Evaluation of ecological effects of recent low water levels in the Peace-Athabasca Delta

by Herman J. Dirschl

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Canadian
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Abstract

Concern about the ecological effects of the altered water regime of the Peace–Athabasca Delta, following completion of the W.A.C. Bennett Dam on the Peace River, led the Canadian Wildlife Service in 1968 to initiate an ecological study. Its objectives are to evaluate the short- and long-term effects of the altered water regime on the ecosystem and to evaluate the environmental parameters which have to be considered in designing measures which would return the delta to a desirable state.

This report is a preliminary account of our study of plant succession on exposed silt surfaces. It discusses the techniques which we have used to (1) classify and map the delta's landscape according to homogeneous units and (2) examine the distribution of those landscape units in relation to topography and moisture regime.

The 1,700-square-mile delta is situated in northeastern Alberta, adjacent to the western extremity of Lake Athabasca. It is largely contained within Wood Buffalo National Park and is important as bison habitat and as a waterfowl breeding, moulting and fall staging area. Muskrat trapping and fishing in the delta have been traditional sources of income for the 1,500 Cree, Chipewyan and Metis residents of Fort Chipewyan. The delta's wildlife resources, through the future development of tourism and recreational hunting and fishing, represent an economic potential for the native population.

The ecological character of the Peace–Athabasca Delta is determined by the flat terrain and the unique hydrological regime formed by the lower Peace River, and by Lake Athabasca and its outflow channels. Under natural conditions, the Peace River annually reached a flood stage during late June and early July, which acted as a hydrological dam on the outflow channels of Lake Athabasca. Consequently, the level of the lake rose rapidly by at least several feet and briefly flooded most of the delta, resulting in recharging of lakes and perched basins, deposition of silt and plant seeds, ingress of nutrients and flushing of products of plant decomposition. Vegetation pattern and animal life in the delta have developed in response to a fluctuating water regime and thus are adapted to it. A change in the hydrological regime, therefore, causes ecological adjustments within the system. Since control of the Peace River through the W.A.C. Bennett Dam began in December 1967, the annual summer flood has not recurred, and water levels of Lake Athabasca and the shallow delta lakes have fallen by several feet. The area of the nine largest delta lakes has decreased since then by 28 per cent. Many of the perched basins on the flood plain have completely dried out in the absence of spill-in of flood waters.

We have examined the position of vegetation types in the landscape and the ongoing vegetational successions through interpretation of existing small-scale aerial photographs and of large-scale strip photography of representative field transects. We have used a Hasselblad 500 EL camera for this purpose and obtained stereo-coverage at a contact scale of 1:6,000 with black and white, true color and infrared color films. Photographs at a scale of 1:30,000 were also obtained for several key transects. Detailed vegetation mapping of these transects is underway, coupled with detailed repetitive ground sampling of permanent stands to evaluate year-to-year successional changes. Elevational profiles of these transects are required to relate vegetation zonation to topography and past and present water regimes.

The germination of seeds contained within the silt or distributed by wind has resulted in rapid colonization of the exposed lake bottoms by numerous species of herbaceous fen vegetation and by willow seedlings. If the present water regime continues indefinitely, the observed plant succession will convert most of the exposed lake and marsh bottoms into willow or phragmites (*Phragmites communis*) thickets and reedgrass (*Calamagrostis* spp.) meadows. The overall effect of the regulated water regime on the landscape of the Peace–Athabasca Delta appears to represent an acceleration in the natural aging rate of the delta deposits. It will include a simplification of the delta's scenic diversity, a pronounced reduction in the number and extent of water bodies and a diminution of productive shallow marsh and wet meadow environments in proportion to mesic shrub and forest communities.

Résumé

Inquiet des conséquences possibles du nouveau régime hydrographique du delta des rivières de la Paix et Athabasca, à la suite de la construction du barrage W.A.C. Bennett sur la rivière de la Paix, le Service canadien de la faune a entrepris, en 1968, une étude écologique. Ce travail a pour but d'évaluer les effets à long et à court termes de la modification du régime hydrographique sur l'écologie de la région et de déterminer les paramètres de l'environnement à considérer pour établir des mesures propres à redonner au delta un état désirable.

Ce document rend compte du début de notre recherche sur la succession des plantes sur les surfaces boueuses du secteur étudié. Il rend compte également des moyens techniques employés pour (1) classer le paysage du delta en secteurs homogènes et le cartographier et (2) étudier la répartition de ces secteurs en fonction de la topographie et du régime des eaux.

Le delta est situé au nord-est de l'Alberta, à l'extrémité ouest du lac Athabasca. Sa superficie de 1,700 milles carrés est presque toute contenue dans le parc national Wood-Buffalo. Son importance tient à ce qu'il sert d'habitat de bisons, ainsi que de lieu de nidification, de mue et de station d'arrêt de la sauvagine à l'automne. Pour les 1500 habitants de Fort Chipewyan, qui sont surtout des Cris, des Chipewan et des Métis, le piégeage du rat musqué et la pêche dans le delta constituent des sources de revenus traditionnelles. Les ressources fauniques du delta, qui entraîneront une éventuelle expansion du tourisme, de la pêche et de la chasse récréatives, représentent un potentiel économique pour les autochtones.

Le caractère écologique spécial du delta est dû à l'étendue de terrains plats et au régime hydrographique particulier de la basse rivière de la Paix et des chenaux de décharge du lac Athabasca. Auparavant, la rivière de la Paix avait, à la fin de juin et au début de juillet, une crue assez

élevée pour retenir, tel un barrage hydraulique, les eaux de décharge du lac Athabasca. Le niveau du lac montait alors rapidement de plusieurs pieds et inondait brièvement la majeure partie du delta. Il en résultait un remplissage des lacs et des bassins supérieurs, un dépôt de limon et de graines de plantes, un apport de matières nutritives et une élimination des déchets végétaux. La flore et les animaux s'étaient adaptés aux fluctuations de l'eau et s'en accommodaient bien. Il n'est donc pas surprenant qu'une perturbation du régime hydrographique occasionne des changements écologiques. Depuis que le barrage W.A.C. Bennett régularise la rivière de la Paix, l'inondation annuelle de l'été ne se produit plus et, en conséquence, le niveau des eaux du lac Athabasca et des petits lacs du delta a baissé de plusieurs pieds. L'étendue des 9 plus grands lacs du delta a diminué de 28% depuis le mois de décembre 1967. Plusieurs bassins supérieurs de la plaine autrefois inondables sont maintenant complètement à sec en raison de l'absence des eaux normalement apportées par les crues.

Nous avons aussi étudié l'état des types de végétation du paysage et la succession des espèces par l'interprétation des photos-aériennes à petite échelle existantes, et de photos à grande échelle de virées transversales représentatives. A cet effet, nous avons utilisé un appareil photo Hasselblad 500 EL et obtenu une représentation stéréographique à une échelle de 1:6,000 par simple tirage par contact, ceci en noir et blanc, en couleur et en infra-rouge. Nous avons aussi pris des photos à l'échelle de 1:30,000 pour plusieurs virées transversales importantes. Des travaux de cartographie détaillée de la végétation de ces divisions transversales sont en cours, parallèlement à des échantillonnages répétés et minutieux de peuplements permanents.

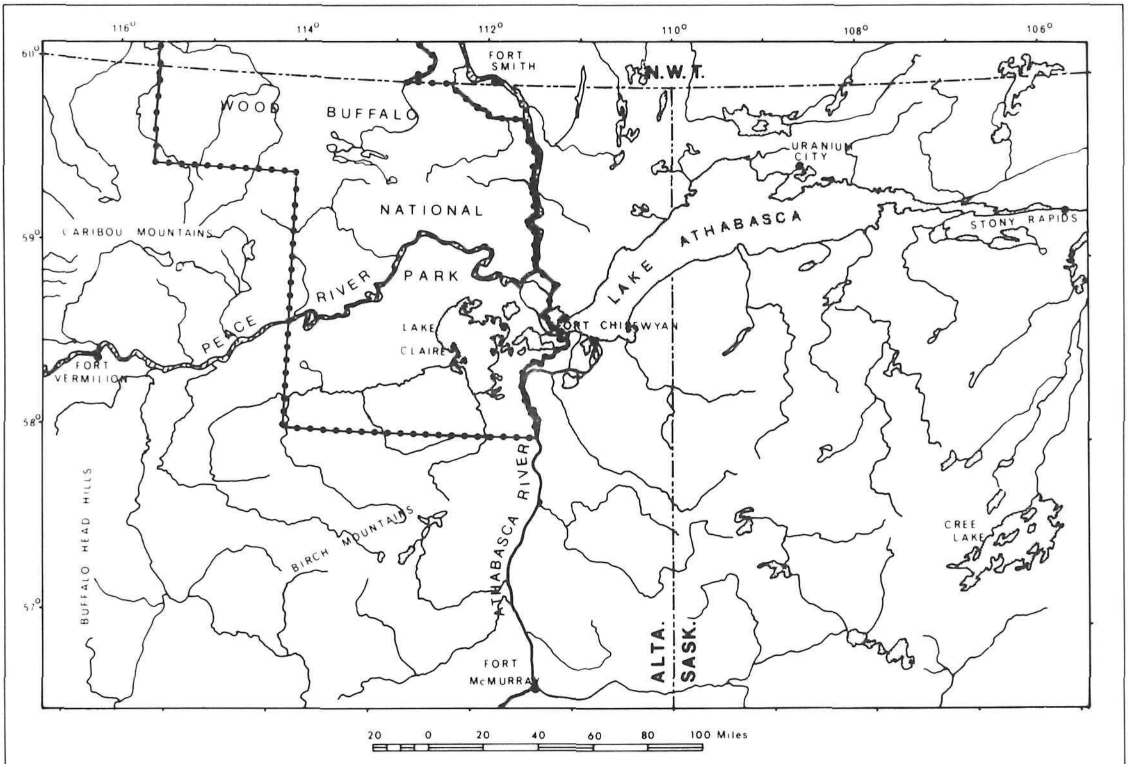
Des profils de ces virées transversales seront nécessaires afin d'établir un rapport entre les zones de végétation, la topographie et les régimes hydrographiques passés et actuels.

La germination des graines contenues dans le limon ou apportées par le vent a contribué à la colonisation rapide des fonds lacustres découverts par de nombreuses espèces de fougères vertes et par de jeunes saules. Si le régime des eaux devait se perpétuer tel qu'il est à l'heure actuelle, l'évolution que nous avons observée transformerait les parties découvertes des lacs et des marais en bosquets de saules ou de roseaux (*Phragmites communis*) et en prairies de calamagrostis. L'effet global de la stabilisation des eaux sur le paysage du delta des rivières de la Paix et Athabasca semblerait donc être une accélération du vieillissement naturel des dépôts du delta. Cela entraînera une diminution de la variété du paysage du delta, une réduction marquée du nombre et de l'étendue des bassins d'eau ainsi que des riches marais et prés humides par rapport aux peuplements d'arbres et de fourrés.

Introduction

Figure 1. Geographical location of the Peace-Athabasca Delta and Wood Buffalo National Park.

Figure 1



In 1967, the W.A.C. Bennett Dam approached completion near Hudson Hope, British Columbia. The Canadian Wildlife Service's concern for the ecological effects of the altered flow regime on the Peace River led to the planning of an ecological study whose focus would lie on the Peace–Athabasca Delta in northeastern Alberta.

Most of the delta lies within Wood Buffalo National Park and the remainder consists of Indian Reserves and of Crown land in right of Alberta (Fig. 1). Since Peter Pond's visit to the delta in 1778 (Mackenzie, 1801), explorers and fur traders have described, in varying detail, the delta's flora and fauna. Fuller and LaRoi (1971) have compiled a brief review of the delta's exploration history. During the summers from 1926 to 1930, Hugh M. Raup made a botanical and ecological survey of Wood Buffalo National Park for the National Museum of Canada and provided the most detailed account of its flora (Raup, 1933; 1935). Novakowski (1967) described the physiography of the delta and indicated the importance

Objectives

of seasonal flooding to vegetation pattern and wildlife habitat conditions.

Approximately 6,000 bison inhabit the delta (McCourt, 1970). It is a moulting and fall staging area for migratory waterfowl and its shallow lakes and marshes accommodate birds from all four, major, North American flyways. Probably the entire population of Ross's Geese migrates through the delta in autumn (Dzubin, 1965). The delta has also ensured survival of ducks displaced by droughts in the prairie region (Smith et al., 1964).

The realized income from muskrat trapping and fishing has provided only subsistence living for most of the 1,500 Cree, Chipewyan and Metis residents of Fort Chipewyan (Fuller, 1951; Dixon, 1971). However, the delta's wildlife resources are both a significant domestic source of human and sled dog food and, through the future development of tourism and recreational hunting and fishing, an economic potential for the native population. No alternative development potential for Fort Chipewyan has been identified.

Field work began in July 1968. The study is scheduled for completion in 1973 (Dirschl, 1970); it seeks to (1) determine the relationships of physical and biotic components and processes which have produced the delta's landscape and wildlife capability, (2) evaluate the short- and long-term effects of the altered water regime on the system, and (3) identify the key environmental parameters which have to be considered in designing measures which would return the delta to a desirable state.

A further objective is to determine the use of common habitat types by waterfowl for breeding, nesting, brood rearing, moulting and spring and fall staging.

This paper is a preliminary report of our study of plant succession on exposed silt surfaces. It discusses the techniques which we have developed and used to (1) classify and map the delta's landscape according to units which are homogeneous as to vegetation, geomorphological features and genetic processes, and (2) examine the distribution of those landscape units in relation to the moisture regime.

The area

The Peace–Athabasca Delta lies between 58°15' and 58°50' N and between 110°40' and 112°30' W. It is situated adjacent to the western extremity of Lake Athabasca in northeastern Alberta and covers an area of about 1,700 square miles, of which more than half is open water.

Topography and drainage

The delta lies in the Peace River Lowlands at the confluence of the Athabasca, Peace and Slave river drainage basins (Fig. 2). It is bounded by the Birch and Caribou mountains on the southwest and the edge of the Precambrian Shield on the northeast. The Birch and Caribou mountains are isolated, flat-topped plateaux of Cretaceous rock at elevations of 2,000 to more than 3,000 feet above sea level. The lowlands lie below 1,000 feet.

Lake Athabasca measures 3,085 square miles but, because of its control over water levels in the contiguous delta, its effective surface area exceeds 4,500 square miles (Bennett, 1970). Two major rivers enter the lake: the Athabasca River from the south and the Fond-du-Lac River from the east. The Athabasca River arises in the Rocky Mountains and consequently shows a flow pattern characteristic of mountain fed rivers—i.e., low winter and high summer flows. The Fond-du-Lac drains Precambrian Shield country and possesses a more even flow throughout the year. The Peace River springs from the mountains of northern British Columbia; it bypasses the Peace–Athabasca Delta on the north and, with the outflow channels of Lake Athabasca, forms the Slave River which in turn drains northward into Great Slave Lake. I shall discuss the hydrological interactions of these streams a little later.

Glacial history and surface geology

Approximately 31,000 years ago, the Keewatin sheet of the Wisconsin glacier covered the Peace–Athabasca Delta with ice as much as 1 mile (1.6 km) thick (Bayrock, 1962). Large ice-marginal lakes formed as the ice sheet retreated gradually. Glacial Lake Tyrrell covered the Peace River Lowlands south and west of the present town of Peace River, extended up the Athabasca River basin to Lac La Biche, and included all of Lake Athabasca and its surrounding lowlands (Taylor, 1958). The ice had retreated completely from the present delta area approximately 10,500 years ago.

After deglaciation, Lake Athabasca was probably about 100 feet (ca. 30 m) higher than it is now (Bayrock, 1962). Since the Peace and Athabasca rivers deposited extensive areas of coarse sands and gravels, they probably had a steeper gradient than they do now. The subsequent lowering of Lake Athabasca reduced the base level of the two major rivers and deposited silt and clay on top of the older, coarser materials (Bayrock, 1962). Closed depressions have gradually filled with flood-deposited silt and clay and with muck and fibrous organic matter since that time.

Regional bedrock ranges from Precambrian granites and gneisses to unconsolidated, Cretaceous sandstones and shales. Precambrian rocks underly the eastern half of the study region; Devonian gypsum, limestones and shales underly the lowlands north of the Birch Mountains (Bayrock, 1961).

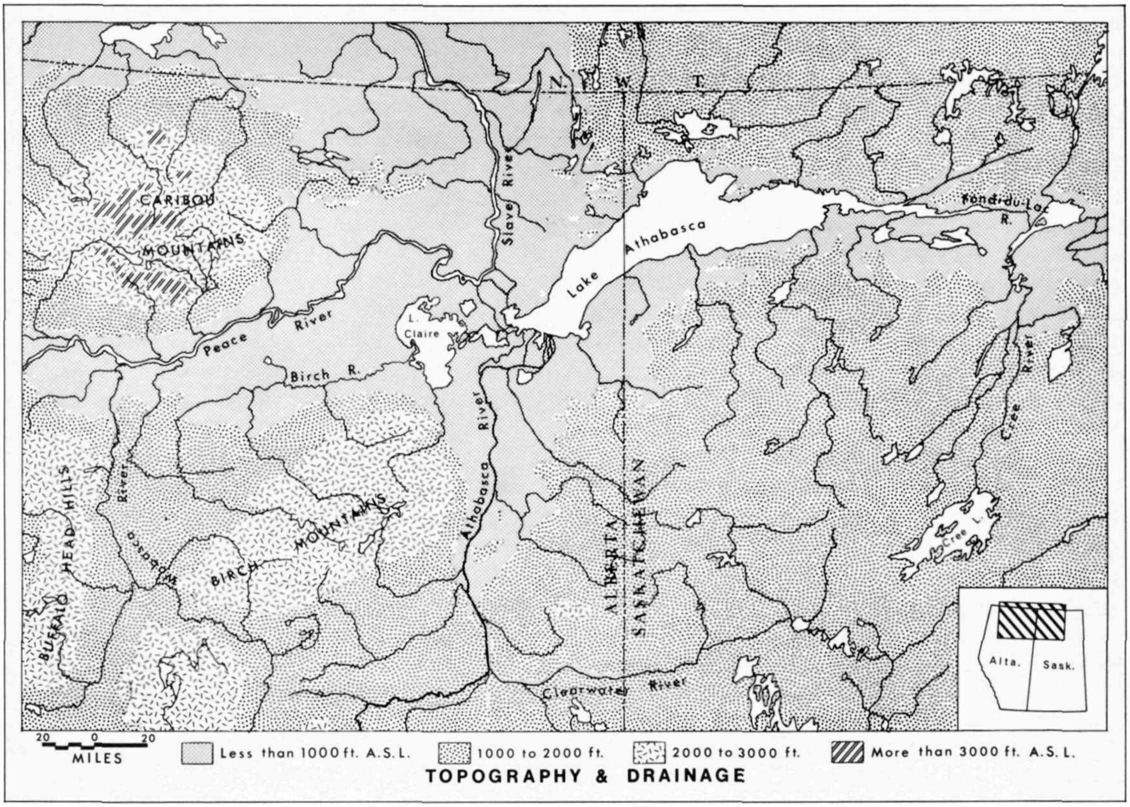
Climate

The study area lies in the subarctic zone (Dfc) of the Köppen classification and is characterized by short, cool summers and long, cold winters. The flow, in summer, of low pressure systems over northeastern Alberta produces in the delta a mean wind direction from the northwest (Odynsky, 1958).

The mean monthly temperatures in the study area are 28 to 30°F (−2.2 to −1.2°C) in April, 60 to 62°F (15.6 to 16.7°C) in July, 34 to 36°F

Figure 2. Topography and drainage of the Lake Athabasca region in northeastern Alberta and northwestern Saskatchewan.

Figure 2



(1.1 to 2.2°C) in October, −10 to −12°F (−23.3 to −24.4°C) in January (Longley, 1968). The moderating influence of the large water bodies extends the frost-free period to 100 days—20 days longer than in the surrounding uplands. The last spring frost normally occurs June 1–15; the first fall frost September 1–15.

Mean annual precipitation is 16 inches (406 mm) of which 9–10 inches (229–254 mm) falls between April 1 and September 30.

Hydrological and ecological characteristics and processes

The flat terrain and the unique hydrological regime formed by the lower Peace River, by Lake Athabasca and its outflow channels, determines the ecological character of the Peace–Athabasca Delta. Under natural conditions, the Peace River's seasonal discharge varied considerably, reaching a median peak flow in July of 345,000 cubic feet per second (cfs) and declining gradually in late summer and fall to a median minimum flow in winter of 11,900 cfs (Coulson, 1970). During the high, spring and summer flows, its water level exceeded that of Lake Athabasca and acted as a hydrological dam which stopped and to some extent reversed the outflow from Lake Athabasca and the contiguous delta lakes. Consequently, Lake Athabasca rose rapidly 5 or 7 feet to a mean annual peak of 688.3 feet (Bennett, 1970) which almost flooded the entire delta and resulted in the recharging of lakes and ponds, the ingress of nutrients, the deposition of silt and plant seeds and the flushing or dilution of the acid products from plant decomposition. After the spring flood and through the remainder of the year, outflow and evapo-transpiration gradually lowered the water levels. It is important to realize that the vegetation patterns and animal life which now characterize the delta have developed in response to this fluctuating water level regime and are thus adapted to it. Any change in the hydrological regime causes ecological adjustments within the system.

The filling of Lake Williston, the reservoir behind the W. A. C. Bennett Dam, began in December 1967. From 1968 through 1970, the peak spring flow at Peace Point near the mouth of the Peace River did not exceed 120,000 cfs. Except for a brief period in April 1969, when an ice jam caused a reversal in the gradient of the outflow channels, the outflow from Lake Athabasca has been continuous (Card and Yaremko, 1970). Lake Athabasca's maximum levels for the three years were 684.6, 685.7, and 684.3 feet — 3–4 feet below the mean peak (Bennett, 1970). I shall show later that these figures represent a drop below the level required to flood the delta.

I foresee no significant improvement for Lake Athabasca's water level when the power plant reaches full operation. The generating station will be used as a baseload plant discharging a nearly constant 36,000 cfs year-round. Sixteen thousand cfs flowed through the turbines in 1970 (Coulson, 1970). The addition of 20,000 cfs to the flow in the lower Peace River will not be sufficient to retard significantly the outflow from Lake Athabasca. Consequently, the water levels of Lake Athabasca and the contiguous delta will not return to pre-1968 levels.

Methods and techniques

We chose our methods with the following considerations and assumptions in mind.

(1) Vegetation zonations in the Peace–Athabasca Delta are principally determined by differences in moisture regime. Since the substrate throughout the area consists uniformly of fine-textured, deltaic deposits, we considered this assumption valid.

(2) Because of the delta's low relief, very slight differences in the topography are reflected in the vegetation pattern.

(3) Since the filling of the reservoir was underway when we began to collect field data, we expected rapid vegetational changes in those portions of the delta directly affected by the falling water levels. To assess these ongoing, vegetational changes, it was essential to obtain efficient and accurate means of monitoring them.

(4) Short-term vegetational adjustments and long-term developmental processes would have to be studied simultaneously.

Therefore, we adopted a system of aerial photographic sampling which permitted rapid recording of vegetation patterns and changes, and ready storage of sets of information for subsequent comparison and analysis. Traditional methods for ground sampling of vegetation and site would not have allowed us to recognize and evaluate vegetational changes in such a large and complex area.

Reconnaissance mapping

Initially, we prepared vegetation maps for three representative portions of the delta (Fig. 3) by interpreting 1955 air photos and uncontrolled mosaics at a scale of 1:37,000. These maps show the distribution of broad physiognomic vegetational categories. A small portion of one of these map sheets is shown in Figure 4. We then selected 15 representative transects and marked them permanently in the field (Fig. 3). All ground and air photo study was then confined to those transects.

To correlate vegetation patterns with topography and water regime, we surveyed several of these transects and drew profile diagrams. We studied soil profiles from several locations along each transect to determine the rates of deposition and the past, successional patterns which had led to the present landscape.

Aerial photographic and ground survey techniques

We used a Hasselblad 500 EL camera. Although this model is not specifically designed as an aerial camera, its use in aerial photographic research is increasing (Marlar and Rinker, 1967; Ulliman et al., 1970). Our camera was equipped with Zeiss Distagon f 4/50 mm, Planar f 2.8/80 mm, and Sonnar f 5.6/250 mm lenses. Nearly all of our aerial photographs were taken with the 80 mm lens. Three film magazines, capable of holding cassette-loaded 70 mm film, facilitated the rapid change of film between flight lines.

We used three types of film consecutively to photograph the selected transect lines: (1) Double-X Aerographic black and white film, (2) Ektachrome Aero true colour film, and (3) Ektachrome Infrared Aero false colour film.

At the end of each day's photographing, the film was processed at the field station in Fort Chipewyan where we could catch mistakes in coverage or exposure and adhere to strictly controlled developing procedures. Uniformity of exposure and processing is essential in a program of repetitive, comparative photo-analysis.

During the course of the 1969 and 1970 growing seasons, we made three coverages of each transect to evaluate the seasonal and annual differences in the photo imagery of existing plant community-types and to monitor quickly and accurately the colonization of newly exposed silt surfaces: (1) A few weeks after growth had begun (June 16–22), (2) At the height of the grow-

Figure 3. Key map of the Peace–Athabasca Delta, showing the three areas covered by reconnaissance vegetation maps and the location of the 15 field transects.

Figure 3

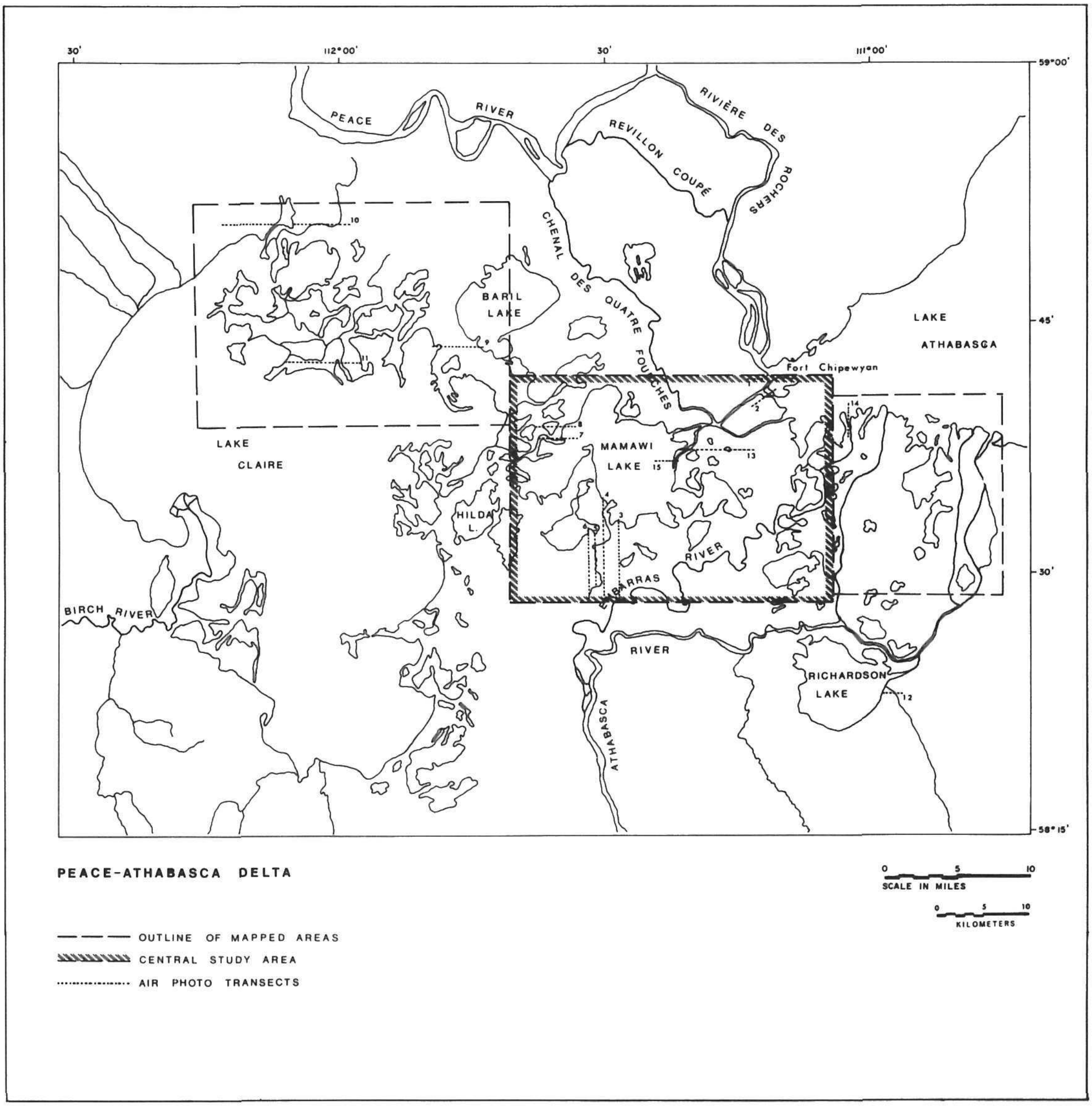


Figure 4. Example of the reconnaissance vegetation maps prepared for three representative portions of the delta.

Figure 4

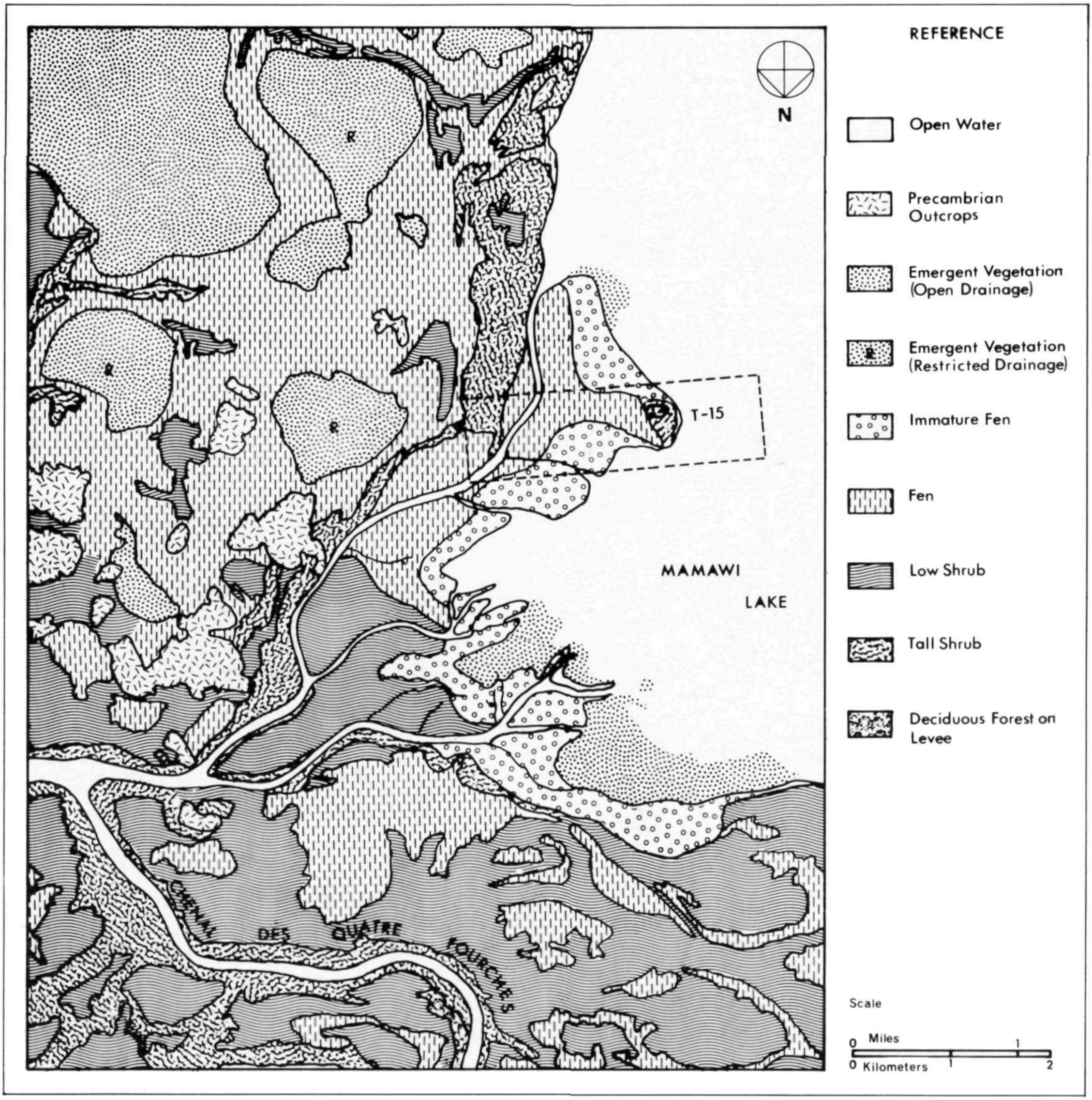
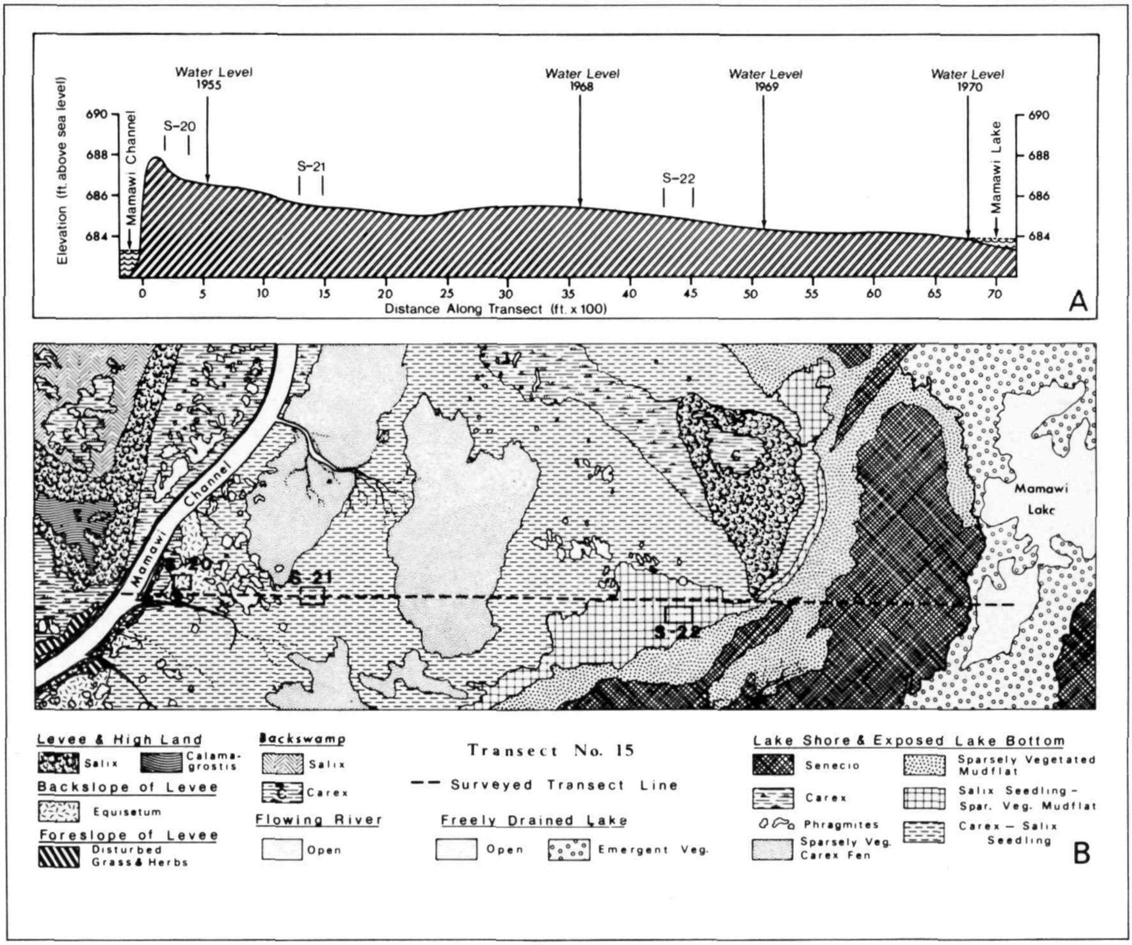


Figure 5. Profile diagram and detailed vegetation map of Transect 15 on the east shore of Mamawi Lake.

Figure 5



ing season (July 22–30), and (3) At the end of the growing season (September 17–19).

We took most of the photographs with the 80 mm lens from 1,500 feet above terrain, an altitude which yielded a contact scale of 1:6,000. We also photographed several transects from 7,900 feet above terrain, yielding a contact scale of 1:30,000.

We shot our vertical stereo photographs from a chartered Piper "Apache" twin-engine aircraft. The photographer held the camera with a Hasselblad double hand-grip and sat in a specially installed seat over the camera hatch. This arrangement permitted him to compensate quickly for the small, rapid changes in aircraft attitude caused by prevalent air turbulence at low altitudes.

Airboat and helicopter transportation enabled us to collect "ground truth" data through an extensive sampling program. We estimated vegetative cover according to these five classes:

Cover class	Range of cover (%)
1	1–5
2	6–25
3	26–50
4	51–75
5	76–100
(+	present but rare)

We sampled herbaceous and low shrub vegetation in systematically placed quadrats of 0.5 m^2. Quadrat number was set at either 20 or 40 depending on the degree of heterogeneity.

We obtained cover estimates of the tall shrub and tree canopy by holding the Hasselblad camera vertically and viewing the image on the 6 x 6 cm ground glass screen through the 80 mm lens (52° acceptance). We then averaged 20 systematically distributed readings from each stand. Black and white photographs, taken at each sampling point, permitted us to verify the visual estimates later. Since 1968, annual sampling of specific stands has provided detail of the vegetational replacement sequence of succession on newly exposed mudflats around the shallow, delta lakes.

Detailed mapping of field-transects

To map the vegetational detail of the field-transects from the 70 mm strip photographs, we initially prepare strip mosaics at a scale of 1:7,000 from high contrast black and white prints.

At this scale, classification for mapping purposes is much more detailed. To map terrestrial communities, we use a subjectively developed landform-vegetation classification which includes the following deltaic land facets: (1) lake shore and exposed lake bottom, (2) levees and ice ramparts, (3) foreslope of levee, (4) backslope of levee, (5) backswamp (depressional meadow), (6) point bar, (7) meander scroll (dry channel), and (8) Precambrian outcropping. To map large relief features such as forest and shrub communities we view the black and white photos in stereo and outline these units on a mylar overlay. However, it is impossible to distinguish between various types of low herbaceous vegetation on the black and white photographs. Since the colour infrared photos clearly show differences between the plant species components of the fen and lakeshore areas, we place 70 mm colour infrared diapositives in a small enlarger, and project their image onto the mylar overlying the mosaic. Once the orientation and placement of the projected image are absolutely correct, the fen communities are marked out on the overlay.

Figure 5 is the result of this detailed mapping procedure applied to Transect 15 on the east shore of Mamawi Lake (Fig. 4).

Recent water levels within the delta area and effects on the landscape

The levels of the three major delta lakes, Claire, Mamawi and Richardson, were measured periodically during the open water seasons of 1968–70 and compared with the 1960 levels for Lake Claire and Mamawi Lake (Collier, 1960). Both sets of data were adjusted to a common geodetic datum (Fig. 6). Unfortunately, the water levels of Richardson Lake in 1960 are not known and the geodetic elevation of the temporary bench mark used in 1968–70 has not been established.

Figure 6 indicates that the water levels of Lake Claire and Mamawi Lake rose sharply during June and July 1960 but declined gradually throughout the 1968 and 1970 open water seasons. In 1969, these levels were lowest in July and then rose slightly. The decline in water levels appeared to be cumulative for the 3-year period; by September 1970, they had fallen to 684 feet above sea level, i.e. approximately 5 to 6 feet below the corresponding level in 1960.

The 1968 and 1969 graphs for Richardson Lake (Fig. 6) show a pattern similar to the other two lakes. In 1970, however, strong flood conditions on the Athabasca River caused a rapid recharge into Richardson Lake during July and early August.

Because relief in the delta is very slight, as illustrated by the profile diagram of Transect 15 (Fig. 5A), falling water levels have led to gross reductions in open water areas. This is quite apparent from a comparison of 1955 and 1970 aerial photographs of the delta. Figure 7 illustrates areas of former lake bottom that have been exposed continuously since the 1967 flood. Table 1 lists the specific reductions of nine delta lakes, each with a basin size of at least 3.0 square miles. Their total area has decreased 28 per cent from 638 square miles to 465 square miles. If the wide expanse of Lake Claire is excluded from the calculations, the average reduction of the other eight lakes is 55 per cent.

Figure 6

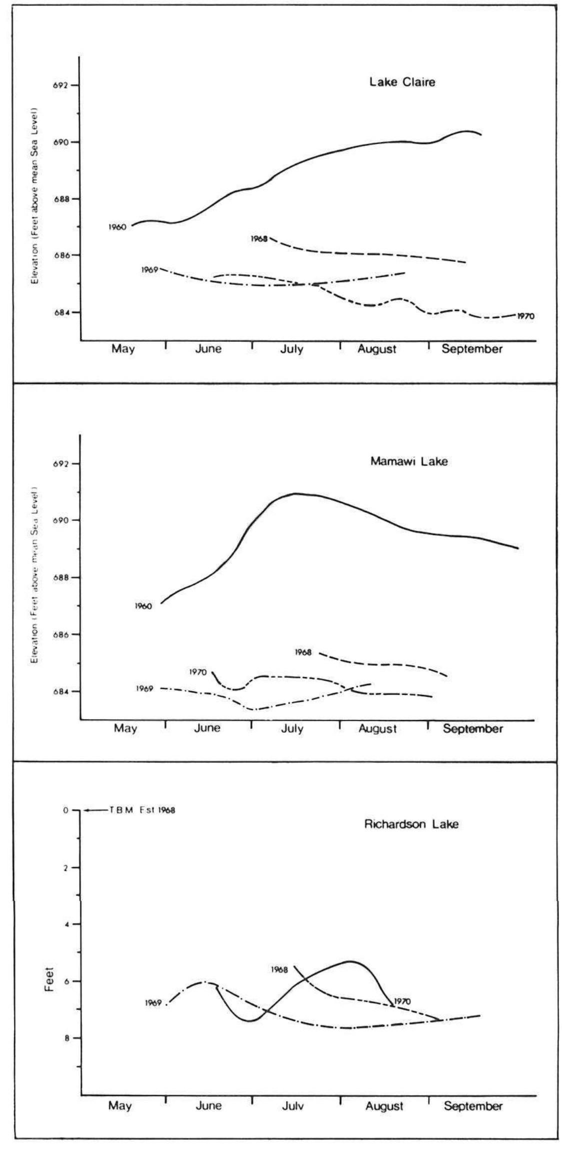


Figure 6. Water level changes during the open water seasons of 1960 and 1968-70 in three large lakes of the Peace–Athabasca Delta.

Figure 7. Decrease in water area in the Peace–Athabasca Delta, resulting from the falling water levels of Lake Athabasca.

Figure 7

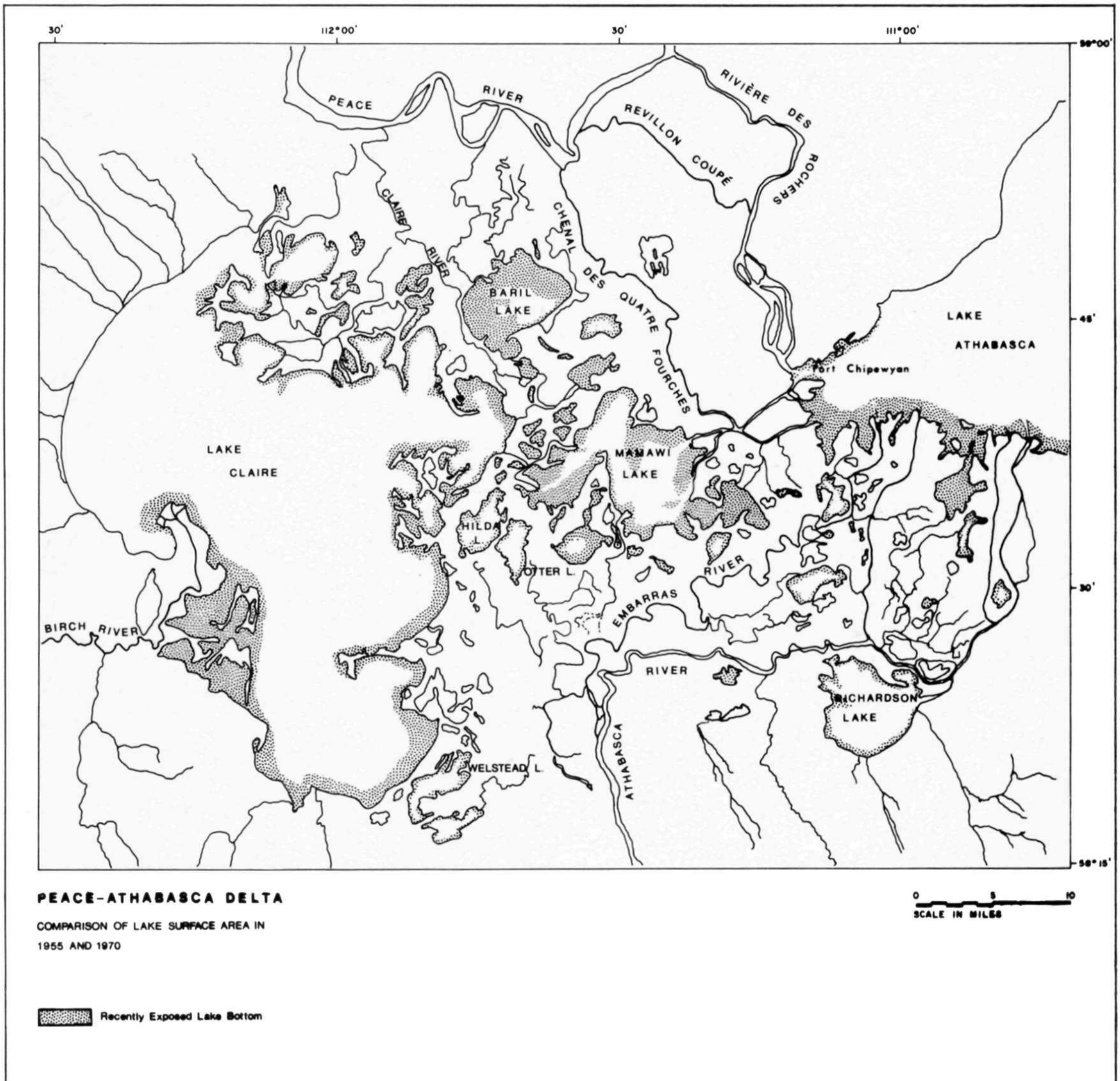


Figure 8. East side of Mamawi Lake in July 1970, showing the low water level of the lake and the dried up outflow channels.

Table 1
Recent reductions in size of major water bodies in the Peace-Athabasca Delta.

Lake	Area under water (square miles) 1955	Area under water (square miles) 1970	Decrease Square miles	Decrease Percent
Lake Claire	496.0	400.0	96.0	19
Mamawi Lake	64.0	25.6	38.4	60
Richardson Lake	27.2	20.2	7.0	26
Baril Lake	25.5	5.3	20.2	79
Welstead Lake (North)	7.3	4.0	3.3	45
Hilda Lake	7.2	5.0	2.2	28
Welstead Lake (South)	4.3	2.8	1.5	34
Otter Lake	3.5	1.8	1.7	49
Sonny's Lake	3.0		3.0	100
Total	638.0	464.7	173.7	28
Total (excluding Lake Claire)	142.0	64.7	77.3	55

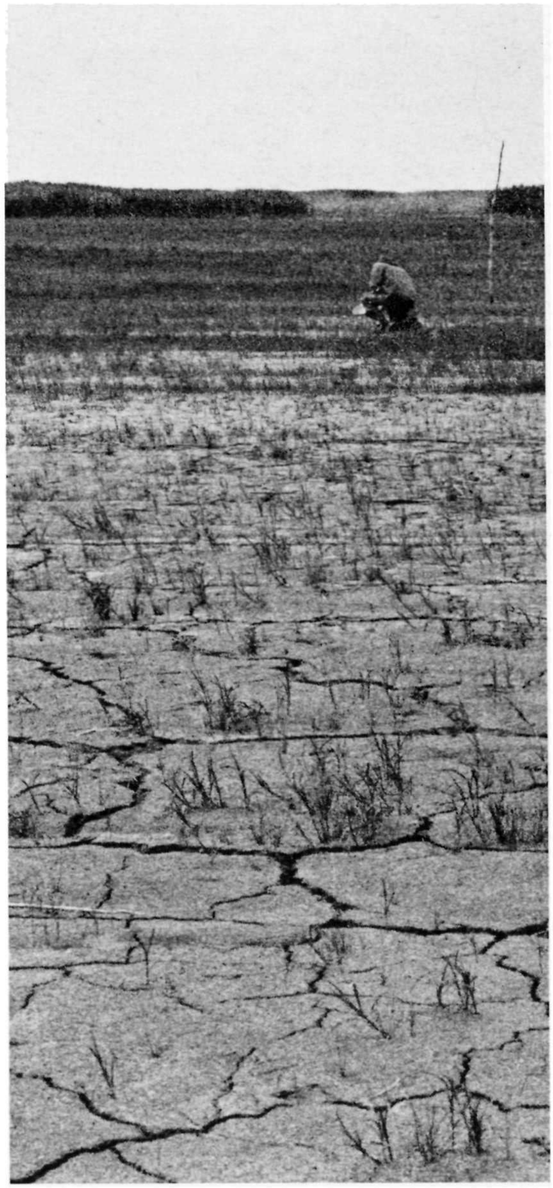
Lakes and ponds in the upper portion of the Athabasca Delta show relatively little reduction in area. This is particularly true of backwaters filled by local runoff or by overflow from spring ice jams in the channels of the Athabasca River.

Much more water area has been lost in the lakes and ponds directly connected to Lake Athabasca. Extensive mudflats have formed in Lake Claire, Mamawi Lake (Fig. 8) and Baril Lake. The latter in particular has decreased to less than one-quarter of its former size, and has become completely cut off from the other lakes. Mamawi Lake has a depth of less than 18 inches and consequently freezes to the bottom each winter. The continuing flow of Birch River water from Lake Claire to the Chenal des Quatre Fourches appears to be eroding a distinct channel across Mamawi Lake. If this process continues, lateral drainage into this forming channel may drain the entire lake within a few years.

An additional 25 lakes in the lower delta, between 1.0 and 3.0 square miles in size and previously replenished through overflow channels from the major lakes, have now completely dried up (Fig. 9).

Figure 9. Closed depression north of Lake Claire, almost dried up in July 1970 due to the absence of the summer flood since 1967.

Figure 10. Photographs of Stand 4 on the east shore of Mamawi Lake, in July 1968–70, illustrating the rapid plant succession on exposed lake bottoms.



The germination of seeds contained within the silt or distributed by wind has resulted in rapid plant growth on the exposed lake bottom (Figs. 10 and 11). In July 1968, five stand-samples on silt surfaces, which had been exposed continuously since the spring, possessed a low, seedling cover of five or seven species. By July 1969, they had become closed meadows containing a mean of 20 species of sedges, grasses and forbs. Also, willow seedlings began to grow beneath the herbaceous field layer, particularly in sites close to established willow communities. By summer 1970, the mean number of plant species had increased to 29 and the willow seedlings had overtopped the herbaceous cover to become visually dominant. In addition, alder and balsam seedlings had occasionally established themselves.

Water levels as low as those experienced during the 1968–70 period have occurred naturally from time to time (Bennett, 1970). Consequently, the observed plant colonization of lake bottoms must also have occurred but subsequently ceased during floods. In fact, a number of soil pits have revealed thin layers of fen vegetation and charcoal seams buried beneath flood-deposited silt.

If the present water regime continues indefinitely, the observed plant succession will convert most of the exposed lake and marsh bottoms into willow or *Phragmites communis* thickets and reedgrass (*Calamagrostis* spp.) meadows. The altered water regime also appears to be initiating the replacement of extant sedge meadows, dominated by *Carex atherodes,* with *Calamagrostis* meadows. Novakowski (1967) estimated that about 260 square miles of fen and marsh may be affected in this manner within the park portion of the delta.

A delta is a dynamic system which grows downstream and matures upstream. During this maturing process, delta sites develop gradually toward drier, and more stable, soil moisture conditions.

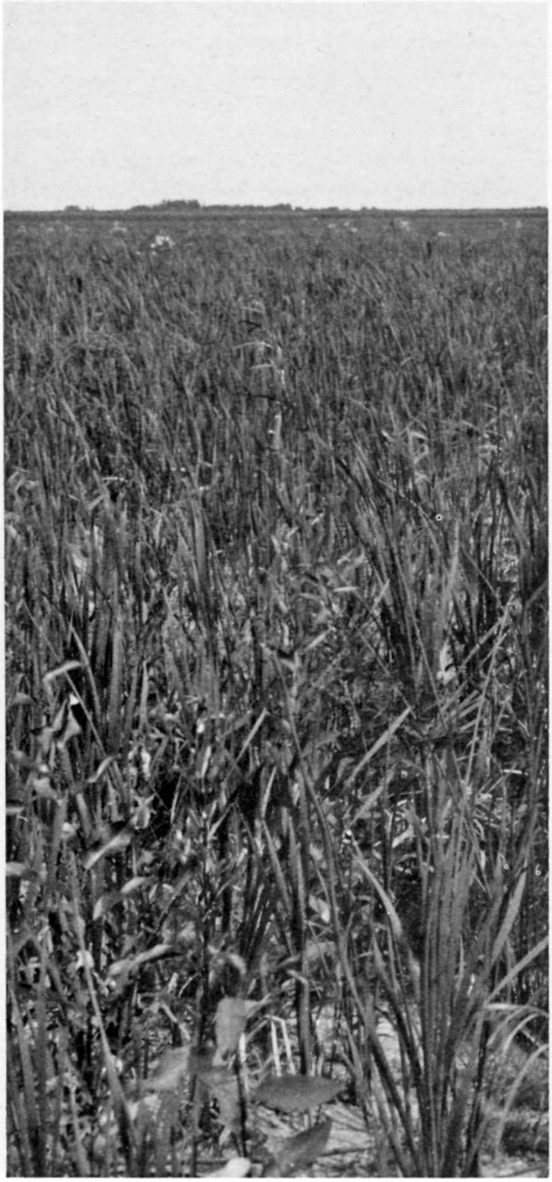
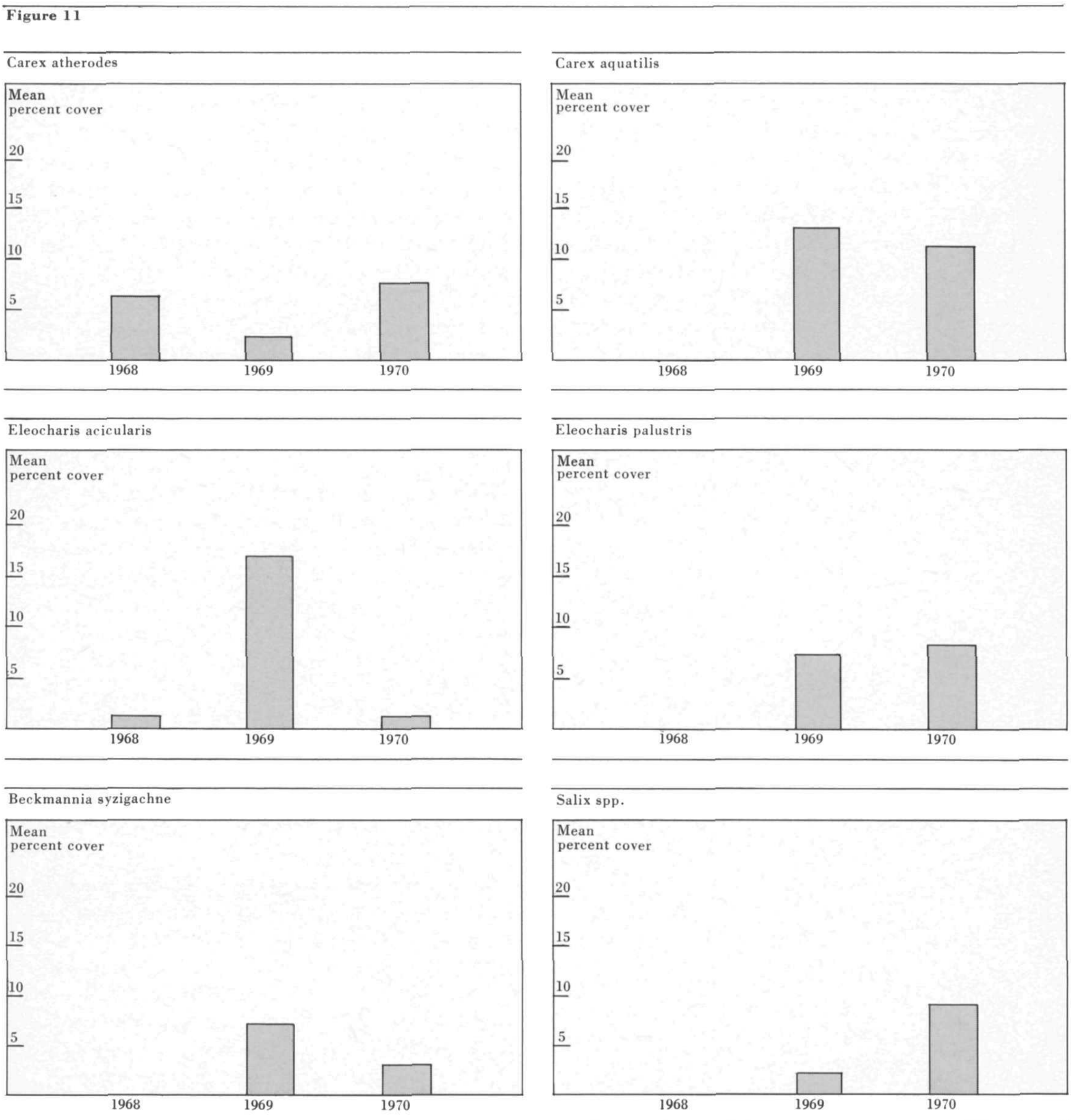


Figure 11. Mean per cent ground cover of six major plant species in five sites on silt surfaces exposed since spring 1968.



Vegetation zonations in relation to topography

Vegetation which is adapted to seasonal inundation is consequently replaced by more mesic communities. Thus the overall effect of the regulated water regime on the landscape of the Peace–Athabasca Delta represents an acceleration in the natural aging rate of the delta deposits. It will include a simplification of the delta's scenic diversity and a pronounced reduction in the extent of open water, of productive shallow marsh and of wet meadow communities. These extensive locations are directly affected by the rise and fall of water levels. They contain the food supply for bison and the breeding habitat for waterfowl and muskrat. The effects of the regulated water regime on those populations will be obvious.

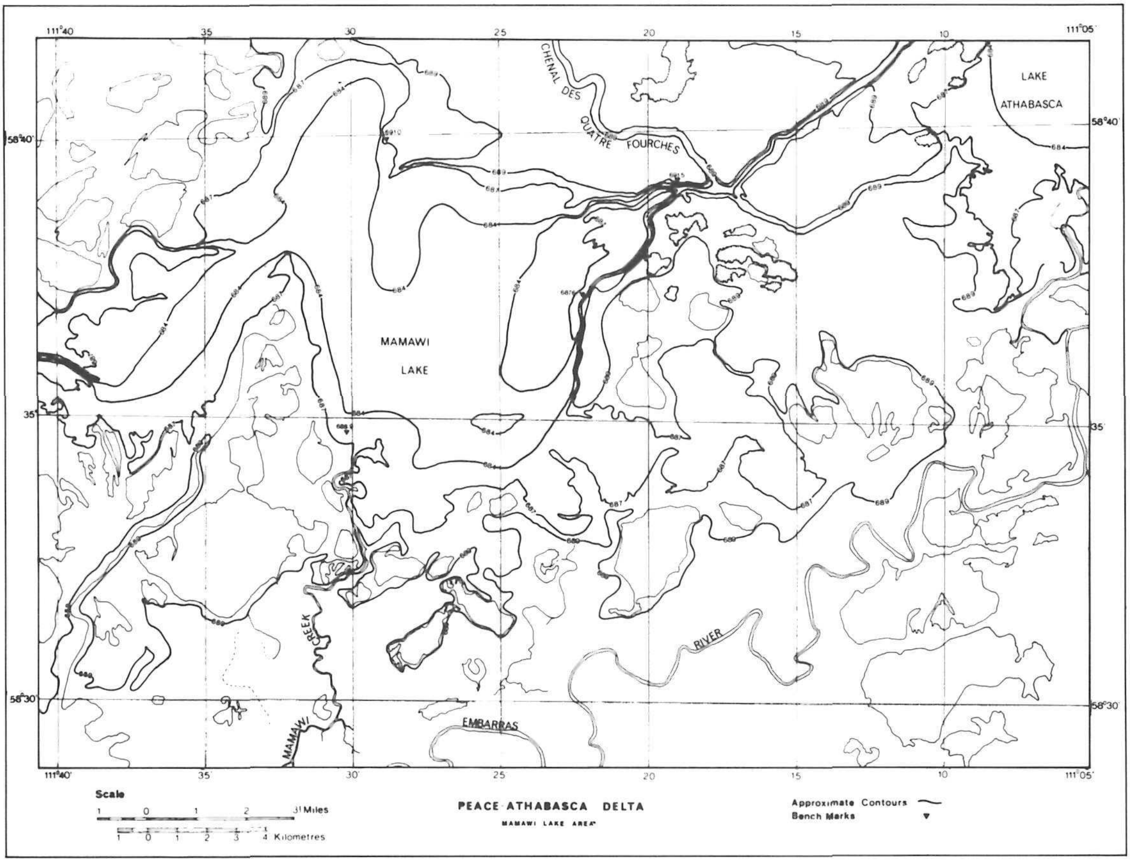
Despite the low relief within the delta, the arrangement of plant cover reflects clearly the minor topographic and moisture regime differences (Raup, 1935). Thus any changes in the seasonal height of the water table have a pronounced effect on vegetation zonation. In the previous section, I described the effects of recent low water levels on vegetation. If water levels in the delta would again rise through increased flows in the Peace River or through construction of outflow controls, the vegetation pattern would respond accordingly.

I expect that our two levels of air photo interpretation, plus concurrent environmental measurements, will provide enough knowledge of the relationships between plant communities, water regime and topography to permit proper management planning.

Recently, the governments of Alberta and Saskatchewan and the federal government formed the Peace–Athabasca Delta Task Force to investigate the physical, biological and socio-economic aspects of the altered water regime on the Peace–Athabasca Delta. The task force will identify a water regime which would permit optimum use of resources in the delta. Determining desirable seasonal and annual ranges and periodicities of water levels is basic to this undertaking. A topographical map of the delta showing the extent of inundation at various water levels is necessary. The size and the extremely low relief of the delta render unfeasible the use of conventional ground survey and photogrammetric techniques. To date, our study indicates that adequate contour maps may be obtained from vegetation zonations. Figure 12 shows a preliminary contour map for the portion of the delta in which the detailed ecological study was concentrated; however, only additional medium-scale photographs and cross-sections of representative belt-transects will provide us with the confidence we need to apply this approach to the entire delta.

Figure 12. Mamawi Lake section of the Peace–Athabasca Delta, showing approximate position of 684 ft, 687 ft, and 689 ft contours as derived from vegetation zonation.

Figure 12



Literature cited

Bayrock, L. A. 1961. Surficial geology. Appendix to Preliminary Soil Survey Report 62–1. Research Council of Alberta, Edmonton. 61 p.

Bayrock, L. A. 1962. Surficial geology. Appendix to Preliminary Soil Survey Report 63–1. Research Council of Alberta, Edmonton. 60 p.

Bennett, R. M. 1970. Lake Athabasca water levels, 1930 – 1970. Water Survey of Canada, Dept. of Energy, Mines and Resources, Calgary. 77 p.

Card, J. R. and E. K. Yaremko. 1970. Athabasca Delta project. Report No. 1. Alberta Dept. of Agriculture, Water Resources Div., Edmonton. 52 p.

Collier, E. P. 1960. Report No. 11 on Peace River investigations. Typewritten report. Water Survey of Canada, Calgary.

Coulson, A. 1970. Water levels in the Peace–Athabasca Delta area. Water Planning and Operations Branch, Dept. of Energy, Mines and Resources, Ottawa. Mimeo report. 9 p.

Dirschl, H. J. 1970. Ecological evaluation of the Peace–Athabasca Delta. Annual progress report 1969–70. Canadian Wildlife Service, Saskatoon. 66 p.

Dixon, P. G. 1971. Local society and economy of Fort Chipewyan, Alberta, p. 249 to 254. *In* Proceedings of the Peace–Athabasca Delta Symposium, Water Resources Centre, The Univ. of Alberta, Edmonton.

Dzubin, A. 1965. A study of migrating Ross' geese in western Saskatchewan. Condor 67:511–534.

Fuller, W. A. 1951. Natural history and economic importance of the muskrat in the Athabasca–Peace Delta, Wood Buffalo Park. Canadian Wildlife Service, Wildl. Mgmt. Bull., Ser. 1, No. 2. 83 p.

Fuller, W. A. and G. H. LaRoi. 1971. Historical review of biological resources of the Peace–Athabasca Delta, p. 153–173. *In* Proceedings of the Peace–Athabasca Delta Symposium, Water Resources Centre, The Univ. of Alberta, Edmonton.

Longley, R. W. (Chairman). 1968. Climatic maps for Alberta. The Alberta Climatological Committee, Dept. of Geography, Univ. of Alberta, Edmonton.

Mackenzie, A. 1801. Voyages from Montreal on the river St. Laurence through the continent of North America to the Frozen and Pacific Oceans in the years 1789 and 1793. London, England. Printed for T. Cadell. 412 p.

Marlar, T. K. and J. N. Rinker. 1967. A small four camera system for multi-emulsion studies. Photog. Eng. 33:1252–1257.

McCourt, K. 1970. Bison study on the Peace–Athabasca Delta. Canadian Wildlife Service, Edmonton. Mimeo report. 12 p.

Novakowski, N. S. 1967. Anticipated ecological effects of possible changes in the water levels of the Peace River–Athabasca River Delta as a result of the damming of the Peace River. Canadian Wildlife Service. Mimeo Report. Ottawa. 20 p.

Odynsky, W. 1958. U–shaped dunes and effective wind directions in Alberta. Can. Jour. Soil Sci. 38:56–62.

Raup, H. M. 1933. Range conditions in the Wood National Park of western Canada with notes on the history of the wood bison. Special Publ. Amer. Comm. for Int. Wildlife Protection 1 (No. 2).

Raup, H. M. 1935. Botanical investigations in Wood Buffalo Park. Nat. Mus. Can. Bull., No. 74 (Biol. Ser. No. 20). 174 p.

Smith, R. H., F. Dufresne and H. A. Hansen. 1964. Northern watersheds and deltas, p. 51–66. *In* Linduska, J. P. (ed.). Waterfowl tomorrow. U.S. Dept. of Interior, Washington. 770 p.

Taylor, R. S. 1958. Some Pleistocene lakes in northern Alberta and adjacent areas. Edmonton Geol. Soc. Quart. 2(4):1–9.

Ulliman, J. J., R. P. Latham and M. P. Meyer. 1970. 70 mm. quadricamera system. Photog. Eng. 36:49–54.

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