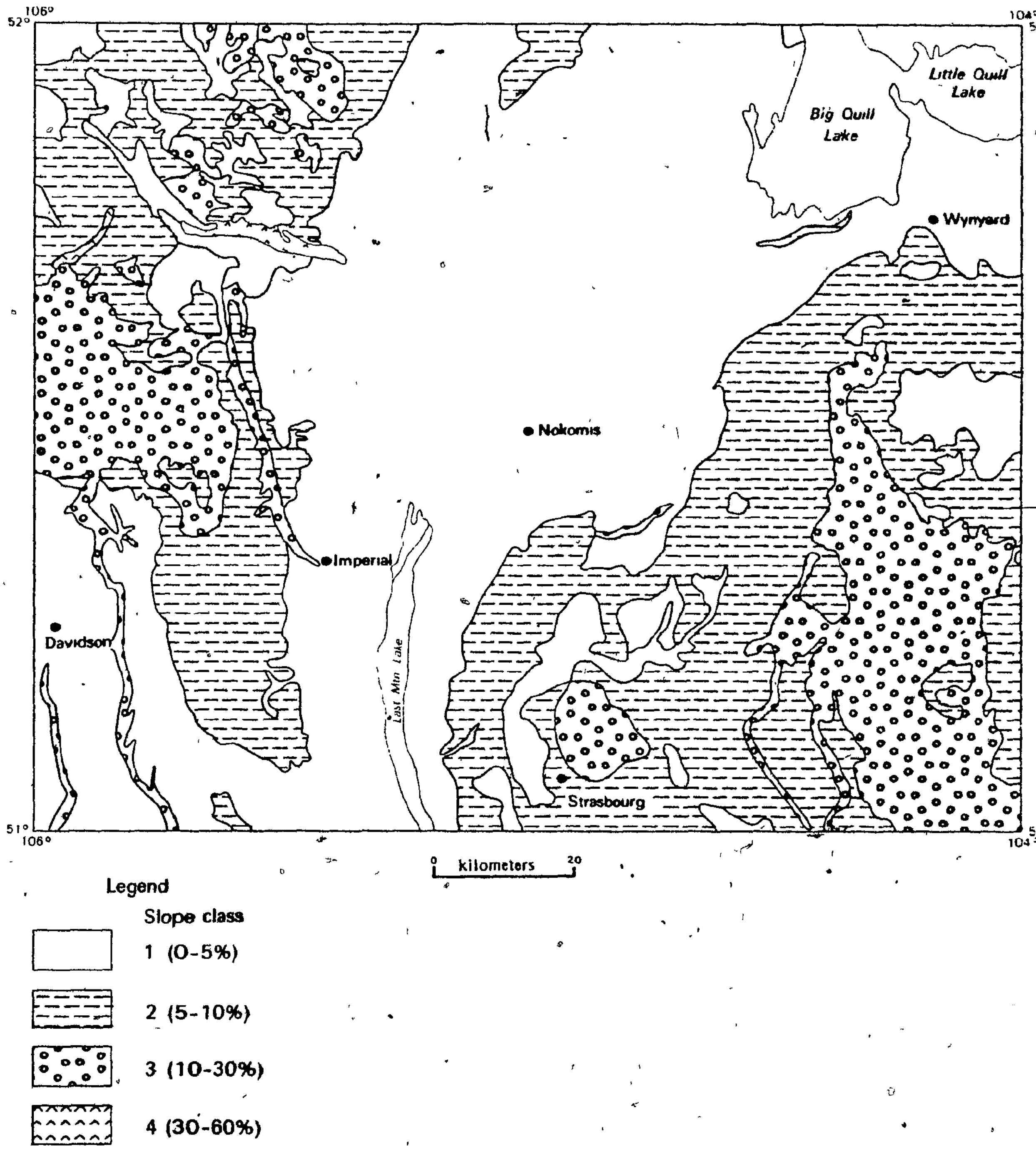


Fig. 5. 2 Distribution of Slope Classes in the Wynyard Area

Parent material

The area occupance of the parent materials of the soils of the Wynyard area is shown in Table 5.2. Morainal materials account for 70 per cent of the total as compared to 18 per cent for lacustrine materials, seven per cent for fluvial materials and five per cent for alluvium. As indicated in Fig. 5.3, the eastern half of the Wynyard area is dominated by morainal materials. Another large morainal belt extends from around Plunkett in the north to the southern border of the Wynyard area and includes the Allan Hills Upland.

Lacustrine materials are concentrated in a north-south zone along Last Mountain Lake and the Arm River, as well as around Colonsay in the northwest. The fluvial materials are mostly found in small areas: the largest single area of this type is in the north around Wolverine. Alluvium also occurs in small areas, the largest being to the southwest of the Big Quill Lake.

Soil texture

The soil textures of the Wynyard area range from sandy loam to clay (Table 5.3). Loamy soils (Group 7) cover 77 per cent of the area, whereas the clays (Group 9) account for only one per cent of the area. In general, the areas of loam soils (Group 7), as shown in Fig. 5.4, are the areas with morainal materials. The sandy loam soils (Group 6)

TABLE 5.2

AREA OCCUPANCE - PARENT MATERIALS

Parent Material	Approximate Area		
	Quarter Sections	$km.^2$	Per Cent
Alluvium	1,213	790	5.34
Fluvial	1,661	1,081	7.32
Lacustrine	4,029	2,623	17.75
Morainal	15,798	10,285	69.59

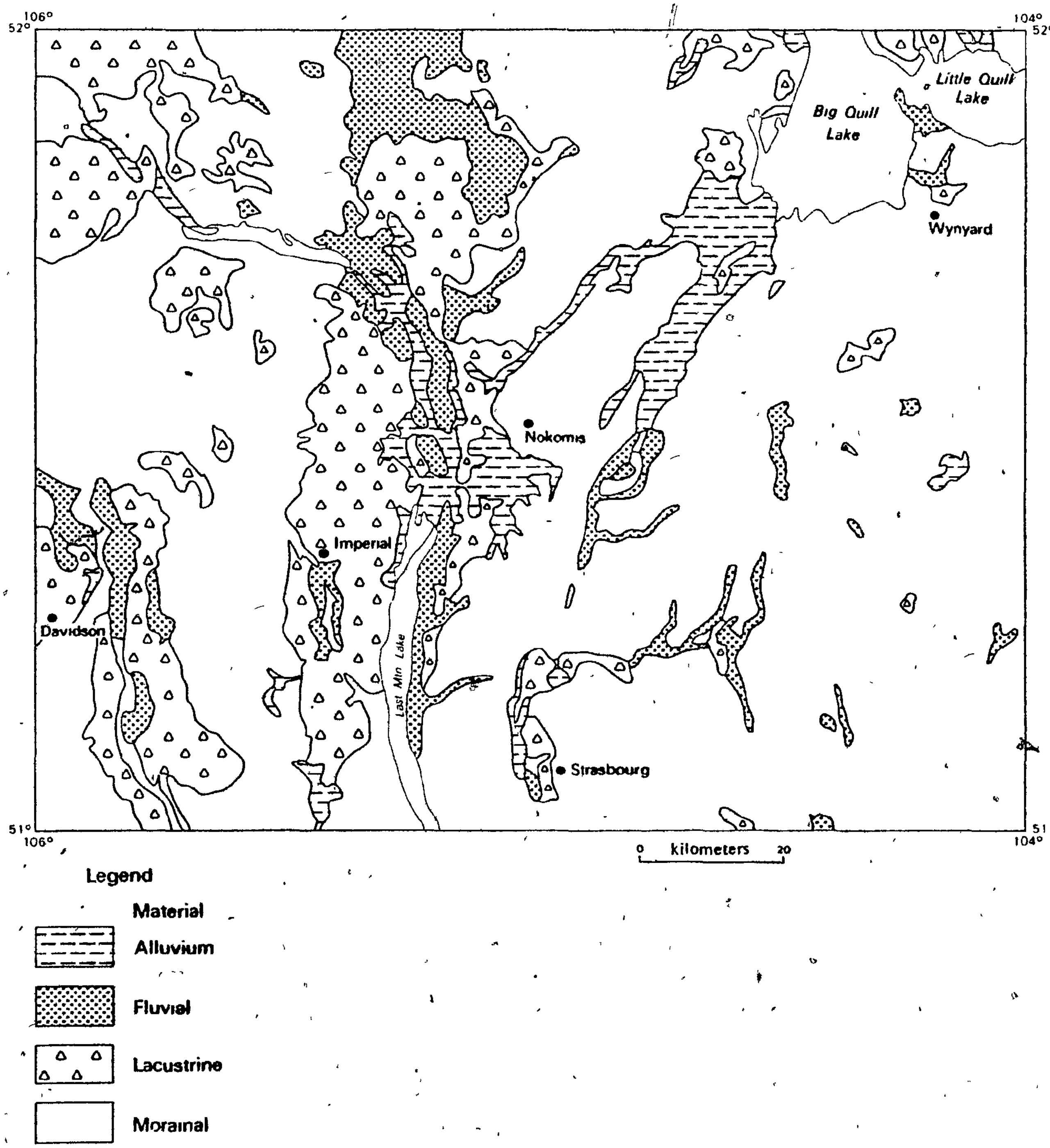


Fig. 5.3 Distribution of Surficial Materials in the Wynyard Area

TABLE 5.3

AREA OCCUPANCE - SOIL TEXTURE

Soil Textural Group	Approximate Area		
	Quarter Sections	$Km.^2$	Per Cent
6 (sandy loam*)	2,930	1,908	12.91
7 (loam*)	17,425	11,345	76.76
8 (clay loam*)	2,018	1,314	8.89
9 (clay*)	328	214	1.44

*dominant texture

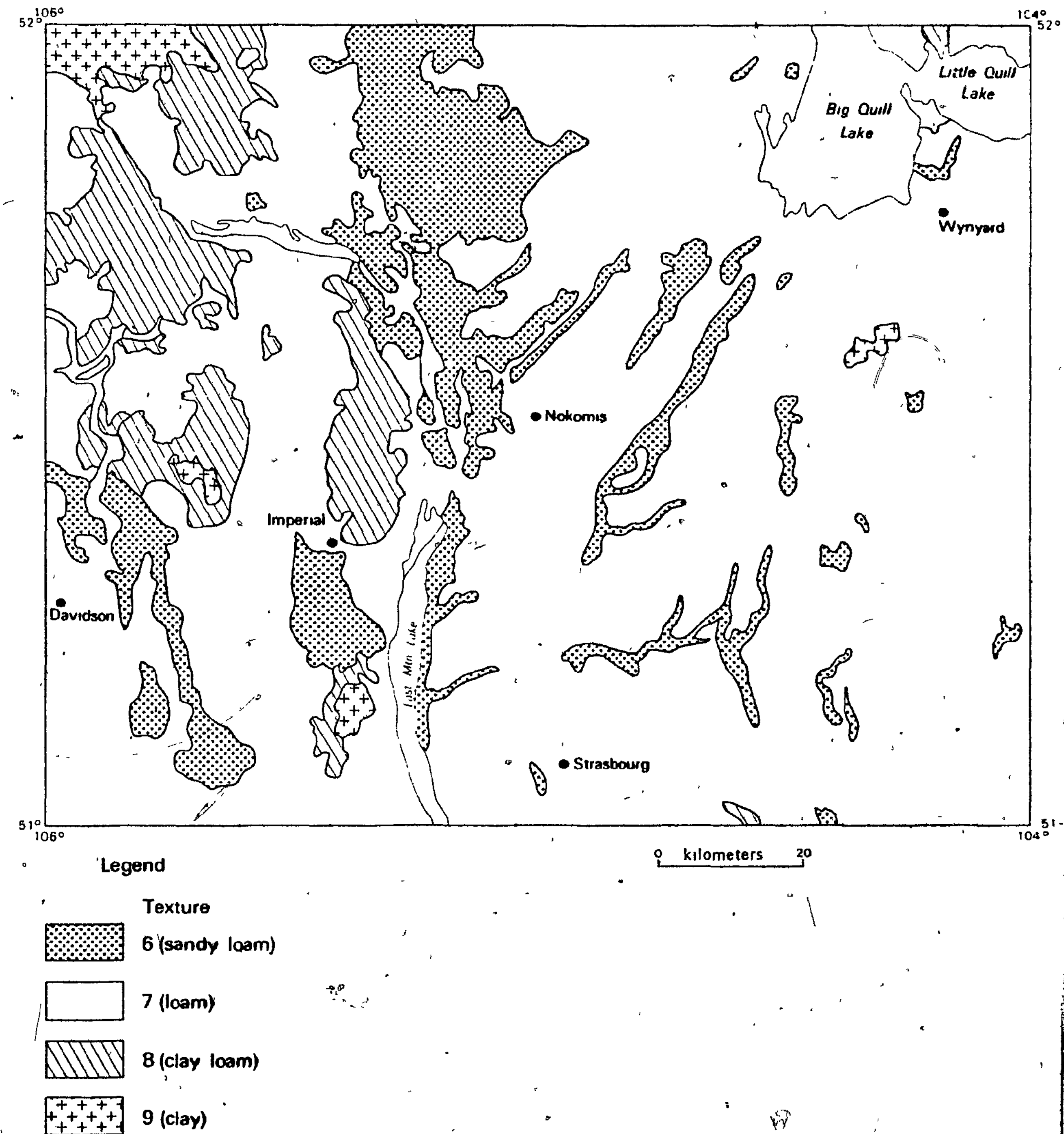


Fig.5.4 Distribution of Soil Textural Groups in the Wynyard Area.

are concentrated in the plains area around Last Mountain Lake and the Arm River. Clay loams are found in the area near Imperial and also in the northwest. Very small areas of clay (Group 9) are found near Last Mountain Lake, in the Allan Hills, around Colonsay, and in the Touchwood Hills.

Landform type

The relative frequency of slope class, parent material and soil texture varies according to the landform type. The per cent frequency of these variables within a particular landform type is illustrated in Fig. 5.5.

The dominant landform assemblage in the Wynyard area is knoll and kettle topography (landform type K), which covers approximately 48 per cent of the area as shown in Fig. 5.6. Landform type J, with its subdued topography and infrequent sloughs, is the second most extensive with a total area of 2963 sq. km. Landform category U, with near level surfaces and an unpatterned airphoto appearance, occupies approximately eleven per cent of the area, and landform category G, with a more irregular topography, accounts for approximately eight per cent of the area.

Knoll and kettle topography occurs in the southeastern quadrant around the Touchwood Hills and in the west-central area in the Allan Hills, covering a total area of approximately 7047 sq. km. (2706 square miles). Landform type J occurs for the greater part within the Central Plains area

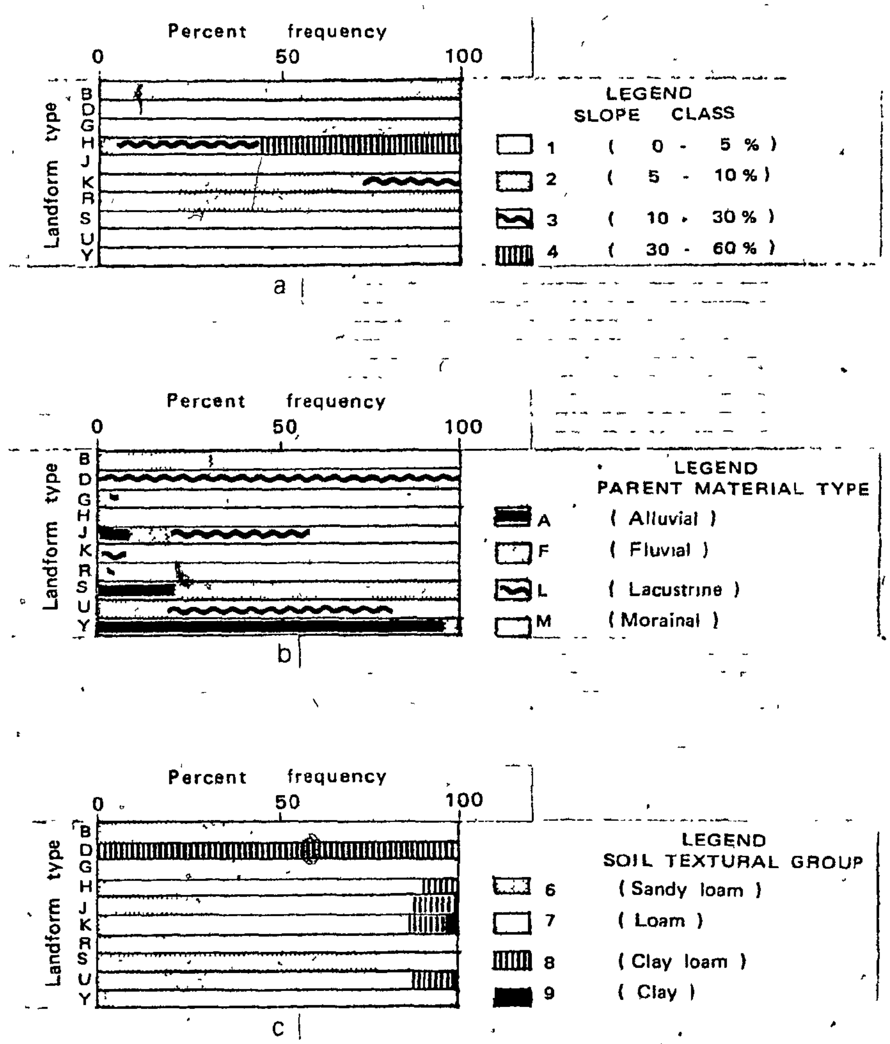


Fig. 5.5 The percent frequency of slope classes (a), parent material types (b), and soil textural groups (c) within each landform .

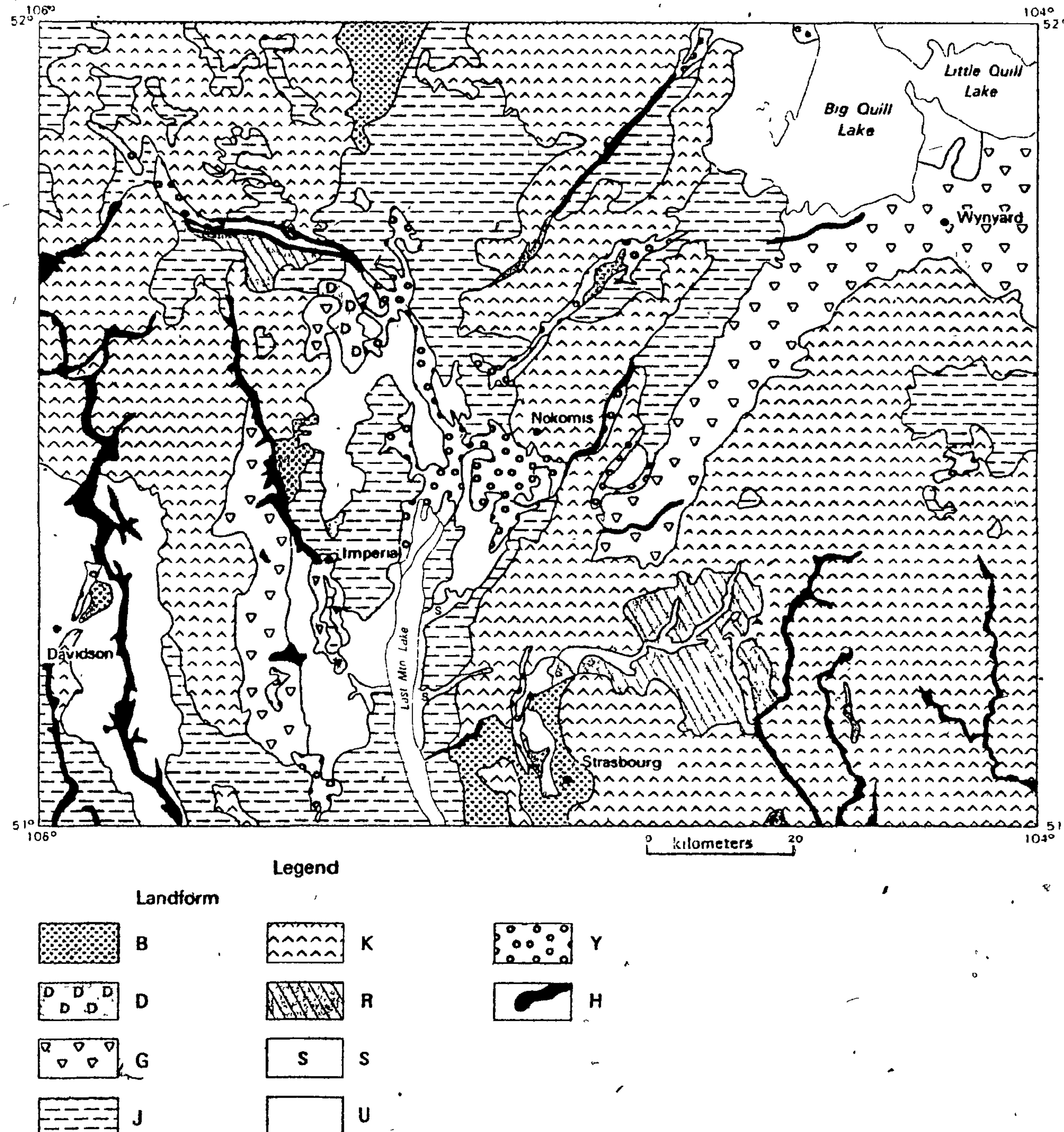


Fig. 5. 6 Distribution of Landform Types in the Wynyard Area

TABLE 5.4

AREA OCCUPANCE - LANDFORM TYPE

Landform Type	Approximate Area		
	Quarter Sections	Km.^{2}	Per Cent
B	584	380	2.57
D	74	48	0.33
G	1,948	1,268	8.58
H	619	403	2.73
J	4,551	2,963	20.05
K	10,824	7,047	47.68
R	598	389	2.63
S	87	57	0.38
U	2,625	1,709	11.57
Y	791	515	3.48

and covers 2963 sq. km. (1138 square miles). Landform type U occurs mainly in the area around Last Mountain Lake and along the Arm River in the west. The total extent of this landform type is approximately 1709 sq. km. (656 square miles). Landform type G covering a total area of approximately 1268 sq. km. (487 square miles) is found in the northeast quadrant between the Quill Lakes and the Touchwood Hills, and along the margin of the Allan Hills. The other landform types are scattered throughout the area and each covers a total area of less than 520 sq. km. (200 square miles).

Soil phase

In addition to the differences in slope class, soil texture, and parent materials, a particular area may be affected in varying degrees by water erosion, wind erosion, or soil salinity. A soil affected by one of these factors is termed a soil phase, and it is readily apparent that the incidence of a particular phase varies according to the slope, parent material and soil texture. The relationship between the per cent area affected by erosion or salinity and the terrain parameters such as slope class, parent material and soil texture is shown in Fig. 5.7.

Water erosion is most severe in landform types G and K with only relatively minor incidence in the other landform categories. The relationship between water erosion and slope is not as simple as might be expected. For example there is

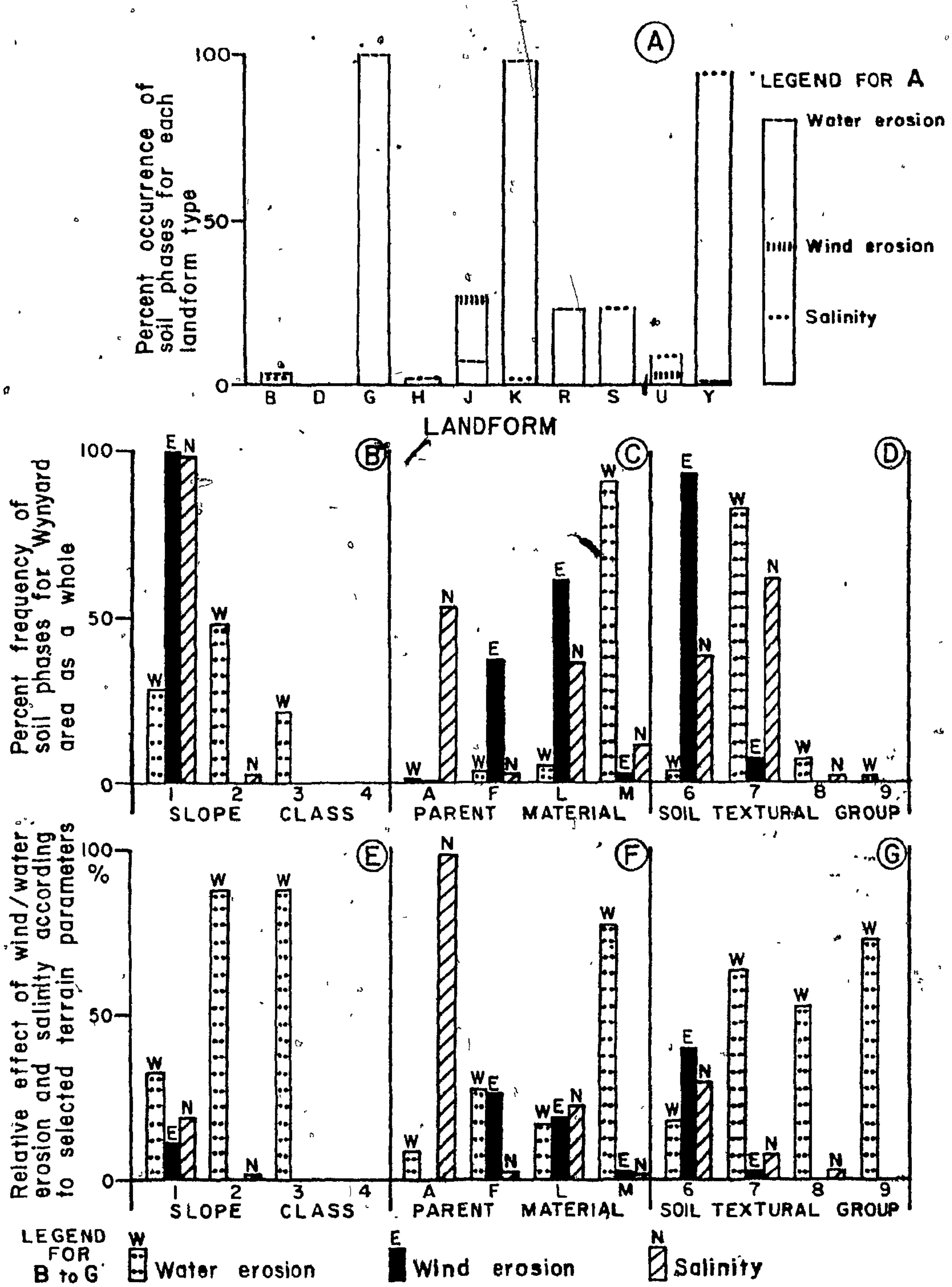


Fig. 5.7 The percent frequency of occurrence of water eroded land, wind eroded land and saline land according to landform type, slope class, parent material and soil textural group.

no erosion on the steepest slopes (Class 4) because these are not cultivated. Similarly there is relatively little erosion on Class 3 slopes (23%) because only a small proportion of this land is in cultivation. The maximum effect is experienced on class 2 slopes with 48% of the total recorded water affected area, and class 1 slopes with 29% of the total. Water erosion predominates in loam textured soils of morainal origin.

Wind erosion, on the other hand, is a serious problem in landform types J and U which are associated with slope class 1. Parent materials most susceptible to drifting are the fluvial and lacustrine sandy loams (texture group 6) as illustrated in Fig. 5.7.

The effect of salinity is widespread in the central plains area. For example, 94 per cent of the low-lying landform type Y is saline and 23 per cent of landform types J and S is affected, whereas, little or no salinity is present within the other landforms. As might be expected, areas affected by salinity are flat and low-lying and approximately 99 per cent of the total occurs on land with Class 1 slopes. Such areas are predominantly alluvium and lacustrine, and the most commonly affected textures are sandy loams and loams. Approximately 30 per cent of the sandy loam soils and eight per cent of the loam soils are affected, whereas, the finer textured clay loams have less than one per cent of the area affected. In general, salinity in the Wynyard area predominates in landform types J, S, U, and Y which have gradients of less than five per cent.

In a study of saline soils, Crosson (1975) found that the same relationships occurred in the Rosetown map area (NTS Map No. 72-0), which lies immediately to the west of Wynyard. The saline soils are concentrated in lowland positions on coarse textured lacustrine materials of unpatterned landforms with less than five per cent slopes.

RESUMÉ OF LAND SYSTEMS IN THE WYNYARD AREA

Seventy-seven land systems (Fig. 4.1) were identified in the Wynyard area. Many of these had multiple occurrences resulting in the delineation of 316 land systems on the map sheet.

Landform type B

This landform occurs in five land systems: namely $\frac{1B6M}{N}$, 1B7M, 2B6F, 2B7M and $\frac{2B7M}{W}$. The first occurs only in the Dark Brown Zone on soils of the Weyburn Association. The saline nature of the soils limits the cultivation of annual field crops and this land system is mainly utilized as rangeland. Land system 2B6F is also used as rangeland due to its low moisture retention capacity and the natural low fertility of its soils, which belong to the Biggar Soil and Whitesand Associations. Land systems 1B7M, 2B7M and $\frac{2B7M}{W}$ are generally arable land and offer better moisture storage capacity for crop production.

The land systems of landform type B are listed in Table 5.5 and the common features of each type are summarized. The characteristic eroded knolls of these land systems are clearly seen as light toned spots in Plate 7 which provides a good illustration of the contrast between the pattern of land system 2B7M and the adjacent $\frac{2K7M}{W}$ in which the depressions are occupied by sloughs. Although there are some limitations for crop cultivation in each of these land systems, sloughs are not a major problem.

Landform type D

This landform is uniform and is described by a single land system (1D8L). With its gentle slopes and clay loam lacustrine soils it is one of the best agricultural districts in the Wynyard area.

Landform type G

This landform type is present in land systems $\frac{1G6F}{W-}$, $\frac{1G7L}{W-}$, $\frac{1G7M}{W-}$, 2G6F and $\frac{2G7M}{W}$ (Table 5.6). All are located within the Dark Brown and Black Soil Zones. Land system $\frac{1G6F}{W-}$ has a low moisture storing capacity and low natural fertility with the result that its major land use is rangeland. Land system 2G6F is utilized for pasture and as a sanctuary for wildlife, whereas, land systems $\frac{1G7L}{W-}$, $\frac{1G7M}{W-}$ and $\frac{2G7M}{W}$ are mostly cultivated cropland.

LAND SYSTEM	NOS.OF OCCUR-RENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE			CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE			MAJOR LAND USE	LIMITATIONS * FOR AGRICULTURE
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
1B6M/N	1	17	46	Weyburn & Alluvium	—	—	5	—	—	rangeland	1, 3, 7a, 17, 19, 21b
1B7M	1	4	60-76	Weyburn	—	—	3	—	—	arable	1, 19
2B6F	3	118	46-107	Biggar	Whitesand	—	4 to 5	4	—	rangeland	1, 2, 3, 17
2B7M	4	227	46-107	Weyburn	—	—	3	—	—	arable	1, 19
2B7M/W	1	14	122-137	Weyburn	—	—	3 to 5	—	—	arable	1, 4b, 19
1D8L	1	48	30-61	Elstow	—	—	3	—	—	arable	3

* MAIN LIMITATIONS FOR AGRICULTURE IN THE WYNYARD MAP AREA

1. Thin or absent soils on knolls
2. Low natural fertility
3. Low moisture storage
4. Water erosion : (a)moderate (b)high (c)severe
5. Wind erosion : (a)moderate (b)high (c)severe
6. Susceptible to wind erosion
7. Salinity (a)moderate (b)high (c)severe
8. Frequent sloughs
9. Frequent steep knolls
10. Frequent eroded ridges
11. Dissection of land by drainageways and gullies
12. Occurrence of steep slopes along fluvial glacial channels
13. Topography unfavourable for heavy farm machinery — greater power requirements, higher operating costs
14. Efficiency limited by drainageways
15. Efficiency limited by sloughs : higher operating costs, time losses
16. Efficiency limited by knolls : higher operating costs, time losses
17. Cultivation of annual field crops limited
18. Limited choice of crops
19. Stone removal required for cultivation
20. Heavy pull on machinery : higher power requirements
21. Summerfallowing could result in (a)wind erosion 9 (b)greater wind erosion
22. Summerfallowing could result in spread of salinity
23. Cultivation could induce erosion
24. Cultivated fields are small and irregular
25. Use of farm machinery impractical

† relief over a large area and not the relief between knoll and depression

TABLE 5. 5 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS — LANDFORM TYPES B AND D

LAND SYSTEM	NOS. OF OCCUR-RENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE			CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE			MAJOR LAND USE	LIMITATIONS* FOR AGRICULTURE
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
1G6F / W–	3	23	30- 61	Biggar	Whitesand	–	4	3	–	rangeland	2, 3, 4 a, 11, 18
1G7L / W–	1	14	15- 38	–	Canora & Yorkton	–	–	2	–	arable	4 a, 11
1G7M / W–	4	718	8- 107	Weyburn	Oxbow	–	3	2	–	arable	4 a, 11, 19
2G6F	1	37	15- 30	Biggar	–	–	3 to 4	–	–	rangeland and wildlife sanctuary	2, 3, 4a, 11, 18
2G7M / W	3	476	30-122	Weyburn	Oxbow	–	3	2 to 3	–	arable and woodland	4 a, 11, 13, 14, 19

* same as in Table 5. 5

TABLE 5. 6 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE G

In land systems with type G landform, the drainageways (or dissections) interrupt the pattern of cultivation and reduce the efficiency of farm machinery. They also result in the fragmentation of the fields and produce irregular field boundaries, particularly on the steeper slopes where water erosion is also a problem.

Land systems $\frac{1G7M}{W-}$ and $\frac{2G7M}{W}$ are shown with land system $\frac{2K7M}{W}$ in Plate 8A. In the first two land systems, there are a large number of drainageways but few sloughs, in contrast with the third which is characterized by numerous sloughs. The drainageways are either streams or gullies as shown in Plate 8 and in some cases they are seepage lines which can be recognized by the surface soil conditions, (Plate 9A and 9B) or by the lack of uniformity in the appearance of the crop (Plate 8B).

Landform type H

This landform category occurs in seven land systems: 2H7M, $\frac{2H7M}{WN}$, 3H6F, 3H7M, 3H8M, 4H7M and 4H8M. All are developed on surfaces cut by meltwater channels and the miscellaneous soils are a mixture of eroded materials that do not belong to any particular soil association (Table 5.7). Because of the unfavourable topography and the risk of erosion, these land systems are generally utilized as rangeland. The eroded slopes and alluvium bottom-land of land system 3H7M is shown in Plate 10 with a portion of land system $\frac{2G7M}{W}$ to the

LAND SYSTEM	NOS. OF OCCUR-RENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE			CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE			MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
2H7M	2	26		—	—	—	—	3	—	rangeland	12, 13, 19
2H7M/WN	1	9		—	—	—	5	—	—	rangeland	4 a, 7 a, 12
3H6F	2	16		—	—	—	4 to 6	—	—	rangeland	2, 3, 12, 13, 18, 23, 24 25
3H7M	10	273		—	—	—	5 to 6	—	—	rangeland	12, 13, 19, 23, 24, 25
3H8M	1	25		—	—	—	3 to 6	—	—	rangeland	12, 13, 19, 23, 24, 25
4H7M	1	40		—	—	—	6	—	—	rangeland	12, 13, 19, 23, 24, 25
4H8M	1	16		—	—	—	6	—	—	rangeland	12, 13, 19, 23, 24, 25

* same as in Table 5. 5

TABLE 5. 7 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE H

west. A ground view of land system 3H7M is shown in Plate 11.

Landform type J

There are nineteen land systems in landform type J. They are $\frac{1J7A}{N+}$, 1J6F, $\frac{1J6F}{E-}$, $\frac{1J6F}{W-E-}$, $\frac{1J6F}{N}$, 1J6L, $\frac{1J6L}{E+}$, $\frac{1J6L}{EN}$, $\frac{1J6L}{N}$, 1J7L, $\frac{1J7L}{E-}$, 1J8L, 1J9L, 1J6M, $\frac{1J6M}{N+}$, 1J7M, $\frac{1J7M}{E}$, $\frac{1J7M}{N}$ and 1J8M. The land systems which are developed on fluvial materials and alluvium, are listed in Table 5.8. Land system $\frac{1J7A}{N+}$ is excessively saline and is utilized as native pasture (Plate 12). Land systems 1J6F, $\frac{1J6F}{E-}$, $\frac{1J6F}{W-E-}$, and $\frac{1J6F}{N}$ occur on soils of the Biggar and Whitesand Associations. These soils, with a low moisture holding capacity are wind eroded or saline, and are not generally suitable for use as arable land.

Eight land systems in this group occur on lacustrine soils belonging to the Asquith, Elstow and Meota Soil Associations. Of the land systems shown in Table 5.9, those with sandy loam soil textures are either saline ($\frac{1J6L}{EN}$ and $\frac{1J6L}{N}$) or wind eroded ($\frac{1J6L}{E+}$ and $\frac{1J6L}{EN}$), whereas, the land systems with loamy lacustrine soils are generally non-saline and are less severely wind eroded ($\frac{1J7L}{E-}$). The coarse lacustrine soils of land system $\frac{1J6L}{E+}$ are severely wind eroded, and these areas are often characterized by a strip cropping pattern (Plate 13). Within these land systems the topography is favourable for the efficient use of farm machinery, but

LAND SYSTEM	NOS.OF OCCUR-RENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE			CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE			MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE *
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
1J7A/N+	2	282	30 – 46	Alluvium	Alluvium	–	6	6	–	rangeland	7 b, 17, 22
1J6F	6	89	15 – 183	Biggar	Whitesand	–	4 to 5	2	–	rangeland	2, 3, 18
1J6F/E–	2	44	30 – 61	Biggar	–	–	4 to 5	–	–	rangeland	2, 3, 5a, 18, 21 b
1J6F/W-E-	1	207	500	–	Whitesand	–	–	4	–	rangeland	2, 3, 4a, 5a, 18
1J6F/N	1	18	183	Biggar	–	–	4 to 5	–	–	rangeland and wildlife sanctuary	2, 3, 7 a, 18, 22

* same as in Table 5. 5

TABLE 5. 8 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE J
(ALLUVIAL AND FLUVIAL MATERIALS)

LAND SYSTEM	NOS.OF OCCUR-RENCES	APPROX. AREA (km ^{2})	APPROX RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE Dark Brown	Black	Gray Luvisol	CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE Dark Brown	Black	Gray Luvisol	MAJOR LAND USE	LIMITATIONS * FOR AGRICULTURE
1J6L	1	20	46 – 61	–	Meota	–	–	3	–	arable and rangeland	3, 6
1J6L/E+	1	97	61 – 122	Elstow and Asquith	–	–	3 to 4	–	–	arable	3, 5c, 21b
1J6L/EN	2	370	15 – 46	Asquith	Meota	–	4 to 5	3	–	arable and woodland	3, 5b, 6, 7a, 21b, 22
1J6L/N	1	11	15 – 46	Asquith	–	–	6	–	–	rangeland	3, 6, 7a, 21b, 22
1J7L	6	219	15 – 76	Elstow and Asquith	–	–	3	–	–	arable and rangeland	3, 6
1J7L/E–	2	37	31 – 46	Elstow	–	–	3	–	–	arable and rangeland	3, 5a, 21b
1J8L	1	30	46 – 61	Elstow	–	–	3	–	–	arable	3
1J9L	1	30	46 – 61	Elstow	–	–	3	–	–	arable and rangeland	3

* same as in Table 5. 5

TABLE 5. 9 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE J
(LACUSTRINE MATERIALS)

the salinity and wind erosion problems limit the land use to pasture over the greater part of the area.

Plate 14A and B shows the cultivation of field crops in land systems 1J8L and 1J9L. The soils belong to the Elstow Association and the gentle undulations of the landscape do not hinder farm machinery, although the heavy clay soils of land system 1J9L may cause tractors to slip or become stuck in wet weather.

Approximately 40 per cent of the area in landform type J is composed of morainal materials and there are six land systems with parent materials of this type: 1J6M, $\frac{\text{1J6M}}{\text{N+}}$, 1J7M, $\frac{\text{1J7M}}{\text{E}}$, $\frac{\text{1J7M}}{\text{N}}$ and 1J8M. The dominant soils of these land systems are the Weyburn Association and the Oxbow Association. Table 5.10 shows that with the exception of land system 1J6M, which has sandy loam soils, and land systems $\frac{\text{1J6M}}{\text{N+}}$ and $\frac{\text{1J7M}}{\text{N}}$, which are saline, the land systems on morainal materials are agriculturally productive. Land system 1J7M with 1097 sq. km. occupies the largest area. As can be seen in Plate 15, the sloughs are shallow, and there is only minimal interference with mechanical cultivation.

Landform type K

There are sixteen land systems in landform category K with a total of 115 occurrences. Slopes range from Class 1 (0-5 per cent) to Class 3 (10-30 per cent), and many farming problems are encountered in this group of land systems.

LAND SYSTEM	NOS. OF OCCUR-RENCES	APPROX. AREA (km²)	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE Dark Brown	Black	Gray Luvisol	CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE Dark Brown	Black	Gray Luvisol	MAJOR LAND USE	LIMITATIONS* FOR AGRICULTURE
1J6M	1	11	46	Weyburn & Biggar	–	–	4	–	–	rangeland	3, 19
1J6M/N+	1	27	46	Weyburn & Alluvium	–	–	6	–	–	rangeland	7 b, 7 c, 18, 19
1J7M	22	1097	15–183	Weyburn	Oxbow	–	3 to 4	1 to 3	–	arable	19
1J7M/E+	1	18	46	Weyburn	–	–	3 to 4	–	–	arable	5 b, 19
1J7M/N	3	31	31	Weyburn	–	–	6	–	–	rangeland and wildlife sanctuary	7 b, 18, 19, 22
1J8M	1	5	62	Weyburn	–	–	3	–	–	arable	19

* same as in Table 5. 5

TABLE 5.10 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE J (MORAINAL MATERIALS)

Water erosion, and to a lesser extent wind erosion, affect the land in varying degrees, and as a result the number of eroded knolls with low crop yields is very high. Within the depressions, kettles or sloughs are very frequent, resulting in irregular fields with many interruptions to agricultural activities. The size and the degree of irregularity depend largely on the slope and the number of sloughs. Particularly in slope classes 2 and 3, the irregularity of the terrain with large numbers of sloughs results in the fragmentation of fields, reducing the field efficiency of farm machinery as well as increasing the operating costs and the time involved in a particular farm operation.

On the more gentle topography, there are four land systems: $\frac{1K6F}{W-}$, 1K8L, $\frac{1K6M}{N+}$ and $\frac{1K7M}{W-}$, with $\frac{1K7M}{W-}$ covering the largest area as shown in Table 5.11. Land system $\frac{1K6F}{W-}$ has a low moisture holding capacity, and land system $\frac{1K6M}{N+}$ is saline. Both of these remain as rangeland, whereas land systems 1K8L and $\frac{1K7M}{W-}$ are cultivated. Plate 16 shows the knoll and kettle topography of land system $\frac{1K7M}{W-}$ near the town of Nokomis (Sect. 27; Tp. 29, R. 22). It has a mottled airphoto pattern due to the eroded knolls which are light in tone and the depressions (often containing water) which show up dark. Shallow depressions which dry up in late spring are cultivated as shown in Plate 17A, however, they cannot be seeded until the soil has dried out with the result that all the farm operations are delayed.

LAND SYSTEM	NOS.OF OCCUR–RENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE Dark Brown	Black	Gray Luvisol	CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE Dark Brown	Black	Gray Luvisol	MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE
1K6P / W–	3	25	15 –61	Biggar	Whitesand	–	3 to 4	3	–	rangeland	1, 2, 3, 4 a, 8, 15, 16
1K8L	1	7	61	Elstow	–	–	3	–	–	arable	1, 3, 8, 15, 19
1K6M / N+	1	77	46	Weyburn & Alluvium	–	–	6	–	–	rangeland	1, 7 b, 8, 15, 16, 19, 22
1K7M / W–	17	1448	15–153	Weyburn	Oxbow	–	3	2	–	arable	1, 4 a, 8, 15, 16, 19

* same as in Table 5 5

TABLE 5.11 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE K
(SLOPE CLASS 1 – 0- 5%)

There are seven land systems with 5 to 10 per cent slopes: 2K6F, $\frac{2K7L}{W}$, 2K8L, $\frac{2K8L}{N+}$, $\frac{2K9L}{W}$, $\frac{2K7M}{W}$ and $\frac{2K8M}{W}$ (Table 5.12). Of these land systems, $\frac{2K7M}{W}$ covers 2873 sq. km. and has the largest total area. Compared with land systems on class 1 slopes, these land systems involve the farmer in greater costs because of the slopes and interruptions. As seen in Plate 18, the pattern of the fields are more irregular than those in the 1K land systems and there is greater contrast between the knolls and the kettles. Land system $\frac{2K7M}{W}$, shown in Plate 19, is developed partly in the Black Soil Zone (A), with a continuation in the Gray Luvisol Soil Zone (B). The difference in the airphoto pattern is due to the lighter colour of the cultivated Gray Luvisol soils and the rows of trees, which have been cut, piled, and burned within the fields. Plate 20 shows land system $\frac{2K7M}{W}$ at the foot of the Touchwood Hills. The knolls with a lower organic matter content show up lighter than the slopes.

Table 5.13 provides a résumé of the land systems of the K landform category on class 3 slopes (10 to 30 per cent). The five land systems are 3K6F, $\frac{3K7L}{W+}$, $\frac{3K8L}{W+}$, $\frac{3K7M}{W+}$ and $\frac{3K8M}{W+}$. They are largely rangeland or woodland, although $\frac{3K7M}{W+}$ and $\frac{3K8M}{W+}$ are partly cultivated. Plate 21 shows land system $\frac{3K7M}{W+}$. The pattern contrast of knolls and kettles is greater than either the 1K or the 2K land systems. This "chaotic jumble" pattern (Lueder, 1959) is due to the larger number of poorly drained sloughs, the steeper slopes, and the more extensive

LAND SYSTEM	NOS OF OCCUR- RENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION			CAPABILITY CLASS FOR AGRICULTURE			MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE*
				SOIL ZONE			SOIL ZONE				
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
2K6F	10	88	31–137	Biggar	Whitesand	–	4	4	–	rangeland	1, 2, 3, 8, 9, 15, 16, 18 24
2K7L/W	3	48	31–183	Elstow	Cudworth	–	3	2	–	arable	1,3,4b, 8, 15, 16,
2K8L/W	4	135	15– 61	Elstow	–	–	3	–	–	arable	1,3, 8, 9, 15, 16
2K8L/N+	1	9	76	Elstow	–	–	3 to 6	–	–	arable	1,3, 4b, 7b, 8, 9, 15, 16, 18, 22, 24
2K9L/W	3	158	46–183	Elstow	–	Kelvington	3 to 4	–	3	arable, *rangeland* and woodland	1, 3, 4b, 8, 9, 15, 16, 20,
2K7M/W	33	2873	15–213	Weyburn	Oxbow	Waitville	3	2 to 3	3	arable, rangeland and woodland	1, 4b, 8, 9, 15, 16, 19,
2K8M/W	6	271	46–198	Weyburn	–	–	3	–	–	arable	1, 4b, 8, 9, 15, 16, 19

* same as in Table 5 . 5

TABLE 5. 12 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE K
(SLOPE CLASS 2– 5 -10 %)

LAND SYSTEM	NOS OF OCCURRENCES	APPROX. AREA (km^2)	APPROX RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE Dark Brown*	Black	Gray Luvisol	CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE Dark Brown	Black	Gray Luvisol	MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE
3K6F	2	11	61–198	Biggar	Whitesand	—	4	3	—	rangeland and woodland	1, 2, 3, 4c, 8, 9, 13, 17, 23, 24
3K7L/W+	2	16	198	Elstow	—	—	3 to 4	—	—	rangeland	1, 3, 4c, 8, 9, 13, 23 24
3K8L/W+	2	19	198	Elstow	—	Kelvington	3 to 4	—	3 to 4	rangeland	1, 3, 4c, 8, 9, 13, 23 24
3K7M/W+	17	1594	46–213	Weyburn	Oxbow	Waitville	4	3	5	arable, rangeland and woodland	1, 4c, 8, 9, 13, 19 23, 24
3K8M/W+	10	271	61–183	Weyburn	—	—	4	—	—	arable and rangeland	1, 4c, 8, 9, 13, 23 24

* same as in Table 5.5

TABLE 5.13 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS — LANDFORM TYPE K
(SLOPE CLASS 3 — 10 to 30 %)

erosion as shown in Plate 22A. The farming problems encountered in the 2K land systems are intensified in the 3K land systems which should as far as possible, be left in their natural state.

Landform type R

There are six land systems within the R landform category: 1R6F, 1R7M, 2R6F, 2R6L, 2R7M, and $\frac{2R7M}{W}$, with 2R7M covering the largest area. All of these land systems, except 1R6F and 2R6F with their coarse fluvial soils, are cultivated as shown in Table 5.14. In these land systems the major problems in cultivation are encountered on the eroded linear ridges, the eroded knolls, and the sloughs. The long parallel linear ridges are clearly visible in Plate 23A. In contrast land system $\frac{1K7M}{W-}$ to the south does not have parallel ridges.

Landform type S

The two land systems in this category are depressional: $\frac{1S7A}{N}$ and 1S6F. Both of these occur in the Wynyard area with the former occurring in two other locations, and the latter with an area of approximately 44 sq. km. having its main occurrence to the east of Last Mountain Lake. These land systems are used as wildlife sanctuaries or as pastures and are not suited to arable agriculture. A small area of land system $\frac{1S7A}{N+}$ is seen in Plate 24 and the ground view of a part of the depression in Plate 25 shows the accumulation

LAND SYSTEM	NOS. OF OCCURRENCES	APPROX. AREA (km ^{2})	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE			CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE			MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE *
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
1R6F	1	5	61	—	Whitesand	—	—	4	—	arable and rangeland	1, 2, 3, 8, 10
1R7M	3	84	61– 76	Weyburn	Oxbow	—	3	2	—	arable	1, 10, 19
2R6F	1	5	61	Biggar	—	—	4	—	—	rangeland	1, 2, 3, 10, 15
2R6L	1	7	76	Asquith	—	—	4	—	—	arable	1, 3, 6, 10, 15
2R7M	5	197	31– 61	Weyburn	Oxbow	—	3	2	—	arable	1, 8, 9, 10, 15, 19
2R7M/W	2	91	46– 92	Weyburn	Oxbow	—	3	2	—	arable	1, 4b, 9, 10, 19

* same as in Table 5.5

TABLE 5.14. SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE R

of salt and the growth of salt tolerant *Salicornia.*

Landform type U

Areas in this category are low-lying and nearly level and include eleven land systems as listed in Table 5.15. Of these, 1U6F covers 288 sq. km.; 1U7L has an area of 335 sq. km. The land systems with loam, clay loam, and clay soils of lacustrine and morainal origins provide land of higher quality, and these are generally cultivated. Land system $\frac{\mathrm{1U6F}}{\mathrm{E}}$ suffers from wind erosion, and salinity affects land systems $\frac{\mathrm{1U6L}}{\mathrm{N}}$, $\frac{\mathrm{1U6L}}{\mathrm{WN}}$, $\frac{\mathrm{1U7L}}{\mathrm{N}}$ and $\frac{\mathrm{1U7M}}{\mathrm{N}}$. Land system 1U8L is shown in Plate 24. There are few sloughs and few knolls, and the gentle slopes of the clay loam soils result in larger fields. Land system 1U6L and 1U7L are shown in Plate 26, and there is a marked pattern contrast compared with land system 3H7M. Plate 27 shows land systems 1U7M and 1U8L stretching over a wide area of level land with few sloughs or potholes and no eroded knolls. Land system 1U7M with morainal soils has a few surface stones, whereas, land system 1U8L on lacustrine materials is stone-free.

Landform type Y

These land systems have slopes of 0 to 5 per cent and occupy runways which are generally not suitable for arable agriculture. Five land systems occur, and the characteristics are summarized in Table 5.16. Land system $\frac{\mathrm{1Y7A}}{\mathrm{N+}}$ occupies the

LAND SYSTEM	NOS.OF OCCUR-RENCES	APPROX. AREA* (km²)	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE Dark Brown	Black	Gray Luvisol	CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE Dark Brown	Black	Gray Luvisol	MAJOR LAND USE	LIMITATIONS FOR AGRICULTURE
1U6F	18	288	8–122	Biggar	Whitesand	–	4	3	–	rangeland	2, 3
1U6F/E	2	45	16–107	Biggar	–	–	4	–	–	rangeland	2, 3, 5b, 21b
1U6L	7	138	16–107	Asquith	–	–	3to 4	–	–	arable and rangeland	3, 6
1U6L/N	1	8	92	Elstow & Asquith	–	–	3 to 4	–	–	rangeland	3, 6, 7a, 21a, 22
1U6L/WN	1	39	92	Asquith	–	–	4	–	–	arable and rangeland	3, 4b, 6, 7a, 21a, 22
1U7L	16	559	31–153	Elstow and Asquith	Canora and Yorkton	–	3	3	–	arable and rangeland	3
1U7L/N	3	95	15– 46	Elstow	Canora	–	3	3	–	arable and rangeland	3, 7b, 22
1U8L	4	161	15– 46	Elstow	Blaine Lake	–	3	1 to 2	–	arable	3
1U9L	1	26	15	Elstow	–	–	3	–	–	arable and rangeland	3, 20
1U7M	9	335	15–137	Weyburn	Yorkton	–	3	2 to 3	–	arable	19
1U7M/N	1	13	61	–	Yorkton	–	–	4	–	arable and rangeland	7a, 19, 22

* same as in Table 5.5

TABLE 5. 15 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE U

LAND SYSTEM	NOS. OF OCCUR-RENCES	APPROX. AREA (km^2)	APPROX. RELIEF (meters)	MAJOR SOIL ASSOCIATION SOIL ZONE			CAPABILITY CLASS FOR AGRICULTURE SOIL ZONE			MAJOR LAND USE*	LIMITATIONS* FOR AGRICULTURE
				Dark Brown	Black	Gray Luvisol	Dark Brown	Black	Gray Luvisol		
1Y6F	1	18	61	Biggar	–		4	–	–	rangeland	2, 3
1Y6L	1	3	61	Asquith	–	–	4	–	–	rangeland	3, 6
1Y7A	1	9	92	Alluvium	–	–	3	–	–	arable and rangeland	–
1Y7A/N+	14	479	15–122	Alluvium	Alluvium	–	6	6	–	rangeland	7b, 22
1Y7A/WN	1	7	61	Alluvium	–	–	5	–	–	rangeland	4b, 7a, 22

* same as in Table 5. 5

TABLE 5. 16 SUMMARY OF LAND SYSTEMS AND AGRICULTURAL CHARACTERISTICS – LANDFORM TYPE Y

largest area with 478 sq. km. The excessive salinity of this land system results in the land being left in natural vegetation, although salt tolerant crops are grown in small areas. The native grassland provides a distinct contrast to land systems 1U7L and $\frac{1U7L}{N}$ in Plate 28. These land systems cover broad areas of land in some areas or become narrow strips of land in others, as shown in Plate 29. The salt accumulation in the surface soil is clearly visible in the foreground of the ground stereogram.

SUMMARY

The greater part of the Wynyard area is under cultivation. Although soil capability varies widely within the area, the soils are mainly arable. Nearly level to undulating land accounts for approximately 85 per cent of the area, allowing a typical cereal farming system. However, as revealed in the analysis a number of problems face the farmer in many of the land systems. Steep slopes occurring in some areas limit the efficient use of farm machinery, and eroded knolls are a problem in many land systems. Due to excessive salinity, several land systems are not cultivated and are utilized as pastures. The coarse sandy loam soils of fluvial materials have a low moisture holding capacity and these areas are generally rangeland. Although such areas are not utilized for crop production, they are important in a region which lies in a transition zone between grain farming and mixed farming. A few areas with low moisture holding capacity or poor drainage remain with a bush cover. In many soils of morainal origin it is necessary to clear the soil of stones before cultivation and in land systems with a knoll and kettle topography the frequent sloughs have a marked effect on the efficiency of farming.

CHAPTER 6

LAND SYSTEMS, FIELD CHARACTERISTICS AND LAND VALUES

INTRODUCTION

Three separate but related topics are treated in this chapter. First, there is an assessment of the extent to which the different land systems have produced variations in directly observable cultural details, such as average field size, the number of fields in a section, the typical field shape, the per cent of cultivated land and the proportion of regular and irregular fields.[1] Second, there is an examination of the role of land system analysis in providing a framework for assessing some of the factors which limit or restrict cultivation and affect the efficiency of farm operations, such as the frequency of sloughs and drainageways. Finally, an attempt is made to assess the extent to which the physical attributes of the land systems are reflected in the economic value as measured by the assessment in dollars per quarter section.

By demonstrating some of the linkages between land systems, observable field characteristics and available measures of land value it is hoped to emphasize the

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[1]Brief definitions of the parameters and terms used, are provided in Table 6.1.

TABLE 6.1

DEFINITION OF TERMS

	TERM	DEFINITION
FIELD CHARACTERISTICS	Section	a parcel of land laid out by the original survey and occupying 640 acr
	Field	a parcel of land which is utilized for a specific agronomic purpose. Its those of neighbouring fields.
	Number of field	the total number of fields in a section
	Field size	the area of a field. (Average field size : the mean of the total field
	Field shape	the shape of a field as seen on the airphoto. It is classed as either re
	Regular field	a rectangular field as seen on the airphoto.
	Irregular field	a field which is not rectangular : its boundaries are irregular – either
	~~Field shape ratio~~	~~the ratio of the shortest to the longest axis.~~
	Percent regular fields	the percent of regular fields in a section
	Cultivated land	land that is cropped or fallowed as opposed to natural pasture, bush
	Percent cultivated	the percent area of a section under cultivation.
PHYSICAL LIMITATIONS	Slough density	the number of sloughs in a unit land area (slough/hectare) i.e. the tota in a given land system. Sloughs are depressional land areas periodically seasonal. However, sloughs can remain dry for several years.
	Drainageway density	drainageway length in a unit land area (meters/hectare) i.e. the total le a given land system. Drainageways include streams, creeks and gullies w
LAND VALUE	Assessed value	the dollar value per quarter section as determined for tax purposes.
	Consolidated holdings	quarter sections which are contiguous and owned by the same individual
	Farmstead	cluster of buildings identified on the Rural Municipal Maps as permaner

TABLE 6.1

DEFINITION OF TERMS

DEFINITION
ɔarcel of land laid out by the original survey and occupying 640 acres (259 hectares).
ıarcel of land which is utilized for a specific agronomic purpose. Its airphoto pattern, tone and texture are distinct from ;e of neighbouring fields
total number of fields in a section
area of a field (Average field size · the mean of the total field sizes in a section)
shape of a field as seen on the airphoto. It is classed as either regular or irregular.
ectangular field as seen on the airphoto.
ıeld which is not rectangular. its boundaries are irregular — either curvilinear or polygonal.
ratio of the shortest to the longest axis.
percent of regular fields in a section.
ɪ that is cropped or fallowed as opposed to natural pasture, bush or wasteland.
percent area of a section under cultivation.
number of sloughs in a unit land area (slough/hectare) i.e. the total number of sloughs divided by the total land area a given land system. Sloughs are depressional land areas periodically filled with water. In most cases, inundation is sonal. However, sloughs can remain dry for several years.
ınageway length in a unit land area (meters/hectare) i.e. the total length of drainageway divided by the total land area in ȝiven land system. Drainageways include streams, creeks and gullies which have intermittent water flow.
dollar value per quarter section as determined for tax purposes.
ırter sections which are contiguous and owned by the same individual.
ster of buildings identified on the Rural Municipal Maps as permanently occupied by a farmer.

importance of the physical factors in limiting land use and demonstrate the value of land system mapping in providing a framework for efficient land management.

SAMPLING PROCEDURE

Before examining the various groups of parameters and the results of the analysis it is necessary to review the sampling procedure. In view of the large size of the study area, it was necessary to follow a sampling procedure in obtaining information on field characteristics and other features. The basis for sampling was to use the township and range grid and to utilize every eighth section, traversing the area west to east, and east to west as shown in Fig. 6.1. The sections provide a convenient sampling base because they have a standard size (one square mile - 259 hectares) and they are readily identifiable on the ground and on maps and airphotos.

The initial sampling grid generated 623 sample sections (0.4% of the total 179,620 sections in the study area). This is a small, but adequate sample, however, it was immediately apparent that some land systems by reason of their limited areal distribution were under-represented and others had not been sampled at all. An additional consideration was the desirability of obtaining more sample sections for the very large land systems. Therefore it was necessary to re-examine the township and range map and select additional sections

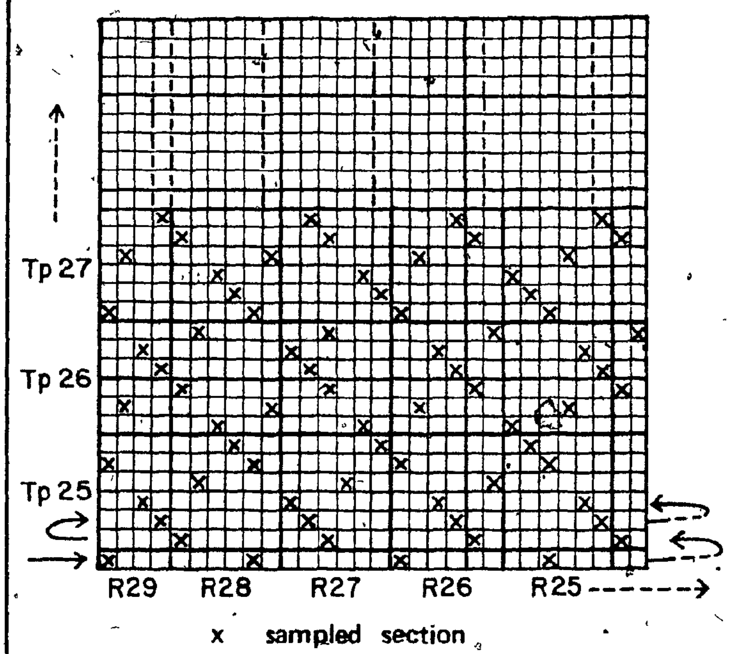


Fig. 6.1 Diagram illustrating a section of the sampling grid.

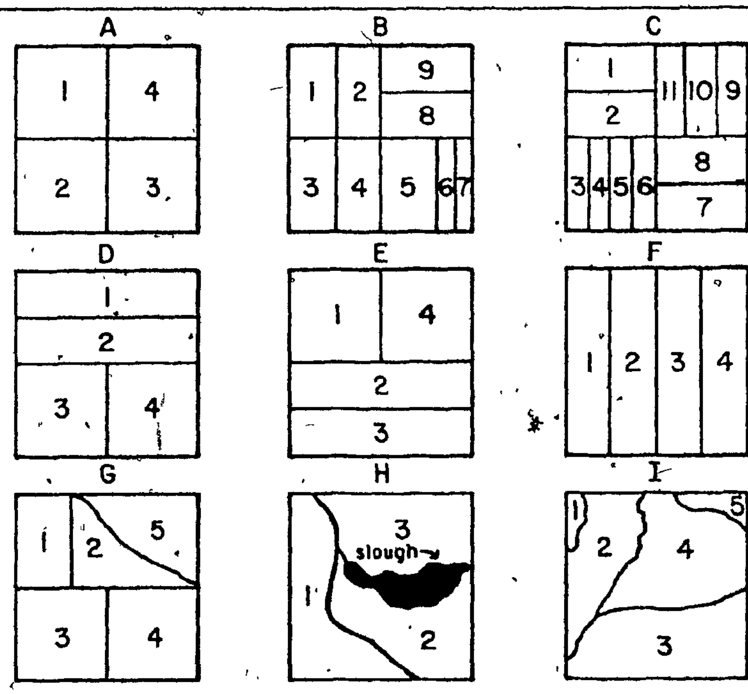


Fig. 6.2 Diagrams illustrating the field numbering system for recording field characteristics.

which fell in particular land systems. This can be considered as a non-random, purposive addition to the sample, bringing the total to 995 sections representing 0.6% of the area. Even so, it was not possible to sample every land type because of the shape of some individual land systems, particularly the long and narrow occurrences, which occupied only part of the square mile section.

The final decision in the sampling procedure was to reject land systems with less than five sample sections from the analysis since these could not be considered as areally significant.

Sample data acquisition - Field characteristics

The sample sections were checked on the topographic map and identified on the airphotos. In each sample section, the field characteristics were assessed or measured beginning in the northwest quarter section and proceeding counterclockwise to the northeast quarter section as illustrated in Fig. 6.2. All the fields in a particular quarter section were examined and the data recorded before proceeding to the next quarter section. For example, in the situation illustrated in Fig. 6.2B the two fields in the northwest quarter section are identified as numbers 1 and 2, the two fields in the southwest quarter section as 3 and 4, and so on. A field which extended from the northeast quarter section into any other quarter section is recorded only once as shown in Fig. 6.2D, F and G. In the situation where the boundary of a land system crossed a section, that section was regarded as belonging to the land system which encompassed 75 per cent or more of its area.

Number of fields. The number of fields in a section was readily established by making a direct count on the airphotos of the number of land parcels which were distinct as to tone and texture, and which could be considered as discrete agronomic units.

Field size. Field sizes were measured with a Bruning Areagraph dot grid (Chart No. 4850) reduced four times for maximum accuracy. The field areas were recorded in hectares, and the summed totals were checked against the reference standard of 259 hectares (640 acres) in a section.

When large sloughs were present their areas were not included in the figures for the field size. Slough areas and field areas were cross-checked so that they totalled 259 hectares (1 square mile) for each section. However, the impracticability of measuring the areas of the numerous small sloughs within the fields, precluded any correction for these features.

Extremely small fields of less than two hectares (five acres) which are very infrequent, were discarded.

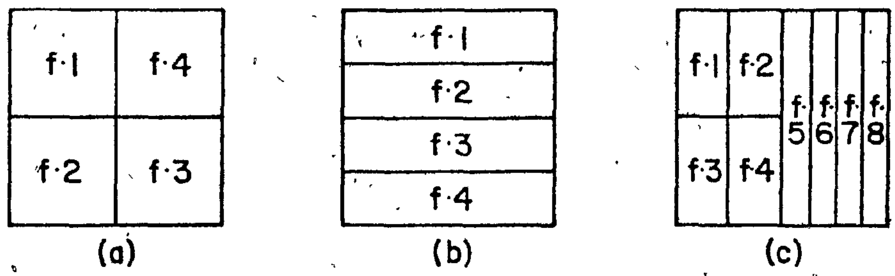
The average field size per section was calculated as the arithmetic mean of all the sample fields in that section.

Field shape and field shape ratio. In classifying field shape, a simple distinction between regular and irregular was made. Fields which were basically rectangular or square were classed as regular and all other fields were considered as irregular. This differentiation was made by visual examination of the airphotos. The degree of regularity for the fields of a particular section was determined as a percentage —thus for a section with entirely regular fields the regularity index is 100 per cent (Fig. 6.3).

The main cause of irregularity in field shapes is the presence of sloughs and drainageways. The section illustrated in Fig. 6.4a contains eight fields, of which six, have irregular shapes, due to the presence of large sloughs on their boundaries. Consequently, the per cent of regular fields is 25. Drainageways and railway tracks have given rise to irregular fields as indicated in Fig. 6.4b and (c) and in both these sections the per cent of regular fields is 0.

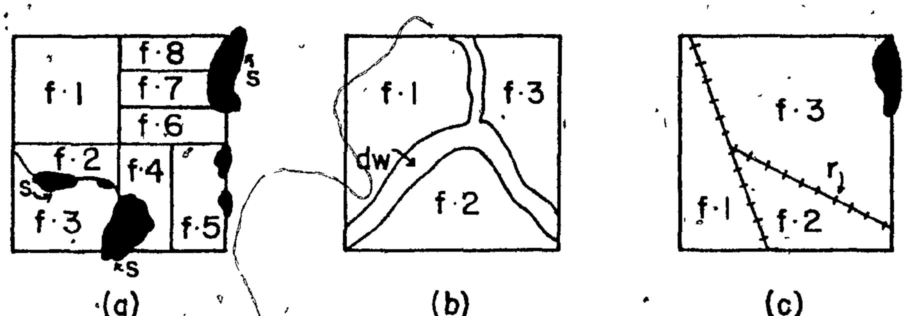
The second index of field configuration—the field shape ratio, was obtained by making measurements of the shortest and longest axes of the field. The measurements were made directly on the airphotos using a transparent overlay scale calibrated in units of 0.1 mile (161 meters). The shape ratios were obtained for all the fields in a particular sample section and the arithmetic mean was calculated. Typical values for sections with irregular fields ranged between 2.3 to 3.3 compared with shape ratios of 3.0 to 6.7 for sections with regular fields.

Per cent of cultivated land. Cultivated land may be



f· = field

Fig. 6.3 Diagrams illustrating sections having regular fields.



Legend: f· = field
s = slough
dw = drainage way
r = railroad

Fig. 6.4 Diagrams illustrating sections with a high percentage of irregular fields.

either cropped or fallowed. The field pattern of cultivated land is easily distinguished from uncultivated land which remains in permanent grass and images in dark tones on the airphotos. In addition, there is an absence of discernable pattern in the uncultivated land in contrast to the varied cultivation patterns of the cropped land.

The cultivated areas in each of the sample sections were measured with an Areagraph dot grid and expressed as a per cent of the total area of the section.

Sample data acquisition - Physical limitations

The two landforms which provide serious limitations for agriculture are the sloughs and drainageways. These are readily interpreted from the airphotos and their significance in the landscape can be expressed as a density—the number of individuals per unit area.

Slough density. Sloughs are one of the characteristic physical features in the prairie landscape and they provide a major interruption to the regularity of the field pattern. They contribute significantly to the time involved in farming operations because of the necessity of skirting their margins. The best index of the slough problem is probably the ratio of slough area to total field area per quarter section. However, because of the relatively small scale of the airphotos used in this study it was not possible to obtain accurate measurements of individual slough areas and so another index was used—the ratio of slough number to total field area. This provides a fairly good indicator of the extent of slough interruption. The number of sloughs in each sample section was obtained by direct count on the airphotos following identification under the stereoscope, and the slough density is expressed as the number of sloughs per hectare.

Drainageway density. Stream channels, gullies and creeks are collectively considered as drainageways. Although water flow may be only intermittent, the presence of a drainageway constitutes a physical interruption to farming operations. It is difficult to assess the significance of drainageways and the index selected was that of drainageway density. Drainageway lengths were measured directly on the airphotos using a travelling micrometer (map measurer). The distances were summed for the section and expressed as the total channel length (meters) per hectare.

Sample data acquisition - Land Values and Ownership

The land values, consolidated holdings and actual land holdings were obtained from the Rural Municipal Maps of the area.

Assessed value. Farmland in Saskatchewan is assessed for tax purposes and the assessment is based on several factors including soil type, land use, acreage and special appreciation or condemnation factors (Freeman et al., 1950). Comparative numerical ratings of soil types express the degree to which the soil profile and the topography represent conditions favourable to the production of grain, particularly wheat. However, for assessment purposes, local conditions are taken into account and points for appreciation such as topsoil depth or the presence of a clay horizon in light textured soils are added to the soil ratings; whereas, points for condemnation are subtracted. Condemnation factors include irregular topography, the degree of stoniness, the presence of gravel and sand pockets, erosion, salinity, burnouts, solodization, podzolization, shallow soil phases, loose top soil, poor internal drainage as well as the presence of draws, ravines, rivers, sloughs and creeks. Man-made factors such as roads, railroads and drainage ditches are also taken into consideration.

The assessed value is calculated by an assessor using a ready reckoner which provides a figure for various acreages from one to 160 acres at all possible index ratings.

The assessed value is recorded for each quarter section on Rural Municipal maps available from each municipality. A full set of these maps was obtained and the assessed values for each sample section was obtained by summing the assessed values for each of the quarter sections (Table 6.2). For example—the assessed value of Section 1 as shown in Fig. 6.5 is 6850 dollars, this being the total of the four quarter sections contained in that particular section. Section 11 is assessed at 11,900 dollars. In the situation where a

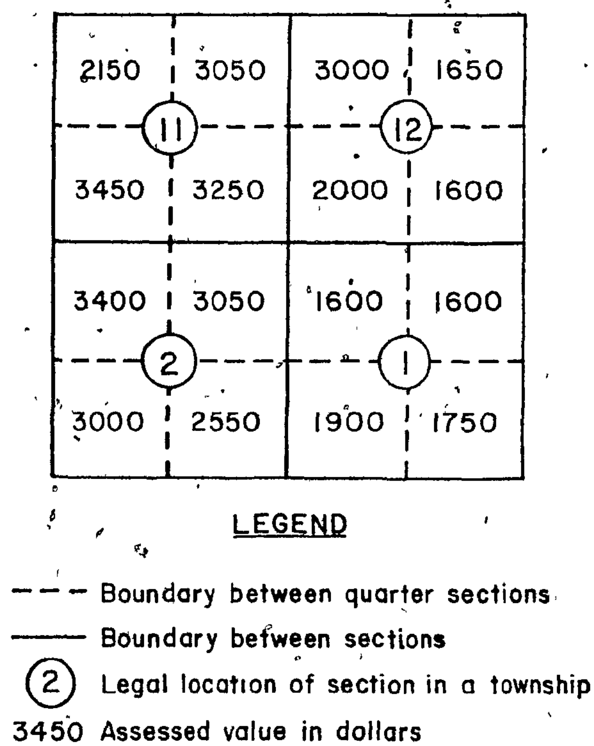


Fig. 6.5 Sample diagram illustrating the assessed value by quarter section.

SECTION	ASSESSED VALUE BY QUARTER SECTION				ASSESSED VALUE PER SECTION (dollars)
	Quarter Sections				
	NE (1)	SE (2)	SW (3)	NW (4)	(5)
1	1600	1750	1900	1600	6850
2	3050	2550	3000	3400	12000
11	3050	3250	3450	2150	11900
12	1650	1600	2000	3000	11900

Table 6.2 The derivation of assessed value from the sample sections illustrated above.

land system boundary passed through a section, it was not possible to determine the assessed value of each portion and so the value for the section as a whole, was entered under both of the land systems.

Consolidated holdings. It is extremely difficult to obtain data on individual farm sizes since a particular owner may have quarter sections in several different municipalities. Moreover, the areal distribution of a farm is not limited to a single land system. It tends to be spread over several land systems and therefore, it is almost impossible to characterize farm size according to land systems. In an attempt to overcome this difficulty, a somewhat different index was used—that of consolidated holdings.

A typical prairie farm is built up over the years by the addition of quarter sections, purchased wherever they become available and not necessarily adjacent to the original, free homestead quarter section. However, it is obviously advantageous to have the fields grouped in contiguous clusters rather than individually scattered. The extent of consolidation as measured by the frequency of consolidated holdings can therefore serve as an indication of farm size in the different land systems.

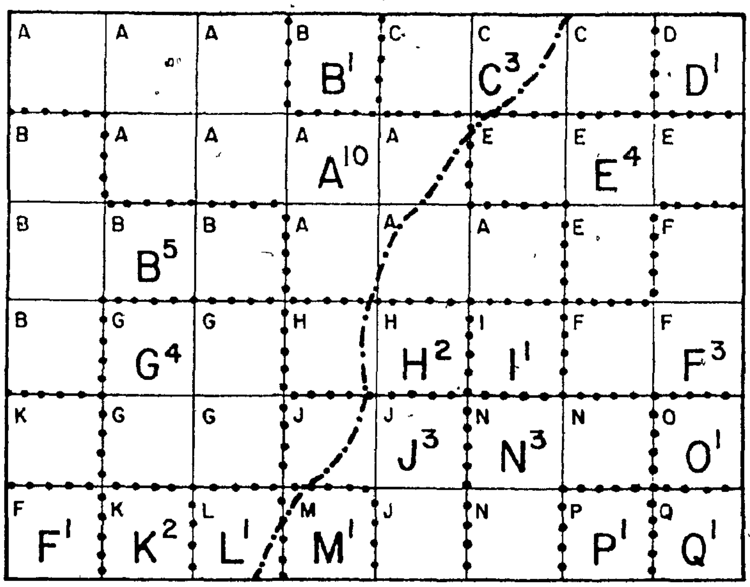
The information on land ownership was obtained from the Rural Municipal maps which show ownership by the quarter section or occasionally, by the eighth of a section. Ownership is also shown for smaller units where these are fragmented along lakes and sloughs.

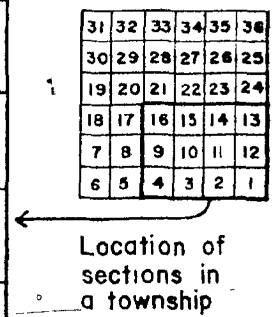
The boundaries from the land systems (Fig. 4.1) were transferred onto the Rural Municipal maps and the consolidated holdings (contiguous quarter sections) were counted on these maps. An example of the procedure is shown in Fig. 6.6. In this area two land systems are present and the land is divided among 17 owners. A owns ten contiguous quarter sections: eight in land system X and two in land system Y. B owns six quarter sections but only five quarter sections located in Sections 9, 10 and 16 are contiguous and the remaining quarter section in Section 15 is separated from the main cluster, by A's land.

The contiguous quarter sections were counted on the Rural Municipal map for each land system and a frequency obtained for the various sizes of consolidated holdings in the different land systems. The frequencies for the area in Fig. 6.6 is shown in Table 6.3.

This procedure was carried out for all the land systems. The sizes of consolidated holdings showed a wide variation from one-eighth of a quarter section to over 30 quarter sections and they were grouped into ten size classes.

<u>Actual farm size</u>. In three dominant land systems—1J7M, $\frac{\text{1K7M}}{\text{W-}}$ and $\frac{\text{2K7M}}{\text{W}}$ and four smaller ones 1U7L, 1U8L, 1J7L and 1J8L, the actual farm sizes were also calculated. Obtaining the data for this was particularly time consuming because individual farmers could not only own land in different





Legend

□ Quarter section

—·—·— Boundary between land systems X and Y

A,B,C Owner of quarter section

• • • • • Boundary between consolidated holdings

A^{10} Size of consolidated holdings owned by A

Fig. 6.6 Sample diagram illustrating the derivation of the sizes of consolidated holdings in two land systems.

SIZE OF CONSOLIDATED HOLDING (Quarter section) (1)	(Hectare) (2)	LAND SYSTEM X TOTAL NUMBER (Quarter section) (3)	FREQUENCY (%) (4)	LAND SYSTEM Y TOTAL NUMBER (Quarter section) (5)	FREQUENCY (%) (6)
1	65	3	12	6	27
2	130	3	12	1	5
3	195	3	12	9	41
4	260	4	15	4	18
5	325	5	19	—	—
10	650	8	30	2	9

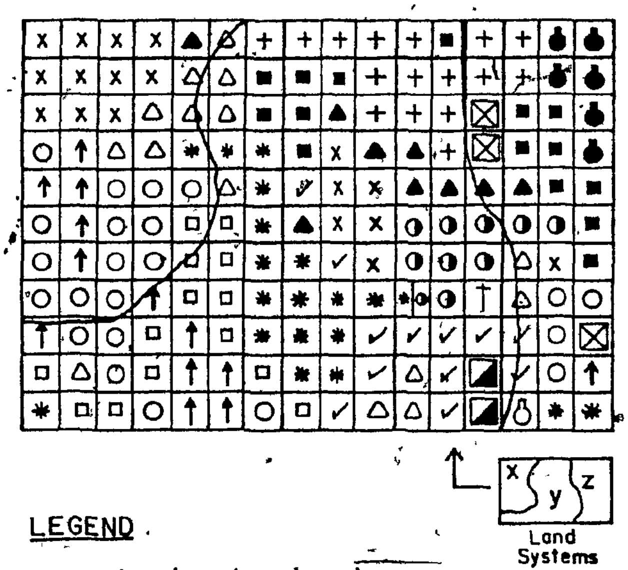
Table 6.3 The frequency of different sizes of consolidated holdings in the two sample land systems illustrated above.

municipalities but also in different land systems. Therefore it was necessary to make a search of all the Rural Municipal maps in a particular land system and collate the quarter sections belonging to individual owners, then continue with adjacent land systems to determine whether the owners in land system X also farmed quarter sections in land system Y, Z and so on.

In some cases a farm is spread over as many as eight land systems. A sample illustration showing how the data were derived is given in Fig. 6.7. Land owned by each person is recorded according to the different land systems, as shown in Table 6.4, columns 1, 3 and 5. The area in each land system is also shown as a percentage (columns 2, 4 and 6) of the total farm size (column 7). A farm was considered as belonging to the land system in which the greater part of the farm area lay. For example, A owned 18 quarter sections of which 61 per cent was in land system X and therefore A's farm was assigned to that particular land system. On the other hand B's farm was assigned to land system Y and D's farm to land system Z.

Actual holdings showed a wide variation in size and they were grouped in the same classes as for the consolidated holdings.

The reason for obtaining actual farm sizes in some of the land systems was to assess the effect of soil texture on the size of farms as well as to investigate the effect of



LEGEND

Land system boundary

x, ■... Land ownership

Fig. 6.7 Sample diagram of actual ownership by quarter section.

REF.	OWNER	LAND OWNED IN LAND SYSTEM X: Quarter Section (1)	LAND OWNED IN LAND SYSTEM X: % * (2)	LAND OWNED IN LAND SYSTEM Y: Quarter Section (3)	LAND OWNED IN LAND SYSTEM Y: % * (4)	LAND OWNED IN LAND SYSTEM Z: Quarter Section (5)	LAND OWNED IN LAND SYSTEM Z: % * (6)	TOTAL FARM SIZE (7)	LAND SYSTEM TO WHICH FARM IS ASSIGNED (8)
x	A	11	61	6	33	1	6	18	X
△	B	6	40	7	47	2	13	15	Y
+	C	—	—	12	75	4	25	16	Y
■	D	—	—	7	47	8	53	15	Z
●	E	—	—	—	—	6	100	6	Z
▲	F	1	11	6	67	2	22	9	Y
⊠	G	—	—	—	—	3	100	3	Z
○	H	13	59	5	23	4	18	22	X
↑	I	5	72	1	14	1	14	7	X
*	J	1	5	16½	85	2	10	19½	Y
✓	K	—	—	10	83	2	17	12	Y
□	L	1	7	13	93	—	—	14	Y
◑	M	—	—	7½	79	2	21	9½	Y
†	N	—	—	1	100	—	—	1	Y
↑	O	—	—	6	100	—	—	6	Y
◪	P	—	—	—	—	2	100	2	Y
♁	Q	—	—	—	—	1	100	1	Z

* Percent of total farm size

Table 6.4 The derivation of farm size from the land ownership sketch above.

zonal soils on occurrences of the same land system. Seven of the most frequently recurring land systems were selected on the basis of their comparable sizes. Because of the occurrence of 1J7L, 1J8L, 1U7L and 1U8L only in the Dark Brown Soil Zone, investigations into zonal differences were carried out only for land systems 1J7M, $\frac{1K7M}{W-}$ and $\frac{2K7M}{W}$.

ANALYSIS AND RESULTS - THE RELATIONSHIP BETWEEN LAND SYSTEMS, FIELD CHARACTERISTICS AND PHYSICAL LIMITATIONS

As mentioned in the introduction, the sampling method used in acquiring the data meant that some land systems were not sampled. In addition, the land systems which generated less than five sample sections were not included in the analysis, with the result that the total number of land systems considered was 39—26 in the Dark Brown Soil Zone, twelve in the Black Soil Zone and one in the Gray Luvisol Soil Zone.

The results of the analyses for each of the field characteristics are presented in graphic form in Fig. 6.8 organized according to land system and grouped by soil zone.

The relationship between land systems and the number of fields per section

The average number of fields per section is seven for the area considered as a whole, with little difference between the figures for the three zones. This reflects the general uniformity of the prairie land subdivision with its regular gridiron of sections.

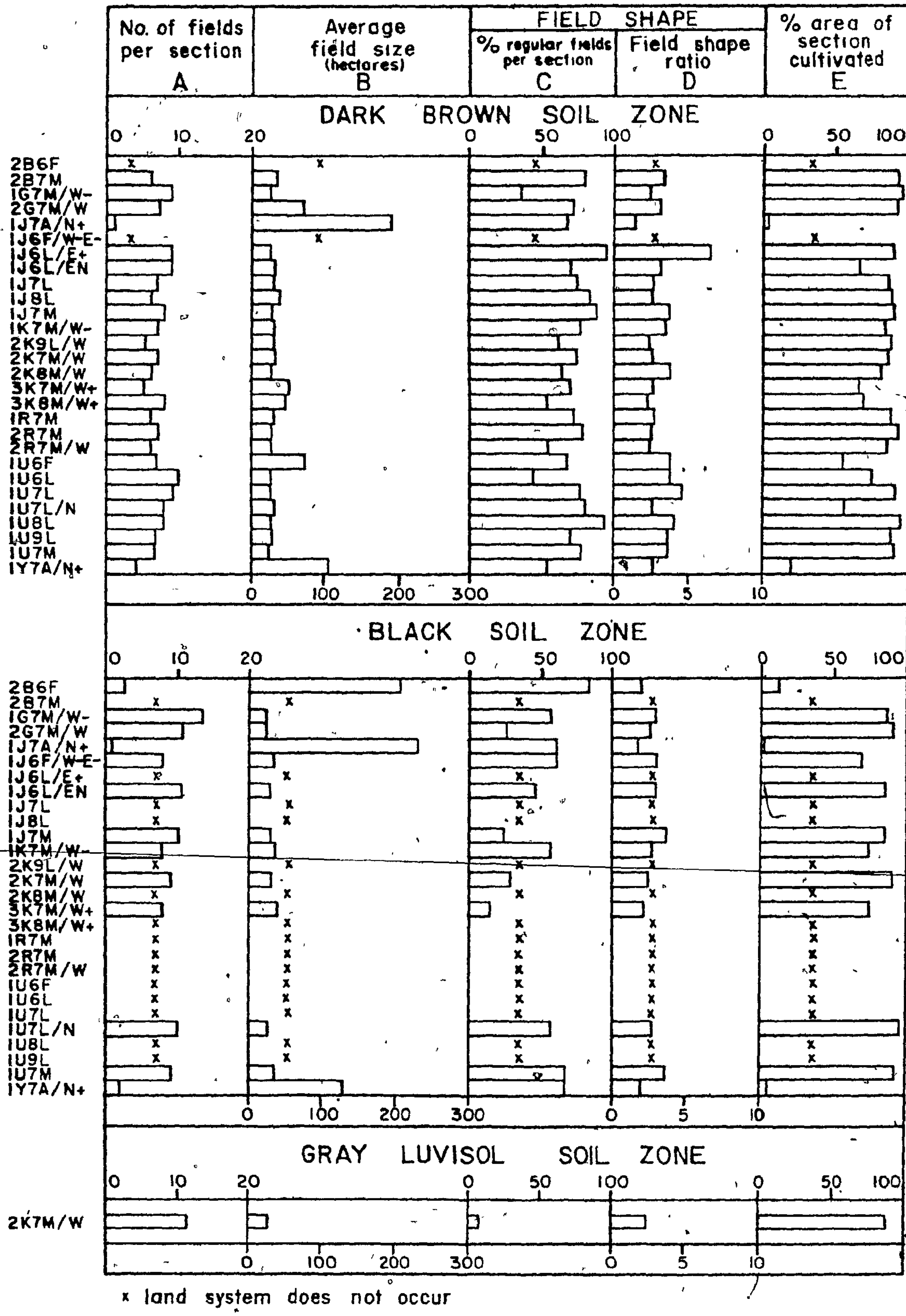


Fig. 6.8 Field characteristics of the different land systems according to soil zones.

In the Dark Brown Soil Zone there are some variations, for example—land systems with fine sandy lacustrine soils susceptible to wind erosion, such as $\frac{1J6L}{E+}$ and $\frac{1J6L}{EN}$ have an average of nine fields per section. Land systems 1U6L and 1U7L also have an above average number of fields per section reflecting the concern of the farmers in preventing soil drifting. In contrast land systems $\frac{1J7A}{N+}$ and $\frac{1Y7A}{N+}$ which are mainly in permanent pasture due to excessive salinity, average only four fields per section since there is no particular reason for further subdivision.

In the Black Soil Zone, the same general trends are discernible: higher numbers of fields for soils of high erodibility and fewer fields for land systems that are very saline or have a lower capacity for moisture retention. For example, land system $\frac{1J6L}{EN}$ has an average of eleven fields; land system $\frac{1Y7A}{N+}$ which is very saline has two fields, and land system 2B6F with coarse fluvial soils and a low moisture holding capacity, has only three fields per section.

It is also interesting to note that for the greater part, land systems in the Black Soil Zone exhibits a somewhat greater number of fields per section than a similar system occurring in the Dark Brown Soil Zone—for example land system $\frac{1G7M}{W-}$ has nine fields in the Dark Brown Soil Zone and 13 fields in the Black Soil Zone; land system $\frac{1J6L}{EN}$ with nine fields in the former and eleven in the latter; and land system 1U7M with eight fields in the Dark Brown Soil Zone and ten fields in the Black Soil Zone. This is probably due to the effect of a higher precipitation and available moisture resulting in the frequent occurrence of woodland on moist sites. Bush and tree clearing involves high costs and where they are not cleared they form interruptions with the result that the number of fields per section is relatively large.

<u>The relationship between land systems and field sizes</u>

Typical field sizes range from 20 to 60 hectares (50 to 150 acres) in the Dark Brown Soil Zone and 20 to 40 hectares (50 to 100 acres) in the Black Soil Zone in all the land systems which are widely cultivated. The smaller field sizes tend to occur on land systems with light soils that are susceptible to wind erosion.

On the other hand, uncultivated land is generally native pasture and so field sizes are very large. For example, land system 2B6F which is mainly native pasture, exhibits large fields averaging 200 hectares (500 acres approximately) in size). Land systems $\frac{\text{1J7A}}{\text{N+}}$ and $\frac{\text{1Y7A}}{\text{N+}}$ which are saline with a high percentage of uncultivated land, also exhibit large fields of approximately 120 hectares (200 acres) and 200 hectares (500 acres) respectively.

In the Gray Luvisol Soil Zone land system $\frac{\text{2K7M}}{\text{W}}$ is divided into relatively small fields averaging 20 hectares (50 acres) in size. The reason for this is the greater extent of woodland and the high costs of tree clearing.

The relationship between land systems, field shapes and field shape ratios

The average occurrence of regular fields is approximately 70 per cent for land systems in the Dark Brown Soil Zone decreasing somewhat to 50 per cent in the Black Soil Zone where the occurrence of woodland has resulted in many more fields with irregular boundaries along the forest line. In the Gray Luvisol Soils, the percentage is substantially lower with only nine per cent of the fields exhibiting regular boundaries.

The most regular field patterns are found in land systems $\frac{\text{1J6L}}{\text{E+}}$ and 1U8L with 98 per cent and 91 per cent regular fields respectively. Strip cropping is practised in $\frac{\text{1J6L}}{\text{E+}}$ to control wind erosion. In addition, the two land systems are near level landscapes with fine lacustrine soils where there are no physiographic limitations such as sloughs or drainageways, with the result that regular shaped land parcels are easily established and maintained. In contrast the frequency of regular fields decreases markedly in the more irregular topography of hummocky land systems such as $\frac{\text{2K7M}}{\text{W}}$ and $\frac{\text{3K7M}}{\text{W+}}$ with only 25 to 30 per cent regular fields.

The field shape ratio in the Dark Brown Soil Zone averages 3.3. In general the 1J and 1U land systems with fine lacustrine soils on near level (unpatterned) topography have very high shape ratios, because of the danger of wind erosion and the necessity of maintaining strip cropping. For example, in an intensively cultivated land system such as $\frac{1J6L}{E+}$ where strip cropping is practised, the field shape ratio is 6.7. In contrast, land systems characterized by salinity such as $\frac{1J7A}{N+}$, $\frac{1U7L}{N}$ and $\frac{1Y7A}{N+}$ are mostly pasture land with large fields generating a lower shape ratio of 1.3.

Land systems in the Black Soil Zone and the Gray Luvisol Soil Zone exhibit lower shape ratios with 2.7 and 2.2 respectively. However, as in the Dark Brown Soil Zone, cultivated land systems exhibit higher shape ratios in contrast to the lower shape ratios for saline land systems or those with low moisture holding capacity.

The relationship between land systems and the per cent of cultivated land

The per cent of cultivated land is generally high throughout the Dark Brown Soil Zone. The most extensive areas of farmland occur in land system $\frac{1G7M}{W-}$ with 98 per cent of the area cultivated.

The per cent of cultivated land decreases in areas with more irregular topography—for example, land systems $\frac{3K7M}{W+}$ and $\frac{3K8M}{W+}$ have less than 70 per cent of the area under cultivation.

Areas with poorer soils also have a relatively small per cent of the land under cultivation—for example 70 per cent in land systems $\frac{1J6L}{EN}$ which is liable to soil drifting and salinity, and only 60 per cent in land system $\frac{1U7L}{N}$ where there is a serious salinity problem. Other areas which have a low moisture storing capacity such as land system 1U6F, exhibit the same relatively low percentages.

The lowest percentages of cultivated land are found on land systems 2B6F, $\frac{1Y7A}{N+}$ and $\frac{1J7A}{N+}$ with 20 per cent, 15 per cent and 1 per cent respectively. These very low figures are the result of coarse gravelly soils in the first land system and serious salinity problems in the other two.

The per cent area cultivated is generally somewhat higher in the Dark Brown Soil Zone than in the Black Soil Zone. This probably results from the occurrence of brush and woodland vegetation in the latter which requires clearing before the land can be farmed.

The relationship between land systems and the physical limitations of sloughs and drainageways

Physical limitations include sloughs and drainageways and the relationships between the 39 land systems and the physiographic interruptions are illustrated in Fig. 6.9.

The relationship between land systems and slough density. The slough density averages 0.08 slough per hectare for the area as a whole. Sloughs are most numerous in knob and kettle topography. For example, in land system $\frac{1K7M}{W-}$ the slough density is as high as 0.11 slough per hectare (0.3 slough per acre) and the other land systems with kettle topography also exhibit a high slough density in all soil zones (Fig. 6.9A).

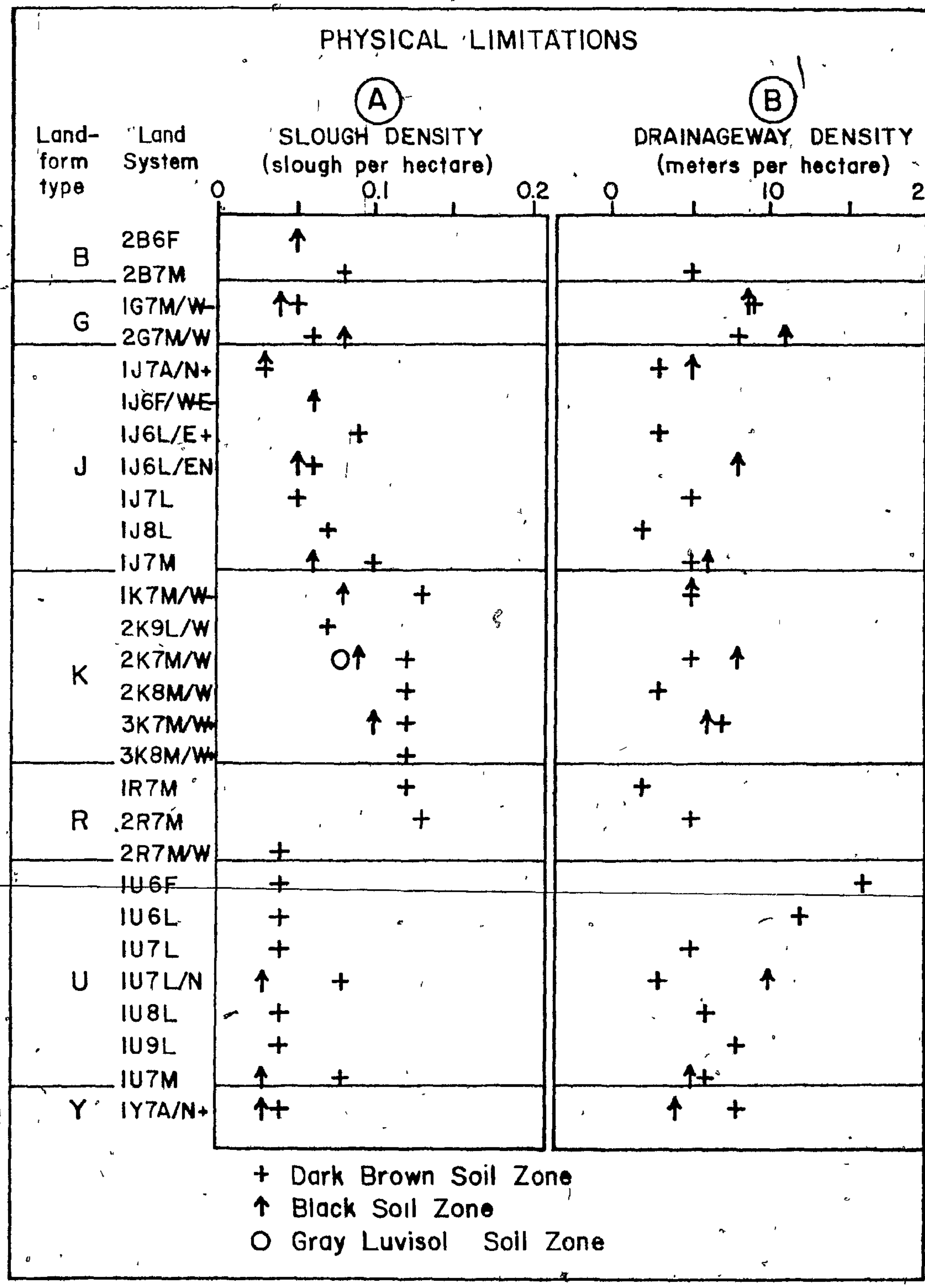


Fig. 6.9 Slough and drainageway densities in the different land systems.

In all the ridged landscapes, hummocky topography occurs but sloughs are only frequent in two of these land systems—1R7M and 2R7M which have a ridged surface with numerous kettles and knobs superimposed on the recessional ridged moraines. In contrast the ridged land system $\frac{2R7M}{W}$ exhibits a low slough density and this probably results from the proximity to Lake Manitou which has permitted external drainage rather than local centripetal drainage.

The lowest slough densities were recorded for the unpatterned land systems—for example 1U6F with a slough density of only 0.04 per hectare.

The relationship between land systems and drainageway density. The average drainageway density is 5 meters per hectare (Fig. 6.9B). The highest drainageway density is recorded for land systems with frequent occurrences of streams, creeks or gullies—for example $\frac{1G7M}{W-}$ with a density of 9 meters per hectare. The drainageway densities are lowest for land systems with J, K and R landform types, and within the unpatterned land systems (landform type U) is a wide variation with high densities for land systems 1U6F and 1U6L and low densities for 1U7L and 1U8L.

General summary

The land systems with a relatively large cultivated area tend to be divided into a larger number of fields than the land systems with more restricted cultivated areas. The fields in the former group tend to be small in comparison with the large uncultivated pastures of land systems with saline or coarse textured soils.

Due to strip cropping practices, field regularity is highest in land systems which are severely wind eroded and these land systems also have the highest shape ratios.

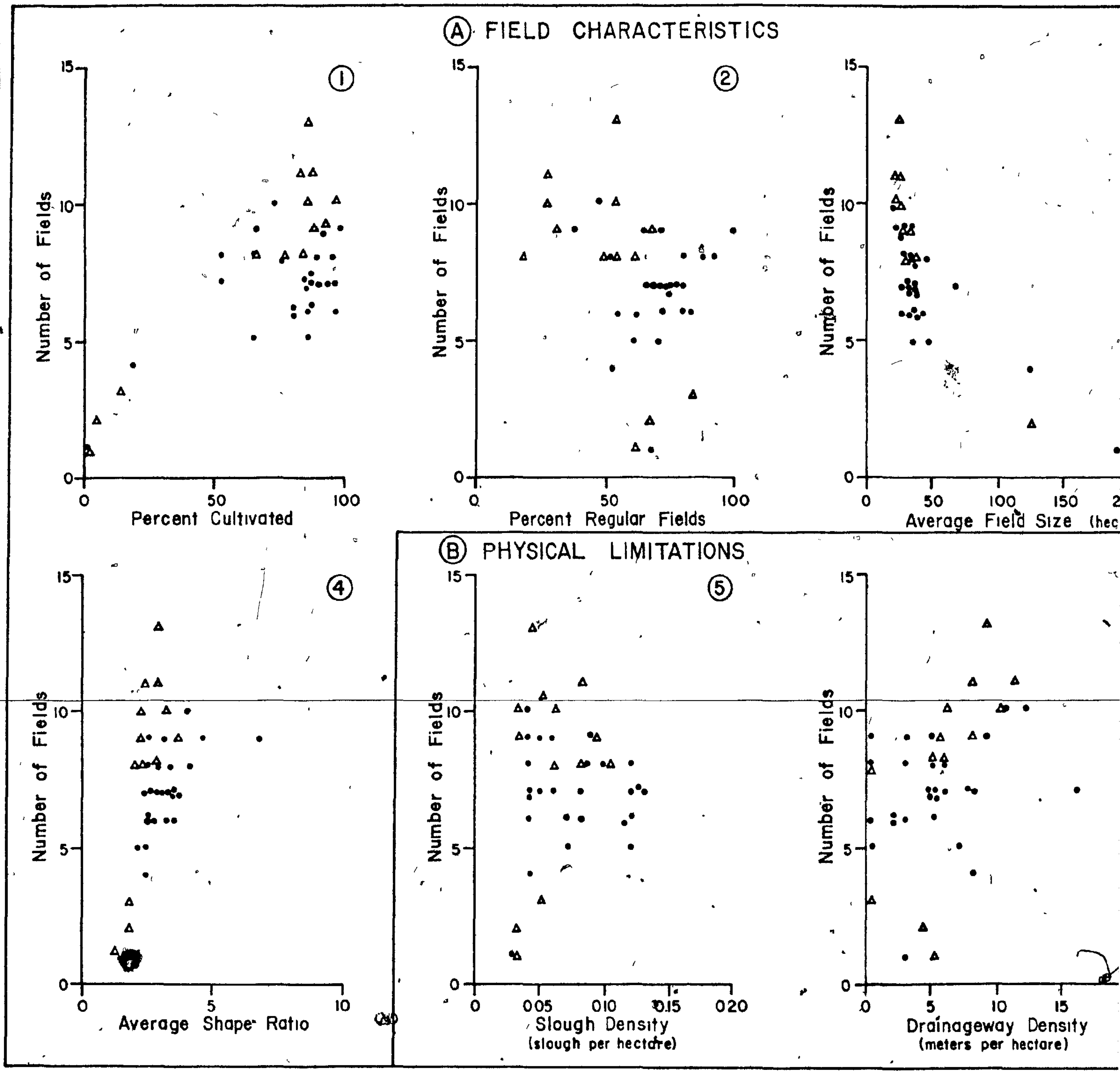
In general, slough density is highest in knob and kettle land systems and lowest in land systems with high drainage-way density.

THE RELATIONSHIP BETWEEN THE VARIOUS FIELD CHARACTERISTICS

The relationships between the various field characteristics were investigated with a view to determining whether correlations existed between particular pairs of parameters. The results are summarized in the form of scatter plots in Figs. 6.10 to 6.14, and because of the very extensive scatter in most plots indicating a general absence of correlation, no further statistical analysis was attempted.

The relationship between the number of fields and the other field characteristics

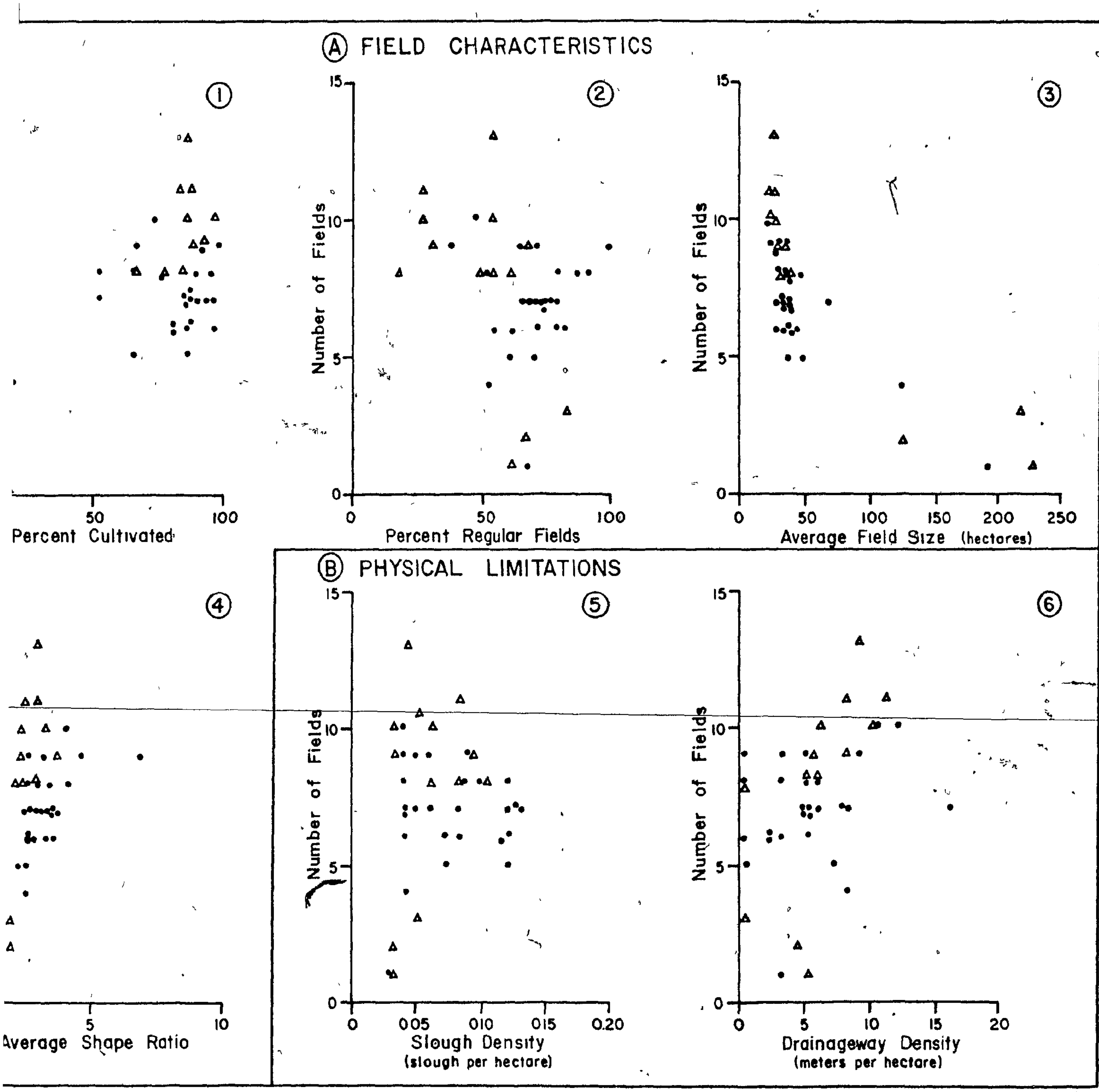
There is some indication of a direct positive relationship between the first pair of parameters considered—the number of fields and the per cent of cultivated land (Fig. 6.10 plot No. 1). This is to be expected since increases in the per cent of land under cultivation result in additional



• Represents a land system in the Dark Brown Soil Zone

▵ Represents a land system in the Black Soil Zone

Fig. 6.10 The relationship between the number of fields and A. the other field characteristics, B. th physical limitations.



presents a land system in the Dark Brown Soil Zone
presents a land system in the Black Soil Zone

6.10 The relationship between the number of fields and A. the other field characteristics, B. the physical limitations.

numbers of fields. The relationship is somewhat more pronounced for land systems in the Black Soil Zone than for those in the Dark Brown Soils.

With the second pair of parameters there is a wide scatter of points and no apparent relationships (Fig. 6.10 plot no. 2). Land systems with large numbers of fields exhibit a wide variation in their regularity with some indication that those in the Black Soil Zone are less regular than those in the Dark Brown Soils.

In the plot involving the third pair of parameters (Fig. 6.10 plot no. 3) there is some indication of a negative relationship. As the average field size decreases, the number of fields increases. The strength of this trend changes appreciably at the fifty hectare size, the land systems on the right side of the scatter plot having very large fields and relatively limited total numbers of fields.

With the fourth pair of parameters there is a fairly strong positive relationship with the shape ratio changing progressively as the number of fields increases, indicating that land systems with large numbers of fields tend to have elongate rectangular fields (Fig. 6.10 plot no. 4).

There is no apparent relationship between the fifth set of parameters (Fig. 6.10 plot no. 5). Slough densities are very low for land systems with small numbers of fields and also for those with large numbers of fields, but in the central zone of the plot there is a wide variation in slough density for land systems with the same numbers of fields.

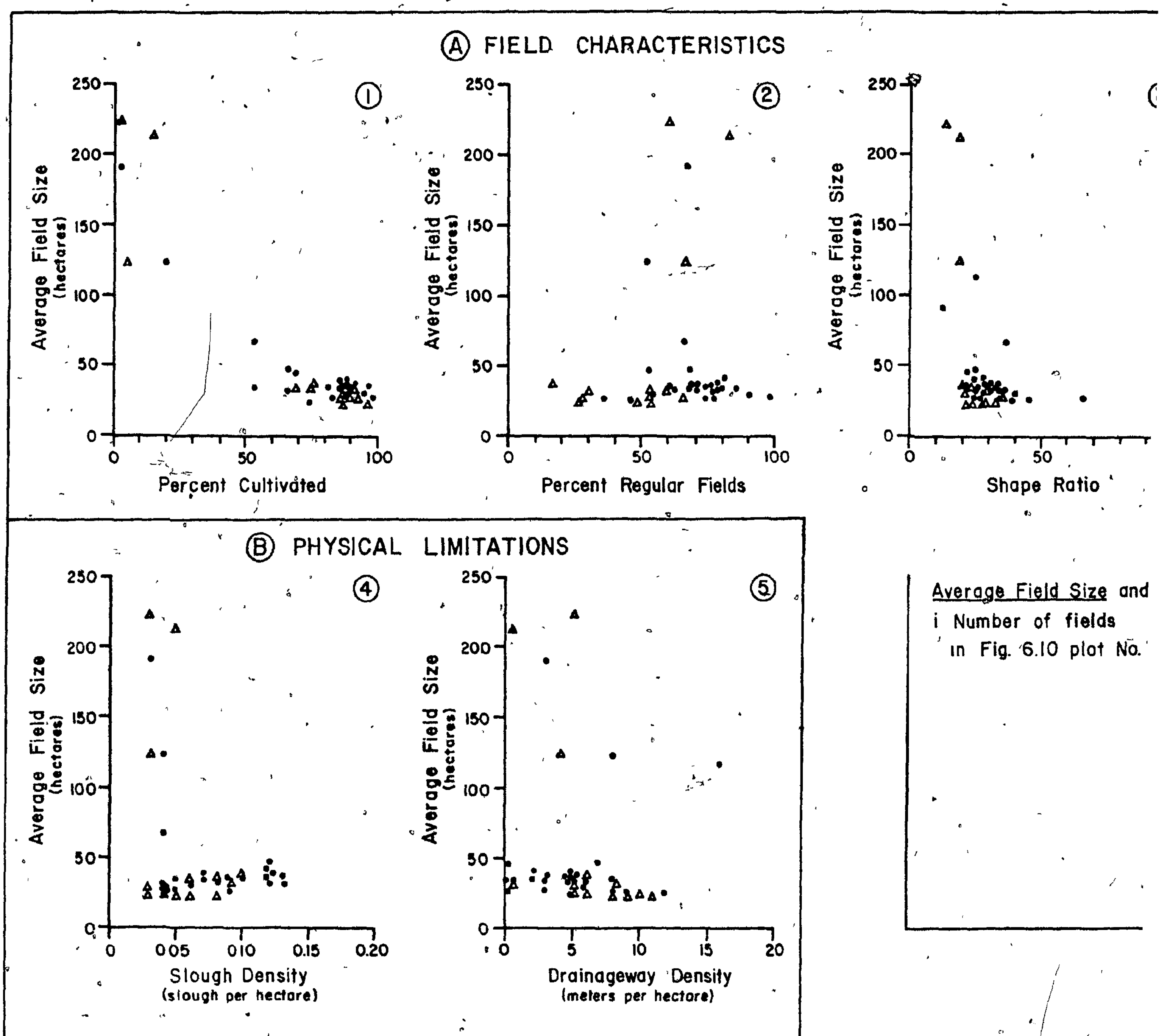
In the final pair of parameters there is a fairly clear positive relationship. Land systems with large numbers of fields tend to suffer from a relatively high drainageway density (Fig. 6.10 plot no. 6).

<u>The relationship between the average field size and the other field characteristics</u>

With the first pair of parameters considered in Fig. 6.11, there is a high concentration of data points in the lower right section of the plot indicating a general similarity in field size for all the land systems. The cluster emphasizes the high per cent of cultivated land in most of the land systems and the general similarity of field sizes. There is a very limited trend of data points indicating that as the per cent of cultivated land increases, the typical field sizes decrease.

In the second plot the wide spread of values for the per cent of regular fields between 20 and 50 hectares indicates that no definite relationship exists between these two parameters.

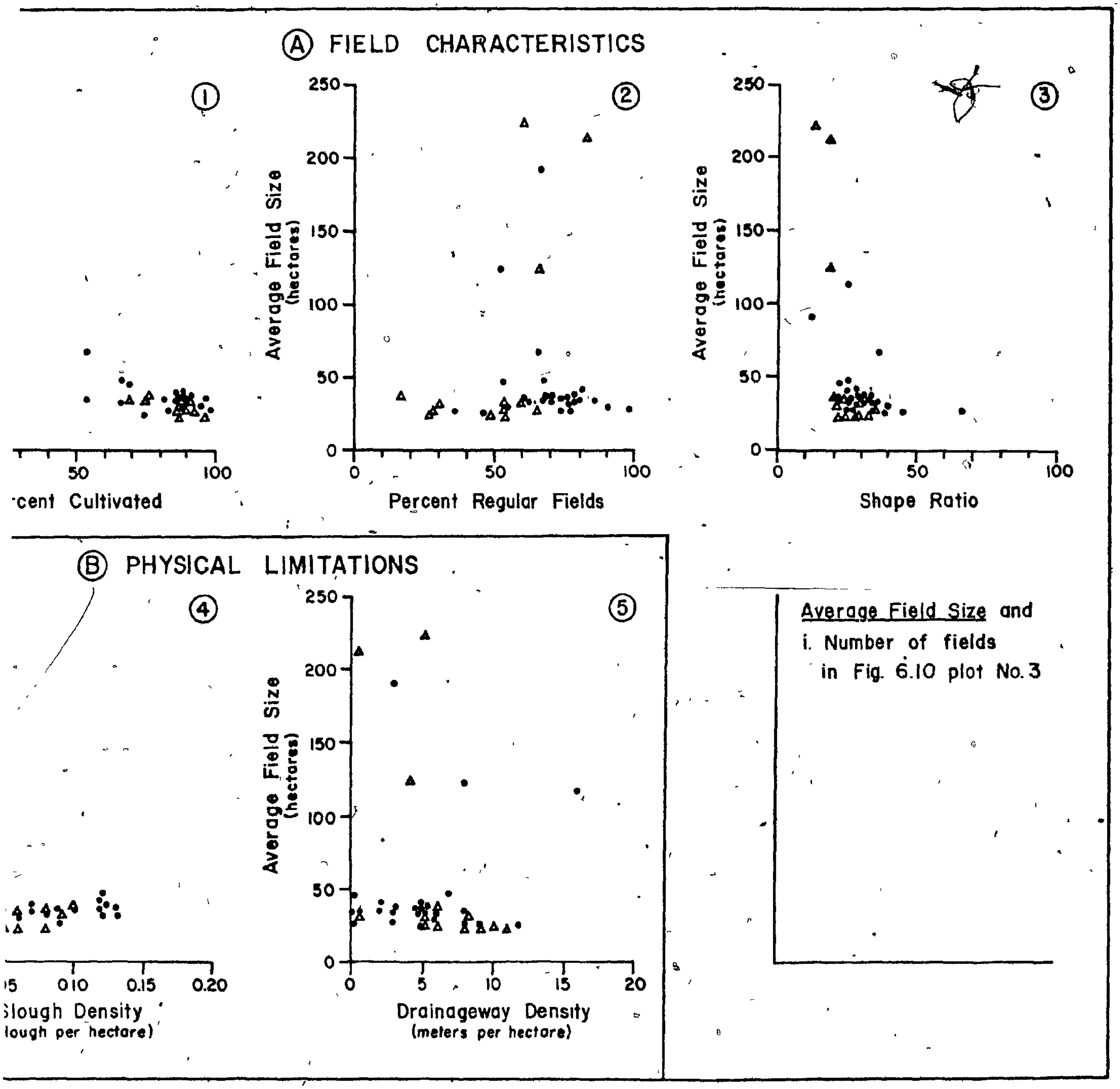
There is a marked clustering of values in the third plot indicating that the majority of small-medium sized fields have a limited range of shape ratios (1 to 4.5). Even the large fields exhibit the same shape ratios and so there is no relationship between these parameters.



• Represents a land system in the Dark Brown Soil Zone

▲ Represents a land system in the Black Soil Zone

Fig. 6.11. The relationship between the average field size and A. the other field characteristics, B. thı physical limitations.



sents a land system in the Dark Brown Soil Zone
sents a land system in the Black Soil Zone

The relationship between the average field size and A. the other field characteristics, B. the physical limitations.

In the fourth and fifth plots there is a concentration of data points indicating a general absence of relationship between the pairs of parameters examined: neither slough density nor drainageway frequency exert an influence on field size.

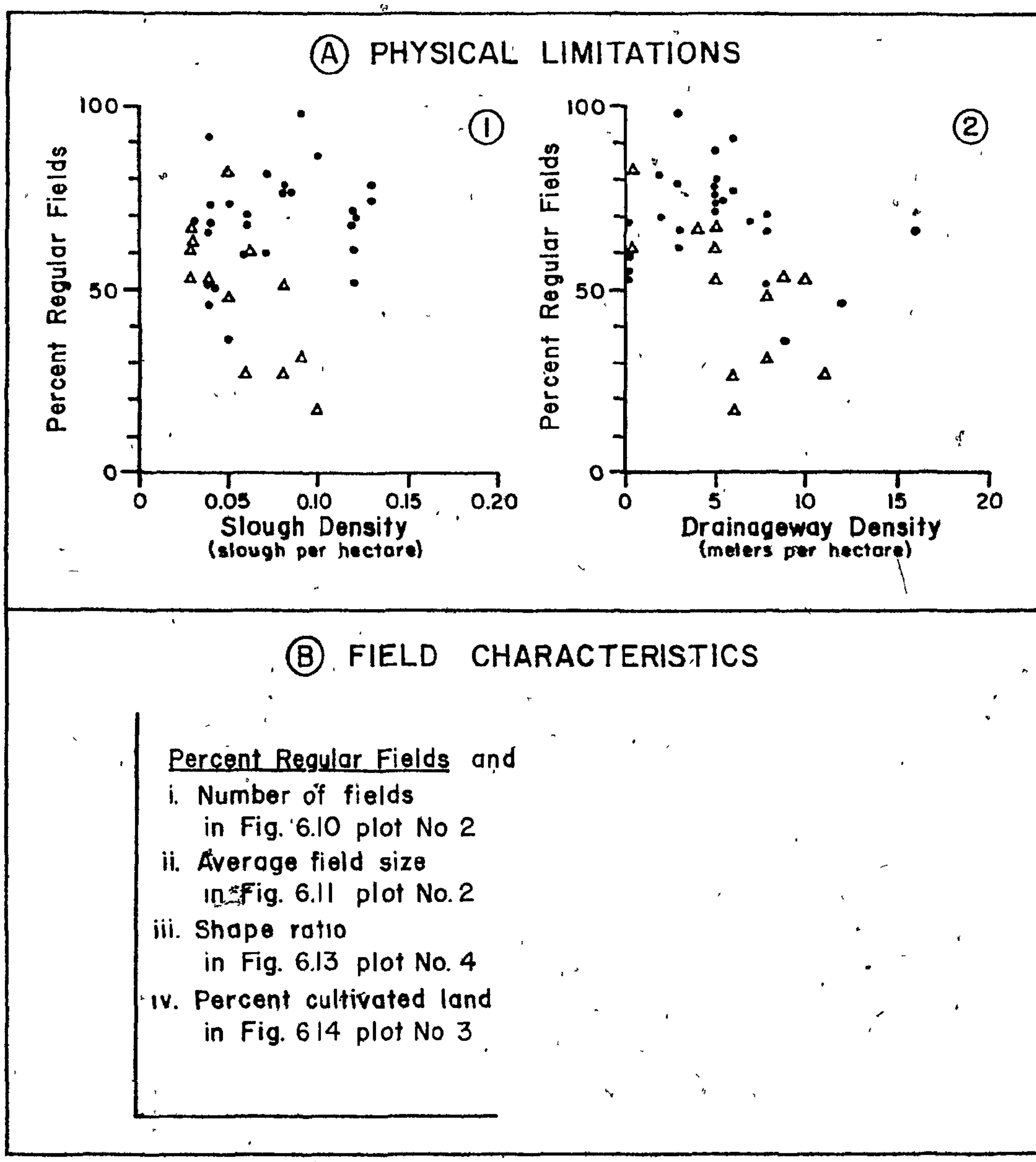
The relationship between field shape and the other field characteristics

In the first plot in Fig. 6.12, there is a negative relationship between the per cent of regular fields and the slough density in the Black Soil Zone: field regularity decreases as the number of sloughs increases. A high drainageway density resulting in a lower per cent of regular fields is also more pronounced in the Black Soil Zone as illustrated in the second plot of Fig. 6.12.

The relationship between the shape ratio and the other field characteristics

In plots 1 and 2 of Fig. 6.13 there is no apparent relationship between the two pairs of parameters considered. Slough and drainageway densities have no direct effect on the shape ratio of the fields.

When the shape ratio and the per cent of cultivated land (plot number 3, Fig. 6.13) are considered, a slight positive relationship is observed, with a trend towards higher shape ratios in land systems of intensive cultivation. Sections in these land systems have generally been divided



• Represents a land system in the Dark Brown Soil Zone
▵ Represents a land system in the Black Soil Zone

Fig. 6.12 The relationship between the percent of regular fields and A. the physical limitations, B. the other field characteristics.

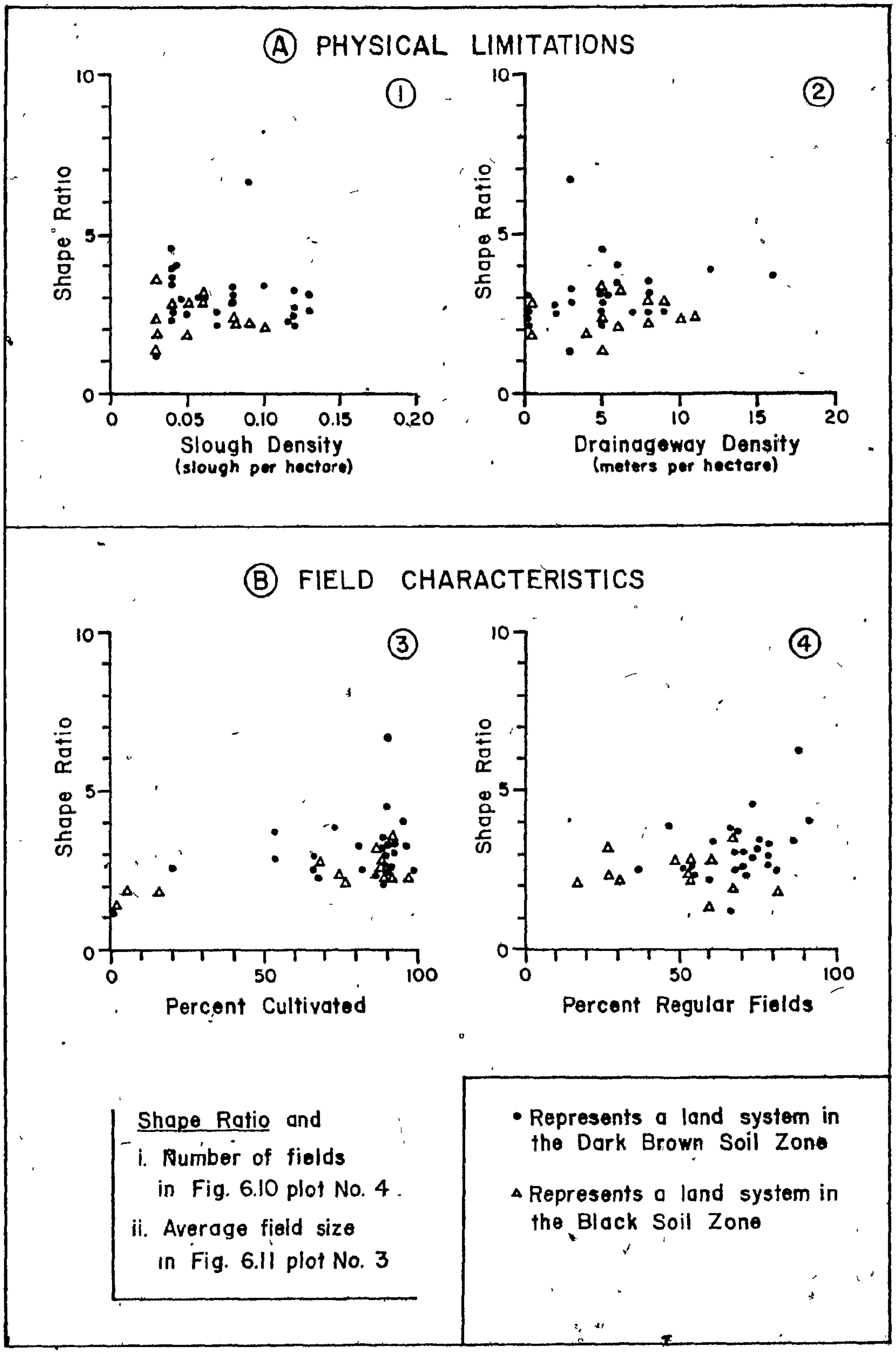


Fig. 6.13 The relationship between the shape ratio and A. the physical limitations, B. the other field characteristics.

into relatively narrow fields to reduce the risk of soil drifting. On the other hand, coarse or saline soils are generally used as pasture and less subject to erosion, and so the field sizes are large. These two situations are reflected in the occurrence of two distinct clusters of points in the scatter plot.

In the fourth pairs of parameters (plot number 4, Fig. 6.13), the wide scatter of points indicates no relationship.

The relationship between the per cent of cultivated land and the other field characteristics

The wide scatter of points in the three plots in Fig. 6.14 indicates that there is no relationship between the slough and drainageway densities and the per cent of cultivated land, nor between the per cent of regular fields and the per cent of cultivated land. Slough and drainageway densities vary appreciably with no apparent effects on the per cent of land in cultivation.

General summary

In most of the scatter plots there is a wide scatter of points and definite relationships are observed in only a few pairs of parameters. Positive relationships exist between the following pairs of parameters:

(i) the number of fields and the per cent of cultivated land;

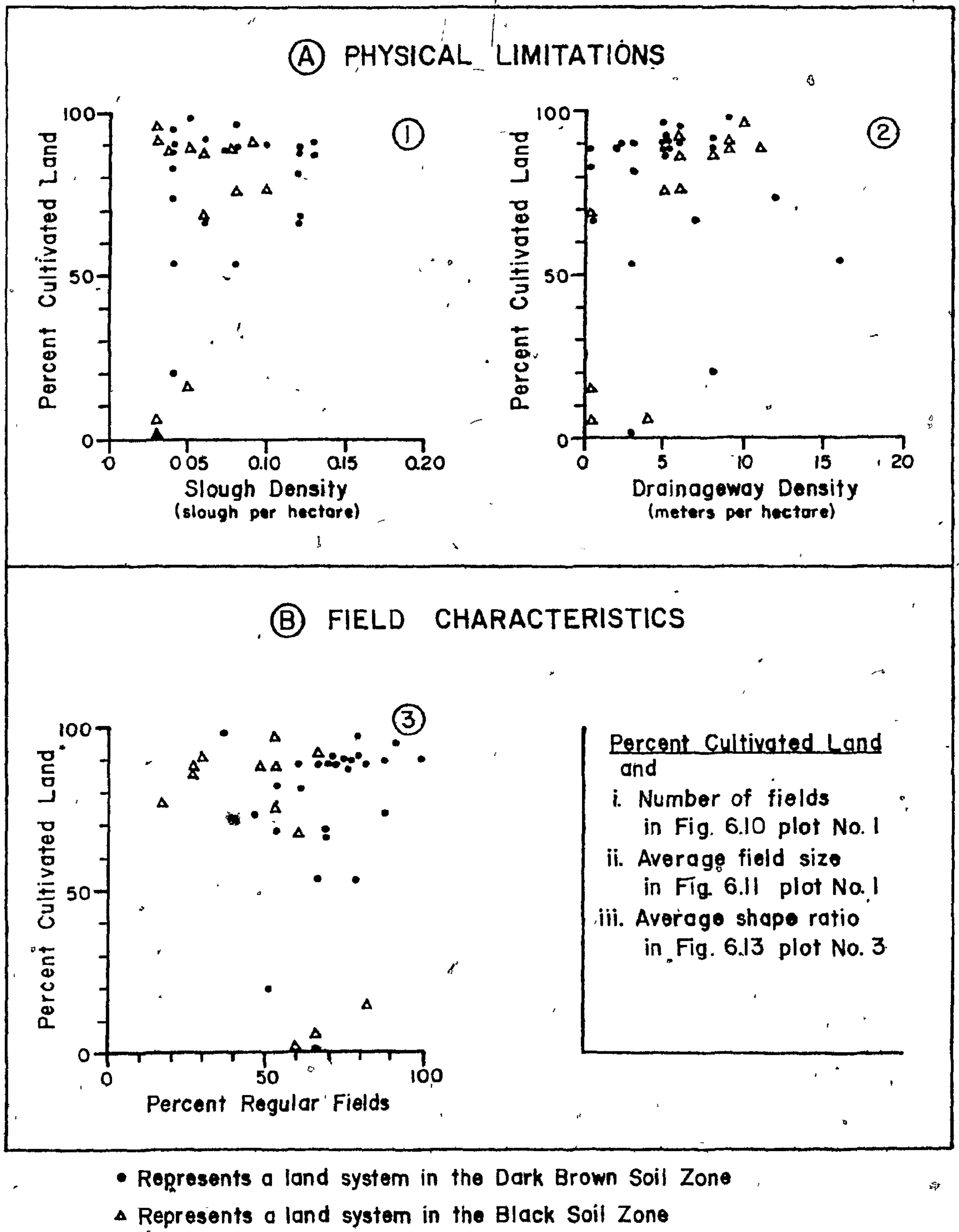


Fig. 6.14 The relationship between the percent of cultivated land and A. the physical limitations, B. the other field characteristics.

(ii) the numbers of fields and the field shape ratio;

(iii) the numbers of fields and the drainageway density, and

(iv) the shape ratio and the per cent of cultivated land.

On the other hand, negative relationships are observed in:

(i) the number of fields and the average field size;

(ii) the average field size and the per cent of cultivated land, and

(iii) the per cent of regular fields and the slough density.

THE RELATIONSHIP BETWEEN THE SLOUGH AND DRAINAGEWAY DENSITIES

The relationship between the slough density and the drainageway density is illustrated in Fig. 6.15 and no clear relationship is observed from the widely scattered points.

THE RELATIONSHIP BETWEEN THE LAND SYSTEM PARAMETERS AND THE FIELD CHARACTERISTICS

The relationship between the land system parameters and the field characteristics are presented in a series of histograms (Fig. 6.16) using the same set of field characteristics as in the previous section and the basic land system parameters of slope class, landform type, soil texture and parent material.

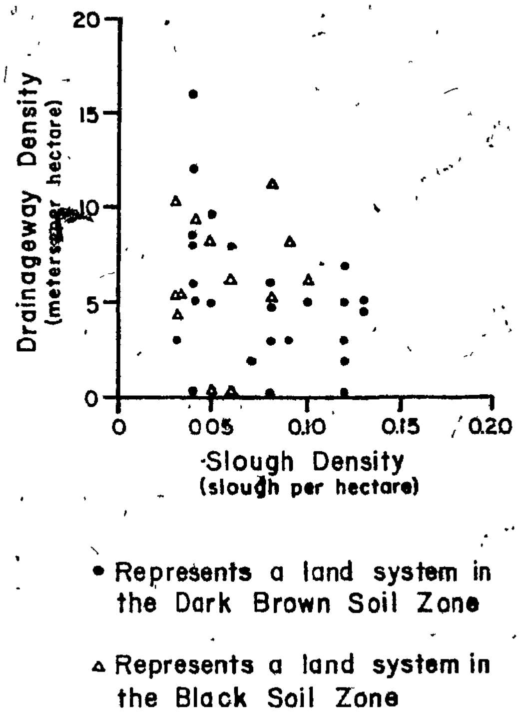


Fig. 6.15 The relationship between the slough and the drainageway densities.

The relationship between the land system parameters and the field characteristics

The relationship between the land system parameters and the field characteristics are presented in the first row of Fig. 6.16. The largest numbers of fields per section are found to occur with the gentler slope classes (8 fields/section in slope class 1 compared with only 2 in slope class 4). The main reason for this difference is that in areas of slope class 4 there is much less cultivation and therefore fewer fields.

When considered in relation to landforms it can be seen from the diagram that landform types D, G and U contain the largest numbers of fields. This is due to D and G being dissected landforms, whereas, in the case of U the near level land offers no obstruction to the wind and it is necessary to divide the land into smaller fields to reduce soil drifting.

The relatively small number of fields in landform types H and Y is due to the former being a glacio-fluvial channel with steep slopes and the latter, a runway. In landform type H, the soils are variable and difficult to manage. In addition, the steep slopes limit cultivation, either because of the impracticability of using farm machinery, or the risk of soil erosion.

Considered in terms of soil textures it can be seen that larger numbers of fields are found with the finer textured

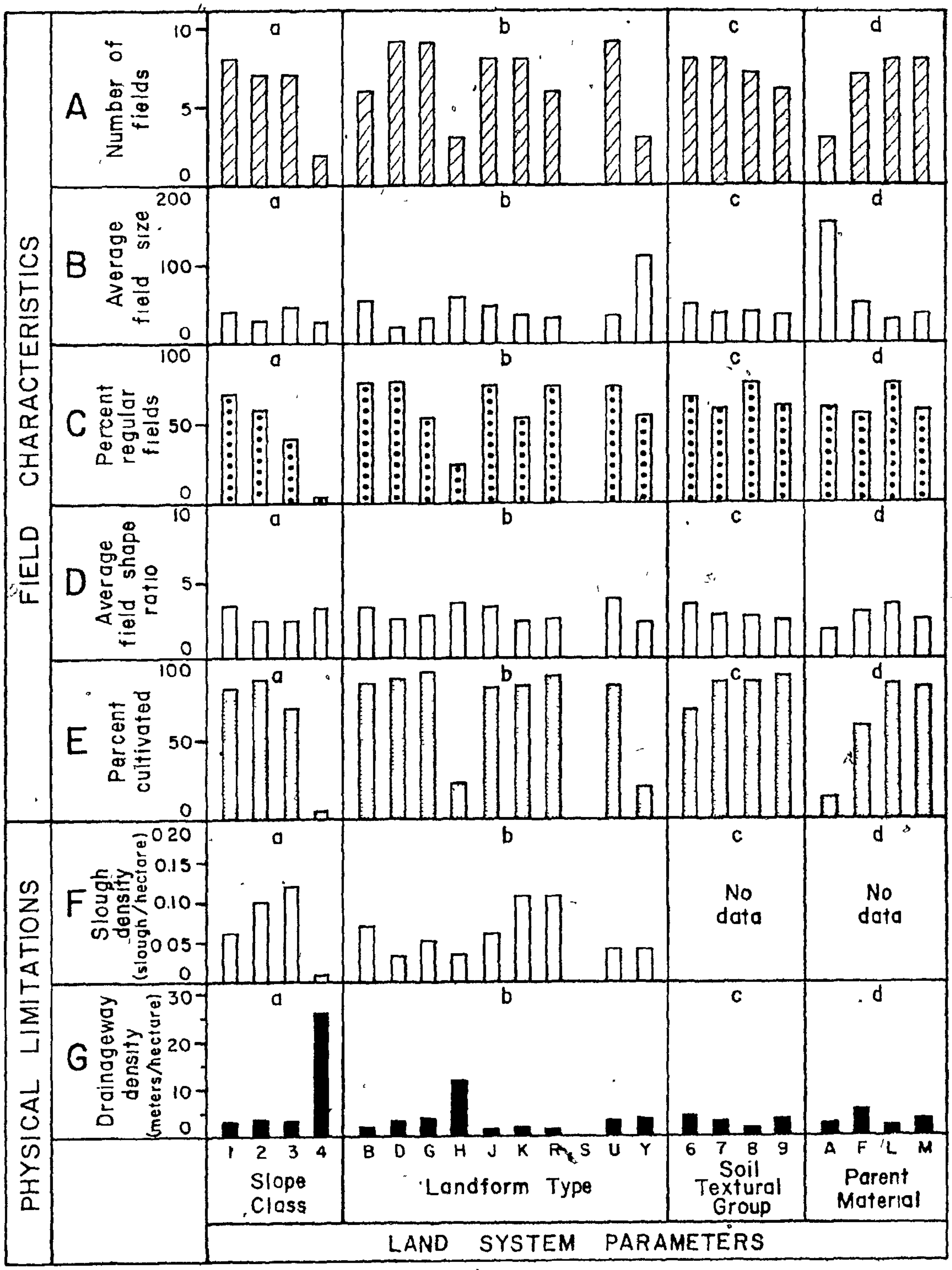


Fig. 6.16 The relationships between the field characteristics, the physical limitations and the land system parameters.

soils of greater erodibility in groups 6 and 7 and with relatively fewer fields in the heavier soils in group 9.

When parent materials are examined it is apparent that the alluvial materials (type A) have significantly fewer fields due in part to the poorer soil materials and in part to the associated topography.

The relationship between the land system parameters and the average field size

The largest fields are shown as occurring in landform type Y which is dominated by runways (Fig. 6.16 row B) and there is marked correspondence between large-sized fields and alluvial parent materials (type A). This suggests that field size is not dependent on a single parameter but is a result of the interaction between two or more parameters including landform type, soil texture, parent materials and salinity.

The relationship between the land system parameters and the percentage of regular fields

The per cent of regular fields (row C, Fig. 6.16) is generally high (in excess of 50 per cent) with some notable exceptions. As might be expected the areas with steeper slopes (slope class 4) have a relatively small percentage of regular fields. The same relationship is observed when landforms are considered, with the lowest values for landform type H on account of the steep topography of glacio-fluvial channels.

Strip cropping practices result in a particularly large percentage of regular fields in the sandy and clay loam lacustrine soil types (texture groups 6 and 7, parent material L).

The relationship between the land systems parameters and the field shape ratio

Little variation is seen in the shape ratios as shown in Fig. 6.16 row D, indicating no appreciable control by particular land system parameters.

The relationship between the land system parameters and the per cent of cultivated land

The per cent of cultivated land (row E Fig. 6.16) is relatively high throughout the area. The obvious limitations are provided by slopes in class 4 and the alluvium parent materials (type A). These same limitations exert an influence when landform type is considered, hence the marked reduction in the per cent of cultivated land in landform type H. The comparable low level in landform type Y is due to the saline soils of this land type and the fact that much of the land is left in pasture.

General summary

When the field characteristics are examined in terms of the land system parameters of slope, landform, soil parent material and texture, it is found that the largest numbers of fields tend to occur on the gentler slopes, particularly in landform types D, G and U, and on sandy loam and loam soils. On the other hand the smallest numbers of fields occur on landform types H and Y: the glacio-fluvial channels and the runways which are generally left in pasture.

The average field size is 50 hectares. Generally, the largest fields (100 to 250 hectares) occur in runways and on alluvial soils, and because of the accumulation of saline deposits, they are for the greater part utilized as pastures.

In the area as a whole, fields are very regular in shape. Irregular fields are found only in the glacio-fluvial channels and in the more irregular knob and kettle topography, where the percentage of cultivated land is also the lowest. Both regular and irregular fields exhibit little variation in shape ratios.

THE RELATIONSHIP BETWEEN THE LAND SYSTEM PARAMETERS AND THE PHYSICAL LIMITATIONS - SLOUGHS AND DRAINAGEWAYS

The relationships between the physical limitations and the land system parameters are shown in Fig. 6.16. The physical limitations include sloughs and drainageways and the land system parameters are the same as in the previous section.

Sloughs are most numerous in areas with moderately steep slopes (slope class 3), hence the relatively high frequency in landform types K and R as shown in Fig. 6.16 row F. The lowest slough density occurs in areas with steep slopes (Class 4) situated along glacio-fluvial channels, hence the low frequency in landform type H. Low densities are also associated with landform types D and G which are dissected, J which is gently undulating, and U which is unpatterned.

The relationships between the drainageway density and the other parameters are presented in row G of Fig. 6.16. In general, drainageway density is below five meters per hectare with two notable exceptions—in areas of slope class 4 and landform type H. In both situations the drainageways are developed in former glacio-fluvial channels.

In summary it can be seen that sloughs are most numerous in kettled and ridged landforms and their density is at a minimum in land systems with a high drainageway density.

THE RELATIONSHIP BETWEEN THE LAND SYSTEMS, THE FIELD CHARACTERISTICS AND THE ASSESSED VALUE

The assessed values used in this section are the arithmetic means of the values of the sampled sections in a given land system. The land system parameters and field characteristics are the same as discussed previously. The results are presented in Figs. 6.17 and 6.18.

The relationship between the land systems and the assessed value

There is an appreciable range in the land values for the Wynyard area, with a maximum of $13,500 per section in the

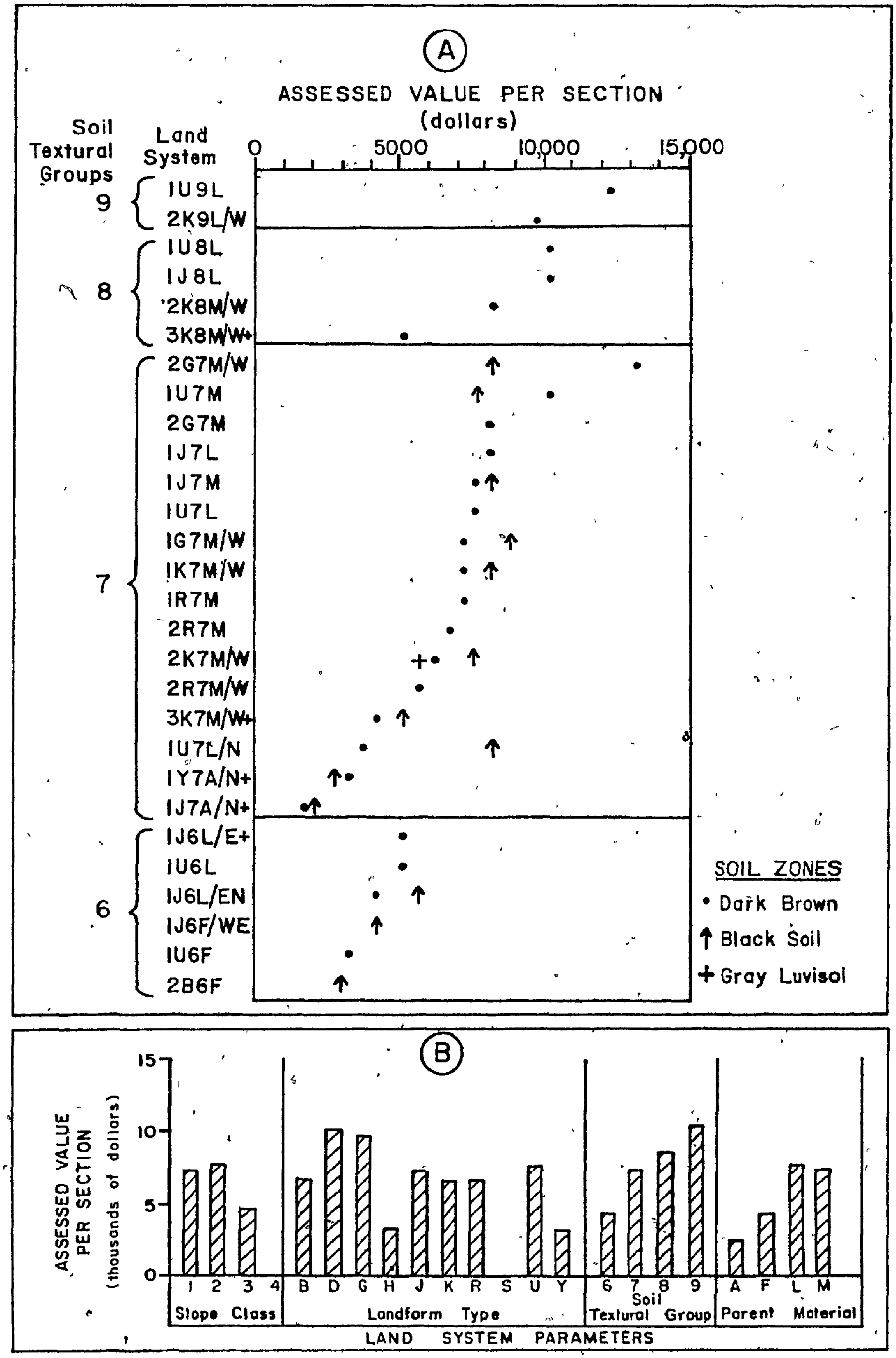


Fig.6.17 The relationship between the assessed land values and
A. the land systems (grouped by soil textures),
B. the land system parameters.

fertile Dark Brown soils of land system $\frac{2G7M}{W}$ and a minimum of $1,640 per section in the very saline soils of land system $\frac{1J7A}{N+}$. The average values of $7,000 to $9,000 are found to occur in some fifteen land systems with predominantly loam soils.

The distribution of the assessed values according to land system is presented in Fig. 6.17A and the reasons for both the high and low values are immediately apparent when the specific attributes of the land systems are examined. In land systems with assessed values per section less than $5,000 there are two control factors which emerge--salinity as in land systems $\frac{1Y7A}{N+}$ and $\frac{1J7A}{N+}$, and the low moisture-holding capacity of recent fluvial soils as in land systems 1U6F and 2B6F. When the six land systems with assessed values more than $10,000 per section are examined the controls are less obvious, but the common factors are level land (Class 1), soils with a relatively high clay content (Class 8 or 9) and an absence of erosional or saline phases.

The general sequence of assessed values for the various land systems is similar in both the Dark Brown Soils and the Black Soils, however, the set of values for the Black Soils tends to be somewhat higher for corresponding land systems. The main factors contributing to this higher value are probably the greater moisture efficiency and the higher content of organic matter in this soil zone. In contrast, the higher precipitation with subsequent acidic leaching and low fertility in the Gray Luvisol Soil Zone, has resulted in a lower assessed value for occurrences of the same land system. Another factor contributing to a lower value, is that the land in the Gray Luvisol Soil Zone requires clearing before it can be cultivated.

The importance of soil texture is very clearly demonstrated in the pattern of assessed values in Fig. 6.17A. Land systems occurring on soils of clay and silty clay textures (texture group 8 and 9) have higher assessed values than the other soil types. Land systems which are developed on sandy loam soils (texture group 6) exhibit the lowest assessed values.

Slope also exerts a significant influence and it can be seen that the highest land values occur on land systems with class 2 slopes. Land with class 1 slopes is somewhat less valuable because of the poorer drainage and tendency to salinity. Areas with steeper slopes (slope class 3) have a higher per cent of uncultivated land; there are limitations to the use of farm machinery and the erosion hazard is greater.

When the relationship between the assessed value and landform is examined, it can be seen that the landform types with poor drainage and steep slopes tend to have the lowest values. In the case of landform type H the slopes along the glacio-fluvial channels are too steep for cultivation and remain in pasture. With landform type Y the flat poorly drained surfaces experience severe salinity and the land remains in unimproved grazing. There is also a tendency for lower values to occur in land systems with landform types K and R: knob and kettle landscape in the former and ridged landscape in the latter.

The relationships between the field characteristics and the assessed value

The relationships between the various field characteristics and the assessed value of the land are shown in a series of scatter plots in Fig. 6.18. Most diagrams exhibit a wide spread of points but in a few cases, definite or partial trends are observable.

In the first pair of parameters (Fig. 6.18 plot no. 1), a positive relationship is observed between the assessed value and the percentage of cultivated land in both the Dark Brown and the Black Soil Zones. Land systems with a high per cent of cultivated land have higher assessed value because arable land is capable of higher returns than pasture. Two categories of land can be recognized on the scatter plot: areas with less than 25 per cent arable land with assessed values of less than $3,500, and areas with more than 50 per cent cultivated with assessed values of greater than $3,500 per quarter section.

In plot No. 2 of Fig. 6.18 the wide scatter of points indicates that there is no direct relationship between the assessed value and the per cent of regular fields. Land

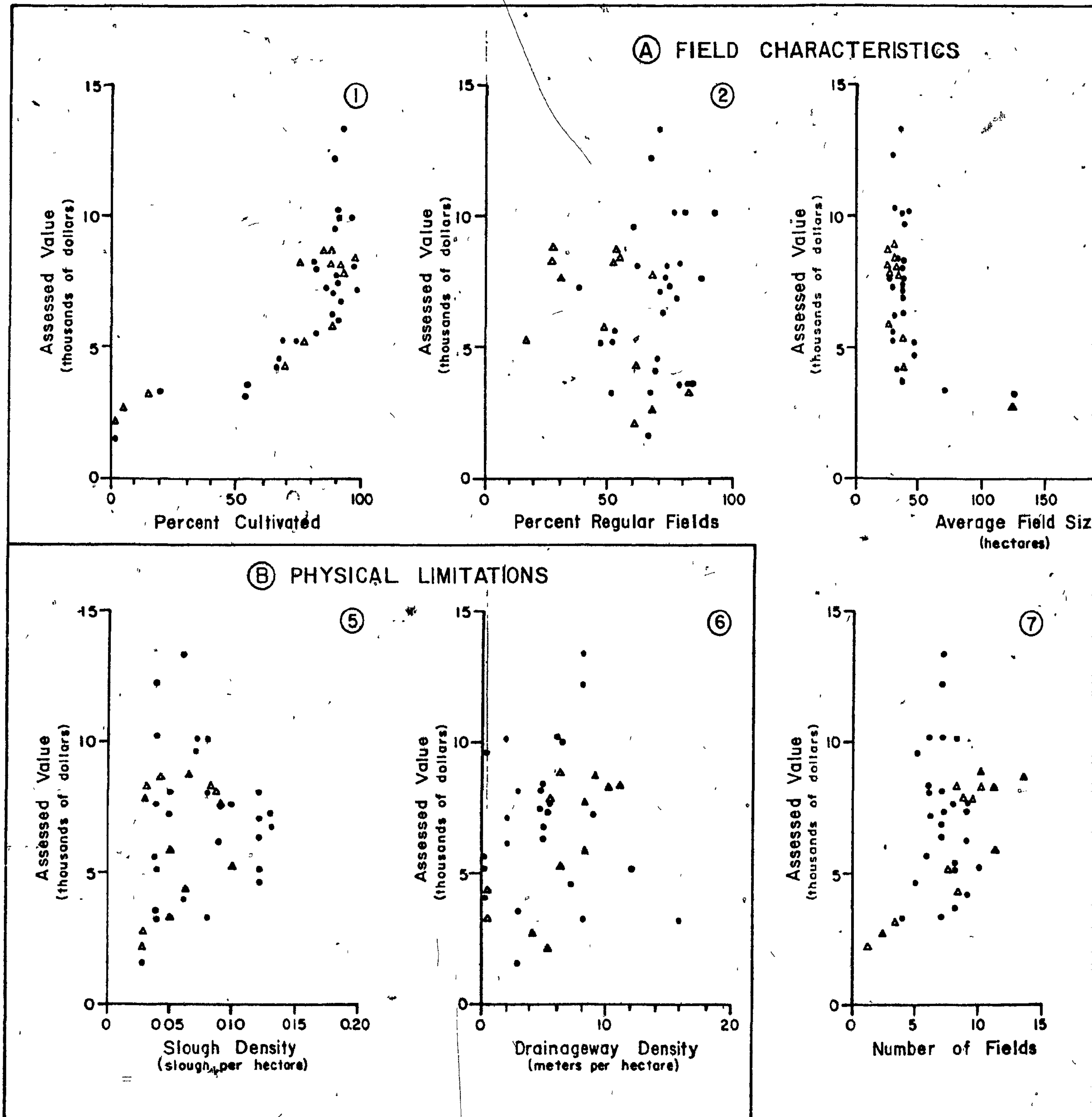
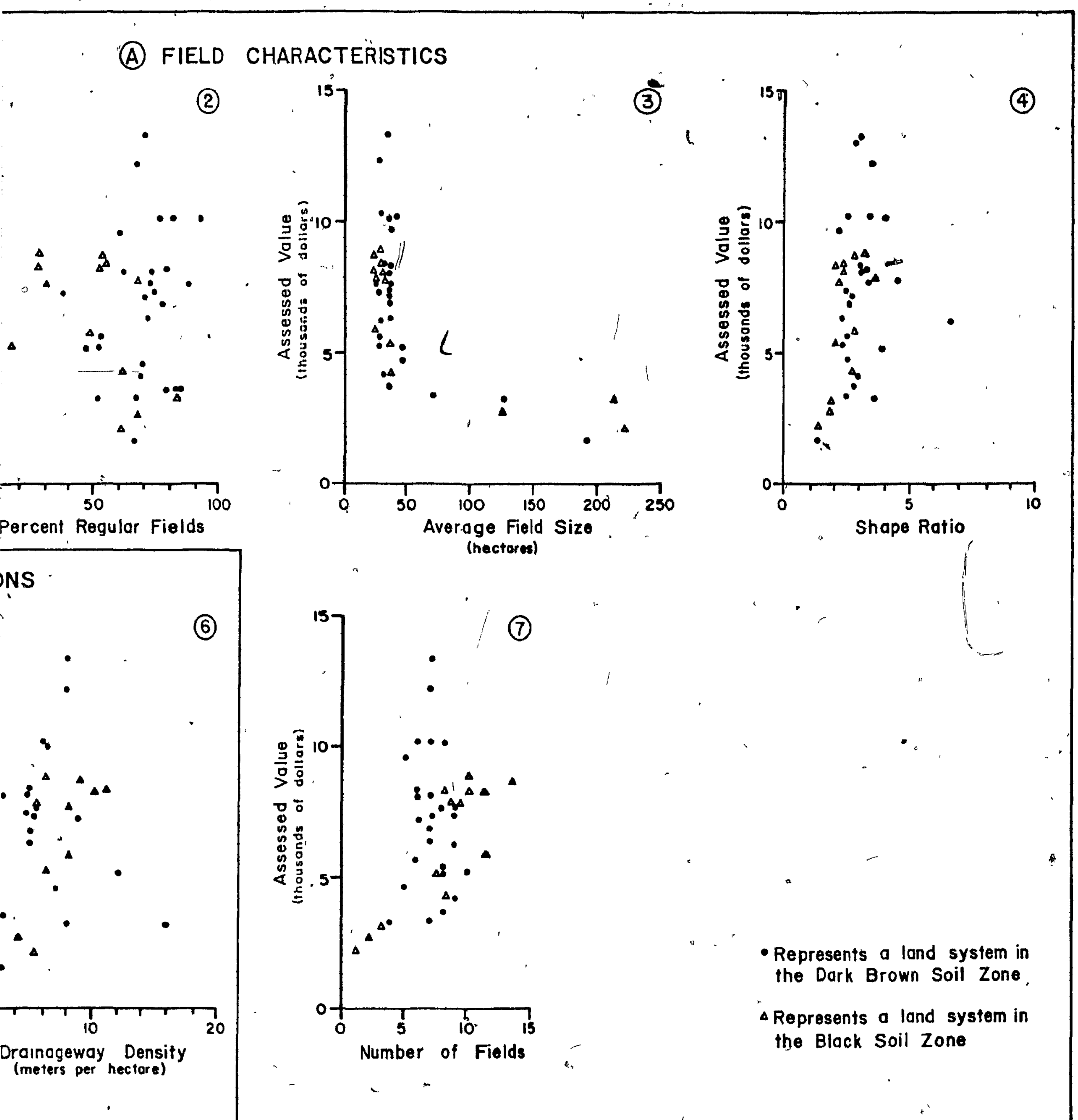


Fig. 6.18 The relationship between the assessed land value and A. the field characteristics.



ween the assessed land value and A. the field characteristics, B. the physical limitations.

systems in the Dark Brown Soil Zone exhibit a high per cent of regular fields which range in value from $1,500 to $13,500. Fields in the Black Soil Zone tend to be somewhat less regular but the range in values is also very wide.

When the assessed value is considered in terms of field size (plot no. 3 of Fig. 6.18) a partial negative relationship exists. However, two definite clusters can be observed: fields that are less than 50 hectares with a wide spread of values ($3,500 to $13,500), and fields that are large to very large, with values below $3,500. Very large fields are generally unimproved pastures, hence the lower values.

In plot no. 4 (Fig. 6.18) there is no apparent relationship between the field shape ratio and the value of the land. Fields generally have shape ratios of less than 5.0 and values that vary widely. It has been noted that the assessed values tend to be high where there is a high percentage of cultivated land (plot No. 1, Fig. 6.18), however, both cultivated and uncultivated land may exhibit variations in field shape and therefore the assessed value is not directly related to the shape ratio of the field, regardless of its use.

In the fifth set of parameters—the assessed value and the slough density—(Fig. 6.18, plot No. 5), no apparent relationship is observed from the wide scatter of points. In an area where continental glaciation has occurred, it might be expected that the assessed value would be somehow influenced by the slough density. However, it must be recognized that the size of sloughs and their potential for cultivation vary appreciably. Large perennial sloughs cannot be cultivated and so have an adverse effect on land values, whereas, shallow sloughs which rapidly dry up in summer can be planted with cereal crops and land values are little affected.

In plot No. 6 (Fig. 6.18) there is no apparent relationship between the assessed value and the drainageway density. The assessed values vary with the areas occupied by drainageways and the degree of channel development. For example, in areas where surface dissection is very subtle, the land can be cultivated and the effect of drainageways on land values is not as great as in areas where dissection has produced steep slopes. Cultivation on such slopes is limited and the land is generally left in pasture resulting in the lower values.

In the last pair of parameters in plot No. 7 of Fig. 6.18, there is a possibility that a relationship exists between the assessed value and the number of fields. The larger numbers of fields would seem to occur in areas of intensive cultivation and as intensively cultivated land tends to have a higher value, the correspondence between the greater numbers of fields and a higher assessed value is logical.

General summary

The assessed values are generally highest for the clay soils (group 9) and lowest for the coarse sandy gravelly soils. Within each soil textural group, the assessed value is lowest where unfavourable topography (slope and landform) or salinity occurs, either singly or in combination. The relationship between the assessed value and some field characteristics is very subtle, and in others there is no observable relationship.

THE RELATIONSHIP BETWEEN THE LAND SYSTEMS AND THE EXTENT OF CONSOLIDATION OF LAND HOLDINGS

The extent of consolidation of land holdings was examined to determine if this varied from one land system to another. The investigation was carried out with a view to assessing the significance of the physical environment in the consolidation of land. In addition, the sizes of consolidated holdings can be used as an indication of farm sizes in the different land systems.

Landownership in the Prairies is mainly on a quarter-section (65 hectares) basis, and so the quarter section forms a convenient unit in which to consider land ownership. The extent to which individual farmers in particular land systems, have organized their holdings in contiguous quarter sections is illustrated in Fig. 6.19. Each histogram shows the per cent frequency of occurrence of consolidated land holdings in ten size classes from 0.25 quarter section to 25 quarter sections (16 to 1619 hectares). There are 77 histograms for all of the land systems examined in the study.

In general, the sizes of consolidated land holdings are small, being less than eight quarter sections. This has evolved from the homestead settlement pattern which established the quarter section as a farm unit. This was often inadequate and the necessity for sufficient production or the desire on the part of some farmers to own larger land holdings, has led to some adjustments. However, the area having long been settled, expansion in most cases, was some distance away from the original homestead because neighbouring quarter sections were not available and land parcels that came up for sale, were rarely concentrated in the same place.

The very large sized holdings 15 to 30 quarter sections (970 to 1943 hectares) tend to occur on saline soils. For example, consolidated holdings larger than eight quarter sections, are found on land systems $\frac{\text{1J7A}}{\text{N+}}$, $\frac{\text{1J6L}}{\text{EN}}$, $\frac{\text{1J6L}}{\text{N}}$, $\frac{\text{1J7M}}{\text{N}}$, $\frac{\text{1K6M}}{\text{N+}}$, $\frac{\text{2K8L}}{\text{N+}}$ and $\frac{\text{1Y7A}}{\text{N+}}$ (histograms 19, 26, 27, 36, 40, 45 and 76). Large consolidated holdings also occur in land systems with steep slopes such as 3H7M which is developed in the glacio-fluvial channels and in land systems with a low moisture holding capacity such as 2G6F, 1J6F, 2K6F, 1U6F and $\frac{\text{1U6F}}{\text{E}}$ (histograms 10, 20, 42, 62 and 63).

Wind-eroded land systems such as $\frac{\text{1J6L}}{\text{EN}}$, $\frac{\text{1J7L}}{\text{E}}$ and $\frac{\text{1U6L}}{\text{E}}$

(histograms 26, 29 and 23) also exhibit a tendency to larger land holdings.

These large sizes are the result of the extensive acreage of submarginal lands which are generally utilized as pasture.

General summary

The sizes of the consolidated holdings do show some variation according to the land systems. They are generally small in land systems with fertile soils and large in land systems which are saline or have a low moisture storing capacity.

THE RELATIONSHIP BETWEEN THE LAND SYSTEMS AND FARMSTEAD DENSITY

Farmstead density was investigated because it can be used as an indirect measure of the productivity of the land system. To yield the same amount of income, fewer acres of land are required in fertile soils than in poorer soils or in areas of rough topography. A unit area of fertile land is capable of supporting more farm families than the same unit area located on poorer soils.

Farmstead density is expressed as the number of acres per farmstead which seems a more realistic measure than the number of farmsteads per section. The data were obtained by direct count of farmsteads on the Rural Municipal Maps and the results are plotted as bar graphs in Fig. 6.19.

The most productive land systems are easily identifiable by the relatively limited acreages per farmstead--for example, land systems 1D8L, $\frac{\text{1G6F}}{\text{W-}}$ $\frac{\text{1G7L}}{\text{W-}}$ and $\frac{\text{1G7M}}{\text{W-}}$ (histograms 6, 7, 8 and 9). These are in marked contrast to the saline land systems or those with low moisture storing capacity such as $\frac{\text{1J7A}}{\text{N+}}$, $\frac{\text{1J6F}}{\text{N}}$, $\frac{\text{1K6M}}{\text{N+}}$, $\frac{\text{1U7M}}{\text{N}}$ and 1J6F (histograms 19, 23, 40, 42 and 20 respectively) where there are between 5,000 and 10,000 acres per farmstead.

In summary, farmstead density is generally low in land systems which have saline soils or which have a low moisture holding capacity.

FARM SIZES IN SELECTED LAND SYSTEMS

Farm size analysis was carried out with a view to determining the extent of the variation produced by soil and topographic differences.

The large size of the study area as well as the large number and the very variable sizes of the different land systems made it very difficult to obtain farm sizes for the whole Wynyard area and therefore only seven land systems were selected. This was done on the basis of their comparable sizes and occurrence in two or three soil zones. Data for total farm size were collected from the Rural Municipal Maps of the area and they are tabulated in Fig. 6.20.

There is little systematic difference between the

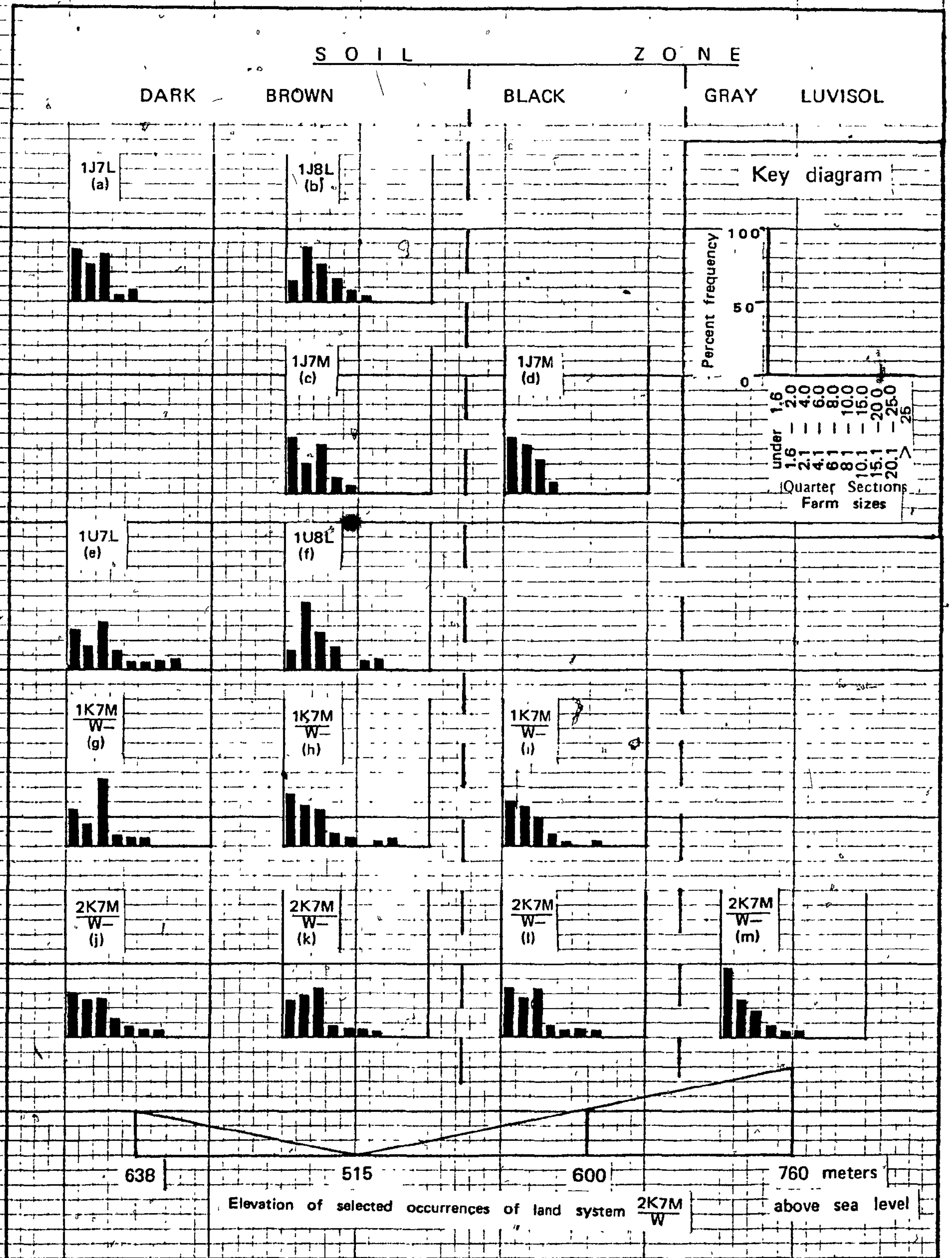


Fig. 6.20 Percent frequency of farm sizes in selected land systems .

various sets of histograms. However, soil and topographic differences do seem responsible for some of the variations in farm sizes. For example, a higher frequency of larger farms occurs in areas of finer soils: land system 1J8L (histogram b) with clay loam lacustrine soils has larger farms than land system 1J7M (histogram c) with loamy glacial till soils.

Where landform types differ, farm sizes also vary. Land system 1J7L (histogram a) gently undulating and containing large shallow sloughs, has a maximum size of less than eight quarter sections. On the other hand, the largest farm in the nearly level unpatterned land system 1U7L (histogram e), is 20 quarter sections.

A greater variation is seen in farms occurring in different soil zones. For example, land system 1J7M (histogram c) in the Dark Brown Soil Zone has a greater frequency of farms of more than six quarter sections, than land system 1J7M (histogram d) in the Black Soil Zone. The zonal difference is better illustrated in land systems $\frac{1K7M}{W-}$ and $\frac{2K7M}{W}$. Land system $\frac{1K7M}{W-}$ (histogram g and h) in the Dark Brown Soil Zone contains farms as large as 20 quarter sections, whereas, in the same land system in the Black Soil Zone, farms do not exceed 15 quarter sections. The same trend is seen in the four selected occurrences of land system $\frac{2K7M}{W}$. In the Dark Brown Soil Zone, this land system exhibits larger farms than is the case in the Black and Gray Luvisol Soil Zones (histograms l and m).

An increase in elevation is a factor in the tendency to smaller farms. A comparison of two occurrences of land system $\frac{2K7M}{W}$ (histograms j and k) in the Dark Brown Soil Zone shows that the land system which is located on higher ground (600 - 642 meters) has 30 per cent small farms of 1.5 quarter sections compared with 25 per cent in the same land system at an elevation of 518 - 600 meters. The per cent frequency of small farms increases progressively with elevation--for example, land system $\frac{2K7M}{W}$ (histogram l) at an elevation between 518 and 683 meters, in the Black Soil Zone has 35 per cent small farms, the frequency increasing to 48 per cent in the Gray Luvisol Soil Zone (histogram m) located between 683 and 765 meters.

Moisture limitations could be a factor contributing to the larger sizes of farms in the Dark Brown Soil Zone, where large holdings could be an insurance against crop failure.

Within the selected land systems, the higher frequencies of small farms of 0.25 quarter section to four quarter sections are probably the result of farm management problems such as timeliness in seeding, swathing and harvesting.

General summary

Farms are generally small in the selected land systems, with the Dark Brown Soil Zone exhibiting larger farms. Soil materials and texture do not contribute significantly to differences in farm sizes, whereas, the greatest variation occurs with a change in elevation, particularly in the Gray Luvisol Soil Zone.

CHAPTER 7

CONCLUSIONS

Land system mapping has been applied extensively in several countries particularly Australia where the significance of the land system approach for assessing the agricultural potential of the areas studied, has been clearly demonstrated. In Canada, the land system approach has only recently been investigated and there has been more emphasis on its application to forest land. This study of the Wynyard area is one of the first to apply the land system methodology to an area of intensive grain cultivation.

In the study it was demonstrated that land systems can be defined in terms of pedologic and geomorphic characteristics which are recognizable on the airphoto and on the ground. The identification and mapping of land systems in the prairie landscape was readily accomplished using vertical black and white airphotographs with nominal scales ranging between 1:73,000 and 1:82,000, and a land system map at a scale of 1:250,000 was prepared.

LAND SYSTEMS

Five soil-climatic subzones were recognized and within these, 77 distinct land systems were delineated and classified using an alpha-numeric coding system. This level of subdivision is adequate for a scale of 1:250,000. However, for large scale mapping, further subdivisions could be used, depending on the amount of detail required for the particular project.

It was found that there was generally good correspondence between the land systems and their agricultural use. Land systems on relatively gentle topography have a higher percentage of arable land, for example, land system $\frac{1G7M}{W-}$ although dissected, has less than five per cent slopes, and arable land covers 98 per cent of the area. Land system $\frac{1J6L}{E+}$, which is gently undulating, and 1U9L, which is nearly level and unpatterned have 90 per cent of their areas under cultivation. As the gradient increases, the proportion of arable land becomes less. On land systems such as $\frac{3K7M}{W+}$ and $\frac{3K8M}{W+}$, because of the high risk of erosion on their steep slopes, there is only 70 per cent of the area under cultivation.

In areas where erosion is a hazard, it was found that soil conservation measures have generally been applied. For example, in land system $\frac{1J6L}{E+}$, which is severely wind eroded, strip cropping is practised. On the poor unimproved soils which are saline or which have a low moisture storing capacity, crop yields are low and poor moisture storage can also result in soil drifting. Land systems with these characteristics are best left uncultivated. In the Wynyard area it was found that saline land systems such as $\frac{1B6M}{N+}$ and $\frac{1J7A}{N+}$, and land systems which have low moisture retention such as 2B6F and 2K6F, are generally utilized as pastures.

LAND SYSTEMS AND FIELD CHARACTERISTICS

In the second section of the study the land system framework was used as a basis for examining some of the other features of the agricultural landscape of the prairies, such as field characteristics and land value.

It was found that in the different land systems, there is little variation in the numbers of fields. Field sizes are large in land systems with saline soils such as $\frac{1J7A}{N+}$ and $\frac{1Y7A}{N+}$, and in land systems with a low moisture storing capacity, such as 2B6F. This is because such areas are not cultivated and the dominant land use is grazing. Typical field sizes in these land systems are 120 to 200 hectares (200 to 500 acres) compared with 20 to 60 hectares (50 to 150 acres) in the areas with cereal crops.

Field shapes are generally square or rectangular, however, some land systems where the soil is susceptible to wind erosion exhibit fields with large shape ratios—the relatively narrow field widths minimizing the effect of wind. Land system $\frac{1J6L}{E+}$, severely wind eroded, strip cropped and with a high shape ratio of 6.7, provides an excellent illustration.

The major physical interruptions—sloughs and drainageways—were assessed in relation to land systems. Sloughs are most numerous in kettled and ridged landforms with a density of 0.11 slough per hectare, and infrequent in unpatterned landscapes where the density is only 0.04 slough per hectare.

Drainage being centripetal in knob and kettle topography and to a lesser extent, in ridged landforms, the density of drainageways averages 4 meters per hectare. This density is considerably lower than that for dissected landscapes where the density averages 9 meters per hectare.

INTERRELATIONSHIPS BETWEEN FIELD CHARACTERISTICS

The interrelationships between the various field characteristics were also investigated and it was found that positive relationships existed between:

(i) the number of fields and the per cent of cultivated land;

(ii) the number of fields and the field shape ratio;

(iii) the number of fields and the drainageway density; and

(iv) the shape ratio and the per cent of cultivated land.

Negative relationships are found between:

(i) the number of fields and the average field size;

(ii) the average field size and the per cent of cultivated land; and

(iii) the per cent of regular fields and the slough density.

In the other pairs of parameters examined, there is no apparent relationship. This is partly because of the general uniformity of the checkerboard pattern of land subdivision in the prairies and partly because very frequently, it is the cumulative effect of the physical environment rather than a single factor that is responsible for the character of a given region.

FIELD CHARACTERISTICS AND LAND SYSTEM PARAMETERS

When the field characteristics were examined in relation to the land system parameters -slope, landform, soil material and texture—some direct links became apparent. The results show that the largest numbers of fields (nine fields per section) occur in areas on the gentler slopes, particularly in dissected landscapes, such as landform types D and G, and on unpatterned land (landform type U), whereas, the smallest numbers (three fields per section) are present in landform type H (glacio-fluvial channels) and landform type Y (runways) which are for the greater part in pasture.

When considered in relation to soils (parent materials and texture), it was found that the largest numbers of fields (eight fields per section) occurred on the finer textured soils, whereas, few fields (three fields per section) occurred on the alluvial materials. In the latter situation, salinity is often a major problem and fields left in native pasture are very large (120 to 200 hectares) and for the greater part located in runways.

In reviewing land systems it was noted that the percentage of arable land is higher in areas with gentler slopes. Cultivation is limited by the steepness of slopes and the highest percentage of cultivated land occurs on undulating land. This control becomes very evident when each land system parameter is examined individually in relation to the proportion of land under cultivation. Very steep slopes (Class 4) with five per cent grade have the lowest percentage of cultivated land, and areas with gentle slopes (Class 1 and 2) have the highest percentage of arable land. When landform type is considered, it is found that landform types with steeper slopes such as H (glacio-fluvial channels) and Y (runways) have only 20-22 per cent of their area under cultivation.

In assessing the area of cultivated land in relation to soils, it was found that sandy loam soils (texture group 6) because of its lower moisture holding capacity has only 70 per cent under cultivation compared with 90 per cent for the heavier soils (texture group 9). Low moisture storage also accounts for only 60 per cent of fluvial soils being cultivated. Soils of alluvial materials are poorly drained and often saline with the result that only about seven per cent is under cultivation.

LAND VALUE

The extent of the variation of the assessment value of the different land systems, was also investigated. It was found that the major physical control on land values is soil texture, with clay soils having the highest values ($12,300 per section). The lowest values are $1,800 for saline soils and $3,000 for gravelly fluvial soils with a very low moisture storing capacity.

When the assessed values were examined in relation to field characteristics, few definite relationships were found. Positive relationships were observed between (i) the assessed value and the percentage of cultivated land, and (ii) the assessed value and the number of fields, whereas, a negative relationship existed between the assessed value and the average field size. Land under cultivation has a higher value than pasture and since cultivated land tends to be divided into relatively large numbers of fields, a section which is cultivated contains smaller fields than one which is in pasture.

FARM SIZE

The investigation of farm sizes in relation to land systems, shows that smaller farms (0.25 to 4 quarter sections) are predominant. Larger farms (10 to 20 quarter sections) do occur in areas with finer soils, such as land system 1U8L, on very gentle topography as in land system 1U7L, and in land systems of the Dark Brown Soil Zone. At increasing elevations there appears to be a decrease in farm size, particularly in the Gray Luvisol Soil Zone. This is probably due to the greater significance of mixed farming in this area. Although natural grassland for grazing is limited, forage crops are important, resulting in more livestock production or dairy farming which requires less land than small grain farming.

An examination of the extent of consolidation of farm land, shows that in land systems which have fertile soils, there is a typical farm size of 1 to 4 quarter sections. whereas, in land systems with saline soils or soils with a low moisture storing capacity, the sizes are appreciably larger, ranging between 15 and 30 quarter sections. In the former group of land systems farmstead density is 700 acres (280 hectares) per farmstead. In contrast, land systems with poorer soils have a lower capacity for supporting farm families and farmsteads are therefore sparse, with a density of 8,500 acres (3400 hectares) per farmstead.

It has been demonstrated that land system mapping is very useful for land evaluation. In the Wynyard area there is good correspondence between land use and the soil capabilities, however, in an intensively cultivated area where the moisture efficiency is critical for crop growth and where the danger of soil erosion is ever present, a re-evaluation of land is essential to ensure high crop yields. In addition, with the growing demands for food, it is imperative that the soil which is one of the most valuable natural resources is used wisely. It is hoped that this study of land systems, field characteristics, land value and farm size, will contribute towards a better understanding of the land in the Wynyard area.

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LAND SYSTEMS MAP (FIG. 4.1) AT BACK OF THESIS,

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LAND SYSTEMS OF THE WYNYARD MAP AREA

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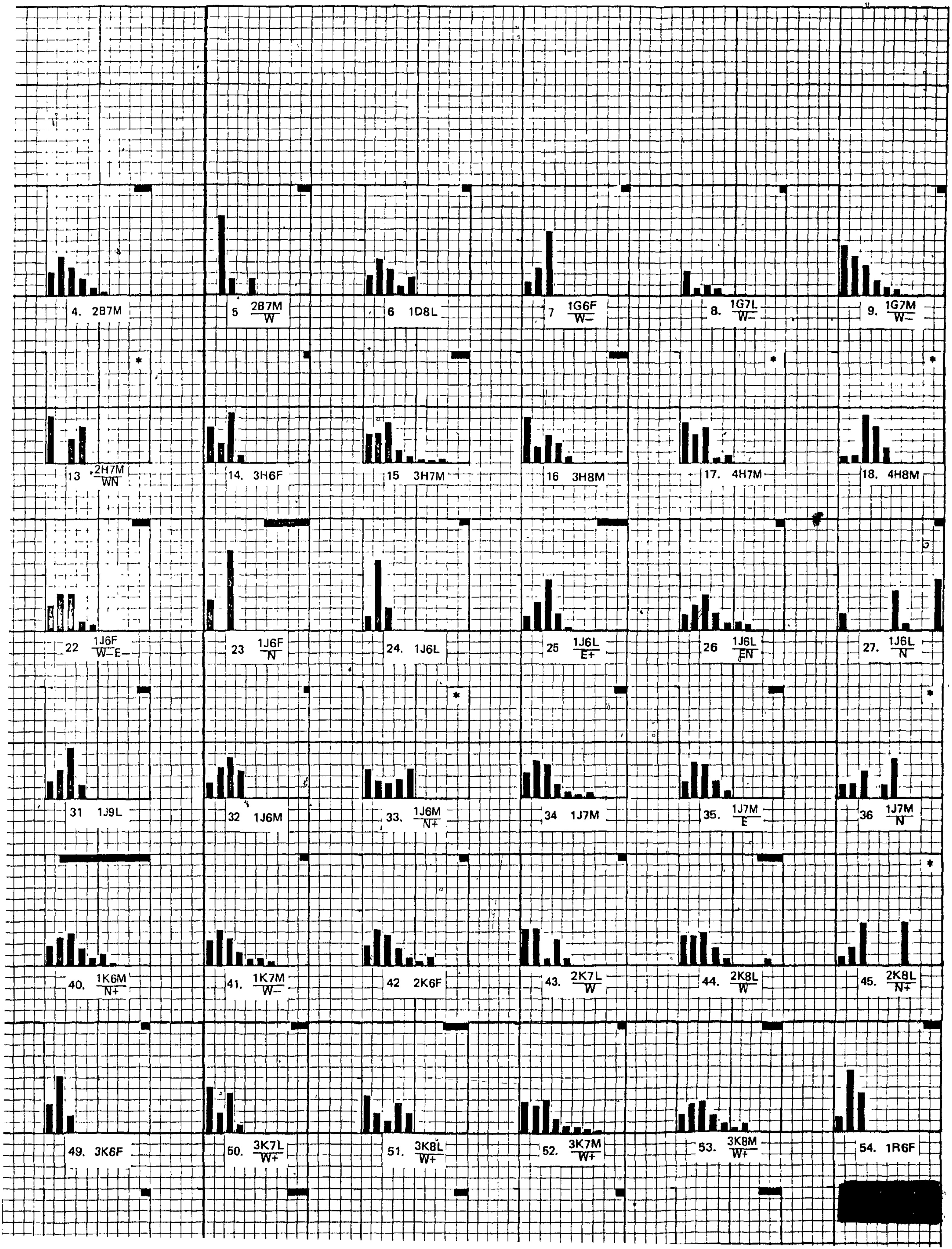
RESEARCH BRANCH, CANADA DEPARTMENT OF AGRICULTURE.

BASE MAP BY THE SURVEYS AND MAPPING BRANCH,
DEPARTMENT OF ENERGY, MINES AND RESOURCES,
OTTAWA, 1977.

Fig. 6.19 Percent frequency distribution of size of consolidated holdings and farmstead density according to land system.


1. 1B6M/N
2. 1B7M
3 2B6F
4 2B7M
5 2B7M/W
6
10. 2G6F
11 2G7M/W
12 2H7M
13 2H7M/WN
14 3H6F
15
19 1J7A/N+
20 1J6F
21 1J6F/E–
22 1J6F/W–E–
23 1J6F/N
24
28. 1J7L
29. 1J7L/E
30. 1J8L
31. 1J9L
32. 1J6M
33.
37. 1J8M
38 1K6F/W–
39. 1K8L
40. 1K6M/N+
41. 1K7M/W–
42.
46. 2K9L/W
47. 2K7M/W
48. 2K8M/W
49. 3K6F
50. 3K7L/W+
51


4. 2B7M
5 2B7M/W
6 1D8L
7 1G6F/W−
8. 1G7L/W−
9. 1G7M/W−
13 2H7M/WN
14. 3H6F
15 3H7M
16 3H8M
17. 4H7M
18. 4H8M
22 1J6F/W−E−
23 1J6F/N
24. 1J6L
25 1J6L/E+
26 1J6L/EN
27. 1J6L/N
31 1J9L
32 1J6M
33. 1J6M/N+
34 1J7M
35. 1J7M/E
36 1J7M/N
40. 1K6M/N+
41. 1K7M/W−
42 2K6F
43. 2K7L/W
44. 2K8L/W
45. 2K8L/N+
49. 3K6F
50. 3K7L/W+
51. 3K8L/W+
52. 3K7M/W+
53. 3K8M/W+
54. 1R6F

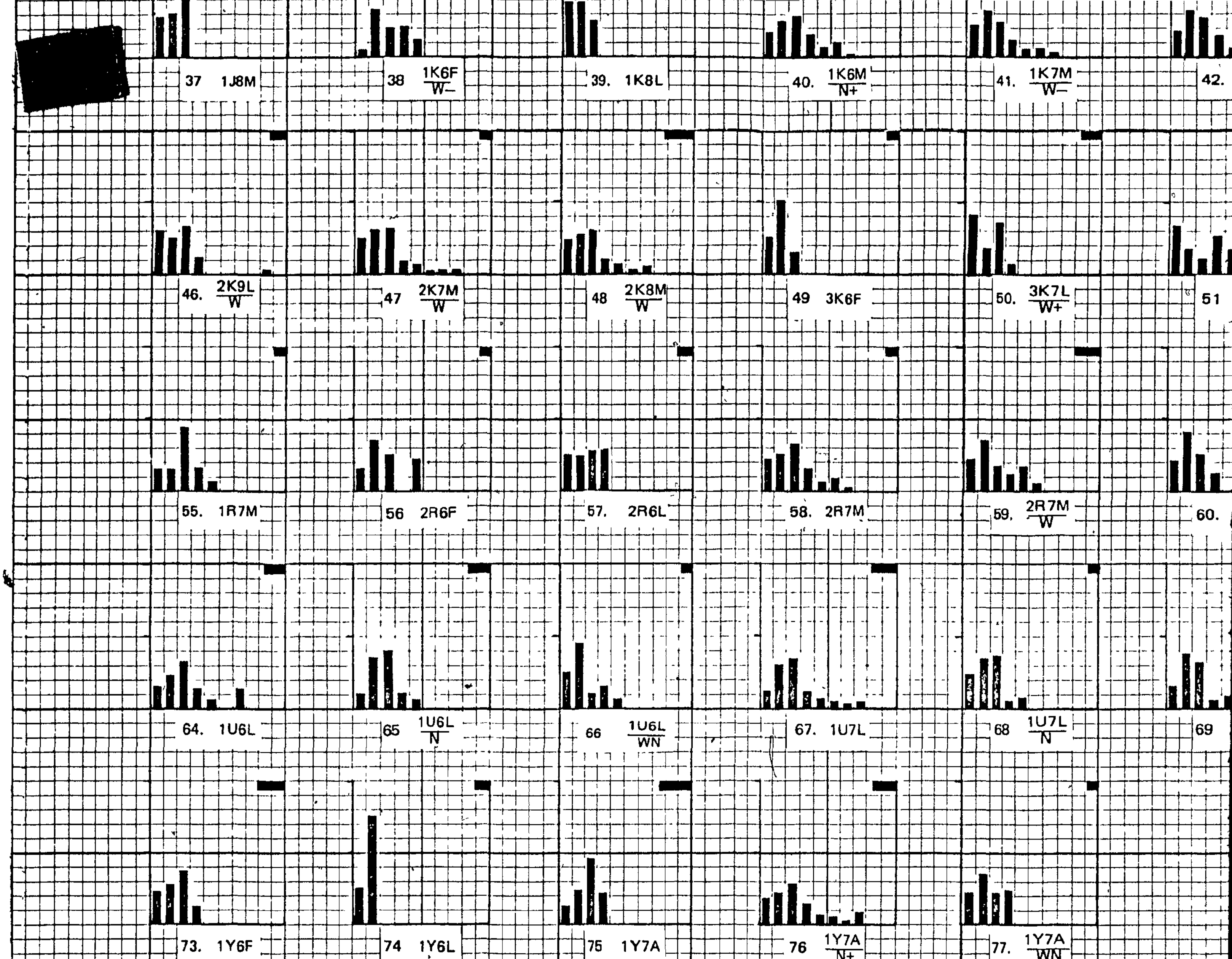
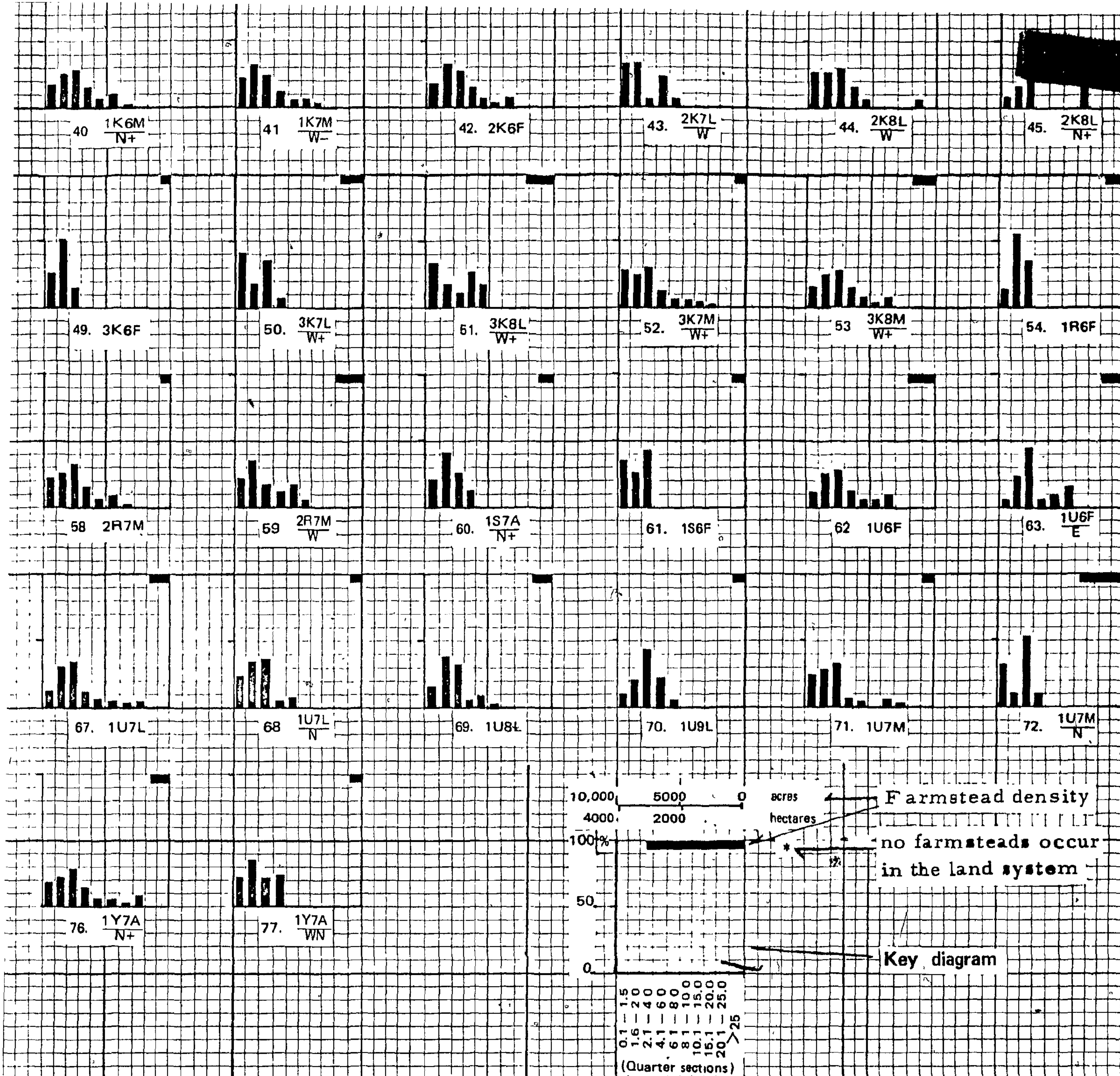
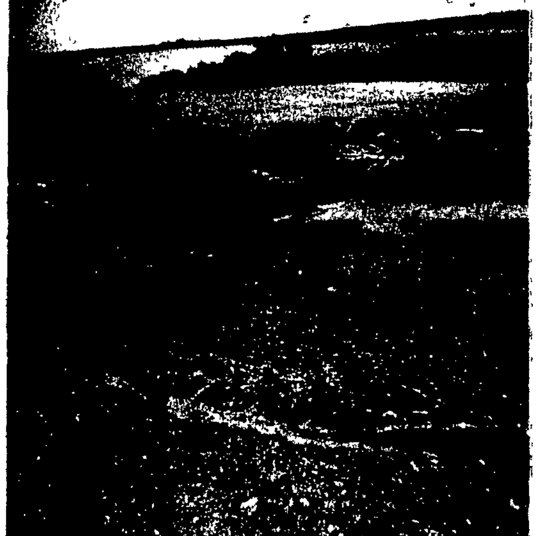


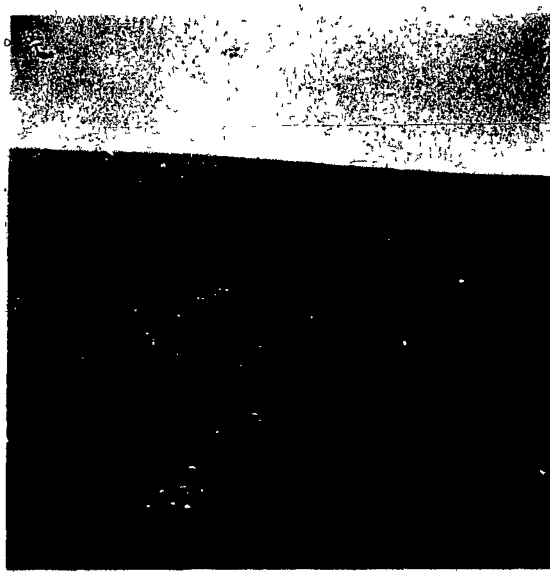
Fig. 6.19 Percent frequency distribution of size of consolidated holdings and farmstea



tion of size of consolidated holdings and farmstead density according to land system .



A. Soil erosion on bare loam soils of morainal origin, after a rainstorm .
(Location : Sect.4; Tp.25; R.16)



B. The same field showing that the amount of soil loss is greater on the lower parts of long slopes.
(Location : Sect.4; Tp.25; R.16)

Due to the slough being seeded at a later date, the crop in the slough and the crop of the neighbouring field cannot be swathed in a single operation

[redacted]

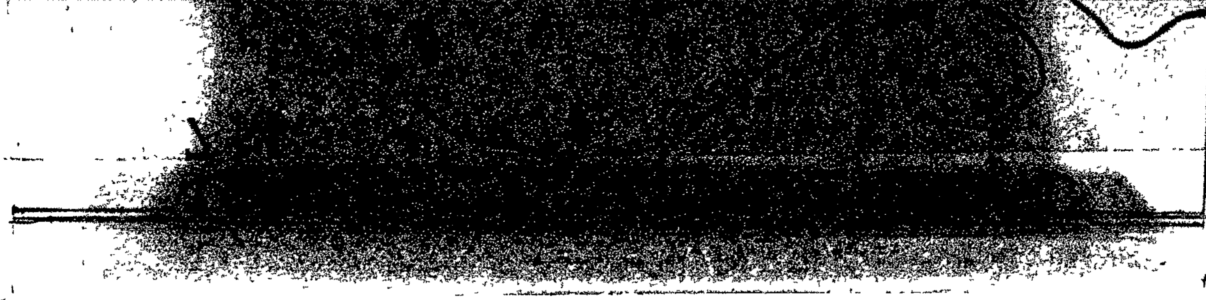
Rill erosion on fallowed loam soils developed on morainal materials
(Location Sect.4, Tp.25, R.16)

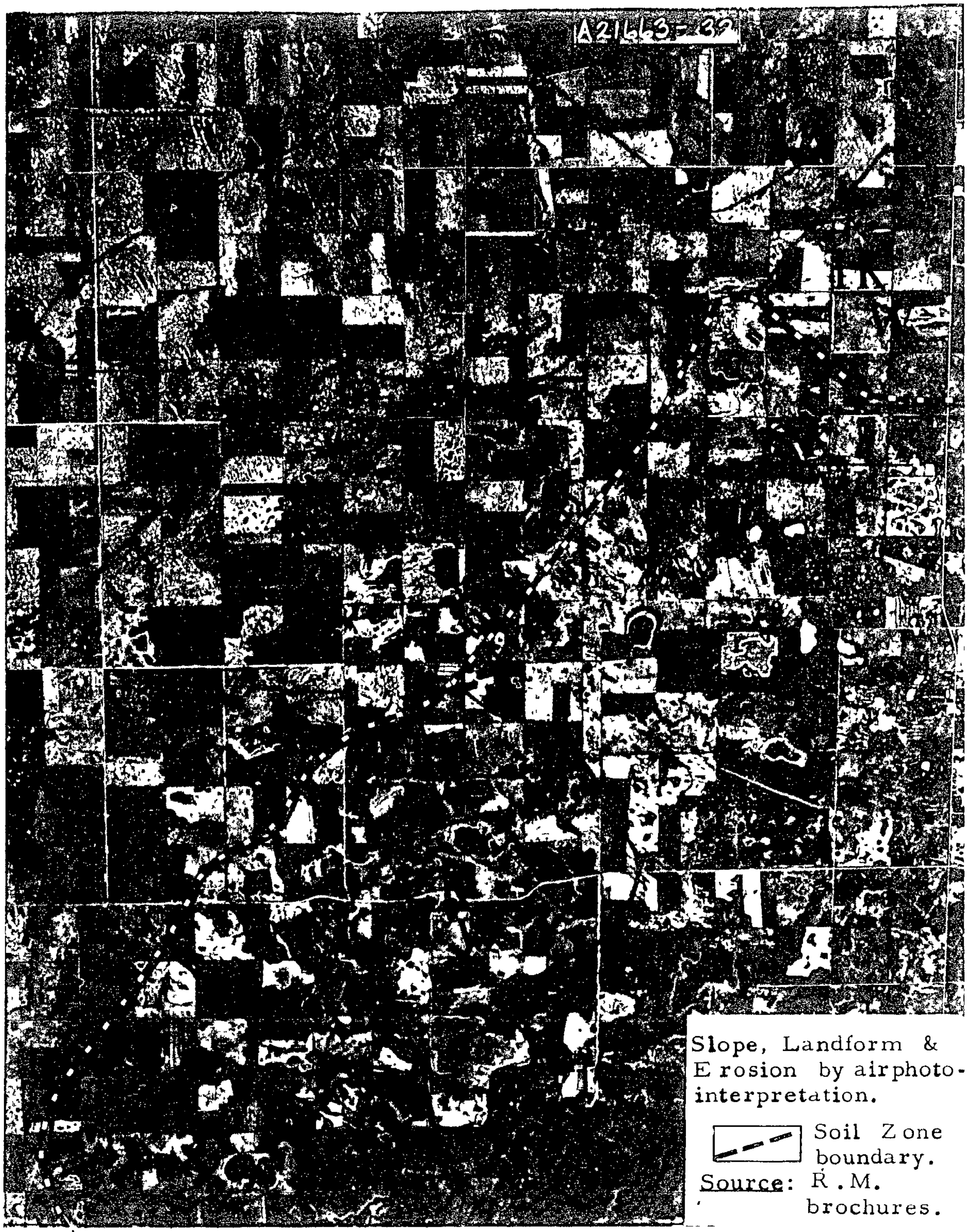
PLATE 4

Accumulation of drifted soil in a blow ridge along a fence indicating severe wind erosion (Class E+)
(Location Sect.34, Tp 24; R 27)

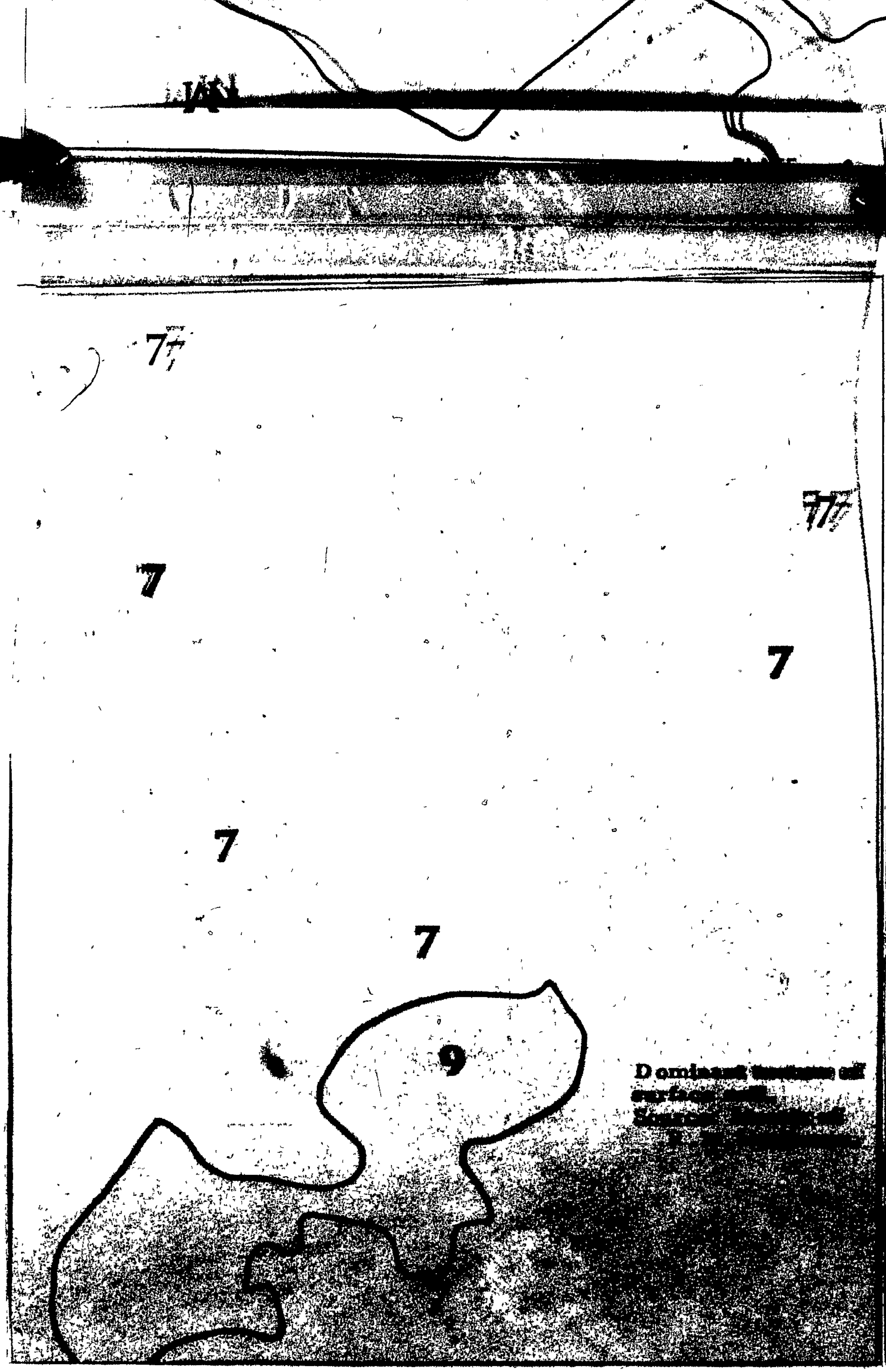
PLATE 5

The presence of salts in a field of wheat in Wynyard, Saskatchewan, is indicated by grayish barren spots and irregularity in crop vigour
(Location Sect 25, Tp 33, R.19)

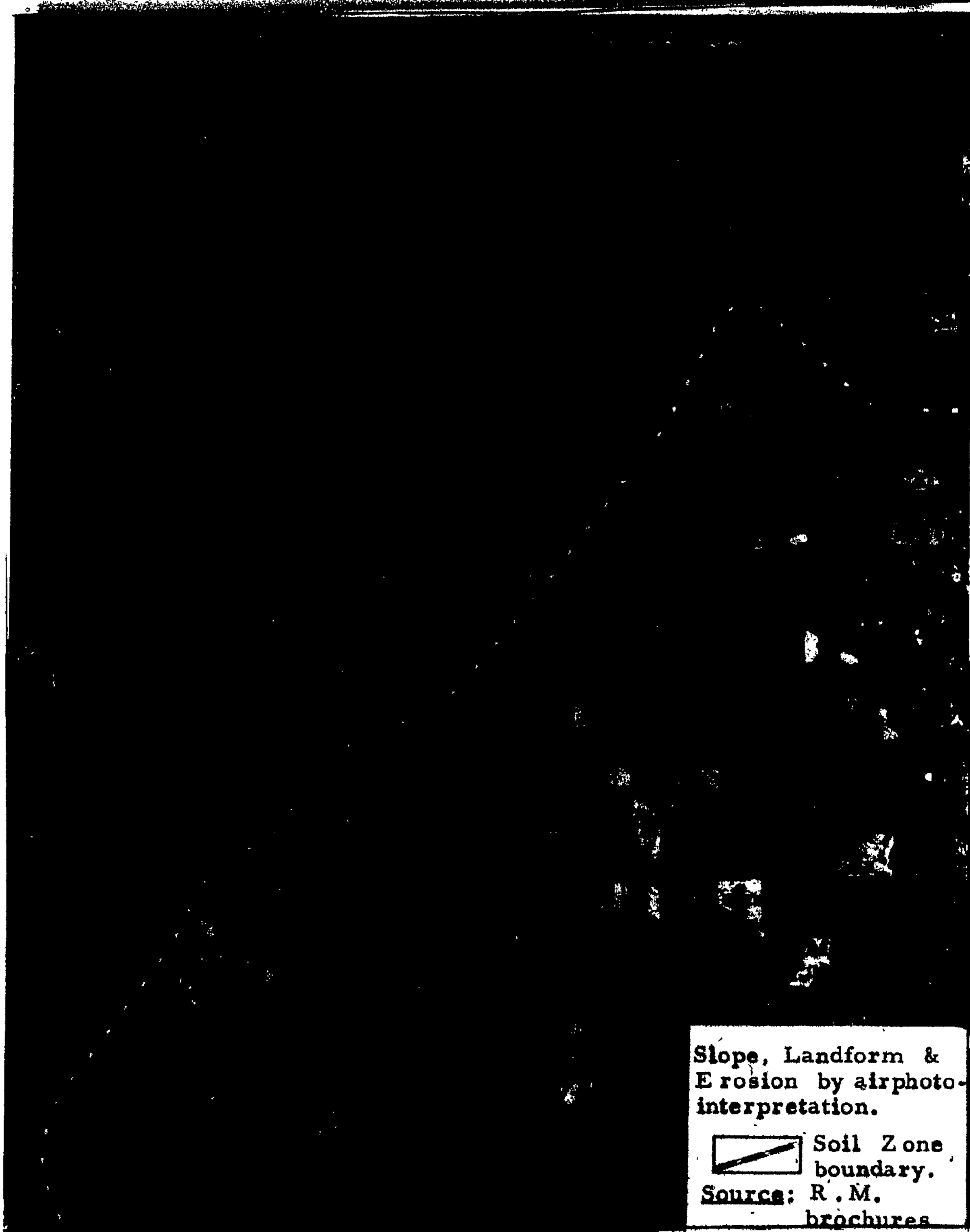




Overlays illustrating the procedure for the derivation of land systems

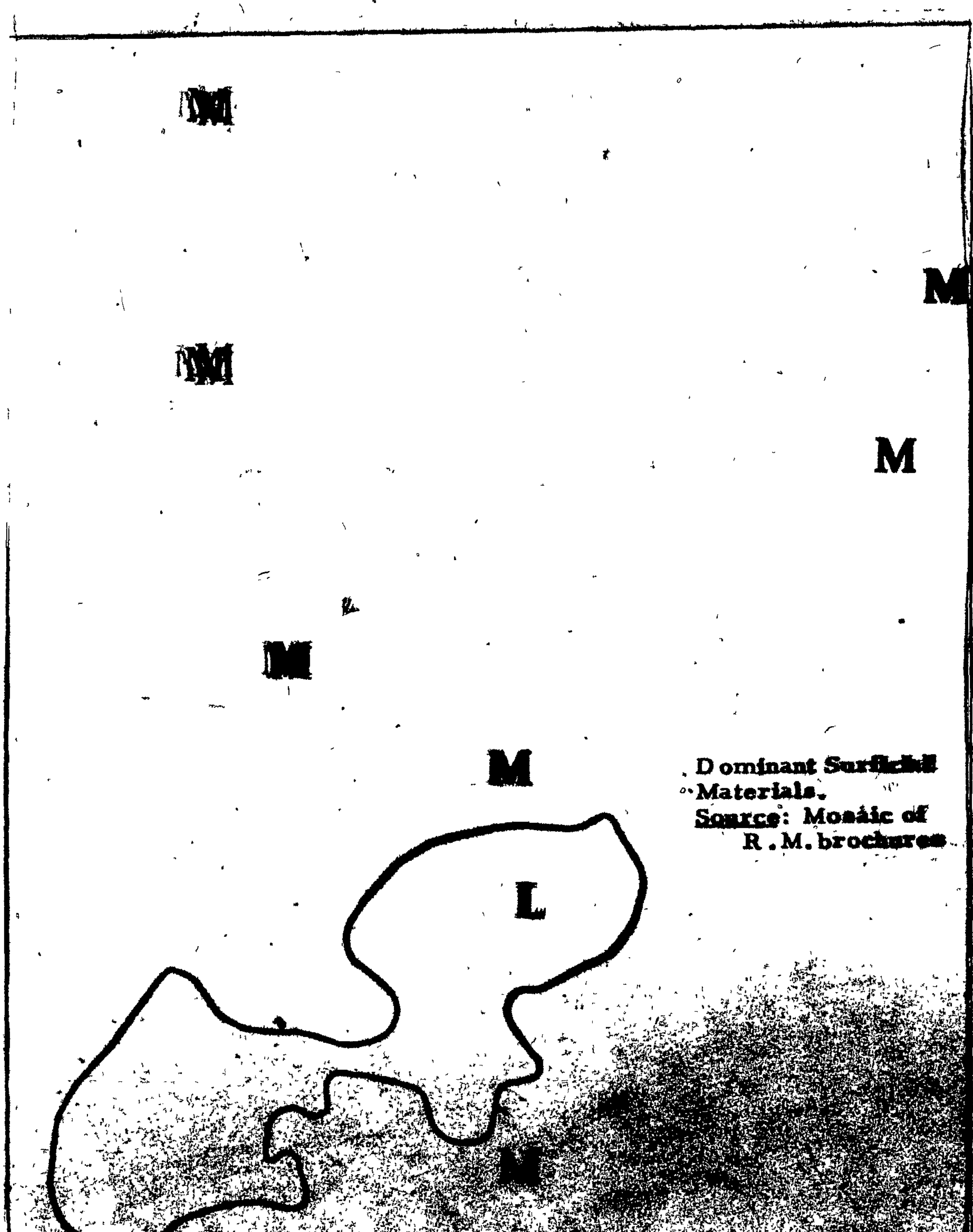


Dominant [illegible]



Overlays, illustrating the procedure for the derivation of land systems.

PLATE 6


M
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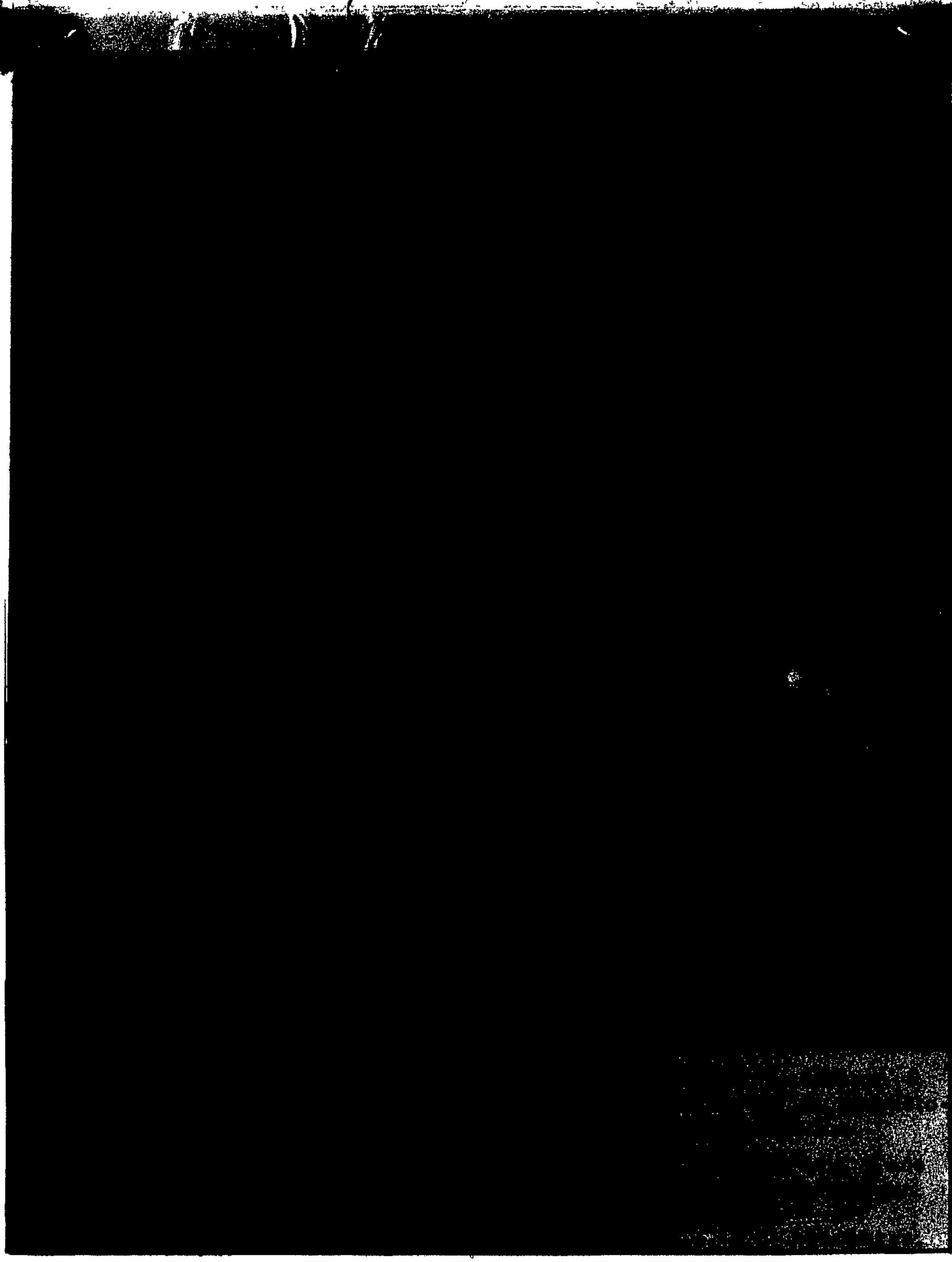
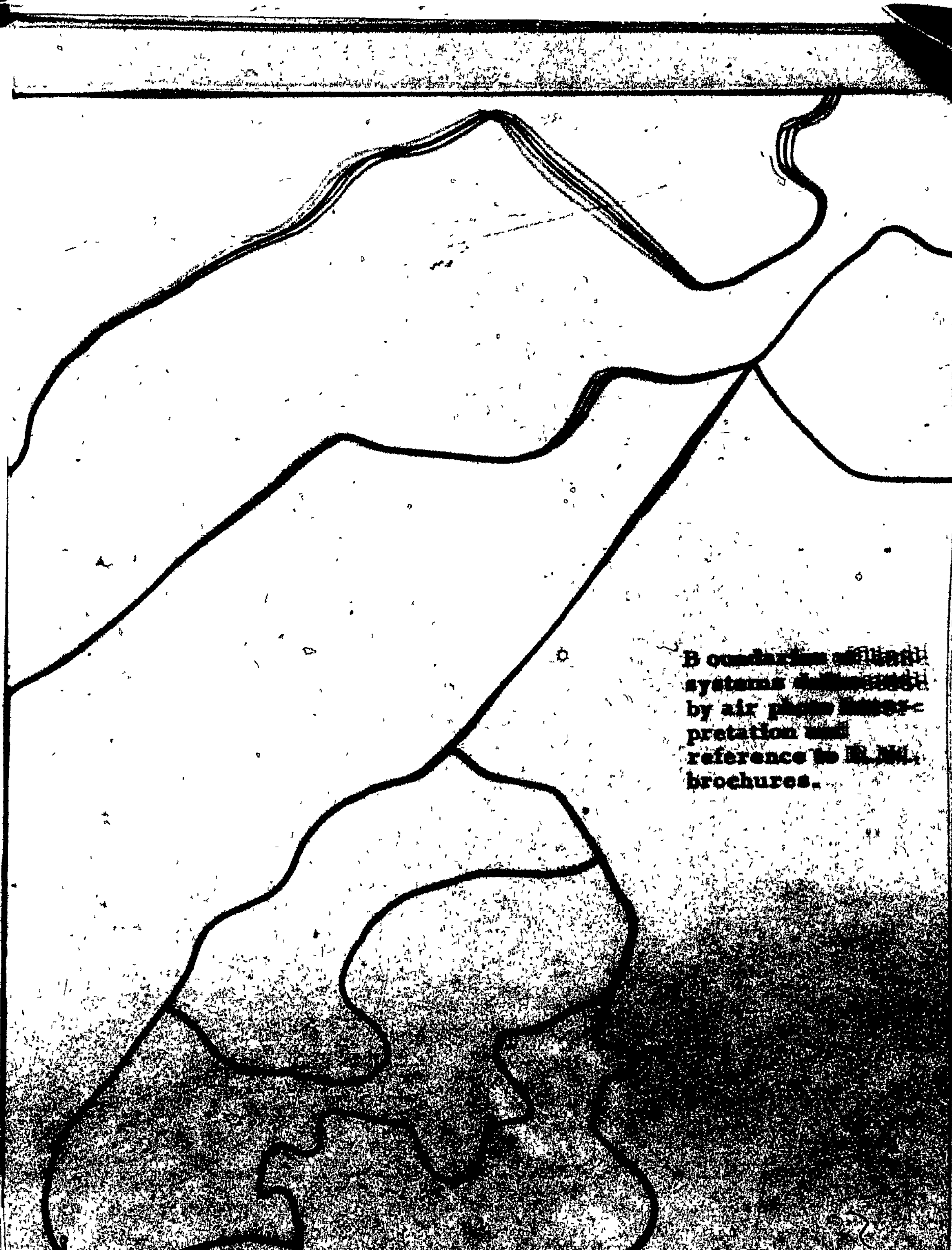
Dominant Surficial Materials.
Source: Mosaic of R.M. brochures

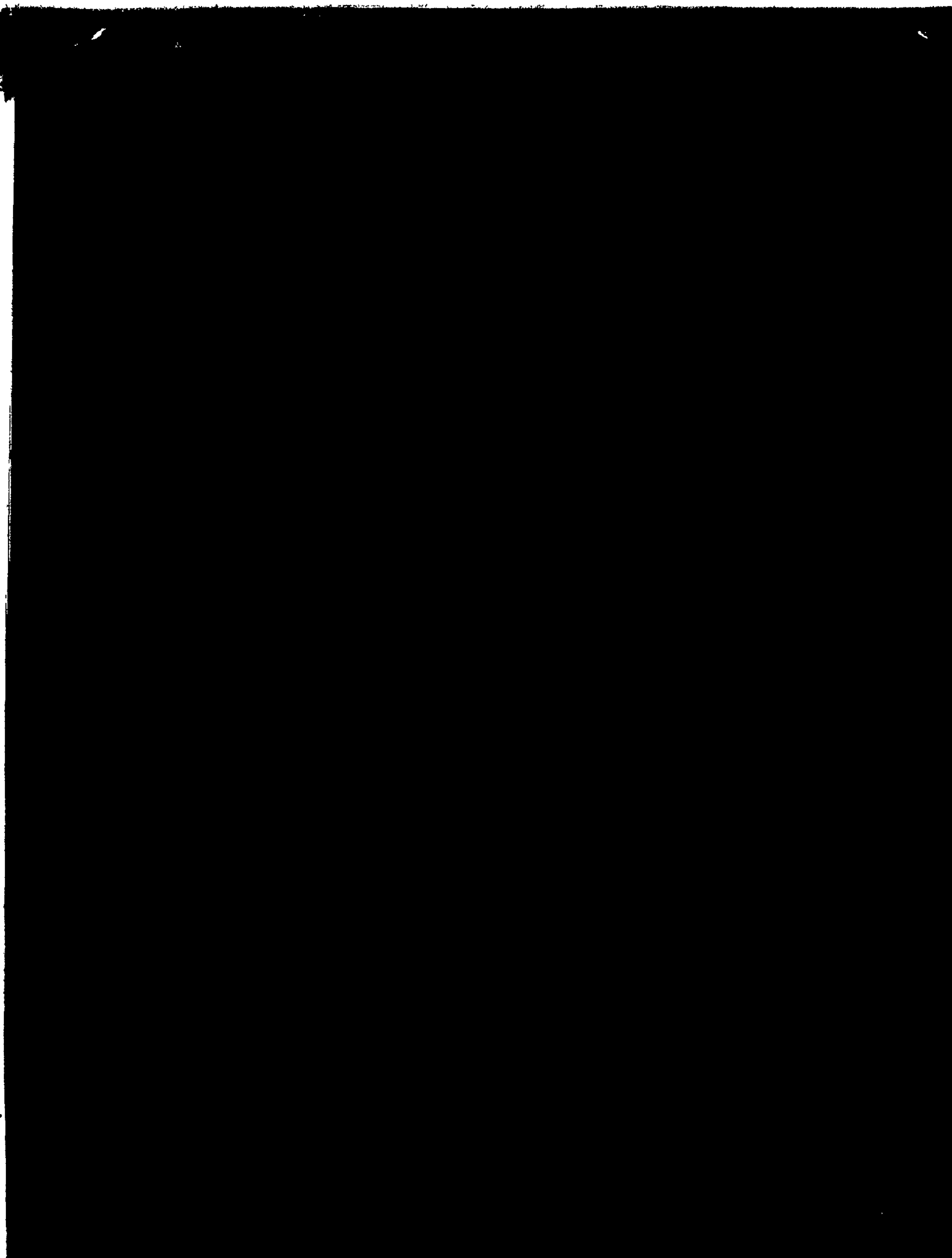
PLATE



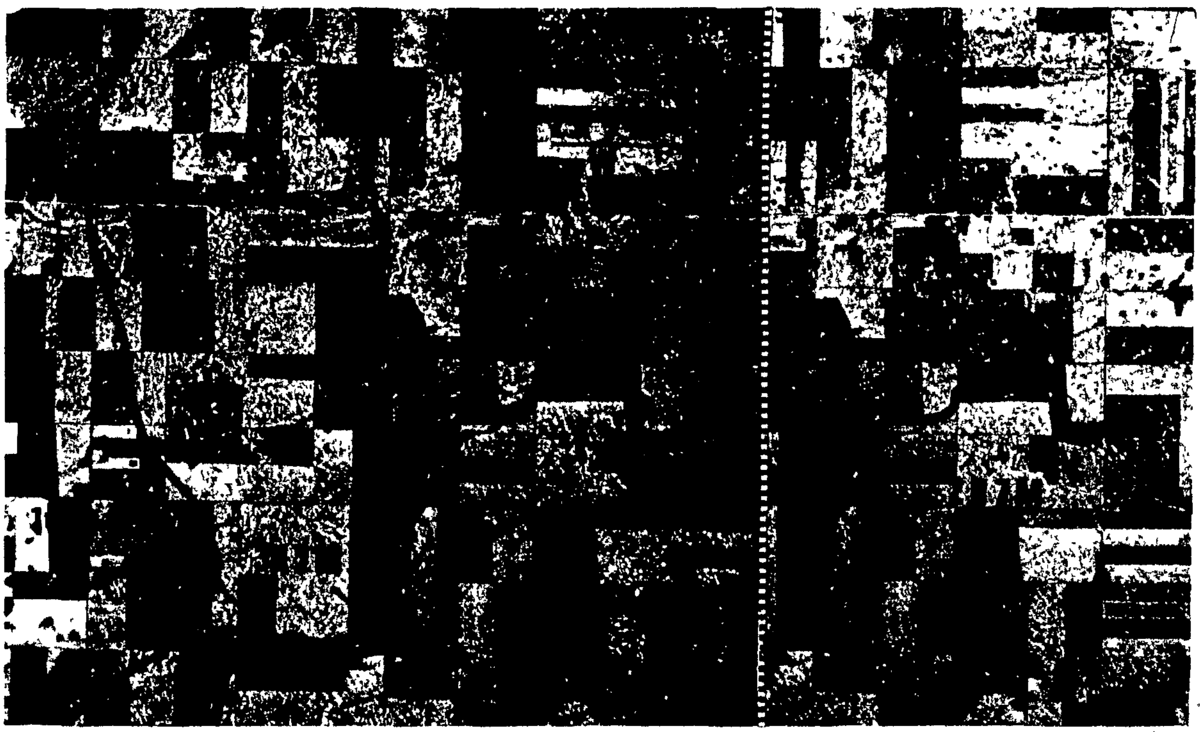
Overlays illustrating the procedure for the derivation of land systems.



Boundaries of land systems delineated by air photo interpretation and reference to R.M. brochures.

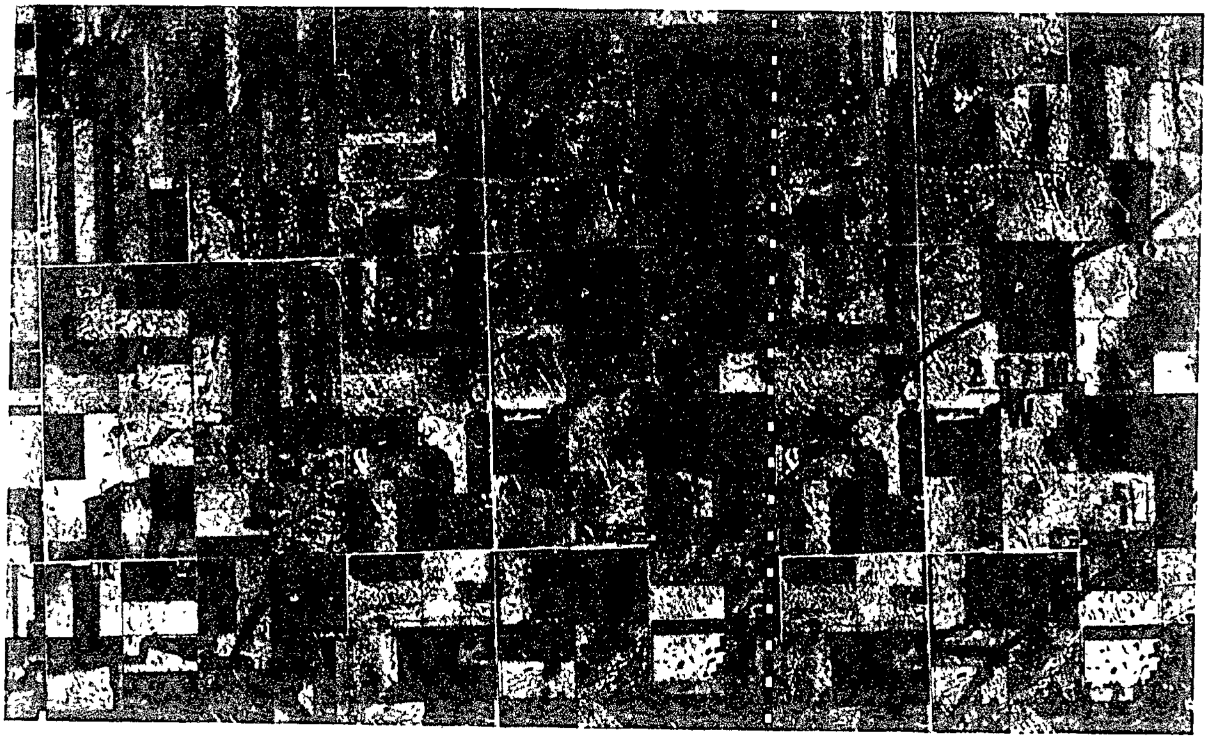


Overlays illustrating the procedure for the derivation of land systems



Scale(Nominal)	1 . 80,700
NAPL Ref	A 21650 - 77, 207
Date	16 July, 1970
Location	Tp.25, R 26

Stereogram of land systems 2B7M and $\frac{2K7M}{W}$. Both land systems are characterized by numerous eroded knolls, however, the former has occasional sloughs, whereas, the latter has numerous sloughs



A Scale(Nominal) 1 81,000

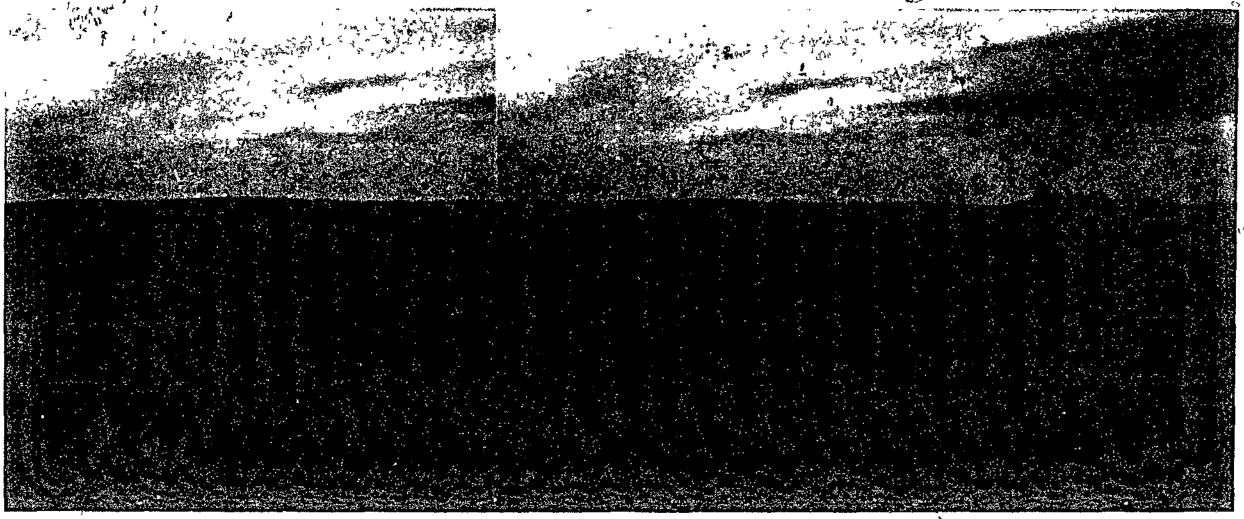
NAPL Ref A 21663 - 31, 32

Date 20 July, 1970

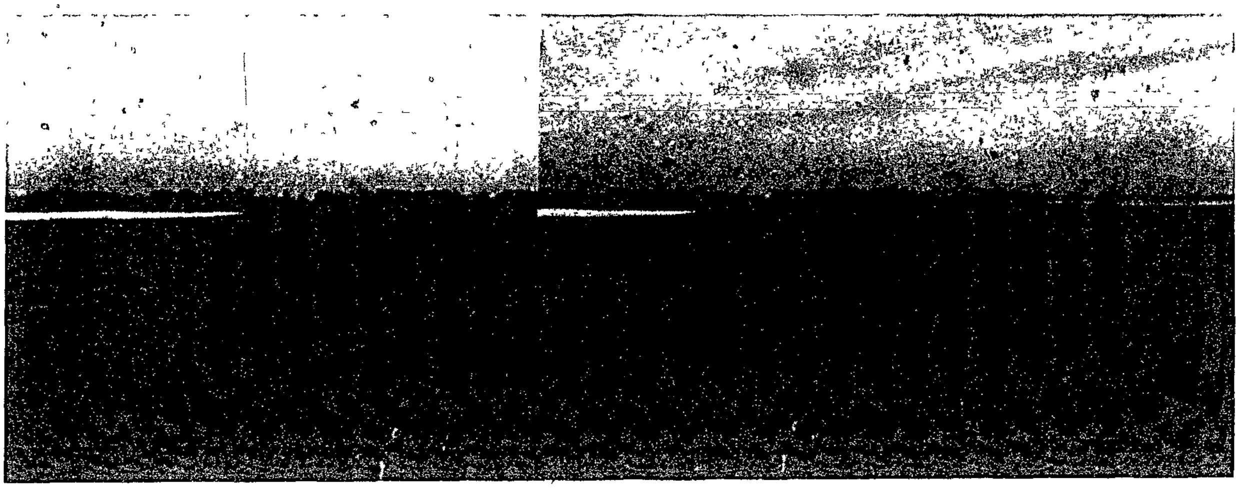
Location Tp 31, R 17

Stereogram of land systems $\frac{1G7M}{W-}$, $\frac{2G7M}{W}$ and $\frac{2K7M}{W}$ The first two land systems are characterized by a hummocky knoll and swale pattern with external drainage, such as at x, and occasional sloughs In contrast, land system $\frac{2K7M}{W}$ is drained internally to numerous sloughs

B Land system $\frac{2G7M}{W}$ showing fields of ripening wheat with green immature crop where drainageways occur
(Location Sect 10, Tp 32, R 16)



A Ground stereogram of land system $\frac{2G7M}{W}$, with subtle surface dissection (x) shown by darker soil patterns (Location · Sect 27, Tp.29, R 26)



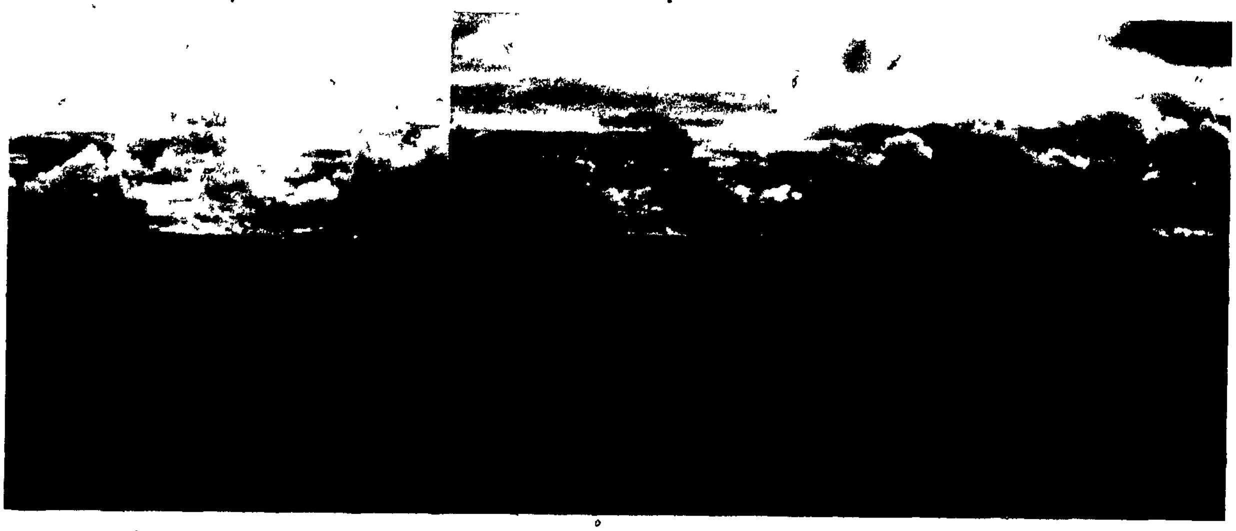
B. Ground stereogram of land system $\frac{2G7M}{W}$ with external surface drainage through dissections at x (Location Sect 31, Tp 31, R 15)

Scale (Nominal)	1 82,000
NAPL Ref	A 21650 · 106, 107
Date	16 July, 1970
Location	Tp 28, R.26

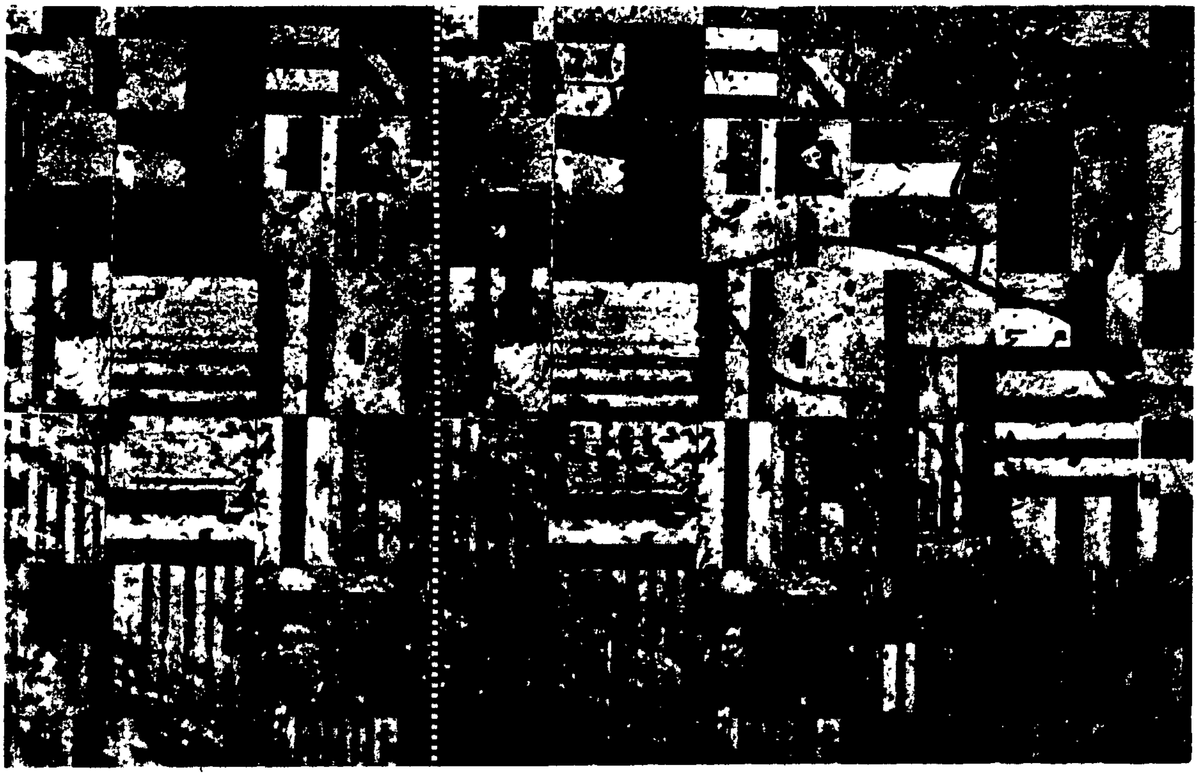
Stereogram of land system 3H7M This land system exhibits a channelled surface of eroded valley slopes and alluvium bottom-land It serves as the drainage outlet for the neighbouring land system $\frac{2G7M}{W}$ Drainage lines are marked at x

PLATE 11

Ground stereogram of land system 3H7M taken from a kame terrace
(Location Sect 14, Tp 24, R 29)



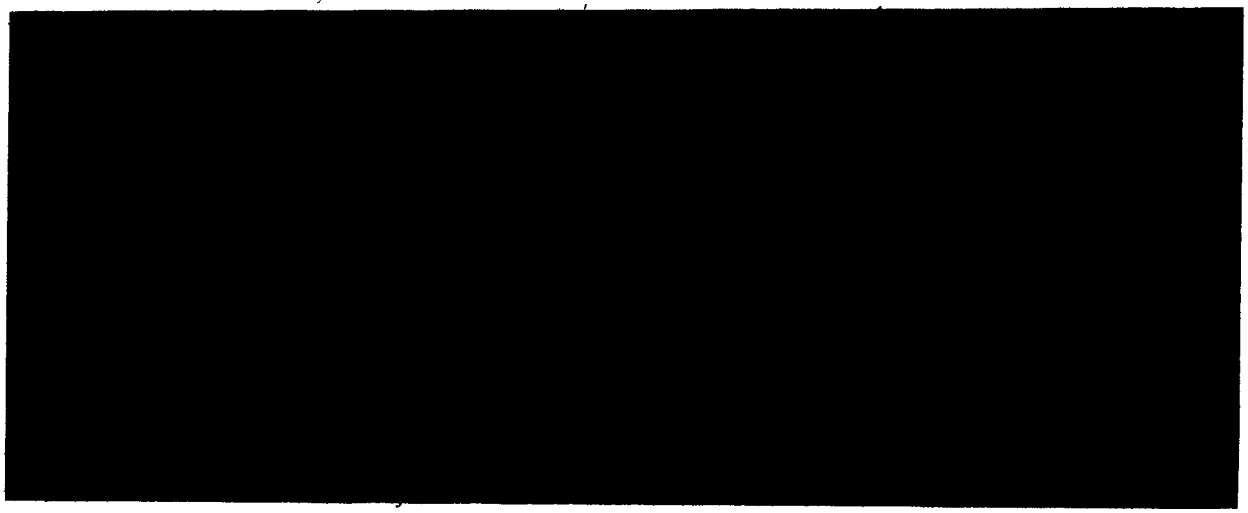
Ground stereogram of land system $\frac{1J7A}{N+}$. This is excessively saline and the dominant land use is pasture. (Location Sect.4, Tp 33, R 19).



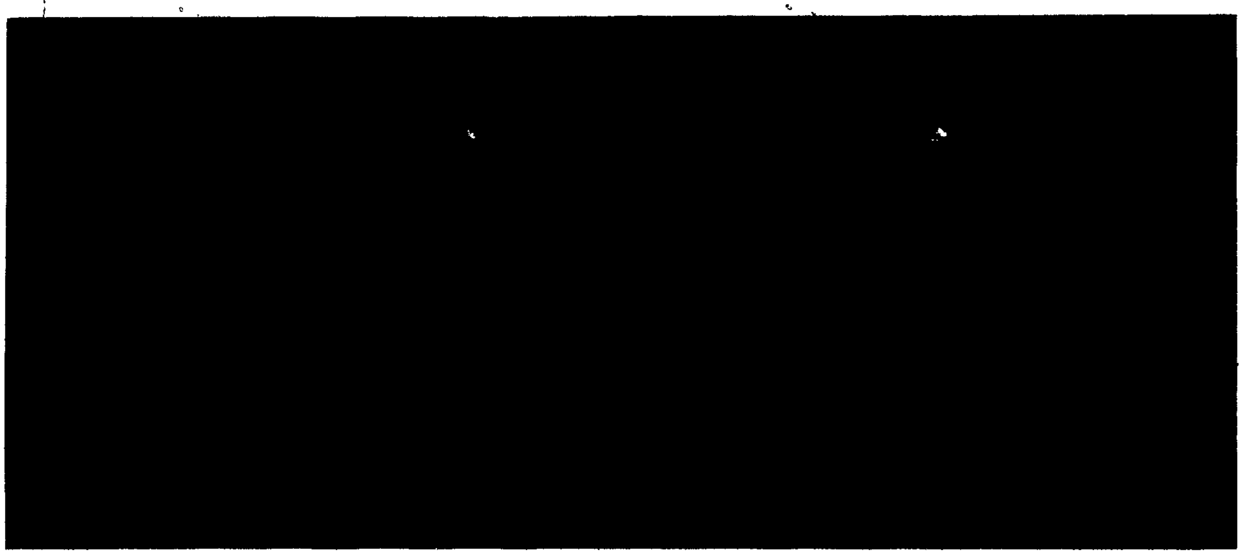
Scale(Nominal)	1 80,800
NAPL Ref	A 21650 - 202, 203
Date	16 July, 1970
Location	Tp.24, R 26

Stereogram of land systems $\frac{1J6L}{E+}$ and $\frac{2K7M}{W}$ The undulating pattern of the former is characterized by low relief with a few sloughs The fine sandy loam soil of lacustrine origin is subject to severe wind erosion, and so this land system is often characterized by a strip cropping pattern

PLATE 14

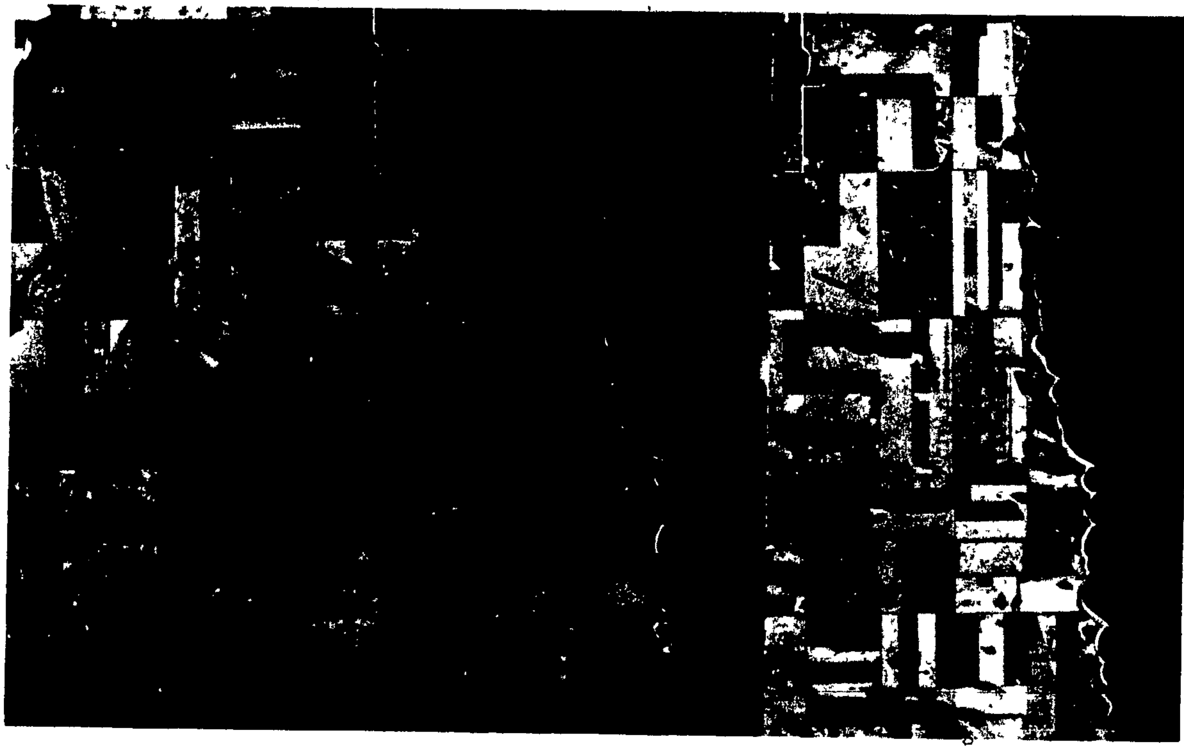


A Ground stereogram of land system 1J8L showing a cultivated field which has been swathed apart from the late seeded slough which was not ripe enough to swath
(Location Sect1; Tp 32, R 27)



B. Ground stereogram of land system 1J9L. The undulating topography is clearly visible at x. The crop in a few late seeded sloughs remain standing until mature enough to harvest
(Location Sect 9, Tp 35, R.28)

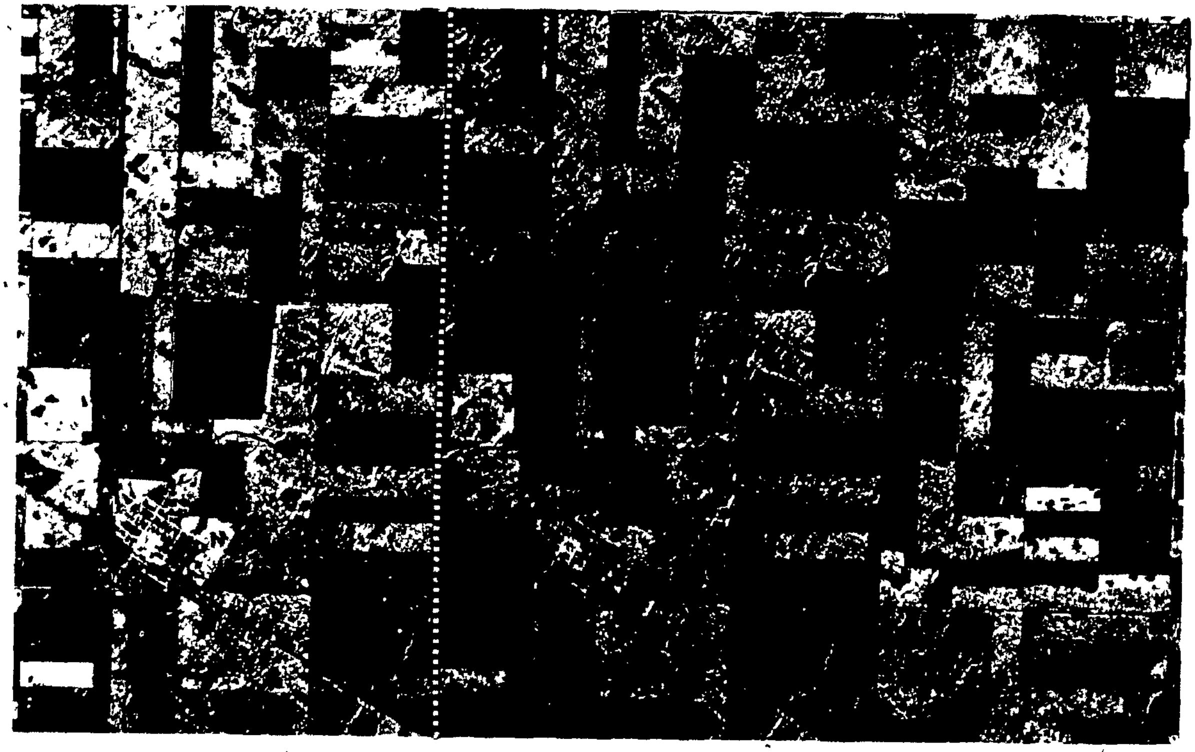
PLATE 15



A	Scale (Nominal)	1 : 81,000
	NAPL Ref	A 21650 - 79, 80
	Date	16 July, 1970
	Location	Tp 25, R.24

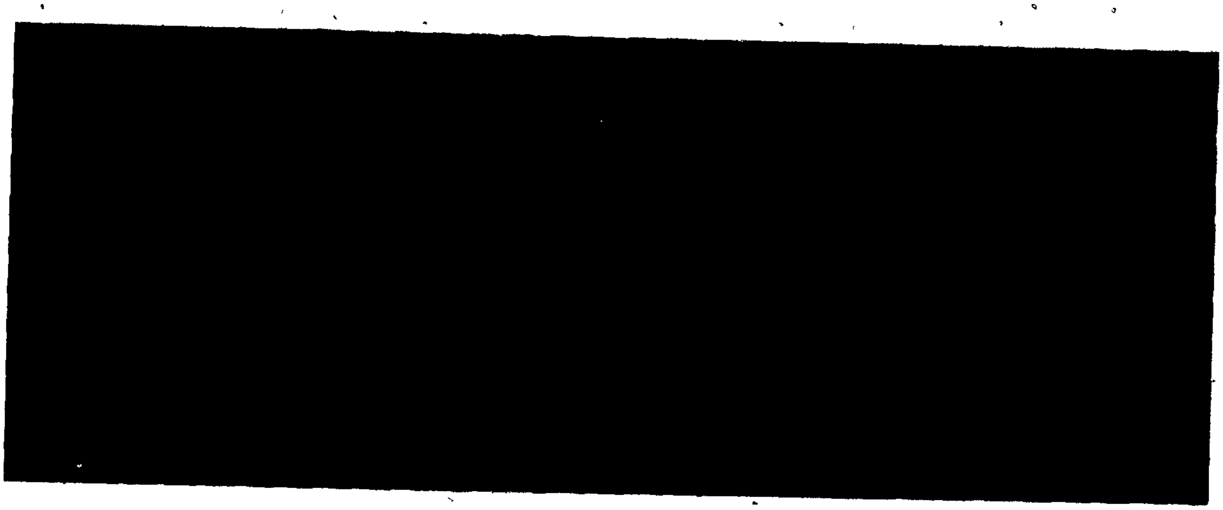
Stereogram of land system 1J7M The land system is characterized by a pattern of low relief with numerous shallow sloughs

B Ground stereogram of land system 1J7M showing a field of wheat which has been swathed The sloughs were not seeded (Location : Sect 11, Tp.24, R 25)



A Scale(Nominal) 1 :82,000
NAPL Ref. A 21740 - 69, 70
Date 24 July, 1970
Location Tp 29, R 22

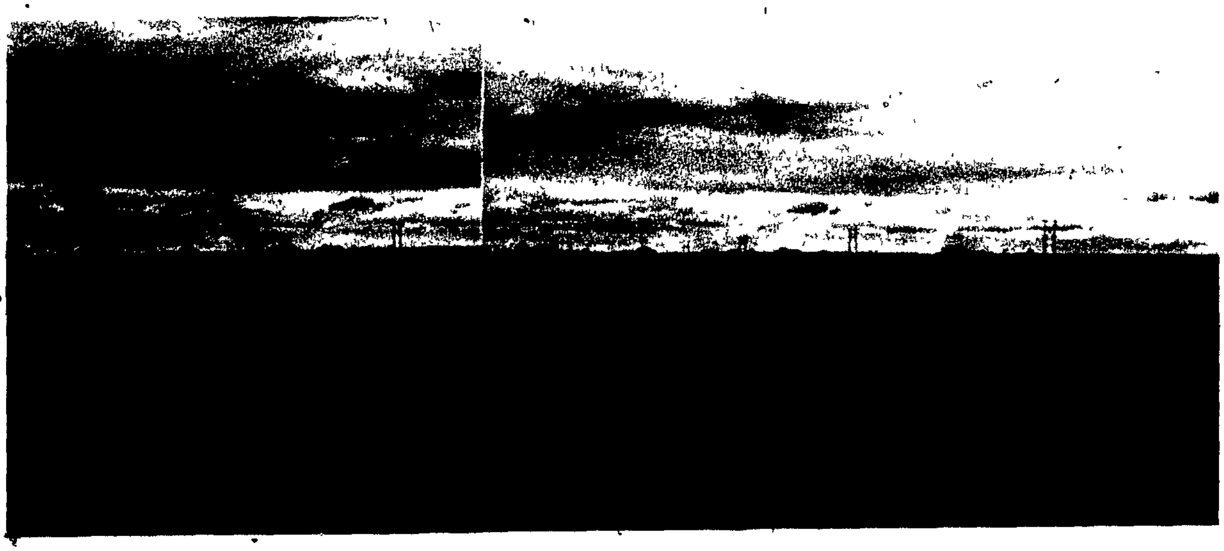
Stereogram of land system $\frac{1K7M}{W-}$ near the town of Nokomis. This land system is characterized by a knoll and kettle pattern of low relief with numerous internally drained sloughs.



B Ground stereogram of land system $\frac{1K7M}{W-}$ (Location : Sect 20, Tp.29, R.21)

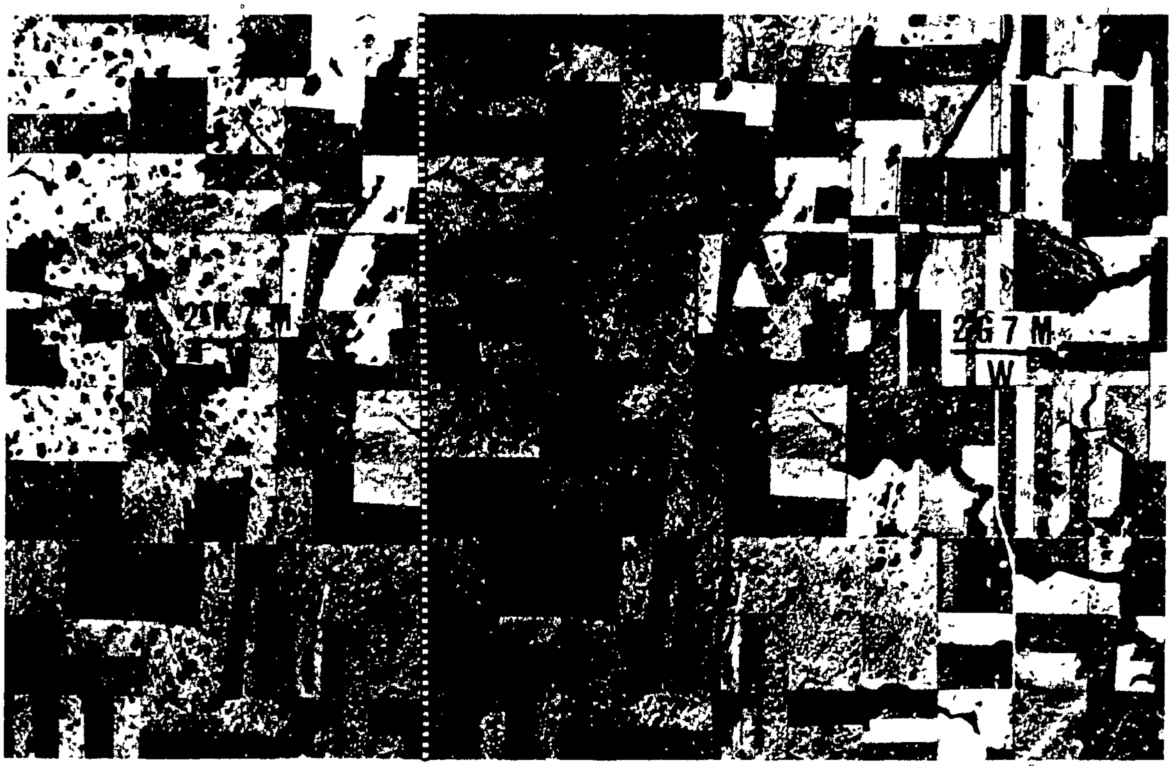
PLATE 1-7

A Ground stereogram of land system $\frac{1K7M}{W-}$ showing a mature crop cover apart from the sloughs which were seeded at a later date (Location Sect.24, Tp 30, R 26)



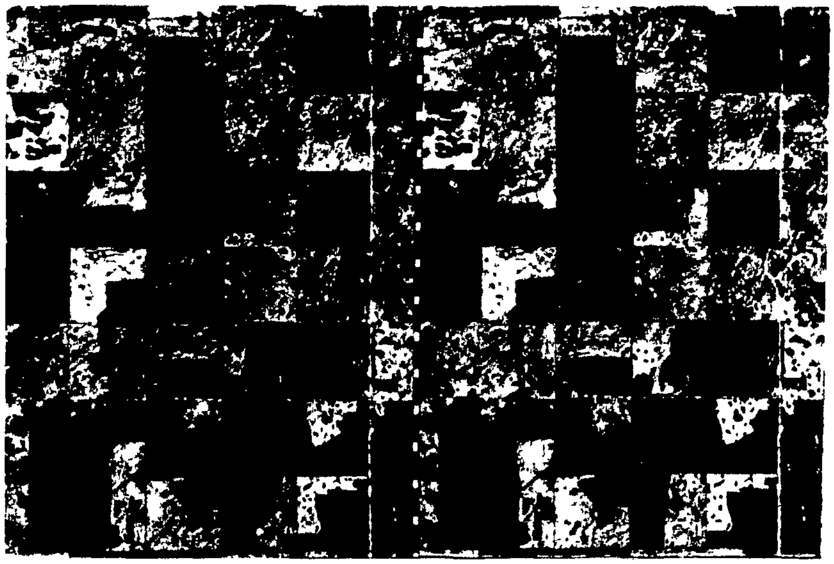
B Ground stereogram of land system $\frac{1K7M}{W-}$ showing fallow land with grassy sloughs which have been harvested for forage (Location Sect 19, Tp 30, R 25)

PLATE 18

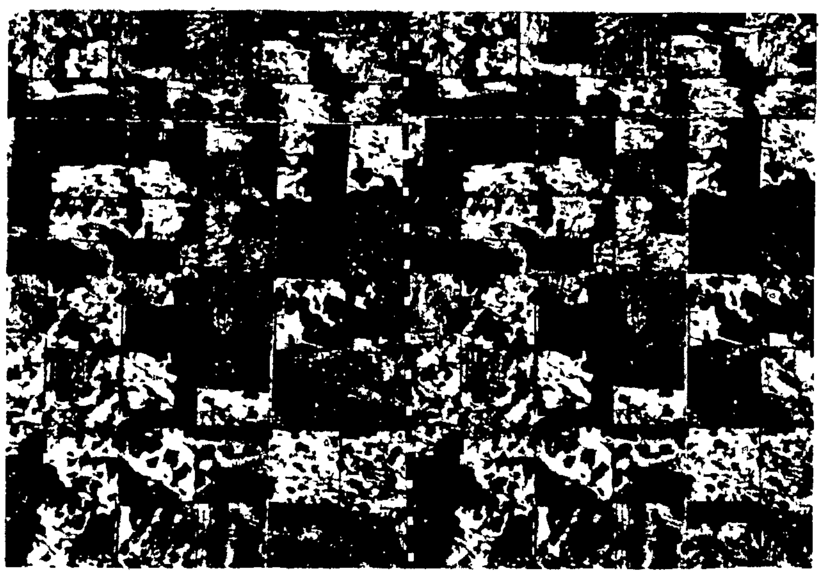


Scale (Nominal)	1 73,000
NAPL Ref	A 21650 - 106, 107
Date	16 July, 1970
Location	Tp 27, R 26

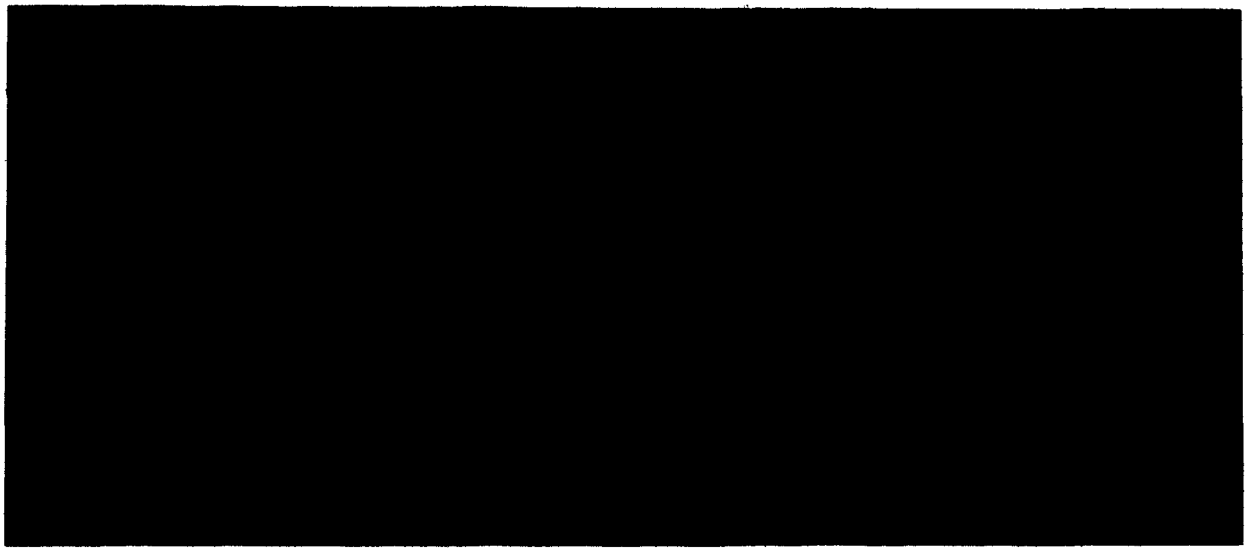
Stereogram of land system $\frac{2K7M}{W}$ This land system is characterized by numerous knolls and sloughs



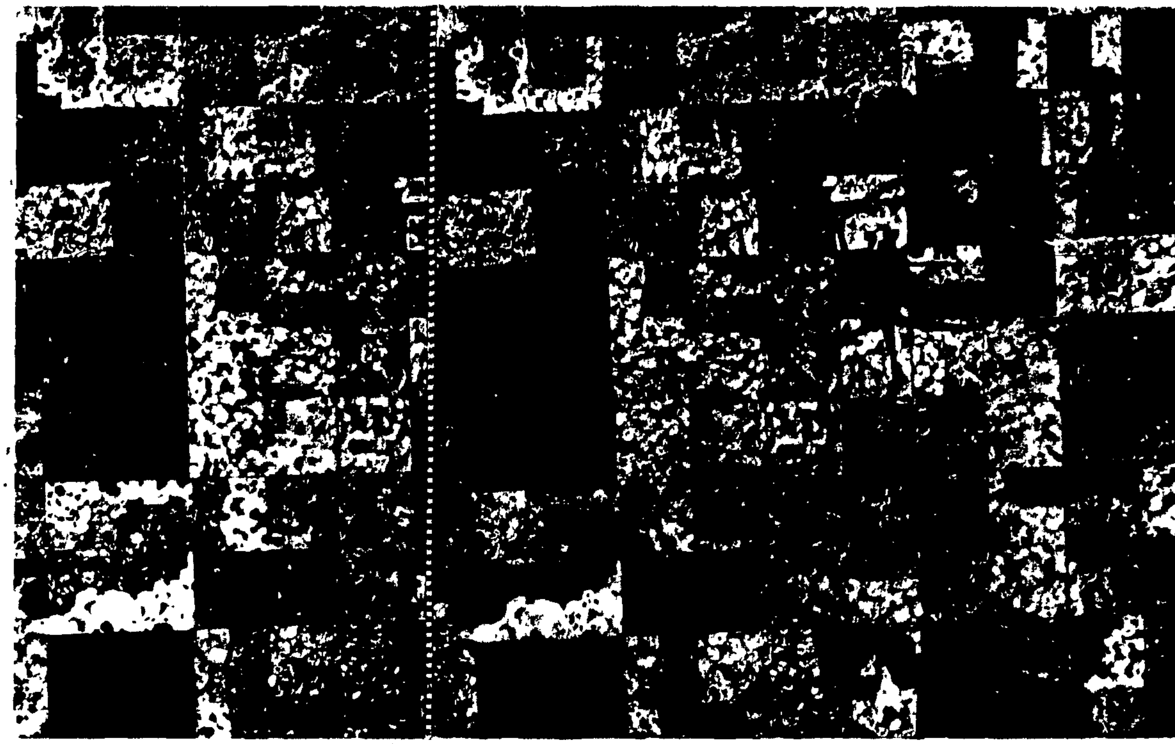
A	Scale(Nominal)	1 : 74,000	Stereogram of land system $\frac{2K7M}{W}$ in the Black Soil Zone
	NAPL Ref	A 21740 - 64, 65	
	Date	24 July, 1970	
	Location	Tp 30, R 18	



B	Scale(Nominal)	1 80,700	Stereogram of land system $\frac{2K7M}{W}$ in the Gray Luvisol Soil Zone. The soils showing through the crop cover are significantly lighter in tone than the Black Soils above
	NAPL Ref	A 21663 - 33, 34	
	Date	20 July, 1970	
	Location	Tp 30, R 16	



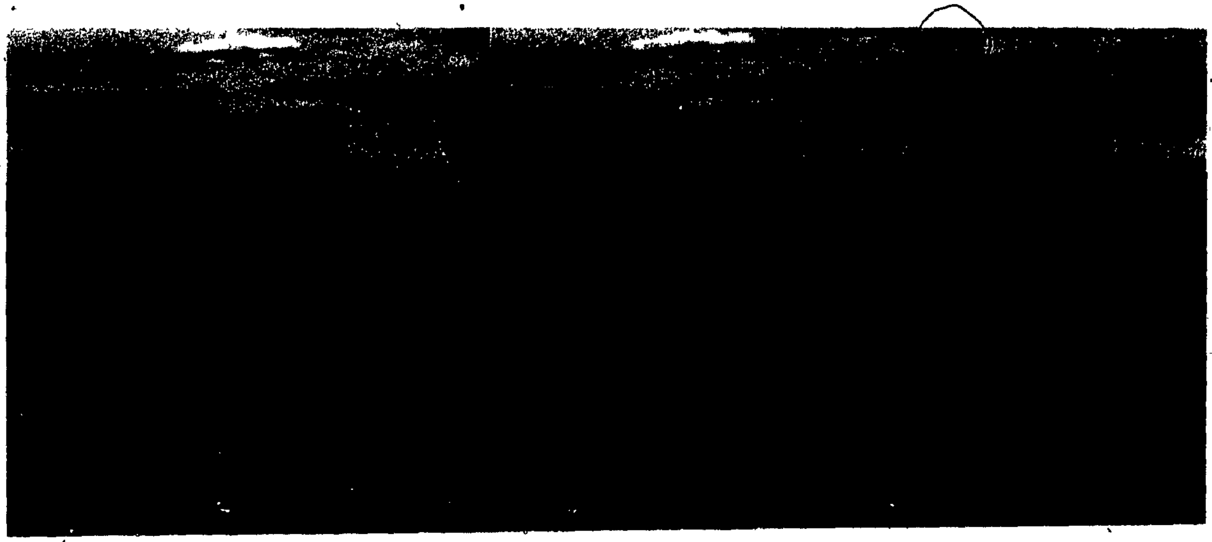
Ground stereogram of land system $\frac{2K7M}{W}$ at the foot of the Touchwood Hills The eroded knolls (x) are a distinct feature in the landscape. (Location Sect 27, Tp.30, R 18)



Scale(Nominal) 1 : 80,300
NAPL Ref. A 21740 - 76, 77
Date 24 July, 1970
Location Tp.29, R.27

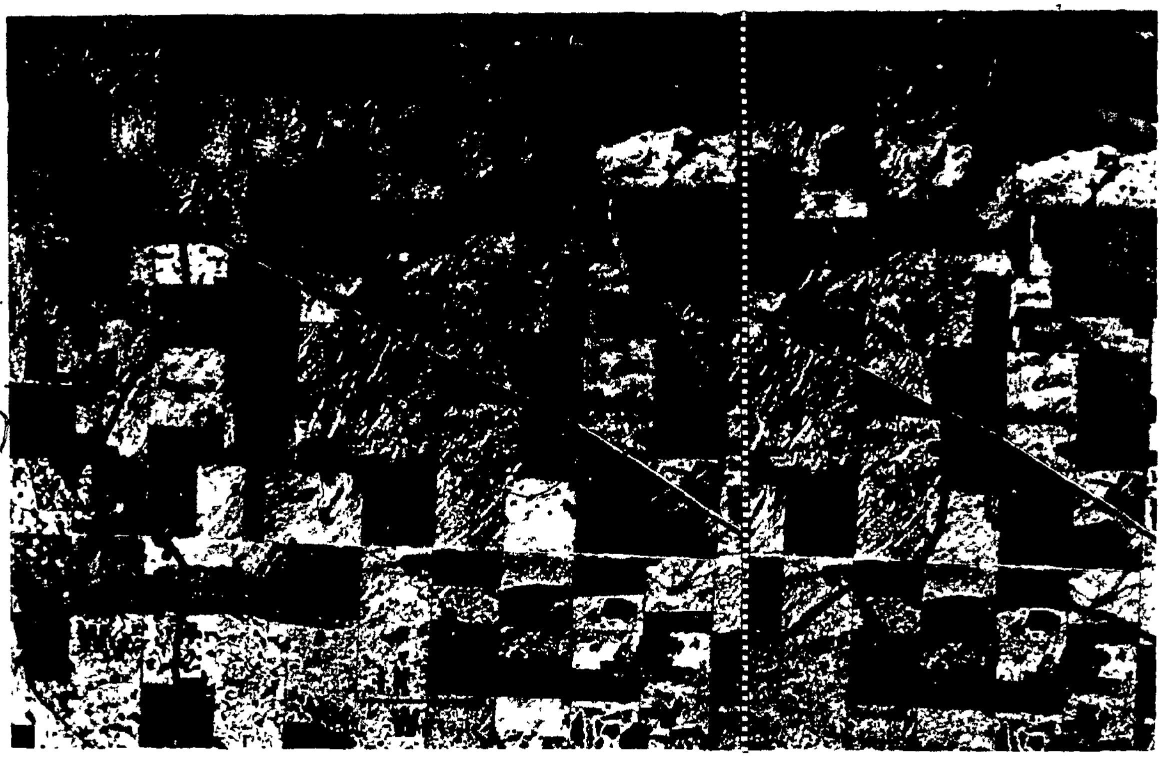
Stereogram of land system $\frac{3K7M}{W+}$ This land system is characterized by knolls with steep slopes and numerous sloughs.

PLATE 22



A. Ground stereogram of land system $\frac{3K7M}{W+}$ showing highly eroded knolls.
(Location Sect 21, Tp.30, R 27)

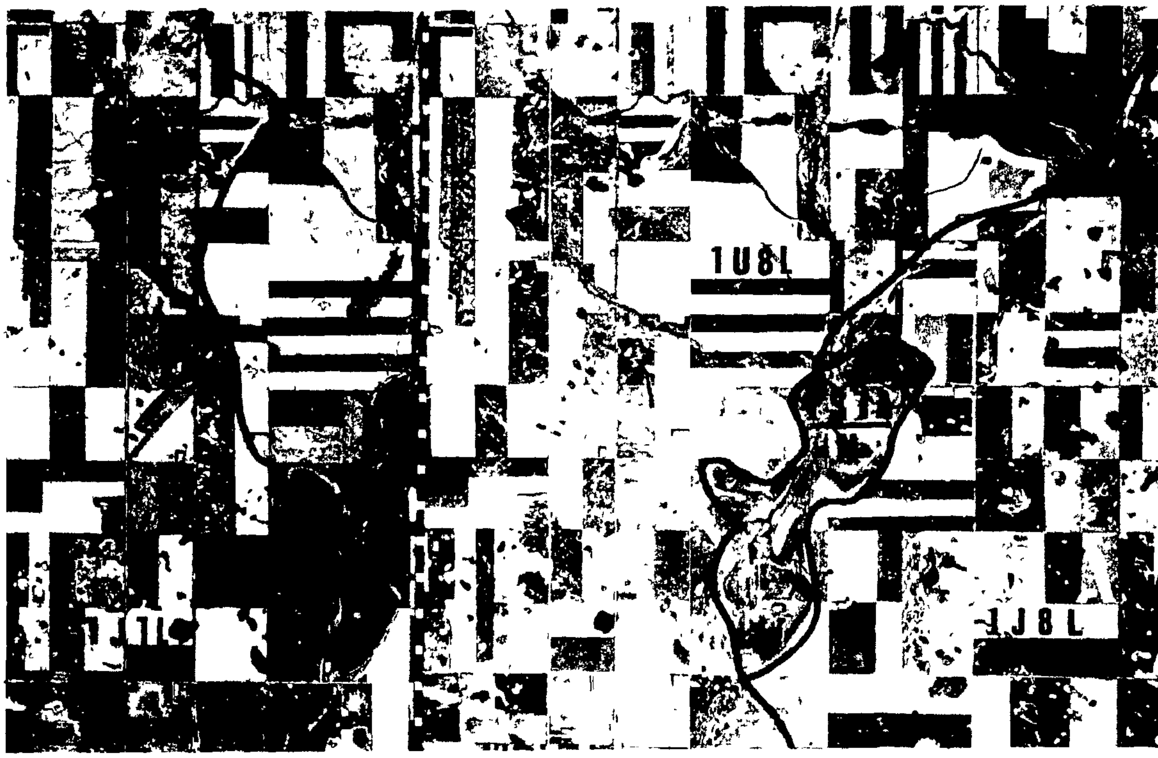
B. Ground stereogram of land system $\frac{3K8M}{W+}$ in the Allan Hills.
(Location : Sect.12, Tp.28; R 27)



A Scale(Nominal) : 1 82,000
NAPL Ref A 21663 - 20, 21
Date 20 July, 1970
Location Tp.31, R.26

Stereogram of land system $\frac{2R7M}{W}$ Characterized by an area of almost parallel eroded ridges and swales, land system $\frac{2R7M}{W}$ appears in marked contrast to land system 1J7M which exhibits an undulating surface of lower relief on similar materials.

B. Ground stereogram of land system $\frac{2R7M}{W}$ (Location : Sect 6; Tp 31, R 26)



Scale (Nominal)	1 82,000
NAPL Ref	A 21650 - 107, 108
Date	16 July, 1970
Location	Tp 28, R 25

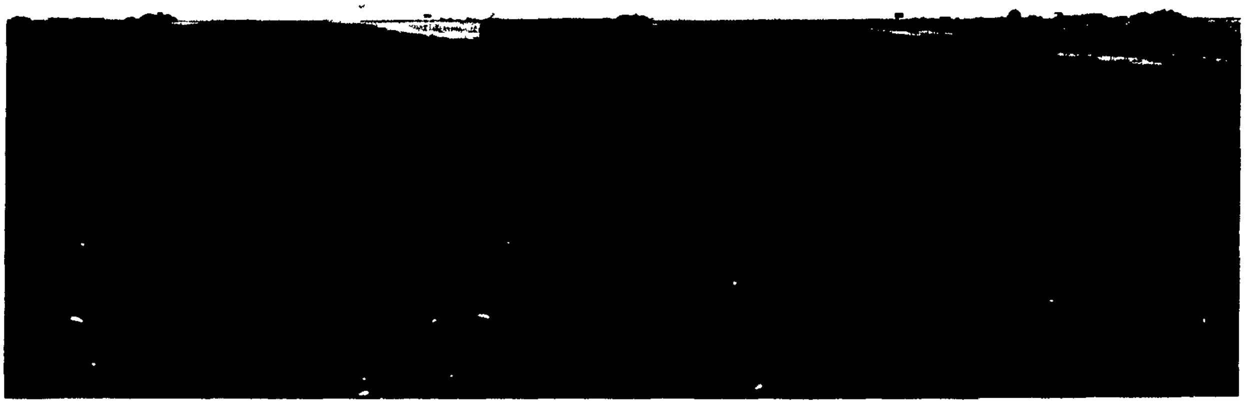
Stereogram of land system $\frac{1S7A}{N}$ This land system occupies a shallow depression between land system 1U8L (a level, unpatterned area) and land system 1J8L which exhibits a pattern containing numerous large sloughs The undulating western section (land system 1J7L) consists of loam textured lacustrine materials with frequent small sloughs.

PLATE 25

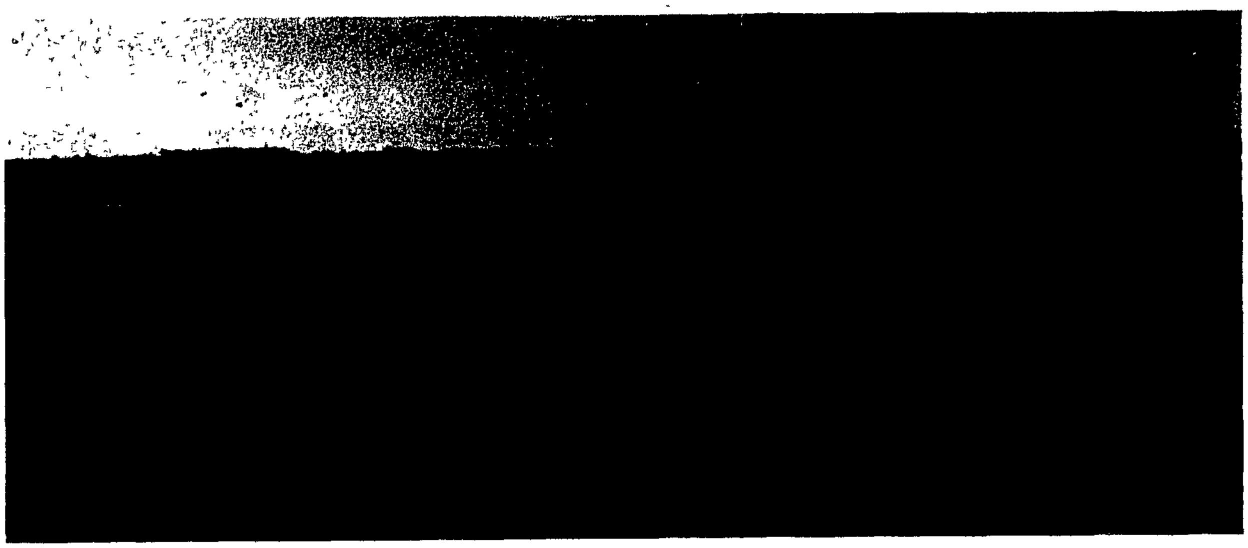
Ground stereogram of land system $\frac{1S7A}{N+}$ showing salt accumulation and salt tolerant Salicornia
(Location Sect 2, Tp 28; R.25)

Scale(Nominal)	1 80,400
NAPL Ref	A 21650 - 177, 178
Date	16 July, 1970
Location	Tp 27, R 28

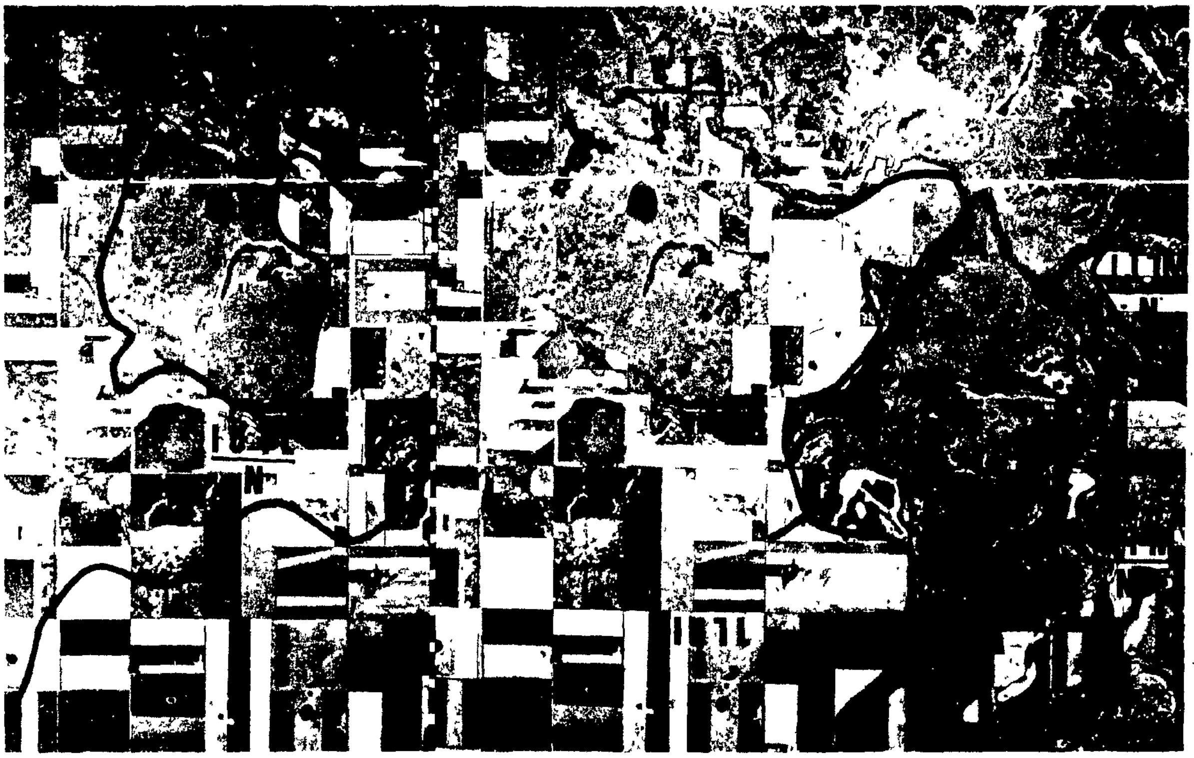
Stereogram of land systems 1U6F, 1U7L and 3H7M. Land system 1U7L is unpatterned The surface is nearly level, and the loamy lacustrine soils have a finer texture than the unpatterned sandy fluvial materials of land system 1U6F The drainage pattern of land system 3H7M consisting of eroded valley slopes and alluvium bottom-land is in marked contrast to the other two land systems



A Ground stereogram of land system 1U7M with its nearly level, unpatterned landscape
Moderate surface stoniness is characteristic of the morainal materials of this land system
(Location Sect.24, Tp 25, R 29)



B Ground stereogram of land system 1U8L The landscape is nearly level with few sloughs
In contrast to land system 1U7M above, the lacustrine materials contain no stones
(Location Sect.29, Tp 30; R 24)



Scale(Nominal) 1 82,000
NAPL Ref . A 21650 - 110, 111
Date 16 July, 1970
Location . Tp.28, R.23

Stereogram of land systems $\frac{1Y7A}{N+}$, $\frac{1U7L}{N}$ and 1U7L. The saline runway ($\frac{1Y7A}{N+}$) provides a striking contrast to the unpatterned saline and non-saline areas of land systems $\frac{1U7L}{N}$ and 1U7L

Ground stereogram of land system $\frac{1Y7A}{N+}$ with high accumulations of saline deposits
(Location Sect.16, Tp.24, R 25)