VEGETATION CHANGES WITH FALLING WATER LEVELS IN THE DELTA MARSH MANITOBA

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ABSTRACT

Quantitative studies have been made on the vegetation of the fresh-water marsh at Delta, Manitoba, under falling water levels, from 1959 to 1961. Twenty widely distributed sites in the 15,000 hectare marsh were studied in detail. Twenty-seven prevalent species were found of which thirteen had a presence rating between 100% and 65%. Included in this group, in diminishing presence order, were: Phragmites communis var. berlandieri, Scolochloa festucacea, Atriplex patula, Chenopodium rubrum, Sonchus arvensis var. glabrescens, Aster brachyactis, Rumex maritimus var. fueginus, Carex atherodes, Hordeum jubatum, Typha latifolia, Scirpus paludosus, Ranunculus sceleratus, and Scirpus validus. Ecological descriptions of these species are given, with particular reference to the part they played in succession, within a season and from one season to the next. Emphasis is placed on those species with the highest presence values, and two groups of 'selective' species are described - those restricted to low and high conductivity sites. Submerged aquatic vegetation is discussed briefly. The soils of the marsh are a complex of Peaty Saline Rego Humic Gleysols and Organo and Saline Regosols. Samples were collected from all the sites and analyzed for pH, conductivity, physical composition, and available cations and anions. Sodium, potassium, calcium, magnesium, carbonates, bicarbonates, sulphates and chlorides were analyzed quantitatively. Topographical relief at Delta is slight but physiographic processes are striking and their influence on the vegetation is discussed.

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SECTION I

INTRODUCTION

This study describes the vegetation of a freshwater marsh at Delta on the southern shores of Lake Manitoba, and the influence upon the marsh of falling water levels as areas denuded of vegetation were exposed.

Water levels in Lake Manitoba undergo periodic fluctuations which effect the marsh. The all-time high of 248.4 m (815 ft) in the lake was reached in 1955 and for three years it was higher than the mean of 247.4 m (812 ft) though it was slowly dropping throughout this period. Water levels were still receding when the major part of this study terminated in 1961.

The marsh covers 15,000 hectares (37,050 acres) and is an intricate network of various sized shallow bays of open water interconnected by channels, and separated by vegetation (Hochbaum, 1944). It is one of the most extensive in the Canadian prairies. Normally, the two most prevalent species in the marsh are Phragmites communis var. berlandieri and Scolochloa festucacea. These communities were described as Phragmition and Scolochloetum by Löve and Löve (1954). During 1958 the vegetation present in the marsh was described quantitatively (Walker, 1959) and the need for continuing the study clearly was indicated in order to follow the seral changes in the vegetation and to determine the role of ecological factors in these changes.

Innumerable studies of freshwater marsh vegetation, particularly of aquatics, have been undertaken by botanists and wildlife biologists. But, with notable exceptions, few of these have presented more than brief qualitative accounts of marsh vegetation, and none has originated in this region. It was in an attempt to fill this gap that the present work was undertaken.

An intrinsic part of vegetation study is concerned with the plants that are associated in communities, the latter having an observable structure and often a definite specific composition. Only the species adapted to a particular habitat will survive under the existing conditions. A full understanding of vegetation therefore draws upon autecological and community studies. Therefore, during 1959, 1960 and 1961 detailed investigations were made in a number of sites to determine the quantitative composition of the emergent plant communities and to describe the seral changes as water levels dropped. Landform is one of the basic influences on vegetation, and, though topographical relief at Delta is slight, physiographic processes are striking, and have an obvious influence on the vegetation.

This thesis has been organized into six sections. The first deals in turn with a description of the general setting of the area, its geology, soils, geography, and climate. Section two comprises descriptions of the vegetation of the Delta Marsh and its changes during falling water levels in selected marsh shores, potholes and sloughs. Also included is a discussion and analysis of empirical data and the resulting ecological descriptions of the most prevalent species. Section three consists of a general discussion of soils found in the marsh and descriptions of the soils from the study areas. Section four is a general discussion of the observations and results. It is followed by a section summarizing the work and a citation of literature. Appendix I gives plant lists and Appendix II the data from chemical analysis.

LITERATURE REVIEW

The study of freshwater marsh vegetation has attracted the attention of two groups of investigators - botanists and wildlife biologists. The majority of their accounts have been qualitative and those of wildlife biologists directed mainly towards management practices. They will be discussed here with no distinction between artificial and natural situations, because both contribute to our knowledge of the dynamics of the freshwater environment.

This review makes no pretense at being complete. It will be divided into the following parts although most of them are inter-related.

(a) Definitions of the term marsh.

(b) Studies relating to vegetation at Delta.

(c) Freshwater marshes
- (1) quantitative
- (2) qualitative
- (3) environmental
  - (i) bottom - soils, sedimentation, texture, catchment areas; (ii) chemical factors; (iii) light; (iv) water depth; (v) fluctuating water levels.
- (4) dynamics

Literature relating to the prevalent species has been reviewed in the appropriate sections of this thesis. It was thought more meaningful to associate it with the specific topic, than to put it in the main literature review.

(a) Marsh

Many botanists have attempted to define the term marsh; and a selection of definitions was reviewed by Walker (1959). It included the following:

Needham and Lloyd (1916), Penfound (1953), Edelman and Staveren (1958), Tansley (1939) and Dansereau and Segadas-Vianna (1952). To these might be added the E.S.A. R1 and R2 (1935), Weaver and Clements (1938), Weaver (1960), Gorham (1953), Mason (1957), Curtis (1959) and others.

Different authors emphasize different criteria. Dansereau and Segadas-Vianna (1952) used physiography, physical and chemical conditions, vegetation and fauna and their treatment is more exhaustive than any of the others. However, the majority of definitions appear to be modifications of Tansley (1939) which is as follows:

> A marsh is "A 'soil-vegetation type' in which the soil is waterlogged, the summer water level being close to, or confirming with, but not normally much above ground level, and in which the soil has an inorganic (mineral) basis. Marsh exists wherever mineral soil is waterlogged, irrespective of its origin, and where the relation of water level to soil level remains approximately stable, marsh may represent an edaphic climax. Marsh vegetation is commonly zoned around or along the edge of any permanent body of water, but if for any cause the soil surface is progressively built up above the water table (or the water table is lowered), so that the root systems of the plants are better aerated, the marsh gives way to a more completely terrestrial type-grassland, scrub or forest - and ultimately to the climatic climax.
>
> Swamp is used for the type in which the normal summer water level is above the soil surface. It is usually dominated by reeds, Phragmites or by other tall grasses, sedges, and rushes".

(b) Studies relating to vegetation at Delta

A brief survey of aquatic plants in the important marsh areas of Manitoba, including Delta, was conducted by Hinks (1936). Hochbaum (1944, 1955) described the Delta Marsh in general terms, and referred to the alternating periods of drought and flooding, as did Sowls (1955). Olson (1959) and Dillon (personal communication), made general comments relating to the vegetation of the Delta area. A floristic account of the marsh was provided by Löve and Löve (1954) and the status of its vegetation in 1958 was described by Walker (1959).

(c) Freshwater marshes

There have been few quantitative studies on freshwater marshes, although there are innumerable papers which allude to marsh vegetation. The majority of these has been concerned with aquatic vegetation in lakes and its relationship to the environment. This thesis describes the effects of falling water levels on a freshwater marsh and therefore literature relating to the various aspects of the marsh environment is relevant, even though it seldom draws from directly comparable physiographic conditions.

(1) Quantiative studies

A recent quantitative study relating to emergent aquatic plants was reported by Curtis (1959) in Wisconsin. He indicated the average structure of emergent species in southern cattail marshes by frequency and density and gave the prevalent species. Emergent aquatics were grouped into:

1. those with their optimum in soft water (50 ppm $CaCO_3$ or less)
2. those with their optimum in medium hard water (50 - 150 ppm $CaCO_3$)
3. those with their optimum in very hard water (150 ppm $CaCO_3$ or more)
4. those with no pronounced optimum

A quantitative study of submerged aquatic communities was undertaken at the same time by Natelson (1954) who recorded the frequency of species within uniform conditions of depth, substrate, and shoreline. Each stand was tested for homogeneity by statistical methods, and relationships between soil and water environment were plotted against the stand gradient and the resulting correlations discussed.

Earlier quantitative studies on the larger aquatic plants in various lakes in Wisconsin had been undertaken by Rickett (1921, 1922, 1924), who showed that some species grew better in shallow water, and others in deep water. Also in Wisconsin ecological factors and vegetation were investigated on a quantitative basis by Wilson (1935, 1937) and by Penfound (1956); the latter found primary productivity in many aquatics similar to that on land.

(2) Qualitative studies

The majority of accounts of freshwater marshes deal briefly with the types of communities present and some provide a qualitative description of the vegetation, among these are: Ewing (1924), Wells (1928), Bordner *et al.*, (1935), Turner (1936), Penfound and Hathaway (1938), Marks (1942), Tolstead (1942), Brown (1943), Davis (1943), Hess and Hall (1945), Sigler (1948), Moore (1949), Sharp (1951), Penfound (1952, 1953), Kamuro (1957), Van der Voo (1961) and Emerson (1962). Moss (1953) described the vegetation which characterizes marshes, swamps, and wet meadows in Alberta; he included many species which occurred at Delta.

(3) Environmental

Environmental studies in marshes have run the gamut of factors involved, and of necessity they are often interrelated. Features which have received the most attention include: the nature of the bottom and water chemistry, light, water depth and turbidity.

(i) Bottom: Pond (1903, 1905) made preliminary studies on the role of larger aquatic plants in the biology of freshwater lakes, and determined that some aquatics were dependent upon rooting in soil for optimum growth while others can absorb their nutrients directly from the surrounding water. Pond (1905) and Brown (1911) demonstrated, after experimenting with numerous aquatic genera possessing roots, that they grew better if rooted in soil than if suspended over it, or rooted in clean washed sand. Brown (1911) observed that CO_2 derived from organic matter is important to rooted plants, and Bourn (1932) and Misra (1938) indicated that nutrients obtained from the soil are necessary for the growth of rooted aquatics. The latter studied aquatic plant distribution in relation to the substratum and the effect of temperature, gas content, and other dissolved substances. He thought available nitrogen, calcium, and iron in the soil were important in determining the nature of the aquatic plant community.

The importance of soils in the physiology of the aquatic plant or in the development of hydrophyte communities was demonstrated as one of the primary factors (Pearsall, 1920, 1921 and Wilson, 1935, 1937). They have shown that there are important relationships between the sedimentation of soils and the succession of rooted aquatic plants.

Veatch (1931, 1933) found the most prolific growth upon soft, slimy sedimentary peat, or organic mud, or upon the soft silty or clayey inorganic muds, but indicated most aquatic plants have a wide range of soil conditions He proposed a classification of water soils. Wilde et al., (1950) indicated that the persistence of marsh plants is largely determined by the bottom.

The importance of soils in the ecology of rooted aquatic plants was recorded by Snell (1908), Brown (1911), Pearsall (1918, 1920, 1921, 1929, 1938), Pearsall and Hanby (1925), Pearsall and Pearsall (1923), Veatch (1933), Wilson (1935, 1937) and others. Observations were made by Wells (1942) on lakes and ponds with sandy bottoms, and indicated that texture of the substrate was more important than water depth in influencing vegetation until the soil habitat had changed to organic or peat, then depth became of major importance. Lambert (1951) described various parallel successions on oozy, unconsolidated lake muds and on more compact, solid peat, or peat and clay.

Moyle (1945) considered water chemistry the most important single factor influencing the general distribution of aquatic plants in Minnesota, and that the type of bottom soil and the physical nature of the water greatly influenced the local distribution of species.

Mortimer (1942) studied the mud water interface and concluded there was a slow rate of diffusion of solutes in the mud and a slow rate of oxidation or reduction of the mud surface. Nitrogen relationships indicated that under oxidizing conditions, nitrification occurred most actively in the oxidized mud surface and that under reducing conditions the mud was the main source of ammonia. He noted that the chemically active interface layer on the surface of the mud is very thin (1 mm) and there appears to be very little exchange of materials between the active bottom immediately beneath it and the water above.

Oxidation and reduction in the soil was discussed by Van Raalte (1941) who, working with rice, realized that the roots themselves bring about oxidation of the environment. Cook and Powers (1958) noted that the roots of some aquatic plants gave off oxygen which might oxidize the toxic ferrous iron to ferric iron in their immediate surroundings, as did Eyre (1963).

Weaver and Himmel (1930) were in general agreement that aeration of roots promoted a better growth of the tops of plants. They grew _Typha latifolia_, _Scirpus validus_ and _Phragmites communis_ in artificial conditions. Dean (1933) also noted increased root growth when there was access to oxygen and removal of carbon dioxide.

Several investigators have considered the catchment area of marshes to be important. Cook and Powers (1958) reported that the concentration of nutrients in an aquatic environment was dependent in part, upon the composition of the soil over which the water drained or through which it percolated. The chemistry of submersed soils may be related to the intrinsic concentration of essential elements in soils of a drainage area, and to site characteristics prior to flooding. Comparable with this observation was the report of Heron (1961) indicating that changes in the chemical composition of water in the English Lake District were attributable to the influence of conditions in the catchment area, rather than to changes in the lakes themselves.

(ii) Chemical factors: Many people have grouped water bodies in relation to hardness, and have listed aquatic and marsh species in relation to various degrees of hardness (Hill, 1934; Bordner *et al.*, 1935; Steenis, 1932; 1933, 1934, 1935; and Wilson, 1939). Moyle and Hotchkiss (1945) divided aquatic situations into groups - hard carbonate, soft carbonate, and sulphate-alkali waters, and listed 300 species in relation to these classes. Curtis (1959) also used hardness classes in relation to aquatics.

Moyle (1956) noted that total alkalinity is often used as a measure of productivity although there are other limiting chemical factors. Moyle (1961) discussed some aspects of the chemistry of fresh waters and submerged soils, including redox, thermal stratification, methane, and organic matter.

Cook and Powers (1958), when considering artificially created marshes in New York state, gave evidence indicating the desirability of controlling the organic matter content of soils and thereby indirectly regulating concentrations of soluble iron and manganese - apparently to aid in keeping phosphorus in solution. They concluded that more than four percent organic material in aquatic soils may be harmful to the aquatic habitat. Moyle (1945) reviewed the papers giving general water quality preferences of some aquatics, including studies by West (1905), Tansley (1911), St. John (1920), Samuelsson (1934) and Drew (1936). Some of the European work was summarized by Naumann (1932) and Samuelsson (1934), and several of the important American papers were considered by Martin and Uhler (1939) and McAtee (1939).

Gorham (1953) made studies on the underwater soils in England indicating their relatively low organic content and considered their exchange capacities and the nutrient status. Physical and chemical characteristics of the soil and water delimit the distribution type of the communities in many aquatic ecosystems (Gorham, 1953). Various chemical aspects of the aquatic environment were described by Pearsall (1938), Pearsall and Mortimer (1939), Gorham and Pearsall (1956). Pearsall and Pearsall (1923) found that the leaf shapes of Potomogeton perfoliatus and P. praelongus varied sufficiently on different soils to suggest that the proportion of lime in the soil was an important factor in determining the leaf shape of these species, and that varieties in P. perfoliatus were only growth forms. Pearsall and Hanby (1925), working on Potomogeton perfoliatus concluded that variability of leaf form was due to the variations under natural conditions of; (1) light intensity, (2) the calcium content of the soil, (3) the ratio of potassium and monovalent ions generally and to calcium in the soil if little calcium is present.

Pearsall (1929) investigated various features in the soil complex in relation to plant communities. Hoagland (1944) discussed inorganic plant nutrition and Bonner (1949) the problems of growth in saline soils.

Kadlec (1960) found a poor correlation between mineral nutrient levels and aquatic plant growth, but showed that the fertility of the marsh habitat seemed to be related to iron and colloidal complexes and possibly to the rapidity with which phosphorus is cycled through organic materials. But Roelofs (1940) found no correlation between Spurway quick tests for phosphorus and plant analyses for phosphorus.

Iversen (1929) found, in lakes in Denmark, that the distribution of aquatic plants could be related to the pH of the waters. Harshberger (1911), Bourn (1932, 1934, 1935), and Penfound and Hathaway (1938) demonstrated that salinity is an important factor, as did Nelson (1954).

Caution against using conductivity as an absolute measure of mineral salt content was deemed necessary by Gorham and Pearsall (1956), who considered the possibility that plant communities maintain themselves under conditions in which they would not establish themselves.

(iii) Light: Aquatic plants in relation to light and water depth were studied by Pearsall (1918, 1920), Pearsall and Hanby (1925), Bourn (1932), Pearsall and Hewitt (1933), Juday (1934), Wilson (1935,1939), Hotchkiss and Stewart (1947), Pearsall and Ullyctt (1934).

(iv) Water depth: Water depths were grouped by Bellrose (1941) into stable, semistable, and fluctuating, and he plotted plant abundance by plainimeter methods. Kamuro (1957) considered water depth to be the most limiting factor in hydric conditions. Physical and chemical conditions influenced distribution of communities in many aquatic ecosystems. Wells (1942) states that water depth is important in control of aquatic communities, but that texture of substrate may be more important than water depth. Chamberlain (1948) ascribed the limited growth in aquatics to turbidity.

(v) Fluctuating water levels: McDonald (1955) described high water conditions from 1943 to 1952 at Pointe Mouillée which closely resembled those at Delta in 1955. At Pointe Mouillée the high water 1943-1948 killed many trees on the Barrier Beach and caused an extension of the marsh inland. A die-off involving *Typha angustifolia*, *Typha glauca*, *Scirpus fluviatilis*, *Scirpus acutus*, *Scirpus validus*, *Phragmites communis* and other emergent species. Sixty-three percent of the marsh had died out in 1945, another die-off occurred in 1952. McDonald discusses the factors involved in the die-off and the effects of the die-off on aquatic vegetation. He described the plants that replaced them while water levels were high. Similar die-offs in Iowa have been described by Hayden (1939, 1946, 1947, 1948).

Destruction of emergent vegetation by flood water has been reported by Yeager (1949) along the Illinois River where a smothering effect was ascribed to the heavily silt-laden water. The diameter of trees and shrubs subjected to flooding had little influence on their death rate.

McLeod (1948) working in northern Manitoba, observed maximum growth 4 or 5 years after flooding. Emergent forms did not normally occur in excess of 30 inches in depth and signs of drowning appeared when the water depth exceeded 2 feet. Similar effects of flooding were noted by Aldrich (1943).

McLeod (1949) reported that during the first few years following flooding the plant growth was enormous but each year the plants died back to the level of stem bases and rhizomes and roots. Leaves accumulated in the stagnant water. Decomposition rarely progressed beyond the amino acid stage, although exposure and aeration might speed up decomposition, and nitrogen would be released in forms available to the plants. There have been a number of studies centered around the artificial manipulation of water levels in freshwater marshes. Among the more recent was that undertaken in northwestern Minnesota where water level manipulations were conducted between 1949 and 1957 (Harris and Marshall, 1963). Their work revealed that the development of five types of vegetation was influenced by seed availability, soil type and moisture, season and duration of drawdown, and the amount of stranded algal debris. Kadlec (1960) reported in detail on a drawdown carried out in 1958 in Michigan where vegetation was studied by means of modified belt transects, camera point photographs, and cover mapping. He found that species composition was not notably effected by the draw-down, as most of the common species were perennials and apparently able to survive drainage for one season.

Tolstead (1942) indicated that plant zonation was due to differences in ability to withstand deficiency in the oxygen available to the roots and that the common species could survive fluctuations to 3 feet. Phenological data was given for Typha, Phragmites and other species. Chenopodium rubrum was described by Tolstead (1942) as the first annual plant to invade bare areas of peat after water recession. In pure stands it covered hundreds of acres. When recession occurs various zones are exposed to the air. Penfound (1953) stated that if the recession was considerable and the aerobic period prolonged, earlier vegetation would be destroyed and new bare areas become available for the ecesis of terrestrial and wetland plants. The type of bottom was very important, in determining the vegetation. The poorest growth occurred on sands and gravels, and the best on organic muds or on soft, silty and clayey inorganic muds. Low (1945) mentioned the elimination of species by fluctuations in water levels in Iowa. Large stands of cattail and reedgrass were broken up by an increase of water level during a 2 year period. Yoshioka (1954) considered fluctuating water depth the most limiting factor in hydric conditions, as did Den Hartog (1951)

A number of workers have discussed plant succession in drained lake basins; Lynch, O'Neil and Lay (1947), McLeod (1949), Baldwin (1950), Martin (1953), Cave-Brown-Cave (1948), Summerhayes and Turril (1948), Kamuro (1957), Penfound (1953), Uhler (1956). All mentioned that many emergent aquatics require bare mudflats for successful germination and seedling establishment. Moyle and Nielsen (1953) describe soil as still wet after 5 years of draw-down. McLeod (1948) suggested water levels must be lowered periodically to renew fertility of the soil and also to stimulate reproduction of the marsh plants and renew their vigour, perhaps every 4 or 5 years. The detrimental effects that prolonged stabilized water levels have on most species of emergent aquatics has been mentioned by several authors (Uhler, 1944; Penfound and Schneidau, 1945; Sharp, 1951 and Martin, 1953).

Dane (1959) reported woody vegetation killed by flooding, and colonization of newly created marshes by Typha, Leerzia oryzoides, Juncus effusus, and Alisma plantago-aquatica. According to Hall et al., (1946) the survival of plants varies with the species, season, water depth, duration of hydroperiods, and size of the specimens. Brumstead and Hewitt (1952) noted Typha and Alisma growing on formerly herbaceous land the first year after flooding. Robel (1962) noted that emergents increased considerably when water levels were raised 3 inches, submerged aquatics increased 32% in shallow areas but decreased 35% in deeper areas. Cook and Powers (1958) described vegetation changes in response to short term flooding and considered the relationship between the drainage basin and marsh.

Fassett (1930) grouped plants by growth form into 4 types:

(1) those with flexuose stems and leaves

(2) stiff leaves in rosette or on short unbranched stems

(3) horizontal rhizome and most leaves floating

(4) bases in water and photosynthetic parts emergent.

Steenis (1932) added a fifth group - floating forms. Daubenmire (1947) produced five morphoecologic groups which are mentioned later.

(4) Dynamic freshwater ecology

Physiography was considered to be the basic key to marsh vegetation by Sears (1926), Pearsall (1918, 1929), Wells (1928) and Davis (1943). The latter indicated that the relatively immature state of much of the vegetation is due in large measure to the nature of the soils and young topography, and that variations in drainage and soil water conditions, plus the texture and chemical nature of the soils, are very important factors. Clements (1928) described the habitat as a complex in which each factor acts upon other factors and is acted upon by them. Zonation is the epitome of succession, but Tansley (1920) indicated that succession may be retrogressive.

When species establish dominance it becomes a potent influence on other members of the community (Macan, 1963). Pearsall (1920, 1921,1929) used the terms primitive and evolved for communities and indicated that the former in time produce the latter by silting. Wilson (1939) applied this concept to Wisconsin lakes.

Although this literature review is brief, it serves to show how little emphasis has been placed upon the quantitative aspects of marsh vegetation. This makes it difficult to compare one study with another.

PHYSIOGRAPHY, GEOLOGY AND SETTING OF THE AREA

Manitoba occupies a central position in North America. The southern part of the province may be divided into two regions. The one on the western side lies above an escarpment and its 396 m (1,300 ft) contour. This is the Second Prairie Steppe. The other lies below the escarpment (and the 396 m (1,300 ft) contour, and is called the First or Eastern Prairie Steppe, (Ellis, 1938) (Fig.1). This eastern Prairie Steppe consists of lake terraces, beaches, rough rock outcrops, shore deposits, stream outwash, river deltas and plains (Ellis, 1938). The area of this study lies in the First Prairie Steppe, at the southern end of Lake Manitoba (lat. 50°18" and long. 98°19").

As glacial Lake Agassiz retreated, depressions in the glacial lake basin were filled with water, and a succession of beaches or sand ridges dammed up shallow areas, some of which developed into marshes. One of these exists today at the southern end of Lake Manitoba and a large part of it is called the Delta Marsh (Fig.1).

The bedrock is of Jurassic age and earlier. There are three main formations, The Sundance formation consisting of glauconitic sandstone, shale, limestone and gypsum; the Gypsum Springs formation of red shale and gypsum; and the Spearfish formation of red to brown shales and red argillaceous sandstone. Silurian dolostone and Devonian limestone lie to the east. As the Wisconsin ice sheets moved south from James Bay they picked up and transported huge quantities of materials from the bedrock over which they passed (Ehrlich, Poyser and Pratt, 1957). During the melting and recession of the ice sheets, rocks, gravel, sand, silt and clay were deposited on the underlying bedrock. These deposits, known

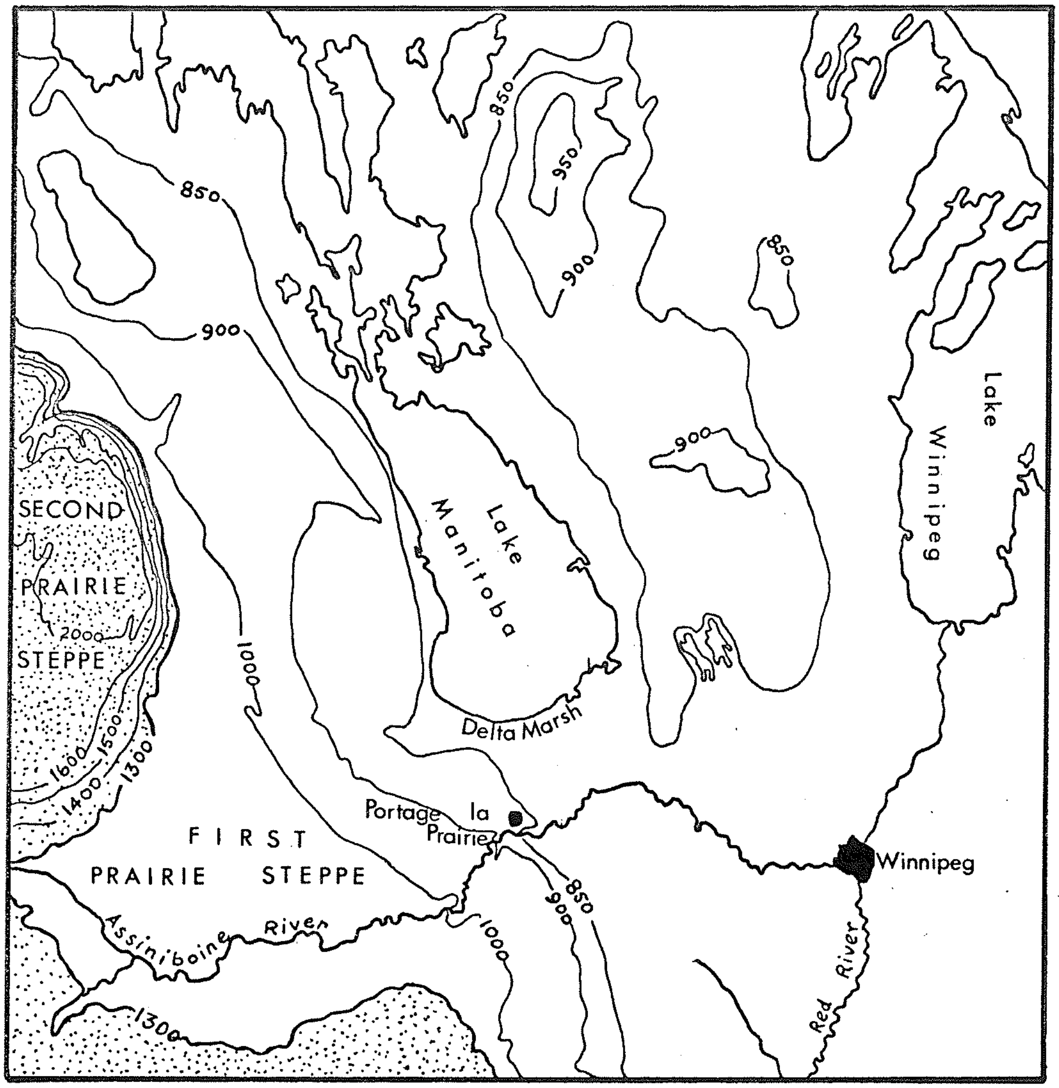


Figure 1. Map of Southern Manitoba Showing the First or Eastern Prairie Steppe Below the 1300 ft Contour and the Second Prairie Steppe Above the 1300 ft Contour.
(Economic Atlas of Manitoba, Wier, 1960).

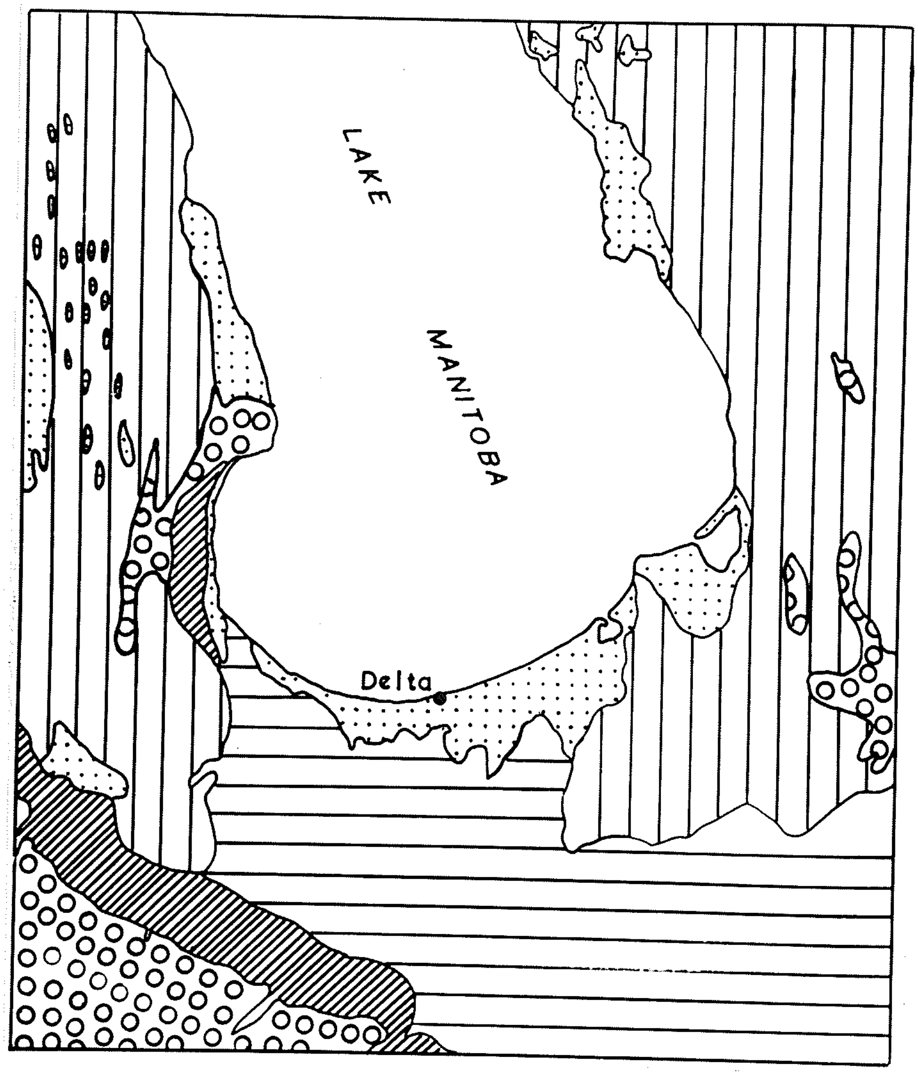
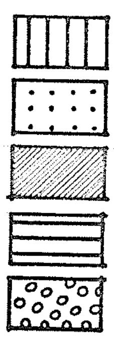


Figure 2. Surface Deposits



Glacial till or boulder clay modified by wave action.

Muck and peat.

Lakebed and flood plain deposits: silty.

Lakebed and flood plain deposits, clayey.

Lakebed and flood plain: sandy.

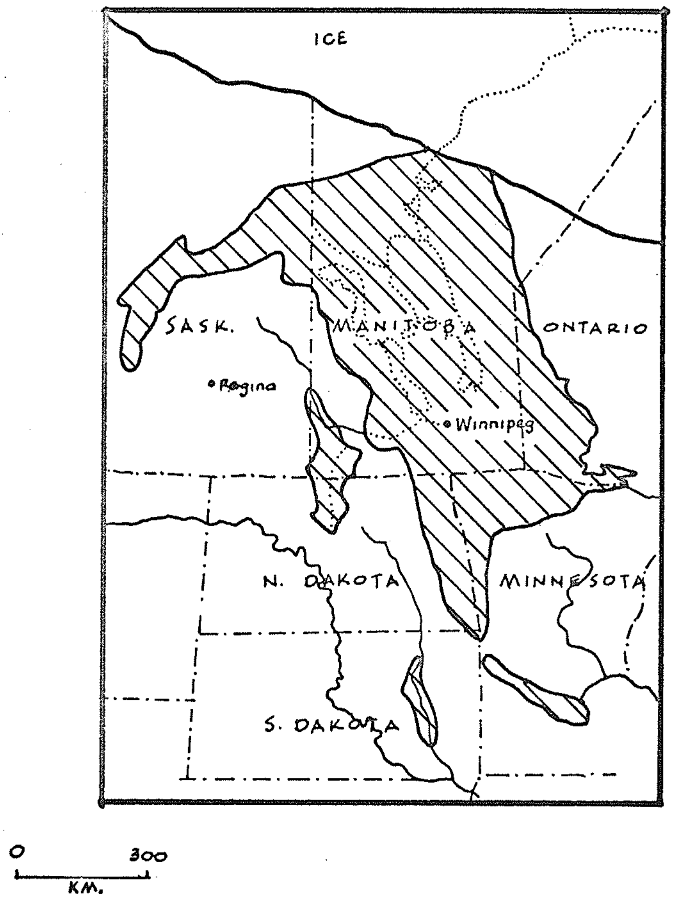
Source: Ehrlich et al., 1957.

as 'boulder till' form the parent material of most of the soils in southern Manitoba (Ellis, 1938)(Fig.2).

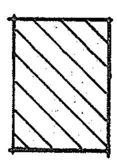
Glacial Lakes Agassiz I and II were formed during the successive retreats of the Wisconsin ice sheets. Lake Agassiz II covered western Ontario, southern and central Manitoba, part of Saskatchewan, Minnesota and North Dakota (Fig.3). At various times the lake eroded its southern shores forming strand lines. When the ice sheets melted and drained through outlets in the north and east, they deposited water-worked sediments, modified till and various other materials, (Johnston, 1934, 1946; Ellis, 1938; Moore, 1958; Elson, 1957).

Ehrlich, Poyser and Pratt (1957) describe the surface deposits of the Delta Marsh as very poorly drained undifferentiated muck and peat soils overlying glacial drift. An Agassiz beach of gravel and coarse sand, of limestone and granitic origin, separates the marsh from Lake Manitoba. In some places the ridge is so unstable that no surface soils have developed and the sand is constantly shifting, resulting in dunes. The majority of the beach is covered by Agassiz soils, a representative one being a weakly developed Black soil. Very dark gray loamy sands overlie coarser grayish brown sands. Black meadow soils occur along the margins of the gravel beaches and merge into the marsh. The marsh itself consists of poorly drained soils composed of thin muck and peat deposits, the depth of peat is variable, but over most of the area it is relatively thin (approximately 30 cm).

At the southern side of the marsh, soils developed on lacustrine deposits are found. Osborne and Red River clays of the Red River Association are interdigitated between materials ranging from very sandy loams



Source: Modified from Taylor and Leverett, U.S. Geological Survey.



Extent of Glacial Lake Agassiz

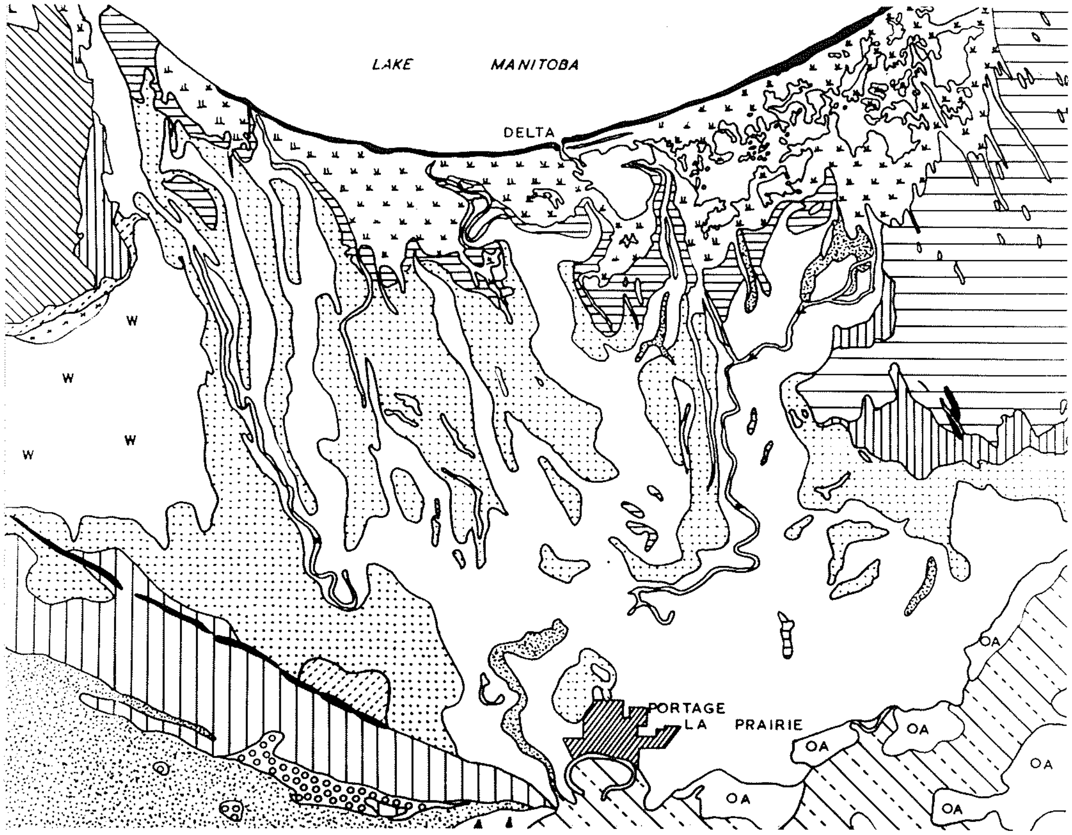
Figure 3. Glacial Lake Agassiz.

to silty clays of the Portage Association. Clays of the Westbourne Association lie to the west and rendzinas of the Isafold Association lie to the south and east, (Fig.4).

Wind erosion affects the Portage Plain and surrounding areas, particularly the coarser textured soils, and fine sediments are sometimes carried into the marsh. During storms, materials from the lakeshore beach deposits including gravel, coarse sand, fine sandy loam and loamy sand may be washed into the marsh in varying quantities and deposited unevenly. A washout of the ridge will result in a considerable amount of deposition in the marsh.

Ten thousand years ago most of Manitoba still lay under glacial Lake Agassiz, but as its waters receeded, residual lakes of various sizes were formed in its basin. Some of these have persisted until today, for example, Lakes Winnipeg, Manitoba and Winnipegosis and many smaller bodies of water.

Lake Manitoba is a large shallow (Hills, 1961) lake at an elevation of 248 metres. It is approximately 180 km long from north to south, and 52 km wide at its southern end. The northern part of the lake is narrow and studded with islands; its southern lobe is a broad expanse of open water. Nowhere does the lake exceed five metres in depth. Along the shore, winds, waves and ice have built up ridges. In some places these have since been eroded away, but at the southern end they are conspicuous (Fig.5). Except for a few scattered dunes they are covered with a growth of trees and shrubs which are dense in some places and sparse in others. On this lakeshore ridge is the fishing village of Delta, and the Delta Waterfowl Research Station; south of it lies the Delta Marsh.



Undifferentiated muck and peat soils, very poorly drained

W Westbourne Association, clay

Osborne clay, fine textured

Woodlands complex, fine sandy loam to silty clay loam

Red River clay, fine textured solonetzic

Agassiz Association, sand to fine sandy loam

Isafold Series, rendzina or highly calcareous boulder till

Portage Association, fine sandy loam to silty clay

Marquette clay, over medium till

L Miniota Association

Burnside Association, silty clay

Almasippi clay substrate

Almasippi loamy sands

Riverdale, fine sandy loam to silty clay

Gladstone Association

OA Oakville Association, silty clay loam to clay

Figure 4. Soils of the Area Between Lake Manitoba and Portage la Prairie. (Ehrlich *et al.*, 1957).

Figure 5. Lake Manitoba, the Forested Ridge and the Delta Marsh, with the Chimney Site in the Foreground, 1959.

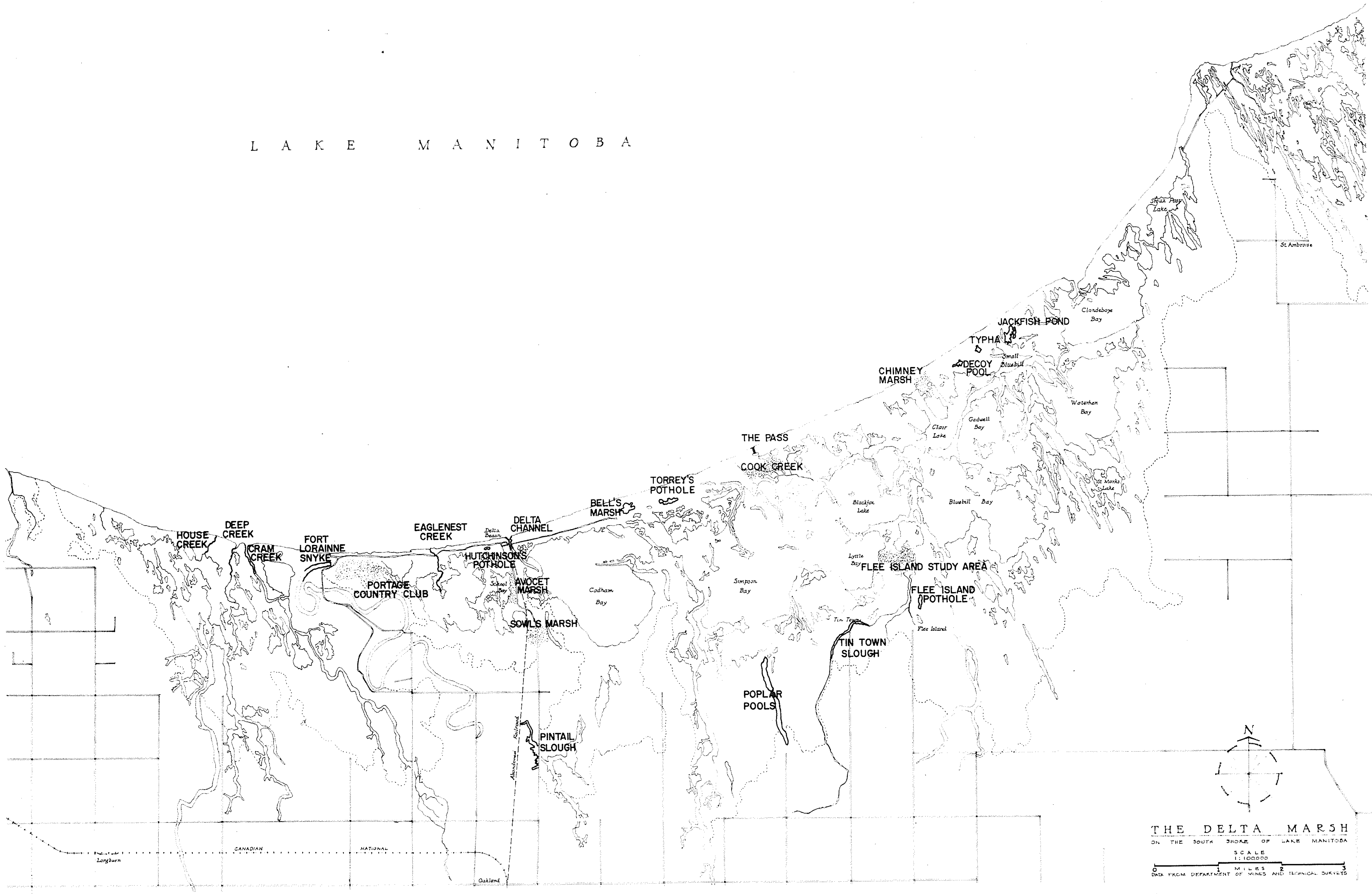
Locations are cited in kilometres measured from the Delta Channel.

The marsh is an intricate system of large and small shallow bays, some covering several hundred hectares, others only a few (Fig.6). They are never more than three metres deep, usually less than one, and their bottom is covered by a thick layer of detritus. The bays are interconnected by gaps or winding creeks set in a matrix of Phragmites communis and under certain conditions they are linked with the lake. Also in the marsh complex there are isolated bodies of water or 'potholes', as they are called locally. Unlike the bays, the potholes normally rely solely upon precipitation and run-off for their water supply (Hochbaum, 1944; Evans, Hawkins and Marshall, 1952). The area of the Delta Marsh considered in this study extends from Fort Lorraine Snyke in the west to Sioux Pass Lake in the east and south of Lake Manitoba between it and the Portage Plain (Fig.7).

For many years there were a number of points where marsh water could pass through the sand ridge to the lake and vice versa. With strong winds from the north, lake water poured into the marsh; with winds from the south, marsh water passed back into the lake. There was considerable scouring action created by this moving water, which helped to reduce the natural silting-up and in-filling of the marsh. As late as 1925 three of these channels were still functional. They are called Eaglenest Creek (1.4 km west of the village of Delta), Delta Channel at the village of Delta, and Clandeboye Channel (17.6 km east of Delta). During 1925 a breakwall was erected cutting off the Delta Channel from the lake, while the exit of Eaglenest Creek silted over in the early

Figure 6. General View of the Delta Marsh 1959, Looking North Towards Lake Manitoba.

Figure 7. Map of The Delta Marsh

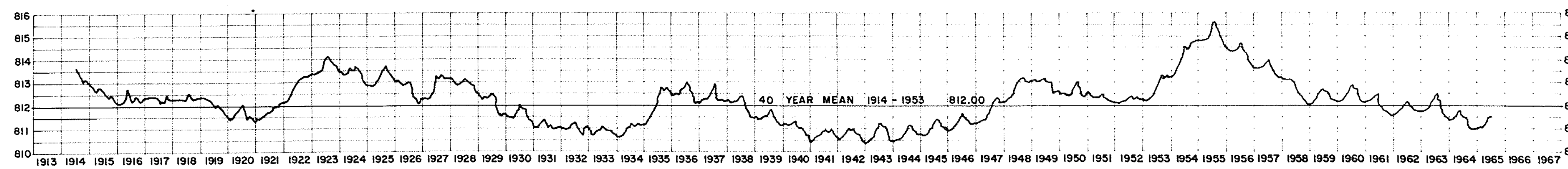

LAKE MANITOBA
HOUSE CREEK
DEEP CREEK
CRAM CREEK
FORT LORAINNE SNYKE
PORTAGE COUNTRY CLUB
EAGLENEST CREEK
DELTA CHANNEL
HUTCHINSON'S POTHOLE
AVOCET MARSH
SOWL'S MARSH
PINTAIL SLOUGH
BELL'S MARSH
TORREY'S POTHOLE
THE PASS
COOK CREEK
Codham Bay
Simpson Bay
POPLAR POOLS
TIN TOWN SLOUGH
Tin Town
FLEE ISLAND STUDY AREA
FLEE ISLAND POTHOLE
Flee Island
Lyttle Bay
Blackfox Lake
Bluebill Bay
CHIMNEY MARSH
Clair Lake
Gadwell Bay
DECOY POOL
Small Bluebill
TYPHA
JACKFISH POND
Waterhen Bay
Clandeboye Bay
St Marks Lake
St Ambroise
CANADIAN NATIONAL
Longburn
Oakland
N
THE DELTA MARSH
ON THE SOUTH SHORE OF LAKE MANITOBA
SCALE
1:100000
0 1 MILES 2 3
DATA FROM DEPARTMENT OF MINES AND TECHNICAL SURVEYS

1930's (personal communication P. Ward, 1965). Only Clandeboye Channel remained as a source of exchange between the marsh and lake, and this was partially blocked by a dam constructed in 1942, with a top elevation of 247.6 m (812.3 ft) (Gauer, 1945), which is 15 cm (0.5 ft) above the forty year mean water level for Lake Manitoba (Fig.8). After 1942 there could be no exchange of water between the marsh and lake or vice versa except when levels were higher than 247.6 m or winds caused a pile-up of water at the southern end of the lake and water was forced over the dam. The erosive effect of the lake wind tides has been virtually eliminated except in times of flood, but there is still a considerable scouring effect within the bays.

Evidence exists of considerable fluctuations in the lake level during the last four decades. From 1945-1949 water levels gradually rose in the lake, remaining fairly stable until 1953, when quite a rapid rise occurred. This rise reached its climax in the spring of 1955, when the level of the lake was 105.1 cm higher than the forty-year mean (Fig.8) and surpassed any observation of high water level recalled by the oldest residents (Olsen, 1959). Prevailing winds from the north-west had caused water to collect at the southern end of the lake. Spring storms tore holes in the ridge and flooded approximately 20% of the emergent marsh vegetation (Dillon, 1956). Throughout 1955 a high water level was maintained in the lake, then it began to drop (Fig.9) and reached the mean in 1958, but the fall in water level continued.

During the high water period, hundreds of hectares of Phragmites communis were killed leaving stubble 25 cm to 150 cm tall (Fig.10). Elsewhere large stands of Typha latifolia, Scirpus acutus and Scirpus validus

Figure 8. Levels of Lake Manitoba 1914-1965



LAKE MANITOBA

SURFACE AREA = 1850 SQ. MILES DRAINAGE AREA = 31000 SQ. MILES

MEAN MONTHLY LAKE LEVELS

INFORMATION COMPILED BY

PROVINCE OF MANITOBA

DEPARTMENT OF AGRICULTURE AND CONSERVATION

WATER CONTROL AND CONSERVATION BRANCH

DATUM GEOGRAPHIC SURVEY OF CANADA (1928 ADJUSTMENT)

Figure 9. High Water Period, 1957. Clandeboye Channel
Note: Lakeshore trees, *Phragmites*, position of Clandeboye Dam.

(Photograph by courtesy of Ducks Unlimited (Canada))

Figure 10. *Phragmites* Stubble After Recession of Flood Water.

Note: 2m permanent quadrat.

as well as many other emergent species were obliterated. Thus the general impression of the Delta Marsh in 1958 was of open water surrounded by many hectares of stubble and bare soil, with a fringe of living *Phragmites* in higher places. The killing of emergent marsh species under prolonged periods of high water has frequently been recorded (Martin, 1953; Uhler, 1944; Moyle and Hotchkiss, 1945; Penfound and Schneidau, 1945; Errington, 1948; McLeod, 1948, 1949; Sharp, 1951; McDonald, 1955; Harris and Marshall, 1963 and others).

On the southern side of the marsh there are scattered sloughs which are only in direct contact with the lake, or with the main bays of the marsh during unusually high water. Like the potholes, they depend on precipitation and run-off for their survival and in normal summers retain some water throughout the season. In dry years their water may disappear completely. Further south lies the fertile Portage Plain, intersected by channels that carry water in times of flood. Today the main drainage channel is Portage Creek, which enters the south side of the marsh. Surface deposits and depressions indicate that Portage Creek once flowed into Cadham Bay, entering it south of Cherry Ridge. Evidence of other channels exists on both north and south shores of the marsh, in the form of elongate slough-like hollows between raised sandy ridges. On the south side of the marsh these so-called drainage channels have probably been formed by intermittent 'backwash' from the marsh gradually eroding them away over a period of years (personal communication J. H. Ellis, 1961).

CLIMATE

The Delta Marsh is in the southern part of Manitoba which is characterized by high summer and low winter temperatures, both more extreme than the world average for the latitude. The mean range from winter to summer, about 70°F, is among the widest in the continent (Kendrew and Currie, 1955). The mean monthly temperature is below 32°F from November to March, and above 50°F from May to September (Fig.11). The spring transition is affected in April and the autumn return to winter, in October. The area of this study lies between the transitional and moist fringe of the sub-humid moisture region, it has an annual moisture deficit of 75 mm - 100 mm (Weir, 1960).

The data in Table I is from Portage la Prairie which has the nearest weather station to Delta.

TABLE I. Frost Dates (air frost) and Precipitation at Portage la Prairie During the Period of Study.

Year	Last Frost	First Frost	Frost-free Days	Mean Annual Precipitation
1958	May 4	Sept. 30	148	48.18 cm (18.97 in)
1959	May 20	Sept. 10	112	68.53 cm (26.98 in)
1960	May 8	Oct. 11	155	43.99 cm (17.32 in)
1961	May 26	Sept. 22	118	33.63 cm (13.24 in)

Source: Weather Station Abstract Book, RCAF Southport, Portage la Prairie, Manitoba

Yearly Precipitation
Total......... 26.98 in. 17.32 in. 13.24 in.

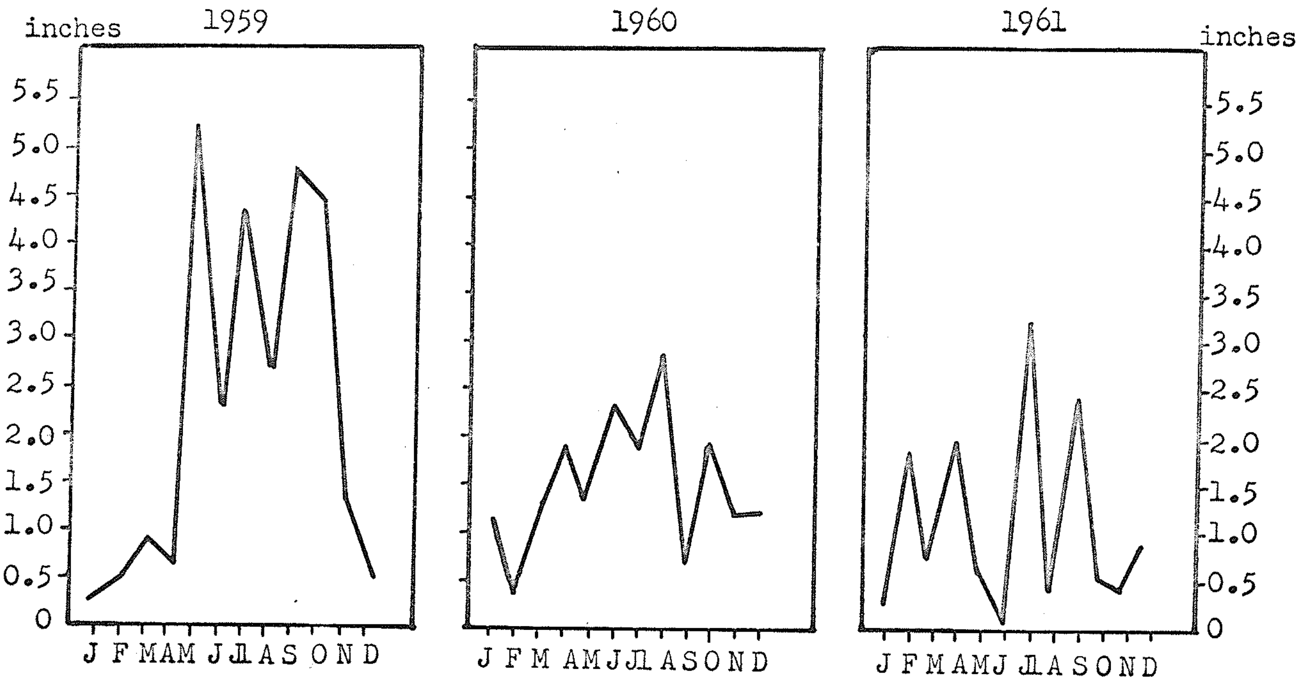
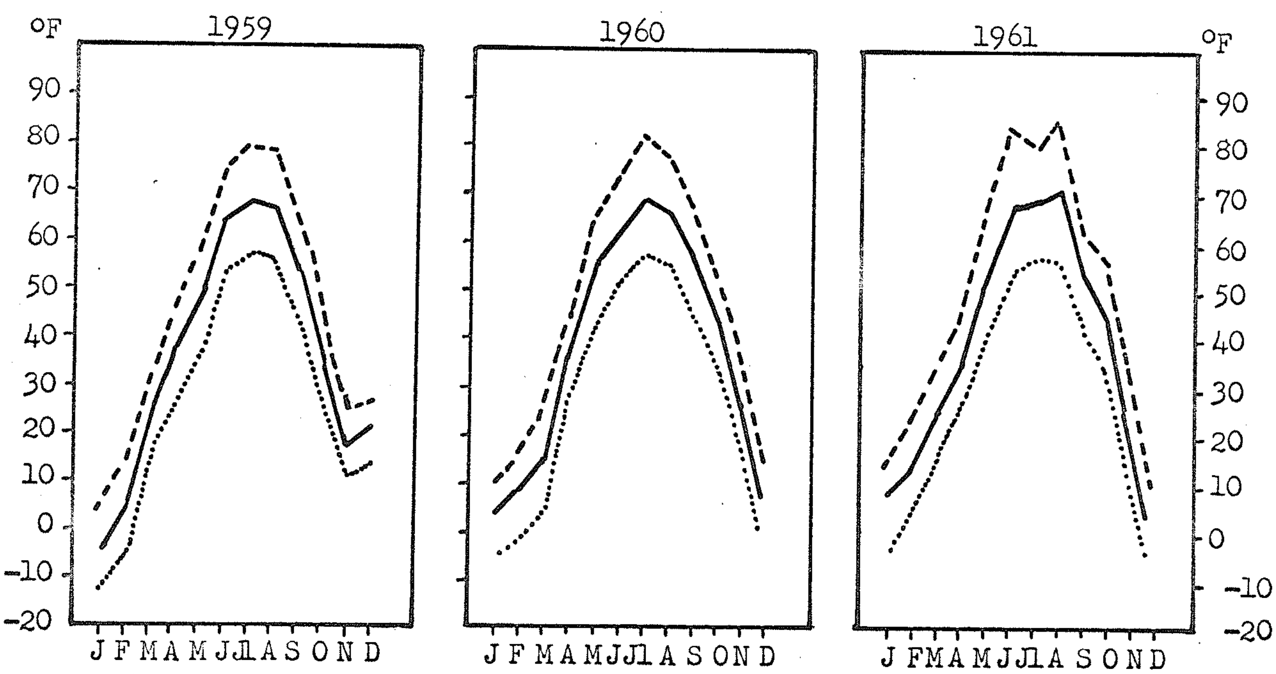


Figure 11. Precipitation
Mean Monthly Precipitation in Inches.



Yearly Mean 37.4 in. 37.2 in. 38.4 in.

---- Maximum
—— Mean
.... Minimum

Figure 12. Temperature
Maximum, Mean and Minimum Temperatures in °F.

<u>Source:</u> Weather Station Abstract Book, RCAF Southport, Portage la Prairie, Manitoba.

Precipitation data for Portage la Prairie during 1959, 60 and 61 is given in Figure 11 and that for temperature in Figure 12. Other climatic data is obtainable from Winnipeg. The mean annual precipitation is 52.07 cm (20.5 in). Approximately 70% of the precipitation falls as rain between April and October and 30% as snow from November to March. Table II shows the average readings for various data at Winnipeg which is 80 km from Delta.

TABLE II. Climatic Data for Winnipeg (for a 76 year period, 1879-1955).

Mean annual total precipitation	20.5 in
Average annual snowfall	54.0 in
Mean date of last spring frost	May 27
Mean date of first autumn frost	Sept.14
Mean frost-free period	110 days
Mean number of degree days above $43^{\circ}F$	2600 - 2700
Potential evapotranspiration	21.65 in
Mean number of sunny days ($\gtrsim 77^{\circ}F$)	70 +
Vegetative growing season	170-180 days

SECTION 2

VEGETATION

As the basin of Lake Agassiz II drained it became invaded by western and south-western prairie floras; plants from Ontario migrated westwards while an arctic flora came south and spruce forests spread over the pre-Cambrian shield (Löve, 1959). The present flora of southern Manitoba contains examples from the Canadian, Hudsonian, and Illinoian biotic provinces (Dice, 1943) mixed with Canadian and Saskatchewan taxa (Löve and Löve, 1954).

Delta lies in the Portage Plain, within the eastern part of the aspen parkland (Bird, 1961). It is between the great plains of central North America and the coniferous forests of the pre-Cambrian shield. The aspen parkland is an intermingling of two major plant communities - forest and grassland. The latter may advance during periods of drought or repeated fires, while forest encroaches upon grasslands in wetter periods (Bird, 1961). In the parkland there are many marsh communities, the most extensive marsh being at Delta.

The sandy ridges separating the marsh from Lake Manitoba are covered by a thin layer of humus, sometimes with only a few centimeters of topsoil. The forested ridges and their associated habitats have been described by Löve and Löve (1954) and Walker (1959).

The most conspicuous plant in the Delta Marsh is *Phragmites communis* var. *berlandieri** which appears to provide a uniform cover for the marsh shores, interrupted here and there by patches of *Scolochloa festucacea*, with *Scirpus* spp. growing in the shallow water of the bays. *Phragmites* grows best in rather wet soils (Fassett, 1940; Muenscher, 1944; Mason, 1957) which are

*Throughout the text names of varieties are omitted. They are listed in Appendix I.

generally inundated for part of each growing season. A closer examination reveals a great variety of plant communities involving a wide range of species associated with the dominants. In part, this thesis involves a quantiative analysis of the plant communities which flourish at the margins of the marsh.

GENERAL METHODS OF VEGETATION ANALYSIS AND DESCRIPTION

In 1958 a preliminary botanical survey of the Delta Marsh was made (Walker, 1959) using aerial photographs of 1954 (scale 1:60,000). The vegetated areas had changed greatly and it was impossible to map the vegetation from these photographs, although they indicated some persistent stands. The Delta Marsh is so large and the pattern of land and water so complex, that it was not practical to study the whole area in detail. Aerial photographs assisted in the selection of a number of study sites for detailed investigations. Accessibility was important, hence sites could not be selected at random. It was decided that the vegetation could best be described quantitatively, by devising a uniform method of analysis and description.

In the initial sampling, base lines were laid out and quadrats were selected randomly. The number of plants in various sizes of quadrats was counted (quadrats 5 cm, 25 cm, 0.5 m, and 1.0 m) and the data were analyzed statistically. The variability of the results, the time taken in setting up the base lines in the waterlogged soil and the counting of the plants showed that this sampling technique was impracticable. This was particularly so because it was thought advisable to consider a number of sites within the marsh, and only one worker was involved. As an alternative, quadrats were placed in a randomized manner throughout the zones or communities.

A standard and simple technique for determining the "minimal area" of the sampling unit was described by Braun-Blanquet (1951). Cain and de Oliveira Castro (1959), and Poore (1955). The concept has been criticized by a number of workers including Goodall (1952, 1954a and b), Cain and de Oliveira Castro (1959), Dahl (1956) and Greig-Smith (1957), but Dahl believes the minimal area, in spite of the theoretical difficulties involved, is a very important concept for the plant ecologist.

In this study the minimum quadrat size was calculated from separate samples, each randomly placed and of increasing size (Greig-Smith, 1957). He indicated that a sample number of 100 or preferably higher should be aimed at, otherwise only gross differences between communities will be detectable. Accordingly in most instances 100 was taken as the sample size. There were exceptions when the uniformity of the stand was revealed after sampling a smaller number of quadrats. Frequency, cover and sociability were recorded for each quadrat in the field, using the following modified scale of Braun-Blanquet, (1932).

For Cover

1. indicates that the species covered less than 5% of the sampling unit (rare).

2. indicates that the species covered between 6% and 25% of the sampling unit (occasional).

3. indicates that the species covered between 26% and 50% of the sampling unit (frequent).

For Sociability

1. indicates the plant grew in one place, singly.

2. indicates that the plant grouped or tufted.

3. indicates that the plant grew in troops, small patches, or cushions.

4. indicates that the species covered between 51% and 75% of the sampling unit (abundant).

5. indicates that the species covered between 76% and 100% of the sampling unit (dominant).

4. indicates that the plant grew in small colonies, extensive patches or formed carpets.

5. indicates that the plant grew in great crowds or pure populations.

In the text, isolated figures for frequency are quoted as percentages, those for cover refer to the appropriate range in the scale given above.

During the study of 1958 (Walker, 1959) and the subsequent investigations from 1959 to 1961, the water level in the marsh gradually dropped. This resulted in the exposure of considerable areas denuded of vegetation. Some were more or less level, while in many places there was a slight gradient to the shore-line. This produced a zoned pattern in the colonizing vegetation.

Complete lists of vascular plants were made in every site. Sampling was done by selecting zones or communities visually. Zones were numbered from the most recent on newly exposed soil (zone 1), to the oldest - zone 3 (or 4) depending on the site. When no zonation existed, the vegetation patterns were described appropriately.

Additional information regarding the growth and spatial arrangements of plants, and changes during the study were recorded by means of quadrats, transects and profile diagrams. In each site, data relating to topography, drainage, soils, exposure and other relevant information were collected. Plant nomenclature follows Scoggan (1957) after Fernald (1950) and Gleason (1952). Specimens of vascular plants are deposited in the Botany Department Herbarium, University of Manitoba.

In each of ten sites, as the water receeded, discs of soil 8 cm in diameter and 6 cm thick were collected and placed in plastic bags. On return to the field laboratory squares 2.5 cm x 2.5 cm and 2 cm thick were cut from the centre of the discs. They were washed in dilute nitric acid (Godwin, 1956). Using a binocular microscope all the seeds present were removed, identified and counted. The areas from which the samples had been taken were kept under observation, in order to ascertain whether seed counts would reflect the forthcoming species and their proportions.

VEGETATION DESCRIPTIONS AND EMPIRICAL DATA

The marsh comprises a number of habitats which can be grouped in a variety of ways. Using physiographic features four categories result namely: marsh shores, potholes, sloughs and wet meadows.

Marsh shores: These are the most conspicuous of the habitats, and border the major water areas in the marsh. Some are wide, sweeping shore-lines, while others are much indented; the essential feature being that the water they border is part of the main water system of the marsh.

Potholes: All the isolated ponds or potholes that are not drainage channels and occur within the matrix of the marsh, are considered as potholes.

Sloughs: These are basically drainage channels. In spring and in times of flood they carry water into the main marsh. Later when water levels fall they become isolated.

Wet meadows: These are the low lying areas around the marsh which become inundated with water periodically and are continuous with the marsh. For several years they may bear typical marsh vegetation and revert to meadow species when the water table drops.

MARSH SHORES

The bays on the north side of the marsh have the forested ridge as their northern boundary. Their marsh shores extend south for varying distances depending on the gradient and on water levels which fluctuate from year to year. Chimney Marsh and others will be described as examples of this type of situation.

Chimney Marsh

Chimney Marsh, 10.9 km east of Delta Channel lies (NW Section 25; T14; R6) on the northern side of one of the finger-like processes in Clair Lake. A sandy spit forms the western boundary. From 1955 to 1958 water rose above the tree line on the forested ridge. A large number of trees were killed on both the lake-shore and marsh side (Fig.13). In 1958 *Scolochloa festucacea*, *Typha latifolia*, *Mentha arvensis*, *Cicuta maculata*, and *Epilobium glandulosum* var. *adenocaulon* grew at the upper reaches of the marsh. During the year the water level fell, exposing vast areas of *Phragmites* stubble (Fig.10), and with the drying of the surface, a zoned pattern of vegetation developed (Walker, 1959).

In 1959 seedlings of *Scolochloa festucacea* (F.80%) had a low cover value (2.9) in zone 1, but being perennials, played an important part in the eventual colonization. They were associated with *Ranunculus sceleratus* (F.65%), *Epilobium glandulosum* (F.40%) and *Chenopodium rubrum* (F.10%). A

Figure 13. Dead Trees on the Lakeshore Which Were Killed During the Highwater Period.

TABLE III. CHIMNEY MARSH. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability of Species Present.

	29.6.59						17.8.59									4.8.60												3.7.61								
	Z1			Z2			Z1			Z2			Z3			Z1			Z2			Z3			Z4			Z1			Z2			Z3		
Species	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Scolochloa festucacea	80	2.9	3.0	74	2.1	2.2	100	3.5	4.2	30	2.0	2.3	20	2.0	2.5				100	2.9	3.1	15	2.3	2.6	10	2.0	1.5				100	3.5	3.5	20	1.8	2.5
Ranunculus sceleratus	65	1.6	2.3	5	1.0	1.0										25	1.0	1.0										32	1.8	1.5						
Epilobium glandulosum	40	2.4	2.8	10	2.5	3.0	10	1.0	1.0																			4	1.0	1.0				45	1.0	1.0
Carex atherodes	15	1.3	1.7	32	1.7	2.2				40	2.0	2.0							55	2.0	1.6	5	2.0	2.0	25	2.4	2.2				80	2.3	1.6	10	1.0	1.0
Senecio congestus	10	1.5	1.0																									32	2.2	1.0						
Lycopus americanus	5	2.0	2.0																												15	1.0	1.0			
Chenopodium rubrum	10	1.0	1.0													25	3.0	2.0										84	1.7	1.6						
Taraxacum officinale	5	1.0	1.0																																	
Cicuta maculata	5	1.0	1.0	22	1.5	1.0	50	1.8	1.8							25	1.0	1.0	10	2.0	1.0															
Galium trifidum	10	2.5	4.0	47	3.2	3.3	20	2.0	2.0																						10	1.0	1.0			
Lemna minor	30	3.0	3.1													25	5.0	5.0										4	1.0	1.0						
Rumex maritimus	10	1.0	1.0																									12	1.5	1.5						
Sonchus arvensis	10	1.0	1.0	26	1.0	1.0				70	1.4	1.0	40	2.0	1.7	25	1.0	1.0				15	1.3	1.0	5	1.0	1.0	12	1.0	1.0	20	1.0	1.0	25	1.0	1.0
Polygonum lapathifolium	5	4.0	5.0																																	
Typha latifolia	5	1.0	1.0	37	1.6	1.7	40	3.0	2.7	20	1.0	1.0	20	1.0	1.0	25	3.0	2.0	70	1.9	1.5	10	1.0	1.0				40	1.8	1.2	75	1.0	1.0	15	1.0	1.0
Atriplex patula	5	2.0	3.0																									4	1.0	2.0						
Mentha arvensis	10	1.0	1.5	90	1.8	2.3	20	1.5	1.0	70	2.7	3.0										45	1.4	1.1							25	1.0	1.0	20	1.0	1.0
Stachys palustris	5	1.0	1.0	11	1.0	1.0				10	2.0	3.0													10	1.5	1.0	4	1.0	1.0	10	1.0	1.0			
Urtica dioica				26	1.4	1.2				10	1.0	1.0	20	1.0	1.5							40	2.5	1.0	15	1.0	1.3							35	1.0	1.0
Scutellaria galericulata				42	2.0	2.5																												5	1.0	1.0
Calamagrostis canadensis				47	1.9	2.2				60	2.7	4.0	60	2.1	3.1				5	1.0	1.0	90	3.8	3.0	25	2.2	1.6				10	1.5	1.5	100	4.8	5.0
Cirsium arvense				16	1.0	1.3																15	1.0	1.0	20	2.0	1.0							20	1.0	1.0
Eupatorium maculatum				11	2.6	1.5				40	2.0	1.0	90	3.5	3.1							35	1.4	1.0	55	4.0	4.3									
Phragmites communis				16	1.3	1.6																						8	1.0	1.0				15	1.0	1.0
Carex bebbii				16	1.6	2.3				60	2.1	2.5										15	1.3	1.6							5	1.0	1.0			
Rorippa islandica				5	2.0	1.0							20	1.5	1.0																					
Scirpus validus							10	1.0	1.0																											
Polygonum coccineum													10	1.0	1.0																					
Teucrium occidentale													10	1.0	1.0																					
Solidago canadensis													10	1.0	1.0										30	3.0	2.6									
Polygonum amphibium																			5	1.0	1.0	10	1.0	1.0							15	1.0	1.0	10	1.0	1.0
Aster brachyactis																						5	1.0	1.0				44	1.0	1.0						
Humulus lupulus																									5	1.0	1.0									
Echinocystis lobata																									5	1.0	1.0							10	1.0	1.0
Polygonum persicaria																															10	1.0	1.0			
Salix amygdaloides																																		10	1.0	1.0
S. interior																																		5	1.0	1.0
Carex sprengelii																			10	1.0	2.0										15	2.0	2.6			

Non-occurrence is indicated by a blank space

variety of other species occurred here, including Carex atherodes (F.15%), which was found in few other places. In zone 2, Scolochloa (F.74%) and Calamoagrostis canadensis (F.47%) were understoried by Mentha arvensis (F.90%), the other species are listed in Table III.

By August 1960 vegetation had extended an additional 15 metres onto newly exposed muck and into the shallow water. Zone 1 was 95% bare stubble and water, with scattered plants of Chenopodium rubrum, Ranunculus sceleratus, Typha latifolia, Sonchus arvensis var. glabrescens and Cicuta maculata. All were colonizing slightly raised mounds formed by the Phragmites. Scolochloa festucacea was abundant in zone 2, growing in five centimetres of water overlying the soft muck. T. latifolia (F.70%) and Carex atherodes (F.55%) were found with it. Further from the water's edge the number of species increased and zone 3 could be divided into two parts. Calamagrostis canadensis was dominant, understoried by Mentha arvensis (F.45%) in the lower portions; while Eupatorium maculatum (F.55% c 4.0) and Solidago canadensis (F.30% c 3.3) characterized the highest part. (Zone 4).

In 1961, C. rubrum (F.84% c 1.7) grew on the newly exposed waterlogged surface in zone 1 associated with Aster brachyactis (F.44% c 1.0), T. latifolia (F.40% c 1.8), R. sceleratus (F.32% c 1.8) and Senecio congestus (F.32% c 2.2). The less frequent species can be seen in Table III. Zone 2 was dominased by S. festucacea (F.100% c 3.5). Scolochloa was particularly dense in the upper parts of the zone where 28 plants occurred along a 0.25 m line. Carex atherodes and T. latifolia both had high frequencies but low cover values (Table III).

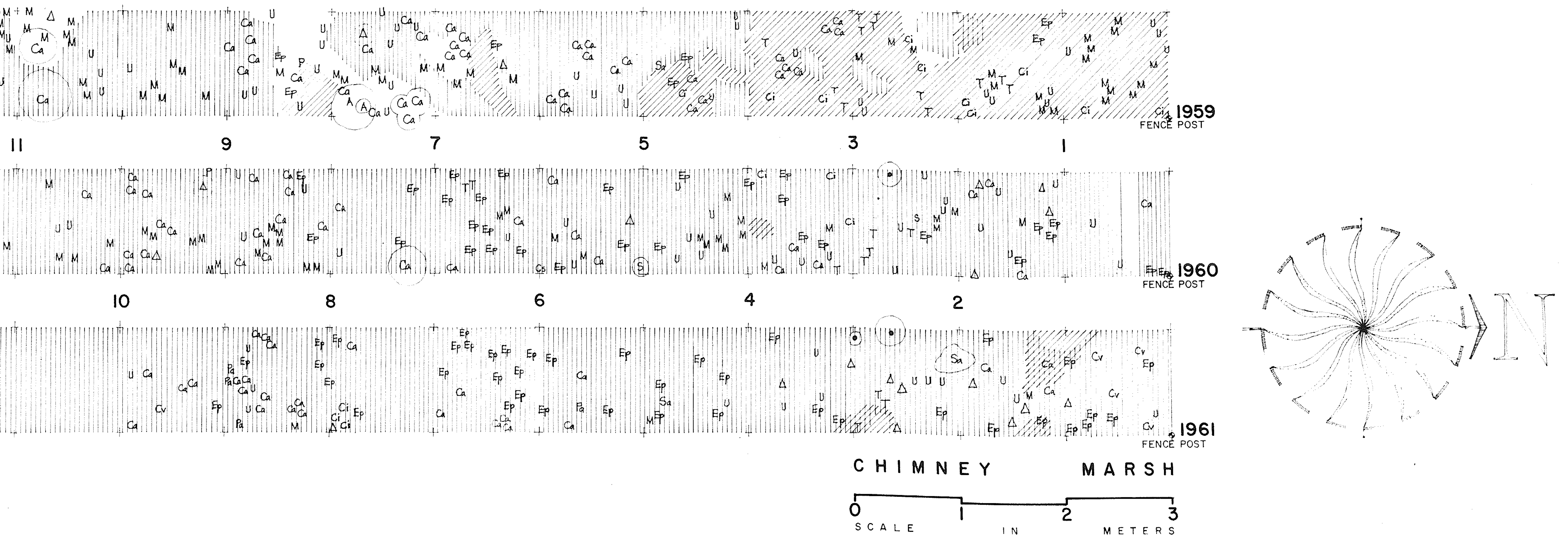
The third and highest zone was well drained and dominated by Calamagrostis canadensis (F.100% c 3.5). In the upper reaches of the zone, at the edge of the tree-bearing area, species such as Urtica dioica, Sonchus arvensis and Eupatorium maculatum increased in frequency.

The transects (Weaver and Clements, 1938, Cain and Castro, 1959) (Fig.14) indicate the characteristics of the plants in a strip 1 m wide, traversing the marsh from the edge of the forested ridge to the limit of pioneering vegetation, during late summer in 1959, 60 and 61 (Fig.15).

Jackfish Pond

This site (NESection 31; T14; R5) lies 14.5 km east of Delta Channel and 3.6 km east of Chimney marsh on the southern side of the forested ridge. It was examined in order to ascertain whether two sites, apparently similar in their relationship with the forested ridge, in topography, water level fluctuations, nature of the soil etc. would support similar plant communities.

When sampled in 1959 Jackfish Pond showed the retreating water surrounded by waterlogged Phragmites stubble and bare muck, approximately 44 m across. This formed the lower part of zone 1 which was being colonized by Scolochloa festucacea, Ranunculus sceleratus and Chenopodium rubrum, the upper part of the zone (25 m wide) was dominated by Scolochloa (height 0.6 - 0.9 m) among which scattered clumps of Scirpus validus occurred. The distinction between zone 1 and zone 2 existed in species composition, but it was emphasized by the height of the mixed community of zone 2 where many components were between 1.5 m and 2 m tall. Typha latifolia and Phragmites both had frequencies of 25% and low cover values; while Atriplex patula (F.40%) and Aster brachyactis (F.30%) had cover values of almost 30%.


1959
FENCE POST
1960
FENCE POST
1961
FENCE POST
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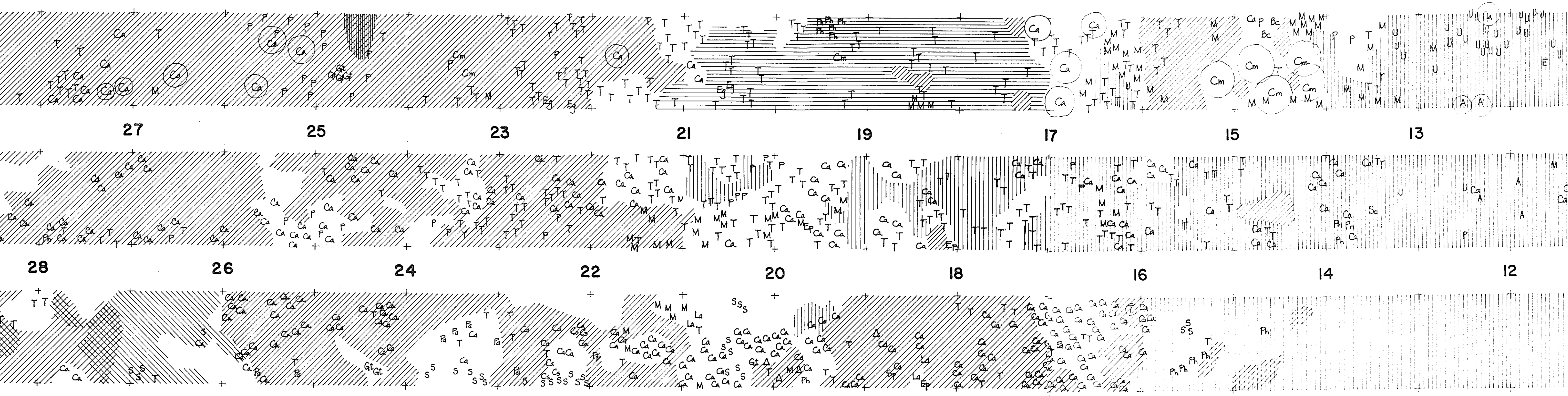
CHIMNEY MARSH
0 1 2 3
SCALE IN METERS



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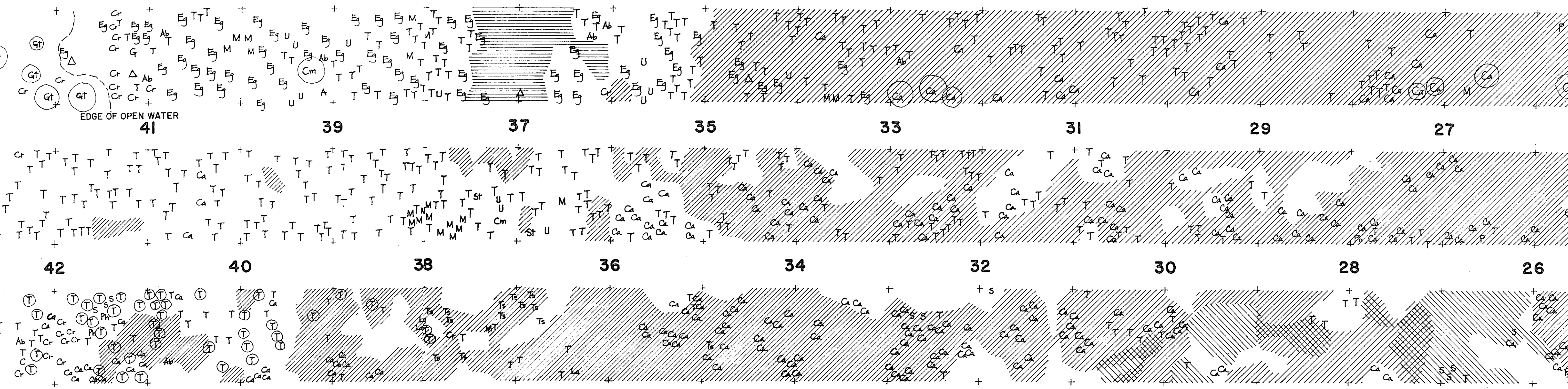
EDGE OF OPEN WATER
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39
37
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33
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42
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34
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26

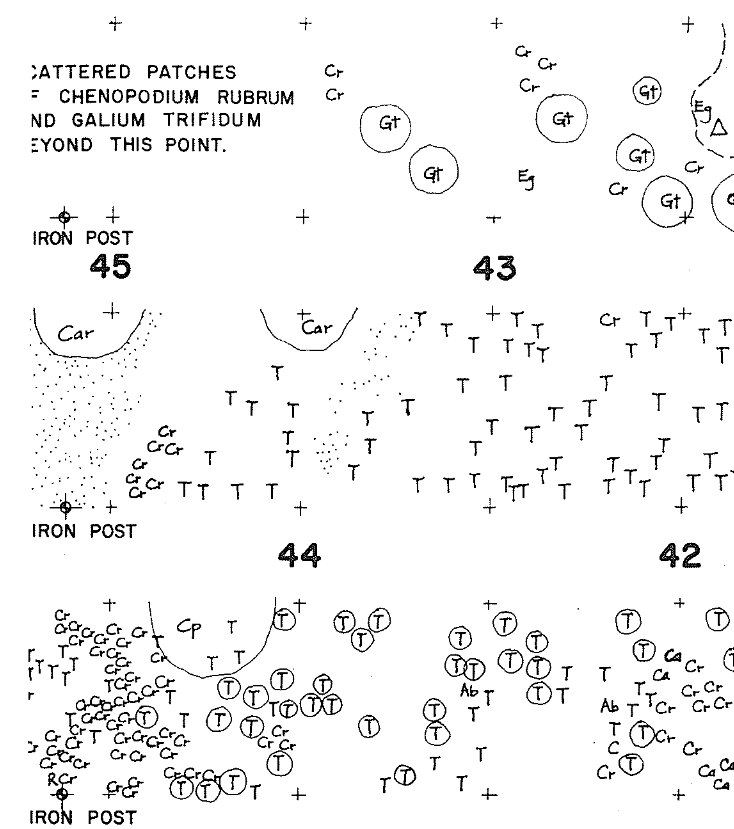
grostis canadensis (F.100% c 3.5). In the upper reaches of the zone, at the edge of the tree-bearing area, species such as *Urtica dioica*, *Sonchus arvensis* and *Eupatorium maculatum* increased in frequency.

The transects (Weaver and Clements, 1938, Cain and Castro, 1959) (Fig.14) indicate the characteristics of the plants in a strip 1 m wide, traversing the marsh from the edge of the forested ridge to the limit of pioneering vegetation, during late summer in 1959, 60 and 61 (Fig.15).

Jackfish Pond

This site (NESection 31; T14; R5) lies 14.5 km east of Delta Channel and 3.6 km east of Chimney marsh on the southern side of the forested ridge. It was examined in order to ascertain whether two sites, apparently similar in their relationship with the forested ridge, in topography, water level fluctuations, nature of the soil etc. would support similar plant communities.

When sampled in 1959 Jackfish Pond showed the retreating water surrounded by waterlogged *Phragmites* stubble and bare muck, approximately 44 m across. This formed the lower part of zone 1 which was being colonized by *Scolochloa festucacea*, *Ranunculus sceleratus* and *Chenopodium rubrum*, the upper part of the zone (25 m wide) was dominated by *Scolochloa* (height 0.6 - 0.9 m) among which scattered clumps of *Scirpus validus* occurred. The distinction between zone 1 and zone 2 existed in species composition, but it was emphasized by the height of the mixed community of zone 2 where many components were between 1.5 m and 2 m tall. *Typha latifolia* and *Phragmites* both had frequencies of 25% and low cover values; while *Atriplex patula* (F.40%) and *Aster brachyactis* (F.30%) had cover values of almost 30%.



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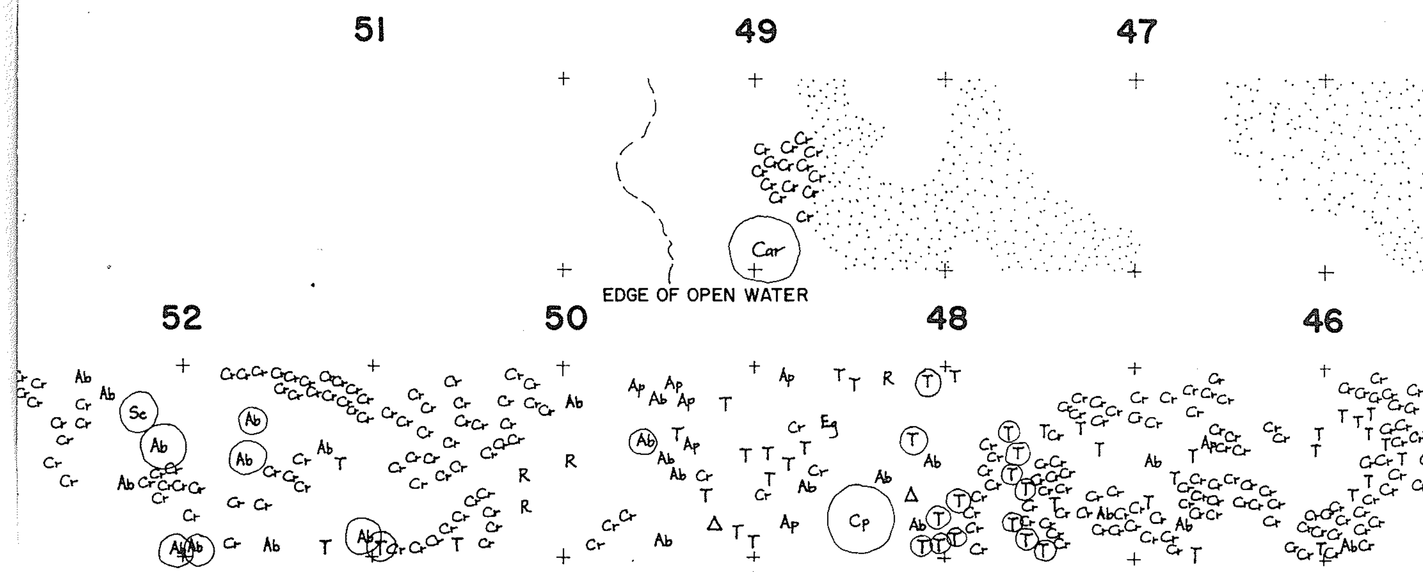


S SCOLOCHLOA FESTUCACEA

Sg SCUTELLARIA GALERICULATA

Sc SENECIO CONGESTUS variety TONSUS

Δ SONCHUS ARVENSIS variety GLABRESCENS

Ts TEUCRIUM OCCIDENTALE

T TYPHA LATIFOLIA

U URTICA DIOICA

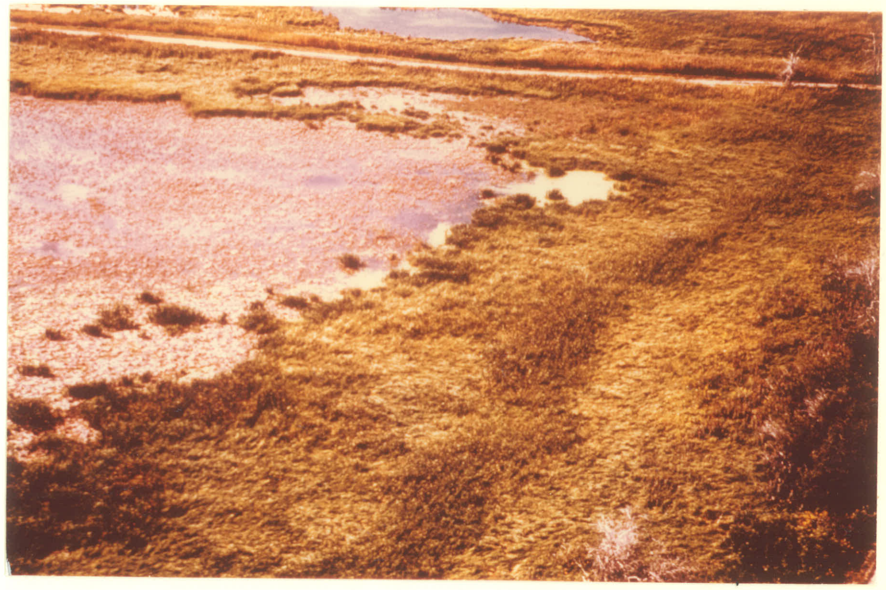
(R) DENOTES SIZE OF PLANT

CHIMNEY MARSH

0 1 2 3

SCALE IN METERS

Figure 14



Z1 Z2 Z3 Z4

Figure 15. Chimney Marsh 1960.

Left to right - water covered area being encroached upon by

- Z1 - mixed pioneering species
- Z2 - Scolochloa festucacea and Typha latifolia (dark green)
- Z3 - Calamagrostis canadensis
- Z4 - mixed community including Eupatorium maculatum, Calamagrostis, Carex atherodes and others at the edge of the forested ridge

In 1960 Scolochloa festucacea again dominated zone 1, among it a few groups of Typha latifolia plants had become established (F.5%). Scolochloa was also the most frequent species in zone 2 but Carex atherodes had increased five-fold from the previous year, and Sonchus arvensis had increased four-fold. Ninety-two percent of the species in zone 2 had higher frequencies than in 1959.

In 1961 Scolochloa maintained its dominance of zone 1 Typha was frequent and a variety of other species were recorded (Table IV). In zone 2, Carex atherodes now had the highest frequency and cover; Calamagrostis canadensis and Sonchus arvensis were co-dominant with it.

Decoy Pool and a number of other shorelines south of the forested ridge were examined in the same manner. They showed species composition and changes similar to those at the Chimney and Jackfish Pond, as did sites as far west as The Pass. The area of ground exposed each year varied considerably. At some sites, for example, Chimney Marsh, it covered up to 400 metres by 1961, at others less than ten metres.

In the marshes with narrow shores Senecio congestus, and Ranunculus sceleratus grew on emergent Phragmites stubble, and on other slightly raised areas. As in other sites Senecio flowered in June, set seed and a second generation of plants appeared in the same year, to overwinter and flower the following spring. As shorelines dried and in slightly drier places Atriplex patula and Rumex maritimus germinated early, followed by Chenopodium rubrum; other species recorded included Epilobium glandulosum, Typha latifolia, Aster brachyactis, Scirpus validus and Scolochloa festucacea.

TABLE IV. JACKFISH POND. Sampling Figures for 1960, 61 and 62 Showing Frequency, Cover and Sociability.

Species	7.9.59						9.9.60						10.8.61					
	Z1			Z2			Z1			Z2			Z1			Z2		
	F%	C	S				F%	C	S	F%	C	S	F%	C	S	F%	C	S
Scolochloa festucacea	80	2.8	2.4				100	4.1	1.3	94	2.5	2.8	85	2.2	2.2	15	1.7	1.3
Scirpus validus	6	1.7	2.0							10	1.0	1.3	5	1.0	1.0			
Ranunculus sceleratus	40	2.1	1.0				25	1.0	1.0				25	1.8	1.0			
Epilobium glandulosum	30	2.0	1.7	10	2.0	2.0							5	1.0	1.0			
Teucrium occidentale	5	1.0	1.0							6	1.0	1.0				20	1.1	1.1
Typha latifolia				25	1.5	1.3	5	3.0	3.0	13	1.5	1.0	50	1.6	1.3	10	1.1	1.0
Phragmites communis				25	1.8	1.8				40	1.8	1.8	5	1.0	1.0	25	1.0	1.0
Sonchus arvensis var. glabrescens				10	1.0	2.4				40	2.5	2.6				90	1.2	1.3
Lycopus americanus				10	1.0	1.0				20	1.3	1.6						
Stachys palustris				10	1.0	1.0				13	1.0	1.0				15	1.0	1.0
Cirsium arvense				10	1.3	1.5				20	1.0	1.0				20	1.0	1.0
Aster brachyactis				30	2.0	2.3							5	1.0	1.0			
Atriplex patula				40	2.3	2.2												
Cicuta maculata				10	1.0	1.5												
Eupatorium maculatum				5	2.4	2.0				15	2.4	1.5				15	1.0	1.0
Rumex maritimus							5	2.0	1.0									
Hordeum jubatum										7	2.0	2.0						
Aster praealtus										20	1.0	1.0				5	1.0	1.0
Carex atherodes				10	1.0	1.0				53	2.5	2.8	20	2.2	2.7	100	3.6	4.3
Urtica dioica										6	1.0	1.0				35	1.0	1.0
Chenopodium rubrum	15	1.3	2.0										30	1.4	1.4			
Mentha arvensis										10	1.1	1.0				25	1.2	1.2
Polygonum persicaria													5	1.0	1.0			
Calamagrostis canadensis										5	1.0	2.0				75	1.3	1.5
Eleocharis acicularis				10	1.0	2.0												

Non-occurrence is indicated by a blank space

Once established, Scolochloa generally increased markedly in abundance in subsequent years. This was particularly true if additional denuded muck was exposed and became colonized by the pioneering species. These paved the way for Scolochloa to spread. The composition of the higher zones partly depended on the surviving vegetation. In many sites this was Phragmites communis which enlarged its stands and put forth runners towards the drying ground thereby spreading effectively. Carex atherodes Spartina pectinata and Calamagrostis canadensis were recorded in the higher zones of some sites.

Avocet Marsh

On both sides of the main road to Delta there are low lying marshy places two of which were sampled to show the effects of falling water levels. In 1958 one of these, Avocet Marsh (NE Section 11; T13; R7) is 1.4 km south of Delta, had a mosaic of species established in a zone parallel with the road (Walker, 1959). In June 1959 the area of vegetation had greatly increased and the water diminished. Bordering the water was a zone dominated by Ranunculus sceleratus (F.100% c 4.2) in in which Scolochloa festucacea (F.30%) was becoming established and occasional plants of Rumex maritimus, Aster brachyactis and Senecio congestus were recorded. Drift lines of debris bore a dense growth, with abundant Rumex maritimus, Aster brachyactis, Ranunculus sceleratus and Chenopodium rubrum; Atriplex patula and Scolochloa festucacea were frequently encountered (Table V).

The central region of the emergent marsh was dominated by Scolochloa festucacea with abundant Aster brachyactis and Atriplex patula understorying it. There were two heights of Scolochloa, those estab-

TABLE V. AVOCET MARSH. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability.

Species	Z1 14.6.59 Marsh shore in 12-18 cm water			Ridge of debris waterlogged			Z2 18.6.59 Wet Major part of marsh			Z1 12.9.60 Marsh Shore			21.7.60 Z2 Major part of marsh			Z1 2.7.61 Shore			Z2 Major Part		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Ranunculus sceleratus	100	4.2	4.6	80	1.9	3.8				15	1.3	2.3	4	1.0	1.0	95	2.3	2.3			
Scolochloa festucacea	35	2.0	1.5	50	1.6	2.5	100	2.6	3.7	10	2.0	2.0	96	3.5	3.5				100	3.9	3.5
Rumex maritimus	20	1.2	2.2	85	2.5	3.3				55	2.2	1.5				100	3.7	3.4	15	2.3	2.3
Aster brachyactis	20	2.0	4.0	80	2.0	3.5	72	3.0	4.0	95	3.0	3.1	28	2.9	4.4	85	1.5	1.5	20	1.2	1.2
Senecio congestus	15	1.0	1.0	5	1.0	1.0				35	1.6	1.3				60	1.5	1.0			
Chenopodium rubrum				75	2.1	3.4	20	2.2	3.2	80	2.2	2.2	16	3.0	4.5	10	1.5	2.0			
Atriplex patula				55	1.2	1.5	60	1.1	1.5	20	1.5	2.0				5	1.0	1.0	10	1.5	2.5
Sonchus arvensis				5	1.0	1.0													20	1.2	1.0
Phragmites communis				5	1.0	1.0										5	1.0	1.0			
Carex atherodes				5	1.0	1.0	5	1.0	1.0												
Puccinellia nuttalliana				5	1.0	1.0										20	1.0	1.2			
Scirpus acutus							5	1.0	1.0												
Hordeum jubatum										5	1.0	2.0				5	1.0	1.0	5	1.0	1.0
Typha latifolia										10	1.0	1.0				10	1.0	1.0			
Lycopus americanus										5	2.0	3.0									
Scirpus paludosus							5	1.0	1.0				5	1.0	1.0	5	1.0	1.0			
Ranunculus cymbalaria										5	1.0	1.0									
Salicornia rubra													5	1.0	1.0						
Scirpus validus										10	1.2	2.0				15	1.4	2.0			
Suaeda maritima							10	1.0	1.0				15	1.0	1.0						

Non-occurrence is indicated by a blank space.

lished in 1958 had grown to a mean height of 50 cm and were flowering, while the plants of the current year were up to 25 cm tall and not in flower. Some depressions were bare, others carried occasional plants of Chenopodium rubrum.

Cladophora grew in the shallow open water, among the protruding Phragmites stubble. A little further off-shore surviving islands of Scirpus acutus were increasing in size and new plants were becoming established vegetatively. Potamogeton pectinatus formed small patches in deeper water.

In 1960, drift-lines, the main central area, and depressions, bore vegetation which was similar to that recorded the previous year. Aster brachyactis (F.95% c 3.0), Chenopodium rubrum (F.80% c 2.3), Rumex maritimus (F.55% c 1.2), Senecio congestus (F.35% c 1.6), Atriplex patula (F.20% c 1.5) and other species of minor importance (Table V) flourished on washed up stems of Phragmites and Typha in which organic debris had been trapped. The central area was again dominated by Scolochloa festucacea understoried by feeble plants of Atriplex patula which occasionally formed patches in depressions.

As the water retreated, waterlogged muck was exposed and from this 10 samples were obtained in a zone parallel with the water. Units 2.5 cm x 2.5 cm x 2 cm were examined for seeds (Table VI).

TABLE VI. Seed Counts in Samples Collected in the Newly Exposed Muck on June 28, 1960.

Species	Sample 1	2	3	4	5	6	7	8	9	10	Total	Mean
Ranunculus sceleratus	81	8	29	-	29	15	30	12	33	22	259	28.8
R. cymbalaria	-	-	4	-	-	-	-	-	2	-	6	3
Rumex maritimus	94	8	82	15	24	3	4	16	-	12	258	28.8
Atriplex patula	-	7	-	-	-	8	9	-	-	-	24	8

A month later quadrats 5 cm x 5 cm were examined for seedling development. The results are given below in Table VII.

TABLE VII. Seedlings Developed in the Above Area on July 29, 1960.

Species	Sample 1	2	3	4	5	6	7	8	9	10	Total	Mean
Ranunculus sceleratus	1	-	-	2	-	-	-	-	2	-	4	1.3
Chenopodium rubrum	-	-	25	-	1	-	-	8	1	-	35	9
Rumex maritimus	120	94	2	82	198	137	192	95	115	143	1178	117.8
Aster brachyactis	-	127	89	-	-	-	-	-	-	-	216	108

In 1961 Avocet Marsh was dominated by *Scolochloa festucacea*, 120 cm tall and flowering sporadically. A few depressions still supported *Atriplex patula*. The shore-line drift once more formed a distinct zone of mixed vegetation including *Senecio congestus*, *Rumex maritimus*, *Ranunculus sceleratus*, *Aster brachyactis* and *Chenopodium rubrum*.

Samples were again collected in the newly exposed muck for seed counts; 2.5 cm x 2.5 cm x 2.0 cm quadrats yielded the following data:

TABLE VIII. Seed Counts in Samples Collected in Newly Exposed Muck at Avocet Marsh, June 3, 1960.

Species	Sample 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	Mean
Chenopodium rubrum	1	-	-	-	2	5	-	3	-	2	1	-	1	1	-	-	1	3	3	2	25	2.1
Ranunculus sceleratus	1	-	-	-	-	-	-	-	1	2	1	-	-	-	2	1	-	-	-	2	10	1.4
Rumex maritimus	1	-	3	-	1	-	-	1	3	1	-	-	-	-	-	-	-	1	-	1	12	1.5

On August 9 the same area was sampled for seedling development, samples 5 cm x 5 cm were used with the following results:

TABLE IX. Seedlings Developed in the Above Area at Avocet Marsh, August 9, 1961.

Species	Sample															Total	Mean
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Chenopodium rubrum	49	77	4	2	8	2	1	-	3	4	17	-	-	3	23	193	16
Ranunculus sceleratus		8	33	89	-	-	42	3	1	38	14	17	-	28	27	300	27
Rumex maritimus	178	105	63	59	80	265	235	111	78	70	86	45	130	78	89	1673	111

Clearly seed counting from such a small number of samples bears no relation to the forthcoming seedling production. It does indicate the range in numbers of seeds found.

A series of photographs was taken to show the vegetation changes. Figures 16, 17 and 18 illustrate the vegetation in one part of the marsh in 1958, 59 and 61.

Sowls' Marsh

The second area, Sowls' Marsh (SE.Section 11, T13, R7) lies immediately south of Avocet Marsh and the disused railway line. In 1959 there were a few depressions in this area which retained water, though the majority had no standing water by mid-July. When sampled in September the marsh was discontinuously covered with *Aster brachyactis* (F.70% c 3.2); *Chenopodium rubrum* grew with it and dominated many of the hollows. Tall plants of *Atriplex patula* had a scattered distribution and *Scolochloa festucacea* was becoming established in places. Tufts of *Puccinellia nuttalliana* and groups of *Salicornia rubra* plants were rare.

Figure 16. Avocet Marsh (1958). General View of Marsh with Vegetated Areas Dominated by *Chenopodium rubrum*

Figure 17. Avocet Marsh (1959). With *Rumex maritimus* on Ridge in Foreground and *Scolochloa festucacea* occupying the Major Part of the Area.

Figure 18. Avocet Marsh (1960). Dominated by *Scolochloa festucacea*.

Note the increase in *Scirpus acutus* from 1958-60 in the open water.

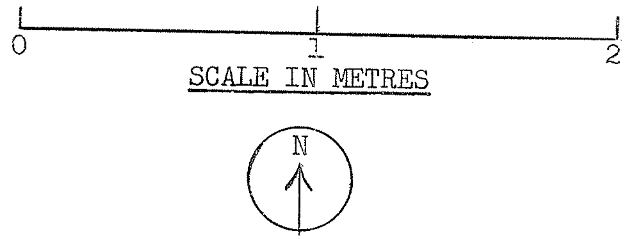
The vegetation pattern remained substantially the same the following year, although Scolochloa increased in abundance and Aster brachyactis decreased. By 1961 Sowls' Marsh was a mosaic of communities with several species common to them all. Atriplex patula was most abundant and had the highest cover value (c 3.5, 3.7, 3.1). In some places it was associated with Hordeum jubatum, in others with Scolochloa festucacea. The number of less important species had increased and the marsh-like character of the area had diminished. It was apparent that with a continuation of the drying trend Scolochloa festucacea would increase in importance as it has an advantage over annual species. Four quadrats 2.0 m x 2.0 m were staked out in 1958 and the species colonizing them mapped each year. Figures 19, 20 and 21 show the series from one quadrat.

Cherry Ridge

Cherry Ridge (NW.Section 18; T14; R6) is a sandy spit which was built up in the past at the junction of Portage Creek and Cadham Bay. It is approximately 1 km long, convex in shape and crowned with a growth of small trees and shrubs. Scirpus acutus flourishes in the shallow water offshore. The shoreline of the Ridge is irregular and the community developed on it in some places could be described as zoned, while in others zoning is non-existent. Therefore, when sampled the vegetation was considered as one unit (Table X).

Portage Creek

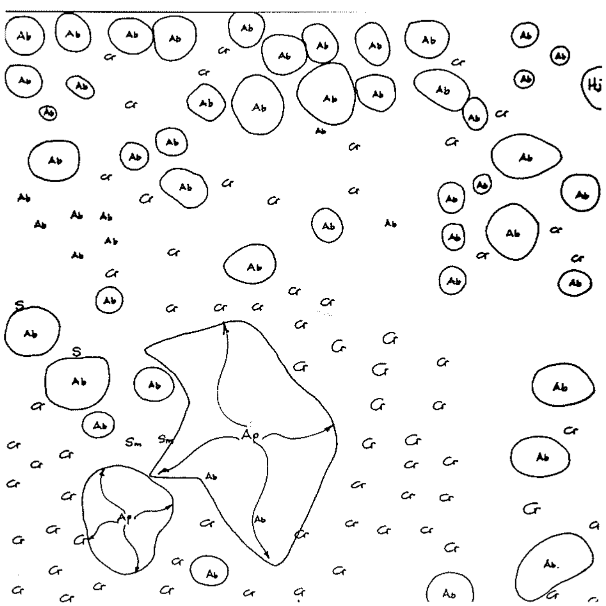
South of Simpson Bay between Portage Creek and Poplar Pools there is an area of marsh 1.7 km across and 3.1 km long (NE.Section 5; T14;R6). In 1958 it was a shallow basin of water with scattered clumps of Scirpus acutus at the southern end, which persisted throughout the period of study, eventually becoming surrounded by Scolochloa festucacea.



LEGEND

Sm	- *Suaeda maritima*	Pn	- *Puccinellia nuttalliana*
Ap	- *Atriplex patula*	Pr	- *Polygonum ramosissimum*
Cr	- *Chenopodium rubrum*	S	- *Scolochloa festucacea*
Ab	- *Aster brachyactis*	Hj	- *Hordeum jubatum*

○ denotes the area of an individual or group



gure 19. 1959

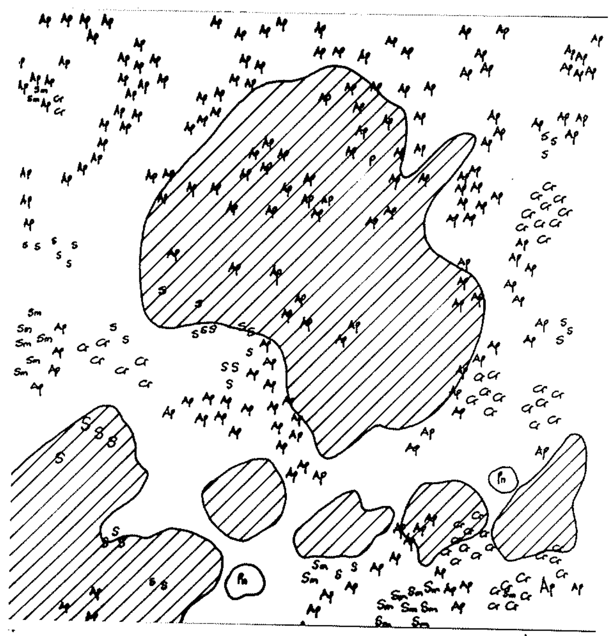


Figure 20. 1960

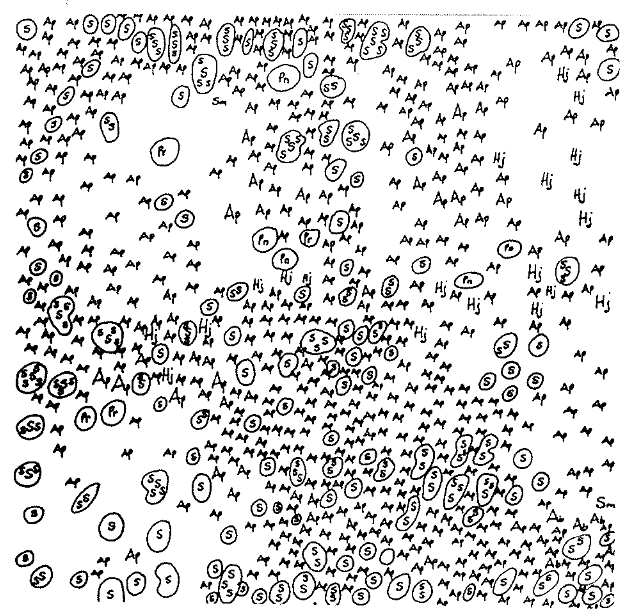


Figure 21. 1961

MAPPED QUADRAT AT SOWLS MARSH IN 1959, 1960 AND 1961

TABLE X. CHERRY RIDGE. Sampling Figures for 1960 and 1961 Showing Frequency, Cover and Sociability.

Species	10.9.60			10.8.61		
	F%	C	S	F%	C	S
Sonchus arvensis	75	2.0	2.0	85	2.5	2.0
Carex atherodes	5	1.0	2.0	10	1.5	1.5
Atriplex patula	10	1.5	1.2	30	2.0	1.6
Phragmites communis	20	1.3	1.4	25	1.4	1.4
Eleocharis palustris	20	1.1	2.1	45	1.1	1.8
Cirsium arvense	60	1.5	1.5	10	1.0	1.0
Aster brachyactis	15	1.4	1.0	25	1.2	1.0
Rumex maritimus	5	1.0	1.0	20	1.5	1.2
Ranunculus cymbalaria	20	1.5	2.0	10	1.5	2.0
Eleocharis acicularis	10	1.5	3.0	10	1.5	2.0
Potentilla anserina	5	1.0	1.0	5	1.0	1.0
Artemesia biennis	5	1.0	1.0			
Salix interior	30	1.0	1.0			
Scirpus paludosus	20	2.0	2.6			
Mentha arvensis	25	2.4	2.0			
Stachys palustris	20	1.5	1.0			
Aster praealtus	25	1.3	1.3			
Verbena hastata	10	1.0	1.0			
Teucrium occidentale				15	1.0	1.0
Glaux maritima				35	1.4	1.2
Ambrosia trifida				5	1.0	1.0
Rumex maritimus						
Lycopus americanus				15	1.0	1.0
Scolochloa festucacea				5	2.0	2.0
Hordeum jubatum				5	1.0	1.0
Chenopodium rubrum				5	1.0	1.0
Scirpus acutus	65	1.6	1.6	85	1.5	3.0
Ranunculus sceleratus	10	1.3	1.0	15	1.5	1.5
Senecio congestus	10	1.0	1.0	10	1.0	1.0
Urtica dioica	5	1.0	1.0	5	1.0	1.0

Non-occurrence is indicated by a blank space

In June 1959, 10-15 cm water covered the marsh uniting it with Simpson Bay; during the year the water level fell but fluctuated considerably due to wind action. Three zones of vegetation developed; the central part became occupied by a mixed community in which Ranunculus sceleratus (F.80% c 2.5) was co-dominant with Scolochloa (F.76% c 1.5); Aster brachyactis was frequent and a number of species occurred occasionally including Scirpus paludosus, Rumex fueginus and Phragmites communis. This central area was fringed by a mixed community (Zone 2) in which Atriplex patula, grew 1 m tall, and together with Chenopodium rubrum and Aster brachyactis, was abundant on the eastern side. While on the western side Atriplex patula (F.92%) was dominant, Aster brachyactis was frequent, and Hordeum jubatum and Suaeda maritima occasional (Table XI). Aster brachyactis had dominated this zone the previous year (Walker, 1959). It merged into the waterlogged third zone dominated by Scolochloa festucacea with frequent Scirpus paludosus and S. validus; associates, like Hordeum jubatum, Ranunculus sceleratus and Puccinellia nuttalliana were occasionally recorded. The Scolochloa zone passed into the meadow which had a composition similar to that described in 1958 (Walker, 1959). The three zones of vegetation distinguishable in June persisted until September. Aster brachyactis interspersed with single tiller shoots of Scolochloa had become dominant in the central area, which was sharply divided from the surrounding second zone. Here Atriplex patula (F.100%) remained dominant; Hordeum jubatum (F.40%) and Chenopodium rubrum (F.40%) were associated with it. The Hordeum became co-dominant with Puccinellia nuttalliana in the third zone, and both had high cover values (Table XI).

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TABLE XI. PORTAGE CREEK. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability of Species Present.

Species	21.6.59												6.9.59									29.8.60									6.8.61
	Z1			Z2 East			Z2 West			Z3			Z1			Z2			Z3			Z1			Z2			Z3			
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	
Ranunculus sceleratus	80	2.9	3.5	8	1.0	2.0																5	1.0	1.0							
Scolochloa festucacea	72	1.4	2.3	12	1.0	2.0				92	2.7	2.3	60	1.7	2.0							100	3.7	4.0							
Aster brachyactis	44	1.2	1.2	64	2.3	3.3	36	2.9	4.2				100	3.4	3.3	10	2.0	1.0													
Scirpus paludosus	12	2.1	2.6	28	1.3	2.0	40	1.0	2.0	52	1.7	1.1	25	2.8	2.8							75	2.1	2.3							
Phragmites communis	16	1.7	3.0																5	1.0	1.0										
Rumex maritimus	12	2.3	2.0																												
Chenopodium rubrum	8	1.5	3.0	64	2.5	3.7	12	2.0	3.0							40	2.2	1.4													
Atriplex patula	4	1.0	1.0	72	2.2	2.9	92	2.7	2.7	4	1.0	1.0	5	1.0	1.0	100	4.5	3.4	20	2.0	1.0	5	2.0	2.0	100	3.2	3.4	100	3.6	3.5	H
Scirpus acutus	8	1.5	3.0	8	1.0	1.5	4	1.0	1.0													5	1.0	1.0							A
Eleocharis palustris	4	1.0	3.0	20	1.4	2.0				4	1.0	1.0	6	1.5	3.0	25	1.7	3.0	4	1.0	1.0				15	3.0	3.0				Y E
Senecio congestus	4	2.0	1.0																												D
Zannichellia palustris	4	3.0	5.0																												
Hordeum jubatum	8	1.5	2.0	8	1.0	1.0	24	2.0	3.0	8	1.0	1.0	5	1.0	1.0	40	1.2	1.7	100	4.0	3.5				35	1.4	1.4	80	3.0	2.8	
Salicornia herbacea				4	1.0	1.0																			45	3.2	3.4				
Polygonum ramosissimum				16	1.0	1.2													10	1.0	1.0										H
Puccinellia nuttalliana	8	1.0	1.0	4	2.0	2.0	16	3.5	4.0	8	1.5	1.5	25	2.2	2.2																A
Typha latifolia				4	1.0	1.0													90	4.0	4.0										Y
Suaeda maritima				4	1.0	1.0	20	1.8	3.0				10	2.0	2.0										75	1.8	1.5	10	1.0	1.0	E D
Ranunculus cymbalaria							12	2.0	3.0	6	1.0	1.0																			
Scirpus validus										32	1.4	1.2																			
Juncus effusus										4	1.0	1.0																			
Artemesia biennis										8	1.5	1.5				10	1.0	1.0													
Ambrosia trifida																			10	1.0	1.0							5	2.0	2.0	
Sonchus arvensis																			10	1.0	1.0							15	1.0	1.0	
Sagittaria cuneata																															

Non-occurrence is indicated by a blank space

In 1960 there were mats of Cladophora sp. and Enteromorpha sp. in the central shallow water where a number of Phragmites stands re-established the previous year were expanding. A few plants of Senecio congestus grew in the soft muck around shallow pools of water. By the end of the season standing water had disappeared but the soil remained waterlogged. Scolochloa festucacea was dominant, flowering sparsely in the extensive central area, abundant Scirpus paludosus was associated with it and Scirpus acutus, Atriplex patula and Ranunculus sceleratus were rarely recorded.

The surrounding second zone, also with saturated soil, was dominated by Atriplex patula (F.100% c 3.2), Suaeda maritima had a frequency of 75%, Salicornia rubra, 45% and Hordeum jubatum 35%. This zone passed into the third where Atriplex patula was still the dominant species, Hordeum jubatum (F.80% c 3.0) was more conspicuous than in zone 2, and Sonchus arvensis was occasional (Table XI). Zone 3 merged into the meadow where a marked decline in the abundance of A. patula was recorded.

Early in 1960 zoning was still apparent though partially masked by the increase in Scolochloa in zones 1 and 2. Zone 2 was approximately 40 m wide and delimited by dead woody stalks of Atriplex patula which overtopped a densely packed understory of Atriplex 10-15 cm tall and flowering well. Hordeum jubatum increased in abundance in drying areas, becoming a dominant with Sonchus arvensis towards the meadow, where the other species included patches of Eleocharis palustris, occasional Atriplex patula, Cirsium arvense, and Ambrosia trifida. Unfortunately the whole area was mown for hay before it could be sampled.

Tin Town

This site (NE.Section 3; T14;R6) lies 8.6 km east of Portage Creek and immediately south of Lyttle Bay. It is part of an extensive marshy tract of land which stretches across the southern borders of the main bays of the Delta Marsh.

In 1959 a drift-line of debris had accumulated at the water's edge; behind it a mixed zone of Senecio congestus, Ranunculus sceleratus, and Chenopodium rubrum was growing on the exposed soil between scattered clumps of Phragmites communis and Scirpus validus which had persisted along the shore. The broad area just south of the Phragmites, which had been dominated by Senecio congestus in 1958, now carried a mixed community. There was a mosaic of patches of varying size (approximately 9.0 sq m. to 20.0 sq m.), each was dominated by one of the following species: Atriplex patula, Aster brachyactis, Scirpus paludosus and Scolochloa festucacea. These patches were in a matrix of Rumex maritimus, Scolochloa, Aster brachyactis, Hordeum jubatum, and Puccinellia nuttalliana. Triglochin maritima, Salicornia rubra and Suaeda maritima were rarely recorded. This irregular zone contrasted markedly with the depressions which bore no vegetation, but had an algal skin over the Phragmites stubble.

In 1960 the offshore Scirpus acutus doubled its area and was surrounded by a dense flowering growth of Potamogeton richardsonii and P. pectinatus among which smaller patches of Myriophyllum exalbescens occurred. The Phragmites on the shore was denser and more vigorous than in 1959 and the 2-6 m zone between it and the open water bore a shoreline community (Table XII, Figure 22). The main area of the marsh was now dominated by Scolo-

Figure 22. Tin Town. Drift Line Community.

Young plants of Aster brachyactis, Ranunculus sceleratus, and Rumex maritimus in foreground. Behind them a line of Chenopodium rubrum with Senecio congestus (fruiting), and Phragmites in background.

FIGURE XII. TIN TOWN. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability.

Species	6.9.59						8.9.60						3.8.61								
	Shore line Z1			S.of Ph. Z2			Shore line Z1			S.of Ph. Z2			Shore line Z1			S.of Ph. Z2			Among the Phragmites		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Senecio congestus	25	2.5	2.0				35	2.7	2.0				70	2.5	2.2						
Ranunculus sceleratus	30	1.0	1.2										5	1.0	1.0						
Chenopodium rubrum	40	2.5	3.0	55	2.2	2.5				30	2.0	2.5	40	1.7	1.1						
Scirpus validus	20	1.5	2.0				15	1.5	2.0				5	2.0	2.0				30	1.5	1.6
Phragmites communis	15	1.0	3.0	15	1.0	1.0				5	2.0	2.0	10	1.0	1.0				100	2.6	2.5
Scirpus paludosus				30	1.5	1.5	40	1.9	1.8	15	1.2	1.2	60	2.3	2.2						
Aster brachyactis	10	1.0	1.0	65	3.4	1.6	30	1.2	1.4				60	1.5	1.5						
Typha latifolia				5	1.0	1.0	5	1.0	1.0												
Rumex maritimus				20	1.0	1.0				30	2.5	2.5	10	1.0	1.0						
Triglochin maritima				5	1.0	1.7															
Scolochloa festucacea	10	1.0	1.0	50	2.5	1.8	15	2.0	1.5	85	3.1	3.1				100	4.6	4.6	60	1.5	1.6
Ranunculus cymbalaria	5	2.0	1.0							25	2.6	3.2	5	2.0	3.0						
Eleocharis palustris				15	2.0	3.0	20	1.1	2.5	5	2.0	2.0	10	1.0	1.0	15	2	2.3			
Puccinellia nuttalliana				20	3.0	3.1				15	1.6	2.0									
Atriplex patula				35	2.0	1.7	25	2.1	2.0	5	1.0	1.0	40	2.0	1.8						
Sonchus arvensis				33	3.1	1.6							10	1.0	1.0	10	1.5	1.5	15	1.5	1.0
Hordeum jubatum	5	1.0	1.0	15	1.3	2.0										5	1.0	1.0			
Carex atherodes										5	1.0	1.0				30	1.8	1.8			
Stachys palustris																			10	1.0	1.0
Suaeda depressa				5	1.0	1.0															
Salicornia rubra				5	1.0	1.0															
Glaux maritima				5	1.0	1.0															
Polygonum aviculare																5	1.0	1.0			

Non-occurrence is indicated by a blank space.

chloa which was understoried by *Chenopodium rubrum*, while former shallow depressions held *Rumex maritimus*.

To obtain some idea of density the plants in 60 quadrats 0.5 m x 0.5 m were counted and showed the mean number per quadrat for 4 species as follows:

Chenopodium rubrum 48 (range 2 to 193),
Aster brachyactis 16 (range 0 to 220),
Ranunculus cymbalaria 2 (range 0 - 84),
Rumex maritimus 1 (range 0 - 32).

The water table was lower in 1961, and the shoreline community had expanded and changed somewhat in composition. *Senecio congestus*, *Scirpus paludosus* and *Aster brachyactis* were abundant and *Chenopodium rubrum* was frequent. The main area had a more uniform appearance than formerly, being dominated by *Scolochloa festucacea*, while *Carex atherodes* had become established near the fringing *Phragmites*. The *Phragmites* and *Scirpus validus* were understoried by a straggling growth of *Scolochloa*; *Stachys palustris* and *Sonchus arvensis* were occasional (Table XII). The whole of the *Scolochloa* was mown in August obliterating sixty marked quadrats that had been counted in 1959, with the result that the hoped for comparison between the beginning and the end of the study was not obtained.

Flee Island Study Area

Flee Island lies 9.6 km east of the main road to Delta and 7.2 km south of the forested ridge. It is between Bluebell Bay and Blackfox Lake on the southern side of the marsh (SW.Section 13; T14; R6).

In 1959 the water's edge was bordered by a clumped growth of *Phragmites*, which did not extend far into the water and flourished best where the depth was less than 0.5 m during the summer. In June, the water being approximately 5 cm deep, occasional plants of *Ranunculus sceleratus* and *Scolochloa festucacea* had become established among the *Phragmites*. In other places a shore-line community developed and was dominated by *Atriplex patula*. During the summer as the water receded, *Phragmites* runners spread over the newly exposed muck which soon bore scattered plants of *Ranunculus cymbalaria* and *Senecio congestus*. The *Ranunculus* flowered but the *Senecio* remained in a vegetative state.

On the landward side of the *Phragmites*, depressed areas were bordered by a well-established zone of *Aster brachyactis* (F.90%), *Scolochloa festucacea* (F.85%), and *Atriplex patula* (F.70%). This gave way centrally to a mixed open community of *Chenopodium rubrum* and *Aster brachyactis* with several species growing in patches and interspersed with bare areas. Individual patches were dominated by *Chenopodium rubrum*, *Atriplex patula*, *Ranunculus sceleratus* and *R. cymbalaria*. Less frequent species scattered throughout included *Salicornia rubra*, *Suaeda maritima*, *Puccinellia maritima* and *Scirpus paludosus*.

In 1960 the arrangement of communities remained essentially the same as in the previous year. The cover of the marginal *Scolochloa* had increased but *Atriplex* and *Aster* had decreased and *Salicornia* had become frequent (F.44%). Other species in this expanding marginal zone are recorded in Table XIII. The central area maintained its patchy appearance, with the same dominants persisting.

TABLE XIII

TABLE

Species
Aster brachyactis
Atriplex patula
Hordeum jubatum
Scolochloa festuc
Phragmites commun
Sonchus arvensis
Rumex maritimus
Carex atherodes
Suaeda maritima
Chenopodium rubru
Ranunculus sceler
Eleocharis acicul
Salicornia rubra
Puccinellia nutta
Glaux maritima
Polygonum ramosis
Scirpus paludosus
Ranunculus cymbal
Juncus effusus
Lemna minor
Typha latifolia
Stachys palustris

Non-oc

As an example of the density of the seedlings in the patches, sixty quadrats 5 cm x 5 cm were counted on August 3, 1960 in each of the following patches:

Chenopodium rubrum dominated areas averaged 33 plants per quadrat (range 9 to 71);

Aster brachyactis dominated areas averaged 17 plants per quadrat (range 1 to 79)

while mixed patches contained an average of 39 *Chenopodium* (range 8 to 60), 26 *Aster* (range 0 to 94), and 0.008 *Salicornia* (range 0 to 2).

A further increase in the *Scolochloa* was obvious early in 1961. It dominated the formerly bare areas in the central part and was cut for hay during the fodder shortage early in August. This unfortunately obliterated one hundred marked quadrats which were being used for density studies and made sampling impossible. The water level in the open bays had fallen exposing an expanse of muck and dead aquatics which varied in extent. It soon became colonized with seedlings, *Chenopodium rubrum* (F.50%) and *Ranunculus cymbalaria* (F.30%) being the most abundant. *Typha latifolia*, *Aster brachyactis*, *Atriplex patula*, *Scirpus paludosus* and *Ranunculus sceleratus* also occurred. The strip traversing the *Scolochloa* which marked the path to the landing stage was still conspicuously different from the remaining area (Table XIII).

There were some areas which remained almost bare throughout the study, some were quite extensive (Fig.23), others less than 10.0 m across. *Atriplex patula* was the most abundant species on the periphery of these bare areas while in and around them grew scattered plants of *Puccinellia nuttalliana*, *Hordeum jubatum*, and *Suaeda maritima*. In 1960 soil conductivities showed a range from 14.7 mmhos/cm to 54.5 mmhos/cm (mean 30.0 mmhos) where it

Figure 23. Flee Island - Bare Area with Depauperate <u>Puccinellia</u> <u>nuttalliana</u>

was bare. The soil conductivity among the peripheral vegetation had conductivities ranging from 14.7 mmhos/cm to 22.4 mmhos/cm (mean 18.9 mmhos/cm).

POTHOLES

Scattered throughout the main matrix of the marsh are many ponds or potholes. These shallow depressions of various sizes are separate from the main bays, and continuous with them only in high water. They are more numerous on the north side of the marsh between the marsh shores and forested ridge, than on the southern side.

The Pass

The Pass lies 7.9 km east of Delta Channel (SW.Section 27;T14;R6) and derives its name from the fact that a strip 100 m wide across the forested ridge is kept clear of woody vegetation to induce the passage of waterfowl from lake to marsh at this place. There is a pronounced gradient from the ridge to the marsh, and the improved drainage in the upper zone is reflected by the species composition; the latter is also influenced by the accessibility of the site to traffic.

Walker (1959) listed the species and their abundance in the three zones of vegetation. In July 1959, zone 1 was narrow, Ranunculus sceleratus was abundant and Senecio congestus var. tonsus occasional. Both these species flowered early and as the season advanced they were replaced by a sporadic growth of Rumex maritimus (F.20%) and Scolochloa festucacea (F.15%). Zone 2 contained abundant Epilobium glandulosum; Galium trifidum and Bidens cernua were frequent and seven other species were recorded. Much of the ground in zone 3 was covered with old fallen branches and debris

TABLE XIV. THE PASS. Sampling Data for 1959, 60 and 61 Showing Frequency, Cover and Sociability.

Species	25.7.59									9.9.60									9.9.61								
	Z1			Z2			Z3			Z1			Z2			Z3			Z1			Z2			Z3		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Scolochloa festucacea	15	2.0	3.0	55	3.0	2.0	65	2.9	2.1	5	1.0	1.0	90	3.4	2.3	70	2.0	1.8	25	4.1	4.5	80	3.0	3.0			
Senecio congestus	25	1.0	1.0							20	1.5	1.0															
Ranunculus sceleratus	60	2.1	3.0																								
Bidens cernua	10	1.0	1.0	35	3.0	1.0																					
Rumex maritimus	20	4.0	4.0	10	1.0	1.0																					
Sium suave	15	1.0	1.0				10	1.0	1.0																		
Epilobium glandulosum	10	1.0	1.0	60	3.0	2.1																					
Aster brachyactis				10	1.0	1.0				30	2.6	2.0										10	1.0	1.0			
Mentha arvensis				10	1.0	1.0	25	2.0	4.3							15	1.0	1.2				10	1.0	1.0	20	1.6	1.6
Rorippa iclandica				10	1.0	1.0																					
Sonchus arvensis				5	1.0	1.2	25	3.0	1.0																20	2.4	1.0
Cicuta maculata				5	1.0	1.0	15	3.0	2.0																		
Galium trifidum				25	2.0	1.0																					
Lycopus americanus				10	1.0	1.0	35	1.0	1.0																10	1.3	1.0
Carex pseudocyperus				5	2.0	1.0																					
Carex atherodes							40	2.1	1.0				60	4.1	2.5	70	2.0	2.4				25	2.8	2.0			
Cirsium arvense							25	3.0	4.1							40	2.0	1.0									
Eupatorium maculatum							5	1.0	1.0							10	1.0	1.0							10	1.0	1.0
Humulus lupulus							5	1.0	1.0							10	1.0	1.0									
Urtica dioica							10	2.0	1.0							10	1.0	1.0									
Typha latifolia							10	1.0	1.0				10	1.0	1.0	20	2.0	2.0	25	2.3	2.0	10	1.0	1.0	25	1.7	1.9
Stachys palustris							15	1.0	1.0																		
Atriplex patula				5	1.0	1.0							5	1.0	1.0												
Scirpus validus							5	1.5	1.0										10	2.0	1.0						
Scutellaria galericulata							10	1.0	1.0																		
Oenothera biennis							5	1.0	1.0																		
Carex bebbii							5	2.0	1.0																		
Chenopodium rubrum										100	4.0	3.4							50	2.3	4.0						
Solidago canadensis																70	2.0	1.8				15	1.2	1.6			
Aster praealtus																70	1.7	1.8				10	1.0	1.0	75	2.1	1.8
Phragmites communis																									10	1.0	1.0
Salix interior																									5	1.0	1.0
Symphoricarpos occidentalis																									5	1.0	1.0
Hordeum jubatum													10	1.0	1.0							10	1.0	1.0			
Melilotus officinalis																									10	1.0	1.0

Non-occurrence is indicated by a blank space

from the former forest floor. A mixed community, including Carex atherodes, Lycopus americanus, Mentha arvensis, Sonchus arvensis and Cirsium arvense was frequently recorded. Other species found are listed in Table XIV.

In 1960 Chenopodium rubrum dominated the newly exposed muck and Aster brachyactis colonized slightly raised Phragmites stubble. Zone 2 had been taken over by Scolochloa festucacea, some Carex atherodes grew with it and they both flourished in zone 3 where the number of weed species had increased. Artificial manipulation of water levels influenced the vegetation in late 1960 and in 1961 when Typha latifolia spread into zone 1 and the division between zone 2 and 3 became indistinct.

Cook Creek

The potholes at Cook Creek lie 5.3 km east of Delta Channel on both sides of the small road which leads from the Ridge Road to the Creek itself (NW.Section 21; T14;R6). There is a series of six potholes between the forested ridge and the open water of Simpson Bay. The northeasterly pothole (VI) (Walker, 1959) is described as an example of the series. Scolochloa festucacea became established in 1958, and in 1959 dominated the edges of the depression where the water had disappeared. Weak plants of Atriplex patula, Aster brachyactis, Chenopodium rubrum and Rumex maritimus understoried it. Chenopodium rubrum crowded smaller hollows and was associated with occasional plants of Aster and Hordeum jubatum, while Rumex maritimus surrounded a persistent pool, and grew up to the fringing Phragmites.

In 1960 dense Scolochloa covered the potholes except in the low-lying places, in these Chenopodium rubrum persisted. Some more or less

TABLE XV. COOK CREEK
Sampling Figures for 1959, 60 and 61
Showing Frequency, Cover and Sociability.

Species	13.6.59			7.9.59			14.6.60			3.9.60			3.7.61		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Scolochloa festucaceae	100	2.0	3.0	100	3.9	3.7	100	3.8	2.5	88	3.8	3.5	100	3.7	3.5
Atriplex patula	48	2.0	2.8	10	2.0	2.0	40	2.0	1.5	56	2.0	1.9	30	1.3	1.6
Chenopodium rubrum	4	2.5	3.0	10	3.0	3.0				40	2.1	2.5			
Aster brachyactis	72	2.6	4.0	70	2.9	2.7	40	1.2	1.6	12	2.3	1.3			
Aster sp.	4	1.0	1.0												
Ranunculus cymbalaria	8	1.0	1.0												
R.sceleratus	20	1.8	2.4												
Stachys palustris							15	1.0	1.0				5	1.0	1.0
Sonchus arvensis							20	1.2	1.0	8	1.5	1.0	5	1.0	1.0
Acer negundo (seedlings)							10	1.0	1.0						
Phragmites communis										4	1.0	1.0			
Cirsium arvense													5	1.0	1.0
Puccinellia nuttalliana															
Rumex maritimus var. fueginus	12	1.0	1.3							20	2.2	2.4	10	1.5	1.0
Ranunculus sceleratus	50	2.0	1.5												
Scirpus paludosus	10	1.0	2.0												

Non-occurrence is indicated by a blank space.

bare areas, covered with dead flattened Scolochloa had Chenopodium seedlings germinating beneath the Scolochloa - others bore small plants of Aster brachyactis and Atriplex patula.

The last standing water disappeared in 1961 leaving an algal mat approximately 4 cm thick in the centre of the depressions. Chenopodium rubrum germinated here and was surrounded by a zone of tall, robust Rumex maritimus on the muck next to the now well-established Scolochloa. This achieved a greater height and flowered most where the density was reduced.

Torrey's Pothole *

This site 4.2 km east of Delta Channel (SW.Section 20;T14;R6) was briefly described by Walker (1959) as one of the few where Typha latifolia was the pioneering and dominant species. The first observation in 1959, indicated that the 1958 Typha seedlings had developed into a tall stand 20 m wide) with Cicuta maculata and Phragmites communis conspicuous on the ridge side; while towards the retreating water a close cover of Chenopodium rubrum existed. The water level of this pothole was maintained artificially by pumping water into the marsh in late August and September.

In 1960 the water was covered with a dense growth of Lemna minor which formed a mat on the soil as the water retreated. Zone 1 included a number of species; Chenopodium rubrum was dominant with a frequency of 100% and cover value of 2.5. Rumex maritimus had almost as high a frequency (90%) but, like all the other species in this zone, it had a cover value of 1.0. Atriplex patula had a frequency of 55%, the other species were of minor importance.

* Torrey's Pothole was called Nest Box 34 in Walker (1959).

Zone 2, approximately 35 m wide, was dominated by Typha (Fig. 24). Rumex, Chenopodium, Atriplex patula and Carex atherodes were frequent while Lycopus americanus, Rorippa islandica, and Bidens cernua were rarely recorded.

In 1961 the water had almost completely disappeared, and as the ground dried it was again colonized by Chenopodium. Atriplex also occurred but had a low cover value (1.6), half that of Chenopodium. Rumex and Polygonum persicaria were frequent and four other species were of minor importance (Table XVI). Typha had apparently been excluded as a pioneering species.

The lower part of zone 2 was dominated by Typha, while towards the forested ridge the number of other species increased in abundance, for example Carex atherodes, Heracleum lanatum, Bidens cernua and Acer negundo occurred exclusively in the upper reaches of the zone; others more widely distributed included Rorippa islandica, Rumex maritimus and Atriplex patula (Table XVI). As an indication of density in zone 2, in August 1961, the sampling figures for 15 quadrats 0.5 m x 0.5 m are given in Table XVII.

Bell's Marsh

Bell's Marsh 2.9 km east of Delta Channel (NW. Section 18; T14; R6) is an example of the small pothole type of marsh. In June 1959, vegetation became established between the surviving Phragmites communis and the retreating water. It consisted predominantly of Scolochloa festucacea (F. 85% c 2.3), associated with Atriplex patula (F. 50% c 4.0), Aster brachyactis (F. 30% c 3.5), and Phragmites (F. 50% c 1.5). By mid-July the water area had diminished and a dense growth of Chenopodium rubrum

Figure 24. Typha latifolia in Zone 2, and Chenopodium rubrum in Zone 1, at Torrey's Pothole.

TABLE XVI. TORREY'S POTHOLE
Sampling Figures for 1960 and 1961 Showing Frequency, Cover and Sociability.

Species	2.9.60						9.8.61					
	Z1			Z2			Z1			Z2		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Chenopodium rubrum	100	2.5	2.6	50	1.7	1.9	80	2.7	2.8	20	1.2	1.2
Rumex maritimus var. fueginus	90	1.0	1.0	30	1.0	1.0	30	1.0	1.0	25	1.0	1.2
Ranunculus sceleratus	5	1.0	1.0									
Atriplex patula	55	1.0	1.0	30	1.0	1.0	75	1.3	1.0	25	1.0	1.0
Sonchus arvensis	5	1.0	1.0							5	1.0	1.0
Epilobium glandulosum	5	1.0	1.0									
Polygonum persicaria	10	1.0	1.0				35	1.0	1.0	10	1.0	1.0
Urtica dioica	5	1.0	1.0									
Scolochloa festucacea	10	1.0	1.0									
Typha latifolia	10	1.6	2.6	90	3.3	3.4	10	1.0	1.0	80	3.7	3.2
Lycopus americanus				5	1.0	1.0						
Rorippa islandica				5	1.0	1.0	5	1.0	1.0	25	1.0	1.4
Bidens frondosa				25	2.0	1.0						
Cicuta maculata				15	1.0	1.0						
Carex atherodes				35	1.7	1.5				45	2.0	2.1
Bidens cernua				5	1.0	1.0				25	1.6	1.2
Phragmites communis							10	1.0	1.0	5	1.0	1.0
Galium trifidum							5	1.0	1.0			
Potentilla norwegica										5	1.0	1.0
Sium suave										5	1.0	1.0
Echinocystis lobata										5	1.0	1.0
Hordeum jubatum										5	1.0	1.0
Stachys palustris										5	1.0	1.0
Heracleum lanatum										20	1.0	1.0
Calamagrostis canadensis										10	1.0	1.0
Acer negundo										25	1.0	1.0

Non-occurrence is indicated by a blank space

TABLE XVII. Torrey's Pothole. Sampling Figures from 0.5 x 0.5 m Quadrats in Zone 2.

Species	Sample															Sum	Mean
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Typha latifolia	11	15	8	13	11	14	7	10	13	9	10	10	8	12	8	159	10.6
Chenopodium rubrum	5	2		1		2		2								12	0.8
Acer negundo	7	21	8	14	3	22	3	12	9	15	7	3	4	3	5	136	9.06
Atriplex patula	3	29		1	4	5		5		10	4		5	6	6	78	5.2
Rorippa islandica	3	4	62		3		1		1				2	1	5	82	5
Rumex maritimus			61	10	4		136		4		11		2	106	4	338	22.5
Sonchus arvensis			1		1											2	.13
Polygonum persicaria					2											2	.13
Bidens cernua					2											2	.13
Carex atherodes					2											2	.13
Galium trifidum			3			1	2						1	1		8	.53
Potentilla norvegicus		2				1	1			1				3		8	.53
Ranunculus sceleratus				11												11	.73
Phragmites communis							1									1	.03

Non-occurrence is indicated by a blank space

TABLE XVIII. BELLS

Sampling Figures for 1959, 60 and 61
Showing Frequency, Cover and Sociability.

Species	13.6.59			16.8.59 Central area Z1			Z2			9.9.60			3.7.61		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Chenopodium rubrum	20	1.0	1.0	100	4.6	4.4	10*	2.0	1.0	10*	2.0	1.0			
Scolochloa festucacea	85	2.3	3.3	20	1.2	1.2	100	4.8	4.9	100	4.0	4.0	100	4.3	4.4
Aster brachyactis	30	3.5	4.0				30*	1.3	2.3						
Atriplex patula	50	4.0	4.1				80*	1.6	2.1	30*	2.6	2.6			
Phragmites communis	50	1.5	2.2										10	1.0	1.0
Hordeum jubatum	10	2.0	2.0												
Sonchus arvensis	20	1.5	1.5												
Stachys palustris	20	1.2	1.7												
Typha latifolia	5	1.0	1.0												
Senecio congestus	5	1.0	1.0												
Tencrium occidentale	5	1.0	1.0												
Ranunculus sceleratus	10	1.0	1.0												
Epilobium glandulosum var. adenocaulon				10	1.0	1.0									
Lycopus asper				10	1.0	1.0									

* grows as an understory species.
non-occurrence is indicated by a blank space

Figure 25. Bells Marsh.

Z1 Chenopodium rubrum (foreground)

Z2 Scolochloa festucacea (middle)

Z3 Phragmites communis (background)

(F.100% c 2.3) colonized the recently exposed waterlogged soil. It was clearly distinguishable from the encircling Scolochloa of zone 2 (Fig.25).

By 1960 Scolochloa (F.100% c 4.0) had increased, growing across the pothole, except in two depressions. Atriplex patula (F.10%), and Chenopodium (F.10%) were the only other species present, apart from occasional runners of Phragmites which had spread in from the marginal zone. In 1961 Scolochloa dominated the whole pothole. It grew taller and flowered more than the previous year. Phragmites had increased its area in the fringing zone and put forth more runners into the Scolochloa. But it had a frequency of only 10% (Table XVIII).

Hutchinson's Marsh

Hutchinson's Marsh is 400 m west of the Delta Channel and immediately south of the forested ridge (SW.Section 14; T13;R7). In 1958 water filled the pothole which is encircled by slightly higher ground. Vegetation had become established on the shores of the pothole in 1958. Early in 1959 it was filled with melt-water approximately 40 cm deep in the centre. In this large patches of Zannichellia palustris were flowering and fruiting well. As the water began to disappear a zone of bare waterlogged soil was exposed. The most abundant pioneering species was Rumex maritimus (F.90% c 2.0) and Ranunculus cymbalaria (F.40% c 1.0) grew in silty, better drained places. Aster brachyactis, Atriplex patula, Hordeum jubatum, Eleocharis palustris, and Scirpus paludosus were all occasional. The second narrow zone was dominated by Aster brachyactis (F.100% c 3.7), Eleocharis and Puccinellia nuttalliana both had frequencies of 50%, Ranunculus cymbalaria (F.38%) and Glaux maritima (F.30%). These four species seem to favour soil with a higher mineral content. Table XIX gives the

TABLE XIX. HUTCHINSONS. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability.

Species	10.6.59						5.9.59												10.9.60						7.8.61					
	Z1			Z2			Z1			Z2			Z3			Z4			Z1			Z2			Z1			Z2		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Chenopodium rubrum							100	4.5	2.2	100	2.5	1.2	80	1.4	1.1				68	3.3	3.9	35	1.0	1.0	5	2.0	3.0			
Rumex maritimus	90	2.0	1.7	13	1.0	1.0	20	1.0	1.0	90	2.6	1.0	30	2.3	2.3	10	1.0	1.0	80	1.8	1.6	80	2.7	2.7	25	3.6	3.6			
Scirpus validus				25	1.0	1.7	40	1.0	1.0	20	1.0	1.0	90	3.0	2.0				28	2.0	1.3	85	3.3	2.5	15	2.0	2.0			
Aster brachyactis	20	1.0	1.0	100	3.7	4.2	20	1.0	1.0	60	1.0	1.0	20	1.5	1.0	70	2.9	2.7	4	1.0	1.0				5	1.0	1.0			
Eleocharis palustris	20	1.0	1.0	50	2.2	3.0	10	1.0	1.0				40	2.3	3.0	10	3.0	3.0	12	2.0	2.6	20	2.2	2.8						
Scolochloa festucacea				13	2.0	3.0				20	1.0	1.0	30	1.6	1.6	30	1.3	2.0	84	2.4	2.2	20	1.5	1.8	80	4.7	4.7	25	1.4	1.4
Atriplex patula				63	2.4	3.4				20	1.0	1.0	90	1.1	1.1	80	2.5	2.5	64	1.1	1.1	40	1.4	1.3	5	1.0	1.0			
Hordeum jubatum	20	2.0	2.0	75	2.7	3.7				10	1.0	2.0	40	1.3	1.5	80	2.3	2.9	4	1.0	1.0	5	1.0	1.0	5	1.0	1.0	65	1.4	1.4
Sium suave				13	1.0	2.0				10	1.0	1.0	10	1.0	1.0							50	1.4	1.2						
Bidens cernua													10	1.0	1.0	10	1.0	1.0				35	1.7	1.3						
Scirpus paludosus	20	1.0	1.0	25	2.0	2.5							10	1.0	1.0				32	2.1	1.8	10	1.0	1.0						
Sonchus arvensis				13	1.0	1.0										80	3.0	2.0	8	1.5	1.0	25	1.0	1.0	5	1.0	1.0	95	3.5	3.6
Epilobium glandulosum																10	1.0	1.0												
Mulhenbergia asperifolia																10	1.0	1.0										5	1.0	1.0
Ranunculus cymbalaria	40	1.0	1.0	38	2.0	3.0																								
Zannichellia palustris	20	3.0	4.0																											
Scirpus americanus				38	1.3	2.0				36	1.3	2.0										20	2.0	2.0				15	1.3	1.4
Puccinellia nuttalliana				50	3.2	4.0																								
Aster sp.				13	1.0	1.0																								
Glaux maritimus				38	1.5	1.3																								
Phragmites communis				25	1.5	2.0													4	1.0	1.0									
Eleocharis calva				13	4.0	4.0																								
Artemesia biennis				13	1.0	1.0																								
Alisma triviale																			12	1.3	1.0									
Typha latifolia																						10	2.5	1.5						
Mentha arvensis																						5	1.0	1.0						
Bidens frondosa																						5	1.0	1.0						
Stachys palustris																												20	1.0	1.0
Carex atherodes																												10	1.0	1.0
Agropyron sp.																												10	1.5	1.5
Cirsium arvense																75	2.0	2.4										15	1.0	1.0
Aster praealtus																												5	1.0	1.0
Lycopus americanus																												5	1.0	1.0

Non-occurrence is indicated by a blank space

sampling figures for the species recorded in this zone.

The water level had dropped considerably by September and the vegetated areas had increased accordingly, but the species composition was different from that recorded in June. Chenopodium rubrum (c 4.5) dominated the wettest areas and in the second zone had a cover of 2.5, in both it had a frequency of 100%. Dead Rumex maritimus which flowered earlier, covered much of zone 2. Aster brachyactis had a frequency of 100% though its cover value was only 1.0. Three species had high frequencies in zone 3, Scirpus validus (F.90%), Atriplex patula (F.90%), and Chenopodium rubrum (F.80%), Eleocharis palustris (F.40% c 2.5) grew in characteristic patches, and Hordeum jubatum (F.40% had a cover value of 1.3.

There was no standing water in Hutchinson's Marsh in late 1960. Sampling figures for September showed two zones of vegetation, one filling the centre of the pothole, the other being on the higher marginal ground. The centre was occupied by a mixed community of Scolochloa (F.84% c 2.4). Rumex maritimus (F.80% c 1.8) and Chenopodium rubrum (F.68% c 1.1) were growing vigorously with other less abundant species. The surrounding zone was co-dominated by Scirpus validus and Rumex maritimus (Table XIX, Fig.26).

In 1961 Scolochloa dominated the central area, large plants of Rumex being associated with it. The other species recorded were of minor importance, but there was a marked increase in the number of weed species in the surrounding zone. Sonchus arvensis was dominant (F.95% c 3.5), growing with tufted plants of Hordeum jubatum, Stachys palustris, Agropyron sp. Cirsium arvense and Scirpus americanus were also present (Table XIX).

Figure 26. Hutchinsons Pothole.
General vegetation in 1960.
Zone 1 Alisma triviale, Chenopodium rubrum, Rumex maritimus, Scolochloa festucacea etc.

Zone 2 Scirpus validus, Typha latifolia etc., and Phragmites near the forested ridge.

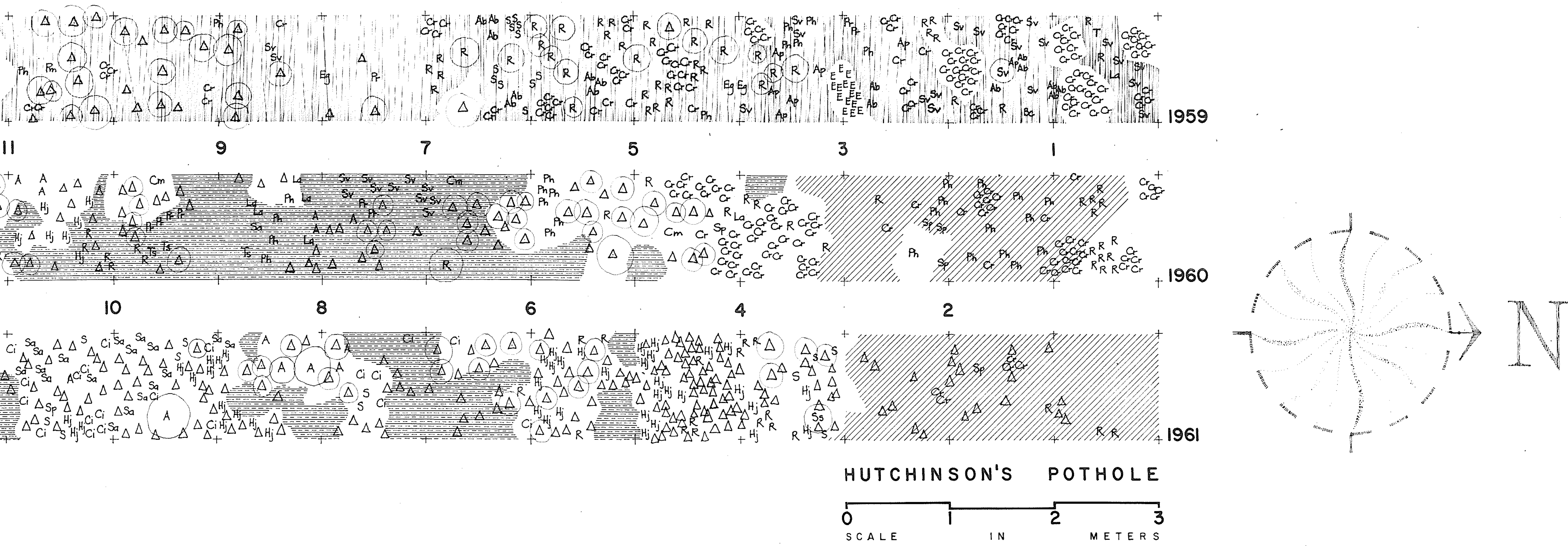
A transect 1 m wide, traversing the zones was mapped in 1959, 60 and 61, to show the spatial relationships in the vegetation of a pothole-type of marsh (Fig.27).

Portage Country Club

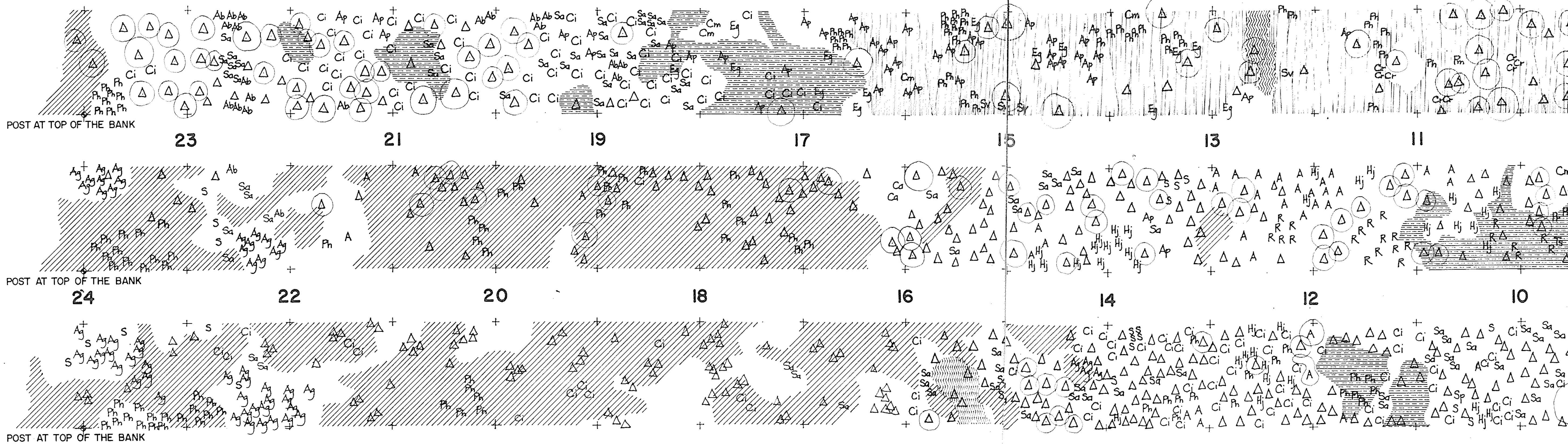
Lying 4.4 km west of Delta Channel (SW.Section 16; T14; R7) this small pothole-type of marsh was representative of many of the emergent areas in the western part of the Delta Marsh.

In 1959 three well-defined zones of vegetation had developed on the waterlogged organic soil. The central area of waterlogged muck had a sparse covering of *Scolochloa* approximately 45 cm tall interspersed with closely-packed *Atriplex patula* seedlings. Zone 2 was dominated by *Scolochloa* almost 1.0 m tall which spread into the marginal *Phragmites*. The following year *Scolochloa* dominated both zone 1 and zone 2. Some of it in zone 1 was flattened; the rest was flowering feebly, and in places understoried by weak *Atriplex patula* plants. *Sonchus arvensis* occurred sporadically throughout zone 2, together with *Scolochloa*, *Atriplex*, *Aster brachyactis*, and a few other species (Table XX). Although the surrounding *Phragmites* had enlarged its stands slightly, the main improvement appeared to be in the quality of flowering.

By August 1961 *Scolochloa* and *Sonchus* were co-dominant, both in the centre of the pothole and in the surrounding zone 2, where the soil was still wet. However in zone 2 they were associated with *Phragmites*, *Carex atherodes*, *Teucrium occidentale*, *Stachys palustris*, *Urtica diocia*, and some minor species. Transects were drawn to illustrate the changes in the vegetation pattern in 1960 and 1961. The mean density of *Scolochloa* in quadrats 0.5 m x 0.5 m was 138 (15 samples, range 79-184).



1959
11
9
7
5
3
1
1960
10
8
6
4
2
1961
N
HUTCHINSON'S POTHOLE
0 1 2 3
SCALE IN METERS



OLIA

FUEGINUS

%
20%

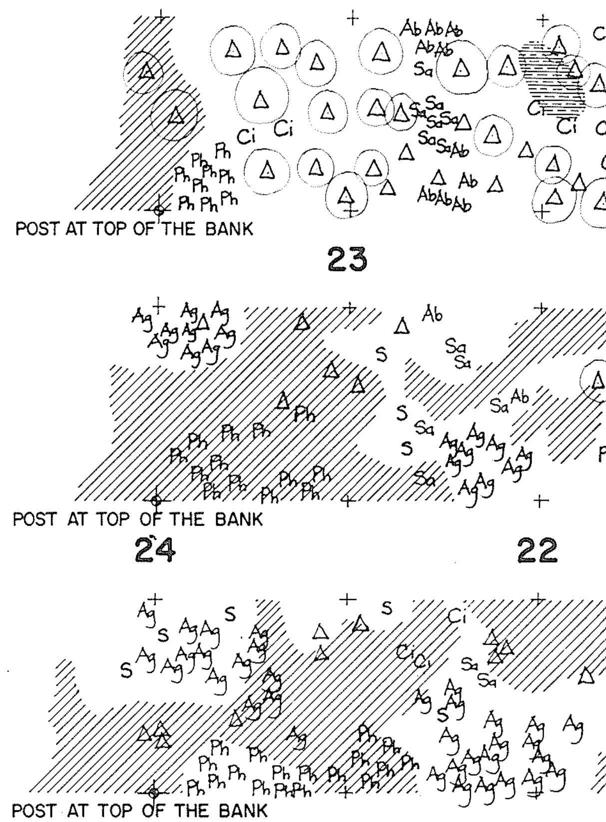
HUTCHINSON'S POTHOLE

0 1 2 3
SCALE IN METERS

Figure 27

LEGEND

Ag	AGROPYRON SP.
Ab	ASTER BRACHYACTIS
A	ASTER PRAEALTUS
Ap	ATRIPLEX PATULA
Cr	CHENOPODIUM RUBRUM
Cm	CICUTA MACULATA
Ci	CIRSIUM ARVENSE
E	ELEOCHARIS PALUSTRIS
Eg	EPILOBIUM GLANDULOSUM variety ADENOCAULON
	HORDEUM JUBATUM (area indication)
Hj	HORDEUM JUBATUM
La	LYCOPUS AMERICANUS
	MULHENBERGIA ASPERIFOLIA
Ph	PHRAGMITES COMMUNIS variety BERLANDIERI
Pm	PLANTAGO MAJOR
Pr	PRUNUS VIRGINIANA
R	RUMEX MARITIMUS variety FUEGINUS
	SCOLOCHLOA FESTUCACEA
Sa	SCIRPUS AMERICANUS
Sp	SCIRPUS PALUDOSUS
Sv	SCIRPUS VALIDUS
S	SCOLOCHLOA FESTUCACEA
△	SONCHUS ARVENSIS variety GLABRESCENS
Ts	TEUCRIUM OCCIDENTALE
T	TYPHA LATIFOLIA
	HORDEUM JUBATUM 40% ELEOCHARIS PALUSTRIS 40% BECKMANNIA SYZIGACHNE 20%



HUTCHINSON'S POTHOLE

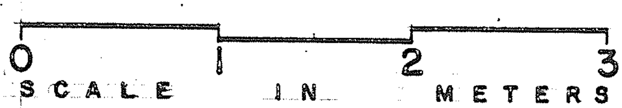


Figure 27

TABLE XX. PORTAGE COUNTRY CLUB. Sampling Figures for 1960 and 61 Showing Frequency, Cover and Sociability.

	3.9.60						1.8.61					
	Z1			Z2			Z1			Z2		
Species	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Scolochloa festucacea	100	4.6	4.7	80	2.8	2.9	100	3.1	3.1	100	2.3	2.6
Phragmites communis	5	1.0	1.0	30	1.0	1.0				60	1.0	1.0
Sonchus arvensis var. glabrescens				90	1.3	1.2	100	2.0	2.0	90	2.4	1.8
Atriplex patula				60	2.1	2.1				10	1.0	1.0
Aster brachyactis				30	1.6	2.3						
Stachys palustris				10	1.0	1.0				30	1.0	1.0
Polygonum ramosissimum				10	1.0	1.0						
Cirsium arvense				20	1.0	1.0				5	1.0	1.0
Typha latifolia				5	1.0	1.0						
Teucrium occidentale										40	1.0	1.0
Carex atherodes										50	1.2	1.0
Urtica dioica										20	1.0	1.0
Chenopodium rubrum				5	1.0	4.0						

Non-occurrence is indicated by a blank space

Flee Island Pothole

At Flee Island the pothole areas lie 1.6 km east of Tin Town (NW.Section 12; T14; R6). They were covered with water in 1958 and bore no emergent vegetation that year. In June 1959 the water had diminished and the exposed muck was colonized by Chenopodium rubrum (F.75%), Aster brachyactis (F.60%) and a clumped growth of Atriplex patula (F.85%), in most places these species were overtopped by a thin growth of Scolochloa. Atriplex also understoried the fringing zone of Phragmites. The vegetation could not be described as zoned, but the amount of Scolochloa increased on the drier sites towards the Phragmites.

By September several species had become established among this fringing growth of Phragmites. They included the following which were rarely recorded, Rumex maritimus var. fueginus, Atriplex patula, Aster brachyactis, Artemesia biennis and Sonchus arvensis - the latter species grew as single plants and in patches up to 1.5 m across. The water had continued to disappear during the summer and the areas exposed after June bore a dense growth of Scolochloa festucacea associated with Chenopodium rubrum. By this time some changes had occurred in the earlier established vegetation (Table XXI).

TABLE XXI. FLEE ISLAND - POTHOLES. Showing Frequency, Cover and Sociability in Potholes During 1959 and 1960.

	19.6.59			6.9.59						20.8.60			1961
	Z1			Z1			Z2			Margin to Centre			
Species	F%	C	S	F%	C	S	F%	C	S	F%	C	S	
Scolochloa festucacea	90	1.4	2.7	85	1.4	1.4	100	4.9	5.0	100	2.6	2.8	
Chenopodium rubrum	75	2.4	3.7	20	2.1	1.0	60	1.5	1.3				
Atriplex patula	85	1.5	2.0	70	2.0	1.8				60	1.4	1.5	H
Salicornia rubra	15	1.0	1.0	5	2.0	2.0				12	1.3	1.0	A
Suaeda maritima	30	1.3	2.0	25	2.0	1.6				8	3.0	2.5	Y
Aster brachyactis	60	2.5	3.7	60	3.7	3.7				40	2.5	2.1	E D
Chenopodium glaucum	10	1.0	3.0										
Puccinellia nuttalliana	10	1.0	1.0							12	1.3	1.3	
Hordeum jubatum										56	1.9	2.0	
Sonchus arvensis	10	1.0	1.0	25	2.0	3.0				15	2.0	2.0	

Non-occurrence is indicated by a blank space

In 1960 *Scolochloa festucacea* was the dominant species in the potholes recorded with it were *Atriplex patula*, *Hordeum jubatum*, *Aster brachyactis* and species of minor importance. This community extended into the fringing *Phragmites*.

Early in 1961 *Scolochloa* was flourishing, but unfortunately the potholes were mown for hay before sampling could take place.

Chimney Back Marsh

Lake Manitoba is bounded by a series of low sandy ridges which have been built up by wind and ice. The width and form varies and involves one, two or more old beach lines. Along much of its length there are two parallel ridges with a central low or depression. In some places this depression is less than 20 m across, in others as much as 0.4 km. Vegetation in the larger 'back marshes' resembles that of the main marsh shores in species composition, and it is not discussed here. In contrast the smaller depressions differ in a number of environmental features and floristically. As an example Chimney Back Marsh will be described briefly.

Chimney Back Marsh (NW.Section 25; T14; R6) immediately north of Chimney Marsh, consists of a series of small shallow depressions running parallel to the lakeshore and lying between the sandy ridges. They are filled with a rich Peaty Humic Gleysol. The marshes are shaded by trees and support a dense growth of vegetation which appears to reflect the availability of seed and the rate of drying of the pothole. Accumulated snow is the main source of moisture, augmented by summer precipitation and floods, therefore the water table fluctuates from year to year.

Early in the growing season a peripheral zone of vegetation surrounds the water. In 1959 Carex retrorsa was the most frequent species, but it was soon surpassed by Bidens frondosa. In the water Sparganium eurycarpum was frequent, Alisma triviale and Scirpus fluviatilis were occasional, but distributed throughout. As the water level dropped vegetation spread across the depression and all indications of zonation disappeared. The species recorded are in Table XXII.

TABLE XXII. CHIMNEY BACK MARSH. Sampling Figures for 1959 and 1960 Showing Frequency, Cover and Sociability.

Species	16.8.59			9.9.60		
	F%	C	S	F%	C	S
Carex retrorsa	50	2.4	3.0	90	2.6	2.4
Bidens frondosa	70	2.0	2.0	100	2.7	2.2
Echinocystis lobata				10	2.0	1.0
Polygonum persicaria	20	1.5	2.5	10	2.0	2.0
Polygonum hydropiper	10	1.0	1.0	10	2.0	2.0
Scutellaria lateriflora	5	1.0	1.0	20	1.5	1.5
Mentha arvensis	30	2.0	2.0	10	1.0	1.0
Sparganium eurycarpum	40	2.5	2.5	15	2.0	1.6
Sium suave	10	1.0	1.0			
Alisma triviale	20	1.0	1.0			
Scirpus fluviatilis	20	3.0	3.0	15	2.5	2.5
Polygonum coccineum	10	1.0	1.0			
Ranunculus macounii				10	1.0	1.0
Epilobium glandulosum				20	1.0	1.0
Lycopus americanus				50	4.3	1.2
Urtica dioica				40	1.2	1.2
Cirsium arvense				10	1.0	1.0
Sonchus arvensis				5	1.0	1.0
Carex lacustris	5	1.0	1.0	10	1.5	2.5
Carex pseudocyperus	5	1.0	1.0	10	1.5	2.5
Phragmites communis				5	1.0	1.0
Typha latifolia	5	1.0	1.0	5	1.0	1.0
Galium trifidum				15	1.0	1.0

Non-occurrence is indicated by a blank space

A similar pattern of development was followed in 1960. There was less water in the depression and drying proceded more rapidly, resulting in a dense heterogenous community with the composition indicated in

Table XXII. Bidens frondosa was dominant in the central part and Carex retrorsa at the edges, with it, Lycopus americanus was frequent and Urtica dioica had a frequency of 40%. Though not found in Chimney Back Marsh, Dryopteris thelypteris var. pubescens was occasionally recorded in several other back marsh areas. It was the only fern noted in the marsh and thrived on a Peaty Humic Gleysol, and was often completely overshadowed by taller species. Rose (1950) reports Dryopteris killed by shading and this may be the cause of its distribution being restricted to sites with an incomplete tree canopy.

SLOUGHS

The four sloughs described here lie on the south side of the marsh. Their connections with the Assiniboine River were severed when it changed its course. Contact of the sloughs with the marsh now exists only in periods of high water, or excessive precipitation and run-off. Under these conditions connection between the sloughs and marsh may be re-established, as in 1955.

Pintail Slough

The most westerly slough discussed is Pintail Slough (SE.Section 35; T13; R7), a three armed, well defined winding channel in the 'wet meadows' 5.6 km south of the village of Delta, which in the past flowed into Cadham Bay. In 1958 water filled the slough and contained a dense growth of Enteromorpha sp. and other algae. On the higher margins there was a fringing zone of Scirpus validus, Phragmites communis and Carex atherodes. The first vegetation to appear on the soft, Saline Humic Gleysol was a zone of Aster brachyactis, with occasional Chenopodium rubrum and Atriplex patula. As further drying took place, Chenopodium extended towards the centre of the slough in the wake of the retreating water. It eventually formed a distinct first zone of vegetation (Fig.28).

During the early part of 1959 water was still present in most of the slough, but near the road where the slough is shallower it became dry and showed a zoned pattern. Zone 1 was dominated by Chenopodium rubrum and contained occasional clumps of Scirpus validus. Scolochloa festucacea, Eleocharis palustris and Rumex maritimus were also present. Zone 2 had Rumex growing densely packed at the front of the zone, and thinning towards zone 3. It was associated with young plants of Scolochloa festucacea which were sparse near zone 1 and formed a pure community near zone 3: Aster brachyactis, Scirpus validus and Atriplex patula were distributed throughout the zone. In zone 2 Atriplex patula (F.95% c 3.6) was co-dominant with Scolochloa (F.65 c 2.7) and the number of minor species had increased (Table XXIII).

More ground was exposed in 1960 and places in the centre of the slough became firm enough to walk on. Chenopodium rubrum increased in abundance as the season advanced, and had a cover of 100% in zone 1; the plants were strikingly uniform in height (20 to 23 cm), straight, single stemmed and beginning to flower by the end of August. In this zone sixty 2.5 cm x 2.5 cm quadrats were randomly chosen in an area 2,000 m^2 and the number of plants in them counted to give an indication of density. Chenopodium averaged 8 plants per quadrat (range 2-19) and in the samples two plants of Scolochloa festucacea were recorded. Zone 2 was also dominated by Chenopodium rubrum (F.100% c 4.9) and contained Rumex maritimus (F.50%), Scirpus validus (F.35%), Typha latifolia (F.20%) and Atriplex patula (F.10%). In the highest zone, Scolochloa festucacea was co-dominant with

TABLE XXIII

Species
Chenopodium r
Aster brachya
Carex atherod
Atriplex patul
Scolochloa fe
Sonchus arven
Typha latifol
Rumex maritim
Sagittaria cu
Scirpus valid
Alisma trivial
Eleocharis pal
Scirpus palud
Ambrosia trifi
Hordeum jubat
Sium suave
Suaeda maritim
Artemesia bie
Puccinellia nu
Polygonum ram
Phragmites com

Figure 28. Pintail Slough 1959. *Chenopodium rubrum* Spreading Onto the Waterlogged Soil.

Figure 29. Pintail Slough 1960.

Z1 *Chenopodium rubrum*

Z2 *Chenopodium rubrum*, *Rumex maritimus*, *Scirpus validus*, *Typha latifolia*.

Z3 *Scolochloa festucacea* (hayed in parts), Sonchus arvensis, Atriplex patula.

Atriplex patula; Sonchus arvensis (F.44%) had become more widespread, and Eleocharis palustris persisted in a few dense patches (Fig.29). Soil discs were collected and seed counts made; soil samples were also taken from each zone.

A further general decrease in water was apparent in 1961. Vegetation grew across the slough in all but the deepest places. Chenopodium dominated the central portion, but there were a variety of other species present. Aster brachyactis had a frequency of 55%; occasionally recorded species included Sonchus arvensis, Rumex fueginus, Atriplex patula, and Carex atherodes, while Eleocharis palustris occurred in occasional patches. Zone 2 was marked by a reduction in Chenopodium rubrum and a corresponding increase in other species, particularly of Scirpus validus and Eleocharis palustris (Table XXIII). Scolochloa was present occasionally in zone 2 but because of the co-dominants in zone 3, with a frequency of 95% and cover value of 4.0 Sonchus arvensis was found with it, particularly on the margin of the meadow, together with Hordeum jubatum, Eleocharis palustris, and a number of less frequent species (Table XXIII).

Portage Slough

Three kilometers east of Pintail Slough lies Portage Creek (SE.Section 5; T14; R6), one of the main drainage channels of the Portage Plain. It has a number of short branches, the one described here is immediately east of the slough at the end of the section road. The sequence of changes relating to the water levels, and colonization is similar in all the sloughs, but differs in detail.

By the end of the 1959 growing season, Portage Slough had become divided into two, by a slightly elevated ridge on which Scolochloa festucacea and Chenopodium rubrum were co-dominants. The central parts of the slough (45 m in width) were bare stubble and waterlogged muck, surrounded by a distinct zone of vegetation dominated by Chenopodium rubrum (F.90% c 5.0) associated with young plants of Scolochloa (F.40%) and Scirpus validus (F.30%). Sagittaria cuneata (F.10%) was flowering and fruiting well.

Zone 2 was dominated by Scolochloa which had spread considerably from the year before. Other species recorded in decreasing order of abundance were Spartina pectinata, Scirpus validus, Artemesia biennis, Phragmites communis, Rumex maritimus and Sium suave, while in one place Scirpus acutus marked an old shoreline. Zone 2 merged into zone 3 in which Hordeum jubatum and Sonchus arvensis were abundant, and more conspicuous than the other species listed (Table XXIV, Fig.30).

In August 1960 the belt transect recorded in 1958 was remapped and the vegetation in the slough sampled again. In the centre Sagittaria cuneata had spread considerably where the stubble had rotted and young plants of Scirpus paludosus were now abundant (Fig.31). Zone 1 had extended towards the centre and contained a dense growth of Scolochloa festucacea seedlings, interspersed with Scirpus validus. Scolochloa and Carex atherodes were co-dominant in zone 2, though this year Suaeda maritina was abundant, Salicornia rubra frequent and the number of subordinate species had increased. In zone 3, Scolochloa, Carex atherodes and Sonchus arvensis were co-dominant and Atriplex patula, and Hordeum jubatum were well distributed throughout the zone. Mentha arvensis, Spartina pectinata,

TABLE XXIV PORTAGE SLOUGH. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability.

Species	6.9.59												29.8.60									6.8.61								
	Z1			Z2			Z3			Z4			Z1			Z2			Z3			Z1			Z2			Z3		
	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Atriplex patula													50	1.2	1.3				41	1.1	1.1	42	1.0	1.0	70	1.7	1.0	50	2.0	3.0
Chenopodium rubrum	90	5.0	5.0										40	2.0	2.1							70	2.2	2.2	28	1.0	1.0			
Typha latifolia				5	1.0	1.0																								
Carex atherodes							10	1.0	2.1							100	2.7	3.4	90	2.3	2.5									
Scolochloa festucacea	40	2.4	4.0	100	4.0	4.0							100	2.8	4.2	100	3.3	3.6	84	1.8	2.0				70	3.8	4.2	56	5.0	5.0
Hordeum jubatum							60	4.0	3.0							35	1.4	1.4	28	1.0	2.8				56	1.5	1.5	28	1.0	1.0
Sonchus arvensis							25	2.0	3.0										90	1.7	1.1							10	2.4	1.0
Spartina pectinata				20	2.0	3.0	10	2.0	3.0																					
Scirpus validus	30	1.0	1.0	10	1.0	1.0	10	1.0	1.4				64	1.5	1.2	15	1.0	1.0												
Artemesia biennis				10	1.0	1.0	25	3.0	1.0																					
Potentilla anserina																			5	1.0	1.0									
Sium suave				5	1.0	2.0																								
Phragmites communis				5	1.0	1.0																								
Rumex fueginus	10	2.3	1.0	5	1.0	1.0							10	1.0	1.0							84	4.0	4.0	84	1.8	2.3			
Beckmannia syzigachne							5	1.0	2.0																					
Sagittaria cuneata	10	2.3	1.0										15	1.0	1.0							56	1.2	1.2						
Chenopodium glaucum																						10	1.0	1.0						
Scirpus acutus																									28	2.0	1.0	14	1.0	1.0
S. paludosus													75	2.1	2.2	15	1.0	1.0	30	1.5	1.5									
Ranunculus sceleratus													5	1.0	1.0															
Suaeda maritima																75	1.8	1.4	10	1.0	1.0									
Salicornia rubra																45	3.2	3.4												
Aster brachyactis							5	1.0	1.0							10	2.0	1.0				15	1.0	1.0	42	1.0	1.0			
Ambrosia trifida																			5	2.0	2.0									
Lycopus asper																			21	1.5	1.0									
Mentha arvensis																			20	1.0	1.0									
Polygonum ramosissimum																			15	1.0	1.0									
Stachys palustris																			5	1.0	1.0									
Teucrium occidentale																			5	1.0	1.0									
Eleocharis palustris				5	2.0	2.0										20	2.5	3.0												
Urtica dioica																			15	1.0	1.0									
Calamagrostis canadensis																20	1.5	2.0	5	1.0	1.0									
Solidago canadensis																			5	1.0	1.0									
Polygonum amphibium																			5	1.0	1.0									

Non-occurrence is indicated by a blank space

Figure 30. Portage Slough Centre (R.H.S.) Showing *Phragmites* Stubble Becoming Invaded by *Chenopodium rubrum* (Z1), *Scolochloa festucacea* (Z2), *Hordeum jubatum*, *Sonchus arvensis* and other species (Z3).

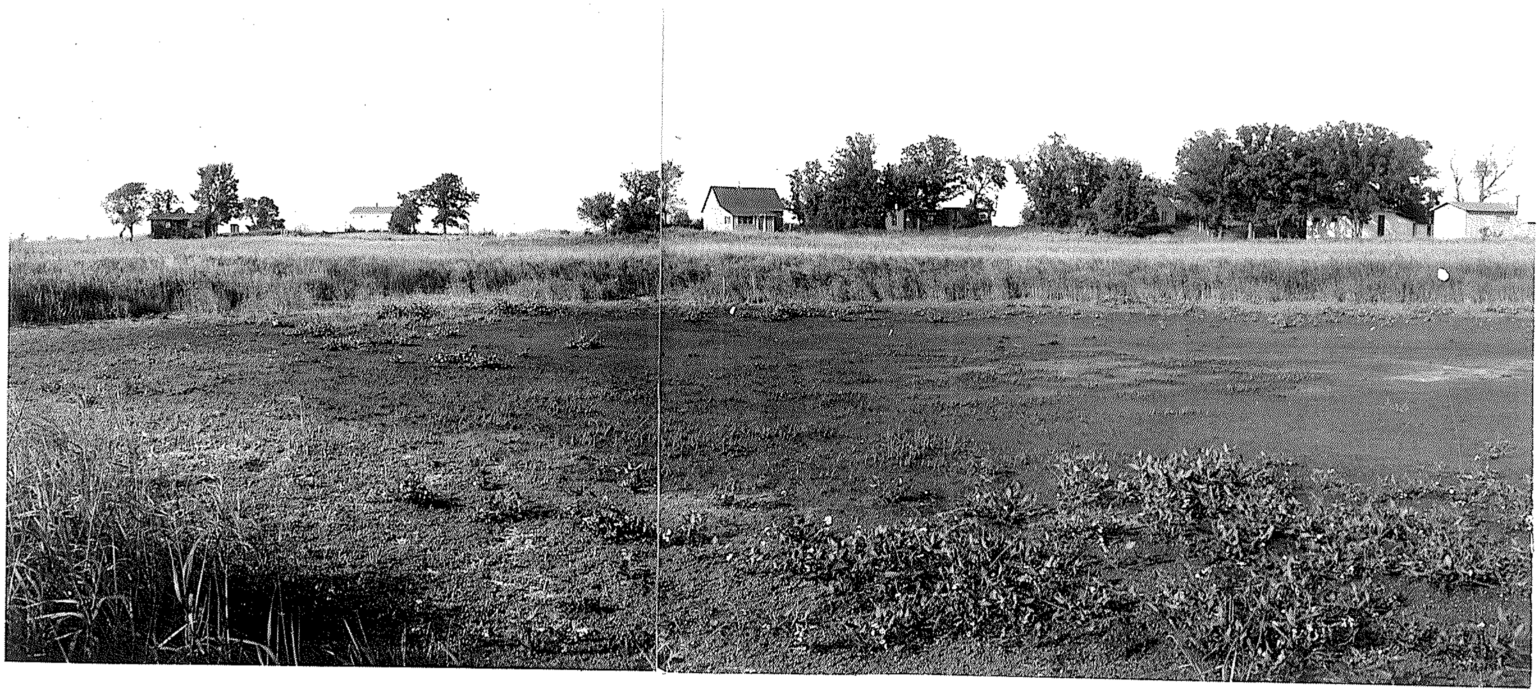


Figure 31. Portage Slough. Note the drying centre of the slough (where few remnants of the Phragmites stubble remain) with Sagittaria cuneata and Scolochloa festucacea forming an encircling zone.

Stachys palustris, Teucrium canadense, Artemesia biennis, Polygonum ramosissimum and other 'meadow' species were recorded, (Table XXIV).

Further drying in 1961 allowed vegetation to spread and almost fill the slough. By the end of August Sagittaria cuneata had become abundant in the wettest central parts, the surroundings being colonized by Chenopodium rubrum, while the neighbouring Rumex maritimus formed a zone 10 to 15 m wide. It was clearly demarkated from the mixed community in zone 2 which included Scolochloa festucacea interspersed with Atriplex patula, Hordeum jubatum, Rumex maritimus and Aster brachyactis. Atriplex grew in clusters in the upper parts of the zone which passed into zone 3, dominated by Scolochloa festucacea. The upper parts of the Scolcohloa zone, and the surrounding meadow had been cut for hay early in August.

Poplar Pools

Poplar Pools slough is an elongate channel-like depression 2.4 km long and 200 m wide in the 'wet meadows' 1.6 km east of the Delta Road (NE.Section 33, T13, R6). It becomes linked with the southern end of Simpson Bay in times of high water. A neck of land divides the slough into almost equal parts, when water levels fall. The changes recorded here were similar to those observed at Pintail Slough. The slough held water at the beginning of each year, considerable reductions occurring during the ensuing seasons.

In September 1959 there was water in the centre of the slough. The first zone of vegetation around the waterlogged bare soil was almost exclusively colonized by Chenopodium rubrum with occasional Scolochloa festucacea, Scirpus acutus and Typha latifolia were rare. Zone 2 was a mixed community with frequent Rumex maritimus, Scolochloa festucacea, Aster brachyactis and Chenopodium rubrum; Scolochloa increased in abundance to dominate zone 3, between the interrupted line of Phragmites communis and the S. acutus clumps. Atriplex understoried the Scolochloa and Hordeum was frequent.

More water evaporated in 1960. The exposed muck became covered with a well dispersed sparse growth of small Chenopodium rubrum plants. To obtain an indication of density, 50 quadrats 0.5 m x 0.5 m were sampled among the Chenopodium. They averaged 10 plants per half metre (range 0 to 29). A few scattered plants of Ranunculus sceleratus and Rumex maritimus occurred among them. Around the Chenopodium, zone 2 occupied a varying area and was dominated by Scolochloa festucacea (F.95% c 3.9) with 59 plants per 0.5 m x 0.5 m quadrat (range 28 to 77); 50% of them were flowering. The Scirpus validus and Phragmites marking the third zone had increased their areas. Sonchus arvensis flourished between the Phragmites clumps.

The following year, water had disappeared in the slough in all but the deepest places, and in these there was less than fifteen centimetres. The drying substratum had cracked into polygonal shapes twenty centimetres across. It bore scattered seedlings of Chenopodium rubrum, five other species were occasionally recorded with it; together they constituted the first zone of vegetation around the slough, in all places except the neck, where the dominant species was Scolochloa - sparsely flowering. Zone 2 was dominated by Rumex maritimus (F.100% c 4.1) associated with frequent Aster brachyactis (F.50% c 1.3); Chenopodium, Scirpus paludosus, Atriplex patula and Hordeum jubatum were occasionally recorded. The surrounding Phragmites, Atriplex and Scolochloa zone contained a variety of other species (Table XXV).

Tin Town Slough

Tin Town Slough, the most easterly of the sloughs, is approximately 3.8 km long and lies 0.5 km south of the shores of Lake II and Lyttle Bay (SE.Section 10; T14; R6). Water was present in the slough in early 1958 though most of it evaporated during the summer. A similar sequence of events occurred in 1959, and when the area was mapped and sampled in September, no standing water remained. The vegetation was clearly divided into three zones characterized by their dominants. Zone 1 contained Chenopodium rubrum (F.95% c 4.7) and occasional Hordeum jubatum (F.30%), Aster brachyactis (F.30%), and Rumex maritimus (F.20%); zone 2 was dominated by Scolochloa festucacea with rare plants of Spartina pectinata; and zone 3 with Spartina (F.100% c 4.5) understoried by Hordeum jubatum (F.95% c 4.0). An intermittent series of clumps of Phragmites communis marked the upper portion of the zone while towards the surrounding meadow Sonchus arvensis became increasingly abundant (Fig.32).

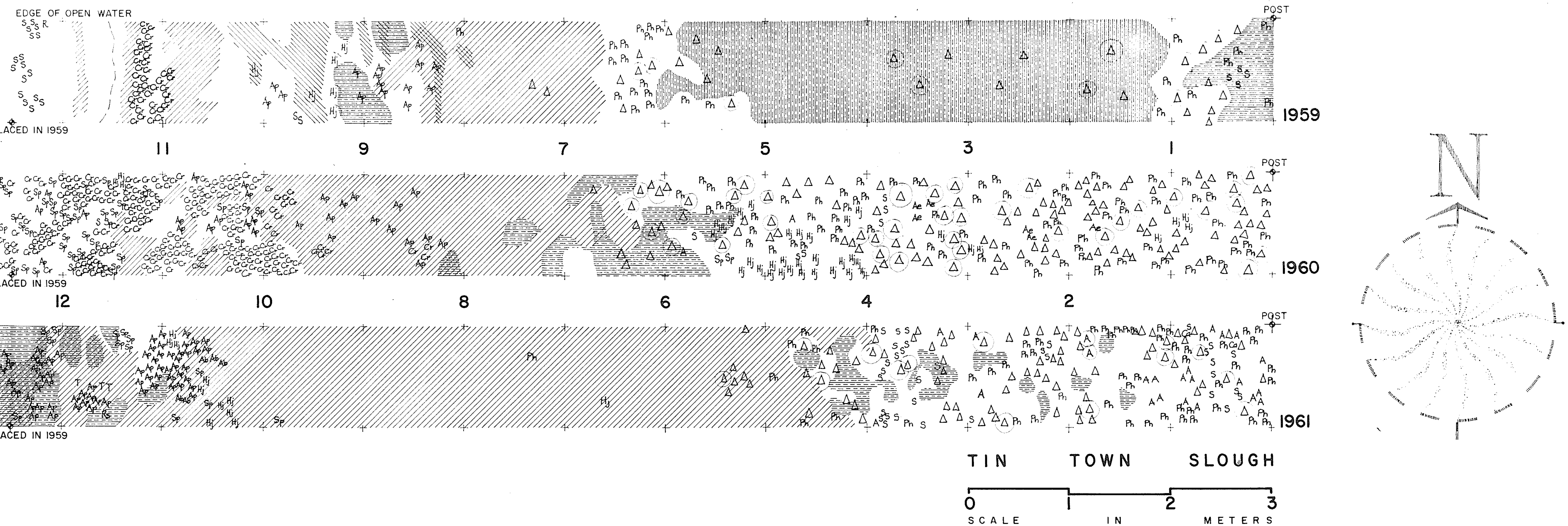
In June 1960 the slough held water approximately 30 cm deep, which covered last year's dead Scolochloa festucacea among which there were abundant shoots of Scolochloa and Scirpus americanus and scattered tufts of Hordeum jubatum. Along the edge of the water Scolochloa was becoming re-established, and new shoots were appearing in the Phragmites clumps. Sampling in September showed clearly marked zones, Chenopodium rubrum dominating the centre, with frequent Scirpus paludosus occurring in distinct patches. Zone 2 was again dominated by Scolochloa, Phragmites had spread into zone 2 and had a frequency of 60%, the size of its clumps in zone 3 had enlarged considerably excluding some of the other species (Fig. 33). Soil samples were taken from the centre and from the Scolochloa zone.

TABLE XXVI. TIN TOWN SLOUGH. Sampling Figures for 1959, 60 and 61 Showing Frequency, Cover and Sociability.

Species	6.9.59 Z1 F%	C	S	Z2 F%	C	S	Z3 F%	C	S	Z4 F%	C	S
Chenopodium rubrum	95	4.7	4.8									
Scirpus paludosus	20	1.2	1.2									
Hordeum jubatum	30	2.0	1.9				45	2.1	2.3	95	4.1	4.1
Aster brachyactis	30	2.0	1.0									
Rumex maritimus	20	3.5	2.0									
Scolochloa festucacea	5	1.0	1.0	100	5.0	3.0	10	1.0	1.0			
Spartina pectinata				10	1.0	1.0	100	4.5	5.0			
Phragmites communis							10	1.0	1.0	10	1.0	1.0
Sonchus arvensis										20	2.0	2.1
Artemesia biennis										10	1.0	1.0
Atriplex patula										60	2.0	1.0
Carex atherodes												
Scirpus validus												
Polygonum amphibium												
Beckmannia syzigachne												
Eleocharis palustris												
Scirpus americanus												
Scirpus acutus												

Species	14.9.60 Z1 F%	C	S	Z2 F%	C	S	Z3 F%	C	S	5.7.61 Z1 F%	C	S	Z2 F%	C	S	Z3 F%	C	S
Chenopodium rubrum	80	2.5	2.8	20	1.6	1.6				5	2.0	4.0						
Scirpus paludosus	75	2.5	2.3							70	2.7	2.6						
Hordeum jubatum	35	1.5	1.7	46	3.0	3.4				65	1.7	1.7	15	1.0	1.0	75	2.0	3.0
Aster brachyactis																		
Rumex maritimus										30	1.5	2.1						
Scolochloa festucacea	20	2.8	2.8	100	3.8	4.0				75	2.7	3.3	100	4.8	4.8	75	1.3	1.3
Spartina pectinata				7	1.0	2.0												
Phragmites communis							65	1.4	1.3	5	1.0	1.0	30	1.0	1.0	100	1.6	1.6
Sonchus arvensis							50	2.0	1.8	15	1.0	1.0	15	2.0	1.0	100	2.5	1.8
Artemesia biennis																		
Atriplex patula				33	1.2	1.4	50	1.1	1.2							100	1.1	1.3
Carex atherodes																25	1.0	1.0
Scirpus validus																		
Polygonum amphibium																		
Beckmannia syzigachne										15	1.3	1.3						
Eleocharis palustris				7	2.0	2.0												
Scirpus americanus	10	1.5	2.0															
Scirpus acutus	5	1.0	1.0							10	1.0	1.0						

Non-occurrence is indicated by a blank space.



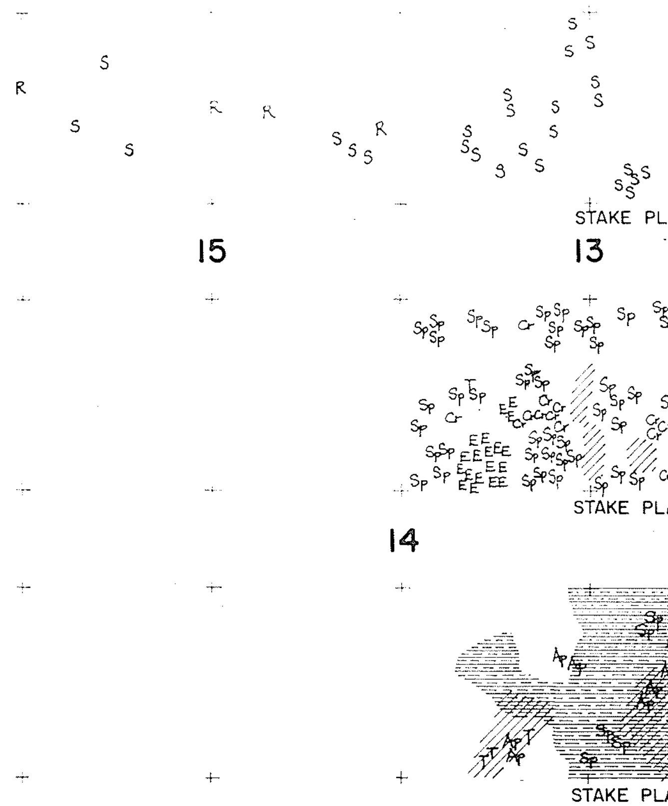
EDGE OF OPEN WATER
POST
1959
11
9
7
5
3
1
POST
1960
12
10
8
6
4
2
POST
1961
TIN TOWN SLOUGH
0
1
2
3
SCALE IN METERS
N

Figure 32. Tin Town Slough 1959.
Chenopodium rubrum and Rumex maritimus on Wettest Soil; Scolochloa festucacea and Spartina pectinata in Intermediate and Phragmites communis in Driest Areas.

Figure 33. Tin Town Slough 1960
Central Area with Scirpus paludosus and Scolochloa festucacea; Narrow Zone 2 of Scolochloa, and Phragmites Forming the Highest Zone

LEGEND

A	ASTER PRAEALTUS
(diagonal hatching)	ATRIPLEX PATULA
Ap	ATRIPLEX PATULA
Ca	CAREX ATHERODES
Cr	CHENOPODIUM RUBRUM
E	ELEOCHARIS PALUSTRIS
(horizontal dashed lines)	HORDEUM JUBATUM
Hj	HORDEUM JUBATUM
Ph	PHRAGMITES COMMUNIS variety BERLANDIERI
Rs	RANUNCULUS SCELERATUS
R	RUMEX MARITIMUS variety FUEGINUS
Sp	SCIRPUS PALUDOSUS
(diagonal hatching)	SCOLOCHLOA FESTUCACEA
S	SCOLOCHLOA FESTUCACEA
Δ	SONCHUS ARVENSIS variety GLABRESCENS
T	TYPHA LATIFOLIA



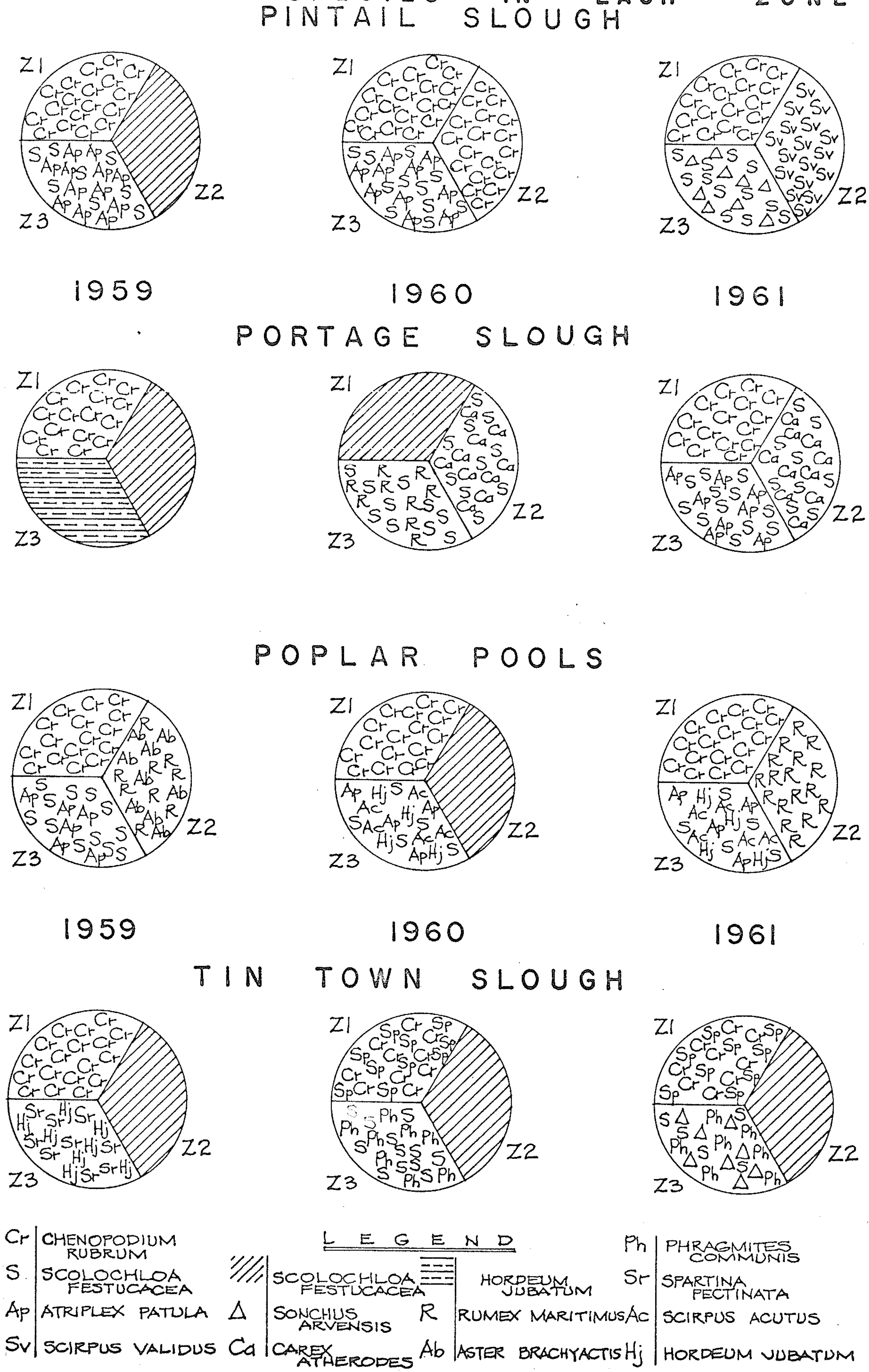
TIN TOWN SLOUGH

0 1 2 3
SCALE IN METERS

Figure 34

figure 35

DOMINANT SPECIES IN EACH ZONE



1961 saw a merging of zone 1 and 2 and a resultant mixed community in which Scolochloa (F.75% c 2.7) and Scirpus paludosus (F.70% c 2.5) had the highest frequencies and cover values, other species are listed in Table XXVI. Phragmites, Sonchus arvensis and Atriplex patula were co-dominant in the zone along the slough bank; the other species recorded were Hordeum jubatum, Scolochloa, and Carex atherodes. Transects from the bank to the centre of the slough were mapped in 1959, 60 and 61 (Fig.34). A comparison of the dominants in the four sloughs in 1959, 60 and 61 can be seen in Figure 35.

ANALYSIS OF DATA AND DISCUSSION

The Delta Marsh encompasses a variety of habitats (Löve and Löve, 1954; Walker, 1959) and the majority of these were examined in the course of this study. However, only the marsh was treated in anything but a reconnaissance manner (Cain and de Oliveira Castro, 1959). The species list is the only information presented here which relates to the peripheral habitats (Appendix I).

Of the 353 species recorded in the Delta Marsh area, 88 or 25% were found in what are considered typical marsh habitats. The remaining 75% were encountered in habitats closely associated with the marsh - relict meadows, forested ridge, lakeshore, wet meadows, and back marshes. The greatest number were members of the Compositae, 60 species (17%) in 27 genera; other well-represented families were the Gramineae with 39 species (11%), the Cyperaceae with 22 species (8%), and the Rosaceae with 19 species (5%). These families contained 41% of the total recorded; 140 as against 213 for the remaining 50 families, and 27 families were represented by a single species (Appendix I).

Workers in Wisconsin (Curtis, 1959) found 68 species in their marsh studies, which with the 12 additional species from Zimmerman's (1953) waterfowl habitat surveys, made a total of 80 for the state of Wisconsin. They report that the actual total for the marshes may have been less than 100. Individual stands had an average species density of 11, and large areas had only three or four species present.

At Delta, in the twenty sites where vegetation was sampled, 88 species were recorded. The number of species per stand ranged from 11 at Flee Island Pothole to 39 at Chimney Marsh, with a mean of 25 (Table XXVII). This mean is the species density (Curtis, 1959). A presence value for each species was obtained by using the 88 species and the 20 sites (Braun-Blanquet, 1951; Dansereau, 1943) (Table XXVIII). The presence value is the number of stands in which the species were found (x) expressed as a percentage of the total number of stands ($\frac{x}{20}$ x 100)(Raunkaier, 1934). The presence values were listed in decreasing order beginning with those of highest presence (Table XXIX). The most widely distributed species were then objectively delimited using the value for species density, i.e., the average number of species per stand. This was 25, but in this discussion 27 has been used because five species each had the same presence rating of 40 and therefore all were included (Table XXIX). According to Curtis (1959) these species would be considered prevalent species since they are the species most likely to be encountered in any stand in the marsh (cp. 'constants' of Braun-Blanquet (1951), and the 'floristic-characteristic species combination' of Raabe (1952)).

TABLE XXVII. FLEE ISLAND STUDY AREA
Number of Species Recorded in Each of the Sites Sampled.

Site	Number of Species in Samples
Avocet	21
Bells	18
Cherry Ridge	30
Chimney	39
Chimney Back Marsh	27
Cook Creek	16
Flee Island	25
Flee Island Pothole	11
Hutchinsons'	32
Jackfish	27
Pintail	24
Poplar Pools	23
Portage Country Club	13
Portage Creek	27
Portage Slough	37
Sowls	17
The Pass	36
Tin Town	32
Tin Town Slough	20
Torrey's Pothole	28
Total	503

$\frac{503}{20} =$ 25 (Mean number of species per stand or species density)

These species are also the ones present in the highest densities within the sites examined. Raunkaier (1934), Curtis and Green (1949) and Raabe (1952) suggest that some idea of homogeneity in communities is a useful concept. This can be obtained by comparing the sum of the presence of the prevalent species with the total sum of presence for all species, namely 1740 and 2515 which, expressed as a percentage, is 69.1%.

Other investigators have used a variety of indices, calculated in various ways, as the basis for a measure of homogeneity. Dahl (1956) used

TABLE XXVIII

Number of Stands in which Species Occurred; Average Frequency and Presence

SPECIES	Number of stands of occurrence	Average frequency	Presence	SPECIES	Number of stands of occurrence	Average frequency	Presence
Acer negundo	3	8	15	Epilobium glandulosum	8	10	40
Agropyrum repens	1	5	5	Erysimum cheiranthoides	1	2	5
Alisma triviale	3	9	15	Eupatorium maculatum	3	11	15
Ambrosia trifida	5	3	25	Galium trifidum	4	7	20
Artemesia biennis	9	5	45	Glaux maritima	4	11	20
Aster brachyactis	18	25	90	Heracleum lanatum	1	10	5
Aster ericoides	1	*	5	Hordeum jubatum	16	19	80
Aster praealtus	8	11	40	Humulus lupulus	2	2	10
Atriplex patula	20	33	100	Juncus effusus	3	3	15
Beckmannia syzigachne	3	5	15	Lemna minor	4	5	20
Bidems cernua	3	12	15	Lycopus americanus	7	9	35
Bidens frondosa	3	46	15	Lycopus asper	3	5	15
Calamagrostis canadensis	3	26	15	Melilotus officinalis	1	1	5
Carex atherodes	14	19	70	Mentha arvensis	7	15	35
Carex bebbii	2	7	10	Muhlenbergia asperifolia	1	1	5
Carex lacustris	1	8	5	Oenothera biennis	1	2	5
Carex pseudo-cyperus	2	6	10	Phragmites communis	20	12	100
Carex retrorsa	1	70	5	Polygonum amphibium	3	3	15
Carex sprengelii	1	4	5	Polygonum aviculare	1	3	5
Chenopodium glaucum	3	3	15	Polygonum coccineum	2	6	10
Chenopodium rubrum	19	28	95	Polygonum hydropiper	1	15	5
Cicuta maculata	5	8	25	Polygonum lapathifolium	1	1	5
Cirsium arvense	9	12	45	Polygonum persicaria	2	9	10
Echinocystis lobata	3	4	15	Polygonum ramosissimum	7	6	35
Eleocharis acicularis	2	7	10	Potentilla anserina	3	4	15
Eleocharis calva	2	4	10	Potentilla norwegica	1	2	5
Eleocharis palustris	8	14	40	Puccinellia nuttalliana	10	9	50

TABLE XXVIII CONTINUED

SPECIES	Number of stands of occurrence	Average frequency	Presence	SPECIES	Number of stands of occurrence	Average frequency	Presence
Ranunculus cymbalaria	10	10	50	Solidago canadensis	3	15	15
Ranunculus macounii	1	1	5	Taraxacum officinale	1	1	5
Ranunculus sceleratus	13	17	65	Teucrium occidentale	9	6	45
Rorippa islandica	3	3	15	Triglochin maritimum	2	3	10
Rumex maritimus	16	19	80	Typha latifolia	15	12	65
Ruppia maritima	3	*	15	Urtica dioica	9	10	45
Sagittaria cuneata	2	7	10	Verbena hastata	1	10	5
Salicornia rubra	8	9	40	Zannichellia palustris	3	1	15
Salix interior	2	16	10				
Salix amygdaloides	1	5	5				
Scirpus acutus	8	20	40				
Scirpus americanus	4	10	20				
Scirpus fluviatilis	1	20	5				
Scirpus paludosus	15	12	75				
Scirpus validus	13	12	65				
Scolochloa festucacea	20	40	100				
Scutellaria galericulata	4	9	20				
Scutellaria lateriflora	1	5	5				
Senecio congestus	9	12	45				
Sparganium eurycarpum	1	40	5				
Spartina pectinata	5	13	25				
Sium suave	7	9	35				
Sonchus arvensis	20	20	100				
Stachys palustris	12	10	60				
Suaeda maritima	9	10	45				
Symphoricarpos occidentalis	1	2	10				

Average frequency

$$= \frac{\text{the sum of the mean frequencies for each year}}{\text{number years of occurrence}}$$

Presence

$$= \frac{\text{number of stands of occurrence}}{\text{Total number stands (20)}} \times 100$$

* indicates the species was recorded but not the quadrats.

the index of diversity as a measure of the floristic richness of the community, which was the difference between the total number of species in all the stands and the average number of species per stand divided by the Naperian logarithm of the number of stands $\frac{88-25}{1.3010} = 48.4$. Dahl suggested that the ratio of the species density (25) to the index of diversity (48.4) might be a good measure of homogeneity, (25/48.4 = .516) with high values indicating homogeneity. In this study the index of diversity (48.4) appears to be closely correlated with the index of homogeneity (51.6), when expressed as a percentage. Similar results were obtained by Curtis (1959) and his co-workers in Wisconsin, when working in comparable habitats.

When both presence and frequency data are available, species can be ranked by an index based on the product of these two figures. This index is called the index of commonness. It has a maximum value of 10,000 where a species is found in all quadrats in all stands, and a minimum value approaching zero for a rare plant found in only one quadrat in only one stand. Anderson (1954) and Etter (1949) developed this approach which has been used in a variety of studies, e.g., Flaccus and Ohman (1964) and White (1965) (Table XXIX).

Each year frequency figures (F%) were obtained for every site, then the mean frequency value for each zone and the mean frequency for each site was calculated. To arrive at the mean frequency of a given species in a site, the sum of the frequencies in each zone was divided by the number of zones (even if the species was absent from a zone) to give one figure for each site. This could then be compared with the mean frequency/site obtained in subsequent years and at other sites (TABLE XXX). In addition the mean frequency throughout the marsh for

TABLE XXIX. Presence Figures in Decreasing Abundance, and Index of Commonness Ratings.

Species	Presence ($\frac{x}{20}$x100)	Index of Commonness (Presence x Frequency)
Phragmites communis	100	1200
Scolochloa festucacea	100	4000
Atriplex patula	100	3300
Sonchus arvensis	100	2000
Chenopodium rubrum	95	2660
Aster brachyactis	90	2240
Rumex maritimus	80	1520
Hordeum jubatum	80	1520
Typha latifolia	75	780
Scirpus paludosus	75	900
Carex atherodes	70	1330
Ranunculus sceleratus	70	1190
Scirpus validus	65	780
Stachys palustris	60	600
Ranunculus cymbalaria	50	500
Puccinellia nuttalliana	50	450
Suaeda maritima	45	450
Senecio congestus	45	540
Cirsium arvense	45	540
Artemesia biennis	45	225
Urtica dioica	45	450
Teucrium occidentale	45	270
Eleocharis palustris	40	560
Scirpus acutus	40	800
Salicornia rubra	40	360
Epilobium glandulosum	40	400
Aster prealtus	40	440
Polygonum ramosissimum	35	210
Sium suave	35	315
Mentha arvensis	35	525
Lemna minor	35	100
Lycopus asper	30	75
Ambrosia trifida	25	75
Cicuta maculata	25	200
Galium trifidum	20	140
Glaux maritima	20	220
Spartina pectinata	20	395
Scirpus americanus	20	200
Beckmannia syzigachne	15	75
Polygonum amphibium	15	45
Lycopus americanus	15	315
Juncus balticus	15	45
Bidens cernua	15	180
Acer negundo	15	120
Alisma trivale	15	135
Rorippa islandica	15	45
Ruppia maritima	15	

TABLE XXIX CONTINUED

Species	Presence ($\frac{x}{20}$ x100)	Index of Commonness (Presence x Frequency)
Scutellaria galericulata	15	180
Taraxacum officinale	15	5
Zannichellia palustris	15	15
Potentilla anserina	15	60
Bidens frondosa	15	690
Calamagrostis canadensis	15	390
Echinocystis lobata	15	60
Eupatorium maculatum	15	165
Solidago canadensis	15	225
Chenopodium glaucum	15	45
Carex bebbii	10	70
Carex pseudo-cyperus	10	60
Eleocharis acicularis	10	70
Eleocharis calva	10	40
Humulus lupulus	10	20
Polygonum coccineum	10	60
Polygonum persicaria	10	90
Sagittaria cuneata	10	70
Salix interior	10	210
Triglochin maritima	10	30
Agropyrum repens	5	25
Aster ericoides	5	-
Carex lacustris	5	40
Carex retrorsa	5	350
Erysimum cheiranthoides	5	10
Melilotus officinalis	5	5
Carex sprengelli	5	20
Polygonum aviculare	5	15
Polygonum hydropiper	5	75
Polygonum lapathifolium	5	5
Potentilla norvegica	5	10
Scirpus fluviatilis	5	100
Scutellaria lateriflora	5	25
Sparganium eurycarpum	5	200
Muhlenbergia asperifolia	5	5
Oenothera biennis	5	10
Ranunculus macounii	5	5
Heracleum lanatum	5	50
Salix amygdaloides	5	25
Verbena hastata	5	50
Symphoricarpos occidentalis	5	10
Total species	88	

Sum of the presence of the prevalent species = 1740
Sum of the presence of all species = 2515
Ratio expressed as a percentage = 69.1%

1

each site

ite but

Cherry Ridge 1961	Chimney 1959	Chimney 1960	Chimney 1961	Chimney Back Marsh 1959	Chimney Back Marsh 1960	Chimney Back Marsh 1961	Cook Creek 1959	Cook Creek 1960	Cook Creek 1961	Flee Island Study Area 1959	Flee Island Study Area 1960	Flee Island Study Area 1961	Flee Island Pothole 1959	Flee Island Pothole 1960	Flee Island Pothole 1961	Hutchinsons 1959	Hutchinsons 1960	Hutchinsons 1961	Jackfish 1959	Jackfish 1960	Jackfish 1961	Pintail 1959	Pintail 1960	Pintail 1961	Poplar Pools 1959	Poplar Pools 1960	Poplar Pools 1961	Portage Country Club 1959	Portage Country Club 1960	Portage Country Club 1961	Portage Creek 1959	Portage Creek 1960	Portage Creek 1961	Portage Slough 1959	Portage Slough 1960	Portage Slough 1961	Sowls 1959	Sowls 1960	Sowls 1961	The Pass 1959	The Pass 1960	The Pass 1961	Tin Town 1959	Tin Town 1960	Tin Town 1961	Tin Town Slough 1959	Tin Town Slough 1960	Tin Town Slough 1961	Torrey's Pothole 1959	Torrey's Pothole 1960	Torrey's Pothole 1961		Average Site Frequency
-	-	-	7	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	12	=	8
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	5
-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	2	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	9
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-		-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	*	-	-	-	-	-		-	-	=	3
-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	6	-	-	-	-	-	2	-	-	3		-	-	-	-	3	-	-	12	-	-	-	-	3	-	-	-	*	-	-	-	-	-		-	-	=	5
25	-	1	20	-	-	-	-	26	-	50	47	45	40	40	-	48	2	2	15	-	2	28	-	30	18		31	-	15	-	36	3	-	2	3	19	70	-	3	3	33	-	-	-	21	7	-	-		-	-	=	25
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-		-	-	=	*
-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	10	2	-	-	-	-		8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-	*	-	-	*		-	-	=	11
50	1	-	1	29	-	-	48	48	30	64	63	20	54	60	-	41	52	2	20	-	-	33	23	30	18		19	-	30	5	42	68	-	-	30	56	35	-	83	*	-	-	-	5	20	15	24	50		42	50	=	33
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	Not sampled in 1960	-	-	-	-	-	-	-	2	-	9	-	-	-	-	-	-	-	-	-	-	-	5	Not sampled in 1959	-	-	=	5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-		2	12	=	12
-	-	-	-	70	100	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		12	-	=	46
-	33	30	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	5	=	26
10	11	28	31	-	-	-	-	-	-	3	-	-	-	-	-	-	-	5	-	27	60	-	-	7	-		4	-	-	25	-	-	*	3	63	-	-	-	-	13	43	33	-	5	-	-	-	8		18	12	=	19
-	15	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-		-	-	=	7
-	-	-	-	-	5	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	8
-	-	-	-	-	5	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-		-	-	=	6
-	-	-	-	50	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	70
-	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	4
-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	3	-	-	3	-	-	-	-	-	-	-	-	-		-	-	=	3
5	2	6	5	-	-	-	7	20	-	26	7	50	39	-	-	45	52	2	7	-	15	38	100	47	55		42	-	3	-	16	-	-	30	13	33	60	-	-	-	33	16	-	30	10	24	50	-		75	50	=	28
-	15	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-		7	-	=	8
10	3	9	10	-	10	-	-	-	5	-	-	-	-	-	-	-	-	7	5	10	10	-	-	-	-		*	10	2	-	-	-	-	-	-	-	-	-	-	8	13	15	-	-	-	-	-	-		-	-	=	12
*	-	1	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	2	=	4
10	-	-	-	-	-	-	-	-	-	-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	7
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6	-	5	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	4
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-	12	-	5	-	20	-	-	-	-	-	-	-	-	-	-	1	-	-	20	-	2	-	13	-	-	Not sampled in 1960	-	-	-	-	-	-	-	-	-	-	-	-	-	23	-	-	-	-	-	-	-	-	Not sampled in 1959	2	-	=	10
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TABLE XXX

Average Frequencies for 1959, 60 & 61

$\frac{\text{Sum of F\%}}{\text{no zones}}$ = Average frequency in each year for each site

* - indicates species was present in the site but not in sampling units

\- indicates species absent

SPECIES / SITES	Avocet 1959	Avocet 1960	Avocet 1961	Bells 1959	Bells 1960	Bells 1961	Cherry Ridge 1959	Cherry Ridge 1960	Cherry Ridge 1961	Chimney 1959	Chimney 1960	Chimney 1961	Chimney Back Marsh 1959	Chimney Back Marsh 1960	Chimney Back Marsh 1961	Cook Creek 1959
Acer negundo	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-
Agropyrum repens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alisma triviale	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-
Ambrosia trifida	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-
Artemesia biennis	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Aster brachyactis	57	62	53	20	15	-	95	-	25	-	1	20	-	-	-	-
Aster ericoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster praealtus	-	-	-	-	-	-	-	26	-	*	-	-	-	-	-	-
Atriplex patula	38	10	12	43	30	-	-	10	50	1	-	1	29	-	-	48
Beckmannia syzigachne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens cernua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	-	-	-	-	-	-	-	70	100	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	33	30	24	-	-	-	-
Carex atherodes	3	-	-	-	-	-	-	5	10	11	28	31	-	-	-	-
Carex bebbii	-	-	-	-	-	-	-	-	-	15	4	-	-	-	-	-
Carex lacustris	-	-	-	-	-	-	-	-	-	-	-	-	-	5	10	-
Carex pseudo-cyperus	-	-	-	-	-	-	-	-	-	-	-	-	-	5	10	-
Carex retrorsa	-	-	-	-	-	-	-	-	-	-	-	-	50	90	-	-
Carex sprengelii	-	-	-	-	-	-	-	-	-	-	3	5	-	-	-	-
Chenopodium glaucum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodium rubrum	32	48	45	43	10	-	*	-	5	2	6	5	-	-	-	7
Cicuta maculata	-	-	-	*	-	-	-	-	-	15	9	-	-	-	-	-
Cirsium arvense	-	-	-	-	-	-	-	60	10	3	9	10	-	10	-	-
Echinocystis lobata	-	-	-	-	-	-	-	-	*	-	1	-	-	10	-	-
Eleocharis acicularis	-	-	-	-	-	-	-	10	10	-	-	-	-	-	-	-
Eleocharis calva	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis palustris	-	-	-	-	-	-	-	20	45	-	-	-	-	-	-	-
Epilobium glandulosum	-	-	-	3	-	-	-	-	-	12	-	5	-	20	-	-
Erysimum cheiranthoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium maculatum	-	-	-	-	-	-	-	-	-	38	23	12	-	-	-	-
Galium trifidum	-	-	-	-	-	-	-	-	-	15	-	5	-	5	-	-
Glaux maritima	-	-	-	-	-	-	-	-	35	-	-	-	-	-	-	-
Heracleum lanatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hordeum jubatum	-	3	5	3	-	-	-	-	5	-	-	-	-	-	-	-
Humulus lupulus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

Chimney 1959	Chimney 1960	Chimney 1961	Chimney Back Marsh 1959	Chimney Back Marsh 1960	Chimney Back Marsh 1961	Cook Creek 1959	Cook Creek 1960	Cook Creek 1961	Flee Island Study Area 1959	Flee Island Study Area 1960	Flee Island Study Area 1961	Flee Island Pothole 1959	Flee Island Pothole 1960	Flee Island Pothole 1961	Hutchinsons 1959	Hutchinsons 1960	Hutchinsons 1961	Jackfish 1959	Jackfish 1960	Jackfish 1961	Pintail 1959	Pintail 1960	Pintail 1961	Poplar Pools 1959	Poplar Pools 1960	Poplar Pools 1961	Portage Country Club 1959	Portage Country Club 1960	Portage Country Club 1961	Portage Creek 1959	Portage Creek 1960	Portage Creek 1961	Portage Slough 1959	Portage Slough 1960	Portage Slough 1961	Sowls 1959	Sowls 1960	Sowls 1961	The Pass 1959	The Pass 1960	The Pass 1961	Tin Town 1959	Tin Town 1960	Tin Town 1961	Tin Town Slough 1959	Tin Town Slough 1960	Tin Town Slough 1961	Torreys Pothole 1959	Torrey's Pothole 1960	Torrey's Pothole 1961	Average Site Frequency
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51	31	-	-	-	-	100	94	100	65	63	-	94	100	-	15	27	52	40	67	50	58	20	45	48		21	-	90	90	34	36	-	47	67	42	15	50	58	45	53	50	30	85	85	29	60	87	-	5	-	40
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SPECIES \ SITES	Avocet 1959	Avocet 1960	Avocet 1961	Bells 1959	Bells 1960	Bells 1961	Cherry Ridge 1959	Cherry Ridge 1960	Cherry Ridge 1961	Chimney 1959	Chimney 1960	Chimney 1961	Chimney Back Marsh 1959	Chimney Back Marsh 1960	Chimney Back Marsh 1961	Cook Creek 1959	Cook Creek 1960	Cook Creek 1961	Flee Island Study Area 1959	Flee Island Study Area 1960	Flee Island Study Area 1961	Flee Island Pothole 1959	Flee Island Pothole 1960	Flee Island Pothole 1961	Hutchinsons 1959	Hutchinsons 1960	Hutchinsons 1961
Juncus balticus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Lemna minor	-	-	-	-	-	-	-	-	-	6	6	5	-	-	-	*	-	-	-	2	-	-	-	-	-	-	-
Lycopus americanus	-	3	2	-	-	-	-	-	15	1	-	2	-	50	-	-	-	-	-	-	-	-	-	-	-	-	2
Lycopus asper	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melilotus officinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mentha arvensis	-	-	-	-	-	-	-	25	-	36	11	12	30	10	-	-	-	-	-	-	-	-	-	-	-	3	-
Muhlenbergia asperifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Oenothera biennis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phragmites communis	17	-	2	-	-	10	-	20	25	3	-	10	-	5	-	-	2	-	4	-	10	-	-	*	4	2	-
Polygonum amphibium	-	-	-	-	-	-	-	-	-	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum aviculare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum coccineum	-	-	-	-	-	-	-	-	-	2	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum hydropiper	-	-	-	-	-	-	-	-	-	-	-	-	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum lapathifolium	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum persicaria	-	-	-	-	-	-	-	-	-	-	-	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum ramosissimum	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	20	-	-	-	-	-	-
Potentilla anserina	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potentilla norwegica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Puccinellia nuttalliana	2	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	19	10	6	12	-	8	-	-
Ranunculus cymbalaria	-	-	3	-	-	-	-	20	10	-	-	-	4	-	-	8	-	-	5	21	15	-	-	-	13	-	-
Ranunculus macounii	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus sceleratus	60	10	47	3	-	-	-	-	40	14	6	-	-	-	-	50	-	-	5	-	-	-	-	-	-	-	-
Rorippa islandica	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumex maritimus	35	28	57	33	-	-	-	5	20	2	-	5	-	-	-	-	10	10	3	-	5	-	-	-	-	80	12
Ruppia maritima	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagittaria cuneata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix amygdaloides	-	-	-	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix interior	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salicornia rubra	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	25	-	8	12	-	-	-	-
Scirpus acutus	2	-	-	-	-	-	-	65	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Scirpus americanus	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Scirpus fluviatilis	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scirpus paludosus	-	-	2	2	2	2	-	20	-	2	-	-	-	-	-	5	-	-	6	8	-	-	-	-	9	21	-
Scirpus validus	-	5	7	-	-	-	-	-	-	2	3	3	-	-	-	-	*	*	-	-	-	-	-	-	25	57	7
Scolochloa festucacea	61	53	60	70	100	100	-	-	5	51	31	-	-	-	-	100	94	100	65	63	-	94	100	-	15	27	52
Scutellaria galericulata	-	-	-	-	-	-	-	-	-	8	-	5	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Senecio congestus	7	18	30	2	-	-	-	10	10	2	-	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sparganium eurycarpum	-	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spartina pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sium suave	-	-	-	-	-	-	-	-	-	-	-	*	10	-	-	-	-	-	-	-	-	-	-	-	5	25	-
Solidago canadensis	-	-	-	-	-	-	-	-	-	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Cherry Ridge 1961	Chimney 1959	Chimney 1960	Chimney 1961	Chimney Back Marsh 1961	Cook Creek 1959	Cook Creek 1960	Cook Creek 1961	Flee Island Study Area 1959	Flee Island Study Area 1960	Flee Island Study Area 1961	Flee Island Pothole 1959	Flee Island Pothole 1960	Flee Island Pothole 1961	Hutchinsons 1959	Hutchinsons 1960	Hutchinsons 1961	Jackfish 1959	Jackfish 1960	Jackfish 1961	Pintail 1959	Pintail 1960	Pintail 1961	Poplar Pools 1959	Poplar Pools 1960	Poplar Pools 1961	Portage Country Club 1959	Portage Country Club 1960	Portage Country Club 1961	Portage Creek 1959	Portage Creek 1960	Portage Creek 1961	Portage Slough 1959	Portage Slough 1960	Portage Slough 1961	Sowls 1959	Sowls 1960	Sowls 1961	The Pass 1959	The Pass 1960	The Pass 1961	Tin Town 1959	Tin Town 1960	Tin Town 1961	Tin Town Slough 1959	Tin Town Slough 1960	Tin Town Slough 1961	Torrey's Pothole 1959	Torrey's Pothole 1960	Torrey's Pothole 1961		Average Site Frequency
85	29	11	10	-	-	-	5	5	1	-	12	15	-	7	17	50	5	20	45	12	7	45	-	Not sampled in 1960	11	-	45	80	-	5	-	8	30	3	-	-	13	10	-	7	-	-	8	5	-	57	Not sampled in 1959	-	-	=	20
	5	2	12	-	-	8	5	-	3	-	-	-	-	-	-	10	5	66	7	-	-	-	-		-	-	5	15	-	-	-	-	2	-	-	-	-	8	-	-	-	-	3	-	-	-		-	2	=	10
-	-	-	-	-	-	-	-	9	17	10	16	8	-	-	-	-	-	-	-	2	-	-	2		-	-	-	-	5	28	-	-	8	-	5	-	8	-	-	-	-	-	3	-	-	-		-	-	=	10
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-		-	-	=	2
-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-		-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	1
15	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	10	-	-	-	-		-	-	20	-	-	-	-	-	2	-	-	-	2	-	-	*	-	-	-	-	-	-		-	-	=	6
-	-	-	-	-	-	-	-	-	1	2	5	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-		-	-	=	3
-	24	26	35	-	-	-	-	-	1	5	-	-	-	-	5	-	12	9	30	-	13	5	3		-	-	-	-	1	-	-	2	2	3	-	-	-	3	10	16	2	-	*	-	-	*		50	45	=	12
5	11	18	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	18	-	-	-	-		-	-	-	10	-	-	-	-	5	-	-	-	-	3	3	-	-	-	-	-	-	-		2	-	=	10
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	10
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	-	-	-	-	-	-	-	-		-	-	-	-	1	-	-	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	=	1

SPECIES / SITES	Avocet 1959	Avocet 1960	Avocet 1961	Bells 1959	Bells 1960	Bells 1961	Cherry Ridge 1959	Cherry Ridge 1960	Cherry Ridge 1961	Chimney 1959	Chimney 1960	Chimney 1961	Chimney Back Marsh 1959	Chimney Back Marsh 1960	Chimney Back Marsh 1961	Cook Creek 1959	Cook Creek 1960	Cook Creek 1961	Flee Island Study Area 1959	Flee Island Study Area 1960	Flee Island Study Area 1961	Flee Island Pothole 1959	Flee Island Pothole 1960	Flee Island Pothole 1961	Hutchinsons 1959	Hutchinsons 1960	Hutchinsons 1961
Sonchus arvensis	2	-	10	6				75	85	29	11	10		10	-	-	-	5	5	1	-	12	15	-	7	17	50
Stachys palustris	-	-	-	6	-	-	-	20		5	2	12	-	-	-	-	8	5	-	3	-	-	-	-	-	-	10
Suaeda maritima	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	17	10	16	8	-	-	-	-
Symphoricarpos occidentalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taraxacum officinale	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Teucrium occidentale	-	-	-	1	-	-	-	-	15	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triglochin maritimum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	5	-	-	-	-	-
Typha latifolia	-	5	5	5	-	-	-	-	-	24	26	35	5	5	-	-	-	-	-	1	5	-	-	-	-	5	-
Urtica dioica	-	-	-	-	-	-	-	5	5	11	18	12	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zannichellia palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	-

species with a prevalence between 100% and 70% was calculated. In some sites a certain species was not listed in the sampling data, but did occur in the species list; this accounts for minor discrepancies between presence and frequency figures.

To provide additional information, data was gathered for profiles, and transects were drawn across the zones illustrating a narrow strip of vegetation, to show the distribution of species and changes during the study in the following sites: Bells, Chimney Marsh, Cook Creek, Hutchinsons, Jackfish Pond, Pintail Slough, Portage Country Club, Portage Slough, Poplar Pools, Sowls, Tin Town Slough, and Torrey's Pothole. Three examples are included in this presentation: a marsh shore (Chimney), a pothole (Hutchinson's), and a slough (Tin Town). The others are available in the University of Manitoba Library.

Permanent quadrats were staked out at several sites - Avocet, Bells, Chimney, Cook Creek, Portage Creek, Sowls and Torrey's Pothole, and the species present in them mapped each year. The resulting diagrams for one set of quadrats at Sowls are presented in Figures 19, 20 and 21, the others are available in the University of Manitoba Library, where the profile data can also be found.

A brief discussion of some aspects of the ecology of the prevalent species with a rating between 100% and 65% is presented next.

ECOLOGICAL DESCRIPTION OF SPECIES WITH THE HIGHEST PREVALENCE

PHRAGMITES COMMUNIS VAR. BERLANDIERI

Prior to 1955 *Phragmites* was the most conspicuous emergent species

Figure 36. Denuded Area After the High Water Period, Surviving *Phragmites communis* on Left-Hand Side.

in the marsh and covered thousands of hectares. The marsh was flooded from 1955 to 1958 and almost all vegetation was obliterated. The water then retreated showing that in huge areas where *Phragmites* had been prolific before, the majority of plants had died during the inundation (Fig.10). Local tradition says that if *Phragmites* is flooded during the growing season for three years or more it will die. This was substantiated during the 1955-1958 period, and more recent observations, involving the raising water levels in small ponds, have shown that *Phragmites* is killed by three years of high water, (Personal communication Hochbaum and Ward, 1965). In 1958 when Walker's (1959) preliminary study began, many sites had a sparse, peripheral, fringing zone of surviving *Phragmites* plants on ground that was slightly higher than its surroundings and therefore had been inundated for a shorter period. The remaining vast areas were denuded of vegetation except for occasional isolated *Phragmites* shoots among the stubble covered expanses. These shoots resumed growth (Fig.36) when the water receded and may have been the progeny from unusually vigorous parents which in time could populate the marsh with a particularly well adapted strain of *Phragmites*, somewhat more resistant to flooding than most ecotypes. This emphasizes the fact that this species is a complex of many ecological races each made up of somewhat variable local populations (Clausen, *et al*., 1940, 1945, 1948; Billings, 1957).

There was no evidence in this study that *Phragmites* established itself by seed on denuded areas. Mature pollen and stigmas were found but studies on viability, seed formation and germination were not undertaken.

Löve and Löve (1954) stated that at Delta, "the reproductive capacity of *Phragmites* is great, although almost exclusively vegetative, since the species flowers so late as to make the development of seed almost impossible in normal summers". Luther (1950a) considered that although it had been held since 1880 that Phragmites would not reproduce by seed, the literature reveals no clear basis for this opinion. Working in Finland, he reported a germination success of 44% but indicated that the seedlings had a high light requirement. In another article (Luther 1950b) he found seedlings relatively often in suitable habitats with adequate light; abundant seed formation, and a high germination rate. Hürlimann (1951) in Switzerland, reported that seeds were freely formed and germinated readily, but germination was generally ineffective because the seedlings had no great competitive power and could not germinate in water. Bakker (1957) found Phragmites germinated well in the East Flevoland polders; Harris and Marshall (1960a, 1963) documented the establishment of Phragmites in experimental conditions and by seedlings on mudflats in Minnesota, while Krasovskii (1962) reported seeds of Phragmites germinating in panicles floating on water in the Barabe steppes of Western Siberia.

Observations on a number of aspects of Phragmites at Delta were reported by Löve and Löve (1934) and Walker (1959). During this study Phragmites was one of the five species with a presence value of 100%. The average frequency was 22%, but it should be mentioned that during this investigation sampling was centred around denuded areas, not among the surviving Phragmites, where the frequency was considerably higher. In many sites the vegetation at Delta was zoned, the greatest number of zones in a given sequence was four, and Phragmites was recorded in all four zones but not necessarily in all at any one site. It was found in 26% of the samples from zones 1, 2 and 3 and 50% of those from zone 4. Zone 3 of Tin Town slough was the only site sampled with a frequency of

100% for *Phragmites*, in others the frequency varied between 4% and 60% (Table XXXI). It had an index of commonness of 1200.

At the beginning of this study, *Phragmites* spread in the wake of the retreating water, consolidating its peripheral position by forming dense stands along ridges and driftlines where it was already established on accumulated organic debris. In isolated clumps it resumed growth after a prolonged dormant period. It grew in places flooded by spring melt-water; at the edge of shores, sloughs and potholes as well as in open water (cp. Holdgate, 1955). It expanded markedly in shallow water, and also in places where channels performed some drainage function, for instance at Cram Creek and Clandeboye Channel. Tall stands on the lake-shore acted as stabilisers on sandbars and performed a similar function at Cherry Ridge, Mink Creek and elsewhere, indicating the deposition of sand, comparable with the report of Taylor *et al*., (1944). It also formed dense jungles on silt deposits resulting from flooding as at Flee Island (cp. Grinnell, 1914). The changes in water level which characterize the Delta Marsh favour the growth of *Phragmites*. It does not spread in water more than 50 cm deep, but can survive both short periods of inundation and a lowering of the water table. Löve and Löve (1954) mentioned that at Delta *Phragmites* does not grow far out into the lakes and bays, seeming to avoid water more than half a metre deep during summer. Hürlimann (1951) stated that it invaded water producing almost pure communities. The development of the edge of the community gave an indication of its dynamism. Weaver and Himmel (1930) remarked that *Phragmites* grew equally well in waterlogged and drained soils and became poorer as the soil became drier. They described the root systems developed

TABLE XXXI PHRAGMITES COMMUNIS. Frequency %, Cover and Sociability in all Sites.

blank = no sampling
\- = non presence

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		-			-											5	1	1			
	12.9.60		-			-																
	2.7.61	5	1	1		-																
Bells	13.8.59		-																			
	16.8.59	50	1.5	2.2		-																
	9.9.60														-						-	
	3.7.61																10	1	1			
Cherry Ridge	10.9.60																20	1.3	1.4			
	10.8.61																25	1.4	1.4			
Chimney	29.6.59		-		16	1.3	1.6															
	6.59		-			-			-													
	4.8.60		-			-			-			-										
	3.7.61	8	1	1		-		15	1	1												
Chimney Back Marsh	16.8.59														-							
	9.9.60													5	1	1						
Cook Creek	13.6.59														-							
	7.9.59														-							
	14.6.60														-							
	3.9.60																4	1	1			
	3.7.61																					
Flee Island Study Area	19.6.59		-		5	1	1										10	1	1		-	
	11.6.60		-			-																
	3.8.61																			2	1	1
Flee Island Pothole	19.6.59		-																			
	6.9.59		-			-																
Hutchinsons	10.6.59		-		25	1.5	2															
	5.9.59		-			-			-			-										
	10.9.60	4	1	1		-																
	7.8.61		-			-																

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		–		25	1.5	1.3															
	9.9.60		–		40	1.8	1.8															
	10.8.61	5	1	1																		
Pintail	5.9.59		–			–		5	1	1												
	26.8.60		–			–		15	1	1												
	4.7.61		–			–		20	1.5	1.5												
Poplar Pools	6.9.59		–			–			–													
	4.8.61		–			–			–		50	2.9	3									
Portage Country Club	3.9.61	5	1	1	30	1.1	1.1															
	1.8.61	60	1	1		–																
Portage Creek	21.6.59	16	1.7	3		–			–													
	6.9.59		–			–		5	1	1												
	29.8.60		–			–			–													
	6.8.61		hayed			hayed			hayed													
Portage Slough	6.9.59		–		5	1	1		–													
	29.8.60		–			–			–													
	6.8.61		–			–			–													
The Pass	25.7.59		–			–			–													
	9.9.60		–			–			–													
	9.9.61		–			–		10	1	1												
Sowls	5.9.59														–							
	7.3.61														–							
Tin Town	6.9.59	15	1	3	15	1	1															
	8.9.60		–		5	2	2															
	3.8.61	10	1	1		–		100	2.6	2.5					–							
Tin Town Slough	6.9.59		–			–		10	1	1	10	1	1									
	14.9.60		–			–																
	5.7.61	5	1	1	30	1	1	100	1.6	1.6												
Torrey's Pothole	2.9.60		–			–																
	9.8.61	10	1	1	5	1	1															
Total zones			45			44			20			4										
" " with *Phragmites*			12			12			9			2										
% Occurrence			27%			27%			30%			50%										
Mean F%			16%			18.8 %			31 %			30 %										
Mean cover			1.1			1.3			1.2			1.6										

in various conditions. Hürlimann (1951) pointed out that the seedlings need a very moist substrate to germinate, and that after germination the plants pass through a building-up stage for several years before attaining mature height. Their great competitive power is due to the height of the culms and the absence of leaves in the lower part of the culm, the latter feature permitting a penetration into deeper water than other marsh species. Phragmites leaves cannot stand submergence, the plants transpire freely and are dependent on free water. In dry-land localities it can only grow where the roots reach ground water. The rhizomes and culms are penetrated by aeration canals and the plants are insensitive to a lack of oxygen in the substratum (cp. Weaver and Himmel, 1930). Growth commences rather late, which puts it at a disadvantage in closed communities. While investigating the water economy of Phragmites Kiendl (1953) found that in two stands the denser one had a lower transpiration per unit weight but a greater total loss of water. Both stands had a high transpiration rate and when densely grown, transpired in a year more than the local rainfall.

Willer and Lieselotte (1944) studied luminosity, wind conditions and humidity beneath Phragmites beds. Luminosity depended on the height of stems, the distance between plants and the numbers of leaves; the last being the most important. At the most 50% radiation was intercepted by the plants, though only 13-30% of incident light reached the water beneath the leafy region of the root bed, wind velocity was diminished and air humidity very slightly increased. Willer (1944) reported that in mature plants 12% of total length of stem was beneath the water, 56% of length was free of leaves, 25% bore leaves, and 7% formed inflorescences.

During this study the pH ranged from 6.4 to 8.1 and the conductivity from 0.34 mmhos/cm to 22.4 mmhos/cm. However, Conway (1940) felt that in soils, a pH between 5.0 and 6.0 was high for *Phragmites*. McVean and Ratcliff (1962), working in Scotland, stated that *Phragmites* may be locally dominant or codominant around the margins of lakes wherever conditions favoured the accumulation of organic debris. Kovacs (1962) described a number of communities in which *Phragmites* was a characteristic species e.g., in Molino-Juncetea and Martin (1959) mentioned its massive clones, 2.4 m tall, on marsh shores with infrequent tidal flooding and on sandy ridges.

At Delta three types of population were encountered. One contained tall, mature plants (between 3.0 and 4.0 m in height) in closed communities which had reached a stable condition and were not expanding. Their stands were dense, with moderately good leaf and flower production, but vegetative growth was restricted. The soil was packed with numerous rhizomes, and it appeared that the only chance for new rhizome growth was by the decay of existing structures to provide space, or by growth on the surface. In these close stands of tall plants substory vegetation was eliminated, and the ground was covered with an accumulation of old culms which took a number of years to decay (little change was reported in some sites in 5 years). Plants at the edge of such populations were larger and more vigorous than those in the centre.

The second type of population grew in open sites and was young, producing small well spaced leafy plants (1-1.4 m tall) with sparse flowers but these populations were in an active state of vegetative reproduction and rapidly colonized bare areas. They occurred in both sandy and organic soils. The presence of a moist soil surface apparently stimulated stolon production which appeared to be governed by environmental conditions (Fig.37). Each stolon gave rise to many new plants - one at each node. New growth also arose from rhizomes. Klimentov (1963) reported the formation of stolons most often in areas where the soil surface was moist for long periods of time. He believed stolon formation to be the result of external factors rather than a varietal characteristic as it is classified by several authors. Klimentov (1960) stated that if creeping shoots of Phragmites reach moist places with silty soil, underground shoots with roots and stems form at the nodes. This was reported to cause the formation of floats in the lower courses of the Dneiper and Dnester rivers.

Walker (1959) and Klimentov (1960) and others have reported that creeping stolons or runners are the most effective means of Phragmites propagation, individual runners at Delta often exceeded 10 m in length. Runners are most commonly produced in moist sites but may be formed by plants at the edge of water, and grow out over the water to become anchored when they again contact the ground. Lambert (1946) recorded this species encroaching upon other vegetation by vegetative means. Erect and decumbent shoots of Phragmites growing on moist saline and rich clay soils in the Odessa Oblast were studied by Nikolaevskii (1962) who reported morphological and anatomical differences in them.

The third type of population found at Delta was intermediate, consisting of well established groups of plants in open sites. Many of the stands were diffuse and had a high ratio of edge. The edge plants had the most active rhizome growth. Their flower and leaf production was very good. These plants grew in water or on drier sites and when conditions changed from wet to dry, runner production was stimulated.

In the drier parts of the Delta Marsh, in open communities, other species were associated with Phragmites. These included Scolochloa festucacea, Sonchus arvensis, Atriplex patula, Cirsium arvense, Mentha arvensis, Hordeum jubatum, Spartina pectinata, Chenopodium rubrum, Stachys palustris, Scutellaria galericulata and Urtica dioica (Walker, 1959). Bakker (1960) mentioned that Phragmites had a high competitive power in the reclaimed polders of the Zuider Zee, and was sown to prevent the growth of Cirsium arvense.

SCOLOCHLOA FESTUCACEA

Scolochloa had a presence value of 100%, a frequency of 40% and an index of commonness of 4000 - the highest of any plant recorded in the Delta Marsh, and it also had the highest cover value (3.0). Löve and Löve (1954) described the drier parts of the marsh as Scolochloetum, mentioning that Scolochloa preferred soils inundated only in early spring. It rarely flowered unless the ground was very wet during its first period of elongation. Walker (1959) commented upon its role in colonization, its place in the emergent plant community and the species with which it was commonly associated.

Early in the study this species was important in the pioneer communities and had a high frequency; later dominating zones 2 and 3, or a merging of these two zones, and being replaced by Chenopodium rubrum in zone 1. In every site, with the exception of Chimney Marsh, Scolochloa maintained its abundance or increased to become the dominant species in the formerly denuded areas. Seventy-five percent of the samples taken in zone 1 contained some Scolochloa, 36% of these had a frequency greater than 90%. The average cover value in this zone was 2.6 (ca.20%). In zone 2, 51% of the samples contained Scolochloa with an average cover value of 3.2 (ca. 30%), and in the third zone 87% of the samples contained Scolochloa with a cover value of 3.5 (ca. 40%)(Table XXXII).

This species grew as a pioneer along irregular shorelines which were drying or covered with up to 10 cm water, and spread into these denuded areas by seed and by vegetative means. Growth was rapid and when seen from a distance Scolochloa soon had the appearance of a dense stand (Fig. 38), but this was often deceptive, for when viewed from directly above, the cover was generally considerably less than 50%. In favourable habitats mature plants were from 1 - 1.6 m tall. Dead, flattened culms and leaves from previous years' growth sometimes formed a mat and prevented plant growth; however when an opening occurred in this covering, growth resumed. Where humus had either not accumulated, or had partially disintegrated, Scolochloa was understoried by other species, the commonest being Atriplex patula as at Cook Creek, either alone or with associates (Table XXX). To obtain an indication of density of mature plants, 60 quadrats 0.5 m x 0.5 m were sampled from zones dominated by Scolochloa. The resulting mean value per quadrat at Poplar Pools was 59 (range 30-80) as compared with a value of 138 (range 119-171) at Portage Country Club.

In sites where the water level dropped steadily Scolochloa became dominant in the intermediate habitats. Enclosed sites however accumulated water in the spring of each year and this influenced the speed with which Scolochloa took over.

TABLE XXXII SCOLOCHLOA FESTUCACEA. Frequency %, Cover and Sociability in all Sites.

Blank = no sampling
- = non presence

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59	35	2	1.5	100	2.6	3.7										50	1.6	2.5			
	12.9.60	10	2	2	96	3.5	3.5															
	2.7.61		-		100	3.9	3.5															
Bells	13.8.59	85	2.3	3.3																		
	16.8.59	20	1.2	1.2	100	4.8	4.9															
	9.9.60																100	4	4		-	
	3.7.61																100	4.3	4.4			
Cherry	10.9.60																					
Ridge	10.8.61																5	2	2			
Chimney	29.6.59	80	2.9	3	74	2.1	2.2															
	8.59	100	3.5	4.2	30	2	2.3	20	2	2.5												
	4.8.60		-		100	2.9	3.1	15	2.3	2.6	10	2	1.5									
	3.7.61		-		100	3.5	3.5	20	1.8	2.5												
Chimney	16.8.59																					
Back Marsh	9.9.60																					
Cook	13.6.59																100	2	3			
Creek	7.9.59																100	3.9	3.7			
	14.6.60																100	3.8	2.5			
	3.9.60																88	3.8	3.5			
	3.7.61																100	3.7	3.5			
Flee	19.6.59	85	1.5	3.5	10	1	1.5										65	1.6	2.6	100	1	1.8
Island	11.6.60	80	2.3	1.3	80	3.1	2.3	30	2.6	2.5												
Study Area	3.8.61														-							
Flee	19.6.59	90	1.4	2.7											-						-	
Island	6.9.59	85	1.4	1.4	100	4.9	5										100	2.6	2.8			
Pothole																						
Hutchin-	10.6.59		-		13	2	3															
sons	5.9.59		-		20	1	1	30	1.6	1.6	30	1.3	2									
	10.9.60	84	2.4	2.2	20	1.5	1.8															
	7.8.61	80	4.7	4.7	25	1.4	1.4															

TABLE XXXII Continued

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59	80	2.9	2.4		-																
	9.9.60	100	4.1	1.4	93	2.5	2.8															
	10.8.61	85	2.2	2.2	15	2.7	1.3															
Pintail	5.9.59	25	1.2	1.4	85	2.9	3	65	2.7	2.7												
	26.8.60		-			-		60	2	2.6												
	4.7.61	10	1.5	1	30	1.3	1.3	95	2.4	2.5												
Poplar	6.9.59	15	1	1	30	2.6	2.9		-													
Pools	4.8.61		-			-		65	3	2.9	20	2.5	2.5									
Portage	3.9.60	100	4.6	4.7	80	2.8	2.9															
Country	1.8.61	100	2.3	2.6																		
Club																						
Portage	21.6.59	72	1.4	2.3	12	2	2	92	2.7	2.3												
Creek	6.9.59	60	1.7	2		-			-													
	29.8.60	100	3.7	4		-			-													
	6.8.61		hayed			hayed			hayed													
Portage	6.9.59	40	2.4	4	100	4	4		-													
Slough	29.8.60	100	2.8	4.2	100	3.3	3.6		-													
	6.8.61		-		70	3.8	4.2		-													
The Pass	25.7.59	15	2	3	55	3	2		-													
	9.9.60	5	1	1	90	3.4	3.3		-													
	9.9.61	25	4	4	80	3	3		-													
Sowls	7.9.59																15	2	2			
	31.7.61																20	1.2	1.2			
Tin	6.9.59	10	1	1	50	2.5	1.8															
Town	8.9.60	85	3.1	3.1		-																
	3.8.61	100	4.6	4.6	60	2.5	1.6															
Tin Town	6.9.59	5	1	1	100	5	3	10	1	1		-										
Slough	14.9.60	20	2.8	2.8	100	3.8	4															
	5.7.61	75	2.7	3.3	100	4.8	4.8	75	1.3	1.3												
Torrey's	2.9.60	10	1	1		-																
Pothole	9.8.61		-			-																
Total Zones			45			44			20			4										
" " with Scolochloa			35			33			12			3										
% Occurrence			78%			75%			60%			75%										
Mean F%			60%			67%			48%			20%										
Mean cover			2.3			2.9			2.1			1.9										

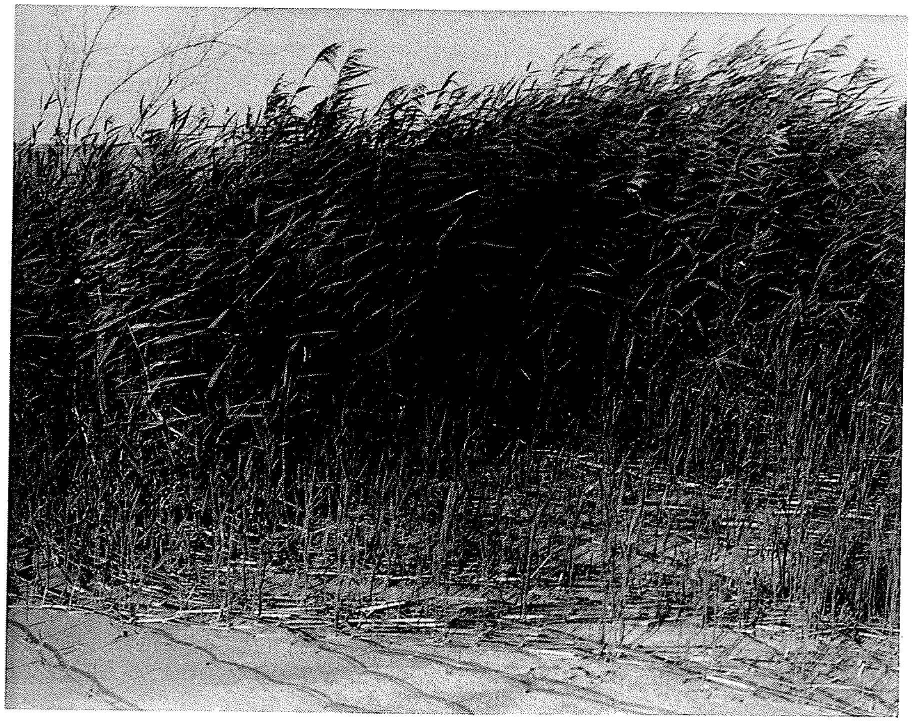

Figure 37. Phragmites communis Runners.

Figure 38. Scolochloa festucacea.

Moss (1953) stated that in Alberta, wherever the water averaged 30-60 cm in depth and persisted throughout most of the summer, the vegetation was a reedswamp dominated by Scolochloa festucacea and Carex atherodes with a few associated species. Harris and Marshall (1963), in Minnesota, mentioned this species merely as part of the mixed community which developed where soil drainage was incomplete, and Moyle and Hotchkiss (1945) state that it is very occasional in Minnesota.

ATRIPLEX PATULA

Atriplex patula had a presence of 100%, an average site frequency of 33% and an index of commonness of 3300, the latter exceeded only by Scolochloa festucacea. It was present in very small amounts at Chimney Marsh (F% 1), remained the same in three sites, increased in six and was reduced in frequency in eight sites, drying out before 1961 in four of them (Table XXXIII). Atriplex flourished where the soil held moisture but was not waterlogged, and drying was reasonably rapid. It was least abundant in sites which dried slowly.

The highest frequencies occurred in zones 3 and 4 and also where conductivities were high. It was more conspicuous at Pintail Slough than in any other site, having a frequency of 100% in each zone in 1960, and cover values between 50 - 75%. During this study A. patula understoried Scolochloa festucacea in a number of locations including Portage Creek, Cook Creek and Avocet. At the latter site the height of 50 plants growing singly and not overtopped by other species was measured (Group A); their maximum height was 56 cm, their minimum height 10 cm, and the mean was 27 cm. The plants had an average of five leaves (range 0 - 10) longer

TABLE XXXIII ATRIPLEX PATULA. Frequency %, Cover and Sociability in all Sites.

blank = no sampling
- = non presence

Site	Date	Z1 F%	Z1 C	Z1 S	Z2 F%	Z2 C	Z2 S	Z3 F%	Z3 C	Z3 S	Z4 F%	Z4 C	Z4 S	Unzoned Areas F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59	-			60	1.1	1.5										55	1.7	1.5			
	12.9.60	20	1.5	2	-																	
	2.7.61	5	1	1	10	1.5	2.5															
Bells	13.8.59	50	4	4.1																		
	16.8.59	-			80	1.6	1.2										30	2.6	2.6		-	
	9.9.60																					
	3.7.61																					
Cherry	10.9.60																10	1.5	1.2			
Ridge	10.8.61																30	2	1.6			
Chimney	29.6.59	5	2	3	-																	
	8.59	-			-			-														
	4.8.60	-			-			-			-											
	3.7.61	-			-			-														
Chimney	16.8.59														-							
Back Marsh	9.9.60														-							
Cook	13.6.59																48	2	2.8			
Creek	7.9.59														-							
	14.6.60																40	2	1.5			
	3.9.60																56	2	1.9			
	3.7.61																30	1.3	1.6			
Flee Island Study Area	19.6.59	70	1.6	2.6	60	2.7	3.7									(path)	50	1.8	2.8	75	3.1	4.1 (shore)
	11.6.60	48	2.4	1.7	55	2	1.7												(meadow)	85	2.9	2.7
	3.8.61															(path)	40	1.5	1.5			
Flee Island Pothole	19.6.59	85	1.5	2																		
	6.9.59	70	2	1.8																		
														(margin Aug.20,1960)			60	1.4	1.5			
Hutchin-sons	10.6.59	-			62	2.4	3.4															
	5.9.59	-			20	1	1	90	1.1	1.1	80	2.5	2.5									
	10.9.60	-			-																	
	7.8.61	5	1	1	-																	

TABLE XXXIII Continued

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59	-			40	2.3	2.2															
	9.9.60	-			-																	
	10.8.61	-			-																	
Pintail	5.9.59	-			5	1	1	95	3.6	3.6												
	26.8.60	100	4	4	100	4.9	4.7	100	3.6	3.8												
	4.7.61	20	1	1	40	1.2	1.3	30	1.1	1.5												
Poplar Pools	6.9.59	-			-			55	2	3												
	4.8.61	-			10	2	1.5	65	1.1	1												
Portage Country Club	3.9.60	-			-																	
	1.8.61	-																				
Portage Creek	21.6.59	4	1	1	72	2.2	2.9e	4	1	1												
					92	2.7	2.7w															
	6.9.59	5	1	1	100	4.5	3.4	20	2	1												
	29.8.60	5	2	2	100	3.2	3.4	100	3.6	3.5												
	6.8.61	hayed			hayed			hayed														
Portage Slough	6.9.59	-			-			-														
	29.8.60	50	1.2	1.3	-			42	1.1	1.1												
	6.8.61	42	1	1	70	1.7	1	55	2	3												
The Pass	25.7.59	-			5	1	1	-														
	9.9.60	-			-			-														
	9.9.61	-			-			-														
Sowls	7.9.59													35	3.1	3.1						
	31.7.61													100	3.8	3.6	55	3.1	3	95	2.6	2.4
Tin Town	6.9.59	-			35	2	1.7															
	8.9.60	25	2.1	2	5	1	1															
	3.8.61	40	2	1.8	-									-								
Tin Town Slough	6.9.59	-			-			-			60	2	1									
	14.8.60	-			33	1.2	1.4															
	5.7.61	-			-			100	1.1	1.3												
Torrey's Pothole	2.9.60	55	1	1	30	1	1															
	9.8.61	75	1.3	1	25	1	1															
Total zones		45			44			20			4											
" " *Atriplex*		20			22			12			2											
% Occurrence		44%			50%			60%			50%											
Mean F%		39%			51%			73%			70%											
Mean Cover		1.7			2			1.7			2.2											

than 10 cm and 12 well developed side branches (range 7-23). Nearby were patches of the same species and these were measured for comparative purposes. Group B comprised 50 plants growing in compact groups; they were considerably smaller than the plants in Group A, but had germinated at the same time. The maximum height was 27 cm, the minimum 9 cm and their mean height 17 cm with an average of two leaves (range 0-7) which were larger than 10 cm and averaging two well-developed side branches (range 0-12). Group C comprised 25 prostrate plants growing well-spaced in exposed drift lines of disintegrating organic debris. Their mean height was 10 cm (minimum 4 cm, maximum 17 cm), they had no leaves as large as 10 cm and an average of 10 side branches (range 5-28) which grew along the ground.

Salisbury (1942) described the striking dimorphism of the seeds of A. patula; the majority of the seeds were small, slightly biconvex, black and shining, and comprised about 98% of the total seed output. The diameter ranged from 1.0 cm - 1.5 mm, and mean weight was 0.000813 gm. The larger seeds were dull brown, flattened, planorbis-like and constituted 1-2% of the seed crop. Most of these larger seeds ranged in diameter from 1.5 to 2.6 mm (maximum 4.2 mm), with a mean weight of 0.0025 gm. Neither in size nor appearance do there seem to be intermediates. Seeds harvested from the same plant, as soon as they were ripe, and sown immediately, did not germinate until the following spring. The larger seeds germinated first and produced larger more vigorous seedlings; but an even more striking distinction was that during ensuing unfavourable climatic conditions, all the seedlings derived from the smaller seeds perished, while approximately 50% of those derived from the larger seeds survived.

Walker (1959) alluded to the types of communities in which *Atriplex* grew at Delta and the prostrate and erect growth forms which may be the progeny of the two types of seed. During this study the erect form was encountered far more frequently than the prostrate type which obviously suffered from shading when overtopped by other species. In the 250 samples from nine sites analysed for seed content, only 30 *A. patula* seeds were detected. Thurston (1961) states that the seeds remained viable for 58 years. The bracts inhibit seed germination (Beadle, 1952; Koller, 1957; Billings, 1957). This species formed a zone around saline 'pans' at Flee Island where the maximum conductivity was 54.5 mmhos/cm and the mean 40.0 mmhos/cm. At the edge of the *Atriplex* the mean conductivity was 18.9 mmhos/cm (maximum 22.4, minimum 14.65 mmhos/cm) indicating a tolerance of high salinities. Miller and Egler (1950) consider it a tidal marsh species and it is recorded in Mason (1957) as common in salt and brackish coastal marshes and around bogs, but not in freshwater marshes. Bird (1961) mentions it in relation to sloughs, but it is not mentioned by Moyle and Hotchkiss (1945) in their marsh vegetation of Minnesota, by Harris and Marshall (1963) or by Löve and Löve (1954) for Delta, though the latter do include the subspecies *A. patula* var. *hastata*.

SONCHUS ARVENSIS VAR. GLABRESCENS

Sonchus arvensis was one of the five species recorded with a presence of 100%. The average site frequency was 20%, and at least 75% of the highest zones (3 and 4) sampled contained this species. At Pintail and Tin Town Sloughs it had a frequency of 100% in the driest zones; and a mean cover value of 20%. This was also true for the neighbouring meadows where Sonchus was often one of the co-dominants and increased in abundance each year. When sampling, the percent occurrence changed

TABLE XXXIV SONCHUS ARVENSIS. Frequency %, Cover and Sociability in all Sites

blank = no sampling
\- = non presence

Sites	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		-			-											5	1	1			
	12.9.60		-			-																
	2.7.61		-		20	1.2	1															
Bells	13.8.59	20	1.5	1.5																		
	16.8.59		-			-																
	9.9.60														-			-			-	
Cherry Ridge	10.9.60																75	2	2			
	10.8.61																85	2.5	2			
Chimney	29.6.59	10	1	1	26	1	1															
	8.59		-		70	1.4	1	40	2	1.7												
	4.8.60	25	1	1		-		15	1.3	1	5	1	1									
	3.7.61	10	1	1	10	1.5	1.5		-													
Chimney Back Marsh	16.8.59														-							
	9.9.60																5	1	1			
Cook Creek	13.6.59														-							
	7.9.59														-							
	14.6.60																20	1.2	1			
	3.9.60																8	1.5	1			
	3.7.61																5	1	1			
Flee Island Study Area	19.6.59		-		5	2	1										(Path 10	1	1)	5	2	2 Shore)
	11.6.60	4	1	1		-									-							
	3.8.61														-						-	
Flee Island Pothole	19.6.59	10	1	1	25	2	3															
	6.9.59	25	2	3		-											15	2	2			
Hutchinsons	10.6.59		-		13	1	1															
	5.9.59		-			-			-		30	1	1									
	10.9.60	8	1.5	1	25	1	1															
	7.8.61	5	1	1	95	3.5	3.6															

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59	-			10	1	2.4															
	9.9.60	-			40	2.5	2.6															
	10.8.61	-			90	1.2	1.3															
Pintail	5.9.59	-			-			35	1.5	1.2												
	26.8.60	100	4	4	100	4.9	4.7	100	3.6	3.9												
	4.7.61	20	1	1	40	1.1	1	75	1.6	1.6												
Poplar Pools	6.9.59	-			-			-														
	4.8.61	-			-			5	1	1	40	3.1	2.6									
Portage Country Club	3.9.60	-			90	1.3	1.2															
	1.8.61	90	2.4	1.8	-																	
Portage Creek	21.6.59	-			-			-														
	6.9.59	-			-			10	2	2												
	29.8.60	-			-			15	1	1												
	6.8.61	-			-																	
Portage Slough	6.9.59	-			-			25	2	3												
	29.8.60	-			-			90	1.7	1.1												
	6.8.61	-			-			10	2.4	1												
The Pass	25.7.59	-			5	1	1	25	3	1												
	9.9.60	-			-			-														
	9.9.61	-			-			20	2.4	1												
Sowls	7.9.59																					
	31.7.61													25	1.4	1				15	1	1
Tin Town	6.9.59	-			35	3.1	1.5															
	8.9.60	-			-																	
	3.8.61	10	1	1	10	1.5	1.5	15	1.5	1				-								
Tin Town Slough	6.9.59	-			-			-			20	2	2.1									
	14.9.60	-			-																	
	5.7.61	15	1	1	15	2	1	100	2.5	1.8												
Torrey's Pothole	2.9.60	5	1	1	-																	
	9.8.61	-			5	1	1															
Total zones		45			44			20			4											
" " *Sonchus*		13			19			15			4											
% Occurrence		29%			43%			75%			100%											
Mean F%		29%			38%			39%			24%											
Mean cover		1.6			1.8			2			1.8											

markedly between zone 1 and zone 4, being 39%, 43%, 75% and 100% respectively. The mean frequencies were 29%, 38%, 39% and 24%, and the index of commonness 2000.

In 1958 it was found among the surviving Phragmites; the plants flowered, set seed and the following year increased in abundance especially in the upper zones where drainage had improved with the lowering of the water table. The rosette growth form with large leaves, effectively prohibited the establishment of other plants. A variety of habitats were occupied, ranging from recently exposed soil which was drying rapidly, to well-drained meadows.

Sonchus is a perennial which spreads rapidly by root shoots that render delimitation of individuals difficult. The seeds germinate throughout the growing season; plants formed early may flower the same year, those produced later remain in a vegetative state. Salisbury (1942) records the average number of fertile fruits per plant as 13,297 ± 1,500, and in spite of the copious vegetative propagation the seed output exceeds that of its annual congeners. Kempski (1906) however records only a 5% germination for the species.

At Delta, in open sites, Sonchus rapidly increased in frequency and abundance, but under some competitive conditions appeared unable to compete and never became dominant. For example, sites with a dense mass of fibrous roots apparently prohibited the spread of Sonchus. It was associated with a number of species, as can be seen in the sampling data. The majority of them prefer drying sites, and include Mentha arvensis, Scutellaria galericulata, Cirsium arvense, Scolochloa festucacea, and Hordeum jubatum. Once established in a site *Sonchus* persisted, with the exception of Bells, but in several instances it did not appear until the second or third year (Table XXXIV).

CHENOPODIUM RUBRUM

Chenopodium rubrum was found in all of the sites except Chimney Back Marsh, maintaining its abundance where new areas continued to be exposed by the retreating water; as at Avocet Marsh (mean F.41%), Portage Slough (mean F.62%), and Pintail Slough (mean F.25%). In sites which had dried completely during the first or second year *Chenopodium* diminished, e.g., at Hutchinsons, Tin Town Slough, and Bells.

Seventy-one percent of the samples taken in zone 1 contained *Chenopodium rubrum*, with an average cover value of 2.6. Fifty-two percent of zone 2, and 20% of zone 3 contained *Chenopodium rubrum*; the cover value in zone 2 was 2.0, that in zone 3 was 1.8. It had a mean frequency of 28% and an index of commonness of 2660.

At Pintail Slough and Poplar Pools *Chenopodium* dominated zone 1 and had a frequency of almost 100% each year, a frequency attained in at least one year at The Pass, Torrey's Pothole, Bells and Hutchinsons. Its abundance was clearly linked with the emergence of denuded areas, and it diminished in drying sites. This is shown by the reduction in occurrence from zone 1 to zone 3 (Table XXXV). The average cover value decreased with increasing dryness (Zone 1 - cover 2.6; zone 2 - cover 2.0; zone 3 - cover 1.8). *Chenopodium* also occurred in unzoned sites which developed where extensive areas were exposed at one time, and the pioneering vegetation assumed a mosaic pattern, such as at Sowls Marsh, and to a large extent at Avocet Marsh.

TABLE XXXV CHENOPODIUM RUBRUM. Frequency %, Cover and Sociability in all Sites.

Blank = no sampling
- = non presence

Sites	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		-		20	2.2	3.2										75	2.1	3.4			
	12.9.60	80	2.2	3.2	16	3	4.5															
	2.7.61	16	3	4.5	10	1.5	2															
Bells	13.8.59	20	1	1																		
	16.8.59	100	4.6	4.4	10	2	1															
	9.9.60																10	2	1		-	
	3.7.61																					
Cherry Ridge	10.9.60														-							
	10.8.61																5	1	1			
Chimney	29.6.59	10	1	1		-																
	8.59		-			-			-													
	4.8.60	25	3	2		-			-			-										
	3.7.61	10	1	1		-			-													
Chimney Back Marsh	16.8.59														-							
	9.9.60														-							
Cook Creek	13.6.59																4	3	4			
	7.9.59																10	3	3			
	14.6.60																	-				
	3.9.60																40	2.1	2.5			
	3.7.61																	-				
Flee Island Study Area	19.6.59	30	1.2	2.2	15	1.3	2.6							Shore				-	Path	60	2.5	3.8
	11.6.60		-		15	3.6	2.6							Meadow			5	1	1		Path	
	3.8.61													Shore			50	2	1.8	50	1.6	1.4
Flee Island Pothole	19.6.59	10	1	3																		
	6.9.59		-			-												-				
Hutchinsons	10.6.59		-			-																
	5.9.59	100	4.5	2.2	100	2.5	1.2	80	1.4	1.1		-										
	10.9.60	68	3.3	3.9	35	1	1															
	7.8.61	5	1.3	2		-																

TABLE XXXV Continued

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59	15	1.3	2		-																
	9.9.60		-			-																
	18.8.61	30	1.4	1.4		-																
Pintail	5.9.59	100	3.7	2.9	15	1.3	2		-													
	26.8.60	100	4	4	100	4.9	4.7	100	3.6	3.9												
	4.7.61	100	3.6	4.2	35	2	3.1	5	1	3												
Poplar Pools	6.9.59	95	3	3	70	2	1		-													
	4.8.61	100	3.3	3.5	25	1.2	1.2	45	1.2	1.2		-										
Portage	3.9.60		-		5	1	4															
Country Club	1.8.61		-			-																
Portage Creek	21.6.59	8	1.5	3	64	2.5	3.7 east)		-													
					12	2	3 west)															
	6.9.59		-		40	2.2	1.4		-													
	29.8.60		-			-			-													
	6.8.61		hayed			hayed			hayed													
Portage Slough	6.9.59	90	5	5		-			-													
	29.8.60	40	2	2.1		-			-													
	6.8.61	70	2.2	2.2	28	1	1		-													
The Pass	25.7.59		-			-			-													
	9.9.60	100	4	3.4		-			-													
	9.9.61	50	2.3	4		-			-													
Sowls	7.9.59													5	2	2						
	31.7.61													60	3.3	3.2						
Tin Town	6.9.59	40	2.5	3	55	2.2	2.5															
	8.9.60		-		30	2	2.5															
	3.8.61	40	1.7	1.1		-																
Tin Town Slough	6.9.59	95	4.7	4.8		-			-			-			-							
	14.9.60	80	2.5	2.8	20	1.6	1.6															
	5.7.61	5	2	4		-			-													
Torrey's Pothole	2.9.60	100	2.5	2.6	50	1.7	1.9															
	9.8.61	80	2.7	2.8	20	1.2	1.2															
Total zones			45			44			20			4										
" " *Chenopodium*			32			23			4			0										
% Occurrence			71%			52%			20%													
Mean F%			56.6%			34.3%			57.5%													
Mean cover			2.6			2.0			1.8													

Walker (1959) commented upon the types of habitats in which C. rubrum was found and upon two growth forms produced. At one extreme the plants grew singly, were triangular in shape, coarse, woody, much branched and attained a height of 1.5 to 2.0 metres. They were well spaced and conspicuous because of this, (Fig.39). At the other extreme, the plants attained a height of approximately 30 cm; they were slender, unbranched and numerous (Fig.40). Intermediate growth forms also existed; each was found alone, which suggested the possibility of ecotypes.

At Cook Creek in 1958 a few, large, scattered plants were found, but in 1959 large numbers of small plants appeared. This could be explained on the assumption of a sparse seed source, resulting in a few scattered plants which in turn could produce an abundance of seed. The following year, if conditions for germination were favourable, a large number of plants would be produced with attendant competition resulting in small crowded plants. The fact that one site can support the extremes of both growth forms in successive years implies that ecotypic variation was not the cause.

In 1960 density counts were made in June and September at Flee Island, Tin Town, Bells and Pintail Slough. The plants in 60 marked quadrats 5 x 5 cm were counted, the results were analyzed and are given in Table XXXVI. It is interesting to note that where Aster brachyactis was associated with Chenopodium rubrum the distribution of the latter was markedly different from sites where Aster was absent (Fig.41). Density counts were also made in other sites and they serve to emphasize the variability (Table XXXVII).

Walker (1959) mentioned the relationship between a daylength and flowering in Chenopodium, Cumming (1962) discussed the sensitivity of Chenopodium

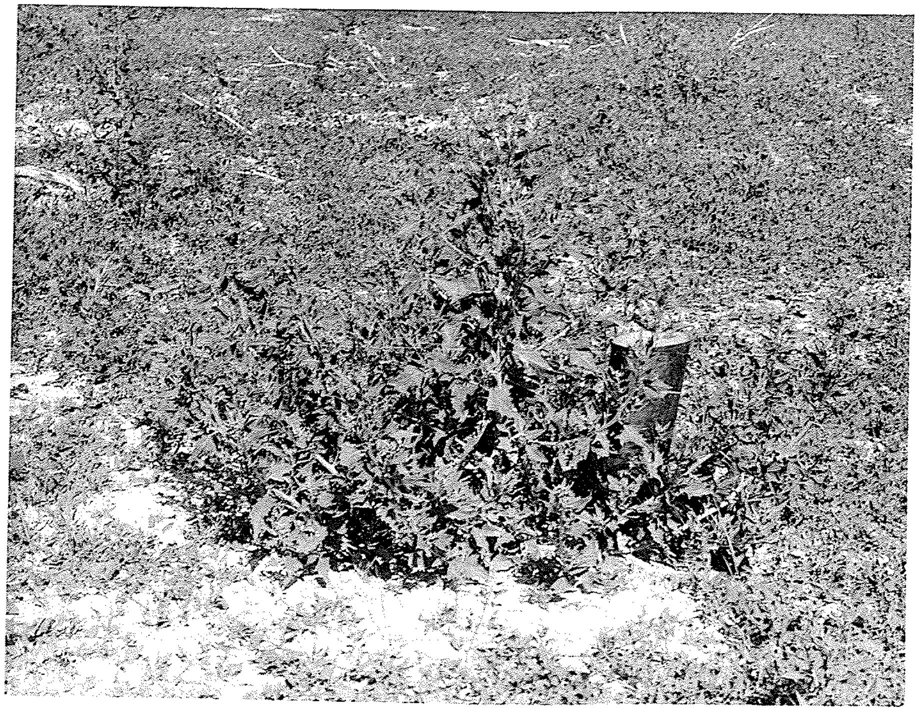

Figure 39. Chenopodium rubrum - Single Large Plant.

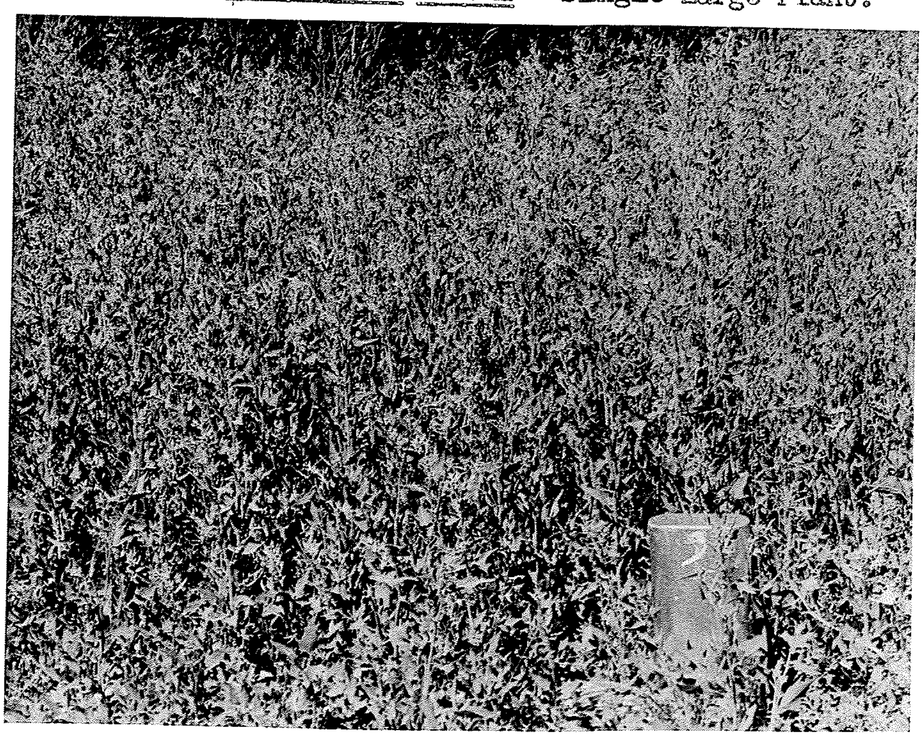

Figure 40. Chenopodium rubrum - Numerous Small Plants.

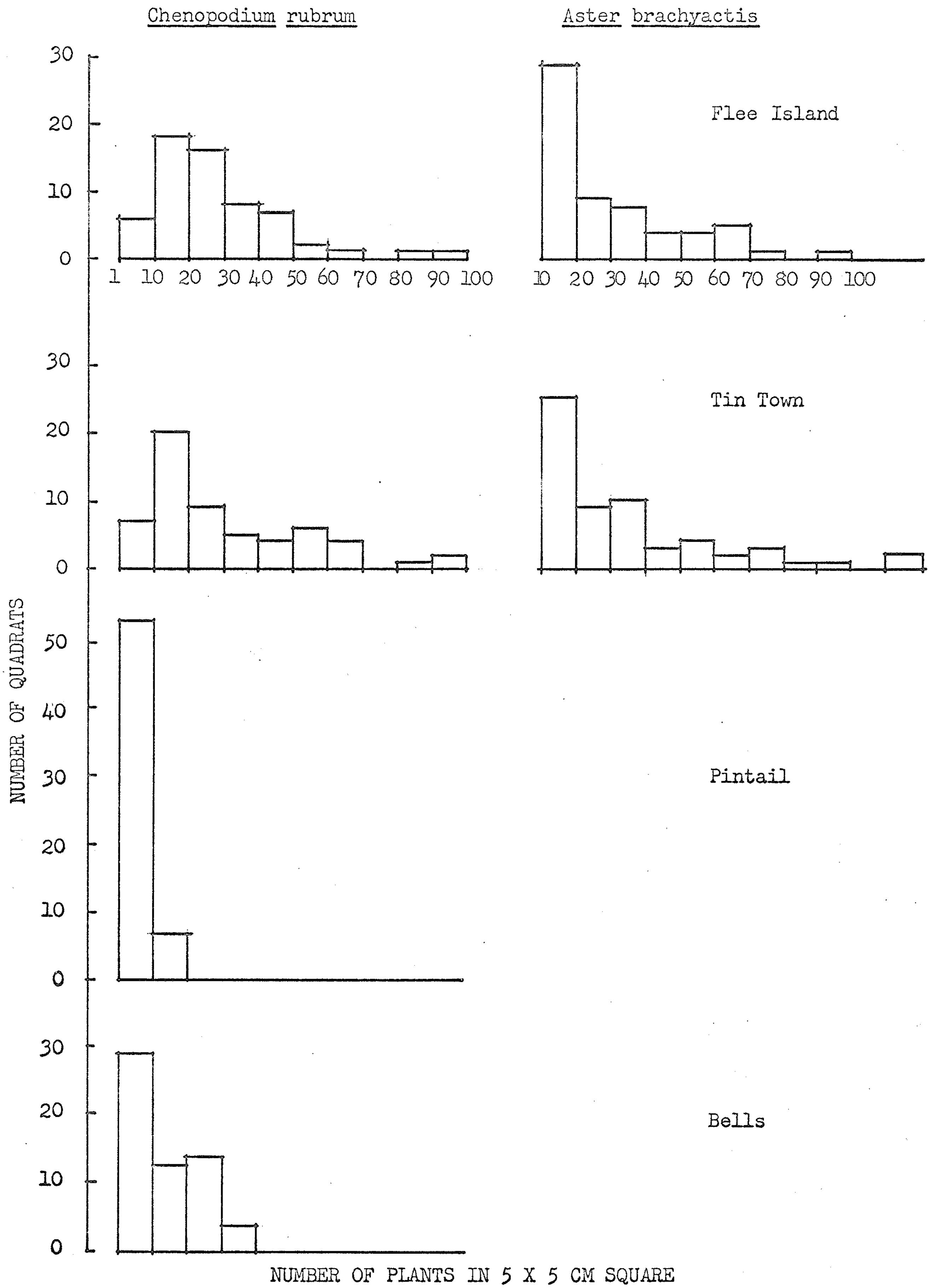

Figure 41. Distribution of *Chenopodium rubrum* and *Aster brachyactis* in Flee Island, Tin Town, Pintail and Bells.

TABLE XXXVI. Density Counts for Plants in 5 x 5 cm Quadrats with Means, Medians and Standard Deviations.

Site	*Chenopodium rubrum* 1960		*Aster brachyactis* 1960		*Rumex maritimus* 1960		*Ranunculus sceleratus* 1960	
	July	Sept.	July	Sept.	July	Sept.	July	Sept.
Flee Island Study Area								
Median	33.5	5.0	14.5	-	-	-	-	-
Mean	38.7	5.6	25.7	0.4	-	-	-	-
Standard Deviation	25.8	3.9	29.9	1.3	-	-	-	-
Tin Town								
Median	30.5	5.0	19.0	-	-	0.5	-	0.5
Mean	48.0	5.7	35.2	0	1.4	1.1	2.2	1.7
Standard Deviation	41.4	3.6	45.6	-	5.0	0.9	10.9	2.7
Bells								
Median	12.5	9.0	-	-	-	-	-	-
Mean	19.8	9.6	-	-	-	-	-	-
Standard Deviation	14.7	5.1	-	-	-	-	-	-
Pin Tail								
Median	7.0	5.0	-	-	-	-	-	-
Mean	8.0	6.6	-	-	-	-	-	-
Standard Deviation	3.7	5.9	-	-	-	-	-	-

TABLE XXXVII. Number of Mature Plants in 5 x 5 cm Quadrats at Various Sites

Number of samples	Flee Island Study Area	Tin Town	Avocet	Pintail	Sowls	Hutchinsons	Poplar Pools
	60	60	30	45	15	15	50
Species							
Chenopodium rubrum	39	48	145	12	180	11	10
Aster brachyactis	26	16	23		13		2/50
Scolochloa festucacea			1	3	0.5	1	
Rumex maritimus		1				1.6	
Ranunculus sceleratus		2					
Salicornia rubra	0.008				0.02		
Atriplex patula					58	1	
Scirpus paludosus					0.001		
Hordeum jubatum					0.02		
Puccinellia nuttalliana					0.02		
Scirpus validus						1/15	0.5
Sonchus arvensis var. glabrescens						1/15	

to photoperiod even in the cotyledon stage, and the pronounced difference between selections depending on their latitude of origin.

Salisbury (1942) considered that the natural habitat for Chenopodium is the exposed mud of ditches, ponds, reservoirs and other shallow waters. He quotes instances of it appearing in remarkable profusion in drying reservoirs and constituting 70% of the vegetation. He gives the height as being 30-140 cm, but if the water levels remain low for several seasons the average height of the plants diminishes, presumably as the supply of nutrients in the newly exposed mud decreases. In appraising the productivity of the species, its initial capacity must be taken into account. That the seeds remain dormant for long periods in the mud is shown by the fact that viable seeds have been obtained 15-30 cm below the surface of caked mud. Seed production for a mud dwelling specimen was considered to be well over 176,000 (Salisbury, 1942).

Many reports cite Chenopodium as a characteristic species of mudflats, both early and late in the growing season. Tolstead (1942) comments on hundreds of acres of seedlings in August. Harris and Marshall (1963) describe areas which bear a mixture of species including C. rubrum. Niemann (1952), and Massart (1956) came to the conclusion that seeds and fruits of the Chenopodiaceae were rich sources of germination inhibitors, this may to some extent be responsible for the almost pure communities that occur where densities of Chenopodium are high.

ASTER BRACHYACTIS

The range of communities in which Aster brachyactis was found in the Delta Marsh has been described by Walker (1959). This species (Fig.41) has

TABLE XXXVIII. ASTER BRACHYACTIS. Frequency %, Cover and Sociability in all Sites.

blank = no sampling
- = non presence

Sites	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59	26	2	4	80	2	3.5										80	2	3.5 Ridge			
	12.9.60	95	3	3.1	28	2.9	4.4															
	2.7.61	85	1.5	1.5	20	1.2	1.2															
Bells	13.8.59	30	3.5	4																		
	16.8.59				30	1.3	2.3															
	9.9.60													-			-					
Cherry Ridge	10.9.60													-			25	1.2	1			
	10.8.61													-			15	1	1			
Chimney	29.6.59	-			-																	
	8.59	-			-			-														
	4.8.60	-			-			-			5	1	1									
	3.7.61	44	1	1	-			-														
Chimney Back Marsh	16.8.59													-								
	9.9.60													-								
Cook Creek	13.6.59													-			72	2.6	4			
	7.9.59													-			70	2.9	2.7			
	14.6.60													-			40	1.2	1.6			
	3.9.60													-			12	2.3	1.3			
	3.7.61													-								
Flee Island Study Area	19.6.59	90	3.2	4.3	20	2.2	3.7							(70	2.1	3) (Path)	(20	1.8	3 Shore)			
	11.6.60	44	2.2	2.7	50	1.7	1.5															
	3.8.61										hayed			(90	3.5	3.5)	(-		Shore)			
Flee Island Pothole	19.6.59	60	2.5	3.7										(Path)								
	6.9.59	60	3.7	3.7	-									(40	2.5	2.1)						
Hutchinsons	10.6.59	20	1	1	100	3.7	4.2							(Margin)								
	5.9.59	20	1	1	60	1	1	20	1.5	1	70	2.9	2.7									
	10.9.60	4	1	1	-																	
	7.8.61	5	1	1	-																	

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		-		30	2	2.3															
	9.9.60		-			-																
	10.8.61	5	1	1		-																
Pintail	5.9.59	15	1.3	1	65	2	1.7	5	1	1												
	26.8.60		-			-			-													
	4.7.61	55	1	1	25	1	1	10	1	1												
Poplar Pools	6.9.59		-		55	3	2		-													
	4.8.61	30	1.1	1	50	1.3	1.2	30	1.6	1.6	15	1	1									
Portage Country Club	3.9.60		-		30	1.6	2.3															
	1.8.61		-			-																
Portage Creek	21.6.59	44	1.7	1.2	64 36	2.3 2.9	3.3 east 4.2 west		-													
	6.9.59	100	3.4	33	10	2	1		-													
	29.8.60		-			-			-													
	6.8.61	15	1	1	42	1	1		hayed													
Portage Slough	6.9.59		-			-		5	1	1												
	29.8.60		-		10	2	1			-												
	6.8.61	15	1	1	42	1	1			-												
The Pass	25.7.59		-		10	1	1			-												
	9.9.60	30	2.6	2			-			-												
	9.9.61		-		10	1	1			-												
Sowls																		-				
																		-				
Tin Town	6.9.59	10	1	1	65	3.4	1.6															
	8.9.60	30	1.2	1.4		-																
	3.8.61	60	1.5	1.5		-																
Tin Town Slough	6.9.59	30	2	1		-			-			-			-							
	14.9.60		-			-																
	5.7.61		-			-			-													
Torrey's Pothole	2.9.60		-			-																
	9.8.61		-			-																
Total zones			45			44			20			4										
" "	Aster		26			23			5			3										
% Occurrence			58%			50%			25%			75%										
Mean F%			39%			42%			15%			1%										
Mean cover			1.8			2.0			1.2			1.6										

not often been reported from freshwater marshes where drawdown studies have been undertaken, and though abundant in some sites at Delta during this study, it was not recorded by Löve and Löve (1954). During the 1959-61 period Aster brachyactis had a presence of 90% and an average frequency of 10%. In four sites it had approximately the same frequency throughout the study, while in seven it diminished (Table XXXVIII). The index of commonness was 1350.

The achenes have a soft, copious pappus (Gleason, 1958) which is an effective aid to dispersal under dry conditions, when wet however, the achenes adhere together in masses. The resulting seedlings may be densely packed, for example the data below are for 10 samples 2.5 cm x 2.5 cm which were taken in a series of areas where A. brachyactis had germinated, in association with A. patula.

Aster brachyactis	62,	316,	67,	20,	25,	30,	209,	101,	92,	36 and
Atriplex patula	15,	0,	3,	0,	3,	0,	2,	0,	8,	0

Aster brachyactis occurred in 58% of the samples taken in zone 1 and 50% of those in zone 2. The mean frequency percent in these zones was approximately 40%. Both the occurrence and frequency percent dropped in zone 3 and 4. The cover value was highest in zones 1 and 2, but in no zone was the average cover value high, although individual sites had relatively high cover values in one or more zones in 1959, e.g., Portage Creek (zone 1), Flee Island Pothole (zone 2) Hutchinsons (zone 2) and Tin Town (zone 2). The results of density counts are given in Table XXXVI.

RUMEX MARITIMUS VAR. FUEGINUS

At Delta *Rumex* had a presence of 80% and a mean frequency of 19%, occurring in 53% of the samples from zone 1, 36% of those from zone 2, and 10% of those from zone 3. The highest mean frequency of 42% was in zone 2, while the frequency in zone 1 was 28%, i.e., more than twice that in zones 3 and 4. The index of commonness was 1520, (Table XXXIX).

In several sites *Rumex* dominated the newly exposed muck and also grew in shallow water along the shores. Walker (1959) commented upon the habitats and growth forms of this species. Avocet Marsh, Portage Slough, and Poplar Pools produced dense growths of *Rumex* in at least one year. In 1959 its plants (70 cm tall) dominated large patches at Avocet Marsh (Fig.43) in the forefront of a mixed community of *Rumex*, *Aster brachyactis*, *Atriplex patula*, and *Scolochloa festucacea*. It was codominant with *Scolochloa* in zone 2 at Pintail and at Poplar Pools.

Rumex is an annual which usually produces an abundance of seed. After fruiting the achenes accumulate in great quantities on the ground, thereby accessible to movement by surface water. They are very light in weight, averaging 0.000221 gm (Salisbury, 1942). Rainfall may wash them into depressions, or wind tides deposit them along shores. This chance movement appears responsible for the majority of the seed distribution, although animals and wind play a part. An adequate seed source must be coupled with good conditions for germination, to produce the dense stands which appear on emergent mudflats. *Rumex* was reported by Salisbury (1942) to have been abundant in the exposed Breckland meres, having germinated from dormant seed in the mud. Experiments with sunbaked seeds yielded 98% germination. Closely related species are known to be dormant when

... % Cover and
Sociability in all Sites.

blank = no sampling
- = non presence

Sites	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59	20	1.2	2.2		-											85	2.5	3.3			
	12.9.60	55	2.2	1.5		-																
	2.7.61	100	3.7	3.4	15	2.3	2.3															
Bells	13.8.59		-																			
	16.8.59		-			-																
	9.9.60														-			-				
	3.7.61																					
Cherry Ridge	10.9.60																5	1	1			
	10.8.61																20	1.5	1.2			
Chimney	29.6.59	10	1	1		-																
	8.59		-			-			-													
	4.8.60		-			-			-			-										
	3.7.61	12	1.5	1.5		-			-													
Chimney Back Marsh	16.8.59														-							
	9.9.60														-							
Cook Creek	13.6.59																12	1	1.3			
	7.9.59																	-				
	14.6.60																	-				
	3.9.60																20	2.2	2.4			
	3.7.61																10	1.5	1			
Flee Island Study Area	19.6.59	5	1	1		-											5	1	1		-	
	11.6.60		-			-												-				
	3.8.61																10	1	1		-	
Flee Island Pothole	19.6.59		-																			
	6.9.59		-			-												-				
Hutchinsons	10.6.59	90	2	1.7	13	1	1															
	5.9.59	20	1	1	90	2.6	1	30	2.3	2.3	10	1	1									
	10.9.60	80	1.8	1.6	80	2.7	2.7															
	7.8.61	25	3.6	3.6																		

TABLE XXXIX Continued

Site	Date	Z1 F%	Z1 C	Z1 S	Z2 F%	Z2 C	Z2 S	Z3 F%	Z3 C	Z3 S	Z4 F%	Z4 C	Z4 S	Unzoned Areas F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		-			-																
	9.9.60	5	2	1		-																
	10.8.61		-			-																
Pintail	5.9.59	5	1	1	50	3.4	1		-													
	26.8.60		-		50	1.3	1		-													
	4.7.61	10	2	1	25	1	1	5	1	1												
Poplar	6.9.59		-		50	3.5	1		-													
Pools	4.8.61	10	2.5	1.5	100	4.1	3.9		-			-										
Portage	3.9.60		-			-																
Country Club	1.8.61		-			-																
Portage	21.6.59	12	2.3	2		-			-													
Creek	6.9.59		-			-			-													
	29.8.60		-			-			-													
	6.8.61		hayed			hayed			hayed													
Portage	6.9.59	10	2.3	1	5	1	1		-													
Slough	29.8.60	10	1	1		-			-													
	6.8.61	84	4	4	84	1.8	2.3		-													
The Pass	25.7.59	20	4	4	10	1	1		-													
	9.9.60		-			-			-													
	9.9.61		-			-			-													
Sowls															-							
															-							
Tin Town	6.9.59		-		20	1	1															
	8.9.60		-		30	2.5	2.5															
	3.8.61	10	1	1		-																
Tin Town	6.9.59	20	3.5	2		-			-			-			-							
Slough	14.9.60		-			-																
	5.7.61	30	1.5	2.1		-			-													
Torrey's	2.9.60	10	1	1	30	1	1															
Pothole	9.8.61	30	1	1	25	1	1.2															
Total zones		45			44			20			4											
" " Rumex		24			16			2			1											
% Occurrence		52%			36%			10%			25%											
Mean F%		28%			42%			12%			10%											
Mean cover		2			1.9			1.6			3.4											

Figure 42. Aster brachyactis.

Figure 43. Rumex maritimus Dominating Part of the Emergent Mudflat at Avocet Marsh.

freshly harvested; one *Rumex limosus* had a seed production which ranged from 24,000 to 118,000 and though that of *R. maritimus* is considered to be appreciably lower, seed output is still large (Salisbury, 1942).

Harris and Marshall (1963) reported *Rumex* occurring as a component of the vegetation of emergent mudflats together with *Chenopodium rubrum*, *Typha latifolia*, *Scirpus validus*, and *Bidens* spp. Löve and Löve (1954) mentioned it as a member of the Puccinellietum and of the frontier association of the Delta marsh.

HORDEUM JUBATUM

Hordeum jubatum had a presence of 80%; and occurred in 29% of the samples from zone 1; 45% of those from zone 2; 65% from zone 3 and 50% from zone 4, showing a preference for drier habitats (Table XL). Low mean frequencies and cover values were recorded in zone 1 with the exception of Tin Town Slough; and also in zone 2 with the exception of Hutchinsons and Portage Slough. The highest mean frequency (52%) and cover value (2.0) was recorded in zone 3, while the mean frequency in zone 4 was 44%, and the cover value 1.6. The mean frequency was 19% and the index of commonness was 1520. It occurred more often on the south side of the marsh than on the north, and was tolerant of a range of conductivities. This was shown by its abundance in patches near saline areas with conductivities as high as 18.9 mmhos/cm in contrast with Portage Slough where the mean conductivity was 3.05 mmhos/cm and the frequency ranged from 28% to 60%. Sites with low conductivities like Chimney and Chimney Back Marsh had no *Hordeum*. Keith (1958) reports that within a single year shoreline vegetation changed from a community dominated by *Juncus balticus* to one predominately of *Hordeum jubatum*, because of increases in salinity, and Moss (1953) mentions it as a leading species in

TABLE XL HORDEUM JUBATUM. Frequency %, Cover and Sociability in all Sites.

blank = no sampling
\- = non presence

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		-			-												-				
	12.9.60	5	1	2		-																
	2.7.61	5	1	1	5	1	1															
Bells	13.8.59	10	2	2																		
	16.8.59		-			-																
	9.9.60																					
	3.7.61														-						-	
Cherry	10.9.60														-							
Ridge	10.8.61													5	1	1						
Chimney	29.6.59		-			-																
	8.59		-			-			-													
	4.8.60		-			-			-			-										
	3.7.61		-			-			-													
Chimney	16.8.59														-							
Back Marsh	9.9.60														-							
Cook Creek	13.6.59														-							
	7.9.59														-							
	14.6.60														-							
	3.9.60														-							
	3.7.61														-							
Flee Island	19.6.59		-		5	1	2							75 1.2 3.2 (shore)								
Study Area														(meadow								
	11.6.60	20	1	1.8		-								15 3 3.3)				-				
	3.8.61														-							
Flee Island	19.6.59		-			-								(Aug.20,1960							-	
Pothole														56 1.9 2 margin)								
	6.9.59		-			-																
Hutchinsons	10.6.59	20	2	2	75	2.7	3.7								-							
	5.9.59		-		10	1	2	40	1.3	1.5	80	2.3	2.9									
	10.9.60	4	1	1	5	1	1															
	7.8.61	5	1	1	65	1.4	1.4															

TABLE XL Continued

Site	Date	Z1 F%	Z1 C	Z1 S	Z2 F%	Z2 C	Z2 S	Z3 F%	Z3 C	Z3 S	Z4 F%	Z4 C	Z4 S	Unzoned Area F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		-			-																
	9.9.60		-		7	2	2															
	10.8.61		-			-																
Pintail	5.9.59		-		20	1	1.7	20	1.2	1.7												
	26.8.60		-			-			-													
	4.7.61		-			-		80	1.4	2												
Poplar Pools	6.9.59		-		15	2	2	40	1	2												
	4.8.61	10	1	1	55	1.1	1.9															
Portage Country Club	3.9.60		-			-																
	1.8.61		-			-																
Portage Creek	21.6.59	8	1.5	2	8	1	1	24	2	3	8	1	1									
	6.9.59	5	1	1	40	1.2	1.7	100	4	3.5												
	29.8.60		-		35	1.4	1.4	80	3	2.8												
	6.8.61		hayed			hayed			hayed													
Portage Slough	6.9.59		-			-		60	4	3												
	29.8.60		-		35	1.4	1.4	28	1	1												
	6.8.61		-		56	1.5	1.5	28	1	1												
The Pass	25.7.59		-			-			-													
	9.9.60		-		10	1	1		-													
	9.9.61		-		10	1	1		-													
Sowls	5.9.59													60	1.8	1.8	10	1	1	35	1.8	1.8
	31.7.61																					
Tin Town	6.9.59	5	1	1	15	1.3	2															
	8.9.60		-			-																
	3.8.61		-		5	1	1								-							
Tin Town Slough	6.9.59	30	2	1.9		-		45	2.1	2.3		-			-							
	14.9.60	35	1.5	1.7	46	3	3.4															
	5.7.61	65	1.7	1.7	15	1	1	75	2	3												
Torrey's Pothole	2.9.60		-			-																
	9.8.61		-		5	1	1															
Total zones			45			44			20			4										
" " with *Hordeum*			13			20			13			2										
% Occurrence			29%			45%			65%			50%										
Mean F%			17%			25%			52%			44%										
Mean cover			1.4			1.4			1.9			1.6										

saline meadows.

At Delta its growth was most effective in well drained areas on soils that had dried early in the season; with a preference for soils that were loams and silty loams rather than highly organic. Muenscher (1944) and Fassett (1940) do not record Hordeum jubatum in their marsh floras, but Mason (1957) includes it.

TYPHA LATIFOLIA

Walker (1959) found the most luxuriant, dense stands of Typha near Clandeboye Channel and commented upon its role in plant communities at Delta, where Löve and Löve (1954) had noted that it was not very common. During this study the stands at Clandeboye Channel and elsewhere expanded considerably and new ones became established.

The majority of Typha stands had been completely eliminated during the high water period while others were greatly reduced. Workers including Uhler (1944), Moyle and Hotchkiss (1945), Low (1945) Penfound and Schneidau (1945), Macleod (1948), Errington (1948), Sharp (1951), Brumstead and Hewitt (1952), Martin (1953), McDonald (1955) and others have observed similar phenomena resulting from excessive inundation. During this study at Delta Typha had a presence value of 75% and an average frequency of 12%, and an index of commonness of 780. In six sites the average frequency was less than 6%, four ranged between 7% and 48% (Table XLI). The sites were all on the northern side of the marsh and showed a range in conductivity, pH, and soil components (cp. McMillan, 1959).

[illegible] TYPHA LATIFOLIA. Frequency %, Cover and Sociability in all Sites.

blank = no sampling
– = non presence

Sites	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		–			–												–				
	12.9.60	10	1	1		–																
	2.7.61	10	1	1		–																
Bells	13.8.59	5	1	1																		
	16.8.59		–			–																
	9.9.60														–						–	
Cherry Ridge	10.9.60														–							
	10.8.60														–							
Chimney	29.6.59	5	1	1	37	1.6	1.7															
	16.8.59	40	3	2.7	20	1	1	20	1	1												
	4.8.60	25	3	2	70	1.9	1.5	10	1	1		–										
	3.7.61	30	1.6	1.3	38	1	1		–													
Chimney Back Marsh	16.9.59														–							
	9.9.60														–							
Cook Creek	13.6.59														–							
	7.9.59														–							
	14.6.60														–							
	3.9.60														–							
	3.7.61														–							
Flee Island Study Area	19.6.59		–			–									–						–	
	11.6.60	4	1	1		–									–							
	3.8.61				10	1	1								–						–	
Flee Island Pothole	19.6.59		–																			
	6.9.59		–			–									–							
Hutchinsons	10.6.59		–			–																
	5.9.59		–			–			–			–										
	10.9.60		–			–		10	2.5	1.5												
	7.8.61		–			–																

TABLE XLI Continued

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		-		25	1.5	1.3															
	9.9.60	5	3	3	13	1.5	1															
	10.8.61	50	1.6	1.3	10	1.1	1															
Pintail	5.9.59		-			-			-													
	26.8.60		-		20	1	1	20	1	1												
	4.7.61		-		15	1	1		-													
Poplar	6.9.59	5	1	1		-			-													
Pools	4.8.61		-			-			-			-										
Portage	3.9.60		-		5	2	3															
Country Club	1.8.61		-			-																
Portage	21.6.59		-		4	1	1 east		-													
Creek						-	west															
	6.9.59		-			-			-													
	6.8.61		-			-			hayed													
Portage	6.9.59	5	1.0	1.0		-			-													
Slough	29.8.60		-		5	1.0	1.0		-													
	6.8.61		-		10	1.0	1.0		-													
The Pass	25.7.59		-			-		10	1	1												
	9.9.60		-		10	1	1	20	2	2												
	9.9.61	25	2.3	2		-		25	1.7	1.9												
Sowls	5.9.59																					
	31.7.61																					
Tin Town	6.9.59		-			-																
	8.9.60		-			-																
	3.8.61		-			-									-							
Tin Town	6.9.59		-		5	1.0	1.0		-			-										
Slough	14.9.60	5	1.0	1.0		-																
	5.7.61		-			-			-													
Torrey's	2.9.60	10	1	1	90	3.3	1.4															
Pothole	9.8.61	10	1	1	80	1.7	1.2															
Total zones			45			44			20			4										
" " with Typha			14			17			7			0										
% Occurrence			31%			38%			35%			0										
Mean F%			17%			28%			16%			-										
Mean cover			1.6			1.4			1.4			-										

TABLE XLII. Frequency, Conductivity, pH, Organic, Sand, Silt and Clay Content at Sites on the North Side of the Marsh.

Site	F%	Conductivity mmhos/cm	pH	% organic	% sand	% silt	% clay
Torrey's Pothole	31	8.05	8.0	39.1	19.5	18.0	23.4
Chimney	25	0.3424	7.2	27.8	29.7	25.8	16.8
Jackfish	17	5.177	7.6	35.4	27.9	26.1	10.7

In zoned sites Typha had a percentage occurrence between 31% and 38%. Zone 2 had a frequency of 28%, and zones 1 and 3 had frequencies of 17% and 16%. In 1959 Typha was recorded at Chimney, Jackfish, Poplar Pools, Portage Creek, Portage Slough, The Pass, Tin Town Slough and Torrey's Pothole.

At Chimney and Jackfish Pond, Typha produced scattered pioneering stands at the water's edge, these later became engulfed by other species but flourished, thereby showing that it can exist both as a pioneer and in well defined persistent zones (cp. Conway, 1949).

Only at Torrey's pothole did Typha rapidly colonize extensive areas of the drying, denuded mud and within one year establish a conspicuous stand of tall plants (Fig.44). This was much less extensive but appears comparable with a report of Typha colonization on a drained lake in Britain (Summerhayes and Turril, 1948), while Harris and Marshall (1963) report that Typha stands containing a light mixture of other emergents were widespread over most areas exposed during the summer, and the most common complex to appear in the marshes of New York state included Typha (Bradley and Cook, 1951). To obtain an idea of density fifteen 0.5 m x 0.5 m quadrats were distributed in zone 2 (in 1961) and the number of plants in

Figure 44. Typha latifolia Stand of Tall Plants.

them counted (Table XVII).

At Delta *Typha* grew in a wide range of conditions. It was found in water up to 1.5 m deep although the optimum was 0.3 - 0.5 m; it thrived in waterlogged soil and also grew in soils with sufficiently low water content to be well aerated. The substratum was sandy, silty or organic.

Many workers have mentioned aspects of the biology of *Typha* including Wilson (1939) who reported it most abundant on the more clayey muds and on a thin covering of black alkaline organic soil over clay or calcareous sand and silt. McLeod (1949) mentioned that *Typha* in Manitoba is found in water between zero and thirty inches deep. Raunkiaer (1934) observed its stolons growing freely out in the water, but entirely overshadowed by densely packed shoots. They grew horizontally as long as they were in the shade, but obliquely downwards as soon as they reached the edge of the community where they were exposed to light. Weaver and Himmel (1930) noted the attenuated distal portions of stolons, but only on rare occasions were stolons observed in this Delta study. The general method of reproduction was by underground rhizomes or by seed, as reported by Hotchkiss and Dozier (1949). Laing (1936) observed that the rhizomes of *Typha* grow best in relatively high oxygen tensions (4.6%) suggesting that aeration may play an appreciable part in determining the increments of the underground organs. Weaver and Himmel (1930) noted that development in *Typha* increased with an increase in water content until saturation was reached. Dean (1933) used *Typha* as an experimental plant when working on root systems and their oxygen supply, and reported its greatest development in muck and least in sand. A phytosociological and ecological study of *Typha* stands in Oakland County, Michigan, was conducted by Segadas-Vianna (1939) who supported the individualistic concept, (Gleason 1939, Cain 1947) and emphasized that *Typha* modified the habitat. A review of *Typha* literature was made by Huenecke (1950).

SCIRPUS PALUDOSUS

Scirpus paludosus had a presence of 75%; 30% of the samples taken in zones 1 and 2, and 15% of those from zone 3 contained it (Table LXIII). The mean frequency in zone 1 was (37%) as compared with zone 2 (18%), and zone 3 (34%). It had an index of commonness of 900. One or more scattered patches of S. paludosus occurred in some sites which did not appear in the sampling data, and they occupied slight depressions and persisted throughout the study changing very little in size or density from year to year (cp. Bolen, 1964). One such patch was present at Cook Creek, one at Bells and several in Avocet Marsh and Sowls. The soil from these areas had higher conductivities than their surroundings, which may account for the presence of this salt tolerant species. Coupland (1950) mentions the ability of S. paludosus to tolerate a high concentration of salts, and its growth in mixed or pure stands around bare central areas. At Portage Creek, Tin Town, and Tin Town Slough the frequency of S. paludosus increased from year to year, but in no site was it even a co-dominant.

RANUNCULUS SCELERATUS

At the Delta Marsh, Ranunculus sceleratus generally germinated early in June, grew to maturity, set seed, withered by the end of July and left little evidence of its passing. A variety of species then came into the sites where it had pioneered; among them Aster brachyactis, Scolochloa festucacea, and Chenopodium rubrum.

It flourished in water up to 30 cm deep at various places along the north and south shores, at Avocet Marsh and at Portage Creek; in other sites the water table was at, or just below the surface. Walker (1959)

TABLE XLIII SCIRPUS PALUDOSUS. Frequency %, Cover and Sociability in all Sites

blank = no sampling
– = non presence

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		–			–												–				
	12.9.60		–			–																
	2.7.61	5	1	1		–																
Bells	13.8.59		–																			
	16.8.59		–			–																
	9.9.60																					
	3.7.61																	–			–	
Cherry Ridge	10.9.60																20	2	2.6			
	10.8.61														–							
Chimney	29.6.59		–			–																
	8.59		–			–			–													
	4.8.60		–			–			–			–										
	3.7.61		–			–			–													
Chimney Back Marsh	16.8.59														–							
	9.9.60														–							
Cook Creek	13.6.59														–							
	7.9.59														–							
	14.6.60														–							
	3.9.60														–							
	3.7.61														–							
Flee Island Study Area	19.6.59		–		15	1.3	1.7								–					(10	1	2
	11.6.60	4	1	1	20	1	1								–							path)
	3.8.61														–				(path	40	1.5	1.5)
Flee Island Pothole	19.6.59		–																			
	6.9.59		–			–									–							
Hutchinsons	10.6.59	20	1	1	25	2	2.5															
	5.9.59		–		10	1	1		–			–										
	10.9.60	32	2.1	1.8	10	1	1															
	7.8.61		–			–																

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		–			–																
	9.9.60		–			–																
	10.8.61		–			–																
Pintail	5.9.59		–		5	1	2		–													
	26.8.60		–			–			–													
	4.7.61		–		5	2	1		–													
Poplar Pools	6.9.59		–			–			–													
	4.8.61	10	1	1	20	1	1	20	1.7	1.7			–									
Portage Country Club	3.9.60		–			–																
	1.8.61		–			–																
Portage Creek	21.6.59	12	2.1	2.6	28 40	1.3 1	2 east 2 west	52	1.7	1.1												
	6.9.59	25	2.8	2.8		–			–													
	29.8.60	75	2.1	2.3		–			–													
	6.8.61		hayed			hayed			hayed													
Portage Slough	6.9.59		–			–			–													
	29.8.60	75	2.1	2.2	15	1	1	30	1.5	1.5												
	6.8.61		–			–			–													
The Pass	25.7.59		–			–			–													
	9.9.60		–			–			–													
	9.9.61		–			–			–													
Sowls	7.9.59																					
	31.7.61													5	1	1						
Tin Town	6.9.59		–		30	1.5	1.5															
	8.9.60	40	1.9	1.8	15	1.2	1.2															
	3.8.61	60	2.3	2.2		–									–							
Tin Town Slough	6.9.59	20	1.2	1.2		–			–			–										
	14.9.60	75	2.5	2.3		–																
	5.7.61	70	2.7	2.6		–			–													
Torrey's Pothole	2.9.60		–		–	–									v							
	9.8.61		–			–									v							
Total zones		45			44			20			4											
" " with *Scirpus*		14			13			3			0											
% Occurrence		31%			30%			15%														
Mean %		37.3%			18.3%			34%														
Mean cover		1.8			1.3			1.6														

referred to *R. sceleratus* as a species characteristic of emergent mud flats and marginal open waters; similar comments have been made by Salisbury (1942), Mason (1957), Harris and Marshall (1963). Arber (1920) remarked upon its amphibious nature and upon some adaptations to these habitats.

Data indicates that the average output of seeds may be 26,494 ± 2,462 achenes per plant. Germination according to Lehmann (1911) ranges from 34-98% (62% ± 5) in light, while in darkness it was from 0-3%. The achenes are dispersed by water (Praeger, 1913) and do not float for more than 3.1/2 days before sinking to the bottom. Here their dormancy and subsequent germination appear to be determined by the fact that the seeds of *R. sceleratus* do not germinate unless subjected to variations in temperature (Gassner, 1915). In darkness, with fluctuating temperatures, Gassner obtained 28% germination. When mud is exposed, the dormant achenes in the surface mud layers are subjected to both high light intensity and diurnal temperature changes. Crocker and Barton (1953) report that *R. scleratus* seeds will not germinate without light. At Delta when water levels dropped exposing the bottom, both requirements of temperature and light were met and *R. sceleratus* became dominant in some sites.

Ranunculus had a presence of 70% and was generally restricted to marsh shores which showed zonation. It was one of the prevalent species that was almost confined to zone 1 and whose frequency and cover was consistently higher in 1959 than later in the investigation (Table XLIV). Thirty-eight percent of the samples taken in zone 1 included *R. scleratus*. In 1959 the mean frequency was 51% (8 zones) whereas in 1960 the mean F% had dropped to 22% (3 zones) (Table XLIV). Eleven percent of the samples taken in zone 2 contained *R. sceleratus* with a mean frequency

TABLE XLIV RANUNCULUS SCELERATUS. Frequency %, Cover and Sociability in all Sites

blank = no sampling
– = non presence

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59	100	4.2	4.6		–																
	12.9.60	15	1.3	2.3	4	1	1										80	1.9	3.8			
	2.7.61	95	2.3	2.3		–																
Bells	13.8.59	10	1	1																		
	16.8.59		–			–																
	9.9.60																					
	3.7.61														–						–	
Cherry Ridge	10.9.60														–							
	10.8.61														–							
Chimney	29.6.59	65	1.6	2.3	5	1	1															
	8.59		–			–																
	4.8.60	25	1	1		–			–			–										
	3.7.61	32	1.8	1.5		–			–													
Chimney Back Marsh	16.8.59														–							
	9.9.60														–							
Cook Creek	13.6.59													50	2	1.5						
	7.9.59														–							
	14.6.60														–							
	3.9.60														–							
	3.7.61														–							
Flee Island Study Area	16.9.59	20	2	2.5		–									–						–	
	11.6.60		–			–									–							
	3.8.61														–						–	
Flee Island Pothole	19.6.59		–			–									–							
	[illegible].9.59		–			–																
Hutchinsons	10.6.59		–			–																
	5.9.59		–			–			–			–										
	10.9.60		–			–																
	7.8.61		–			–																

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59	40	2.1	1		–																
	9.9.60	25	1	1		–																
	10.8.61	25	1.8		–																	
Pintail	5.9.59		–			–			–													
	26.8.60		–			–			–													
	4.7.61		–			–			–													
Poplar Pools	6.9.59		–			–			–													
	4.8.61		–			–			–			–										
Portage Country Club	3.9.60		–			–																
	1.8.61		–			–																
Portage Creek	21.6.59	80	2.9	3.5	(8 (	1 –	2 east west		–													
	6.9.59		–			–			–													
	29.8.60	5	1	1		–			–													
	6.8.61		hayed			hayed			hayed													
Portage Slough	6.9.59		–			–			–													
	29.8.60	5	1	1	5	1	1		–													
	6.8.61		–			–			–													
The Pass	25.7.59	60	2	3		–			–													
	9.9.60		–			–			–													
	9.9.61		–			–			–													
Sowls																						
Tin Town	6.9.59	30	1	1.2	5	1	1															
	8.9.60		–			–																
	3.8.61		–			–																
Tin Town Slough	6.9.59		–			–			–			–			–							
	14.9.60		–			–																
	5.7.61		–			–			–													
Torrey's Pothole	2.9.60	5	1	1		–																
	9.8.61		–			–																

	Z1	Z2	Z3	Z4
Total zones	45	44	20	4
" " with Ranunculus	17	5	0	0
% Occurrence	38%	11.4%		
Mean F%	37.4%	5.5%		
Mean cover	1.7	1		

of 6%. It was absent from zones 3 and 4 and had an index of commonness of 1190.

CAREX ATHERODES

This species had a presence of 70%, average frequency of 19% and an index of commonness of 1190. In three sites it was found in zone 1, while in 10 sites it occurred in zone 2 where the highest individual frequency (63%) was recorded, clearly indicating a preference for intermediate habitats. At Chimney and Jackfish Pond *C. atherodes* became established in 1958, the frequency increasing each year to reach 80% and 100% respectively. In 1960 it was co-dominant with *Scolochloa* in zone 2. Only at The Pass did the frequency in this zone diminish, probably due to competition from upland species which had easy access to this site because of its open aspect and frequent traffic along the ridge road. It was most commonly reported in sites with conductivities below 6 mmhos/cm. The mean percent occurrence of *C. atherodes* ranged from 7% in zone 1, to 41% (zone 2), 45% (zone 3) and 50% (zone 4). The frequencies are given in Table XLV. It was most abundant in sites with conductivities below 6.0 mmhos/cm, and was absent from saline areas.

Carex atherodes at Delta flourished where water was above the soil surface for part of the growing season (cp.Tolstead, 1942; Marks, 1942). Harris and Marshall (1963) describe it as one of the three coarse sedges of emergent marshes in contrast to Curtis (1959) who reported *C. trichocarpa* (*C. atherodes*) as a plant of the deepest water. The remarkable ecological amplitude of *C. atherodes* was noted by Moss (1953). It was a leading dominant throughout the entire reedswamp-marsh-wet meadow-low grassland sere in his studies in northwestern Alberta.

TABLE XLV CAREX ATHERODES. Frequency %, Cover and Sociability in all Sites

blank = no sampling
– = non presence

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		–		5	1	1							5	1	1						
	12.9.60		–			–																
	2.7.61		–			–																
Bells	13.8.59		–																			
	16.8.59		–			–																
	9.9.60														–						–	
	3.7.61																					
Cherry Ridge	10.9.60																5	1	2			
	10.8.61																10	1.5	1.5			
Chimney	29.6.59	15	1.3	1.7	32	1.7	2.2															
	8.59		–		40	2	2		–													
	4.8.60		–		55	2	1.6	5	2	2	25	2.4	2.2									
	3.7.61		–		80	1.6	1.6	10	1	1												
Chimney Back Marsh	16.8.58														–							
	9.9.60														–							
Cook Creek	13.6.59														–							
	7.9.59														–							
	19.6.60														–							
	3.9.60														–							
	3.7.61														–							
Flee Island Study Area	19.6.59		–		5	1	1										(5	1	1 shore)			
	11.6.60		–			–															–	
	3.8.61														–							
Flee Island Pothole	19.6.59		–												–						–	
	6.9.59		–			–																
Hutchinsons	10.6.59		–			–												–				
	5.9.59		–			–			–			–										
	10.9.60		–			–																
	7.8.61		–		10	1	1															

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59		-		10	1	1															
	9.9.60		-		53	2.5	2.8															
	10.8.61	20	2.2	2.7	100	3.6	4.3															
Pintail	5.9.59		-			-			-													
	26.8.60		-			-			-													
	4.7.61	15	1	1		-		5	1	1												
Poplar Pools	6.9.59		-			-			-													
	4.8.61		-			-		5	2	2	10	1	1									
Portage	3.9.60		-			-																
Country Club	1.8.61		-		50	1.2	1															
Portage	21.6.59		-			-			-													
Creek	6.9.59		-			-			-													
	29.8.60		-			-			-													
	6.8.61		hayed			hayed			hayed													
Portage	6.9.59		-			-		10	1	2.1												
Slough	29.8.60		-		100	2.7	3.4	100	2.3	2.5												
	6.8.61		-		80	3.8	4.2	76	2.4	2.5												
The Pass	25.7.59		-			-		40	2.1	1												
	9.9.60		-		60	4.1	2.5	70	2	2.4												
	9.9.61		-		25	2.8	2		-													
Sowls	7.9.59																					
	31.7.61														-							
Tin Town	6.9.59		-			-																
	8.9.60		-		5	1	1															
	3.8.61		-		30	1.8	1.8								-							
Tin Town	6.9.59		-			-			-			-			-							
Slough	14.9.60		-			-																
	5.7.61		-			-		25	1	1												
Torrey's	2.9.60		-		35	1.7	1.5															
Pothole	9.8.61		-		45	2	2.1															
Total zones		45			44			20			4											
" " with *Carex*		3			18			9			2											
% Occurrence		7 %			41%			45%			50%											
Mean F%		17%			41%			28%			18%											
Mean cover		1.5			1.9			1.6			1.7											

SCIRPUS VALIDUS

In the emergent marsh at Delta Scirpus validus had a presence of 65%. During 1959 it was recorded in 35% of the samples taken in zone 1, as young plants became established at the water's edge. The same year mature plants were present in zone 3 at Hutchinsons, Portage Creek, Portage Slough, and The Pass, where they indicated the limits of the area in which some plants had survived. This species was not tolerant of deep water and had been eliminated in all but the higher shallow areas. It occurred in 31% of the samples taken in zones 1, 20% of the sample in zone 2 and in 25% of those in zone 3; with respective mean frequencies of 21%, 30% and 28%, and approximately the same cover value in each zone (Table XLVI), showing that this species can grow in emergent conditions for several years. It had an index of commonness of 780.

The most extensive and robust stands of S. validus grew on the lake-shore in waterlogged soil which was partially protected but inundated by wind tides. It was a minor constituent of the developing reedswamp community in a number of sites including Jackfish Pond, Chimney, Hutchinsons and Avocet contrasting with the observations of Moss (1953) who reported it as one of the characteristic species of shoreline vegetation. McAtee (1939) stated that S. validus and its allies were notable for being the first colonizers and silt gatherers of firm, sandy bottoms, but Weaver and Himmel (1930) noted that its growth became progressively poorer as the soil became drier. It did not grow far out into the open water even in the shallow bays at Delta. Probably because it cannot withstand heavy wind or wave action, a feature concomitant with the bays. But it was recorded in water 0.5 m deep in sheltered sloughs (cp. Bird, 1961) and behind the

TABLE XLVI SCIRPUS VALIDUS. Frequency %, Cover and Sociability in all, Sites

blank = no sampling
\- = non presence

Site	Date	Z1 F%	Z1 C	Z1 S	Z2 F%	Z2 C	Z2 S	Z3 F%	Z3 C	Z3 S	Z4 F%	Z4 C	Z4 S	Unzoned Areas F%	C	S	F%	C	S	F%	C	S
Avocet	14.6.59		-			-												-				
	12.9.60		-		10	1.2	2.0															
	2.7.61		-		15	1.4	2.0															
Bells	13.8.59		-																			
	16.8.59		-			-																
	9.9.60																					
	3.7.61														-						-	
Cherry Ridge	10.9.60														-							
	10.8.61														-							
Chimney	29.6.59		-			-																
	8.59	10	1	1																		
	4.8.60		-		10	1.0	1.0		-			-										
	3.7.61		-		10	1.0	1.0		-													
Chimney Back Marsh	16.8.59														-							
	9.9.60														-							
Cook Creek	13.6.59														-							
	7.9.59														-							
	14.6.60														-							
	3.9.60														-							
	3.7.61														-							
Flee Island Study Area	19.6.59		-			-									-						-	
	11.6.60		-			-									-							
	3.8.61														-						-	
Flee Island Pothole	19.6.59		-																			
	6.9.59		-			-																
Hutchinsons	10.6.59		-		25	1	1.7								-							
	5.9.59	40	1	1	20	1	1	90	3	2		-										
	10.9.60	28	2	1.3	85	3.3	2.5															
	7.8.61	15	2	2		-																

TABLE XLVI Continued

Site	Date	Z1			Z2			Z3			Z4			Unzoned Areas								
		F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S	F%	C	S
Jackfish	7.9.59	6	1.7	2	-																	
	9.9.60	-			10	1	1.3															
	10.8.61	5	1	1	-																	
Pintail	5.9.59	45	2.9	2.4	10	1	1	-														
	26.8.60	-			35	2	2.1	-														
	4.7.61	5	1	1	100	2.9	2.6	5	1	1.5												
Poplar Pools	6.9.59	5	1.0	1.0	-			-														
	4.8.61	15	1.5	2.0	-			-			-											
Portage Country Club	3.9.60	-			-																	
	1.8.61	-			-																	
Portage Creek	21.6.59	-			- east - west			32	1.4	1.2												
	6.9.59	-			-			-														
	29.8.60	-			-			-														
	6.8.61	hayed			hayed			hayed														
Portage Slough	6.9.59	30	1	1	10	1	1	10	1	1.4												
	29.8.60	64	1.5	1.2	15	1	1	-														
	6.8.61	-			-			-														
The Pass	25.7.59	-			-			5	1.5	1												
	9.9.60	-			-			-														
	9.9.61	10	2	1	-			-														
Sowls																						
Tin Town	6.9.59	20	1.5	2	-																	
	8.9.60	15	1.5	2	-																	
	3.8.61	5	2	2	-												(among the Phrag.) 30	1.6	1.6			
Tin Town Slough	6.9.59	-			-			-			-			-								
	14.9.60	-			-																	
	5.7.61	-			-			-														
Torrey's Pothole	2.9.60	-			-																	
	9.8.61	-			-																	
Total zones		45			44			20			4											
" " with Scirpus		14			13			5			0											
% Occurrence		31%			20%			25%														
Mean F%		21.3%			30%			28.4 %														
Mean cover		1.7			1.6			1.6														

S. acutus zone in the southern parts of Portage Creek.

It produced an abundance of seed although seedlings were very rarely found on the denuded mudflats. Low and Bellrose (1944) reported that it produced more seed than any other bullrush. A study of the conditions that affect the germination of *Scirpus* seed was made by Isely (1944) and Harris and Marshall (1960b) undertook planting and germination experiments in Minnesota which showed that the highest germination occurred under natural conditions. After "planned" storage no germination took place.

ECOLOGICAL OBSERVATIONS ON SOME OTHER SPECIES

There are several other species which deserve mention because their role in the plant communities.

SCIRPUS ACUTUS

A few sparse clumps of Scirpus acutus survived the high water period at scattered sites throughout the Delta Marsh. Tolstead (1942) and others consider it can grow in water deeper than Phragmites, Martin and Uhler (1939) reported it frequently thriving in water with a depth of one and a half metres.

During this study it had a presence of 40% in the emergent sites examined, and flourished at several places such as Pintail Slough where it was emergent for most of the growing season. However, it was generally found as an emergent anchored hydrophyte (Daubenmire, 1947) in water between 0.5 m and 1.0 m deep, and was characteristic of the bay shores where the bottom was hard. It grew in isolated patches or islands from 2 m to 12 m across and also formed an interrupted offshore zone, sometimes as far as 150 m from the water's edge. This afforded some protection for submerged aquatics as it produced a buffer against wind and wave action. The majority of the S. acutus stands expanded during the study, this was particularly true along the lakeshore, in the sloughs and in shallow open water as at School Bay. S. acutus was reported by Gates (1948) to gradually increase through vegetative growth until a period of extremely low water promoted a spurt in growth - particularly along edges. Many seeds were produced at Delta but no seedlings were ever formed even on emergent mudflats.

SENECIO CONGESTUS

Senecio had a presence of 45% and a mean frequency of 12%. It was always found in zone 1 and generally at the forefront, in shallow water or on soft waterlogged soil. Phragmites rhizomes and associated muck, drift lines, and beaver houses were other suitable places for its establishment. Walker (1959) described its habitat, manner of growth and associated species.

Löve and Löve (1954) mentioned _S. congestus_ as one of the many species of frontier associations, but it was rarely seen prior to 1953, (Personal Communication, P. Ward, 1959). It attained its greatest abundance in 1958, the first year of extensive mud-flat exposure, and showed a marked general decline in each subsequent year, although there were exceptions. During this study, _Senecio_ increased its frequency fourfold at Avocet Marsh (from 7%-30%) which was a marked increase, particularly as the area of muck exposed each summer remained more or less constant. At Chimney, _Senecio_ had a frequency of 2% in 1959 and of 35% in 1961 but the exposed area had increased approximately tenfold. Although denuded mudflats were exposed each year _Senecio_ had a sporadic distribution and its abundance varied greatly from place to place.

With the exception of a few stretches of emergent shore on the northern side of the marsh _Senecio_ was not dominant. Differences from place to place seemed to depend primarily on seed availability, because in neighbouring sites with similar soils and time of drying, it was abundant in one and absent from the other, and the following year rare in both. Harris and Marshall (1963) described _S. congestus_ as a major component of the vegetation on marsh drawdown areas and co-dominant with _Scirpus validus_, _Typha_ spp. and _Eleocharis palustris_ when colonizing mudflats of peat-silt. Although it grew in similar habitats at Delta, in the marsh as a whole it could not be considered as a major component of the vegetation.

"SELECTIVE" SPECIES

The preceding species all were widely distributed throughout the marsh. However, there were others which were restricted to particular areas within the marsh complex. They were selective of the habitat and can be compared in some respects with the exclusive species (restricted to a particular community) of Hanson (1938) or the concept of fidelity of Braun-Blanquet (1951).

Any environmental factor or an interaction of a number of factors may influence marsh plant distribution. These include the type of soil, its physical and chemical nature; drainage and the degree of exposure and isolation of the site. It seems apparent that soil type and conductivity plays a part in restricting the distribution of the selective species. Sampling data indicate one group, tolerant of high conductivities and saline soils, but not found where conductivities have low values, and another group intolerant of saline conditions and found only in low conductivity soils.

Selective species have low presence values, and this is borne out by both groups, though they may be locally dominant in restricted areas. Those intolerant of saline conditions include Galium trifidum, (although a halophytic form is reported by Gleason, 1952), Calamagrostis canadensis, Cicuta maculata, Eupatorium maculatum, and Scutellaria galericulata (species influenced by shading have been omitted), contrasting with those found only in conditions of high conductivity. The latter group contains such species as Glaux maritima, Suaeda maritima, Salicornia rubra, Triglochin maritima, and Puccinellia nuttalliana. In the saline species the highest frequency in any one year was found in Glaux (35%), the lowest in Triglochin (F5%). Wherever saline tolerant species with a restricted distribution were found there was always more than one present. Salicornia and Suaeda were recorded together (Fig.45) and occurred in seven sites: Avocet, Flee Island, Flee

Island Pothole, Portage Creek, Portage Slough, Sowls, and Tin Town. Puccinellia nuttalliana was found with them, and in addition at Pintail Slough and Poplar Pools. With the exception of Portage Slough, these sites had conductivities higher than 5 mmhos/cm, the mean being 14.1 mmhos/cm. Glaux had a presence of 20% and grew particularly in disturbed sites, often associated with Triglochin maritima (Fig.46) Spartina pectinata and Atriplex patula. Spartina represents the last stage in succession from aquatic habitats to wet meadows where it was frequently became dominant, growing in dense stands.

The danger of making generalizations about conductivity from a few soil samples is appreciated particularly where they are known to be variable, but the range between the limits of 0.43 mmhos/cm and 28.73 mmhos/cm is sufficiently wide to have some significance. Despite this range in conductivity some species grew almost everywhere in the marsh exhibiting their tolerance of environmental conditions, and the importance of microenvironmental considerations within a site.

SUBMERGED AQUATIC VEGETATION

Submerged aquatics were present in all the open bays, along the marsh shores, in the potholes and sloughs and often in smaller wet areas such as roadside ditches. Vascular hydrophytes of four types (Daubenmire, 1947) were found - floating, suspended, submerged-anchored and floating-leafed anchored. They were briefly discussed by Löve and Löve (1954), and Walker (1959) commented upon their distribution, but this and their population fluctuations at Delta clearly merited a far more detailed study. A quantitative investigation is at present being undertaken, and will be reported elsewhere, nevertheless some general comments on the aquatic vegetation are pertinent.

Figure 45. Salicornia rubra, Suaeda maritima and Atriplex patula.

Figure 46. Triglochin maritima with Spartina pectinata in the Background. Note Surface Encrustation of Salts on Soil.

Cadham Bay with a maximum depth of 2.0 m is the largest of the open water areas. It and some of the other large bays contained a number of patches of submerged aquatics whose position had remained more or less unchanged since 1954 when the aerial photographs were taken. During this study Potamogeton pectinatus increased in abundance each year to have a frequency of 37% in 1961. It grew in extensive patches particularly in the larger bays where the water was 0.6 to 1.5 m deep, and the bottom was soft. P. vaginatus (F15%), P. pusillus (F.5%), and P. filiformis (F.2%) grew in similar situations. P. richardsonii (F.10%) was widespread but its growth was poor except in the deeper sheltered waters of Portage Creek where it was abundant.

Myriophyllum exalbescens (F.37%) and to a lesser extent M. verticillatum (F.10%) had their highest frequencies in the shallow water at the edge of open shores; they were considerably less abundant in the deeper bays (F.2%). Ruppia maritima was another species confined to shallow water, particularly of potholes and sloughs. Almost contiguous patches of Zannichellia palustris occupied many square metres of the silty, detritus covered bottom in Clandeboye Bay. Elsewhere scattered groups of plants were recorded. The free floating Ceratophyllum demersum was another plant of shallow shores and sporadically reported, while Chara was found only in School Bay and early in the season.

In many shallow water areas a wide variety of floating and filamentous Cyanophyta and Chlorophyta flourished early in the summer and produced extensive floating masses (e.g., Anabaena, Microcystis, Enteromorpha spp., Cladophora and Spirogyra). Cladophora and other species grew as epiphytes on a number of vascular plants, severely reducing their productivity. In a comparable manner Lemna minor virtually obliterated submerged aquatics when it formed a superficial mat over the water surface, and when the water diminished the mat restricted germination in the emergent marsh as did that formed by filamentous green algae. Lemna trisulca was rarely reported, generally in the marginal water of sloughs and potholes.

Two aquatics were found only in artificial situations. Utricularia vulgaris produced a dense growth in potholes on the north side of Cadham Bay, and Ranunculus circinatus flourished in the ditch along the side of the Delta Road. Aquatic vascular plants were far less abundant than expected. This may have been due to a number of factors including the algal growth and increasing turbidity of the water as the season progressed. This obviously affected light penetration which influences aquatic vegetation (Pearsall, 1920, 1929; Pearsall and Hewitt ,1933; Juday, 1934; Wilson, 1935, 1939 and others). Secchi disc readings taken bi-weekly at twenty points substantiated this visual impression. In early June 1964, the bottom of shallow areas was clearly visible while in deeper places the Secchi disc could be seen at 85 cm. At the beginning of July readings had dropped to 70 cm; in the 3rd week to 20 cm and on August 1st to 10-12 cm. The turbidity was influenced by the presence of Carp (Cyprinus carpio) and was considerably affected by adverse weather.

The pH of the water in the marsh ranged from 8.4 - 9; oxygen saturation at the top of the mud and at 10 cm below the surface was measured each week with a 39-592 Y.S.I. Oxygen analyser model 51 complete system with a 39/592/2 oxygen probe and sampler. The range was between 5.0 and 10.0 ppm, the mean 8.9 ppm. The seasonal mean conductivity was 2.96 mmhos/cm (range 1.9 to 4.13 mmhos/cm). The lowest monthly mean was recorded in

May - 2.09 mmhos/cm) and the highest monthly mean in July - 3.58 mmhos/cm (range 2.73 to 4.13 mmhos/cm).

In the submerged aquatic environment the communities may be diverse in their composition and show considerable variation within short distances. The main environmental controls are the nature of the substrate, its chemistry and that of the water, water depth as related to light penetration and water movement, and degree of protection from waves. Various intensities of these factors can interact to influence the local composition of the community. A number of relatively homogenous stands occur in many of the bays and it is somewhat unrealistic to group them together. Nevertheless an indication of the abundance of a species in the marsh as a whole can be gained from the average frequency figures.

SECTION III

SECTION III

SOILS

There are many interpretations of what is meant by soil. The one defined by Dokuchaev (1883) opened the way to a dynamic view of soils, by stating that soils are quite autonomous natural-historical bodies. Since that time the definition of soil has changed many times for example, Glinka, 1927; Rode, 1955; (translated 1962) Carpenter, 1956; Buckman and Brady 1960, and United States Department of Agriculture (USDA), 1960. Comparisons of the last three will show how variable the definition remains. The interpretation of the Soil Conservation Service of the USDA (1960) will be adopted here, it states "soil is the collection of natural bodies on the earth's surface, containing living matter, and supporting, or capable of supporting plants".

The soils of the Delta Marsh as mentioned elsewhere, have been described as peat and muck (Ehrlich et al., 1957). Internationally there is wide variation in the meaning of these terms and a brief discussion is presented here.

In 1924 von Post suggested a graded scale of ten units for measuring the degree of humification of peat and Waksman (1936) reviewed various definitions for peat ranging from Fruh (1883) to Waksman (1929). He used the term to designate a layer of the earth's crust which is largely organic in nature and which has been formed, under certain specific conditions, from plant residues and plant products submerged in water, or from plants growing in very wet environments. Microbial and chemical transformations are involved. In the classification of peat, various features were used: the nature of the plant associations at present growing in the surface of the bog; the nature of the plants which gave origin to the specific type of peat; the relation of peat formation to water level, below or above the surface of the water; the autochthonous or allochthonous nature of the plant residues which gave rise to the peat; the concentration of nutrient elements available to the growing plants; the physical and mechanical properties and the botanical composition of the peat. The major types of peat were then defined as lowmoor, highmoor, forest and sedimentary. A considerable amount of work centered around the nature of peat and many classification systems evolved.

Fraser (1954) considered azonal and intrazonal peats to be characteristic of marshes. The separation of shallow peat from non-peaty humose deposits was somewhat vague; he pointed out the need for clarification in the classification. Appleton (1962) stated that peat is a predominantly organic material, which accumulates under anaerobic conditions and this separates it from other organic soils' horizons. Low temperature and nutrient deficiency reduce microbial activity and favour peat development. In other European countries bog soils are grouped either as oligotrophic, mesotrophic, or eutrophic peats, or as high and low moors.

The generalized systematic list of Russian soils Rode, 1955;(translated 1962) used in survey work and mapping, indicates that there is no satisfactory system of soil classification. It has 21 categories, one which includes marshy soils (No. 4), as follows:

(a) peat marsh soils (of upland marshes)
(b) peat glei soils
(c) peat soils
(d) humus-peat marsh soils (of transitional marshes)
humus-peat glei soils; humus-peat soils
(e) humus-marsh soils (of lowland marshes)
humus-glei soils (dark glei); humus [soils] (slimy glei)

A considerable amount of work has evolved around organic soils in Scandinavia and eastern Europe but it is not discussed here.

Two general groups of soils are recognized in the United States, mineral and organic. The mineral soils have from a trace to 20% organic matter, and organic soils have from 20% to 95% organic material (Buckman and Brady, 1960). Within these two categories there is considerable need for international agreement in relation to soil classification. Proposals in the United States (USDA 1960) differ from those adopted at present in Canada, where the National Soil Survey Committee of Canada (NSSCC) is evolving system for the classification of soils. The NSSCC is attempting to classify organic soils and mineral soils, the latter being divided into six Orders. These are Chernozemic, Solonetzic, Podsolic, Brunisolic, Regosolic and Gleysolic. (NSSCC 5th Report 1963). In this report the designation of soil horizons is explained and details of the classification of the Orders, Great Groups and Subgroups is given.

The symbols used in the brief discussion presented here are as follows: The L-H organic horizons are characterized by an accumulation of organic materials with the decomposition of original structures increasing with depth. The mineral A horizon is in the zone of maximum removal of materials in solution and suspension and of maximum accumulation of organic material. The Ah contains organic matter which has accumulated as a result of biological activity. The mineral C horizon is comparatively unaffected by pedogenic processes, except that of gleying, and the accumulation of dolomite and salts more soluble in water. The Cg is characterized by reduction and gray colours often mottled (gley).

The soils sampled in the Delta Marsh can be classified as a complex of Peaty Saline Rego Humic Gleysols and Organo and Saline Regosols. The latter having a conductivity in excess of the criteria for placing them with the Saline members of the Gleysol Great Group.

Soils of the Gleysolic Order are saturated with water at one or more seasons and the soils develop under hydrophytic vegetation. At Delta this was dominated by *Phragmites*, with *Scolochloa*, *Scirpus* spp. *Typha*, *Carex* spp. and other species tolerant of a pH between 6 and 9. The soils generally have an organic horizon less than 30 cm (12 in) in thickness, a pronounced Ah horizon, although this is sometimes absent, and gleyed C horizons. The soils belong to the Humic Gleysol Great Group. The Ah horizon is more than 7.5 cm thick, has more than 3% organic matter. The colour when rubbed or crushed is darker than 3.5 when moist, and is at least 1.5 units of value darker than the next underlying horizon. The term humic indicates that the organic material is in the most decomposed state, with less than one-third fibre in the total mass and no colour change when rubbed wet. The sodium pyrophosphate extract on white filter paper is lower in value, and higher in chroma than 10YR7/3.

The Rego Humic Subgroup includes soils with a noncalcareous Ah horizon which grades into dull coloured, gleyed soil material, and surface horizons up to 7.5 cm thick (L-H), Ah Cg (Cag), (Ccag). The Saline Humic Gleysol

Subgroup is characterized by soils with a conductivity more than 4 mmhos/cm within 60 cm of the surface, or a salinity exceeding 6 mmhos/cm between 60 cm and 120 cm. It may have up to 15 cm peat on the surface. The soils of this Subgroup should be named either Saline Rego Humic Gleysols or Saline Orthic Humic Gleysols. The Peaty Humic Gleysol Subgroup includes those Humic Gleysols with 15-30 cm compacted muck, peat or both. The Gleysol Great Group is composed of soils that may have a dark coloured surface horizon up to 7.5 cm thick under virgin conditions or when mixed to a depth of 15 cm. It has either less than 3% organic matter or it differs from the next underlying horizon by 1.5 units or less of value when moist. It may have organic horizons not exceeding 30 cm.

The Rego Gleysol Subgroup has an Ah or Ap, Cg or Cg horizon sequence. The Ah if present is less than 7.5 cm under virgin conditions, (L-H), (Ah), Cg (Ckg),(Ccag).

The second Order present in the complex of soils at Delta is the Regosolic Order, with well and imperfectly drained soils lacking discernible horizons or in which development is limited to an organo-mineral surface horizon (Ah) or to organic surface horizons (L-H) less than 30 cm thick. The Organo Regosols ((L-H), (Ah), C) contain a relatively high content of organic matter in the profile as layers or pockets separated by mineral material without visible evidence of salt or gleying; while Saline Regosols contain soluble salts in the parent material. ((L-H), (Ah), Cs - a C horizon with salts including gypsum, which may be detected as crystals, or as surface crusts of salt crystals, or the presence of salt tolerant plants). This classification scheme was not available when the soils were being collected or when they were analysed. If it had been the approach to the soil investigation would have been somewhat different.

METHODS

Soil samples were collected in 1960, from sites where vegetation was sampled. A small pit was dug to a depth well below the rooting area of the plants (Spurway, 1933) where the soil appeared to be uniform, on the basis of structural characteristics and colour. Composite samples (Jackson, 1958; Spurway, 1933) were not obtained because of the time involved and problems of handling, and also because it was thought advisable to collect from as large a number of sites as possible. Frequently the high water table made work difficult. An arbitrary scale describing wetness was applied to the soils: under water; waterlogged (with the water table at the surface throughout the growing season); wet (with the water table just below the surface); mesic (with the water table at the surface during one or more seasons of the year). Samples were separated whenever possible into layers each approximately 15 cm thick on the basis of structural characteristics and colour. Each was numbered and the layers designated, a, b and c. They were stored in numbered plastic bags. The pH and oxidation-reduction potentials were measured on the field moist samples, with a Beckman pocket pH meter and a Beckman Redox potentiometer model N2. The latter readings were taken only on samples collected early in the season because fluctuations in the galvanometer readings were so great they were impossible to interpret.

The soils were air dried, then ground in a porcelain mortar and thoroughly mixed. In many instances it was not possible to adopt the usual practice of passing the dried soil through a 2 mm screen owing to the presence of a high proportion of organic material. The soils were stored in numbered plastic bags, securely tied.

PHYSICAL ANALYSIS

Reagents: 35% Hydrogen peroxide

3% Sodium hexametaphosphate (dispersing agent)

ASSAY OF SAND, SILT, CLAY AND ORGANIC MATTER

A 10 gm sample of air-dried soil was placed in a 600 ml beaker. Approximately 10 ml 35% H_2O_2 was added, stirred and the beaker placed on an electric hot plate at low heat. Hydrogen peroxide in 10 ml aliquots was added and the mixture stirred until an ash-gray appearance indicated that the organic matter had been destroyed. It was heated for a further 30 minutes to remove excess H_2O_2. The sides of the beaker were washed down until there was one inch of water in the beaker and the mixture was left overnight. If the supernatant liquid was clear the excess water was siphoned off, but when turbid this was followed by centrifugation. The mixture was transferred to a tared beaker, dried and weighed. It was then placed in a 600 ml beaker. The organic matter content was calculated from the loss in weight. Ten millilitres 3% sodium hexametaphosphate was added and made up to 500 ml with distilled water. Mixing with a mechanical stirrer followed for 2 to 3 minutes. The mixture was transferred to an 800 ml beaker, triturated, and poured through a 300 mesh sieve into a 1000 ml graduated cylinder and a few millilitres of distilled water was added to the beaker, the sand triturated and the suspension poured off. This was repeated several times, then the sand was transferred to the sieve. Distilled water was added and the sieve gently tapped until all the silt and clay had been removed. It was found that the use of a cork policeman facilitated the processes. The sands were transferred to a tared 100 ml beaker, excess water siphoned off, and the residue dried and weighed. The sands were not separated into their various fractions.

The contents of the graduate cylinder were made up to 1 litre and stirred using approximately twenty strokes of a brass plunger. A 25 ml aliquot was withdrawn from the homogenous suspension and placed in a tared 25 ml beaker, dried and weighed. This gave the weight of the silt and clay in the aliquot. From this the total silt and clay was calculated. Sedimentation of the remainder of the contents continued for an appropriate time as determined by Stoke's Law. A 25 ml aliquot was then taken from a depth of 10 cm, and transferred to a tared 50 ml beaker, dried and weighed to give the weight of clay less than 0.002 mm in diameter in the aliquot. The total clay was calculated. By subtraction, the total silt (0.05 - 0.002 mm) was obtained. The percentages of the different separates were calculated on the basis of the total weight of the separates. Ten ml of the dispersing agent was dried and weighed and the amount in a 25 ml aliquot subtracted from all the silt and clay weights.

SOIL COLOUR

Soils as collected (wet) were described using the Munsell method for determination of soil colour. The hue indicates its relation to red, yellow, green, blue, and purple; the value notation indicates its lightness; and the chroma notation indicates its strength or departure from a neutral of the same lightness (Munsell, 1954).

CONDUCTIVITY

Electrical conductivity measurements were used for the determination of soluble salts. For each sample, a saturation paste extract was prepared by adding distilled water to approximately a 250 gm soil sample while stirring with a glass rod. When saturated, the soil glistened with reflected light and flowed slightly when the container was tipped (Richards et al., 1954). This was allowed to stand for at least an hour and the criteria for saturation were rechecked. Humic soils required overnight wetting to obtain a definite end-point for the saturation paste.

The soil paste was transferred to a Buchner filter funnel with a Whatman No.40 filter paper and suction applied. The filtrate was transferred to a test tube. If the initial filtrate was turbid it was refiltered (Richards et al., 1954). Using a Radiometer (Copenhagen) CDM2 Conductivity Meter and a glass electrode (Radiometer type CDC 104.49) readings were recorded in mmhos and the correction factor supplied with each electrode was applied.

pH

The pH of the soil saturation paste extracted was taken using a Beckman Pocket pH meter and the values compared with those obtained in the field. An abrupt rise in pH with alkaline soils of pH 7.5 and above just before the moisture saturation percentage is reached, is reported by Jackson (1958), but this was not found to occur. The pH values obtained with the saturation paste extracts were closely related to those obtained in the field.

RESULTS AND DISCUSSION OF SOIL ANALYSIS

The summer of 1959 was spent sampling vegetation and collecting data in the sites established for detailed study. Preliminary analysis showed that some plant species were widely distributed and others were confined to certain sites, as had been indicated in 1958 (Walker, 1959). Topography, water conditions, rate of drying and aspect appeared to be more or less constant throughout the marsh, therefore it was decided to investigate some of the edaphic factors and to try and correlate the variations in vegetation with them. Accordingly soil samples were collected. In some sites single samples were taken, in others several were collected in order to have an impression of variation within a site, and between those collected early and late in the season. They were analysed in the field laboratory for water content, pH, conductivity and qualitatively for available anions and cations using the Spurway Tests (Spurway, 1933), the data are available in the University of Manitoba library, but not presented in this thesis. Quantitative chemical analysis and mechanical analysis were undertaken upon return to the University of Manitoba. Calcium, magnesium, sodium, potassium, carbonates, bicarbonates, chlorides and sulphates were determined using the methods advocated by the standard soil analysis manuals (Richards et al., 1954; Atkinson et al., 1958 and Jackson, 1958). Nitrates were not determined quantitatively as the Spurway test showed them to be in adequate supply.

The quantitative analysis showed great variation in both anions and cations. Statistical analysis of anions and conductivity showed a positive correlation with a significant relationship (Fig.47), but there was a great deal of scatter in individual readings. A similar relationship existed between cations and conductivity.

The data from conductivity are indicative of soil conditions and at Delta appear to be more reliable figure to use than those resulting from the detailed analysis of the various anions and cations. This may be due partially to the inapplicability of standard analysis techniques for highly organic soils. The figures resulting from the analysis of cations and anions

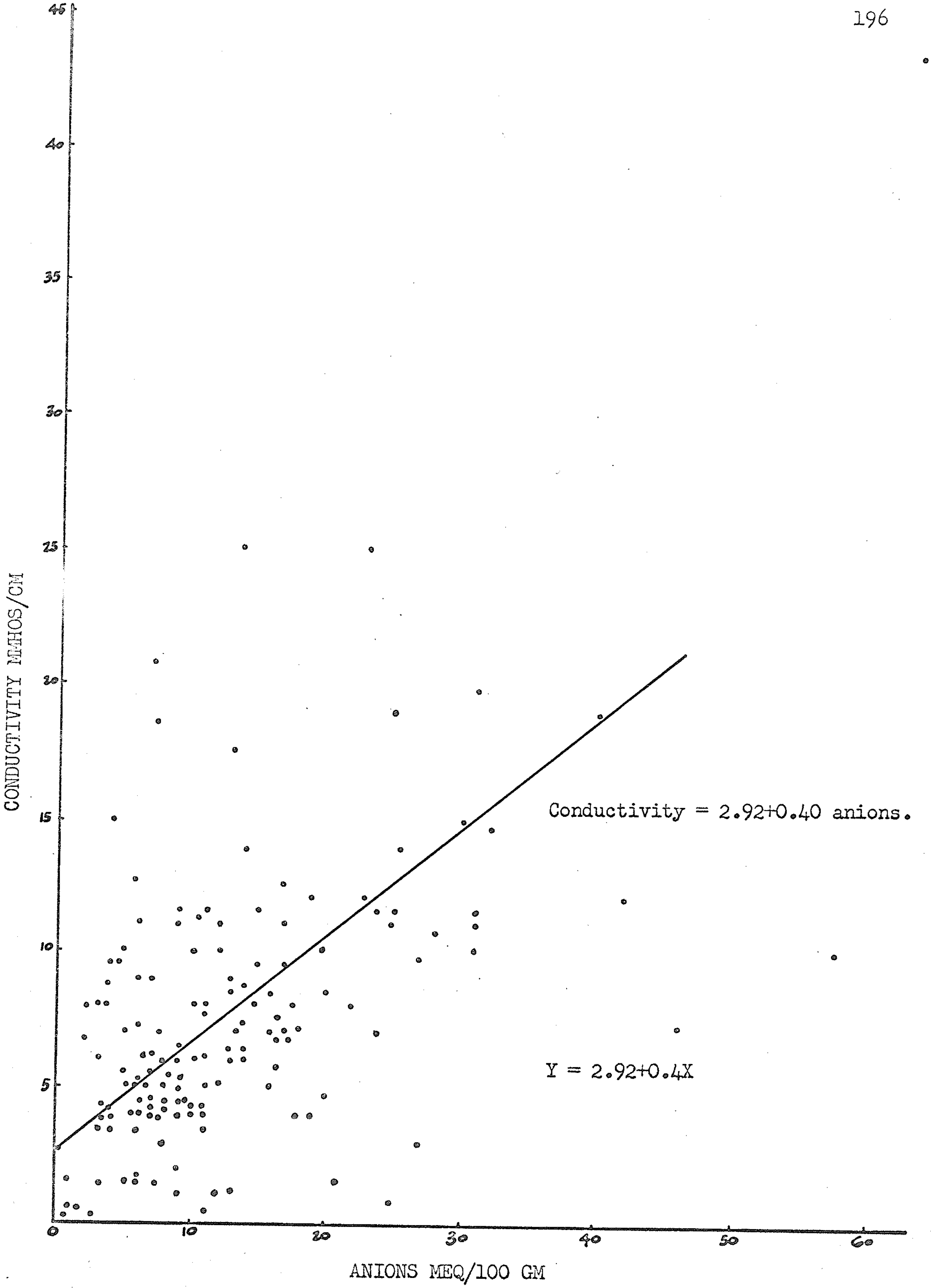

Figure 47. Anions and Conductivity

TABLE XLVII

SOIL ANALYSIS DATA

Particle Size Distribution Analysis, pH, Conductivity and Colour.

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell	Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Conditions
MARSH SHORES										
Chimney Marsh	12.6.60	11a	7.7	0.7	10YR 2/1 Black	23.9	0.1	64.0	12.0	Scolochloa festucacea.
		11b	6.7	0.3	10YR 5/1 Gray	60.7	2.9	1.0	27.2	Carex atherodes. (Waterlogged)
	12.6.60	12a	7.0	0.3	5Y 6/1 gray	25.0	3.4	40.0	32.0	Scolochloa
		12b	7.0	0.3		5.0	80.3	5.2	10.0	Cicuta maculata
		12c	7.8	0.3		10.1	89.9	0	0	(Wet mesic)
Jackfish Pond	10.8.60	42a	7.6	4.0		44.8	10.0	31.6	13.6	Scolochloa
		42b	7.2	4.1		46.1	40.7	1.6	11.6	(Under water)
	"	43a	7.8	3.5	10YR2/1 Black	37.9	6.1	35.2	20.8	Scolochloa
		43b	7.8	4.5	10YR4/1 Dk.Gray	20.0	31.1	36.6	12.3	(West Zone)
		43c	8.0	4.4	10YR2/1 Black	26.7	25.7	35.6	12.0	(Under water)
	"	44a	7.4	5.9	10YR2/1 Black	44.6	16.6	38.8	0	Scolochloa
		44b	7.4	5.5		19.3	64.7	3.6	12.4	(Middle Zone)
		44c	7.3	4.4		27.7	23.1	32.4	16.8	(Water logged)
	"	45a	7.6	5.1	10YR3/1 Very dark gray	61.1	4.5	34.4	0	Scolochloa
		45b	7.5	8.8		46.0	14.0	24.0	16.0	(Top Zone)
		45c	8.4	6.8		4.8	72.8	22.4	0	(Wet)

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Conditions
Decoy Pool	27.8.60	68a	7.3	2.7	5Y 3/1	Very dark gray	41.9	48.9	5.6	3.6	*Chenopodium rubrum* (Wet)
		68b	7.1	3.6			64.4	30.0	4.4	1.2	
		68c	7.2	3.7			63.7	31.0	4.3	1.0	
	"	69a	8.6	3.6	5Y 6/2	Light olive gray	16.7	68.5	14.8	0	*Aster brachyactis* (Wet mesic)
		69b	8.1	2.8			3.8	95.3	0.9	0	
		69c	8.6	2.9			4.2	79.0	12.8	4.0	
Avocet	10.6.60	3s	7.6	10.8			53.8	6.6	22.8	16.8	Sparse *Scolochloa festucacea* (Waterlogged)
		3a	7.3	9.9	5YR2/1	Black	15.2	8.4	3.2	73.2	
		3b	7.5	1.2	10YR2/1	Black	33.9	22.7	35.0	8.4	
		3c	7.6	2.2			27.0	33.0	36.0	4.0	
	28.6.60	21a	6.6	18.8			39.6	1.2	12.8	46.4	*Chenopodium rubrum*
		21b	6.8	8.4			26.0	26.8	21.6	24.8	
		21c	6.6	9.8	25Y2/0	Black	38.8	0.7	26.8	33.6	
	9.8.60	38a	7.1	10.9			76.8	0	23.2	2.8	Bare quadrat (Waterlogged)
		38b	7.0	9.8			24.2	4.6	53.6	17.6	
		38c	7.0	12.4	5Y 4/1	Dark gray	8.0	30.8	51.6	9.6	
	"	39a	8.4	4.1			52.2	4.1	30.4	12.4	Bare shore line (Under water)
		39b	8.4	3.5			72.8	6.0	18.4	2.8	
		39c	7.4	4.5	10YR2/1	Black	34.3	4.8	4.2	19.6	
	"	40a	6.1	10.6			44.3	2.4	32.4	20.8	Counted quadrat (Wet mesic)
		40b	6.2	9.8	10YR2/2	Dark reddish brown	30.2	0.3	33.6	32.8	
		40c	7.2	11.5			26.6	15.4	42.4	15.6	
	"	41s	8.0	30.3			20.7	7.5	44.8	28.0	Bare quadrat (Wet mesic)
		41a	6.5	17.9	5Y 3/1	Very dark gray	20.2	4.2	55.6	20.0	
		41b	6.8	12.6			22.0	9.2	56.0	12.8	
		41c	6.5	13.5			82.6	14.0	1.5	1.8	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Conditions
Avocet	23.8.60	61a	7.1	12.5	5Y 3/1	Very	28.7	12.9	44.4	14.0	Chenopodium
		61b	7.1	19.9		dark	44.2	5.4	41.2	9.2	rubrum
		61c	6.8	19.9		gray	17.3	24.7	44.8	13.2	(Wet mesic)
	"	62a	7.0	17.7	10YR3/1	Very	34.6	3.0	62.4	-	Atriplex
		62b	7.0	17.7	5Y 3/1	dark	16.0	2.8	42.4	38.8	patula
		62c	7.1	20.4		gray	17.0	19.6	53.0	10.4	(Wet mesic)
	"	63a	6.7	26.6	5YR 2/1	Black	45.6	-	32.0	22.4	Aster
		63b	6.5	23.0			40.2	8.2	30.0	21.6	brachyactis
		63c	6.5	25.1			50.5	9.4	30.0	10.0	(Wet mesic)
	4.9.60	102a	7.6	3.9	10YR3/1	Very	54.8	-	31.2	14.0	Water's
						dark					edge
						gray					
	12.9.60	105a	6.8	12.4			41.9	2.4	40.8	14.8	Chenopodium
		105b	7.2	17.8			13.6	6.3	80.0	-	rubrum
		105c	7.4	18.8	5YR 2/1	Black	35.0	6.4	59.0	-	(Waterlogged)
	"	106a	7.8	3.2			49.7	1.5	28.0	20.8	Chenopodium
		106b	7.3	3.3	25Y 3/0	Very	46.1	1.9	38.0	14.0	rubrum
		106c	7.4	3.1		dark	56.8	-	21.6	21.6	(Waterlogged)
						gray					
	"	107a	7.1	2.6			80.1	0.4	19.6	0	Chenopodium
		107b	7.0	2.6			74.2	0.7	17.2	9.8	rubrum
		107c	6.8	2.8	5YR 2/1	Black	39.2	0	30.0	30.8	(Wet mesic)
	"	108a	6.8	17.8			84.3	6.9	8.8	0	Denuded
		108b	6.5	19.6			43.0	0.8	36.0	19.0	quadrat
		108c	7.0	16.7	5Y 2/1	Black	33.0	10.8	41.0	15.2	(Wet)

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Conditions
Avocet	12.9.60	109a	6.6	10.7	5Y 2/1	Black	41.0	0	41.0	16.0	*Chenopodium rubrum* (Wet)
		109b	6.3	13.1			49.0	1.8	26.0	23.2	
		109c	7.4	17.0			22.2	10.9	52.0	14.8	
	"	110a	8.6	14.1	5Y 3/1	Very dark gray	43.5	2.9	39.6	14.0	*Aster brachyactis* (Wet)
		110b	6.4	8.9			57.6	2.8	12.8	26.8	
		110c	6.0	5.7			43.3	4.7	36.0	16.0	
	"	111a	7.0	8.1	5YR 2/2	Dark reddish brown	39.9	13.7	12.8	33.6	*Chenopodium rubrum* (Wet mesic)
		111b	8.5	8.5			38.5	3.1	25.6	32.8	
		111c	6.0	10.7			12.7	21.3	38.4	27.6	
	"	112a	7.4	15.8	10YR2/2	Very dark brown	10.4	3.9	80.8	4.8	Bare quadrat (Wet mesic)
		112b	6.4	19.8			25.2	21.6	35.6	17.6	
		112c	7.4	19.8			17.1	40.8	24.2	14.8	
Sowls	29.8.60	72a	7.6	31.4	7.5YR3/0	Very dark gray	22.8	12.0	32.4	32.8	*Atriplex patula* (Wet mesic)
		72b	7.6	31.9			9.0	16.6	62.4	12.0	
		72c	7.8	22.0			19.4	23.6	44.8	13.2	
	"	73a	7.6	16.9	2.5YR3/0	Very dark gray	37.0	1.8	56.8	4.4	*Atriplex patula* (Wet mesic)
		73b	7.6	21.8			6.4	4.0	3.6	86.0	
		73c	7.7	24.7			42.0	5.3	4.4	48.0	
	"	74a	7.5	18.1	10YR2/1	Black	35.4	5.4	21.6	37.6	*Atriplex Chenopodium* (Wet)
		74b	7.4	20.4			18.5	18.3	46.0	17.2	
		74c	7.7	20.9			7.4	15.4	66.4	10.8	
	"	75a	7.6	14.2	10YR2/1	Black	45.0	3.0	37.6	14.4	*Atriplex patula* (Wet mesic)
		75b	7.6	18.2			0	6.6	77.2	15.2	
		75c	7.6	20.3			8.1	18.7	60.8	12.4	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Sowls	29.8.60	76a	7.6	14.6	10YR3/1	Very	22.7	7.5	60.8	16.0	Atriplex
		76b	7.3	25.3		dark	16.6	7.0	58.4	18.0	patula
		76c	7.5	23.6		gray	23.3	5.7	54.2	16.8	(Wet mesic)
	"	77a	7.6	12.1	2.5Y4/0	Dark	66.1	2.7	15.2	16.0	Atriplex
		77b	7.6	22.0		gray	23.9	6.1	54.4	15.6	patula
		77c	7.7	20.4			27.2	6.8	54.0	12.0	(Wet mesic)
	"	78a	7.7	13.4	10YR2/1	Black	50.9	2.3	26.8	20.0	Chenopodium
		78b	7.7	23.0			6.9	7.5	57.2	18.4	rubrum
		78c	7.7	24.4			44.0	11.2	35.6	9.2	(Wet mesic)
	"	79a	7.6	12.6	10YR2/1	Black	47.7	3.7	32.0	16.6	Chenopodium
		79b	7.6	16.7			17.9	12.1	58.4	11.6	rubrum
		79c	7.9	15.2			39.7	18.7	28.4	13.2	(Wet mesic)
	"	80a	7.6	13.3	5YR 2/1	Black	24.0	2.6	57.2	15.6	Chenopodium
		80b	7.6	16.7			12.5	1.9	55.6	30.0	rubrum
		80c	7.6	17.2			0	4.4	96.6	0	(Wet mesic)
	"	81a	7.4	14.7	10YR2/1	Black	31.2	2.8	49.6	16.4	Chenopodium
		81b	7.5	21.0			94.2	4.0	1.4	0.4	rubrum
		81c	7.4	23.2			21.0	2.3	64.8	11.6	(Wet mesic)
	"	82a	7.2	11.5	5Y 4/1	Dark	35.1	3.6	47.2	14.0	Chenopodium
		82b	7.8	20.1		gray	11.0	7.5	82.8	0	rubrum
		82c	7.8	22.5			89.6	8.5	1.9	0.03	(Wet mesic)
	"	83a	7.4	12.7	10YR2/2	Very	43.0	2.0	40.0	16.4	Chenopodium
		83b	7.6	12.5		dark	0	3.0	57.2	41.0	rubrum
		83c	7.4	13.8		brown	95.9	2.1	1.7	0.3	(Wet mesic)
	"	84a	7.6	27.7	5Y 5/1	Gray	54.0	2.3	26.4	17.2	Bare
		84b	7.5	33.0			39.0	2.2	29.2	39.2	(Wet mesic)
		84c	7.6	22.5			36.0	2.2	47.2	14.4	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Portage Creek	19.6.60	17a	7.8	4.0	5Y 2/1	Black	34.6	0	62.0	3.4	Senecio congestus
	"	18a	7.9	7.52	10YR2/1	Black	28.2	1.8	40.0	30.0	Scolochloa (Permanent quadrat) (Waterlogged)
		18b	7.7	12.6			51.0	3.0	34.0	12.2	
	"	19a	7.4	13.9	2.5Y4/0	Dark gray	17.2	6.8	28.0	48.0	
	"	19b	7.8	14.1			0	37.0	50.0	15.0	Scolochloa (Under water)
		19c	7.8	8.1	Water						
	"	20a	7.4	22.5	7.5YR4/0	Dark gray	7.0	10.0	31.0	52.0	Puccinellia (Wet)
		20b	7.9	18.7			10.5	13.5	32.0	44.0	
	29.8.60	85a	8.1	16.9	5Y 4/1	Dark gray	30.0	12.5	41.6	16.8	Atriplex patula (Wet mesic)
		85b	7.9	18.7			27.0	24.6	44.0	4.0	
		85c	7.8	13.2			0	32.7	40.0	28.2	
	"	86a	7.8	11.7	5Y 4/1	Dark gray	60.2	18.6	5.9	15.2	Hordeum jubatum (Wet mesic)
		86b	7.9	15.6			28.0	15.4	4.8	50.0	
		86c	7.9	10.5			49.0	1.4	36.1	14.0	
	"	87a	7.8	6.0	10YR4/1	Dark gray	54.0	3.1	21.6	21.2	Scolochloa (Permanent quadrat) (Wet mesic)
		87b	7.5	12.0			32.4	1.2	66.4	0	
		87c	7.4	6.3			9.0	18.1	67.6	6.4	
	"	88a	7.8	5.5	7.5YR4/0	Dark gray	54.0	2.1	28.8	15.2	Scolochloa (Mesic)
		88b	7.0	13.1			30.0	2.7	53.0	14.8	
		88c	8.0	13.9			27.0	15.3	41.6	16.8	
Tin Town	5.8.60	30a	7.8	4.6			51.0	0	46.8	2.2	Senecio congestus (Waterlogged)
		30b	7.6	4.3			63.0	0	27.4	9.0	
		30c	7.8	4.0			6.7	10.1	47.4	35.8	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Tin Town	5.8.60	31s	7.6	12.7			4.0	7.2	88.8	0	Scirpus paludosus (Waterlogged)
		31a	7.4	11.3			47.4	2.2	30.0	20.4	
		31b	7.2	10.8			39.5	18.1	10.0	32.0	
		31c	7.0	9.0			1.4	74.6	20.0	4.0	
	"	32a	7.6	2.3	5Y 4/1	Dark gray	28.7	0	69.3	2.0	Water's edge muck (Underwater)
	"	33a	7.4	5.8	5Y 4/1	Dark gray	11.4	8.2	60.0	20.4	Chenopodium rubrum (Waterlogged)
		33b	7.4	4.0			2.6	10.6	65.6	11.2	
		33c	7.4	4.2			16.4	18.8	58.8	16.0	
	"	34a	7.5	4.8	10YR3/1	V.dk.gray	24.4	0	56.4	19.2	Chenopodium (Wet)
		34b	7.6	4.6	10YR2/1	Black	11.0	8.9	64.8	16.0	
		34c	7.6	3.3	10YR4/1	Dk.gray	51.6	7.2	9.0	32.2	
	4.9.60	98a	7.1	4.7	5Y 3/1	Very dark gray	17.0	1.8	56.8	24.4	Scirpus paludosus (Wet mesic)
		98b	7.0	6.1			19.7	4.9	61.2	15.2	
		98c	7.0	6.3			54.9	11.9	14.8	18.4	
	"	99a	7.0	2.5	5YR 2/1	Black	53.0	1.4	19.2	26.4	Senecio congestus (Wet mesic)
		99b	7.0	3.8			63.1	1.9	13.0	22.0	
		99c	7.0	5.8			33.3	2.3	48.4	16.0	
	"	100a	7.6	2.4	5Y 4/1	Dark gray	23.7	6.8	54.0	15.6	Water's edge (Under water)
	"	101a	7.5	4.6	5YR 2/1	Dark gray	19.8	6.1	35.6	38.4	Chenopodium rubrum (Wet mesic)
		101b	7.4	4.1			31.4	9.4	44.0	15.2	
		101c	7.4	4.9			28.7	11.9	47.6	10.8	
Flee Island Study Area	11.6.60	8a	8.2	14.7	5Y 2/1	Black	12.5	11.5	56.0	20.0	Scolochloa festucacea (Waterlogged)
		8b	8.0	12.9			30.0	0	62.0	8.0	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Flee Island Study Area	11.6.60	9a	8.5	2.8	5Y 4/1	Dark gray	48.6	2.6	32.8	16.0	Landing stage
		9b	8.5				46.0	1.2	10.0	42.8	
		9c					33.0	19.8	43.6	3.6	<u>Phragmites</u> (Under water)
	2.8.60	27a	7.6	11.7	7.5YR3/0	Very dark gray	43.3	18.7	35.6	2.4	<u>Puccinellia nuttalliana</u> (Wet mesic)
		27b	7.4	9.6			36.8	21.2	40.2	1.8	
		27c	7.2	9.4			17.2	64.8	17.6	0.4	
	"	28a	7.8	25.3	2.5YR2/0	Black	7.7	64.0	28.0	0.3	Mixed species (Wet mesic)
		28b	7.9	20.8			40.8	45.3	13.2	0.7	
		28c	7.7	12.2			0	50.0	39.0	11.0	
	"	29a	7.6	17.8	10YR2/1	Black	42.7	13.2	42.2	1.8	<u>Scolochloa festucacea</u> (Wet mesic)
		29b	7.5	18.5	5Y 3/1	V.dk.gray	49.0	17.0	33.0	1.0	
		29c	7.6	15.8	5Y 3/1	V.dk.gray	19.0	60.0	14.0	7.0	
POTHOLES Cook Creek	10.6.60	2a	8.0	12.3	5Y 3/1	Very dark gray	11.3	35.4	53.2	0	<u>Scolochloa festucacea</u> (Waterlogged)
		2b		12.6			4.7	67.2	12.4	15.2	
	14.6.60	13a	7.8	4.2	5YR2/1	Dark reddish brown	12.0	0	48.0	40.0	Bare (Underwater)
		13b	7.8	7.5			7.9	20.9	37.2	34.0	
	22.7.60	22a	6.4	4.1	2.5YR2/0	Black	46.4	0	32.4	21.1	<u>Chenopodium</u> (Wet).
		22b	6.6	4.8			50.8	0	17.2	32.0	
		22c	7.3	5.3			20.2	22.5	44.8	12.4	
	"	23s	7.3	5.1	10YR2/1	Black	12.2	0	70.0	18.8	<u>Aster brachyactis</u> (Wet mesic)
		23a	7.2	4.8			0	15.9	70.6	14.4	
		23b	7.3	5.6			0	25.4	75.2	0.8	
		23c	7.3	6.17			7.5	31.3	35.2	26.0	
	"	24a	7.4	11.6	10YR4/1	Dk.gray	47.3	2.3	32.0	18.4	<u>Atriplex patula</u> (Wet mesic)
		24b	7.7	12.58	10YR2/1	V.dk.brn	29.6	32.8	24.4	13.2	
		24c	7.8	14.12	5YR 4/1	Dk.gray	5.7	56.0	25.0	13.2	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Cook Creek	22.7.60	25a	7.1	12.1	5Y 3/1	Very dark gray	32.1	6.1	31.2	29.6	* Bare (Wet mesic)
		25b	7.4	10.6			6.7	45.9	34.4	12.8	
		25c	8.1	12.1			9.2	63.6	22.6	5.2	
	"	26a	7.8	36.6	2.5YR5/0	Gray	15.4	39.4	41.6	3.6	
		26b	8.0	25.1			11.7	35.5	38.8	14.0	
		26c	8.0	12.6			15.0	50.6	34.4	0	(Wet)
	20.9.60	96a	7.4	5.2	5YR 3/1	Very dark gray	52.6	2.0	27.0	18.0	Chenopodium rubrum (Wet)
		96b	7.2	6.3			41.7	8.2	33.6	16.0	
		96c	7.6	6.8			49.8	1.4	38.8	10.0	
	"	97a	7.7	8.8	7.5YR3/0	Very dark gray	35.9	3.3	44.0	16.8	Chenopodium rubrum (Wet mesic)
		97b	7.4	8.4			56.7	4.5	21.6	17.2	
		97c	8.0	6.5			25.0	33.8	32.8	8.4	
Torrey's Pothole	14.6.60	15a	8.0	2.7	5Y 6/2	Light gray	40.8	17.0	22.0	20.0	Typha latifolia (Waterlogged)
		15b	8.1	2.3			37.3	21.9	14.0	26.8	
Bells	10.6.60	1a	8.6	4.9	5YR 2/2	Dark reddish brown	23.2	4.8	40.0	32.0	Chenopodium rubrum (Waterlogged)
		1b	7.2	4.6			48.9	7.5	40.0	3.6	
		1c	7.4	8.9			19.1	13.1	62.6	5.2	
	12.8.60	51a	7.0	8.4	10YR2/1	Black	36.0	5.4	32.0	26.5	Chenopodium Atriplex (Wet)
		51b	6.8	6.5	10YR3/1	V.dk.gray	41.0	24.0	34.8	0.1	
		51c	7.3	7.0	10YR3/1	V.dk.gray	3.5	50.4	28.6	17.6	
	"	52s	7.4	7.3		Very dark gray	61.6	-	13.2	25.2	Chenopodium rubrum (Wet)
		52a	7.4	7.9			30.6	17.8	42.0	9.6	
		52b	7.7	9.4			8.6	39.8	43.2	8.4	
		52c	7.5	8.4			31.8	9.4	30.8	2.8	
	1.9.60	95a	8.0	8.8			49.0	4.6	37.6	8.8	Chenopodium rubrum (Wet mesic)
		95b	7.6	8.0			51.7	8.3	29.6	10.4	
		95c	8.0	8.2	5Y 5/2	Olive gray	14.1	33.5	42.4	10.0	

TABLE XLVII Continued

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Hutchin-	10.6.60	5a	8.3	3.6	5YR 2/1	Black	38.7	6.1	43.6	11.6	Scolochloa
sons		5b	7.5	2.9			42.0	2.8	40.8	14.8	festucacea
											(Waterlogged)
	11.8.60	48a	7.5	7.9	10YR2/1	Black	72.8	5.2	21.8	0.2	Scirpus
		48b	7.5	5.5	10YR2/1	Black	76.0	11.6	8.0	2.0	validus
		48c	7.5	5.8	10YR3/1	V.dk.gray	27.1	27.2	31.2	14.4	Typha
											Scolochloa
											(Waterlogged
	"	49a	7.2	7.6		Dark	52.7	11.3	0	36.0	Scolochloa
		49b	7.4	4.8	5Y 4/1	gray	12.2	26.6	50.6	10.6	festucacea
		49c	6.8	3.6			39.3	53.1	7.6	0	(Wet)
	"	50a	7.4	13.4	2.5YR2/0	Black	82.9	12.3	3.9	1.1	Hordeum
		50b	7.4	3.66			37.0	6.8	57.2	0	jubatum
		50c	7.3	1.93			12.7	44.5	18.8	24.0	
Portage Country Club	10.6.60	6a	7.8	7.9	10YR3/1	Very dark gray	71.0	1.5	17.6	10.6	Scolochloa
		6b	7.4	13.5			25.0	15.0	40.0	20.0	festucacea (Wet)
Flee Island Pothole	11.6.60	10a	7.9	27.2	5Y 4/1	Dark	13.2	42.8	32.0	12.0	Chenopodium
		10b	7.6	22.5		gray	35.8	12.2	40.0	12.0	rubrum
											(Waterlogged)
	1.9.60	93a	7.4	54.5	5Y 4/1	Dark	16.5	23.1	56.8	3.6	Bare
		93b	8.0	43.5		gray	3.8	35.0	52.0	9.2	(Wet mesic)
		93c	8.4	25.3			10.6	31.8	42.0	15.6	
	"	94a	8.0	14.7	5Y 4/1	Dark	8.8	28.0	63.2	0	Edge of
		94b	7.7	19.8		gray	18.8	12.8	58.4	10.0	vegetation
		94c	7.6	22.4			0.1	22.9	77.0	0	(Wet mesic)
Chimney Back Marsh	10.8.60	47a	6.0	0.6	5YR 3/0	Very	31.9	49.3	18.4	0.4	
		47b	6.4	1.9		dark	49.1	37.7	6.0	7.2	Carex
		47c	6.4	0.4		gray	6.9	49.1	6.8	37.2	retrorsa (Waterlogged)

TABLE XLVII Continued.

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell		Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Chimney Back Marsh	27.8.60	70a	6.4	0.9	5Y 6/1	Gray	34.5	4.7	60.8	0	Mixed species *Lycopus* *Carex* *Atherodes* *Bidens* (Waterlogged)
		70b	6.8	1.8			46.2	33.0	20.8	0	
		70c	8.0	1.2			8.4	79.0	12.4	0.2	
	"	71a	6.8	0.6	5Y 3/1	Very dark gray	59.8	33.0	0	7.2	Mixed species (Waterlogged)
		71b	6.4	0.7			35.7	45.9	18.4	0	
		71c	7.8	0.3			53.8	34.2	3.2	8.8	
SLOUGHS											
Pintail Slough	9.8.60	35a	6.3	6.6	2.5Y3/0	Very dark gray	41.8	9.6	6.4	42.2	*Chenopodium rubrum* seedlings (Wet mesic)
		35b	6.4	4.6			1.3	1.5	54.0	44.4	
		35c	6.5	3.9			8.1	4.9	48.0	39.0	
	"	36a	6.4	6.3	2.5YR4/0	Dark gray	0.9	4.1	60.8	34.2	*Chenopodium* *Scirpus validus* (Wet mesic)
		36b	6.4	2.9			30.0	0	66.0	4.0	
		36c	6.4	2.7			12.6	6.6	55.6	25.2	
	"	37a	6.6	7.5	10YR2/1	Black	31.0	8.1	61.0	0	*Scirpus validus* (Waterlogged)
		37b	6.5	6.0			25.0	3.1	48.0	24.0	
		37c	6.5	5.8			23.8	0.9	45.6	29.6	
	12.9.60	113a	6.6	15.1	2.5Y4/0	Dark gray	45.0	2.5	25.0	27.0	*Chenopodium rubrum* (Wet)
		113b	6.2	8.9			40.1	0.7	44.0	15.2	
		113c	6.4	7.0			19.0	3.3	66.0	11.0	
	"	114a	6.8	11.5	5YR 2/1	Black	90.6	0.2	1.2	0	*Chenopodium* *Scirpus validus* (Wet)
		114b	6.6	8.2	5YR 2/1	Black	45.5	3.7	43.8	7.2	
		114c	6.5	6.7	5YR 4/1	Dk.gray	17.1	4.1	64.4	14.4	
	"	115a	6.4	9.7	10YR3/1	Very dark gray	25.8	3.4	58.2	11.6	*Scirpus validus* *Scolochloa* (Wet)
		115b	6.6	10.0			35.2	3.6	26.8	33.6	
		115c	6.4	9.9			31.2	4.4	31.2	33.6	

TABLE XLVII Continued.

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell	Particle Size Distribution Organic %	Sand %	Silt %	Clay %	Condition
Portage Slough	19.8 60	55a	7.7	5.0		60.2	6.6	18.0	15.2	Bare
		55b	7.2	2.8		61.5	3.8	30.7	4.0	(Waterlogged)
		55c	7.4	2.6		52.7	10.5	31.6	5.2	
	"	56a	6.3	2.3	2.5YR3/0 Very	49.6	18.3	32.1	0	Scolochloa
		56b	6.9	2.5	dark	43.8	35.4	20.8	0	festucacea
		56c	7.0	2.1	gray	63.5	15.0	10.0	11.0	(Waterlogged)
	"	57a	7.8	3.7	2.5Y 3/0 Very	7.3	60.0	8.7	24.0	Sonchus
		57b	7.4	2.9	dark	4.0	78.0	12.0	6.8	Scirpus
		57c	7.6	2.2	gray	0	80.0	0	22.0	acutus (Wet mesic)
	"	58a	7.6	4.4	5YR 2/1 Black	49.7	12.5	28.7	9.1	Scolochloa
		58b	6.3	4.8	5YR 2/1 Black	48.1	9.9	27.6	14.4	festucacea
		58c	7.4	1.4	10YR4/2Dk.gr.brn.	22.8	66.8	8.4	2.0	(Mesic)
Poplar Pools	17.8.60	53a	6.8	8.4	7.5YR4/0 Dark	34.8	6.0	26.4	32.8	Chenopodium
		53b	6.6	4.2	gray	53.2	32.8	10.0	4.0	rubrum
		53c	7.4	4.4		0	72.5	24.8	3.2	(Waterlogged)
	"	54a	7.0	9.1	10YR 2/1 Black	71.9	21.2	6.0	2.0	Scolochloa
		54b	7.3	4.6	10YR4/1 Dk.gray	25.2	68.0	5.0	2.6	Scirpus
		54c	7.2	7.9	10YR4/1 Dk.gray	3.4	48.0	38.0	9.6	validus Chenopodium (Waterlogged)
	12.9.60	103a	7.1	5.9	10YR3/1 Very	57.9	7.3	2.0	32.8	Chenopodium
		103b	7.4	5.8	dark	38.7	6.9	30.4	24.0	rubrum
		103c	7.5	4.7	gray	28.6	6.7	35.2	29.6	(Wet)
	"	104a	7.1	5.8	2.5YR3/0 Very	52.0	15.0	16.0	17.0	Scolochloa
		104b	6.8	5.8	dark	31.1	3.2	61.6	4.0	festucacea
		104c	7.6	4.9	gray	2.2	52.4	39.0	6.4	(Wet mesic)

TABLE XLVII Continued.

Site	Date	Sample Number	pH	Conductivity mmhos/cm	Colour Munsell	Particle Size Distribution Organic%	Sand %	Silt %	Clay %	Condition
Tin Town Slough	11.6.60	7a	7.5	5.9	2.5YR3/0 Very dark gray	44.8	0.2	16.0	40.0	Sparse *Scolochloa* *Phragmites* (wet)
		7b	7.6	6.8		77.1	18.5	0.4	4.0	
	20.8.60	59a	6.8	8.4	10YR 2/1 Black	27.9	5.3	34.4	32.4	Bare (Waterlogged)
		59b	6.6	10.8	10YR4/1 Dk.gray	29.8	6.2	57.2	6.8	
		59c	7.0	9.2	10YR4/1 Dk.gray	28.4	8.0	25.2	38.4	
	"	60.a	6.8	7.0	7.5YR2/0 Black	50.8	4.2	32.0	13.0	*Scolochloa festucacea* (Wet)
		60b	6.6	7.0		14.2	9.0	40.8	36.0	
		60c	7.2	8.4		0	14.0	35.0	51.0	
Lake-shore	10.8.60	46a	7.8	2.0	5Y 6/1 Gray	0	88.8	22.0	0	*Scirpus americanus*
		46b	7.9	2.1		0.1	51.1	43.6	5.2	
		46c	8.1	2.1		0.2	99.8	0	0	
Clande-boye channel	27.8.60	67s	7.6	0.7	5Y 6/1 Gray	45.0	39.4	11.6	4.0	*Typha latifolia* (Waterlogged)
		67a	7.6	1.0		56.6	42.7	0.4	0	
		67b	7.5	1.2		7.3	84.7	5.6	2.4	
		67c	7.4	3.7		7.9	74.9	15.6	1.6	

TABLE XLVIII. PARTICLE SIZE DISTRIBUTION AND ORGANIC MATTER
(a) Mean % Organic, Sand, Silt, and Clay per Sample
(b) Mean % Sand, Silt and Clay (Excluding Organic Material).

	Site	A Mean % Organic, Sand, Silt and Clay Per Sample				B Mean % Sand, Silt and Clay (Excluding Organic Material)		
		% Org.	% Sand	% Silt	% Clay	% Sand	% Silt	% Clay
1.	Chimney	27.8	29.7	25.8	16.8	34.6	40.4	25.0
2.	Jackfish	35.4	27.9	26.1	10.7	43.6	39.8	16.6
3.	Decoy Pool	31.4	58.7	8.5	1.5	85.0	12.0	2.8
4.	Avocet	39.6	7.9	35.2	17.3	12.1	57.4	30.4
5.	Sowl's	31.1	7.1	43.8	18.1	9.9	63.8	26.3
6.	Portage Creek	28.1	10.7	40.0	21.5	14.0	56.7	29.3
7.	Tin Town	29.1	7.9	46.6	16.4	10.5	65.4	24.0
8.	Flee Island Study Area	29.9	26.3	35.1	8.7	36.7	50.0	13.3
9.	Cook Creek	22.9	24.1	36.7	16.3	28.6	48.2	22.1
10.	Torrey's Pot-hole	39.1	19.5	18.0	23.4	32.0	29.6	38.4
11.	Bell's	32.1	16.9	37.1	13.9	24.2	54.8	20.5
12.	Hutchinson's	44.5	17.7	27.1	10.7	31.9	49.5	18.6
13.	Portage Country Club	48.0	8.3	28.8	13.4	15.9	54.8	29.2
14.	Flee Island Pothole	14.7	26.2	50.8	8.3	31.1	58.9	10.0
15.	Chimney Back M.	36.3	40.7	16.3	6.8	64.8	24.6	10.6
16.	Pintail Slough	29.6	3.6	44.8	22.1	5.1	63.6	31.3
17.	Portage Slough	38.6	33.1	19.0	9.5	47.3	37.8	14.9
18.	Poplar Pools	33.2	28.4	24.5	14.0	41.4	36.6	22.0
19.	Tin Town Slough	37.1	8.3	27.7	27.1	13.2	43.9	42.9

are so variable that they are not included in the main part of this thesis but in Appendix II. Also determined were the organic, sand, silt and clay fractions. The results of the mechanical analysis are presented in Table XLVII together with pH, conductivity and colour ratings. The water content of the soils was consistently high and the data are not presented.

From the mechanical analysis data calculations were made showing the percentage of organic matter, sand, silt and clay per layer (Table XLVII), and the mean percentage of organic matter, sand, silt and clay per site, and the percentage of sand, silt and clay excluding organic matter (Table XLVIII). From the latter can be gained some indication of texture by the standard techniques (Buckman and Brady, 1961). The following list indicates the range in textural classes found in the soils examined.

Textural Class	Site
loamy sand	Decoy Pool
sandy loam	Chimney Back Marsh
loam	Chimney, Jackfish Pond, Poplar Pools, Portage Slough
silt loam	Avocet, Bells, Cook Creek, Flee Island Study Area, Flee Island Pothole, Hutchinsons, Portage Country Club, Sowls, Tin Town
clay loam	Torrey's Pothole
silty clay loam	Pintail, Portage Creek
silty clay	Tin Town Slough

It does however seem somewhat unrealistic to eliminate the organic fraction which contributes such an important part to the soil, and which in many instances masks the mineral components. Figure 48 indicates the distribution of organic material, sand, silt and clay in the soils examined, using the

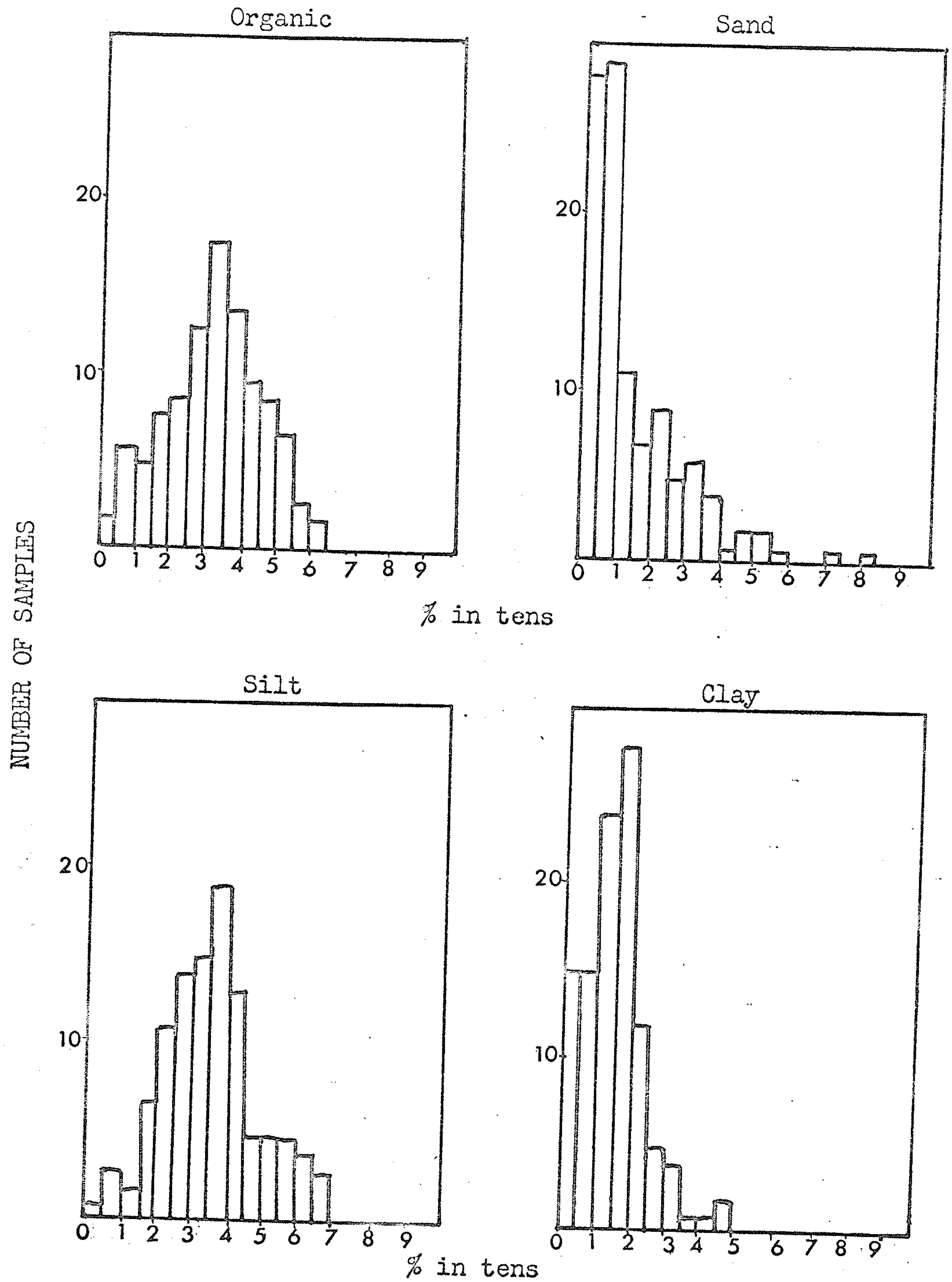

Figure 48. Histogram of Total Organic, Sand, Silt and Clay Using the Data from All the Sites.

data from all the sites. Means and standard deviations were calculated for each whole sample and these serve to emphasize how variable is the soil, as do the minimum, maximum and mean conductivities for all the sites which are summarized in Table XLIX. From the soils data the following accounts have been summarized in order to give an indication of some of the soil characteristics in the sites examined, in which the soils are a complex of Peaty Saline Rego Humic Gleysols and Organo and Saline Regosols.

TABLE XLIX. Minimum, Maximum and Mean Conductivities for all Sites.

Site	Number of Samples	Min.	Max.	Mean
Chimney	5	0.21	0.65	0.34
Jackfish	11	3.54	8.8	5.18
Decoy	6	2.72	3.66	3.21
Avocet	55	1.19	30.30	12.12
Sowls	39	11.5	33.00	19.64
Portage Creek	20	4.00	22.50	12.23
Tin Town	24	2.25	12.7	5.25
Flee Island Study Area	11	9.40	25.30	15.33
Cook Creek	26	4.14	36.60	9.10
Torrey's Pothole	2	8.00	8.1	8.05
Bells	12	4.92	9.42	7.63
Hutchinsons	14	0.52	13.40	3.29
Portage Country Club	2	7.87	13.49	9.68
Flee Island Pothole	19	9.40	54.50	28.73
Chimney Back Marsh	9	0.32	1.95	0.95
Pintail	9	2.71	7.45	5.13
Portage Slough	12	1.35	4.97	3.05
Poplar Pools	12	4.2	9.10	5.94
Tin Town	8	5.85	10.77	7.92

MARSH SHORES

CHIMNEY, JACKFISH POND AND DECOY POOL

These sites are considered together as they have similar physiographic features and vegetation. Soils were collected from the two zones of vegetation at Chimney Marsh in June, from four zones at Jackfish Pond and two zones at Decoy Pool in August. The pH ranged from 6.7 to 8.6, the mean being 7.6. The mean conductivities were 0.34 mmhos/cm at Chimney; 5.18 mmhos/cm at Jackfish and 3.21 mmhos/cm at Decoy Pool, the details are given in Table XLVII.

Sample 11 from the Scolochloa zone at Chimney: Peaty Rego Gleysol.

0 - 4 cm organic, humic, black, 10YR2/1
4 - 34 cm organic, humic, slightly more mesic with depth black, 10YR2/1
35 - 50 cm sand, dark stained, grayish brown, 10YR5/1

The thickness of the organic layer overlying the sand varied from 25 to 54 cm in the samples examined, but was only partially consolidated. At Jackfish there was a clear stratification in the soil as shown in Figure 49:

Sample 44 from the Scolochloa zone; Peaty Saline Rego Gleysol

0 - 30 cm organic with abundant roots, black, 10YR2/1
30 - 40 cm sand dark gray, 10YR4/1
40 - 46 cm organic, humic black, 10YR2/1
46 + cm sand, dark gray 10YR4/1

AVOCET MARSH

In Avocet Marsh 18 samples were collected between June and September (Table XLVII). Considerable variation existed in the area. Sample 3 had the (c) layer with a conductivity of 1.1 mmhos/cm while the upper layers were (a) 10.8 mmhos/cm and (b) 9.95 mmhos/cm indicating that salts had been drawn towards the surface and deposited there. Sample 21, from an area of young Chenopodium rubrum seedlings, had comparable but higher conductivities, layer (a) 18.8 mmhos/cm (b) 8.36 mmhos/cm and (c) 9.84 mmhos/cm, while sample 39 from the water's edge had lower conductivities, namely layer (a) 4.09 mmhos/cm, (b) 3.53 mmhos/cm, (c) 4.54 mmhos/cm. Of the eighteen samples, six had an

Scale is 15 cm long.

Figure 49. Peaty Saline Rego Gleysol from Jackfish Pond. (L-H Cg)

organic content of more than 70%, with an overall mean of 36.9%. Silt predominated in some samples, for example sample 112 contained 80%, but the mean was 33.9%, while sand and clay were both less than half this.

Sample 3 in sparse Scolochloa festucacea. Saline Organo Regosol

0 - 4	cm undecomposed litter, Scolochloa leaves and culms etc.
4 - 18	cm organic material becoming more decomposed with depth, mesic, humic black (5YR2/1)
18 - 48	cm silty with some organic material, dark stained, humic, black (10YR2/1)

SOWL'S MARSH

Thirteen soil samples were collected from the area north of the disused railway line in August. They were analyzed for pH, conductivity, organic matter and particle size distribution. The pH ranged from 7.2 to 7.9 with a mean of 7.6, and the conductivities showed a considerable variation, from 11.5 mmhos/cm to 33.0 mmhos/cm with a mean of 19.64 mmhos/cm (Table XLIX). The content of organic material, sand, silt and clay varied greatly, even when conditions appeared similar, samples were neighbouring and only one species of plant was involved. The mean organic content was 39.7% and in most of the samples the major part of the organic material was in the (a) and (b) layers. Table XLVII gives the analysis figures. Particular attention was paid to the soils beneath two of the dominant species, Atriplex patula and Chenopodium rubrum which grew in pure patches of various size, (from approximately 2 m^2 to 16 m^2).

The mean value for the organic content of the (a) layers was calculated separately because it is in this layer that the maximum root penetration occurs, and it was thought that if there had been a marked difference it might be responsible for the vegetation pattern. However, no difference

	Number of samples	Average % organic (%) layer a	(%) layer b	(%) layer c	sand	silt	clay	pH	Conductivity mmhos/cm
Atriplex patula	6	[38.7	11.2	24.0]					
			24.9		8.1	45.6	22.1	7.6	21.04
Chenopodium rubrum	6	[38.6	23.7	48.4]					
			36.9		5.5	44.6	13.0	7.6	17.34

was detected in the (a) layers, the mean silt content or in the pH, and the data from the very small number of samples examined suggests that there is little difference in composition of the soils beneath the two species. The soils are a complex of Saline Organo Regosols.

PORTAGE CREEK

The marshy region between Portage Creek and Poplar Pools was sampled in June and in August. The pH varied from 7.0 to 8.1 with a mean of 7.7 (8 samples). There was a wide range in the conductivity of the layers, from 4.0 mmhos/cm to 22.5 mmhos/cm.

The percentage organic content ranged from 7% to 60%, thereby being lower than in some sites, while the silt and clay were higher than in many sites. The silt content ranged from 5-68% and the clay content from 0-52% (Table XLVII).

Sample 87 in *Scolochloa festucacea*. Saline Humic Gleysol.

0 - 4	cm roots and undecomposed plant remains
4 - 10	cm organic, humic, black (5YR2/1)
10 - 54	cm organic with proportion of silt increasing with depth, black (5YR2/1)
54 +	cm silt, dark stained, dark gray, (10YR4/1)

TIN TOWN

In August and September samples were collected at, and behind the shore-line *Phragmites*, and from areas dominated by various plant species (Table XLVII).

The mean conductivity was 5.25 mmhos/cm (Table XLIX) with a range from 2.25 mmhos/cm at the water's edge to 12.7 mmhos/cm among *Scirpus paludosus* in a part of the site which had been exposed to the air almost continuously, thereby drying and allowing for the accumulation of salts near the surface and hence a higher conductivity.

Sample 34 in *Chenopodium rubrum*. Saline Organo Regosol

0 - 8 cm	silty-organic, mesic, very dark gray (10YR3/1)
8 - 10 cm	silty-organic, humic, black, (10YR2/1)
10 - 38 cm	organic, humic, black (10YR2/1)
38 - 60+	silty-clay, dark gray (10YR2/1)

FLEE ISLAND STUDY AREA

Two samples were collected in June, one at the water's edge and one in the *Scolochloa*, both were hydric. Three samples were collected in September among well established species, they too were hydric. Conductivities ranged from 2.82 mmhos/cm at the waters edge to 25.3 mmhos/cm among the mixed vegetation (Table XLVII).

The soils were black, very dark gray, and dark gray, and had a lower proportion of organic material than other sites. The (b) layers had the highest average organic content - 40.4%, the average for the (a) layer was 30.4% and that of the (c) layer 15.3%.

Sample 29 in Scolochloa festucacea. Saline Organo Regosol

0 - 3 cm roots and partially decomposed humus
3 - 11 cm organic, humic black, (10YR2/1)
11 - 17 cm organic with interrupted thin calcareous layer of mollusc shells, very dark gray (5Y3/1)
17 - 38 cm organic, humic, very dark gray (5Y3/1)
38 + fine sand, silt and clay mixture, dark stained, black (2.5 Y2/0).

POTHOLES

COOK CREEK

Sample 13 was collected in June from the north eastern pothole at Cook Creek, in September sample 96 was taken adjacent to it. In July sample 22 came from a Chenopodium patch and in September 97 adjacent to it (Table XLVII). The pH of the soils ranged from 6.4 to 8.0 with a mean of 7.6 (9 samples).

The mean conductivities showed considerable variation from sample to sample within the pothole (Table XLVII). Nine samples were analyzed and showed that the average percentage of the silt (56.8%) was higher than that of organic matter (50%), but it varied considerably within the area. Only two samples had 50% or more organic material. Sand and silt had a higher proportion than in the majority of sites.

Sample 24 in Aster brachyactis, Saline Rego Gleysol.

0 - 5 cm organic with some silt, humic, black (10YR2/2)
5 - 14 cm sandy, organic, stained, dark gray, (10YR4/1)
14 - 16 cm organic uneven wedge-shaped layer, very dark brown (10Y2/2)
16 - 33 cm sandy-silt, sand; layered, gray (10YR6/1)
33 - 66 cm sand, dark gray, (5YR4/1)
66 - 70 cm organic, humic-mesic, dark reddish brown (5YR2/2)
70 + sand, dark gray, (10YR4/1)

BELL'S MARSH

The pH ranged from 7.2 to 8.6 with a mean of 7.5. The lowest conductivity readings of 4.6 mmhos/cm was from the upper layers in June, the readings in August being slightly higher, indicating the upward movement of ions as the soil dried. Thirteen layers were analyzed. The organic content ranged from 8-61% (mean 37.4%), sand from 0-54% (mean 12.7%), silt from 13-63% (mean 34.8%), and clay from 0.1-32% (mean 11%). The (a) and (b) layers had the highest organic content. As was true of all the sites examined on the north side of the marsh, stratification of organic and mineral layers occurred in the soil.

Sample 51 in *Chenopodium rubrum*. Saline Rego Humic Gleysol.

0 - 10 cm organic with silt, humic, black (10YR2/1)
10 - 14 cm organic with sand and silt, humic, very dark gray (10YR3/1)
14 - 26 cm sand with dark staining, very dark gray (10YR3/1)
26 - 32 cm organic, mesic-humic, black (10YR2/1)
32 - 55 cm sand, dark gray (5YR4/1)
55 - 60 cm organic, dark reddish brown (5YR2/2)
60 + cm sand, dark gray (5YR4/1)

HUTCHINSONS

Three samples were collected from the pothole in August (Table XLVII). The pH ranged from 6.8 to 7.5 with a mean of 7.4 . The conductivity was slightly higher in the surface layers of the samples 48 and 49, than in the (b) and (c) layers and considerably higher in the *Hordeum* zone where the (a) layer was 13.4 mmhos/cm, (b) was 3.66 mmhos/cm and (c) 1.93 mmhos/cm, again indicating a movement of ions towards the surface. The mean conductivity for the site was 3.29 (Table XLIX).

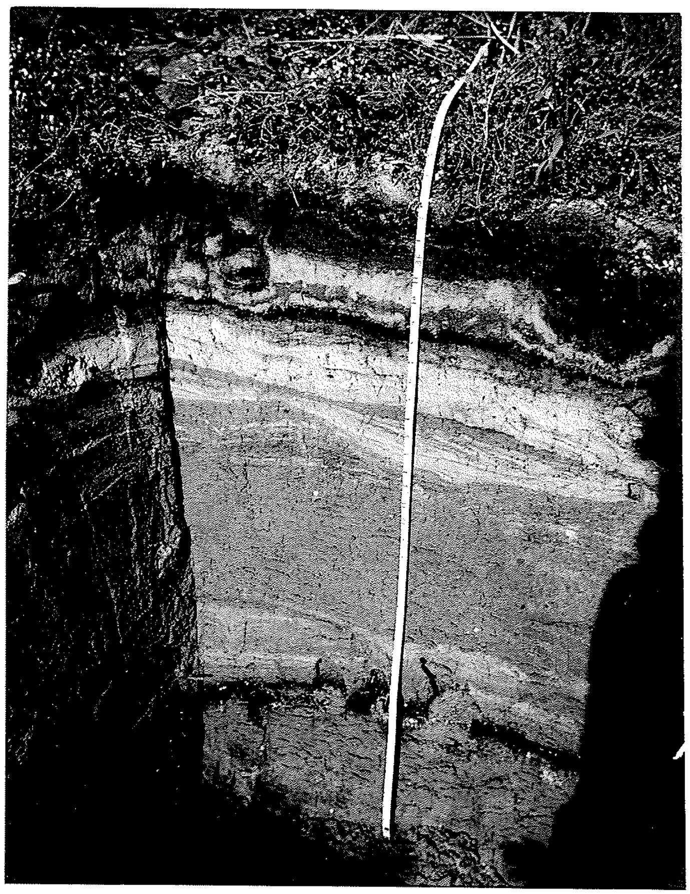

Figure 50. Peaty Saline Rego Gleysol from Cook Creek (L-H, Cg).

Sample 48 in mixed vegetation, *Scolochloa festucacea*, *Typha latifolia*, *Sium suave* etc, was a Saline Rego Humic Gleysol.

0 - 26 cm organic stratified with feint silty bands a few mm thick, mesic-humic, black, (10YR2/1)

26 - 31 cm sand, with humic organic material, very dark gray, (10YR3/1)

31 - 38 cm humic organic, with silt and sand, black (10YR2/1)

38 + sand, stained unevenly, gray, (10YR5/1)

FLEE ISLAND POTHOLE

In June a sample was taken where *Chenopodium* covered the ground, and the conductivities were 22.5 and 27.2 mmhos/cm. Two samples were taken in September, sample 93 in an extensive bare area,(Fig.23) where the mean conductivity was 41.1 mmhos/cm, (range 25.3 - 54.5 mmhos/cm); and sample 94 just within the vegetation surrounding this bare area. Here the conductivity ranged from 14.65-22.4 mmhos/cm and the mean was 30.15 mmhos/cm. The average pH was 7.8 (7.6-8.4) and the organic content was lower than in many sites. The soils were Saline Regosols.

SLOUGHS

PINTAIL SLOUGH

Three soil samples were collected in August and three in September from the three zones of vegetation (Table XLVII). The pH ranged from 6.2 to 6.9 with a mean of 6.4. The conductivities in the August samples showed a decrease in the layers from (a) to (c) indicative of a drying site and the accompanying movement of salts towards the surface (TABLE XLVII).

There was considerable variation in the physical composition of the soils. In the hydric centre of the slough, unconsolidated humic organic material was 50 cm thick. This was underlain by silty-clay containing less coarsely divided organic material. Towards the shores the organic material was more compact and less deep. Six samples were analyzed and showed the mean values to be 33% for organic matter, 3.5% for sand, 43.1% for silt, and 21% for clay. The soils were Saline Humic Gleysols.

Sample 114 in Chenopodium rubrum and Scirpus validus

0 - 15 cm organic, hydric, black (5YR2/1)
15 - 50 cm organic and silt, black, (5YR4/1)
50 + silt, increasing with depth.

PORTAGE SLOUGH

Soil samples were collected in August in the four vegetation zones (Table XLVII). Sample 55 was taken in the bare wet soil in the depression, the hole formed filled immediately with water. Sample 56 was in the young Scolochloa festucacea and Chenopodium rubrum; sample 57 in zone 2 (Scolochloa, Sonchus, Atriplex) and sample 58 in the driest part of the Scolochloa in zone 3. Each sample had three layers. The pH ranged from 6.3 to 7.8 with a mean of 7.2. The conductivities were relatively uniform (considering the variation in other sites) readings being highest in the drier zones. The mean conductivity was 3.05 mmhos/cm (Table XLIX).

The physical composition of the soil was very variable, the high proportion of sand in sample 57 probably indicating that the sand may have been deposited as a spill-over from the nearby Portage Creek in times of flood. The highest organic content of 52%, 61% and 60% were from the sample in the depression. Apart from the top 5 cm of the soil the organic accumulations in the soil were of a humic nature. The soils were classed as Peaty Rego Humic Gleysols.

Sample 58. in Scolochloa festucacea. Peaty Rego Humic Gleysol

0 - 4 cm humic, organic, with fibrous roots, black (5YR2/1)
4 - 20 cm humic, organic, with some silt and sand, black (5YR2/1)
20 - 49 cm sandy, dark stained, dark grayish brown (10YR4/2).

POPLAR POOLS

In August, sample 53 was collected from the central zone dominated by Chenopodium, and sample 54 from the edge of the Scolochloa and Scirpus acutus zone. In September samples 103 and 104 were taken adjacent to 53 and 54 respectively. The pH ranged from 6.6 to 7.5 the mean being 7.2. Conductivities of the (a) layes were higher than the (b) and (c) layers in both sets of soils, but the difference was less marked in September (Table XLVII). The organic content of the (a) and (b) layers was higher than in the (c) layer. Varying proportions of sand, silt, and clay were mixed with the organic material, clay being found in its highest proportion in the (a) layers: its maximum value was 32.8%.

Sample 54 in Scolochloa festucacea with Scirpus validus and Chenopodium rubrum, Saline Rego Humic Gleysol

0 - 20 cm organic plant materials with some degree of recognition but disintegrating when rubbed, humic, black (10YR2/1)
20 - 24 cm sand, stained, dark gray (10YR4/1)
20 - 30 cm organic, humic, dark gray (10YR4/1)
30 + sand, stained, very dark gray (10YR3/1)

TIN TOWN SLOUGH

In June the slough contained water 18.5 cm deep which covered more than half its area. Soil sample 7 was collected in June from the zone parallel with the water where Scolochloa was established. In August sample 59 was taken from the drying centre of the depression and sample 60 from the Scolochloa zone adjacent to sample 7. The pH ranged from 6.6 to 7.6 with a mean of 7.1. In June the conductivity mean was 6.3 mmhos/cm, in August the mean was 8.4 mmhos/cm when the soils were drier.

Analysis of the physical composition of the soil showed considerable variation, for example the organic content of the layers ranged from 0% - 77%. The upper organic layer was black and the proportion of mineral components increased with depth. Their average percentage of organic material was 34.1%, of sand 8.1%, of silt 30.1% and of clay 27.7%.

Sample 59. Bare. Waterlogged. Saline Rego Humic Gleysol.

0 - 35	cm organic, the upper 6 cm containing fibrous roots among humic organic matter, black (10YR2/1)
35 +	stained silty, clay, dark gray, (10YR4/1)

SECTION IV

DISCUSSION

This investigation was planned as a continuation and expansion of the study initiated in 1958 at Delta, Manitoba, to describe the vegetation of a freshwater marsh. At that time water levels in the marsh were falling. The expansion of vegetation on progressively drying areas was described by Walker (1959).

In order to determine the effects of prolonged drying on seral succession in the marsh, the need to follow-up the original observations was emphasized. To do this it was necessary to estimate the overall composition of the vegetation and to study variation within the marsh complex.

In an area of approximately 15,000 hectares sampling had to be restricted. Criticism has been levelled at the inaccuracy of subjective estimates of cover (e.g., Hope-Simpson, 1940; Smith, 1944) and there is no doubt that criticism is valid if conclusions are drawn which are more detailed than the data justify. In this study analytical comparisons have been confined to differences in presence and frequency; cover and sociability data being considered as additional useful information. The methods used, provided a suitable way of obtaining the necessary data and allowed comparisons with earlier work.

Under conditions of falling water levels a number of factors affect plant invasion and succession. These include the time and rapidity of drainage; the nature of the soil and the physical and chemical changes in the soil; the degree of isolation of the site from similar habitats (Godwin, 1923); seed availability and conditions necessary for germination; the degree of exposure of the site; and residual vegetation. With the removal of the original vegetation by flooding, the more or less closed biological cycles are disrupted. In addition other conditions which may be conducive to colonization are produced. The soil surface is usually modified. There is an absence of shade, often leading, even if only for brief periods, to temperature extremes and high surface evaporation. Light intensity is also high (cp. Bunting, 1960).

Moyle and Nielsen (1953) indicated that after drawdown, the ensuing invasion and succession may be contrasted with the classical concept of plant succession whereby the plants themselves gradually change the habitat from the xeric or hydric, to a mesic state. It should be noted, that drainage of formerly submersed soils involves changes other than the removal of water. Submersed soils often contain toxic substances such as ferrous iron and sulphides. These particular toxic conditions will be offset by aeration. Soil aeration following drainage results in an accelerated rate of decomposition of accumulated organic materials, liberating phosphates, nitrates and other nutrients. Cook and Powers (1958) and Kadlec (1960) discuss the complexities of these interactions.

At Delta there was a considerable exposure of denuded mudflats in the first year (1958). They became colonized with a variety of species, usually in a zoned pattern. Pioneers early in the season included Ranunculus sceleratus, R. cymbalaria, Senecio congestus, Epilobium glandulosum, Rumex maritimus, Aster brachyactis and Galium trifidum. Later the same year the most important pioneers were Chenopodium rubrum, Scolochloa festucacea, Atriplex patula and occasionally Typha latifolia (Walker, 1959).

In the three following years striking changes occurred in the marsh as water levels continued to fall. Sites with a large circumference such as marsh shores (e.g.,Chimney) exposed new denuded areas each year. In sites with smaller dimensions (e.g., Bells), the whole area was exposed the first year; and a third group (sloughs and a few large potholes) became completely exposed by the end of the first year, but in contrast with the second group, each spring they became at least partially filled with water for the early phase of the growing season and repeated the drying process. Clearly there are three situations - sites with new waterlogged soil uncovered each year; sites in which the whole area became progressively drier each year; and sites with the same ground submerged and then uncovered each year.

From the empirical data the percentage frequency of the various pioneers was calculated (Table L). It is interesting to note that *Scolochloa festucacea* and *Chenopodium rubrum* were always dominant and that *Chenopodium* maintained the same frequency, continuing to be found on water-logged newly exposed soil.

TABLE L. Relative Frequency of Pioneering Species

Species	1959	1960	1961
Scolochloa festucacea	26	28	14
Chenopodium rubrum	19	24	24
Ranunculus sceleratus	14	3	9
Aster brachyactis	13	11	8
Atriplex patula	10	15	7
Rumex maritimus	9	9	14
Epilobium glandulosum	3	-	-
Senecio congestus	3	3	10
Carex atherodes	1	-	2
Typha latifolia	2	2	7
Scirpus paludosus	-	2	3

In 1961 Scolochloa became reduced in frequency as a pioneer, because the type of site in which it had pioneered no longer had denuded areas open for colonization. Epilobium was only recorded as a pioneer in 1959; Senecio displayed its characteristically erratic occurrence by trebling its frequency in 1961. Even where the physical features of the habitat seem constant, rapid changes in the floristic features may occur. Some are successional, but other species are abundant one year and not the next, and may return a few years later. Seeds are present but fail to germinate for many years and the plant population may be reduced to a few individuals.

In contrast with relatively transient species, the growth of Scolochloa was so effective that throughout the marsh it had the highest index of commonness (4000). It increased in abundance each year, to dominate or be co-dominant in all sites except Cherry Ridge and Torrey's Pothole. The low frequency in these sites can be explained. Cherry Ridge is a sandy spit and had no emergent mudflats or other habitats suitable for Scolochloa associated with it, and the water levels at Torrey's Pothole were artificially manipulated, thereby disrupting the natural sequence of succession.

To summarize the distribution of the five most prevalent species during this study, a histogram of the mean site frequencies has been drawn (Figure 51). These species have been discussed in detail in Section I.

On the average, the species of intermittently available habitats have by far the largest seed output, followed in diminishing order by those of permanently open habitats, those of semi-open habitats and those of closed but unshaded habitats. The frequency and abundance of species of intermittent habitats are dependent upon rapid exploitation of a transient phase of the environment which they occupy (Salisbury, 1942).

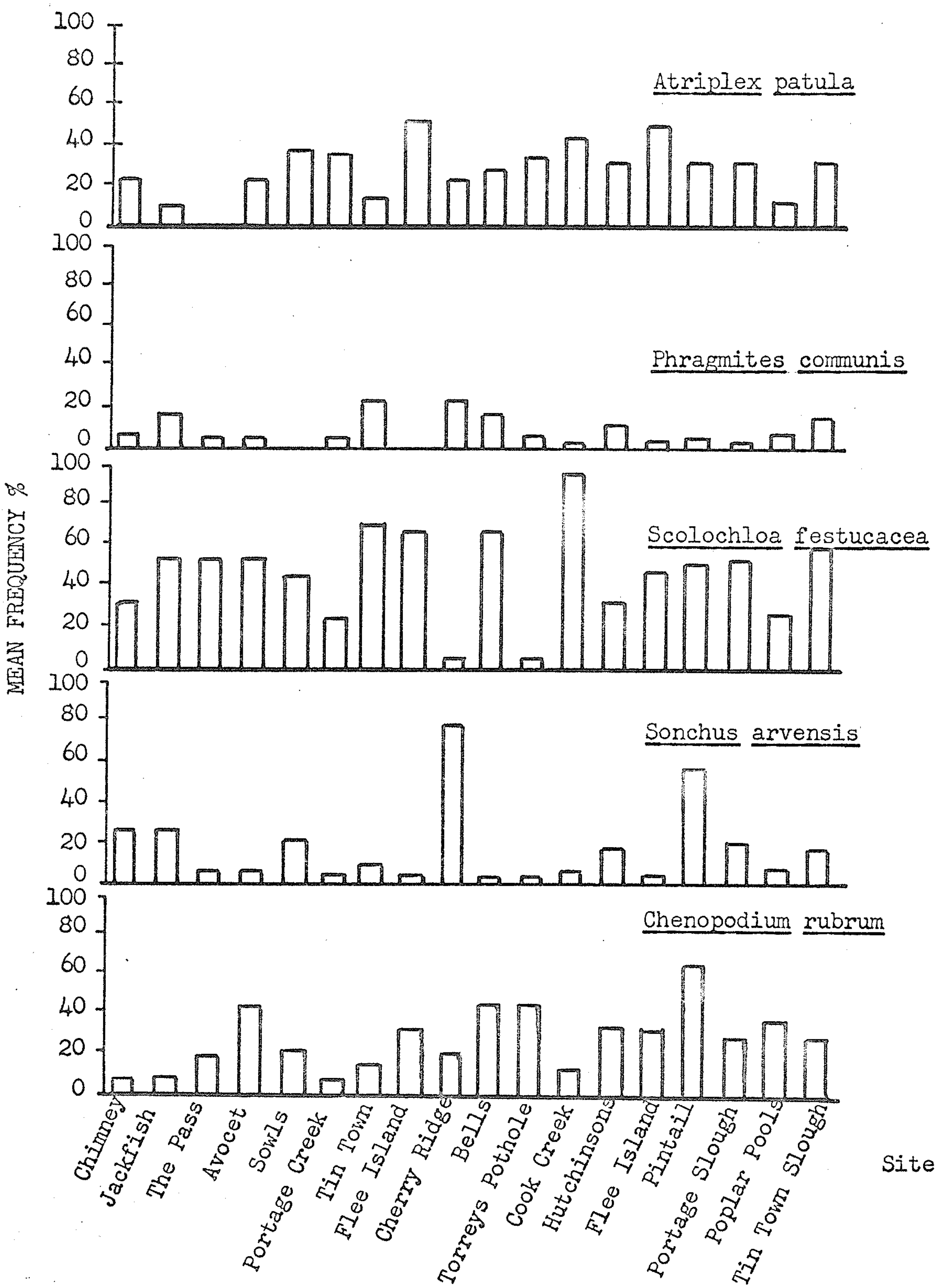

Figure 51. Histogram of the Average Site Frequency of the 5 Most Prevalent Species from 1959-1961.

After drainage the great majority of species develop from seed lying in the mud, although extensive seed counts are needed to determine potential availability of species. Penfound (1953) considers bottom soils contain ample quantities of seed which germinate when conditions are favourable and Uhler (1956) noted that the availability of seed was one of the important factors in determining the pioneering vegetation on drained pond bottoms. Seed distribution in the Delta Marsh has a very erratic pattern, influenced as it is by wind, water and animals. Water appears to be particularly important. A shallow flood over an emergent mudflat can produce great aggregations of seed in one sector of a shore while none are present elsewhere. Seeds have a bewildering range of requirements for breaking dormancy (Crocker and Barton, 1955) and though seeds may be present in large numbers their species may not germinate under the existing conditions. Muenscher (1936) found that seeds of Typha sp. can withstand drying for a considerable time without loss of viability, others, like Potamogeton sp. are killed. It seems strange that with its abundance of seed and effective dispersal mechanism Typha was not more common on drying flats at Delta, particularly where stands of mature plants existed. Hotchkiss (1941) noted that the permanent establishment of water plants was regularly limited by the physico-chemical characteristics of their environment, and propagation by seed was less effective than by vegetative means. Often conditions for mature growth were unsuited to the establishment of young plants of the same species.

Soil samples were collected throughout the summer of 1960. The water content varied from saturated to field capacity, the majority being water-logged. The soil analysis data varied greatly as shown in Table XLVII and Appendix II. For example conductivities ranged from 0.21 mmhos/cm at

Chimney Marsh to 54.50 mmhos/cm at Flee Island; pH from 6.4 to 8.5. These data varied within a site and at different times in the season. The mechanical fractions also covered a wide range, - from 0 to 86% for clay; 0 to 87% for silt; 0 to 95% for sand and 0 to 99% for organic matter.

A factor affecting marsh soils is their relationship to adjacent areas. South of the Delta Marsh, Black and Black Solonetz soils are reported. Associated with them are Saline Meadow, Solonetzic Meadow, Calcareous Meadow and Peaty Meadow soils. The topography is nearly level and the land periodically flooded (Ehrlich et al., 1957). Flooding occurred in 1955, 1956 and 1957 and in some places for a longer period. Soluble salts, particularly of magnesium and calcium are recirculated by flood water, and carried into the marsh from the neighbouring areas. After recession of the high water when the soils are drying out, toxic salts are drawn to the surface and form an incrustation. If the concentration is high, plant growth is inhibited, or the number of species is restricted as at Flee Island.

During periods of high water, older more mature soils are inundated with water and become continuous with marsh areas from which they may have been separated for considerable periods of time. This allows for a partial solution and recirculation of salts which normally would not take place. Microtopography could account for some of the variability, since analysis of soils from shallow depressions sometimes gave results markedly different from their immediate but slightly more elevated surroundings. After rain, salts are washed into the soil to some extent depending on the dryness and nature of the substratum. Conversely after a drying period, certain salts may be carried upwards, sometimes being deposited as a layer or crust on the surface. Owing to the relief, flood water covers a far greater area around the southern shores of the marsh than in the north. Periodic incursions of water over the adjacent saline soils has a marked effect on salt concentration and on vegetation in the marsh. Cook and Powers (1958) state that marsh basin soils, before and after they are flooded, are generally more richly supplied with essential nutrients than are contiguous upland soils, and calcium and magnesium tend to accumulate in basin soils. In contrast, submergence increases the solubility of phosphate (Bartholomew, 1931; Ponnamperuma, 1955). Mortimer (1941) reported an increase of 100% after flooding.

The movement of ions that occurs within the soil depends on a number of factors, among them utilization, decay and water movement (Kadlec, 1960). During water recession a decrease in bases can be attributed to leaching, and the extent of drying has a marked effect on the nutrients released from formerly inundated soils (Cook and Powers, 1958; Kadlec, 1960).

The sites examined in this study can be grouped in various ways. Using physiography, four types emerge, namely marsh shores, potholes, sloughs and wet meadows. When textural soil classes are employed seven classes are involved - loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and silty clay. If conductivity is the criterion and the mean value per site is plotted, it can be seen that the sites with lowest conductivities lie on the north side of the marsh or are sloughs, and that those with the highest conductivities come from sites on the south side of the marsh, or are from wet meadow - marsh transitional areas (Fig.52). Related to conductivity, sites could be classified using saline tolerant, saline intolerant and indifferent species.

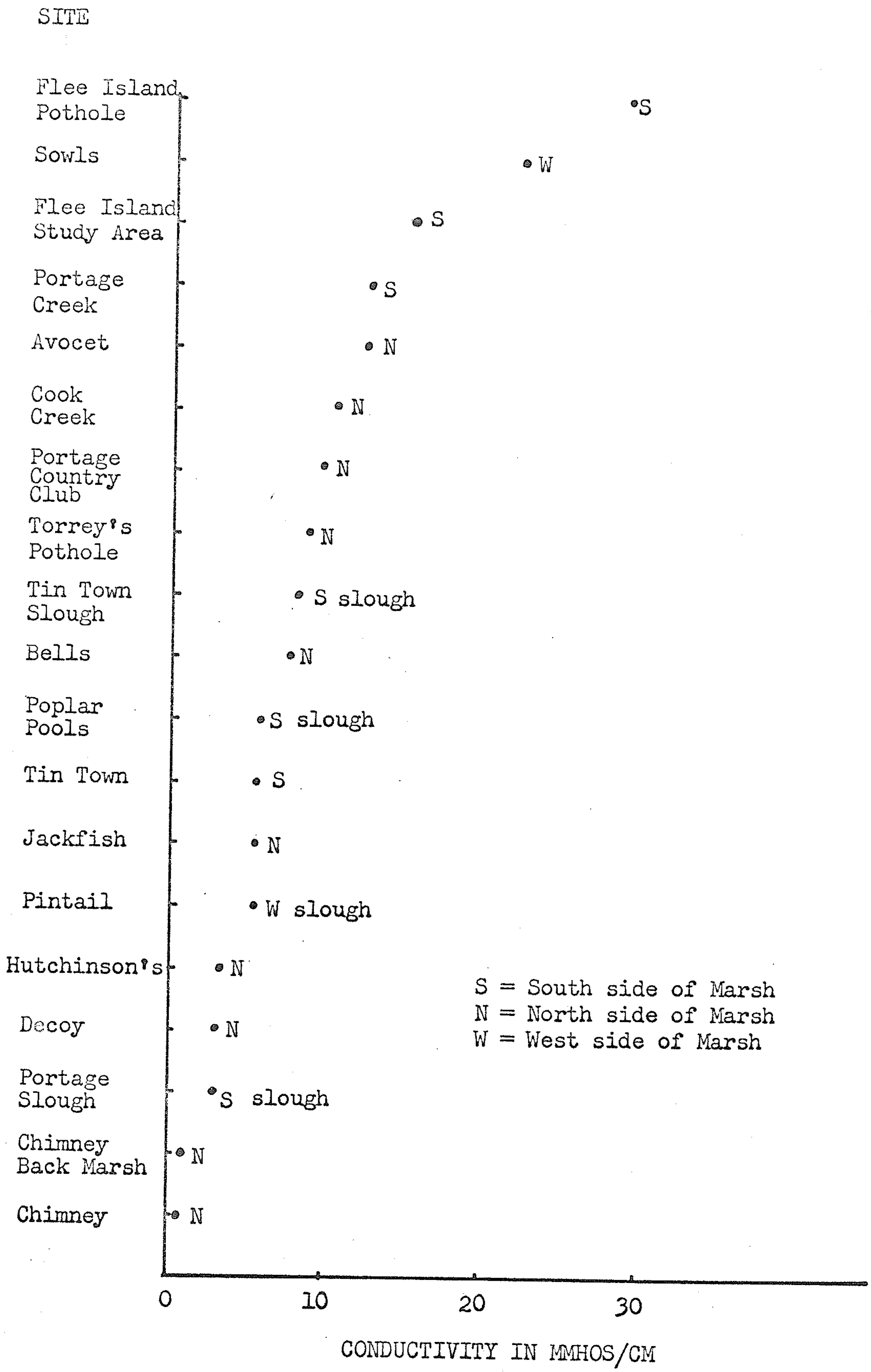

Figure 52. Mean Conductivities and Sites

The surface organic deposits vary in depth, some are a few centimetres thick, while others are up to 30 centimetres. They have been built up in layers of varying thickness, and are interbedded with sand, silt and clay (Fig.50). The mineral layers also vary in depth and area. In some cases they overlie additional muck and peat, in others they lie on the parent material. It seems clear that the majority of the organic materials accumulated under water. Recognizable remains of Phragmites, Typha and Scirpus are commonly encountered, usually in a mesic-humic condition. At Delta the ground level is relatively stable both in the marsh and its surroundings. The alternate submergence and emergence of the marsh appears to be partly responsible for the stable ground level and for the shallow organic deposits. These contrast markedly with the Deep Peat soils in S.E. Manitoba where 1 m - 4 m of organic deposits exist, consisting of mosses, sedges, aquatic and semi-aquatic plants, moderately decomposed and usually strongly acid to neutral in reaction (Smith et al., 1964). These have accumulated under conditions of more or less constant water levels.

Under aquatic conditions poorly decomposed fibrous strata of plant residues - mainly cellulose and lignin - accumulate, when conditions are anaerobic and decomposition is slow. The nature of the plant remains appears to have a considerable bearing on the type of humus formed (Waksman, 1936). Then the water level falls, aeration improves, and bacterial activity is promoted; this results in more highly fragmented residues in which some humification takes place.

It is possible that the aggregation of autochthonous organic materials is hindered by water level fluctuations. An area may have been submerged for several years, then with falling water levels become emergent and slowly dry out. In the ensuing warm, moist, well-aerated soils (with a circumneutral or basic reaction) conditions for microbial activity are near optimum and the soil organic fraction remains relatively constant. A balance exists between the annual production of plant debris on the one hand and humification and mineralization on the other, although the rate at which decomposition takes place, depends on the nature of the organic residues involved.

Enough decomposition occurs during emergent periods to slow down the in-filling of the marsh. Seral terminology can be used to describe the plant communities involved, and at present cyclical water conditions perpetuate the reed swamp as a sere-climax (Chapman,1958-59). In isolated places within the marsh complex shrub invasion takes place but only endures until the following cycle of high water. The water table does not become low enough for the regional climax to be attained. Coupled with this is the physiographic structure of the marsh.

The majority of water areas at Delta cover such an extensive area that they are very much influenced by wind, and the effects of wind disturbance become considerable. A frequent sight in the open water areas is the appearance of 'whitecaps' produced when the crest of a wave falls forward.

Waves are mainly wind produced (Welch, 1952). They occur on every body of water in forms and magnitude depending upon various local conditions, such as the area of open water, the direction and duration of wind velocity, the shape of the shoreline and relative amounts of deep and shallow water. Hutchinson (1957) considers that waves may be produced by wind, barometric pressure and other pressures, local showers of rain, earthquakes and the electrostatic effects of thunderstorms. Any of these may start water oscillating. The usual fate of a shallow wave is to enter shallow water and break near the shore. Water, thrown upon the shore by these waves, runs back down the shore forming an undertow. The downflowing water is met by the next expiring wave, so that the shifting shore materials are alternately swept or rolled back and forth. Drift lines of debris mark the temporary incursion of water over emergent areas, and the materials washed up show that elements from the bottom of the bays become deposited on the shore. A thorough mixing appears to take place and may be important in slowing down the in-filling of the marsh.

The effect of wave action in shallow water is to cause a considerable degree of turbulence, (Thijsse, 1952) both in the open areas and along shores. All the water areas at Delta are shallow, only in a few channels where flowing water passes does the depth exceed two metres. Reversing currents are probably important in keeping these channels leading from one bay to another unsilted (Krecker, 1931). It is through these channels, that periodically, major incursions of mineral material occur. When unusually high water is coupled with strong winds, mineral materials are carried over, through and from the lakeshore ridge into the marsh. They are deposited on the existing accumulated organic materials as layers of intermixed sand, silt, clay and calcareous materials. They can be seen in the control soil sections as strata quite distinct from organic materials which lie below and are accumulating above. Normal circulation through wave action described earlier, is responsible for spreading and redistributing these mineral deposits.

Another source of minerals is the flood water which drains from the Portage Plain before flowing into the southern borders of the marsh. It carries considerable quantities of sediments. An earlier path of Portage Creek to the lakeshore of Lake Manitoba via the Delta Channel can be clearly traced by sand deposits in the marsh bed. Today its exit is into Simpson Bay some distance east of Cherry Ridge, but it still transports sediments into the marsh.

The Delta Marsh is a complex environment influenced by many factors both natural and man made. Under normal conditions it would be expected that in time evolution would take place in the marsh and it would be replaced by a more mesic type of community. However at present a number of interacting factors are apparently slowing down the natural in-filling process. The scouring action of wind tides and flood waters brings about circulation of mineral and organic materials. The deposition of organic detritus on shorelines and its decomposition influences the nutritional status of the soils, as does the alternate flooding exposure of large areas. Although the marsh is near saline soils, which particularly affect its southern part, the presence of organic matter tends to counterbalance the unfavourable effects of soluble salts. Fluctuating water levels affect the physical, chemical and vegetational aspects of the marsh. Long term investigations on accretion should be undertaken to determine the extent to which the marsh is affected by the accumulation of organic and mineral materials. An analysis of the chemical nature of marsh soil does not necessarily indicate the nutrients available for plant growth, because the relationship between availability and uptake still poses a problem, despite the work of many investigators.

This study of vegetation response to falling water levels had illustrated the complexity of the interacting factors, and indicated the need for continued research in the marsh ecosystem.

SECTION V

SUMMARY

A study was made between 1959 and 1961 on emergent vegetation during a period of falling water levels at the Delta Marsh, Manitoba. The Delta Marsh occupies 15,000 hectares and the high water had killed most of the emergent aquatic vegetation. Recolonization of the denuded areas occurred as water levels fell. The pioneering species included: *Ranunculus sceleratus*, *Senecio congestus* var. *tonsus*, *Chenopodium rubrum*, *Rumex maritimus* var. *fueginus*, *Typha latifolia*, *Scolochloa festucacea*, *Atriplex patula*, *Epilobium glandulosum* var. *adenocaulon*, *Aster brachyactis*, *Ranunculus cymbalaria* and *Galium trifidum*. Twenty widely distributed sites throughout the marsh were studied in detail and twenty-seven prevalent species were found, of which 13 had a presence rating between 100% and 65%. Included in this group in diminishing order were: *Phragmites communis* var. *berlandieri*, *Scolochloa festucacea*, *Atriplex patula*, *Chenopodium rubrum*, *Sonchus arvensis* var. *glabrescens*, *Aster brachyactis*, *Rumex maritimus* var. *fueginus*, *Carex atherodes*, *Hordeum jubatum*, *Typha latifolia*, *Scirpus paludosus*, *Ranunculus sceleratus*, and *Scirpus validus*. Ecological descriptions of these species were given, with particular reference to the part they played in succession, within a season and from one season to the next. The colonizing vegetation was in either a zoned or mosaic pattern. The species composition varied from site to site some being restricted to only a few sites while others were widely distributed. *Scolochloa festucacea* had the highest index of commonness (4000). Its abundance increased as drying proceeded and by 1961 it had become dominant in the majority of formerly denuded areas. The *Phragmites communis* var. *berlandieri* which had survived in peripheral areas spread rapidly by vegetative means. It grew in three types of population and by the end of 1961 had again formed extensive stands. *Chenopodium rubrum* was found throughout the marsh, being one of the most important plants on newly exposed

areas, but as sites became drier it decreased in abundance. *Atriplex patula* had the second highest index of commonness (3300) and was most frequently found in sites which dried rapidly as was *Sonchus arvensis* var. *glabrescens*.

It was shown that periods of high water prevent the survival of species that cannot tolerate flooding. This resulted in the maintenance of the marsh at a sere climax stage.

The soils are a complex of Peaty Saline Rego Humic Gleysols and Organo Regosols. Soil analysis indicated a very variable chemical composition; a pH between 6.4 and 8.5; conductivities between 0.21 mmhos/cm and 54.50 mmhos/cm; and a high organic content. Conductivity was the most effective soil characteristic for comparison with the vegetation.

The need for further studies relating to the most prevalent species and to aquatic vegetation was indicated, because at present little is known of the population dynamics and productivity of marsh species.

SECTION VI

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APPENDIX I

APPENDIX I

TABULAR CLASSIFICATION

Pteridophyta

Family	Genera	Species
Equisetaceae	1	4
Lycopodiaceae	1	3
Polypodiaceae	1	1
3 Families		

Angiospermae
Monocotyledoneae

Family	Genera	Species
Sparganiaceae	1	1
Zosteraceae	2	2
Juncaginaceae	2	8
Alismataceae	2	3
Gramineae	25	39
Cyperaceae	4	22
Lemnaceae	1	2
Liliaceae	6	6
Orchidaceae	1	1
Typhaceae	1	1
10 Families	45	85

Dicotyledoneae

Family	Genera	Species
Salicaceae	2	10
Betulaceae	1	1
Fagaceae	1	1
Ulmaceae	2	2
Cannabinaceae	1	1
Urticaceae	1	1
Santalaceae	1	1

Dicotyledoneae (continued)

Family	Genera	Species
Polygonaceae	2	13
Chenopodiaceae	7	12
Amaranthaceae	1	2
Nyctaginaceae	1	2
Portulacaceae	1	1
Caryophyllaceae	5	8
Ceratophyllaceae	1	1
Ranunculaceae	5	12
Menispermaceae	1	1
Papaveraceae	1	1
Cruciferae	14	14
Saxifragaceae	1	2
Rosaceae	8	19
Leguminosae	9	13
Oxalidaceae	1	1
Euphorbiaceae	2	2
Celastraceae	1	1
Aceraceae	1	1
Balsaminaceae	1	1
Rhamnaceae	1	1
Vitaceae	2	2
Violaceae	1	2
Eleagnaceae	1	1
Onagraceae	2	3
Haloragaceae	1	2
Hippuridaceae	1	1
Araliaceae	1	1
Umbelliferae	6	8
Cornaceae	1	4
Pyrolaceae	1	1
Primulaceae	3	3
Oleaceae	1	1
Gentianaceae	2	3

Dicotyledoneae (continued)

Family	Genera	Species
Apocyanaceae	1	1
Ascelepiadaceae	1	3
Convolvulaceae	2	3
Boraginaceae	4	4
Labiatae	10	13
Solanaceae	1	2
Scrophulariaceae	4	6
Lentibulariaceae	1	1
Plantaginaceae	1	1
Rubiaceae	1	4
Caprifoliaceae	3	3
Cucurbitaceae	1	1
Campanulaceae	1	1
Compositae	27	60
54 Families	154	260

SUMMARY

	Families	Genera	Species
Pteridophyta	3	3	8
Angiospermae			
Monocotyledoneae	10	45	85
Dicotyledoneae	54	154	260
			353

ALPHABETICAL SPECIES LIST OF VASCULAR PLANTS

OF THE DELTA MARSH AREA

LL. indicates the species was recorded by Löve and Löve (1954.

W. indicates the species was recorded by Walker (1959) and this study.

W	LL	Acer negundo L.
W	LL	Achillea millefolium L.
W	LL	Actaea rubra (Alt.) Willd.
W		Agoseris glauca (Nutt) Greene.
	LL	Agrimonia striata Michx.
W	LL	Agropyron dasystachyum (Hook.) Scribn.
	LL	Agropyron gryposepala Wallr.
W	LL	Agropyron latiglume (Scribn. & Sm.) Rydb.
W	LL	Agropyron repens (L.) Beauv.
W	LL	Agropyron smithii Rydb.
W		Agropyron trachycaulum (Link) Malte.
W		Agropyron trachycaulum var. glaucum (Pease & Moore) Malte.
W		Agropyron trachycaulum var. novae-angliae (Scribn.) Fern.
W		Agropyron trachycaulum var. unilaterale (Cassidy) Malte
	LL	Agrostis gigantea Roth.
W		Agrostis stolonifera L. var. major (Gaud.) Farw.
	LL	Agrostis palustris Huds.
W	LL	Alisma triviale Pursh
W	LL	Alopecurus aequalis Sobol.
W	LL	Alyssum alyssoides L.
W	LL	Amaranthus graecizans L.
W	LL	Amaranthus retroflexus L.
W		Ambrosia artemisiifolia L. var. elatior (L.) Descourtils
W	LL	Ambrosia psilostachya D.C. var. coronopifolia (T.&G.) Farw.
W	LL	Ambrosia trifida L.
W		Amelanchier alnifolia Nutt.
W	LL	Amelanchier humilis Wieg.
	LL	Andropogon gerardi Vitman
W	LL	Andropogon scoparius Michx.
	LL	Anemone cylindrica Gray
W	LL	Anemone canadensis L.
W	LL	Anemone quinquefolia L. var. interior Fern.
	LL	Antennaria parvifolia Nutt.
W	LL	Apocynum androsaemifolium L.
	LL	Aquilegia canadensis L.
W	LL	Arabis divaricarpa Nels.
W	LL	Aralia nudicaulis L.
		Arctium lappa L.
W	LL	Arenaria lateriflora L.
W		Artemisia absinthium L.

W	LL	Artemisia biennis Willd.
W	LL	Artemisia frigida Willd.
	LL	Artemisia glauca Pall.
W	LL	Artemisia ludoviciana Nutt. var. gnaphalodes (Nutt.)
W		Artemisia ludoviciana var. latifolia (Bess.)
W		Artemisia ludoviciana var. pabularis (Nels.) Fern.
W	LL	Asclepias incarnata L.
W		Asclepias ovalifolia Dcne.
	LL	Asclepias speciosa Torr.
W		Asclepias syriaca L.
W		Aster brachyactis Blake
W		Aster ciliolatus Lindl.
W	LL	Aster laevis L.
W		Aster novae-angliae L.
W	LL	Aster pansus (Blake) Cronq.
W	LL	Aster praealtus Poir.
	LL	Aster ptarmicoides (Nees) T. & G.
W	LL	Aster simplex Willd.
W		Astragalus bisulcatus (Hook.) Gray
W		Astragalus canadensis L.
W		Atriplex patula L.
	LL	Atriplex patula var. hastata (L.) Gray
W	LL	Axyris amaranthoides L.
W	LL	Barbarea orthoceras Ledeb.
W	LL	Beckmannia syzigachne (Steud.) Fern.
W		Bidens cernua L.
W		Bidens frondosa L.
W	LL	Bidens vulgata Greene
W		Brassica kaber (DC) L. C. Wheeler
W		Bromus inermis Leyss.
	LL	Bromus purgans L.
W	LL	Calamagrostis canadensis (Michx.) Nutt.
	LL	Calamagrostis inexpansa (Gray) var. brevior (Vasey) Stebbins
W	LL	Camelina microcarpa Andrs.
W	LL	Campanula rotundifolia L.
W	LL	Capsella bursa-pastoris (L.) Medic.
W		Cardamine pensylvanica Muhl.
W	LL	Carex assiniboinensis Boott.
W	LL	Carex atherodes Spreng.
W		Carex bebbi Olney
W		Carex deweyana Schwein.
W		Carex lacustris Michx.
W		Carex praticola Rydb.
W		Carex pseudo-cyperus L.
W		Carex rosea Schk.
W		Carex sprengelii Dew.
W		Carex stipata Muhl.

W		Castilleja miniata Dougl.
W		Celastrus scandens L.
	LL	Celtis occidentalis L.
W	LL	Cerastium nutans Raf.
W	LL	Ceratophyllum demersum L.
W	LL	Chenopodium album L.
W		Chenopodium berlandieri Moq.
W	LL	Chenopodium hybridum L. var. gigantospermum (Aellen) Rouleau
W	LL	Chenopodium glaucum L. var. salinum (Standl.) Boivin
W	LL	Chenopodium rubrum L.
W	LL	Chrysopsis villosa (Pursh) Nutt.
W		Cicuta bulbifera L.
W	LL	Cicuta maculata L.
W	LL	Cirsium arvense (L.) Scop.
W		Cirsium discolor (Muhl) Spreng.
W	LL	Cirsium flodmanii (Rydb.) Arthur
W	LL	Comandra richardsiana Fern.
W	LL	Convolvulus sepium L.
W		Corispermum simplicissimum Lunell
W		Cornus alternifolia L. F.
W	LL	Cornus canadensis L.
W		Cornus racemosa Lam.
W	LL	Cornus stolonifera Michx.
W		Corydalis aurea Willd.
W	LL	Corylus americana Walt.
W		Crepis tectorum L.
W		Cuscuta gronovii Willd.
W		Cuscuta megalocarpa Rydb.
	LL	Cyperus schweinitzii Torr.
W	LL	Cypripedium calceolus var. pubescens (Willd.) Correll
W	LL	Descurainia richardsonii (Sweet) O.E. Schulz
W		Distichlis stricta (Torr.) Rydb.
W	LL	Draba nemorosa L. var. lejocarpa Lindbl.
W		Dracocephalum formosius (Lunell) Rydb.
W		Dryopteris thelypteris (L.) Gray var. pubescens (Lawson) Nakai
W		Echinochloa crusgalli (L.) Beauv.
W	LL	Echinocystis lobata (Michx.) T. & G.
W	LL	Elaeagnus commutata Bernh.
W	LL	Eleocharis acicularis (L.) R. & S.
W		Eleocharis palustris (L.) R. & S.
W		Eleocharis calva Torr.
	LL	Eleocharis pauciflora (Lightf.) Line
W	LL	Elymus canadensis L.
	LL	Elymus hirsutiglumis Scribn.
W	LL	Elymus virginicus var. submuticus Hook
	LL	Elymus repens (L.) Novski
W	LL	Epilobium angustifolium L.
W	LL	Epilobium glandulosum Lehm. var. adenocaulon (Haussk.) Fern.
W	LL	Equisetum arvense L.
W	LL	Equisetum fluviatile L.

	LL	Equisetum laevigatum A. Br.
W	LL	Equisetum pratense Ehrh.
W		Erigeron asper Nutt.
W		Erigeron canadensis L.
W		Erigeron glabellus Nutt.
W	LL	Erigeron philadelphicus L.
W		Erysimum cheiranthoides L.
W	LL	Eupatorium maculatum L. var. bruneri (Gray) Breitung
W	LL	Euphorbia glyptosperma (Englem.)
W	LL	Fraxinus pennsylvanica Marsh. var. austini Fern.
W	LL	Galeopsis tetrahit L. var. bifida (Boenn.) Lej. & Court
W		Galium aparine L.
W	LL	Galium septentrionale R & S
W	LL	Galium triflorum Michx.
W		Gentiana affinis Griseb.
W		Gentiana andrewsii Griseb.
W		Geum macrophyllum Willd. var. perincisum (Rydb.) Raup
W	LL	Geum triflorum Pursh
W	LL	Glaux maritima L.
W	LL	Glyceria grandis Wats.
W		Glycyrrhiza lepidota (Nutt.) Pursh
W	LL	Grindelia squarrosa (Pursh) Dunal
W	LL	Hackelia americana (Gray) Fern
	LL	Helianthus giganteus L.
	LL	Helianthus laetiflorus var. subrhomboideus (Rydb.) Fern.
W	LL	Helianthus maximiliani Schrad.
	LL	Helictotrichon hookeri (Scribn.) Henr.
W	LL	Heliopsis helianthoides (L.) Sweet var. scabra (Dunal) Fern.
W	LL	Heracleum lanatum Michx.
W	LL	Hierochloë odorata (L.) Beaur.
W	LL	Hippuris vulgaris L.
W	LL	Hordeum jubatum L.
W	LL	Humulus lupulus L.
W	LL	Impatiens capensis Meerb.
W	LL	Iva xanthifolia Nutt.
W		Juncus alpinus Vill. var. rariflorus Hartm.
W	LL	Juncus balticus Willd. var. littoralis Englem.
W	LL	Juncus bufonius L.
W	LL	Juncus dudleyi Wieg.
	LL	Juncus nodosus L.
W	LL	Juncus tenuis Willd.
W	LL	Juncus torreyi Coville

	LL	Kochia scoparia L. (Schrad.)
W	LL	Lactuca pulchella (Pursh) D C.
W		Lappula echinata Gilib.
W	LL	Lathyrus japonicus Willd. var. glaber (Ser.) Fern.
W	LL	Lathyrus palustris L.
W	LL	Lemna minor L.
W	LL	Lemna trisulca L.
W		Leonurus cardiaca L.
W	LL	Lepidium densiflorum Schrad.
W	LL	Liatris ligulistylis (Nels.) K. Schum.
	LL	Lithospermum canescens (Michx.) Lehm.
W		Lycopodium clavatum L. var. megastachyon Fern.Bissel
W		Lycopus americanus Muhl.
W		Lycopus asper Greene
W		Lycopodium complanatum L.
W		Lycopodium obscurum L.
W		Lysimachia terrestris (L.) BSP
W	LL	Maianthemum canadense var. interius Fern.
W	LL	Matricaria matricariodes (Less.) Porter
W	LL	Medicago sativa L.
W	LL	Melilotus alba Desr.
W	LL	Melilotus officinalis (L.) Lam.
W		Menispermum canadensis L. P.I.P.
W	LL	Mentha arvensis (L.) var. villosa (Benth) Stewart
	LL	Menyanthes trifoliata L.
W	LL	Mirabilis hirsuta (Pursh) MacN.
W	LL	Mirabilis nyctaginea (Michx.) MacM.
W	LL	Monarda fistulosa L.
W	LL	Muhlenbergia asperifolia (Nees & Mey.) Parodi
W		Muhlenbergia racemosa (Michx.) BSP
W		Myosotis arvensis (L.) Hill
W	LL	Myriophyllum exalbescens Fern.
W	LL	Myriophyllum verticillatum L. var. pectinatum Wallr.
W		Nepeta cataria L.
W	LL	Oenothera biennis L.
W	LL	Orthocarpus luteus Nutt.
W		Osmorhiza longistylis (Torr.) DC
	LL	Oxalis stricta L.
W	LL	Panicum capillare L.
W		Parthenocissus quinquefolia (L.) Planch.
W		Pastinaca sativa L.
W		Pedicularis lanceolata Michx.
W		Petalostemum candidum (Willd.) Michx.
W	LL	Petalostemum purpureum (Vent.) Rydb.
W	LL	Petasites sagittatus (Pursh) Gray
W		Phalaris arundinacea L.

W		Phleum pratense L.
W	LL	Phragmites communis Trin. var. berlandieri (Fourn.) Fern.
W	LL	Plantago major L.
W		Poa glauca Vah.
W	LL	Poa palustris L.
W	LL	Poa pratensis L.
	LL	Polygonatum canaliculatum (Muhl) Pursh
W	LL	Polygonum achoreum Blake
W	LL	Polygonum amphibium L. var. stipulaceum (Coleman) Fern
W	LL	Polygonum aviculare L.
W		Polygonum coccineum Muhl.
W		Polygonum convolvulus L.
W		Polygonum interior Brenckle
W		Polygonum lapathifolium L.
	LL	Polygonum prolificum (Small) Robins
W		Polygonum punctatum Ell. var. confertiflorum (Meisn.)
W	LL	Polygonum ramosissimum Michx.
W		Polygonum scandens L.
W	LL	Polypogon monspeliensis (L.) Desf.
W	LL	Populus deltoides Marsh.
W		Populus deltoides Marsh. X Populus balsamifera L.
W	LL	Populus tremuloides Michx.
W	LL	Portulaca oleracea L.
W		Potamogeton friesii Rupr.
W	LL	Potamogeton pectinatus L.
W	LL	Potamogeton richardsonii (Benn.) Rydb.
W	LL	Potamogeton vaginatus Turcz.
W		Potamogeton pusillus L.
W	LL	Potentilla anserina L.
W	LL	Potentilla fruticosa L.
W	LL	Potentilla norvegica L.
	LL	Potentilla palustris (L.) Scop.
W		Potentilla paradoxa Nutt.
W		Potentilla pensylvanica L.
W		Prenanthes racemosa Michx.
W	LL	Prunus virginiana L.
W	LL	Psoralea argophylla Pursh
W	LL	Puccinellia nuttalliana (Schultes) Hitchc.
W	LL	Pyrola asarifolia Michx.
W	LL	Quercus macrocarpa Michx.
W		Ranunculus abortivus L.
W	LL	Ranunculus flabellaris Raf.
W		Ranunculus macounii Britt.
W		Ranunculus pensylvanicus L.F.
W	LL	Ranunculus sceleratus L.
W	LL	Rhamnus alnifolia L'Her

W	LL	Rhus radicans L.
W	LL	Ribes americanum Mill
W	LL	Ribes oxyacanthoides L.
W		Rorippa islandica (Oeder) Borbas var. fernaldiana Butt. & Abbe.
W	LL	Rosa arkansana Porter
W	LL	Rosa blanda Ait.
	LL	Collective species Rubus arundelanus Blanchard
W	LL	Collective species Rubus flagellaris L.
W		Rubus idaeus L. var. strigosus (Michx.) Maxim.
W	LL	Rubus pubescens Raf.
W		Rudbeckia laciniata L.
W	LL	Rudbeckia serotina Nutt.
W	LL	Rumex crispus L.
W	LL	Rumex maritimus L. var. fueginus (Philippi) Dusen.
W	LL	Rumex mexicanus (Meisn)
W		Rumex occidentalis Wats.
W		Ruppia maritima L. var. occidentalis (Wats.) Graebn.
W	LL	Sagittaria cuneata Sheldon
W		Salicornia rubra Nels.
W		Salix alba L.
W	LL	Salix amygdaloides Anderss.
W		Salix discolor Muhl.
W	LL	Salix interior Rowlee.
W	LL	Salix lucida Muhl.
W	LL	Salix nigra Marsh.
W	LL	Salsola kali var. tenuifolia Tausch.
W	LL	Sambucus pubens Michx.
W		Saponaria vaccaria L.
W	LL	Scirpus acutus Muhl.
W	LL	Scirpus americanus Pers.
	LL	Scirpus atrovirens Willd. var. pallidus Britt.
	LL	Scirpus cespitosus L. var. callosus Bigel.
W	LL	Scirpus paludosus Nels.
W	LL	Scirpus validus Vahl.
W	LL	Scolochloa festucacea (Willd.) Link.
W	LL	Scutellaria galericulata L. var. epilobiifolia (Hamilt.) Jordal.
W		Scutellaria lateriflora L.
W	LL	Senecio congestus (R. Br.) DC.
W		Senecio integerrimus Nutt.
W	LL	Setaria viridis (L.) Beauv.
W		Sisymbrium altissimum L.
W	LL	Sium suave Walt.
W	LL	Smilacina stellata (L.) Desf.
W	LL	Smilax herbacea L. var. lasioneura (Hook.) A. DC.
W		Solanum nigrum L.
W	LL	Solanum triflorum Nutt.
W	LL	Solidago canadensis L.
W	LL	Solidago canadensis var. gilvocanescens Rydb.

W		Solidago gigantea Ait. var. leiophylla Fern.
W		Solidago graminifolia (L.) Salisb. var.major (Michx.) Fern.
W		Solidago missouriensis Nutt.
W	LL	Solidago rigida L.
W		Solidago rugosa At.
W	LL	Sonchus arvensis var. glabrescens Guenth.Grab. and Wimm.
W		Sonchus asper (L.) Hill
W		Sparganium eurycarpum Englem.
W	LL	Spartina pectinata Link.
W	LL	Spergularia marina (L.) Griseb.
W	LL	Spiraea alba Du Roi
W		Sporobolus cryptandrus (Torr.) Gray
W	LL	Stachys palustris L. var. pilosa (Nutt.) Fern
W		Steironema ciliatum (L.) Raf.
W		Stellaria graminea L.
W		Stellaria longifolia Muhl.
W		Stellaria media (L.) Cyrillo
W		Stellaria longipes Goldie
W	LL	Suaeda depressa (Pursh) Wats.
W	LL	Symphoricarpos occidentalis Hook.
W		Taraxacum officinale Weber
W	LL	Teucrium occidentale Gray
W	LL	Thalictrum dasycarpum Fisch. & Lall.
W	LL	Thalictrum venulosum Trel.
W	LL	Thlaspi arvense L.
W	LL	Trifolium repens L.
W	LL	Triglochin martima L.
W	LL	Trillium cernuum L.
W	LL	Typha latifolia L.
W	LL	Ulmus americana L.
W	LL	Urtica dioica L. var. procera Wedd.
W	LL	Utricularia vulgaris L.
W		Veronica americana (Raf.) Schwein.
W		Veronica salina Schur.
W	LL	Veronica scutellata L.
W		Viburnum lentago L.
W		Vicia americana Muhl.
W	LL	Viola canadensis L.
W	LL	Viola rugulosa Greene
W		Vitis riparia Michx.
W	LL	Xanthium strumarium L.
W	LL	Zannichellia palustris L.
W	LL	Zigadenus elegans Pursh
W		Zizia aptera (Gray) Fern.
W	LL	Zizia aurea (L.) W.D.J. Koch

APPENDIX II

APPENDIX II

Data from Chemical Analysis of Soils

Date	Sample Number	Site	meq/100 gm.						
			Cl	Ca	Mg	Na	K	HCO_3	SO_4%
12.6.60	11	Chimney	0.8	80.0	25.0	1.5	1.0	0.66	0.018
"	11a	Marsh	1.8	70.4	25.0	2.0	1.0	3.6	0.015
"	12		2.1	32.5	36.0	14.0	0.2	0.56	0
"	12a		0.28	11.0	38.5	0	0.1	0.16	0
"	12b		0.48	13.0	58.0	0	0.4	0.28	0
10.8.60	42	Jackfish	6.7	29.6	51.0	12.1	3.7	1.52	0.09
"	42a		7.2	24.8	84.0	9.1	2.4	1.32	0.16
"	42b		5.2	32.8	96.0	10.8	2.0	1.8	0.17
"	43		7.5	20.7	36.3	23.0	0.8	1.68	0.145
"	43a		6.3	34.0	22.0	15.6	0	1.60	0.157
"	43b		6.2	34.4	16.3	15.8	0.26	1.72	0.037
"	44		12.0	37.5	38.3	21.4	0.6	3.04	0.145
"	44a		3.4	44.0	32.0	10.4	0	1.16	0.052
"	44b		6.7	37.0	31.2	19.0	0.26	1.32	0.075
"	45		3.0	42.4	22.0	13.2	0	1.48	0.041
"	45a		1.6	17.6	42.6	4.4	.10	1.0	0
27.8.60	69	Decoy	1.2	23.6	16.6	11.6	0.2	0.56	0
"	69a	Pool	1.6	30.8	3.3	0.4	0.1	0.42	0
21.7.60	38	Avocet	14.7	12.6	26.0	36.0	1.4	0.56	1.19
"	38a		16.2	17.0	33.3	18.2	0.2	0.72	1.42
"	38b		7.2	35.0	23.3	19.0	0.26	0.08	1.10
"	39		7.5	32.0	22.0	23.0	1.2	1.52	0.256
"	39a		4.4	18.8	34.3	17.6	0.24	1.08	0.277
"	39b		8.1	21.5	30.0	17.8	0	0.92	1.03
"	102		3.0	14.0	29.0	9.0	1.0	0.64	0.016
12.9.60	105b		11.0	23.2	19.0	18.6	0.96	0.2	0.073
8.6.60	21		16.9	57.2	120.0	11.0	5.0	0.24	0.79
"	21a		11.5	48.8	69.0	17.7	3.4	0.24	1.0
"	21c		13.4	50.4	96.0	17.7	4.0	0.16	0.62
21.7.60	40		41.0	35.2	71.0	41.7	8.3	1.12	1.48
"	40a		16.5	31.2	84.0	16.0	3.3	0.36	0.27
"	40b		12.3	47.2	110.0	17.5	4.3	1.0	1.13
19.6.60	17	Portage	9.6	31.0	54.3	17.6	1.4	0.80	0.12
"		Creek							

Anions were extracted with water
Cations were extracted with NH_4Ac

Cf. p.195 for references to methods.

Date	Sample Number	Site	meq/100 gm.						
			Cl	Ca	Mg	Na	K	HCO_3	SO_4%
29.8.60	87	Portage Creek	5.86	15.9	70.0	15.0	1.0	1.36	0
"	87a		11.5	17.2	57.1	18.1	0.9	0.76	0.48
"	87b		7.9	19.2	58.4	18.2	0.8	0.72	0.22
"	88		7.0	19.2	31.6	18.8	1.15	1.44	0.38
"	88a		18.0	20.0	28.0	21.4	1.54	2.08	1.08
"	88b		8.7	17.6	25.6	15.2	1.26	1.08	0.53
19.6.60	19		9.5	50.2	115.0	11.0	4.7	0.44	0.12
"	19a		6.3	43.2	71.0	15.7	3.4	0.6	0.71
"	18		8.2	69.6	120.0	13.0	4.2	0.52	0.48
"	18a		4.1	66.4	110.0	3.0	4.5	0.32	0.45
"	20		16.5	47.2	125.0	13.7	4.3	0.36	1.04
"	20a		9.8	40.0	75.0	15.0	3.4	0.32	0.76
5.8.60	30	Tin Town	10.8	45.6	71.0	31.2	4.2	1.2	0.5
"	30a		2.7	47.2	84.0	10.7	4.1	1.24	0.19
"	30b		4.7	48.8	63.0	7.3	3.0	1.2	0.54
"	31		9.6	40.0	110.0	11.5	2.7	0.44	0.64
"	31a		7.3	41.6	28.0	11.8	3.8	0.68	0.19
"	31b		3.2	41.6	28.0	8.7	3.4	0.68	0.14
"	31c		15.5	52.8	58.0	18.0	4.5	0.92	0.65
"	32		2.96	33.0	52.0	10.0	1.2	0.68	0.24
"	33		4.2	29.6	52.0	14.1	1.6	0.64	0.15
"	33a		4.3	31.3	46.7	14.0	1.4	2.4	0.07
"	33b		2.4	40.8	44.0	11.4	1.1	0.92	0.04
"	34		6.9	28.2	52.0	16.8	1.6	0.64	0.3
"	34a		2.4	28.0	52.0	11.0	1.4	1.33	0.06
"	34b		2.2	34.0	34.3	10.9	1.2	0.92	0.05
4.9.60	98		5.1	18.0	17.3	11.6	1.5	0.96	0.33
"	98a		6.0	19.8	17.3	15.6	1.28	0.88	0.62
"	98b		5.4	17.2	22.0	12.8	1.04	0.72	0.59
"	99		7.3	19.8	33.3	18.8	1.76	1.88	0.35
"	99a		11.9	20.0	28.0	21.4	0.94	1.56	0.75
"	99b		4.5	18.2	22.0	9.6	1.04	1.04	0.39
"	101		2.92	16.3	19.7	10.0	1.08	0.96	0.29
"	101a		3.5	12.0	16.6	10.6	1.04	0.88	0.23
"	101b		4.8	18.0	19.7	11.6	1.22	1.36	0.30

Date	Sample Number	Site	meq/100 gm. Cl	Ca	Mg	Na	K	HCO_3	SO_4%
11.6.60	8	Flee	21.5	40.0	125.0	8.2	3.8	0.6	1.01
"	8a	Island	3.6	33.6	96.0	7.5	2.7	0.56	0.22
"	8b	Study Area							
"	9		4.4	21.0	67.0	17.6	2.5	1.04	0.02
2.8.60	27		7.0	48.4	115.0	24.0	4.2	0.52	0.28
"	27a		3.0	21.6	75.0	15.7	2.9	0.12	0.12
"	27b		17.4	29.6	125.0	9.0	6.4	1.6	0.79
"	28		10.8	16.0	96.0	19.5	1.9	0.48	0.17
"	28a		4.5	17.6	71.0	14.0	1.6	0.68	0.18
"	28b		35.8	29.6	128.0	16.5	0.4	1.96	0.45
"	29		8.8	21.6	96.0	44.1	1.6	0.44	0.37
"	29a		5.0	12.8	63.0	13.2	1.4	0.52	0.17
"	29b		20.4	29.6	11.0	10.7	3.7	1.0	0.90
2.9.60	96	Cook	4.2	19.6	36.3	10.3	0.86	1.44	0.35
"	96a	Creek	9.1	14.4	22.0	16.4	0.80	0.92	0.70
"	96b		6.2	16.2	16.6	11.4	0.50	0.76	0.64
10.6.60	2		15.0	47.2	115.0	18.0	2.8	0.96	0.67
"	2a		6.5	23.2	25.0	7.0	0.8	0.44	0.54
"	13		3.8	56.0	75.0	3.0	3.3	0.4	0.10
"	13a		2.9	48.8	51.0	2.0	2.5	0.64	0.18
22.7.60	22s		1.0	23.2	67.0	4.0	0	1.32	0.49
"	22		6.9	62.4	75.0	14.7	4.3	0.8	0.98
"	22a		4.1	50.4	71.0	20.5	2.7	0.36	0.27
"	22b		3.0	45.6	48.0	15.2	2.3	0.44	0.28
"	25s		40.0	56.0	140.0	15.7	6.9	0.96	0.91
"	25		16.9	35.2	110.0	12.7	3.5	0.68	0.77
"	25a		5.4	43.2	84.0	16.5	2.5	0.52	0.63
"	25b		15.8	43.2	63.0	12.2	1.6	0.28	1.43
14.6.60	15	Torrey's	1.0	56.0	21.0	4.5	0.10	0.46	0.011
"	15a	Pothole	0.6	36.4	61.0	6.5	0.65	0.56	0.014
12.8.60	52	Bells	28.6	47.2	69.3	44.0	1.0	1.16	1.59
"	52a		11.7	52.0	59.6	25.2	0.66	0.80	0.5
"	52b		4.5	48.0	49.3	7.2	0.24	0.60	0.075
"	52c		13.7	39.7	59.6	22.0	0.74	1.16	0.35

Date	Sample Number	Site	meq/100 gm. Cl	Ca	Mg	Na	K	HCO_3	SO_4%
12.8.60	51a	Bells	10.0	56.0	75.0	16.0	1.9	0.68	0.28
"	51b		3.8	41.6	84.0	9.3	2.0	0.44	0.67
"	95		13.1	15.7	90.0	32.8	0.4	1.88	0.6
"	95a		9.5	20.3	35.0	26.0	0.05	1.52	0.33
"	95b		7.95	13.5	16.7	15.4	0.03	1.56	0.3
11.8.60	48	Hutchinsons	13.7	35.2	95.0	15.0	4.6	0.68	0.87
"	48a		7.3	59.2	110.0	12.6	4.0	0.44	0.36
"	48b		4.3	56.0	51.0	8.5	3.1	6.88	0.41
"	49		14.8	35.2	56.0	20.8	1.2	0.88	0.09
"	49a		6.1	32.8	49.3	11.2	0.9	0.80	0.008
"	49b		2.5	27.2	39.3	4.4	0.5	0.36	0.165
"	50		14.6	43.2	59.6	30.0	1.5	1.24	0.79
"	50b		23.8	86.4	75.3	36.8	0.96	1.8	1.24
1.9.60	93	Flee Island Pothole	59.3	15.2	73.0	44.0	0.5	0.72	0.47
"	93a		45.2	12.6	53.4	16.4	1.4	0.42	1.7
"	93b		19.6	10.6	68.0	11.2	0.4	0.56	0.34
"	94		9.8	20.1	85.3	17.8	0.65	0.62	1.44
"	94a		25.4	18.0	73.0	40.4	0.65	0.64	0.5
9.8.60	35	Pintail Slough	12.0	37.6	140.0	16.6	1.5	1.96	0.28
"	35a		2.6	26.4	63.0	5.5	3.6	0.12	0.30
"	35b		4.3	43.2	115.0	9.3	5.2	0.56	0.33
"	36		15.0	34.0	52.0	22.0	3.2	0.04	0.86
"	36a		2.8	11.0	22.3	12.0	1.2	2.4	0.25
"	36b		2.6	16.0	33.3	12.0	1.2	0.6	0.02
12.9.60	37		8.3	16.5	34.3	18.2	1.0	0.08	0.43
"	37a		4.0	14.5	28.7	10.4	0.6	0.72	0.35
"	113 (35)		3.1	10.8	17.3	8.0	1.3	0.24	0.024
"	114 (36)		2.55	10.8	17.3	7.0	1.26	0.2	0.039
"	115(37)		4.1	26.4	25.0	8.6	1.26	0.28	0.021
	115a		4.5	15.6	17.0	9.6	1.3	0.16	0.025

APPENDIX II CONTINUED

Date	Sample Number	Site	meq/100 gm.						
			Cl	Ca	Mg	Na	K	HCO_3	SO_4%
19.8.60	55	Portage Slough	7.8	38.4	48.0	12.3	5.0	0.40	0.08
"	55a		4.0	50.4	84.0	9.7	4.1	0.64	0.21
"	55b		4.3	54.4	75.0	9.5	3.5	0.56	0.06
"	56		6.8	21.6	19.6	20.2	2.2	1.88	0.05
"	56a		10.3	24.8	16.6	19.4	1.86	1.20	0.05
"	56b		4.6	20.4	14.6	12.4	1.16	0.28	0.03
"	57		1.6	27.4	13.0	8.0	1.16	0.92	0.04
"	57a		0.94	14.0	10.5	4.0	0.24	0.48	0
"	57b		0.94	12.8	27.3	2.0	0.2	0.32	0
17.8.60	53	Poplar Pools	15.2	32.0	52.6	24.0	0.32	0.56	0.48
"	53a		4.8	32.0	39.3	10.0	1.76	1.20	0.14
"	53b		1.13	32.5	28.0	17.6	0.2	0.64	0
"	54		3.14	49.6	19.7	20.0	1.8	3.0	0.13
"	54a		14.0	31.2	14.3	8.0	1.1	2.0	0.40
"	54b		1.42	61.1	6.6	1.2	0.6	1.2	0
5.9.60	103		8.7	14.8	24.3	14.6	1.3	0.32	0.024
"	103a		5.5	21.8	23.3	10.6	1.08	0.28	0.052
"	103b		4.5	20.0	11.6	9.2	1.16	0.30	0.017
"	104		8.2	12.4	24.0	12.4	1.08	0.36	0.029
"	104a		7.2	15.6	44.3	14.0	1.26	0.24	0.035
"	104b		3.9	17.2	21.6	8.0	0.76	0.28	0.162
11.6.60	7	Tin Town Slough	11.4	59.8	11.5	13.2	6.9	1.44	0.13
"	7a		7.0	54.2	75.0	7.5	4.7	0.24	0.07
20.8.60	59		9.6	43.2	11.0	12.1	3.3	0.36	0.30
"	59a		8.3	31.2	20.0	8.9	2.2	0.20	0.24
"	59b		12.5	47.2	9.0	10.9	3.3	0.40	0.39
20.8.60	60		18.3	26.4	21.3	22.0	1.54	0.20	0.02
"	60a		17.3	25.6	19.6	17.6	0.96	0.16	0.05
"	60b		9.0	22.4	16.6	10.4	0.86	0.20	0.02