# EVALUATION OF ECOLOGICAL EFFECTS OF RECENT WATER REGIME CHANGES IN THE PEACE-ATHABASCA DELTA

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# INTRODUCTION

Concern about the possible effects of regulation of the Peace River by the W. A. C. Bennett Dam on landscape and wildlife resources of the Peace-Athabasca Delta, led the Canadian Wildlife Service in 1968 to implement a 5-year ecological study of the area. The Peace-Athabasca Delta is situated in northeastern Alberta, adjacent to the western extremity of Lake Athabasca and encompasses nearly 2,000 square miles. Most of it forms part of Wood Buffalo National Park. The delta is very important in the life cycle of a large number of waterfowl for breeding and moulting, as a congregating area during the spring and fall migrations, and as a refuge for prairie ducks displaced by drought (Smith et al. 1964). It has also traditionally produced large harvests of muskrat for the 1,500 Indian and Metis residents of Fort Chipewyan (Fuller 1951, Dixon 1971) and has maintained a population of approximately 6,000 bison (McCourt 1970).

The ecological character of the Peace-Athabasca Delta is determined by the extremely 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 had a pronounced variability in seasonal discharge, characterized by a median peak flow in July of 345,000 cubic feet per second, followed by a gradual decline during late summer and fall to a median minimum flow in winter of 11,900 cfs (Coulson 1970). During the high spring and summer flows, the water level in the Peace River exceeded the level of Lake Athabasca and thus acted as a hydrological dam that stopped, and to some extent reversed, outflow from Lake Athabasca and the contiguous delta lakes.

In consequence, Lake Athabasa rose rapidly by 5 to 7 feet to a mean annual peak water level of 688.3 feet during the period 1930-1969 (Bennett 1970). At such high stages, almost the entire delta was under water, resulting in recharging of lakes and sloughs, ingress of nutrients, deposition of silt and plant seeds, and flushing or dilution of acid products of plant decomposition. Following the spring flood, water levels in the delta gradually fell during the remainder of the year through outflow and evapotranspiration. It is important to realize that vegetation patterns and animal life, now characterizing the delta, have developed in response to this fluctuating water level regime and are thus adapted to it. Any change in the hydrological regime, therefore, causes ecological adjustments within the system.

Filling of Lake Williston, the reservoir behind Bennett Dam, began in December 1967. Peak spring flow at Peace Point near the mouth of the Peace River, during 1968-1970, did not exceed 120,000 cfs; outflow from Lake Athabasca, therefore, has remained essentially continuous (Card and Yaremko 1970). Lake Athabasca maximum elevations for those 3 years were 684.6, 685.7, and 684.3 feet, i.e., 2-3 feet below the mean peak water level (Bennett 1970). This represents a drop below the level required to flood the delta, as shown by a comparison of measured water levels of three delta lakes in 1960 and 1968-1970.

No significant improvement is foreseen for Lake Athabasca water levels when the power plant reaches full operation, probably in 1971. The generating station will be used as a baseload plant, discharging a nearly constant 36,000 cfs year-round. This compares with 16,000 cfs that flowed through the turbines during 1970 (Coulson 1970). The addition of another 20,000 cfs to the flow in the lower Peace River will not be sufficient to significantly retard outflow from Lake Athabasca. Consequently, water levels of Lake Athabasca and the contiguous delta are not expected to return to pre-1968 levels.

The study seeks to determine the relationships of physical and biotic components and processes which have produced the delta's landscape and wildlife capability, and to evaluate the short- and long-term effects of the altered water regime on the system. It aims to identify key environmental parameters that have to be considered in remedial measures designed to return the delta to a desirable state.

This presentation will be restricted to those aspects of the study dealing with methods and techniques used or developed to (1) classify and map the delta's landscape according to units, homogeneous as to vegetation, geomorphological features and genetic processes, and (2) to examine the distribution of those landscape units in relation to the moisture regime.

## METHODS

The methods for this study were chosen 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 uniformly consists of deltaic deposits, this assumption is considered valid.

(2) Because of the low relief, very slight differences in topographic position are reflected in the vegetation pattern.

(3) As the filling of the reservoir was underway when the study began, rapid vegetational changes were expected in those portions of the delta directly affected by the falling water levels. In order to assess these changes, it was essential to obtain an efficient and accurate means of monitoring ongoing vegetation changes.

(4) Study of the immediate vegetational adjustments and of the long-term developmental processes would have to be carried out simultaneously.

It was evident, that complete reliance on traditional methods of ground sampling of vegetation and site would be too inefficient for the recognition and evaluation of vegetation-environmental relationships in such a large and complex area. A system of aerial photographic sampling was, therefore, adopted since it allows rapid recording of vegetation patterns and changes, and ready storage of sets of information for subsequent comparison and analysis.

Initially, vegetation maps were prepared for representative portions of the delta by interpretation of 1955 airphotos and uncontrolled mosaics at a scale of 1:37,000. These maps show the distribution of broad physiognomic vegetational categories. A number of representative transects were then selected and permanently marked in the field. All ground and airphoto study was subsequently confined to those transects.

In order to correlate vegetation patterns with topography and water regime, some of the transects were surveyed and profiles drawn. Soil profiles were studied in several locations along each transect, in the hope of establishing rate of deposition and past successional patterns that led to the present landscape.

In the following, I shall briefly indicate the nature and extent of the ecological adjustments that have become evident during the past 3 years, and then Mr. Dabbs will provide details on the remote sensing techniques that we have used.

## APPARENT EFFECTS OF FALLING WATER LEVELS ON THE LANDSCAPE

In the delta's level terrain, the absence of the spring flood for three consecutive years has meant a gross reduction in open water area. Comparison of 1955 and 1970 aerial photography shows a decrease of 28 per cent in the area of the major lakes (Dirschl 1971).

Plant succession on the exposed lake bottoms has been dramatic. For instance, sites exposed since spring 1968 changed from a thin cover of seedlings in July 1968 to dense fen meadows in 1969, and by the summer of 1970 were visually dominated by willow and alder seedlings.

There was also evidence that extensive areas of sedge meadows, adapted to annual flooding were beginning to change into drier reedgrass and willow communities.

Assuming that the present water regime will continue indefinitely, the observed plant succession will proceed to convert most of the exposed lake and marsh bottoms and the adjacent wet meadow communities into drier shrub communities. Waterfowl, muskrat, and bison habitat is thus decreasing both in quantity and in quality. Traditional sources of income and food for the local inhabitants through trapping, hunting, and commercial fishing are thus disappearing, as is the potential for wildlife-based tourism, the one enterprise that seemed to offer a possible economic future for Fort Chipewyan. It is against this background that works to re-establish the previous water regime are being considered by the federal and Alberta governments.

## AERIAL PHOTOGRAPHIC EQUIPMENT AND TECHNIQUES

The camera used in this study is a single Hasselblad 500 EL which, although not specifically designed as an aerial camera, is increasingly being used for aerial photographic research (Marlar and Rinker 1967, Ulliman et al. 1970). The camera is equipped with the Zeiss Distagon f.4/50 mm, the Planar f.2.8/80 mm, and the Sonnar f.5.6/250 mm lenses. Nearly all of the aerial photographs have been taken with the 80 mm lens. Three film magazines, each capable of taking cassette-loaded 70 mm film, faciliate rapid changing of film between flight lines.

The selected transect lines, mentioned by Dr. Dirschl, were photographed with three different films: (1) a high dimensional stability black and white film, Double-X Aerographic, (2) true colour film, Ektachrome Aero, and (3) false colour film, Ektachrome Infrared Aero.

Following the completion of a day's photography, the film was processed at the field station in Fort Chipewyan to ensure (1) that there were no mistakes in coverage or exposure before releasing the plane and (2) to ensure that proper controls and developing procedures were strictly adhered to. It has been the experience of colleagues at the University in Saskatoon that commercial processing firms are often not prudent in maintaining proper developing controls. It is absolutely essential in a program of repetitive, comparative photo analysis that uniformity of exposure and processing be maintained to ensure reproducible results.

In order to evaluate seasonal differences in the photo imagery of existing plant community-types, and to quickly and accurately monitor the colonization of newly exposed silt surfaces, three coverages of each transect were made during the course of the 1969 and 1970 growing seasons:

(1) A few weeks after growth had begun (16-22 June),

(2) At the height of the growing season (22-30 July), and

(3) At the end of the growing season (17-19 September).

The photos were taken at two scales. Most of the photography was from 1,500 feet above terrain, yielding a contact scale of 1:6,000 with the 80 mm lens. Several transects were also photographed from 7,900 feet above terrain which produces a contact scale of 1:30,000.

The vertical stereo photography was carried out from a Piper "Apache" twin-engine aircraft. The camera was purposely not mounted to the airplane but was hand-held with a Hasselblad double hand-grip by the operator sitting over the camera hatch in a specially installed seat. This arrangement was necessary to permit the camera man to quickly compensate for small, rapid changes in aircraft attitude that are caused by prevalent air turbulence at this low altitude.

"Ground truth" data were procured through an extensive sampling program using airboat and helicopter transportation. A five-point cover class sampling procedure using a 1/2 $m^2$ quadrat was used to obtain data on character and structure of existing plant community-types. [Repeated annual sampling since 1968 of specific stands, has provided detail of the vegetational replacement sequence of succession on newly exposed mudflats around the shallow delta lakes.]

Photo analysis and mapping have been in two phases. The first phase was the previously mentioned construction of an uncontrolled mosaic and the mapping of a central portion of the delta. The most recent, available photography of adequate quality for mosaic construction was taken in 1955. Photos taken in 1968 were of poor quality and 1970 photos are not yet available. A mylar overlay map was prepared by using a second set of photographs and viewing stereoscopically through the mylar and marking out units on the overlay sheet.

The classification of the vegetation for mapping at this scale (1:37,000) was strictly physiognomic:

DELTAIC DEPOSITS - coniferous forest
- deciduous forest
- tall shrub - 3 to 6 meters
- low shrub - less than 3 meters
- fen - predominantly graminoids, may contain a few scattered low shrubs
- immature fen - scattered low plants, newly colonized area

PRECAMBRIAN ROCK - forest
- grass

Water systems were classified as follows:

WATER CHANNELS - flowing streams and rivers
- intermittent streams
- abandoned stream beds and meander scrolls

STANDING WATER - freely drained - deep and open (e.g., Lake Athabasca)

- freely drained
  - shallow - open
    - with emergent vegetation (e.g., Mamawi Lake)
- restricted drainage
  - open
  - with emergent vegetation
- severely restricted drainage
  - open
  - with emergent vegetation

The second phase of the mapping operation was the analysis of our own photography. Transects 4 and 15 were chosen for preliminary evaluation of the airphoto sampling technique.

Transect 4 is of particular interest because the area which it covers was mapped by Hugh M. Raup 40 years ago and thus offer a unique opportunity to examine the long-term successional trends in this delta.

High contrast black and white prints were prepared at a scale of 1:7,000. Strip mosaics of these prints were assembled and a mylar overlay map prepared in the same manner as described before.

The classification for mapping purposes at this scale was much more detailed. Terrestrial ecosystems were mapped using a subjectively developed landform-vegetation classification. The permutations of land facets and major species groups are too numerous to mention here. The deltaic land facets used were:

(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 bars

(7) Meander scroll (dry channel

(8) Precambrian outcropping

The classification of water types was only slightly modified from the small scale classification. Of course, at the larger scale the accuracy of mapping is greatly facilitated.

The mapping of large relief features such as trees and shrubs was accomplished by simply viewing the black and white photos in stereo and outlining these units on the overlay. However, interpretation of low, herbaceous vegetation types proved impossible on black and white photographs.

The colour infrared photos, however, showed the differences between the plant species components of the fen and lakeshore areas very clearly. Therefore, 70 mm colour IR photography were put in a small enlarger and the image projected, in the dark, onto the mylar overlying the mosaic which ensured that the orientation and placement of the projected image was absolutely correct. The fen communities were then marked out on the overlay.

The results of this mapping phase are shown in the slide of Transects 4 and 15.

Note that the level profile of Transect 15 is included at the top. Level profiles of Transect 4 and several other transects will be run this winter. This information is required to determine accurate relationships between vegetation and microtopography.

Information obtained on the position of vegetation types in relation to the moisture regime through the two levels of airphoto interpretation and the concurrent environmental measurements will help to elucidate the dynamic, ecological processes that have been operational in the delta, and is thus of considerable scientific interest. There is also a more immediate, practical application to be derived from this mapping exercise.

In order to return the Peace-Athabasca Delta to its former ecological state, it is necessary to determine what the desirable seasonal and annual range and periodicity of water levels should be. A contour map, showing the extent of inundation at various water levels is essential for this purpose, but the size of the area and the extremely low relief render the use of conventional ground survey and photogrammetric techniques unfeasible. We are convinced, however, that knowledge of vegetation patterns reflecting microtopography can be used to produce contour maps of adequate accuracy for management planning. The following slide illustrates this approach.

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