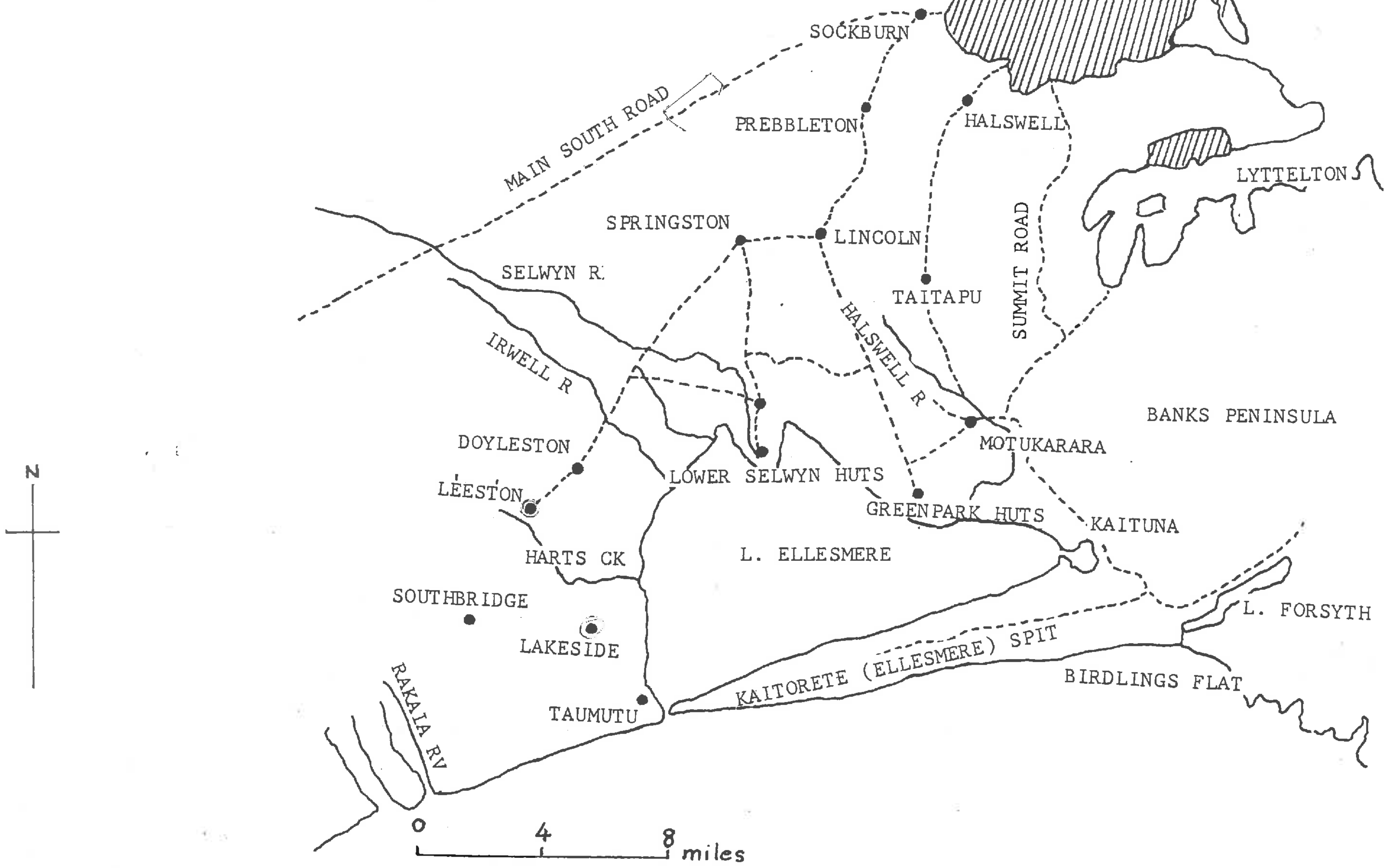
Master

Botany Department University of Canterbury

A HANDBOOK OF BACKGROUND MATERIAL TO THE ECOLOGY OF THE LAKE ELLESMERE AREA

Compiled by C.J.Burrows, 1969.

FIG. 1 LAKE ELLESMERE : LOCALITIES, ROADS.



THE LAKE ELLESMERE DISTRICT

THE LAKE AND ITS ENVIRONS

(Compiled from Evans (1953), Speight (1930), and information from R.P. Suggate, J.E. Cox, and V.Stout.)

Lake Ellesmere (fig.1) is a large body of brackish water retained against the shingle fans of Rakaia, Selwyn and Waimakariri rivers and the volcanic rocks of Banks Peninsula by a shingle bar, the Kaitorete (Ellesmere) Spit. Much of the surrounding terrain is flat and lowlying and sand and mud flats border the northern and parts of the southern margins and form the floor of the lake. The fine material is derived from silt from Selwyn, Halswell and Irwell rivers and other streams, and from old estuarine deposits.

The lake drains some 250 square miles of foothills and 600 square miles of plains. Inflow of water from various streams averages 320 cusecs (10,000 million cubic feet a year) but there is an unknown inflow from artesian springs and the amount of evaporation is unknown. Salt water seeps in through the bar or flows in through the outlet and in heavy storms waves break over the Spit near Taumutu. The level of the lake is controlled by the North Canterbury Catchment Board. The maximum depth is some 6 feet below mean sea level and normally the lake level is not allowed to rise higher than 3 feet 6 inches above m.s.l. When high levels are reached a cut is made at the Taumutu end of the Spit. This scours to about 8 chains wide and stays open, on an average, 6 weeks, until closed by a southwest storm. About 3-5 openings are made a year. Salinity varies within the lake, depending on proximity to the rivers, and it varies through the year with the lake level. At a low level and high tide, seawater can flow in. Salinity varies in time and over the area of the lake from about 56% of seawater downward and is generally about 20% of sea water. Areas of the lake at different levels above mean sea level are: at m.s.l. 38,000 acres, 2ft above m.s.l. 45,000 acres, 4ft above m.s.l. 54,000 acres. Rising lake levels affect the water table of all surrounding farm land.

THE SPIT

(Compiled from Speight (1930), Suggate (1958,1963), Cox and Mead (1963), Schofield (1963), Suggate and Burrows (1965) and information from R.P.Suggate and J.E.Cox).

The Kaitorete Spit, composed largely of gravel, but with sand-dunes on its southern side, is a prominent feature to the south of the lake. Its geomorphic history is complex, as will be mentioned later. The Spit is about 18 miles long, 2 miles wide at its widest point near Birdlings Flat but only a few chains wide near Taumutu. Its area is about 12,000 acres. Its general height is from about 12-25 ft above m.s.l. but individual crests of some of the sand dunes are up to 50ft above m.s.l. At the eastern end of the Spit (Birdlings Flat) there is an extensive area of stony beach ridges. Further west about 2 miles these merge into the sand dunes which form a narrow fringe along the southern side of the Spit almost to Taumutu. On the lakeward side of the dunes, gravel flats slope gently down toward the shore of Lake Ellesmere, broken only by a few shingle ridges and merge into muddy and sandy deposits. Fig.2 shows cross sections at intervals along the Spit.

GEOMORPHIC HISTORY

Various pieces of evidence allow an outline of the geomorphic history of the area to be constructed. This is of some ecological interest because the ages of surfaces, as well as the materials of which they are composed, determine the soil types and ultimately the vegetation found on them. This outline is to some extent conjectural (at least as far as its time scale is concerned) but some C14 dates from boreholes, buried wood, charcoal etc., permit control in some cases. In other cases dating is by analogy with known events elsewhere in Canterbury. The notes related to sea-level changes ignore possible tectonic movements and the fact that logs on the Spit are bored by teredo is ascribed to their having been driftwood.

Time	
ca. 15,000 yrs ago.	Full glacial conditions in Southern Alps. Sea level at least 100ft lower than now. Fans of Rakaia and Waimakariri rivers extended. Banks Peninsula valleys being eroded. Loess deposition on hills.
ca. 10,000 yrs ago.	Early post-glacial. Sea level at least 70ft lower than now but rising. Beginning of aggradation by Rakaia and Waimakariri rivers to form Springston Formation. Beginning of truncation of ends of older river fans. Forest development in the area Christchurch-Lake Ellesmere (matai, kahikatea).

FIG 2 SECTIONS ACROSS KAITORETE SPIT

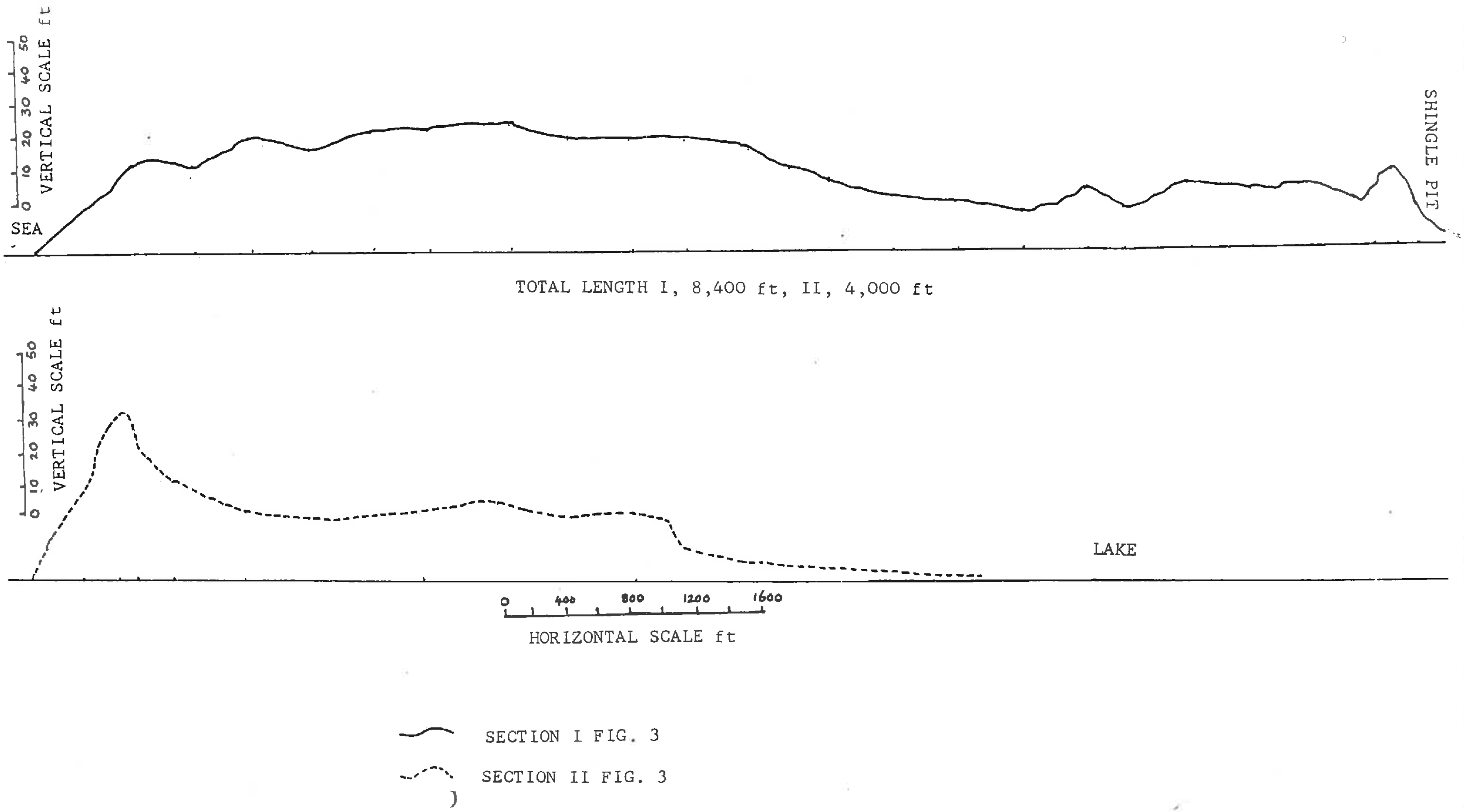
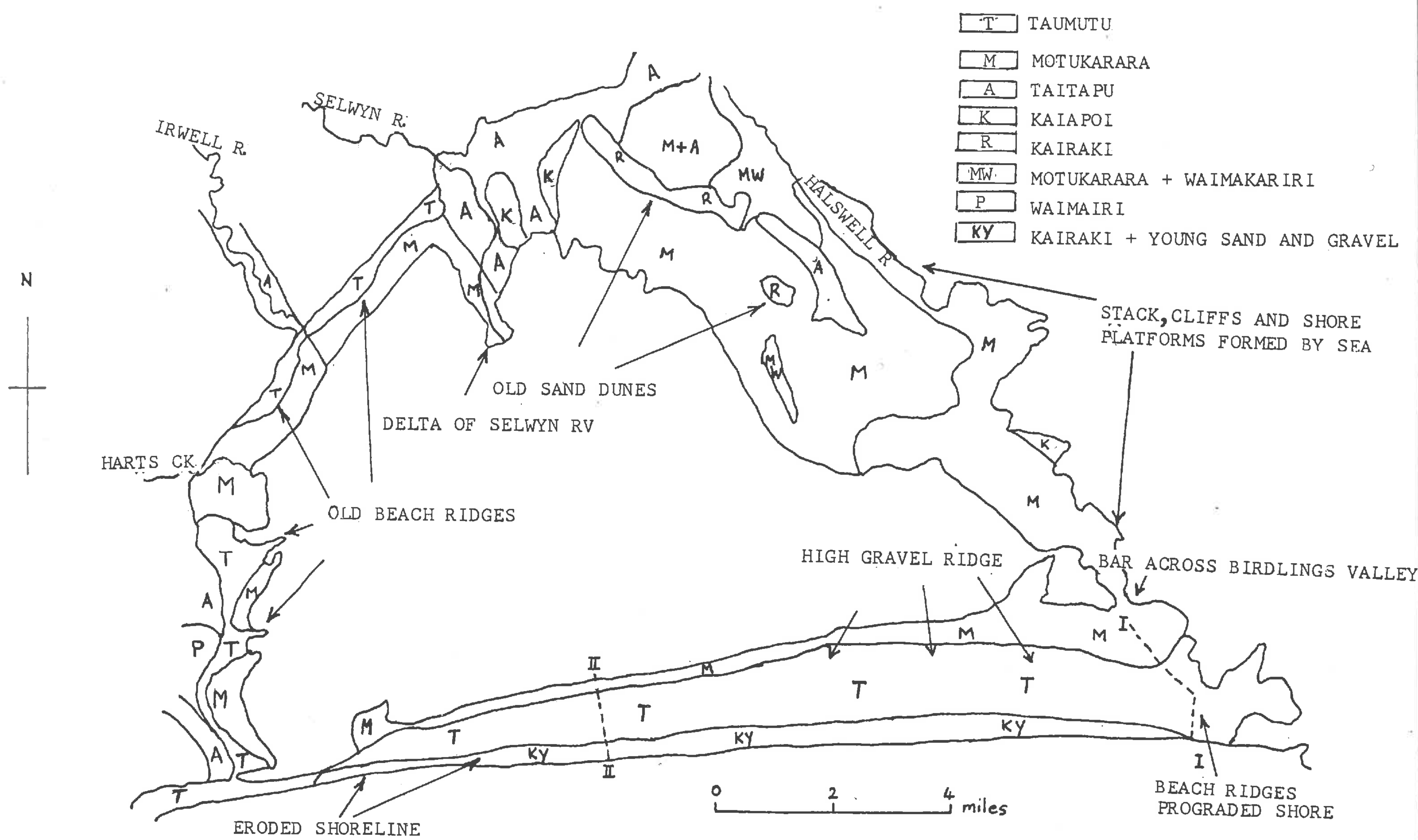


FIG. 3 SOILS AND DISTRIBUTION OF SOME GEOMORPHIC FEATURES



ca. 6,000 yrs ago.	Mid post-glacial. Continued rise in sea-level to near present level. Continued aggradation, including lower parts of Banks Peninsula Valleys.
ca. 4,000 yrs ago.	Mid post-glacial. Final rise in sea-level to at least 10ft above present level. Rakaia and Waimakariri rivers flowing into "Ellesmere Bay" at times. Cliffing of headlands, stack and shore platform formation near Motukarara. Formation of old sand dunes near Greenpark and beach ridges near Irwell and Selwyn mouths, Harts Ck and Taumutu.
ca. 2,000 yrs ago.	Late post-glacial. Gradual fall in sea-level to about present mean sea-level. Formation of Spit as a wide shingle barrier beach ridge during this recession. High lake level and formation of highest gravel ridge on Spit and bar across Birdlings Valley by wave action in the lake.
ca. 1,000-500yrs ago.	Modern. Continued erosion of truncated river fans. Erosion of western end of Spit and development of low outflow area there, formation of dunes on Spit, progradation at Birdlings Flat. Minor aggradation of Selwyn River and other streams.

Fig.3 shows the distribution of soils and some of the features mentioned above. The main material of the Spit is greywacke gravel (and sand), mainly from Ashburton and Rakaia rivers. There is also an admixture of quartz pebbles, jaspilite, rhyolite etc. Some of the gravel is from the bed load of the rivers at the time, but some has been derived from the sea-eroded cliffs of the truncated river fans. The prevailing drift from the south-west has carried it alongshore to its present position. At the Taumutu end of the Spit, truncated rows of beach-ridges, their projected lines extending out diagonally into the sea, show that considerable erosion has occurred recently. Maori tradition records the loss of the old pa Te Rangatamau, by this means some centuries ago. At Birdlings Flat, however, successive lines of shingle beach ridges show that the shore is being prograded. Maori canoes were formerly landed through an open channel into Lake Forsyth and in the early days of European settlement small schooners could also be taken into Lake Forsyth, so that direct access has been cut off in only very recent times. The sand-dunes on the Spit are derived from the plantiful supply of sand washed up on the beach and blown higher onto the shore by strong south-west winds. The stumps of dunes on the inland side of the main chain of dunes may represent earlier lines of dune ridges. A well marked shingle ridge about 18ft a.s.l. on the lakeward side of the Spit near Birdlings Flat was considered by Speight to have been formed by the sea as a high storm beach, but its form and position are much more suggestive of formation by wave action in the lake. Speight was also in error in recording the sea level changes as being caused by movement of the land. Lake levels were, no doubt, higher during the early period of Maori occupation within the last 2000 years, before the Spit became eroded and before the low outlet area near Taumutu was formed.

SOILS

(Compiled from Ward & Harris (1964), Kear, Gibbs and Miller (1967) and information from J.E.Cox and C.Vucetich).

The main soils of the Lake Ellesmere area (fig.3) are Motukarara, Taumutu and Taitapu series, with smaller areas of Kairaki, Kaiapoi, Waimakariri and other series including some very recent soils with little profile development.

On areas more distant from the lake to west and north the soils of the old swamplands, developed on peats and waterlogged alluvium are Windermere, Waimairi, Temuka and Waterton series. On better drained alluvium Wakanui, Waimakariri, Templeton and Paparua soil series are important (see Kear, Gibbs & Miller). The soils immediately round the lake fit into the main New Zealand soil classification as follows

Yellow-brown Sands
Kairaki

Recent Soils on Beach Ridges
Taumutu

Gley Recent Soils
Taitapu

Saline Gley Recent Soils
Motukarara

Recent Soils on Flood Plains (alluvial)
Waimakariri
Kaiapoi

... Some very recent soils are also present in sand-dunes, on beach ridges and on alluvial flats.

Kairaki soils form a complex in sand-dune areas with freely-draining sands of the dunes and slow-draining soils of the interdune hollows. On the younger dunes there is little or no topsoil differentiation and a humus-stained horizon passes to raw sand. Older dunes have better developed topsoil and signs of B horizon development. The soil is almost structureless; sand particles are mainly held together by plant roots. There is low cation exchange capacity because of the low humus and clay content.

Profile:

A	6in. olive brown (2.5y4/4) sand, loose, very weakly developed fine granular structure; diffuse boundary;
C	on yellowish-brown (10hr5/6) sand, loose, single grained, few roots.

Taumutu soils are grouped with the yellow-brown sands, but are mainly developed on beach gravels, though sandy areas may be present. Sand has been blown onto the gravel surface near the dune areas on the Spit. The soils are shallow and very gravelly or stony. Most areas of these soils are elevated enough to be freely drained but some lie close to lake level and are gleyed. Topsoils are thin, with weakly developed structures that break down very readily. These overlie raw sands, gravels or sandy gravels. At Birdlings Flat there is a phase consisting of young beach deposits of flattened stones, with little fine material. Other phases are recognised, depending on amounts of sand and gravel present. The soils are moderately acid and moderately well supplied with bases.

Profile:

A	7in. very dark grey (10yr3/1) very gravelly sandy loam, loose; weakly developed fine nutty structure, many roots; distinct boundary;
B	9in. brown (7.5yr5/4) gravelley sand, very loose, structureless, very few roots; diffuse boundary;
C	on pale grey (5y7/2) weakly cemented gravels.

Taitapu soils of old swampland, now drained, are developed on fine alluvial sediments deposited on a former sea floor. They have high groundwater levels in winter even when drained and the massive, poorly drained, poorly aerated subsoils do not favour root growth. In summer the soils dry out and develop deep vertical cracks which can break plant roots crossing them. The soils are moderately acid to near neutral and well supplied with plant nutrients. Several phases are recognized, dependent on the nature of the predominant sediment present (silt, sand) and the degree of gleying.

Profile:

A1	7in. very dark brown (10yr2/2) silt loam with prominent reddish-brown (2.5yr5/4) flecking and staining along root channels, firm to friable; moderately developed fine granular and some medium nutty structures; distinct boundary;
Cg	13in. grey (5y5/1) silt loam with faint diffuse reddish-yellow (5yr7/6) mottling; distinct root channels, grey lined yellowish-red (5yr4/8) merging to strong brown (7.5yr5/8); moderately coarse blocky, breaking to fine blocks; indistinct boundary;
GC	18in. grey (5y5/1) silt loam with contrasting greenish-grey (5GY5/1) in vertical veins and diffuse indistinct reddish-yellow (5yr7/6) mottling in matrix; weakly developed coarse blocky structure; horizon saturated below 29in.; distinct boundary;
A	on dark brown (10yr3/3) peaty silt loam.

Profile:

A1	9in. greyish brown (10yr5/2) silt loam, friable, moderately developed medium to fine worm-cast granular structure, many roots; distinct boundary;
Cg	7in. pale brownish-grey (10yr6/2) silt loam, firm; weakly developed coarse nutty structure, many cast granules, many distinct strong brown (7.5yr5/8) mottles; few roots; indistinct boundary;
GC	on pale grey (5y6/1) silt loam with many prominent yellowish-red (5yr4/8) mottles, firm and massive.

Motukarara soils are developed on poorly drained sandy and silty lake sediments often covered by a thin sheet of gravel, with saline ground-water lying close to the surface throughout the year. There is periodic flooding by salty water in many areas. Salts appear at the surface by capillarity and are concentrated by evaporation, especially in hollows. Salts are beached by heavy rainfall so that there are seasonal fluctuations in salt concentration. There is little profile development. Topsoils are mostly thin, lying on raw sands, gravels, silts or clays. Subsoils show strong signs of gleying. The topsoils may be moderately acid but are usually near neutral and well supplied with bases. Subsoils are slightly alkaline. Phosphorus levels are high. Weakly saline higher above water level and better drained.

Profile:

A 5in. dark brown (10yr2/2) fibrous salt loam, soft peaty consistency, structureless; sharp boundary;

GC on pale grey (5y6/1) soft silt loam with many fine brown (7.5yr5/4) mottles in root channels, which are confined to the topmost 9ins., very few roots.

Profile:

A 8in. dark greyish-brown (2.5y4/2) sandy loam, very friable; weakly developed fine granular and medium nutty structures, many worm casts, abundant roots; distinct boundary;

CG on grey (5y5/1) sand, coherent, structureless, many distinct brown (7.5yr5/4) mottles with prominent yellowish-brown (10yr5/6) veins and few small soft dark reddish-brown (5yr2/2) concretions below 18 inches; few roots.

The other soils shown on fig.3 are Waimakariri Sandy loam, Kaiapoi silt loam and sandy loam and Waimairi peaty loam, all of small area. A brief description of the Waimakariri soil is given below because Taumutu soils and the drier phases of Motukarara soils resemble it. The wetter phases of Motukarara soils resemble Taitapu soils.

Waimakariri soils are developed on greywacke gravels with a veneer of loess or fine alluvium of varying thickness. They embrace a wide textural range. Some with very thin topsoils are only about 100 years old, others are several thousand years old and have deeper topsoils. Cations and phosphorous supplies are generally favourable for plant growth. The sandy loam phase is a very free-draining, friable soil.

Profile:

A 10in. dark greyish-brown (10yr4/2) fine sandy loam, friable; weakly developed coarse nutty structure with many medium and fine cast granules, many roots; diffuse boundary;

BC 18in. olive brown (2.5y4/4) fine sandy loam, very friable; weakly developed coarse blocky structure with much fine cast granular structure in places, few roots; sharp boundary;

C2 on loose greywacke stony alluvium.

Some chemical analyses are given in a table, but physical analyses are not available except for the Taitapu soil. Physical characteristics are, however, noted briefly in the profile

CHEMICAL ANALYSES OF SOILS

Soil Type	Depth (in.)	Horizon	pH	Citric acid Sol. P, mg%	C%	N%	C/N	CEC me%	TEB me%	BS %	Ca me%	Mg me%	K me%	Na me%	Total salts %
Kairaki sand	0-6	A	5.4	19	1.2	0.08	15	5.0	1.7	34	1.7	0.6	0.55	-	
	6-12	C	5.5	18				5.3	1.8	34	1.8	0.7	0.40	-	
Taumutu very gravelly sandy loam	0-5	A	5.8	20	3.2	0.28	11	13.7	7.7	56	5.8	2.5	2.20	-	
Taitapu silt loam	0-6	A1	5.9	13	8.0	0.58	14	36.5	33.0	91	24.6	5.0	0.25	0.5	
	8-19	Cg	6.8	34	0.7	0.05	14	9.1	8.8	97	6.6	1.1	0.10	0.3	
	21-27	GC	6.4	34	0.7	0.05	14	8.0	6.8	85	5.0	1.6	0.10	0.2	
Motukarara sandy loam, strongly saline phase	0-6	A	5.9	21	3.5	0.18	19	14.0	13.4	96	7.7	7.1	0.80	0.7	0.91
	6-12	GC1	6.3	29				6.2	5.7	92	3.1	3.3	0.40	0.3	0.31
	12-18	GC2	6.3	46				6.4	6.3	99	3.6	3.8	0.35	0.4	0.22
Waimakariri sandy loam	0-7	A	5.9	14	2.7	0.19	14	13.1	9.9	74	7.3	2.1	0.40	-	
	10-16	B	6.5	8				8.1	8.7	100	6.0	2.3	0.15	-	
	18-24	C	6.8	15				8.3	6.4	77	5.5	1.7	0.95	-	

CLIMATE

(Compiled from N.Z. Meteorological Service Summaries to 1960 (1966) Ward & Harris (1964), Kear, Gibbs and Miller (1967).

Long-term climatic records have not been kept for stations nearer Lake Ellesmere than Lincoln, Leeston and Southbridge and the only comprehensive records are those for Lincoln. These, along with some Christchurch records and short-term records for rainfall and fog at Lake Ellesmere are given below. Although there will be some minor differences in the climate of the area round the lake from that at Lincoln, (e.g. average rainfall is less than 25ins per annum), they are probably substantially the same. It must be remembered that the climatic records were taken under standard meteorological conditions which are not necessarily simply related to conditions in vegetation at ground level.

The climate of the Lake Ellesmere area is influenced strongly by its geography. Exposure to wind is important. The most important wind direction is south to south-west, but north to north-east and east and west to north-west (less commonly) also influence the lake. On the shingle area at Birdlings Flat shrubs are shaped by the south-west wind and salt burn and the lines of dune crests and blowouts are dependent on it also. Lake water is often piled up to about two feet above normal at the north end by this wind; north-east winds cause a less pronounced rise at the southern end of the lake. Stock have been drowned by this phenomenon. In the winter period the greatest rainfall and lowest evaporation occur and water tables are high round the lake at this time. Still periods in winter bring about widespread fog banks round the lake and frosts are common, notwithstanding proximity to the sea. Summer is characterised by drought and high temperatures.

The evapotranspiration graph (fig.6) demonstrates that lack of soil moisture is likely to limit plant growth for much of the summer (unless the water table is high) and this will be exaggerated on the excessively drained sandy and gravelly soils. The "annual" grassland on the Spit is maintained by this drought which is enhanced by the rapid drainage, poor water holding capacity of the soil and high evaporation. The climate approaches the Mediterranean type.

H1/j/CB

CLIMATOLOGICAL TABLE

Based on Observations 1881-1960 Unless Otherwise Stated

LAT 43 38 LONG 172 30 HT 36 Ft

	Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURES - DEGREES F														
MEAN	1944-60	60.9	61.5	57.8	52.8	47.1	42.3	41.4	44.0	48.0	51.8	55.6	58.3	51.8
MEAN DAILY MAXIMUM		71,9	71.9	67.6	62.3	56.2	51.2	50.5	53.2	58.3	62.0	66.7	68.4	61.7
MEAN DAILY MINIMUM		50.2	51.1	48.0	43.3	38.2	33.4	32.3	34.8	37.8	41.7	44.5	48.1	42.0
MEAN DAILY RANGE		21.3	20.8	19.6	19.0	18.0	17.8	18.2	18.4	20.5	20.3	22.2	20.3	19.7
MEAN DAILY GRASS MINIMUM		45.3	45.8	42.2	37.3	32.5	28.2	27.3	29.7	32.3	37.1	39.5	42.8	36.7
MEAN MONTHLY MAXIMUM	1944-60	88.1	88.8	84.7	77.6	69.0	62.1	62.3	64.8	72.1	77.2	81.1	83.8	90.8
MEAN MONTHLY MINIMUM	1944-60	38.0	37.2	34.4	29.2	26.0	22.7	21.8	23.4	26.4	30.1	31.9	36.1	20.4
HIGHEST MAXIMUM		100.2	97.4	93.0	84.9	81.0	72.9	69.0	72.0	88.0	87.2	91.0	98.4	100.2
LOWEST MINIMUM		30.7	32.5	28.5	24.1	21.0	18.9	11.1	19.5	19.0	21.4	27.2	29.8	11.1
EARTH TEMPERATURES AT 9AM														
1 FOOT	1943-60	63.3	63.2	60.1	54.9	49.4	44.4	42.5	44.0	47.6	51.8	56.5	60.6	53.2
3 FEET	1943-60	60.6	61.5	60.0	56.6	52.4	48.2	45.4	45.4	47.5	50.6	54.3	58.0	53.4
RELATIVE HUMIDITY - %														
MEAN AT 9AM		63	65	73	79	84	83	85	82	72	68	64	66	74
BRIGHT SUNSHINE - HOURS														
MEAN	1935-60	221	184	181	141	124	112	122	141	169	191	209	209	2004
PERCENTAGE OF POSSIBLE		49	49	49	45	43	44	45	46	50	48	49	45	47
RAINFALL - INCHES														
MEAN	1921-50	2.2	1.9	1.8	1.7	2.7	2.7	2.3	2.3	1.9	2.0	2.0	2.6	26.1
NUMBER OF RAINDAYS		9	8	10	10	12	12	11	10	10	10	10	10	122
MAXIMUM DAILY RAINFALL		3.84	4.03	3.61	3.10	3.11	4.16	3.20	2.36	1.84	2.55	2.00	2.45	4.16
SPECIAL PHENOMENA - MEANS														
DAYS OF SNOW		-	-	-	-	0.1	0.1	0.9	0.6	0.3	0.1	-	-	2.1
DAYS OF HAIL		0.4	0.1	0.2	0.1	0.3	0.5	0.6	0.5	0.5	0.4	0.4	0.3	4.3
DAYS OF THUNDER		0.7	0.3	0.3	0.1	-	-	-	0.1	0.1	0.3	0.6	0.6	3.1
DAYS OF FOG		0.2	0.3	0.8	1.0	1.7	1.7	1.6	1.4	0.7	0.2	0.2	0.1	9.9
DAYS OF GROUND FROST		0.3	0.4	2.1	5.7	11.5	16.5	18.2	15.5	9.8	5.3	2.3	1.0	88.6
DAYS OF FROST IN SCREEN		-	-	0.2	1.0	4.6	9.4	11.2	7.8	3.2	1.0	0.2	-	38.6
WIND MILES RUN (20FT)														
MEAN		241	243	218	180	173	157	148	179	212	241	229	223	204
EVAPORATION (TANK,R.F.0.87*)inches														
MEAN	1945-55	5.9	5.0	3.8	2.1	1.3	0.8	0.8	1.5	2.6	3.4	4.7	5.2	37.2

R.F. = *reduction factor to open water evaporation

Wind Frequencies (as a percentage of all windy days)

	SW	W	NW	N	NE	E	SE	S	Calm	Gales(days)
Lincoln (1930-1950)	24	6	12	13	29	3	4	9	21	5

Length of Drought

	up to 5 weeks	over 5 weeks	over 6 weeks	over 7 weeks	over 9 weeks	no. of droughts	average length (days)
Christchurch (69 years)	40	60	34	17	5	96	43

Evapotranspiration (Thornthwaite)

	Height a.s.l. (ft.)	Moisture index	Potential Evapotranspiration for year (in.)	Water deficiency (in.)	Water surplus (in.)	Climatic class
Lincoln	36	6.9	25.2	2.1	3.0	Subhumid mesothermal '1'

Ellesmere Annual Rainfall ca. 22.6   Days of Fog 15-20

ANCIENT VEGETATION

(Compiled from Molloy et al. (1963), Speight (1930), Cox & Mead, (1963), Beattie (1945), Suggate & Burrows (1965).

Apart from peat, which has received no macro- or micropalaeobotanic study, the traces of former vegetation which was developed about Lake Ellesmere prior to Maori Settlement are mainly in the form of forest remains.

A log, dated at 9400 B.P. (before 1950) was found in a borehole 71ft below present sea level at Lake Ellesmere. At Lincoln wood of Podocarpus dacrydioides (kahikatea) was found buried in an old peaty topsoil 3ft below the surface and dated at 8895 B.P. Buried charcoal of Nothofagus fusca (red beech) and Podocarpus spicatus (matai), dated 6,495 B.P. was found at Broadfields and other dates are Prebbleton 5650 B.P., charcoal; Templeton, 3500 B.P., charcoal (Leptospermum); Lincoln, 2440 B.P., wood (P. spicatus) buried in old peaty topsoil; Broadfields 1725 B.P., charcoal (Nothofagus fusca.) More recent dates are plentiful for wood and charcoal, including one of 760 B.P. for stumps of a buried Podocarpus totara forest at Halswell. It appears that mosaics of extensive forest and swampland were present in the area from Christchurch to Lake Ellesmere throughout the post-glacial period. When Maori people entered the area they probably began forest clearance by fire, but prior to this there was considerable forest destruction from time to time as sea-level changed, rivers aggraded and through the agency of natural fires. However the forests were still extensive early in the Maori period of occupation. In the swamp deposits round Motukarara podocarp and broadleaved tree wood is plentiful. Charcoal from podocarp and broadleaved trees is found about the Rakaia mouth. Maori tradition records a place near here as Tahi-totara. Round Taumutu and the south western end of the lake are ample remains of forest. Stumps of trees described as "totara" are present, exposed by erosion of the Spit gravels and there are other standing stumps of "kahikatea" in the lake near Harts Creek. The lake margin forests must have been continuous with those on Banks Peninsula, and those near Christchurch and forest must have extended southward along the coastline to Timaru, broken by strips of Leptospermum scrub on the light, dry soils. By the time European settlers arrived almost all of this forest was gone. The removal by fire, was possibly assisted by a marked decline in rainfall, although the forests on the heavy waterlogged soils round Lake Ellesmere would not have been dependent on rainfall. Banks Peninsula was heavily forested before and during Maori times but milling and disastrous fires (especially in the 1860's) removed this.

The replacement vegetation round Lake Ellesmere consisted of swamp on the peats and other waterlogged soils and scrub and tussock grassland on the well-drained strips. The Spit and the lake shore would have had vegetation as shown in Fig.4 before and after Maori occupation.

SETTLEMENT

(Compiled from Evans (1953), Acland (1951), Andersen (1927), Beattie (1945).

Prior to 1810 the Lake Ellesmere area was relatively closely settled by Maori (fig.4) but internecine feuds reduced their numbers considerably after this time. The lake played an important part in the economy of the Canterbury Maori. Eels, other fish, freshwater mussels and birds were taken and dried eels were used for trade. This was about the southern limit of kumera cultivation. From about 1830 there was some flax trading with European ships. The lake level was prevented from rising more than about 10ft a.s.l. by the Maori because high water threatened the Taumutu settlement. Graziers began to take up land in large blocks around the lake from 1845 to 1855, run cattle and sheep were grazed on the open country and dairying was carried out on some of the heavier land. Although large swamp areas remained in 1860 the primitive vegetation (Fig.4) was already strongly modified. The Maori and then the Europeans used fire to clear the swamps and the Spit was also burned. Many plants were introduced by Europeans which, together with native plants form the present day semi-natural plant communities (fig.5). Between 1860 and 1920 the large runs to west and north were divided into the network of farms which exists today and most of the swampland was drained. The Spit, on very light land, is, however, still managed in the form of grazing runs and the lake shore subject to flooding, together with some areas of saline soil, is used for extensive stock grazing. Various settlements (fig.1) were established in the period 1860 to 1920. Between 1865 and 1884 timber was rafted across the lake from Banks Peninsula mills to near Harts Creek for transport to Christchurch.

Drainage of the swamp areas has virtually been completed but many areas around the lake are prone to waterlogging, especially in winter. Changing lake levels bring about grazing practices and problems which probably are peculiar to this locality. At low lake levels cattle may be seen

FIG. 4 MAORI LOCATIONS AND PRIMITIVE VEGETATION

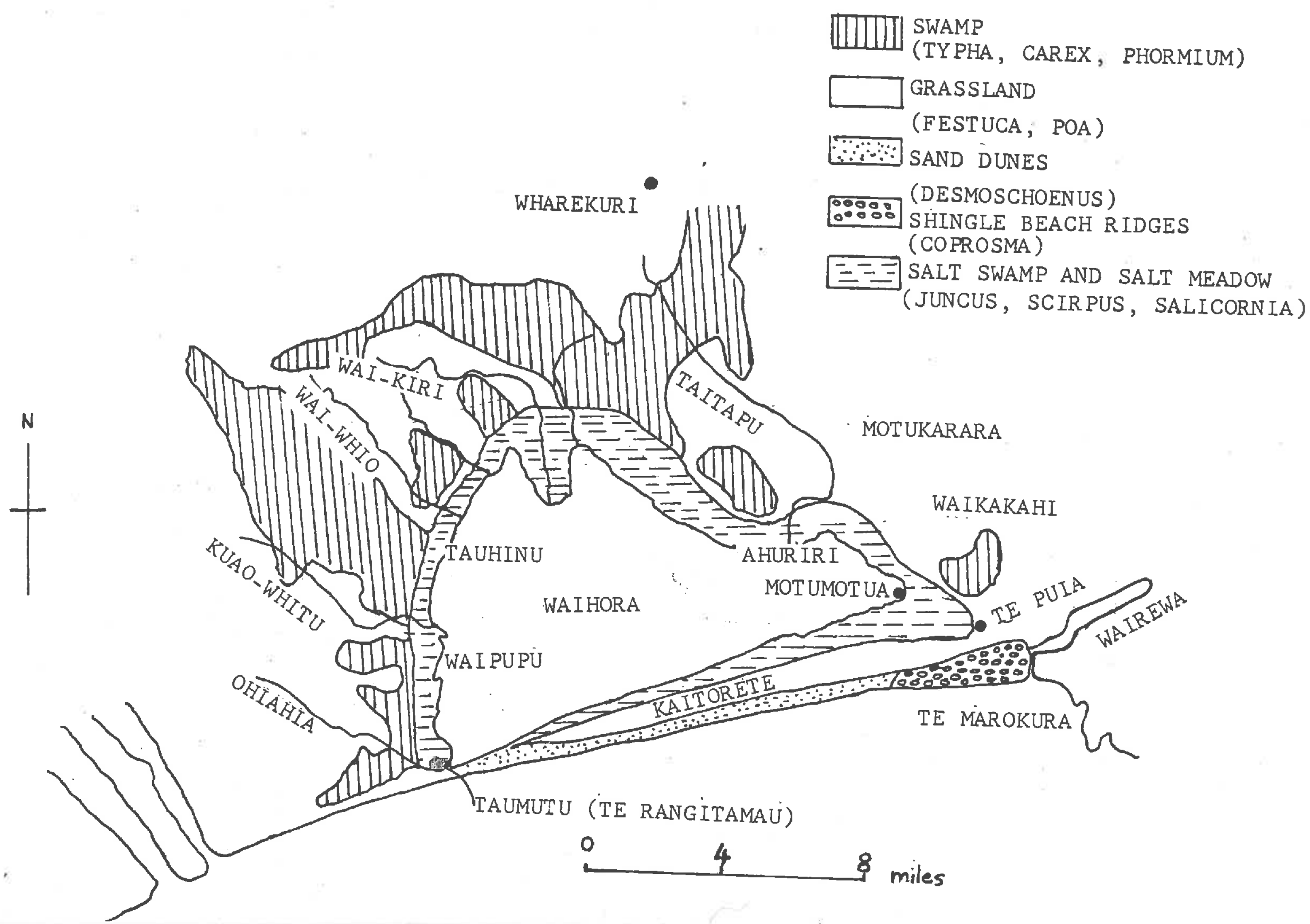


FIG. 5 PRESENT VEGETATION (GENERALIZED)

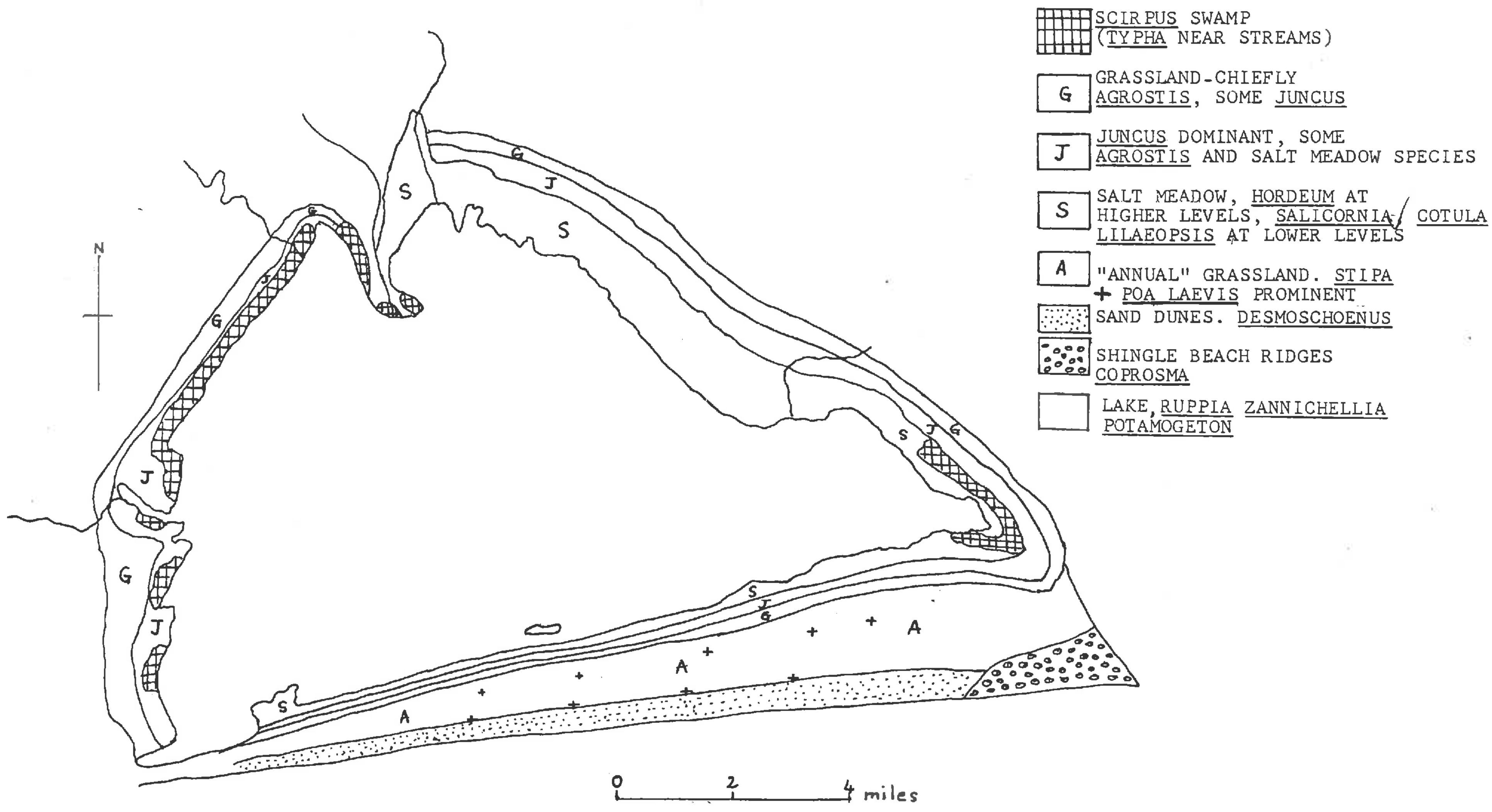
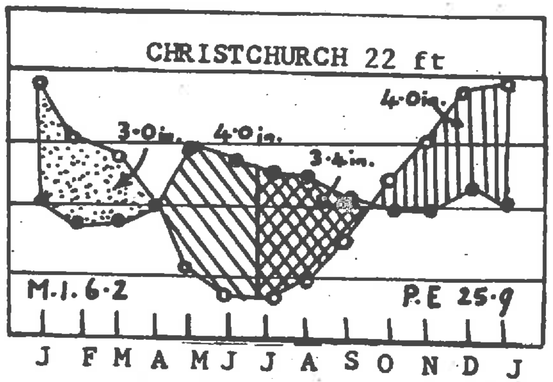


FIG 6 EVAPOTRANSPIRATION



KEY

- POTENTIAL EVAPOTRANSPIRATION
- PRECIPITATION
- M.I. MOISTURE INDEX
- P.E. THERMAL EFFICIENCY (POTENTIAL EVAPOTRANSP. FOR YEAR)
- WATER SURPLUS
- WATER DEFICIENCY
- SOIL MOISTURE UTILISATION
- SOIL MOISTURE RECHARGE

PRESENT VEGETATION

(Compiled from Evans (1953), Wraight (1957, 1964) and information from Miss R.Mason and Botany Hons. part III projects).

A broad picture of the present vegetation is shown in fig.5. A checklist of plants and their habitats is appended. Round the lake edge there is stratification of the vegetation which could be divided into more categories than have been indicated here. The main original swamp areas have been replaced by farmland. They contained Typha muelleri, Phormium tenax and Carex secta as dominants. The swamplands which remain are intermingled with areas of Agrostis stolonifera and contain as the commonest components Juncus gregiflorus and nearer the lake, J. maritimus. Occasional rows of Salix fragilis have been planted. Stands of Leptocarpus simplex and Scirpus caldwellii are relatively uncommon. Plagianthus divaricatus shrubs are present near the northern shore and occasionally on the southern shore. Typha muelleri stands stands are present round the fresh water streams, especially at Harts Creek. The lake shore vegetation commonly contains Scirpus americanus as a tall component. Immediately round the lake edge, especially on the wide saline flats subject to periodic flooding there is short, zoned vegetation. In the highest zone on the northern side of the lake Agrostis stolonifera is common, then there is a zone toward the lake edge where the main species is Hordeum marinum. Lower than this Salicornia australis, Cotula coronopifolia, Mimulus repens Lilaeopsis novae-zelandiae and Spergularia marginata form the main cover, with Samolus repens, Selliera radicans and other species present.

On the southern side of the lake and elsewhere on light soils a similar zonation occurs in the salt meadows but the higher zones are characterized by the presence of Puccinellia, Scirpus nodosus, Poa caespitosa, Stipa, Notodanthonia and Trifolium fragiferum.

The ecology of the lake edge vegetation was carefully investigated by Evans (1953). He concluded that the three main external environmental factors influencing the distribution of vegetation zones were flooding, salinity and soil texture. Although soil texture is to some extent independent of flooding, Evans points out that flooding is the master factor controlling most of the others (salinity, organic matter in the soil and soil moisture). Other important factors, intrinsic to the plants present, are the differing ranges of tolerances of the different species for such factors as salt content in factors, the ability of species to compete with one another. Thus certain dominant species under certain conditions grow too densely to permit the presence of others. Different assemblages of plant species are found under various different combinations of the external environmental conditions, (dependent partly also on the tolerances of individual species, and the intensity of competition). Although there is a gradient in frequency of periodic flooding towards the lake shore, salinity is highest some distance above the mean water level and lower both above and below this. Species such as Salicornia, Triglochin, Puccinellia and Hordeum are the most salt-tolerant of the plants and Agrostis, Plantago and Selliera are only moderately salt-tolerant. The species of the vegetation zones highest above water level are tolerant of dry conditions but also tolerate occasional flooding. Those found growing near the water require plentiful water and tolerate frequent flooding and submergence for considerable periods. Species such as Mimulus, Lilaeopsis and Scirpus americana prefer a fine silt and mud substratum, but species such as Salicornia, Hordeum and Plantago are intolerant of this and require a sandy substratum. Grazing by stock probably has an effect on the presence of palatable species such as Apium filiforme and, in shallow water ducks graze species such as Lilaeopsis and Mimulus heavily. A characteristic feature of the lake edge vegetation is its seasonal periodicity. Species such as Salicornia, Scirpus americanus, S. caldwellii and Typha die down in winter and begin growth again in spring.

Another characteristic feature of the lake is the submerged aquatic vegetation. No plants grow on the soft muds, sands, or pure shingles. On silts in not too deep or turbid water Ruppia spiralis forms extensive beds, growing at times as tall as 6 feet. Potamogeton pectinatus, a similar tall, fine-leaved plant is sometimes mingled with it, and Zannichellia palustris and Lepilaena bilocularis, both smaller but also fine-leaved, the charophytes Chara globularis and Lamprothamnion macropogon, and various green and blue-green algae are also likely to be found. This vegetation is not very stable and in the past has disappeared and later gradually returned. Weed beds occur mostly along the shore from the Selwyn to Taumutu, near Kaituna, and on the mudbank near the Spit. During storms large quantities of these plants are uprooted and washed up on the shores.

(on

The important factors for distribution of the submerged species, then, are nature of substratum, depth of water, turbidity and wind-caused wave action. Grazing by swans and geese is an important factor influencing the vegetation of deeper water. The effect on growth of plants of faecal enrichment by the vast flocks of birds is unknown. In still water among taller plants the floating species *Lemna minor* and *Azolla rubra* may be present.

The vegetation of the Spit is varied. The shingle beach ridges at Birdlings Flat carry mosaics of low shrubs (shaped by salt spray blown by southwest winds and also by browsing by stock) and open shingle or more or less closed "annual" grassland with mosses and lichens. The main shrub species are *Coprosma* spp. and *Muehlenbeckia complexa*. Strips of scrubby vegetation occur in other stony areas on the Spit. On much of the Spit proper, dense "annual" grassland has replaced the former tussock grasslands although some *Poa laevis* is still present. The "annual" grassland is dominated by *Stipa variabilis* but *Vulpia bromoides*, *Notodanthonia* sp. and *Aira caryophyllea* are important. There are various forbs present including some clovers. *Hypoxis pusilla* the only New Zealand relative of narcissus reflects the "mediterranean" nature of the climate by producing leaves and flowers in autumn, winter and spring, then dying back to its bulb in summer. The annual grasses behave in a similar way by getting their life cycle over before the summer drought. Tran sitions are present between the flats carrying "annual" grassland and the rear-dunes, with *Pteridium esculentum* and shrubs interspersed with stands of *Raoulia australis* and *Zoysia minima* (on (on sandy flats) and annual grasses such as *Lagurus ovatus* and *Bromus gussonii*. The main plant of the sand dunes proper is *Desmoschoenus spiralis*. Blowouts frequently carry a sparse cover of *Carex pumila*.

The form of these dune plants adapts them to survive sand movement and burial and *Zoysia* and *Raoulia*, though requiring more stable conditions, also are adapted to a habitat where there is much movement of sand. No detailed studies of the ecology of the dunes and grassland has been made other than that of Wraight (1957) which was concerned chiefly with the influence of grazing on the plant communities. Wraight showed that differences in stocking rates were correlated with floristic differences, e.g. *Pteridium*, *Scirpus nodosus* and *Poa laevis* are scarce where grazing is heavy and *Stipa*, *Vulpia* and *Aira* are abundant under controlling the distribution of species in these communities are, in the dunes, the abundance of sand, newly deposited, and strongly affected by wind, which provides an unstable, excessively drained substrate; in the rear dunes the substrate is somewhat more stable, there has been some build-up of organic material and there are probably somewhat better water-storage conditions. The sand flat areas are influenced by the presence of shallow sand over gravel and, though drift of sand occurs and drainage is very free, these are more stable sites than the dunes. In the grassland the substrate is completely stable and there has been build-up of considerable organic matter because the landform has existed in its present state for a long time. The overriding factor is free drainage permitted by the underlying gravel and consequent summer drought. Nevertheless, water storeage potential in the A horizon of the soil is greater than for the dune areas. The role of different tolerances of the plant species present, and of competition, in helping to determine the nature of the vegetation patterns may be seen here too. Plant growth form, length of life and seasonal growth pattern are intrinsic characteristics which influence these matters. The dunes and sand-flats have rather open vegetation, the rear dunes more closed vegetation and the grassland relatively little bare ground. Moss cover between the tufts of grass is a characteristic feature of the grassland.

LAKE ELLESMERE CHECKLIST OF PLANT SPECIES
(Brief list only)

Beach, Dune area, and Annual Grassland

KEY: S - shore, D - dune, A - area transitional from dunes to grassland, R - shingle beach ridge, Ad - adventive G - grassland.

Shrubs and Sub-shrubs

Carmichaelia appressa	Prostrate broom	D A
C. violacea	Native broom	R
Clematis afoliata	Leafless clematis	R
Coprosma crassifolia	Thick-leaved Coprosma	R
C. propinqua	Miki miki	R
Discaria toumatou	Matagouri	R
Haloragis erecta		R
Hymenanthera crassifolia	Porcupine bush, Wharekarara	A R
Muehlenbeckia complexa	Pohuehue	A R
M. ephedrioides	Leafless Pohuehue	R
Pimelea prostrata	N.Z. daphne, strathmore weed	D A
Rubus squarrosus	Leafless lawyer	R

Grasses and Grass-like plants

Aira caryophyllea Ad	English hair grass	G R
Ammophila arenaria Ad	Marram grass	D
Bromus gussonii Ad	Barren brome	D A G R
Carex pumila	Sand sedge	S D
Desmoschoenus spiralis	Pingao, Golden sand sedge	D
Holcus lanatus Ad	Yorkshire fog	R
Hypoxis pusilla	N.Z. narcissus	G
Lagurus ovatus Ad	Harestail grass	D A R
Notodanthonia sp. Ad	Danthonia	G R
Poa laevis (formerly caespitosa)	Silver tussock	A G
P. pratensis Ad	Kentucky bluegrass	G
Stipa variabilis Ad	Needlegrass	G R
Vulpia bromoides Ad	Hairgrass	G
Zoysia minima	Pygmy twitch	A

Other herbs

Acaena ovina Ad	Sheeps Burr	D A R
A. novae-zealandiae	Bidi-bidi	A
Arenaria serpyllifolia Ad	Sandwert	D A G
Cakile edentula Ad	Sea rocket	
Calystegia soldanella	Sand convolvulus	D A
Chenopodium allanii	[illegible]	R
Craspedia uniflora	Woollyhead	A
Cyathodes fraseri	Patotara	G
Dichondra repens	Mercury Bay weed	G
Erodium cicutarium Ad	Cranesbill	A G R
Eryngium vesiculosum	Sea holly	R
Galium perpusillum	Pygmy bedstraw	D A G
Geranium sessiliflorum	N.Z. Cranesbill	G R
Hypochaeris radicata Ad	Catsear	D A G
Leontodon taraxacoides Ad	Hawkweed	D A
Lepidium murale Ad	Dune Cress	D R
Oxalis corniculata	yellow oxalis	R
Pterostylis mutica	Green orchid	G
Polycarpon tetraphyllum Ad	All seed	G
Raoulia australis	Scabweed	D A
Rumex acetosella Ad	Sorrel	D A G R
Salsola kali Ad	Saltwort	S
Senecio glaucophyllus	Shore groundsel	S D
Scleranthus uniflorus	Kohukohu	A
Silene gallica Ad	Catchfly	D A G
Spergularia marginata	Sand spurrey	D
Tillaea sieberiana	Coastal tillaea	G R
Trifolium arvense Ad	Haresfoot trefoil	A G R

LAKE ELLESMERE CHECKLIST OF PLANT SPECIES

Beach, Dune area, and Annual Grassland

Continued.....

T. dubium Ad	Yellow suckling clover	G R
T. fragiferum Ad	Strawberry clover	G
T. repens Ad	White clover	G R
Verbascum thapsus Ad	Woolly mullein	R
Vicia sp. Ad	Vetch	R
Vittadinia australis		D G R
Other plants		
Pteridium esculentum	Bracken	D
Polytrichum juniperinum	Moss	G
Rhacomitrium crispulum	Moss	
Lichens		A G R

Lake edge

KEY: L - swamp plants and taller lake shore plants, U - floating or submerged plants, O - salt meadow plants.

Shrub		
Plagianthus divaricatus	Shore ribbonwood	L
Grasses and grass-like plants		
Agrostis stolonifera Ad	Creeping bent	L O
Holcus lanatus Ad	Yorkshire fog	L
Hordeum marinum Ad	Sea barley grass	O
Juncus gregiflorus	Common rush	L
J. maritimus	Sea rush	L
J. pallidus	Giant rush	L
Leptocarpus simplex	Jointed "rush"	L
Parapholis strigosa Ad	Sea hard grass	O
P. incurva Ad	Sickle grass	O
Polypogon sp. Ad	Beard grass	O
Puccinellia stricta	Salt grass	O
Scirpus americanus	Three square	L
S. caldwellii		L
S. cernuus		O
S. nodosus	Node sedge	L
Triglochin striatum var. filifolium	Arrowgrass	O
Other herbs		
Apium filiforme	Slender celery	L O
Atriplex hastata	Goosefoot	O
Centaurium exaltatum Ad	Centaury	O
Chenopodium ambiguum	Goosefoot	O
Cotula coronopifolia	Batchelors button	O
C. squalida	Pincushion	O
Lemna minor	Duckweed	U
Lepilaena bilocularis		U
Lilaeopsis novae-zelandiae	Tape measure	O
Mimulus guttatus Ad	Monkey musk	L
M. repens	Purple mimulus	O
Myosotis palustris Ad	Forget-me-not	L
Nasturtium sp. Ad	Water cress	L
Plantago coronopus Ad	Buckshorn plantain	O
Potamogeton pectinatus Ad	Narrow-leaved pondweed	U
Ranunculus sceleratus Ad	Celery buttercup	L
Rumex obtusifolius Ad	Dock	L
Ruppia megacarpa	Horses mane	U
R. spiralis	Horses mane	U
Samolus repens	Sea primrose	O
Salicornia australis	Glass wort	O
Selliera radicans	Remu-remu	O
Spergularia marginata		O

Continued.....

Suaeda novae-zealandiae	Sea-blite	O
Trifolium fragiferum Ad	Strawberry clover	L O
Zannichellia palustris		U
<u>Other plants</u>		
Azolla rubra	Water fern	U
Various algae and Charophytes		U

ANIMAL LIFE

(Compiled with the aid of G. Tunnicliffe, V.M. Stout & W.Thomas)

A checklist of animals and their habitats is appended. The area in and about Lake Ellesmere is rich in vertebrate and invertebrate life relatively undisturbed by the cultural activities of man. On the lake and its margins the most striking aspect of the wild fauna is the richness of bird life. Black swan Cygnus atratus, Canadian goose Branta canadensis, grey duck Anas superciliosa, mallard A. platyrhynchos, shoveller A. rhynchotis and paradise duck Tadorna variegata feed on the weed beds. Some of the ducks and canadian geese inhabit the lake margins, especially at night. Pukeko, Porphyrio porphyrio and various wading birds (pied stilt Himantopus himantopus oyster catcher Haematopus ostralegus, white faced heron Notophoyx novae-hollandiae) are numerous on mudflats, shallows and swampland. The scavenging harrier hawk Circus approximans is ubiquitous as are the tern Sterna striata, the gulls Larus dominicanus, L. novae-hollandiae, the shag Phalacrocorax carbo and the kingfisher Halcyon sancta. Many of the waterfowl breed round the lake, the vast numbers of black swan nesting mainly near the southern and western sides. The seasonal occupation in summer by migratory wading birds from the northern hemisphere (knot, Calidris canutus, sandpipers C. spp. and godwit, Limosa lapponica) is of particular interest. Recent colonization by welcome swallows, Hirundo neoxena is also interesting and these birds may be seen hawking over the open water. Grazing round the lake by domestic stock is a significant ecological factor.

Lake Ellesmere has a small number of species of aquatic invertebrates but many of them are of considerable interest. There appear to be forms both of marine and of freshwater affinities. Two species of mysids, a predominantly marine group, have been reported, Tenagomysis chiltoni and T. novae-zealandiae, often occurring in large numbers in the water at the edge of the lake. Also of intrest are the larvae and pupae of the moth, Nymphula nitens, living on the rooted aquatic vegetation particularly at the western side of the lake. The most abundant macroscopic invertebrates in the lake are the amphipod, Paracallio fluviatilis and the gastropod, Potamopyrgus antipodum, both of which occur in large numbers among the vegetation and on the mud throughout the greater part of the lake. The vegetation around the edge of the lake supports a number of other invertebrates, including another amphipod, Paracorophium lucasi; several species of caddis larvae (Pycnocentria, Pycnocentrodes, Paroxyethira and Olinga) water boatmen (Sigara and Diaprepocoris); damselfly nymphs (Xanthocnemis) and at least one more species of Potamopyrgus, P. corolla salleana. In the mud are both oligochaetes & polychaetes

together with at least one species of midge larvae, (Chironomus) the adults of which sometimes form ~~large~~ vast swarms in the vicinity of the lake. The plankton of the open water has two species of copepods; one belongs to the common fresh-water genus Boeckella, and the other is Gladioferens subsalaria, described by Percival from Lake Ellesmere material.

Fish form an important element of the lake fauna. There is commercial fishing in the lake for flounder, of which three species are present, for yellow-eyed mullet and for eels. Other permanent residents of the lake include the native fish, Galaxias attenuatus and several species of Gobiomorphus, together with the introduced brown trout and quinnat salmon. Sprat, Maugaclupea antipodum, and Retropinna have also been reported. Temporary visitors when the lake is open have included the common sole, greenback flounder, kahawai, elephant fish, red cod, dogfish, skate and one basking shark.

On the dryland area of the Spit a different assemblage of animals is to be found. Large numbers of skylark, Alauda arvensis, pipit, Anthus novae-zelandiae harrier hawk, and in the breeding season dotterel Charadrius bicinctus are present. The invertebrate fauna is varied (see checklist) and there are numbers of small mammals (rabbit Oryctolagus cuniculus, hedgehog Erinaceus europaeus, hare Lepus europaeus and stoat Mustela erminea) in addition to the stock which graze the area. Skinks, Lygosoma sp. are the common lizards in the dunes and grassland in contrast to the presence of geckos, Hoplodactylus sp. in the stony beach ridge area.

The coastal side of the Spit with its narrow belt of dunes provides an interesting area showing sharp gradients in distribution of the invertebrate life. The common butterflies Crysophanus spp., Lycaena, cricket Gryllus, grasshopper Phaulacridium, flies etc. of the grasslands and dunes rapidly give way to supralittoral faunas in the driftwood zone. These include sand scarab Pericoptus, the large earwig, Anisolabis, katipo, Latrodectus and further down the beach sand hoppers (Crustacea) and kelp flies. The beach is also the habitat of gulls, terns and waders.

USE OF THE LAKE

Present economic use of the lake is for commercial fishing. The lake margins are grazed by cattle and sheep. The other main use of the lake is for recreation. Power boating, water skiing, trout fishing and duck shooting are the main activities. Game sanctuaries are established at Harts Creek and Ahuriri Lagoon and the North Canterbury Acclimatization Society maintains a game farm and fish hatchery at Greenpark.

Recreational use and fishing conflict with farming use in various ways. Agricultural interests have long wished to maintain the lake permanently low so that the flats might be developed into better pasture but salinity is a problem. Fishermen (commercial and sporting) and shooters wish to retain what is the only easily accessible area for them in Canterbury. Their desire is legitimate in view of the fact that population increase in Christchurch will bring increasing pressure on recreational facilities nearby. The potential of the lake for food production from fish possibly exceeds its possibilities in the farm production line. The activities of game-birds such as pukeko, swan and geese are viewed askance by farmers who see their pastures being eaten or fouled. The question of access to the lake shore is also a vexed one.

The surface has only been scratched in the pure and applied fields of scientific study at Lake Ellesmere. The semi-natural plant communities, aquatic animal communities and birdlife offer an excellent opportunity for ecosystem research. Applied research on the fish and game birds finds a rich field at Lake Ellesmere and a great deal of other biologic and general scientific work awaits study. This area, so close to a main centre of New Zealand population should be studied intensively from all angles in order to determine its best economic and recreational uses.

LAKE ELLESMERE CHECKLIST OF ANIMALS (Brief list only)

"Terrestrial" Animals.

KEY: S - shore; D - dune; G - Annual grassland; M - salt meadow; L - lake; W - lake edge swamp; I - shingle beach ridges.

Mammals

Bos taurus	Domestic cattle	G W M
Erinaceus europaeus	Hedgehog	D G
Lepus europaeus	Hare	D G
Mus musculus	Mouse	D G
Mustela erminea	Stoat	D G
Oryctolagus cuniculus	Rabbit	D G
Ovis aries	Domestic sheep	D G W M

Birds

Alauda arvensis	Skylark	D G
Anas gibberifrons	Grey Teal	L
A. platyrhynchos	Mallard	L
A. rhynchotis	Shoveller	L
A. superciliosa	Grey duck	L W
Anthus novae-zelandiae	Pipit	D G M
Arenaria interpres	Turnstone	W
Botaurus stellaris	Bittern	W
Branta canadensis	Canadian goose	L W
Calidris acuminata	Siberian sandpiper	W
C. canutus	Knot	W
C. melanotos	American sandpiper	W
Charadrius bicinctus	Dotterel	S
C. dominicus	Golden plover	L
Circus approximans	Harrier	D G L W
Cygnus atratus	Black swan	L
C. olor	Mute swan	L
Egretta alba	White heron	L
Haematopus ostralegus	Pied oystercatcher	L
Halcyon sancta	Kingfisher	L W
Himantopus himantopus	Pied stilt	L
Hirundo neoxena	Welcome swallow	L
Larus dominicanus	Black-backed gull	S L
L. novae-hollandiae	Red-billed gull	S L
Limosa lapponica	Godwit	W
Notophoyx novae-hollandiae	White faced heron	L W
Phalacrocorax carbo	Black Shag	L
P. melanoleucos	Little Pied Shag	L
Porphyrio porphyrio	Pukeko	W
Porzana pusilla	Marsh crake	W
Sterna striata	White fronted tern	S L
Sturnus vulgaris	Starling	W
Tadorna variegata	Paradise duck	L

Reptiles

Hoplodactylus sp.	Gecko	I
Lygosoma sp.	Skink	D

Invertebrates

Anisolabis littorea	Large earwig	S
Calliphora quadrimaculata	Blowfly	S
Costelytra zelandica	Grass Grub	G
Crysophanus boldenarum	Purple butterfly	D G
C. sallustius	Common copper	D G
Gryllus servillei	Cricket	G
Latrodectus katipo	Katipo	S
Locusta migratorioides	Locust	G
Lycaena labradus	Little blue butterfly	D G

CHECKLIST OF LAKE ELLESMERE ANIMALS Contd.

Melampsalta sp.	Cicada	D G
Pericoptus truncatus	Sand scarab	S
Porcellio scaber	Wood louse	D I
Phaulacridium marginale	Grasshopper	G
Salius sp.	Spider hunting wasp	D G
Sarcophaga sp.	Flesh fly	G
Sigaus campestris	Grasshopper	G

Various Diptera, Lepidoptera, Coleoptera, Arachnida etc.

"Aquatic" Animals

Rhabdocoela:		
Microstomum sp.		- plankton
Tricladida:		
Procerodes sp.	Flatworm	- southern edge (F.R.Allison)
Nematoda:		
species undetermined		- among aquatic vegetation
Polychaeta:		
Fam. Aricidae		- bottom mud
Eumenia sp.?		- among aquatic vegetation
Oligochaeta:		
Tubificidae		- mud throughout
Copepoda:		
Boeckella hamata		- plankton
Gladioferens subsalaria		- plankton (Percival)
Ostracoda:		
Two species, undetermined		- among aquatic vegetation
Mysidacea:		
Tenagomysis chiltoni		- among aquatic vegetation
T. novae-zealandiae		- among aquatic vegetation
Amphipoda:		
Paracalliope fluviatilis		- throughout
Paracorophium lucasi		- throughout
Isopoda:		
Idotea marina		- mud, open water area
Odonata:		
Xanthocnemis zealandica	Damsel fly	- among aquatic vegetation, northern side.
Trichoptera:		
Pycnocentria sp.	Caddis	- northern side
Pycnocentrodes sp.	"	- " "
Paroxyethira sp.	"	- " "
Olinga sp.	"	- " "
Lepidoptera:		
Nymphula nitens	Moth	- northern and western sides
Hemiptera:		
Diaprepocoris zealandiae	water boatman	- northern and western sides
Sigara arguta	" "	" " " "
Diptera:		
Ephydra sp.		- among aquatic vegetation
Chironomus zealandicus	Midge	- throughout
Gastropoda:		
Potamopyrgus antipodum		- throughout
P. corolla salleana (or P. badia)		- among aquatic vegetation
P. spelaeus		- reported by Percival
Bivalvia:		
Cyclomactra ovata		- " " "

FISH: (Excluding temporary visitors when the lake is open to the sea)

Aldrichetta forsteri	Yellow-eyed mullet
Anguilla australis,	Short-finned eel
A. dieffenbachi	Long-finned eel
Galaxias attenuatus	Whitebait
Gobiomorphus gobiodes	Giant bully
Gobiomorphus spp.	Bullies
Maugaclupea antipodum	Sprat
Oncorhynchus tshawytscha	Quinnat salmon
Retropinna retropinna	Smelt, silvery
Rhombosolea retiaria	Black flounder
R. leporina	Yellow-belly flounder
R. plebia	Sand flounder
Salmo trutta	Brown trout

* (Determinations by G.A.Knox (Polychaeta, Aricidae), D.E. Hurley (Amphipoda), E.C. Young (Hemiptera), T.Gorman (Fish), plus information obtained by the Zoology Honours Part III students. Information on aquatic animals compiled by Dr V.M. Stout)

REFERENCES

Acland, L.G. 1951: The Early Canterbury Runs. Christchurch.

Andersen, J. 1927: Placenames of Banks Peninsula. Wellington.

Beattie, H. 1945: Maori Placenames in Canterbury. Dunedin.

Cox, J.E. & Mead, C.B. 1963: Soil Evidence Relating to Post-Glacial Climate on the Canterbury Plains. Proc. N.Z. Ecol. Soc. 10, 28-37.

N.Z. Meteorological Service 1966: Summaries of Climatological Observations at N.Z. Stations to 1960. Wellington.

Evans, L. 1953: The Ecology of the Halophytic Vegetation of Lake Ellesmere, N.Z. J. Ecol. 41, 106-22.

Hight, J. & Straubel, C.R. 1957: A History of Canterbury. Christchurch.

Kear, B.S., Gibbs, H.S. & Miller, R.B. 1967: Soils of the Downs and Plains Canterbury and North Otago, New Zealand. Soil Bureau Bulletin 14.

Mason, R, 1968: The Vegetation of the Coast in "The Natural History of Canterbury". (Ed. G.A.Knox), Wellington.

Molloy, B.P., Burrows, C.J., Cox, J.E., Johnston, A. & Wardle, P: 1963. Distribution of Subfossil Forest Remains in the Eastern South Island, N.Z. N.Z. J. Bot. 1, 68-77.

Moore, L.B., and Adams, N.M. 1963: Plants of the New Zealand Coast. Auckland.

Oborn, L.E. and Suggate, R.P., 1959: Sheet 21, Christchurch (1st Edn) Geological Map of New Zealand 1:250,000 D.S.I.R., Wellington.

Schofield, J.C. 1963: Climatic Evidence From Sea-Level Fluctuation. Proc. N.Z. Ecol. Soc. 10, 21-23.

Speight, R. 1930: The Lake Ellesmere Spit (with Appendix by A. Wall: The Plant-covering of the Spit) Trans. N.Z. Inst. 61, 147-

Suggate, R.P., 1958: Late Quaternary Deposits of the Christchurch Metropolitan Area. N.Z. J. of Geol. and Geophysics 1, 103-22.

1963: The Fan Surfaces of the Central Canterbury Plain. N.Z. J. of Geol. and Geophysics 6, 281-7.

Suggate, R.P. & Burrows, C.J. 1965: South Island Radiocarbon Dates in "Recent Work on the History of the last 25,000 Years" Univ. of Canterbury.

Ward, W.T. & Harris, C.S: 1964: Soils and Agriculture of Ellesmere County. Soil Bureau Bulletin 21.

Wraight, M.J. 1957: The Ecology of Lake Ellesmere Spit. thesis for M.Agr.Sci., Lincoln.

Wraight, M.J. 1964: Modification of Grasslands by Grazing Animals. Proc. N.Z. Ecol. Soc. 11, 27-32.