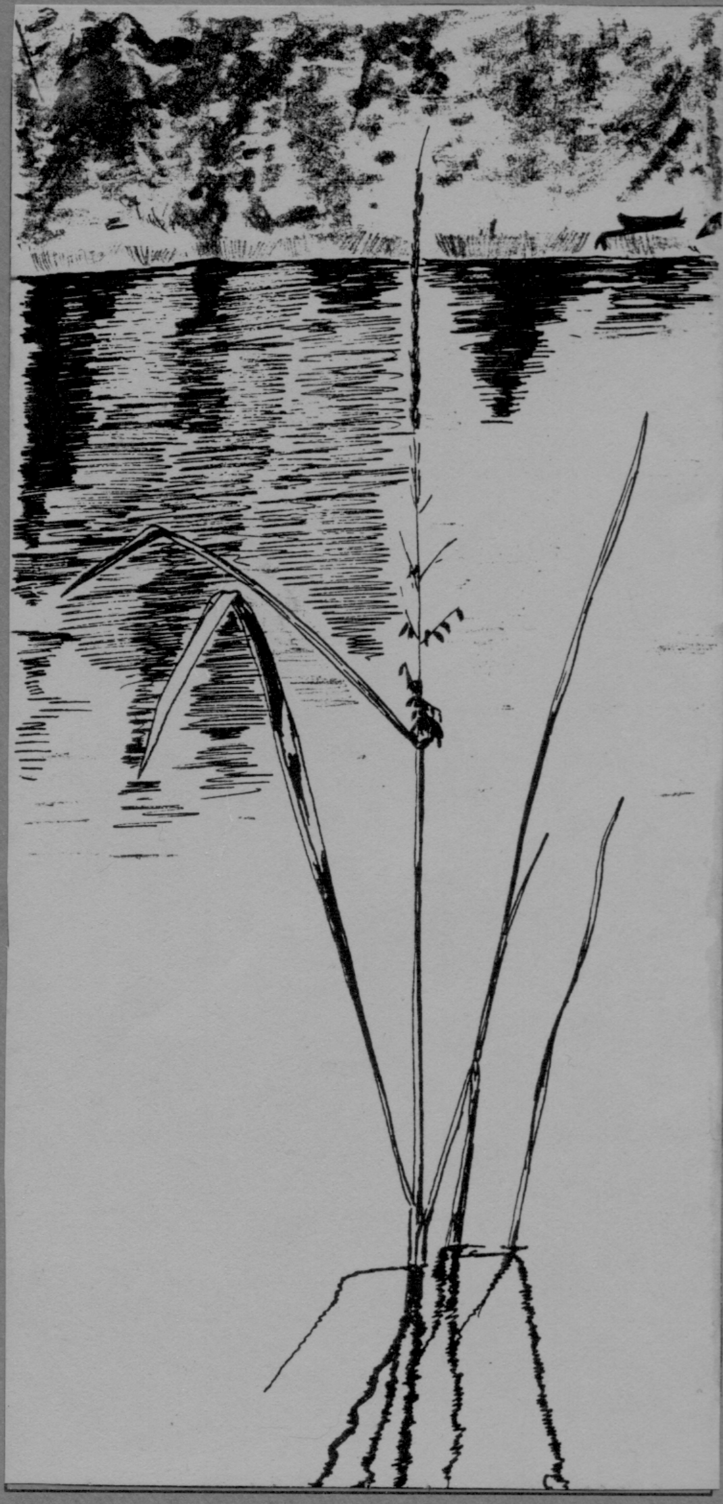
INDIAN COMMISSION OF ONTARIO



# STUDY OF WILD RICE INDUSTRY IN LAKE OF THE WOODS , RAINY LAKE , NAMAKAN LAKE, LAC LA CROIX , ENGLISH RIVER AND WINNIPEG RIVER

OCTOBER , 1981

UNIES Ltd.
Consulting Engineers

UNIES Ltd.
Consulting Engineers
1666 Dublin Avenue
Winnipeg, Manitoba R3H 0H1
Phone (204) 633-6363

December 4th, 1981

File #355-100

LETTER OF TRANSMITTAL

Indian Commission of Ontario,
236 Avenue Road,
3rd Floor,
Toronto, Ontario
M5R 2J4

Attention Mr. Leon Mitchell

Dear Sirs:

We are pleased to submit our report on the study of the wild rice industry in the Lake of the Woods, Rainy Lake, Namakan Lake, Lac La Croix, English River and Winnipeg River. The study was carried out to meet the requirements of our agreement of September, 1980.

In our opinion, the study has demonstrated, through the analysis of relevant hydrological, climate and wild rice harvest data, a close relationship between the water level regime in the study area and wild rice production. It also indicates a potential for improving wild rice production through judicious modification to the present operation of the reservoirs in the study area. This improvement would involve a relatively small reduction in electric energy generation on the Winnipeg River.

The study has been a very interesting and challenging assignment and we greatly appreciate the opportunity of contributing to it. We are prepared to provide clarification and further information if required.

Yours very truly,

G. Spafford, P.Eng.

UNIES Ltd.

GS/sd
Encl.

INDIAN COMMISSION OF ONTARIO

# STUDY OF WILD RICE INDUSTRY IN LAKE OF THE WOODS, RAINY LAKE, NAMAKAN LAKE, LAC LA CROIX, ENGLISH RIVER AND WINNIPEG RIVER

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## ACKNOWLEDGEMENTS

This study is entirely the result of review, analysis and processing of existing knowledge and data. Published and some personal contact sources are referenced throughout the text, but many contributions of less specific character are not. These contributions are especially appreciated by the study team for providing a broadened perception of the physical, commercial and cultural setting of the wild rice industry. They came from many individuals of the Treaty Three office staff, The Lake of the Woods Control Board Secretariat, the Kenora and Fort Frances offices of The Department of Indian and Northern Affairs and of the Ontario Ministry of Natural Resources. The operating staffs of Boise Cascade Canada Ltd., Ontario Hydro and Manitoba Hydro provided essential information on the operation and characteristics of hydro-electric components in the system. Their interest in the study and helpful suggestions are valued. The assistance of the Chiefs of the Treaty Three bands in the study area was essential in the conduct of the band surveys. They put us in contact with individuals of the bands whose time and patience in describing their activities and problems in the harvesting, utilizing and marketing of wild rice are greatly appreciated. The efforts of Sonny McGinnis, Ray Bruyere, Paul Watts and Steve McGillis in guiding, interpreting and generally clearing the way for the band surveys and reaching knowledgeable people, were particularly valuable.

*"The wild rice crop has failed in the Lake of the Woods and Shoal Lake rice grounds. In Lake of the Woods the failure is attributable to high water in the early part of the summer; there was great hope for an abundant crop, but the water rose faster than the rice could grow, and drowned it. We have had very little rain during the summer, the floods were caused by the damming up of the channel of the Winnipeg River at the foot of the Lake of the Woods."*

Quotation from the report of G. McPherson, Indian Agent to the Honourable Superintendent General of Indian Affairs, Ottawa, dated 21st September, 1887.

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CHAPTER 1

## INTRODUCTION

### 1.1 GENERAL SETTING

Wild rice is harvested throughout many of the more accessible areas of the central North American boreal and eastern prairie zones, with some of the more productive areas located in the Winnipeg River drainage system of Northwestern Ontario. It grows in shallow waters on the margin of lakes and rivers where bottom sediments are sufficient to provide rooting and soil nutrients. This report deals with the production of wild rice in those portions of the Winnipeg River system in Northwestern Ontario influenced by reservoir regulation (Figure 1.1).

The history of wild rice production in the study area is not well recorded. It is known to have been an important part of the diet, culture, and commerce of the Ojibwa people who inhabit the area. How it came to the area of the upper Great Lakes is not known, but it has been postulated[1] that it migrated into the area through progressive seeding by the inhabitants. The migration is thought to have progressed from the Mississippi River delta via the Atlantic coast and up the St. Lawrence River system.

Wild rice provided a relatively stable food supply which helped the Ojibwa to maintain cultural and territorial dominance throughout a

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[1] Jenks, 1899.

region extending at times from upper Lake Huron to the eastern limits of the great central plains. In the early days of European exploration and fur trade, wild rice obtained from the Indians of the region was also a major source of food for these travellers. In recent years wild rice has been marketed as a specialty food item as well as maintaining its traditional place in the Ojibwa culture and diet.[2]

Throughout the study area, some 20 to 50 thousand acres of lake and river habitat may support the growth of wild rice depending upon growing conditions during the current season.

Wild rice plant development and seed production are sensitive to both water depth and water level fluctuation over the growing season. Rate of growth is also sensitive to the amount of sunlight and water temperature during the growing season. Rain, hail and wind, before and during the time of ripening and harvest, may reduce or destroy the harvest.

Of the many factors which influence the growth and harvesting of wild rice in its natural habitat, only the regime of water levels (exclusive of direct crop management practices) is to some extent controllable by man. In the Winnipeg River drainage basin, many of the most productive rice areas are located on lakes and streams in which water levels are controlled for electric power production and, to a lesser extent, for other uses. As well, under the supervision of the Lake of the Woods Control Board and the I.J.C., Lake of the Woods, Rainy Lake and

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2 Steeves, 1952.

Namakan Lake levels are regulated to protect shoreline property at the extreme high and extreme low portions of the lake level range. All of these interests have influenced lake levels and streamflows in the Winnipeg River system for over 90 years. Throughout this period the effect of water levels on the production of wild rice has not been a consideration in the regulation of these waters.

The littoral zone of the lakes and streams in the study area supports a complex community of marsh and aquatic plant species. Among these, wild rice seems generally to occupy a portion of the lower littoral zone and shallower portions of the continuously flooded zone. It appears that the upper areas of the littoral zone, which might produce rice in high water years, are occupied by other species. These plants tolerate water level fluctuation and, once established, retard the movement of littoral zone sediments by wave and current action. Rice on the other hand, growing each year from seed, is probably assisted by this littoral zone sediment movement in its competition with other emergent species. Given water depths in the range of 0.2 to 1.5 meters over this potential wild rice producing zone and some viable wild rice seed, the conditions for growth exist.

As water temperature rises each spring, rice will germinate and grow in those seed beds relatively free of competing species. Upon reaching the water surface, the growing plant extends floating leaves which provide an increase in photosynthesis for growth of the plant. If, during this submerged and floating leaf phase, water levels rise at an excessive rate, growth will be retarded and the plant may fail to produce a stalk and head.

The regulation of the principal lakes in the Winnipeg River system has been directed mostly toward the production of hydro-electric power from generating plants in Winnipeg River, and more recently, toward production from plants on the Nelson River as well. As the demand for electric power and the system supplying it have grown the requirements for regulation on the Winnipeg River have changed.

Until the 1960's, hydro-electric plants on the Winnipeg River were the principal source of electrical supply for Manitoba and a contiguous portion of Northwestern Ontario. In this circumstance the major reservoirs used to regulate the system, Lake of the Woods, Rainy Lake, and Lac Seul, were generally held at high levels so that an adequate electrical energy supply through periods of low runoff was assured. In recent years, major development on the Nelson River, regulation of Lake Winnipeg outflow, and transmission interconnection with neighbouring utilities have reduced the need to maintain a reserve of water in the Winnipeg River system reservoirs. Furthermore, large capacity transmission interconnections with neighbouring utilities provide a market for excess energy. As a result of these changes, which took place over the past 10 to 15 years, there is a tendency for the regulated lakes of the Winnipeg River system to be maintained at levels lower than in the past, except for periods of high inflow, usually in late spring and early summer, when levels may rise rapidly. Correspondingly, streamflow below these lakes will remain at somewhat more than the average except for periods when storage in the lakes is depleted, in which conditions outflow may be reduced to the available net inflow. Occasionally, above normal spring runoff will fill the lakes and cause the discharge of flood flows to the Winnipeg River system.

Wild rice grows only on submerged soil and is sensitive to the patterns of water level fluctuation in which it grows. For this reason, the size of crop grown is influenced by any alteration in the pattern of water levels imposed by regulation of the Winnipeg River system reservoirs.

## 1.2 STUDY OBJECTIVE

The objective of the study was to define the relationship between the wild rice harvest and the water level regime in the study area. The knowledge gained would be used to define those water regulating principles conducive to production of rice and at the same time to define the impact on other interests of the imposition of these principles. The analysis was to make use of existing wild rice, hydrological, and climatic data. The objectives stated in the study agreement are as follows:

> "To determine what actions and policies may be implemented to realize a viable wild rice industry, improved annual production and improved crop reliability in the water basins defined hereunder. In formulating these actions and policies the matters of primary concern include:

Phase I

1) Preferences for control of water levels and water level fluctuations throughout the water basins to the extent that they may be regulated by existing facilities and in what way such control preferences may impact other interests using the waters in those water basins.

2) Ecological characteristics, including among others, soils, water clarity, exposure to wind and wave action, competing aquatic vegetation and other present uses of water areas, of successful existing, past and possible future sites, insofar as they affect the growth of wild rice."

## 1.3 AUTHORITY AND TERMS OF REFERENCE

This study was authorized through the Indian Commission of Ontario, in accordance with a study agreement dated September, 1980. A management committee was established, comprised of representatives of the Indian Commission of Ontario, the Department of Indian Affairs, Treaty Three and the Ontario Ministry of Natural Resources. The terms of reference in the agreement read, in part, as follows:

TERMS OF REFERENCE

1. TO collect and review existing reports and research on wild rice production and habitat, as well as licenses and agreements governing water levels and water use.

2. TO define and map current and historic harvesting areas by surveying band members, government and industry representatives and using satellite and airphoto reconnaissance.

3. TO prepare a location plan for principal rice harvesting areas.

4. TO examine selected rice harvesting areas by field reconnaissance and prepare a classification system for rice production and classify producing areas in accordance with the ecological characteristics as outlined under Objective, Phase I, Item 2 thereof.

5. TO select preferences for water regime for rice production and define growing area treatment to enhance production.

6. TO collect and review all available wild rice production and marketing records.

7. TO determine processing and marketing methods by surveying representatives of Bands, governments and industry.

8. TO develop production and market value relationships and estimate band income and harvesting effect.

9. TO collect, review and check hydrological data and to correlate historic rice production in each area classified with seasonal hydrologic regime.

10. TO prepare monthly hydrological simulation models, mean monthly lake levels and streamflows, and to review the aforementioned simulations in terms of potential rice production and crop reliability.

11. TO compare simulations and define impact of preferred wild rice regulation on power production and other uses of water bodies described previously.

## 1.4 COMPONENTS OF STUDY

To realize the objective and accomplish the tasks defined by the terms of reference, the following main study components were undertaken:

1. A band survey to collect data relating to rice growth and harvest experience, and social and economic significance of the wild rice industry.

2. Identification of rice producing areas and their classification by airphoto interpretation.

3. Definition of the characteristics of wild rice growth and crop volume and the relationship between these and key environmental factors such as water levels, climate, soils and competition.
4. Development of models relating rate of wild rice growth and crop to climate and water level parameters and calibration of these models with observed harvest dates and volume.
5. Development of hydrological models of mean monthly streamflows and water levels to permit the testing of a variety of reservoir operating assumptions including historic and current operation.
6. Determination of the impact on wild rice growth of the various reservoir operating assumptions by application of the hydrological model results to the wild rice growth and crop models.

The band survey data, item 1 above, was particularly useful in determining the place of wild rice in the social and economic activities of the native people of the area (Chapter 4). The survey also included an attempt to extend the record of crop volumes or harvest success in terms of both time and area harvested. This was generally inconclusive and only recent harvest records provided by the Ontario Ministry of Resources were used for the calibration of the wild rice growth and crop model. The conduct of the band survey is discussed and its results presented in Section 4.8.

Wild rice harvest data vary throughout the study area and are particularly difficult to define in terms of specific water bodies. Lake of the Woods was the only water body in the study area for which a harvest record could be isolated. The wild rice mapping and classification obtained by airphoto interpretation provided a means of proportionally estimating crop in water bodies other than Lake of the Woods. The interpretation was carried out for the entire area using high level photography at a scale of approximately 1:50,000. Larger scale photography was used to check species identification in selected areas and an unsuccessful attempt was made to identify wild rice habitat using satellite imagery.

Maps of the study area showing the results of the airphoto iterpretation and incorporating plotted information obtained from aerial reconnaissance by the Ontario Ministry of Natural Resources have been produced as Appendix E to this report. The results of this work are described in Section 3.2.2.

To develop an understanding of the growth of wild rice, an extensive literature review was carried out. In addition, the accumulated knowledge of key staff and others with botanical training was drawn on. The understanding of wild rice growth and its relation to climate and hydrological parameters were used in conjunction with harvest records to develop and calibrate a wild rice growth and harvest model. Chapter 2 summarizes the characteristics of wild rice growth while Chapter 3 deals with its distribution in the study area. Chapter 5 deals with the relationship between the wild rice harvest and climate and hydrological factors, and with the impact of altered hydrological regime. Chapter 6 describes the hydrological assumptions tested and their impacts on wild rice harvest. In Chapter 7 the social and economic significance of these impacts is described.

## 1.5 SUMMARY OF RESULTS

A major purpose of the study was to improve understanding of the relationship between water level regime in the study area and wild rice production, and further, to identify measures which may improve production. The following conclusions reached as a result of the study are relevant:

1. There is a strong correlation between the volume of the wild rice crop and water levels throughout the growing season. Harvest size and rate of growth are sensitive to the mean seasonal water level, the changes in level throughout the season and the change in level from one season to the next.
2. Average annual rice harvest in the study area can be substantially improved by modification of the present reservoir operating criteria for Lake of the Woods, Lac Seul and Rainy Lake. The best case tested indicated an increase in average annual harvest of approximately 67,000 lbs. green.
3. The improvement in rice harvest for the best operating case tested is not uniformly distributed throughout the various water bodies of the study area. This case indicated a substantial increase in the Lake of the Woods harvest, minor increases in the Winnipeg and English River harvest, and a minor decrease in the Rainy Lake harvest.

4. Throughout most of the study area, crop reliability would be substantially improved by modification of present operating criteria. That is, a decrease in frequency of crop failures would occur and low crop year volumes would improve.

5. Of the cases tested, the operating rules to maximize the wild rice harvest involved some restriction on the magnitude of change in reservoir target levels from month to month. This would result in a reduction in the average annual electrical energy production from hydro-electric plants on the Winnipeg River system above Lake Winnipeg estimated at approximately 7 million kWh. The modification would also cause an increase in energy generation during winter and a decrease in generation during summer.

6. Taking the appropriate economic multipliers into account, the improvement in estimated wild rice harvest achieved through modification of reservoir operating criteria is slightly greater in value than the loss in estimated electrical energy production. The benefits and costs accrue to different parts of the economy and the improvement in wild rice harvest is proportionally much greater in terms of the study unit than the loss in electrical energy.

7. The modifications to reservoir operating criteria preferred for rice production result in changes in water levels and streamflows too small to have an appreciable impact on resources other than wild rice and electrical energy.

8. The simulation models were used to estimate wild rice harvest on Lake of the Woods for both historic water levels and what would have been natural levels without controls at the lake outlet. It was estimated that natural conditions would have provided an annual average harvest slightly less than that of the preferred operating criteria but substantially more than either operation with present operating criteria or the historic operation.

The study results are presented in greater detail in Chapter 8.

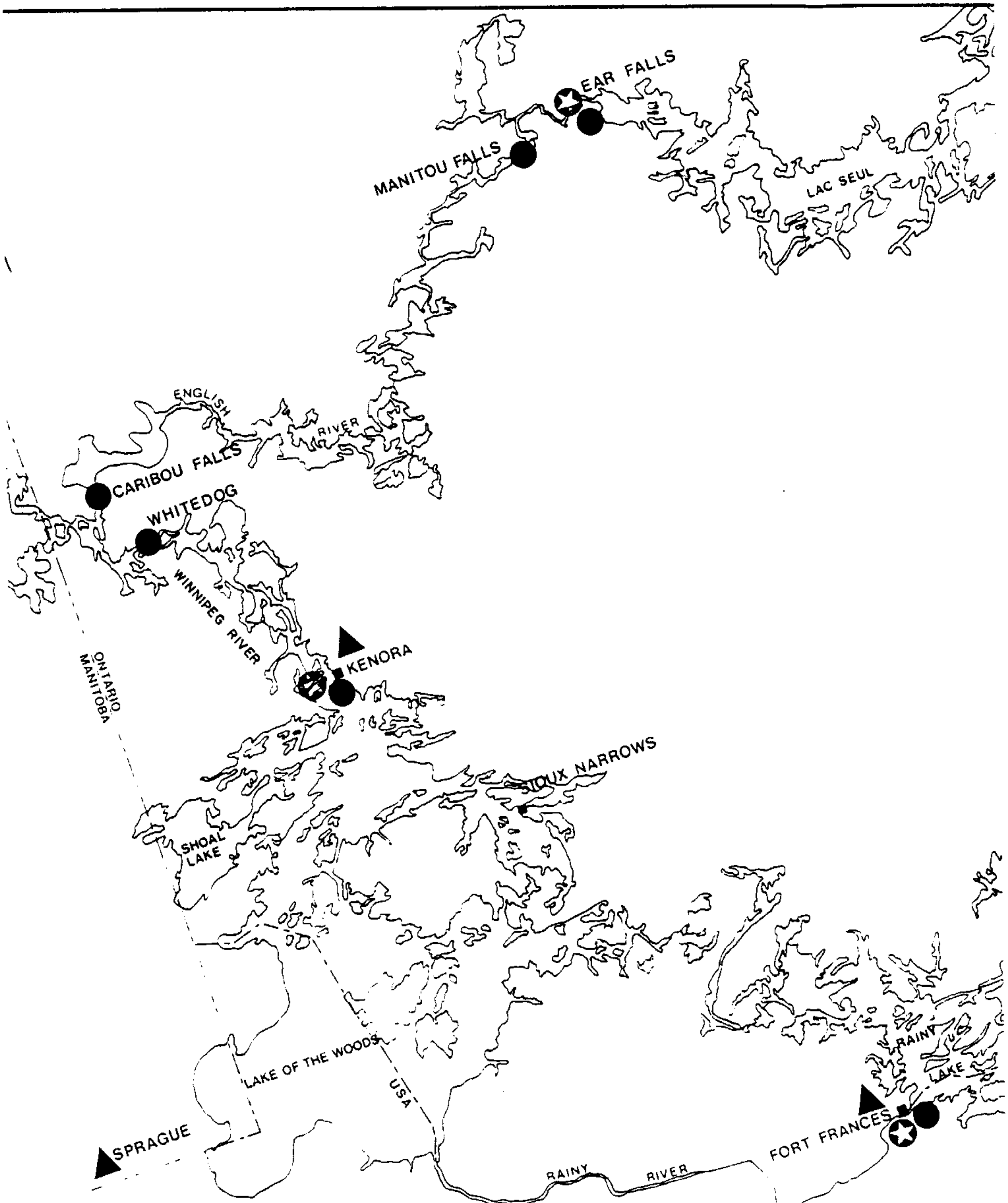
## 1.6 APPLICATION OF RESULTS

The objective of the study is, in part, to "determine what actions and policies may be implemented to realize a viable wild rice industry, improved annual production and improved crop reliability". As indicated in Section 1.5, the objectives are physically achievable. It remains to determine what actions and policies may be implemented. The study results provide some indicators.

The study shows that the wild rice industry is affected by the regulation patterns of the reservoirs in the study area and that the industry would benefit through being a consideration in arriving at reservoir operating decisions. The study also indicates that the size and reliability of the wild rice harvest can be appreciably improved with a relatively small modification to reservoir operating criteria. As described in Chapter 6, the maximum difference in reservoir target levels between the operating criteria preferred for wild rice and those of the inferred present operating criteria is 0.2 m. On the average, the target levels preferred for rice are set 0.14 m lower on Lake of the Woods, 0.02 m higher on Rainy Lake, and 0.12 m higher on Lac Seul than those inferred for the present reservoir operation. These represent relatively small changes to the pattern of water levels for these lakes to accommodate an appreciable improvement in wild rice production and to produce a corresponding decline in electric energy production.

The sensitivity of both wild rice and power production to changes in regulating decisions indicate a requirement for a systematic and consistent approach to reservoir regulating decisions fully supported by reasonably sophisticated analyses. These analyses and the approach to decision-making should be based on a clear statement of objectives formulated to include the production of wild rice as a benefit. The current decision-making and analytical processes will require improvement and a more adequate statement of objectives will need to be formulated before the suggested multiple benefits can be fully realized. However, with the existing approach to regulation, some improvement could be achieved if the sensitivity of wild rice to water level patterns is recognized in the decision-making.

FIGURES


EAR FALLS
MANITOU FALLS
LAC SEUL
ENGLISH
RIVER
CARIBOU FALLS
WHITEDOG
WINNIPEG RIVER
KENORA
ONTARIO
MANITOBA
SIOUX NARROWS
SHOAL LAKE
LAKE OF THE WOODS
USA
SPRAGUE
RAINY LAKE
FORT FRANCES
RAINY RIVER

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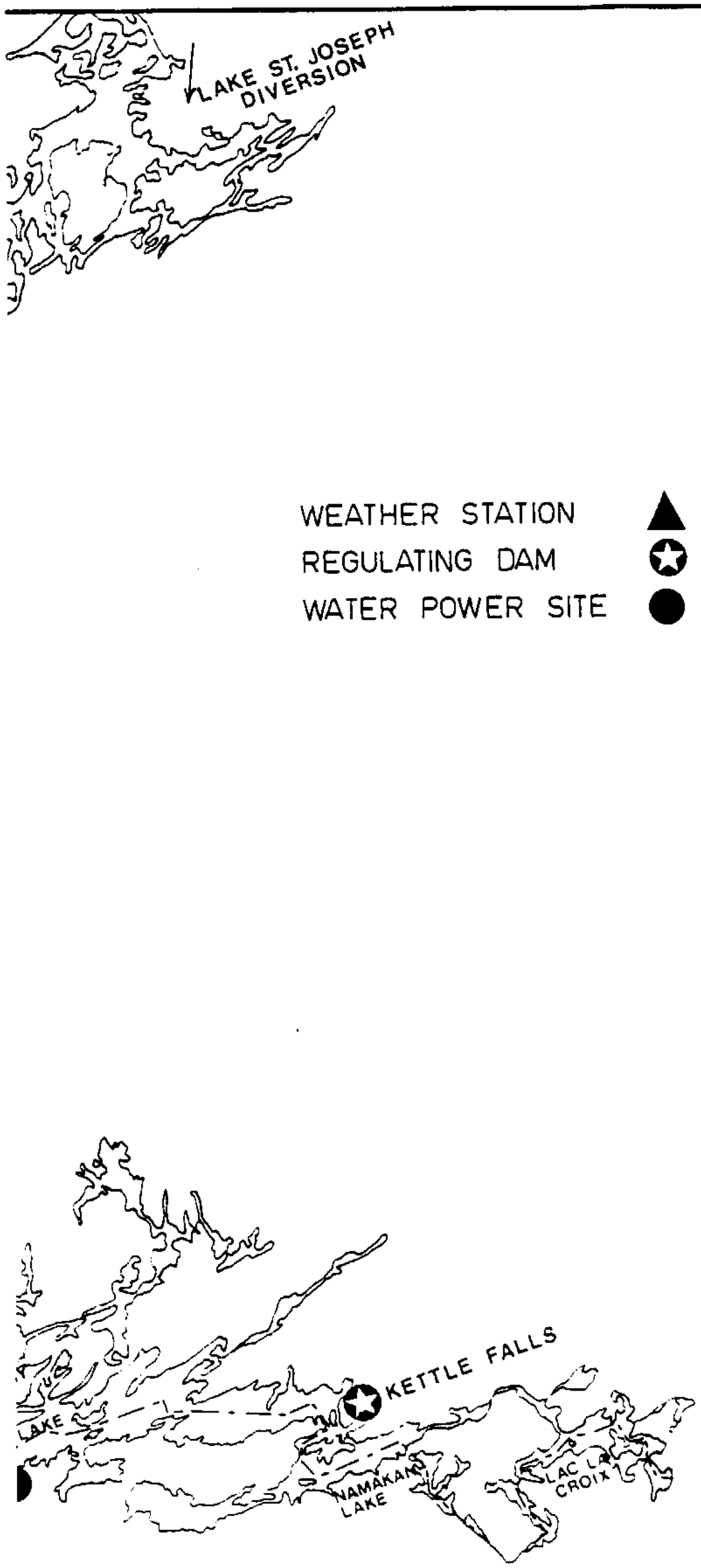


MAP OF STUDY AREA
SCALE 1:1000000

FIGURE 1.1

CHAPTER 2

# WILD RICE GROWTH CYCLE AND HARVEST

## 2.1 INTRODUCTION

The study area includes some of the more productive wild rice stands in Canada, and their improvement and management are of major concern to those who harvest and process this resource. A careful analysis of wild rice growth and its interrelationships with the factors controlling its growth are prerequisite to any management undertaking. Knowledge of life cycle dynamics is also vital to effective management.

Wild rice is an aquatic, annual, self-sowing member of the grass family growing in shallow waters of lakes, marshes and slow-moving streams. It grows each season from seed which germinates each spring as water temperatures start to rise. Growth takes place through late spring and early summer with the new seed reaching maturity from August to mid-September. Figure 2.1 illustrates the idealized growth curve for wild rice. The new seed ripens over a period of several weeks so that the seeds, when mature, 'shatter' individually. The harvest involves capture of the shattering seed before it falls into the water. It is estimated that, at any one time during the harvest season, all but about 10 percent of the plant's grain is either green or has fallen in the water. The harvest in any one location is therefore repeated several times to maximize the total yield of annual harvest.

Wild rice in the natural habitat has adapted to a short growth season and is consequently found growing as far north as Lac La Ronge, Saskatchewan. Natural beds of wild rice can remain relatively free of competing species due, in part, to geographical isolation, mechanisms of seed dispersal, and particularly good adaptability to certain littoral zone conditions. Normally a good natural stand produces up to about 1,000 lbs. per acre, but only about one-tenth of the seed is likely to be harvested. This extreme loss is due to shattering of ripened seed, which provides ample seed for survival of the species in the following year.

The following are some problems encountered in obtaining a consistently good harvest from natural stands:

1) Fluctuating Water Levels
2) Weeds
3) Weather - high wind velocity, rain and hail storms and sustained temperatures above 30°C can all be detrimental to wild rice production in natural stands. High temperatures can cause pollen viability to decrease and rain prevents pollen from being carried in the wind.
4) Yields fluctuate drastically each year and a sustained yield is only possible at the expense of the natural community.

## 2.2 THE SCIENTIFIC HISTORY OF WILD RICE

The time period in which wild rice first appeared in Northwestern Ontario is unknown. Pollen, and seed analysis and radiocarbon datings in Rice Lake, Becker County, Minnesota date the age for the spread of wild rice into the lakes of the area approximately 2,000 years ago.[1] This date is believed to be about 1,000 years earlier than the records for Late Woodland peoples believed to be the first harvesters of wild rice.[2]

Wild rice was first identified scientifically as Zizania aquatica by Carolus Linnaeus in 1754 when he confirmed Grovius' description in his Flora Virginica 1753 edition.[3] The main characteristics of the genus zizania identified by Linnaeus are quoted from Dore as follows:

> "Flowers unisexual, on separate branches of the same panicle; glumes obsolete or absent; stamens 6, lemma and palea of the pistillate flower flanged together and separating only at the base at flowering time when stigmas protrude, closely surrounding but not adhering to the grain at maturity, the lemma prolonged into a coarse awn; grain elongate and cylindrical, the embryo extending its full length; stellate pith, diaphragms present in culm cavity; leaf epidermal cells with low papillae, studded cuticle and X-shaped silica casts."[4]

There is some confusion in the literature over the naming of the species of this genus. Linnaeus recognized two species for North America namely, Z. aquatica and Z. palustris, each with two varieties respectively, Z. aquatica var. aquatica and Z. aquatica var. brevis and Z. palustris var. palustris and Z. palustris var. interior[5]. In Northwestern Ontario, Z. palustris var. palustris or northern wild rice is the principal variety although the variety interior also occurs throughout

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1 McAndrews, 1969.
2 Johnson, 1969.
3 Dore, 1969.
4 Ibid.
5 Ibid.

the region as a result of its use in extensive seeding programs. However, it should be mentioned that these two varieties are capable of cross-fertilization and the intergradations in morphology make varietal distinctions very difficult.

Another taxonomic designation for wild rice exists in the literature, in which Hitchcock[6] and Fassett[7], in his subsequent revisions of 1924, recognized a single species with four varieties, namely: aquatica, brevis, interior, augustifolium. Since the rules of nomenclature decree the first taxonomic description takes precedence in the naming of species, Linnaeus' description should stand. Dore advocated "a classification into four varieties divided between the two original species, and based simply on morphological and geographical features, is preferred."[8]

Because of infraspecific crossing, geographic separation has, until recently, kept the varieties separate. Nowadays the extensive reseeding programs have led to confounding of varietal differences.

## 2.3 LIFE CYCLE STAGES

### 2.3.1 Seed

The seeds of wild rice are cylindrical in shape, approximately 2 cm long by 1.5 mm wide, longer than any other grass. The seed or grain is light green in colour during the soft 'milk' stage and becomes dark

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6 Hitchcock, 1950.
7 Fassett, 1924.
8 Dore, p. 22, 1969.

brown to black during the mature hard kernel stage (Figure 2.2). When mature, the seeds very quickly shatter due to rapid formation of the abscission layer.

Botanically, wild rice seeds or caryopses, as the fruits of grasses are called, are modified achenes in which the seed coat is fused to the seed itself. In this it is similar to kernels of other cereal grains. The seed consists of an endosperm (starch and 77% of seed by dry weight) surrounded by an aleurone (protein) layer and a tough outer pericarp (cellulose). At the base of the endosperm is an embryo with its miniature leaves, stem and roots. Surrounding the grain proper are the hulls (palea and lemma) which together with the long barbed awn complete the structure of the seed.[9]

The seed detaches or shatters at maturity from the parent plant and usually falls into water where it quickly sinks, deflected from a vertical descent by its long awn, and embeds itself into the soft sediments. Because the seed falls close to the parent plant, its dissemination under natural conditions is usually very slow. Some seeds do travel a distance away from the parent stand either by being embedded in ice during the spring melt, by currents, animals (attached via mud or barbed awns) or by man. Man more than any other agency is believed to be responsible for both the 'natural' distribution on this continent prior to the arrival of Europeans and the subsequent artificial spread of the seed on a world-wide basis during the latter half century.

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[9] Dore, 1969.

### 2.3.2 Dormancy

The wild rice seeds shatter and lie dormant in the sediment during the fall and winter. The following spring, when given the correct environmental stimulus, they germinate. The physiology of germination appears to be triggered by water and sediment temperatures reaching 4°C or more for at least 10 days. Also, the pericarp (seed coat) becomes permeable so that this growth promoter-inhibitor ratio favors the growth hormone system. Investigations have found that dormancy can be interrupted in even freshly harvested seed by either mechanically piercing the pericarp or completely removing the hard seed coat. This technique is of value when determining seed viability prior to reseeding.

### 2.3.3 Germination

The act of germination is easily observed in the spring by dredging seeds from the bottom of a known rice stand. Slashes of white in the dark seed coat indicate the emergence of the young root near the seed base. A single primary root protrudes from the seed base anywhere from 5 to 12 days following the splitting of the seed coat. The first internode or epicotyl elongates up to 2 inches. This plus the cotyledon extension of 1 to 2 inches, allow the wild rice seedlings to emerge from a depth of up to 3 inches of overlying sediment. Elongation of the epicotyl is small when germination takes place at the surface of the sediment.

### 2.3.4 Submerged Leaves

The first two or three leaves to emerge are submerged and are characterized by the absence of any epicuticular wax. These leaves are thin, pale green ribbon-like leaves and grow rapidly, with each succeeding leaf larger than the preceding one. They tend to die rapidly once the latter leaves reach the water's surface.

### 2.3.5 Floating Leaves

Once the third or fourth submerged leaves reach the water's surface, wax forms on the upper epidermis thus aiding in their flotation.[10] At this stage it is believed that tissue differentiation allows air to reach all internal parts of the plant. Growth is vigorous at this stage with the rapid development of long ribbon-like leaves floating across the surface with the prevailing wind or waves. As the stem internodes elongate the first aerial leaves emerge, usually in June. At this stage the stem primordia switch from a vegetative to a reproductive mode, probably triggered by the occurrence of maximum photoperiod at this time. Floating leaves generally number two to three, the number increasing with depth, and remain until the aerial leaf stage is well established.

### 2.3.6 Aerial Leaves

Following the floating leaf stage the plant develops a further 3 to 5 leaves which are completely aerial with epicuticular wax on both surfaces. The leaf blade dimensions are variable with length commonly

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[10] Hawthorne & Stewart, 1970.

ranging from 38 cm to 76 cm and width from 1.3 cm to 3.8 cm. The last leaf to emerge prior to the elongation of the reproduction structure is called the flag leaf in cereals, and is shorter in length than the others. Its appearance coincides with the emergence of the 'boot' or reproductive structure and heralds the final morphological development of the plant.

### 2.3.7 Reproductive Structure

The female portion of the flower is the first stage to emerge thereby assuring no self-pollination. The female and male portions are jointly called the panicle, a structure ranging from 28 to 56 cm in length with the female or seed portion ranging from 23 to 30 cm in length. The female flowers or pistillate florets are receptive to pollination as soon as they emerge. This receptivity, however, is of short duration, in the region of 72 hours. In the study region, flowering occurs most commonly between late July and the first two weeks of August and is very sensitive to weather conditions. The number of pistillate florets is variable depending on morphological variety and environmental stresses to which the plant is exposed. Generally the female flower can produce from 40 to 220 grains per panicle. The male flowers or staminate florets produce large quantities of pollen for release into the surrounding air. The structure of the male portion of the panicle contains from 12 to 15 male inflorescence branches, each branch producing 50 to 60 staminate florets and each staminate floret with 6 stamens (unique among Canadian grasses).

Following fertilization, the stigma withers, the ovary enlarges, and grain filling begins. Two weeks after fertilization the seed is visible and after four weeks the seed is mature. While it is generally observed that the seeds mature and shatter from the top down, there are some plants in which maturation apparently takes place at random throughout the panicle. Seed maturity reaches its conclusion upon shattering, a process that can take place over a 7 to 12 day period.

### 2.3.8 Litter

Following seed shatter the plant dies, and by freeze-up, a combination of decomposers and weather are often sufficient to cover the rice bed with litter. If sedimentation occurs in the habitat, the straw gets incorporated during the winter. The ice melt and spring turnover in lake bodies will also move the litter. Generally wild rice litter disappears by the time the rice bed is ready for the next crop of litter. Occasionally litter buildup from 2 years is possible and the thick litter combined with competition for oxygen between aerobic decomposers and germination can lead to reduced growth and vigour of the wild rice seedlings.

## 2.4 PLANT STRUCTURE

### 2.4.1 Stems

The stem is visible at the aerial leaf stage and consists of three to five internodes. The lower internodes are about 30 cm long whereas the upper internodes can elongate to 76 cm. The stem is really a structure consisting of enveloping leaf sheaths surrounding the culm or central axis. The height of the stem depends on the wild rice variety, water depth, water currents, nutrient status, etc. It is the presence of the well marked nodes which distinguish wild rice anatomically from all other grasses. Each node has internally a unique fringe of very small hairs. The internodes are hollow air-filled cavities separated by cross-partitions of thin tissue believed to be pith remnants. Such structures aid in the aeration of all plant tissues, especially roots which may be in anaerobic sediments; and in maintaining buoyancy in deeper water. Stem diameters range from .5 cm to 1.5 cm depending upon wild rice variety, density and water depths.

### 2.4.2 Tillers

In a natural stand with a density of about 40 plants per $m^2$ and in 1 m of water, each individual primary stem will produce from 3 to 5 secondary shoots or tillers from stem nodal plates. Up to 50 tillers per plant have been recorded in paddy situations. However, not all tillers develop sufficiently to produce panicles. Since each tiller is capable of producing seed and enhancing production, it is advantageous to have environmental conditions which encourage tillering.

### 2.4.3 Roots

Several adventitious roots emerge from the first node and grow diagonally, thus anchoring the plant stem securely. This root system is unique among grasses and appears to be an adaptation which helps wild rice to colonize soft organic oozes. Later, other roots; the prop roots, will extend from the other nodes thus ensuring some anchorage, especially in softer organic sediments.

## 2.5 BIOLOGICAL REGIME

Competing species, pests and disease can limit growth or seed production in wild rice stands. Figure 2.3 shows some of the hazards affecting the growth of wild rice in natural stands, related to critical stages in the life cycle.

### 2.5.1 Competing Plant Species

The annual wild rice has difficulty in competing with the more persistent perennial aquatic plants in shallow waters. The most common weed problem in Minnesota wild rice paddies is the common water plantain. Researchers at the University of Minnesota[11] have shown this weed to cause yield losses of 43% with 10 water plantain plants per $m^2$. Attempts to control these weeds with herbicides has also resulted in the death of wild rice plants.

No research has been undertaken on the weeds associated with wild rice in natural stands other than listing those aquatic plants present. Figure 2.4 illustrates some common aquatic plants. Table 2.1 lists some of the more common weeds in competition with wild rice as determined by Lee for northwestern Ontario.

Experience gained from paddy operations suggest that weed control measures in natural stands might included the following practices:

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11 Minnesota Agricultural Experimental Station, 1972-1981, Progress Reports.

TABLE 2.1

COMPETING SPECIES IN NATURAL WILD RICE STANDS

| Submerged | Floating | Emergent |
|---|---|---|
| Ceratophyllum demersum | Lemna trisulca | Alisma trivale |
| Fontinalis duriaei | Nuphar variegatum | Equisetum fluviatile |
| Megaladonta beckii | Numphaea odorata | Ranunculus sceleratus |
| Myriophyllum alterniflorum | Numphaea tuberosa | Sagittaria latifolia |
| Myriophyllum exalbescens | Ranunculus longirostris | Sagittaria rigida |
| Potamogeton amplifolius | Spirodela polyrhiza | Scirpus acutus |
| Potamogeton gramineus | | Scirpus validus |
| Potamogeton natans | | Sium suave |
| Potamogeton praelongus | | Sparganium angustifolium |
| Potamogeton richardsonii | | Typha latifolia |
| Potamogeton robbinsii | | Vallisneria americana |
| Potamogeton zosteriformis | | |
| Utricularia americana | | |
| Utricularia vulgaris | | |

Lee, 1979.

a) rotovation/ploughing of the sediment in the fall prior to reseeding;

b) manipulating water levels to reduce weed populations by either raising or lowering water levels according to the weed species problem.

Some of the more common weeds known to compete with wild rice both in natural stands and paddies are described in Table 2.2.

Algae can reduce wild rice populations during the submerged and floating leaf stages by forming dense floating mats on the water surface thereby excluding light. In some paddy operations, copper sulfate at 17 kg/ha or 15 lb/acre is effective in suppressing algae mat formation.

It should be emphasized that no chemicals have been approved by the Federal Goverment of Canada for the specific use of controlling the competitors of wild rice in either natural stands or paddy operations.

2.5.2 Predators

Probably the wild rice worm is the major insect pest in both natural stands and paddies. Table 2.3 lists some of the more common insect pests. Experience in paddy operations indicates that insect pests can be controlled by malathion or carbaryl[12] applied during cortical larval stages of the insect.

Some animals can cause transitionary damage to stands of wild rice. Carp, a coarse omnivorous fish, can dislodge wild rice as it

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12 Sevin, "The Wild Rice Growers Reports."

TABLE 2.2

DESCRIPTION OF SOME COMMON COMPETING SPECIES

1. Common waterplantain (Alisma trivale Pursh) - This perennial germinates and emerges from the water before wild rice. Its leaves form a canopy which shades wild rice resulting in fewer tillers and lower grain production. The only herbicide approved for paddy use is 2-4-D amine at 0.25 lb/acre in Minnesota.[13]

2. Cattails (Typha spp.) - This emergent perennial has an extensive rhizome system. Its dense canopy shades out all other shade-intolerant species including wild rice. During successive periods of high water, cattails recede shorewards.

3. Burreed (Sparganium spp.) - Burreed actively competes with wild rice for space and can shade out wild rice in shallow waters. High water levels over two growing seasons can retard the spread of this species.

4. Common arrowhead (Sagittaria spp.) - This emergent can grow prolifically in shallow areas usually under 2 feet of water. It outcompetes wild rice at the floating leaf stage probably for space, nutrients and light.

5. Cursed crowfoot (Ranunculus sceleratus L) - This annual competes with wild rice stands in shallow waters during the submerged and floating leaf stages. It rarely reaches population densities to be a significant pest.

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[13] Wild Rice Growers Reports, Minnesota.

TABLE 2.3

DESCRIPTION OF SOME COMMON INSECT PREDATORS

1. Wild rice worm (Apamea apamiformus) noctuid moth - Female moths lay eggs on wild rice flowers. Since infested flowers do not form rice grains, yields can be greatly reduced. Malathion at 11 lb/acre applied at specific instar stages can be effective.[14]

2. Midge (Chironomidae & Dixidae families) e.g. Cricotopus - Often associated with algae growth, warmer than normal springs, and shallow water. Control of this pest is possible at the floating leaf stage when Malathion at 0.5 lb/acre can be effective, for it feeds on submerged and floating leaf stages of development.

3. Rice stalk borer (Chilo plejadellus Zincken) - Infest stems during and after the floating leaf stage of development. This pest can often be controlled biologically by a braconid wasp (Chelonus spp.). Sevin is known to be effective when applied during the aerial leaf stages in concentrations of about 1 lb/acre.

4. Rice water weevil (Snout beetles) - Feed on wild rice leaves and stems during July and August.

5. Rice leafminer (flies) - Lay eggs on floating leaf or erect leaf after which larva feeds on aerial leaf stages.

[14] Wild Rice Growers Reports, Minnesota.

forages in shallow water and stirs up the sediments and dislodges growing plants. Crayfish, Orconectes virilis, have also caused stand reduction in Minnesota by foraging on the seedling plants.

Blackbirds are a major pest who start feeding on the wild rice heads at the milk stage. The blackbirds have been observed to squeeze the glumes forcing the soft milky kernel out through the split in the glume coverings.

Various control measures have been tried to reduce the damage caused by flocks of blackbirds. Bangers, scarecrows, hawk kites, speaker systems which loudly broadcast the distress calls of blackbirds all have been used in the war against blackbirds. Even lure crops, e.g. oats, have been sown around paddies in an effort to attract the blackbirds away from the rice. Methiocarb, a bird repellent known to induce aversion in blackbirds, has been tried on paddies but it must be sprayed onto hulls of the rice, an expensive operation. While no method is really effective in keeping blackbirds out of wild rice stands, each offer some level of control.

Wild rice stands are also a resting, foraging, nesting and brood-rearing habitat for both migratory and resident water and shoreline birds. Many species of ducks, e.g. mallards and pintails, use the natural stands during the nesting season. Over 35 species of shorebirds and wading birds have been observed using wild rice stands in Minnesota for a variety of reasons. Damage caused by waterfowl is of little economic importance.

Both deer and moose have been observed grazing in wild rice stands but the little damage they do is believed not to be important. Muskrats and beavers use the areas in summer with many of their lodges constructed from wild rice straw. Beavers can either assist or be a nuisance in water level control by their dam-building activity.

### 2.5.3 Diseases

The important diseases identified as having economic impact on the wild rice plants in Minnesota paddies are blight, stem rot, and stem smut. Epidemics of such diseases in natural wild rice stands are rare because of their higher resistance to infection and higher plant species diversity in natural wild rice stands. There have been some reports of ergot heavily infesting some lakes in Minnesota. It was reported that approximately 8.6 kg of ergot was collected from one lake. Such infestation was believed to cause a 40% reduction in yield.

Agricultural practices in use for controlling disease in paddies include:

- removal of hosts of pathogens from the immediate area,
- use of clean, healthy seed in fall seeding,
- rotation crops,
- summer fallow as a rotation practice,
- selection of nonhosts for use on dykes,
- crop residue removal each fall,
- application of fungicide.

Such practices are not practical in natural stands. Some of the more common fungal and bacterial diseases known to affect wild rice are listed in Table 2.4.

TABLE 2.4

DESCRIPTION OF SOME COMMON DISEASES

1. Brown spot blight (Fusarium spp.) - All aerial parts of wild rice are susceptible to brown spot (approx. 2 mm dia.). Where infections are heavy, Dithane at 2 lb/acre is successful when applied during flowering and grain filling.[15]

2. Stem rot (Sclerotium sp. & Helminthosporium sigmoidium) - The small oval purplish spots on the stems and floating leaves at water level can result in stem lodging and premature death of the plant. Crop residue removal is one method of prevention recommended.[16]

3. Ergot (Claviceps zizaniae) - Occasionally reaches epidemic concentrations in natural stands. During flowering the sclerotia germinate producing windborne ascospores which infect the flower thereby reducing yields.[17]

4. Stem Smut (Entyloma lineatum) - On mature stems the glossy black lesions can girdle the stem resulting in reduced yields.

5. Bacterial Leaf Streak (Pseudomonas syringae) - This pest produces long dark green streaks which if they join up can result in leaf death and reduced yields.[18]

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15 Percich, J.A. 1978-1981.
16 Ibid.
17 Pantidouz, 1959.
18 Percich, J.A. 1978-1981.

## 2.6 PHYSICAL/CHEMICAL REGIME

In the aquatic system, it is the interaction of the physical, chemical, and biological components which determines the wild rice's community structure and function at any point in time. The components which determine primarily the distribution and interrelationships of wild rice are climate, topography, sediment, water and biota. Some of the more important characteristics of the physical and chemical environment of wild rice are summarized in Table 2.5.

## 2.7 SIGNIFICANCE OF CLIMATIC FACTORS

Weather conditions during the growing season can enhance or detract from optimal growth. Weather conditions during harvest time have an effect not only on the maturing seeds, but also on the effort required to gather the seeds. It also affects the harvest effort, a factor not dealt with in this study.

Some of the more important climatic factors during the growth cycle of wild rice are: solar radiation, air temperature, wind and precipitation.

### 2.7.1 Solar Radiation

Sunshine is directly important to the plant for photosynthesis and indirectly through its effect on air and water temperatures. While the plant is in submerged stages, the water must be clear so that sunlight can penetrate to the submerged leaves of the growing plant. Any turbidity created, for example, by wind and waves, can affect the amount

TABLE 2.5

SOME PHYSICAL AND CHEMICAL FACTORS
AFFECTING THE GROWTH OF WILD RICE

| Factors | Effects | References |
|---|---|---|
| A PHYSICAL ENVIRONMENT | | |
| 1. Light | - promotes root absorption | - Sculthorpe, 1967 |
| | - shade intolerant | - Dore, 1969 |
| | - tillering promoted by increased light exposure | - Sain, 1981 |
| | - submerged leaf growth limited if Sechi Disc reading less than 50 cm. | - Sain, 1981 |
| 2. Temperature | - wide temperature tolerance | - Dore, 1969 |
| | - high temperatures lowers viability of pollen | - Dore, 1969 |
| 3. Wind | - aids seed shatter and stem lodging | - Brooks, 1980 |
| 4. Rainfall Intensity | - affects pollination and aids seed shatter | - Dore, 1969 |
| 5. Water Depth | - below 10 cm grain yield and dry weight are reduced | - Weber & Simpson, 1967 |
| | - water must cover submerged leaves & be sufficient to support the floating leaves | - Thomas & Stewart, 1969 |
| | - will grow in water from 0.05 - 2.5 m deep, but performs best in 0.5 - 0.9 m. water depths | - Brooks, 1981 |
| | - grows best in waters with a depth of less than 1 m measured or expected at the floating leaf stage (end of May in NW Ontario) | - Sain, 1981 |
| 6 Water Level Fluctuations | - noticeable changes in water depth during the floating leaf stage can cause uprooting | - Chambliss, 1940 |
| | - increase of more than 1 ft. ( 30 cm ) can wipe out a crop | - Moyle, 1944 |
| | - rapid changes during the mature stages can cause lodging | - Sain, 1981 |
| | - rate of increase greater than 20 cm/mo. damaging to crop | - Ibid., 1981 |
| 7. Flow of Water | - promotes germination and availability of nutrients during growth | - Moyle, 1944 |
| | - seldom found growing in water bodies with no visible inlet or outlet | - Lee, 1975 |
| | - increases the decomposition rate | - Sain, 1981 |
| | - distributes dissolved oxygen to the sediment | - Sain, 1981 |
| B. CHEMICAL ENVIRONMENT | | |
| 1. Total alkalinity | - 40 -200 ppm range for best growth | - Moyle, 1945 |
| 2. Total dissolved solids | - 150 - 300 ppm range for best growth | - Moyle, 1945 |
| 3. pH | - 6 - 9 for best growth | - Moyle, 1945 |
| 4. sulfates | - up to 10 ppm for best growth | - Moyle, 1945 |
| | - up to 60 ppm for best growth | - Brooks, 1968 |
| | - up to 500 ppm in soil not a deterrant to growth | - Vicario & Halstead, 1968 |
| | - dry weight accumulation positive up to 200 ppm | - Lee & Stewart, 1978 |
| 5 oxygen | - low concentration stimulates germination | - Svare, 1960 |
| 6. N, P, K | - increases the production of dry matter and seed | - Wild Rice Grower's Reports 1972 - 81 |
| C. SEDIMENTS | | |
| 1. Texture | - rocky, gravelly and sandy sediments deficient in essential nutrients & do not allow development of good root structure | - Sain, 1981 |
| 2. Organic matter | - mineral sediments with 10 % or more organic matter good for growth | - Sain, 1981 |
| 3. Thickness | - 30 cm or more necessary for good growth | - Sain, 1981 |

of solar radiation reaching the plant during these early stages. During emergent stages sufficient solar radiation is needed for continuing photosynthesis.

Solar radiation and air temperature affect the water temperature. This effect is especially important during the germination stage. Air temperature and solar radiation must be sufficient for the water temperature to be at 4°C for approximately 10 days to initiate and sustain germination.

### 2.7.2 Air Temperature

Air temperature is indirectly important to the plant during submerged stages through its effect on water temperature, as explained above. Once the plant becomes emergent the temperature of the water becomes less important and the direct effect of air temperature more important. Frost can damage the growing plant during the flowering and seed maturation stages. During flowering and pollination high air temperatures can have a devastating effect on the viability of the pollen. The pollen is normally viable in the morning and evening because of cooler temperatures. High air temperatures (of 25°C or greater) throughout the day elminate the cooler viable period for the pollen. Reduced pollination means reduced seed production for the crop.

### 2.7.3 Wind

Wind can create currents that mix the water, changing the temperature distribution and increasing turbidity. Wind, through the currents created, can then cool the water, possibly slowing growth during submerged stages. The stirring of bottom sediments could be sufficient to limit sunlight reaching the submerged plants. During emergent stages, wind, in conjunction with rain or hail, can flatten or lodge plants, or knock off maturing seeds. Over open water, wind can create waves which can batter or lodge emergent plants.

#### 2.7.4 Precipitation

Precipitation in large amounts can have a cooling effect on water temperature. Continuous rain through the pollination period can limit or destroy pollen viability. The distribution of wild rice pollen is impeded by sustained rainfall, as it is by high air temperatures. Rain or hail above a certain intensity can have a catastrophic effect on a rice stand, in conjunction with wind, especially during harvest time. An entire crop can be virtually destroyed by one day of heavy winds and precipitation.

### 2.8 SIGNIFICANCE OF WATER LEVELS

The study area lies in lakes and rivers downstream of a relatively large drainage basin. This basin contains sufficient natural storage, in the form of lakes, that runoff is greatly attenuated following the precipitation and snowmelt events. The relation between these events and runoff, and hence water changes, is made even more remote by man-made control of large lakes in the basin. As a result of these factors, the study area exhibits a highly variable pattern of water levels from season to season. Wild rice growth and crop volume are influenced by water depth and by changes in water depth to varying degrees throughout its growth cycle.

2.8.1 Water Levels and Depth During the Growing Season

As noted in Table 2.5, wild rice will germinate and grow in water depths up to a maximum of 2.5 meters. Germination and growth will occur first in the shallower water because water and sediment temperatures will be highest in the shallows. The submerged leaf stage also decreases in length with decreasing depth as growth requirement to reach the floating leaf stage is reduced. With increasing water depth, the longer floating leaf stage produces less vigorous plants and hence less seed.[19]

Once the floating leaf stage is reached water depth is not a factor in rate of growth. However, as noted in Table 2.5, the plant and crop volume decline as water depths exceed 0.9 metres. Given a steady water level, it will be found that, at a given time in a particular bed of rice, plant maturity varies inversely with water depth.

Changing water level during the growing season has several impacts. A steady fall during the submerged, floating and early aerial stages will tend to accentuate the gradation of plant maturity with depth referred to above, while a steady rise in water level can reverse this gradation as seed germinates in newly flooded sediments.

If changing water level reaches an excessive rate plant development will be adversely affected (Table 2.5). Rapid fluctuations in

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[19] Chambliss, 1940.

water level are particularly harmful to the plant during the floating leaf stage. Since the plants have limited root development at this stage, a rapid rise of 15 cm or more in the water level can uproot them. If the plant spends a lot of energy reaching the water surface during the early stages then less energy can be devoted to seed production. Therefore yield is decreased if the water level rises and exceeds the rate of growth during submerged stages. High water also reduces tillering and thereby reduces productivity. A rapid fall in water levels during emergent stages, especially at harvest, can cause the plants to lodge.

The best water level conditions for a given natural wild rice habitat during one growing season seem to be as follows:

1) moderate to low spring water levels with a minimal gradual increase during early summer,

2) gradual decrease, or at least no increase in water levels during flowering, ripening and harvest. However, rapid and extensive water level changes during the aerial leaf stages may aid in regulating herbivores such as muskrats that graze on wild rice. Drawdown of water levels can also control fish such as carp that can damage many submerged and emergent species including wild rice.

### 2.8.2 Water Level Changes From Season To Season

Although moderate to low water levels generally mean a good crop for one growing season, continued repetitions of the same water level over several seasons can have several bad effects on the crop.

Low water levels for two or more consecutive years results in weed invasion of the wild rice zone, eliminating the rice.

Another problem of repeated moderate to low water level is the accumulation of litter. A good crop produces a lot of plants, and a lot of straw is deposited at the end of the season. If the water is at the same level the next year, the litter buildup and consequent oxygen depletion could reduce germination.

A decrease in water level from one season to the next would seem to improve the crop because the wild rice plant naturally seeds itself outward from the shore. However, with repetition, this also encourages invasion of the wild rice habitat by other species and reduction in the total area producing rice.

An increase in water level from one year to the next seems to harm the crop because the zone at the right water depth for rice growth may not have viable seed, or may be colonized by other plants. Although the rice seed can remain viable for several years, it is not tolerant of dry conditions and does not compete well with perennials. To summarize, in a natural system fluctuating levels from season to season are necessary for wild rice. Yields may not be consistently high but over a period of time will be better than if the level remains completely stable over the years.

Management practices such as reseeding, weed control, litter clearing, and thinning can make the crop more reliable with controlled water level conditions.

## 2.9 HARVEST

The study area includes a large portion of the more productive natural wild rice stands historically harvested by the Ojibwa. The harvestable crop fluctuates from year to year. Research by Moyle in Minnesota indicates a 4 to 7 year cycle with an average cycle of one bumper season, two fair years and one failure. The reasons for this fluctuation include changing environmental conditions, disease and pests, and physical restrictions of the habitat. Different harvesting methods can be used to increase the amount of seed gathered.

### 2.9.1 Environmental Conditions

The following changing conditions can create major variations in the amount of seed produced, and available for harvest:

1) Annual variations in climate during the growing season. The significance of climatic factors such as rain, wind, air temperature and sunshine is discussed in Section 2.5.
2) Changes in water levels during the growing season. The significance of water levels to the growth of the plant and to the production of seed is discussed in Section 2.8 of this chapter.
3) Differences in patterns of antecedent water level regimes and crop density.

### 2.9.2 Disease and Pests

Blight, stem rot, and stem smut are the major diseases affecting wild rice harvest, however, they are rare on natural stands. The wild rice worm is the major insect pest in both natural stands and paddies. This pest can damage or destroy the forming seeds. Other pests include carp, crayfish, deer, moose, ducks and especially blackbirds. Blackbirds are a major pest because they remove the seeds, making them unavailable for harvest.

### 2.9.3 Shattering Characteristics

Only 10% of the wild rice seeds are ripe at any one time during the harvest period, and when ripe, the seeds "shatter" or fall into the water. This long period of ripening, and shattering action are natural processes for reseeding that limit the amount of seed available for harvesting.

### 2.9.4 Physical Restrictions of Habitat

Some of the areas where wild rice grows are remote, sometimes inaccessible. Obstructions such as logs, rocks, stumps in the rice bed restrict harvesting activity. Rice growing in water depths less than 15 cm in natural stands is also generally inaccessible.

## 2.10 HARVESTING METHODS

Traditional canoe harvesting is still predominant in the study area, although mechanical harvesters are gaining popularity. In the traditional method, ricers usually function in family groups. The gathering of the rice seeds takes place over approximately 10 to 30 days.

The harvesting team consists usually of two people in a canoe; one poling the canoe while the other uses two sticks to bend the rice over the side of the canoe and beat the seeds from the stalks. The ripe seeds fall into the bottom of the boat while unripe seeds adhere to the plant for later harvesting.

Estimates of the proportion of seed collected by this method range from 5% to 25% of the mature kernels. A good yield from natural stands, with the traditional harvest method is usually 50 lbs. per acre with a range of 40 to 80 lbs. per acre. An experienced ricing team in a canoe can harvest up to 500 lbs. per day, or approximately 80 lbs. per hour.

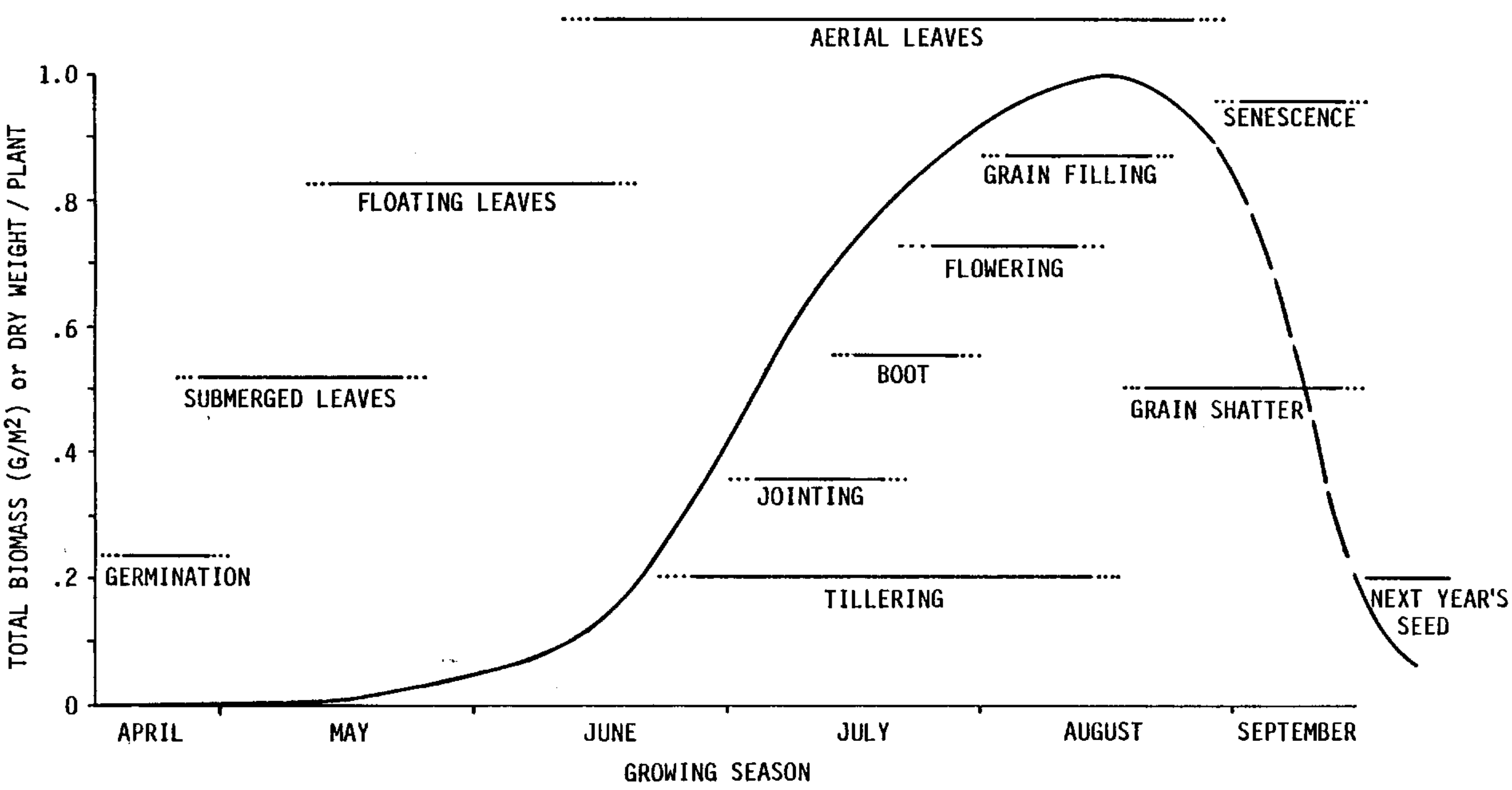
Mechanical harvesting of wild rice was used as far back as 1917 in Lac du Bois, Manitoba, but did not become widespread until the late 1960's. Today the mechanical harvesters are mostly air boats of either the pontoon or flat-bottom type with front-end scoopers.

Some of the advantages of mechanical pickers are:

1) facilitate harvesting of certain remote and inaccessible areas,
2) can economically harvest areas of sparse growth,
3) can harvest a greater percentage of the crop,
4) lower labour costs (A.D. Little, 1969).

Although it is difficult to substantiate, people claim that rice harvested in a given stand by mechanical means can be 2.5 that obtained by the traditional canoe method. The major disadvantages of mechanical picking are the difficulty of operation in shallow water, the problems created by obstructions such as logs and rocks, and the limited turning room for the machines available in many rice stands. Operation at excessive speed and the slipstream of an airboat can damage the rice crop.

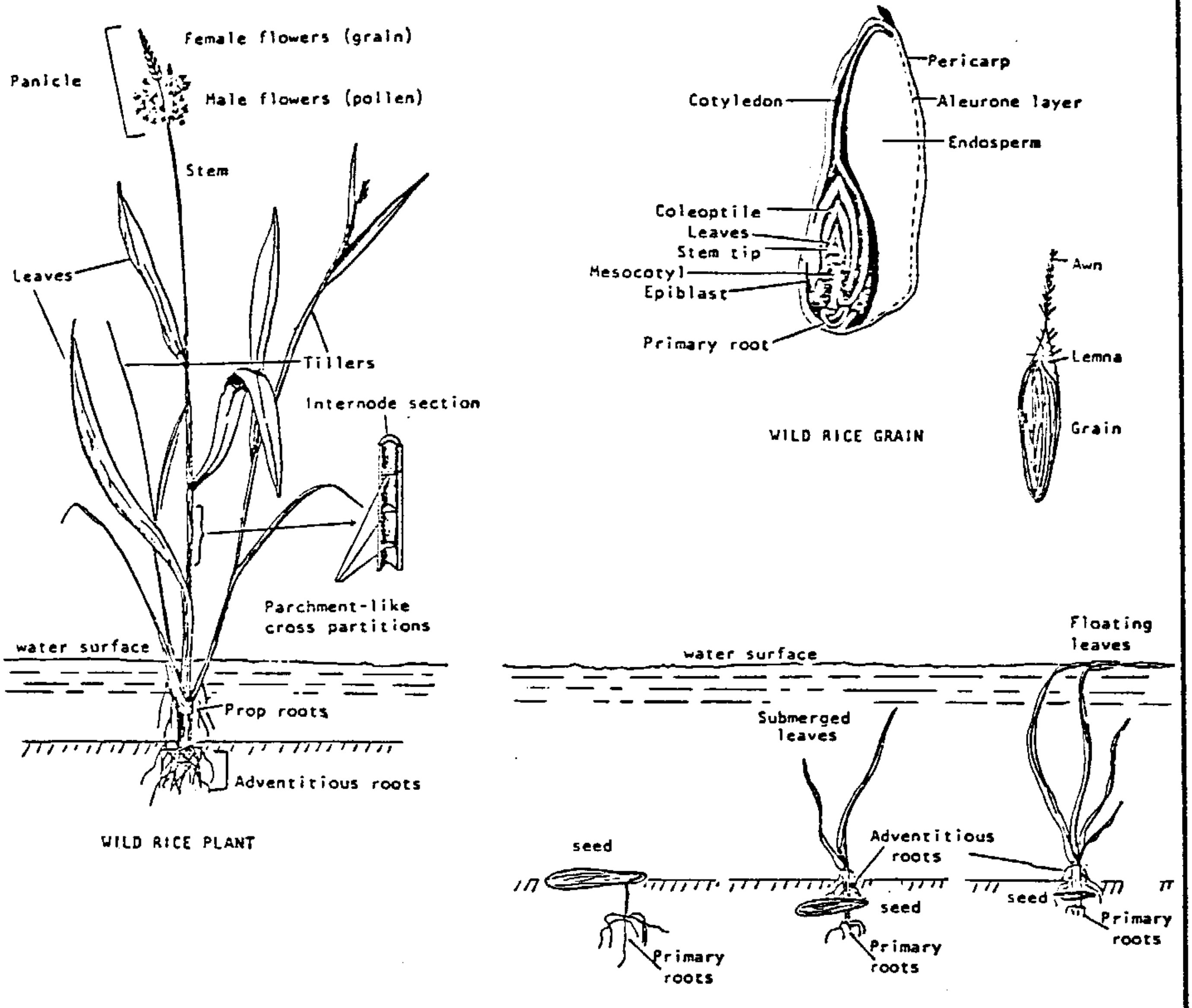
FIGURES




NOTE: Actual growth will vary with water depth, climate, location, sediment, biological competition and other groups of factors

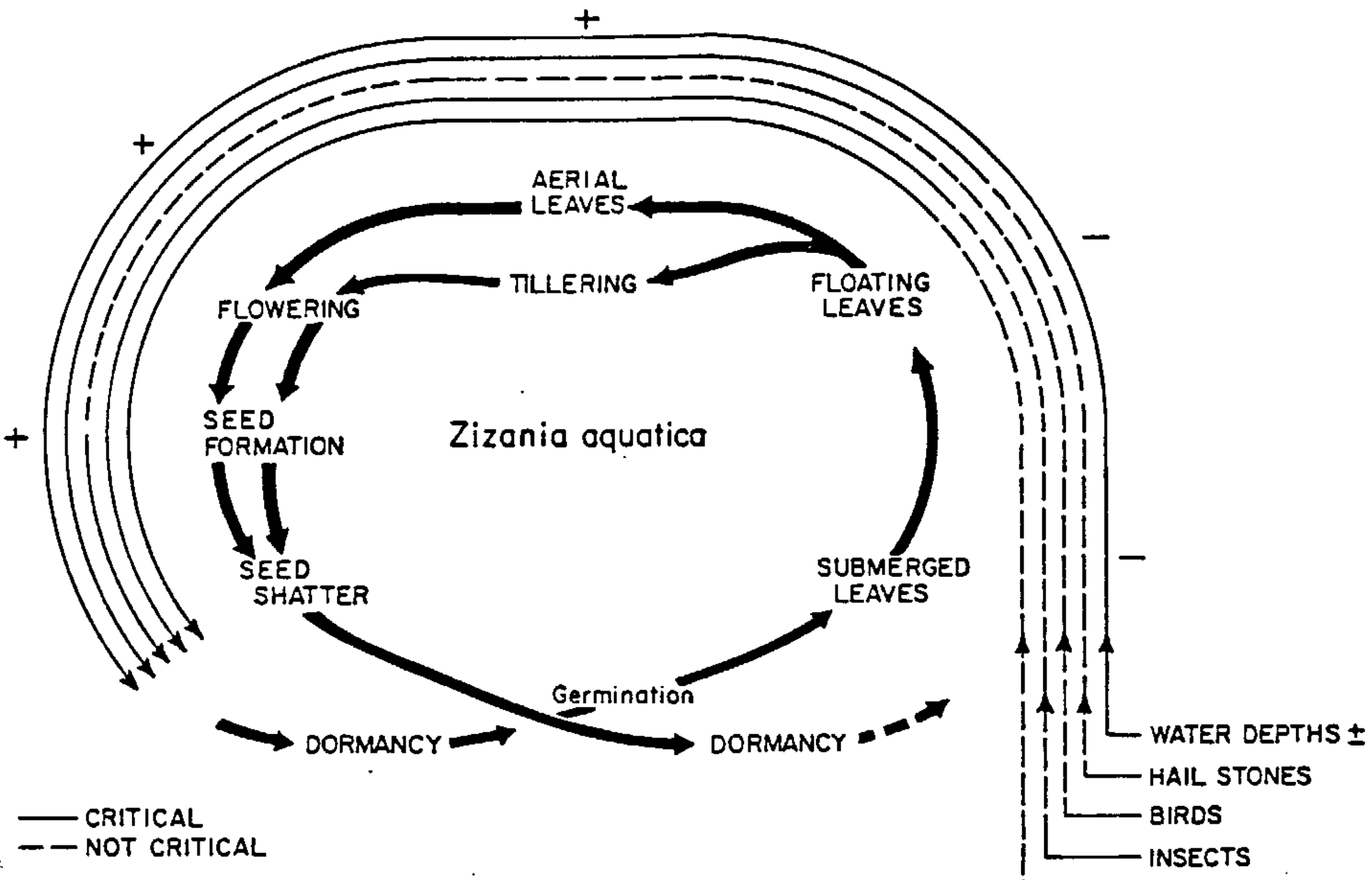
IDEALIZED GROWTH OF SHATTERING WILD RICE FOR NORTHWESTERN ONTARIO

FIGURE 2.1



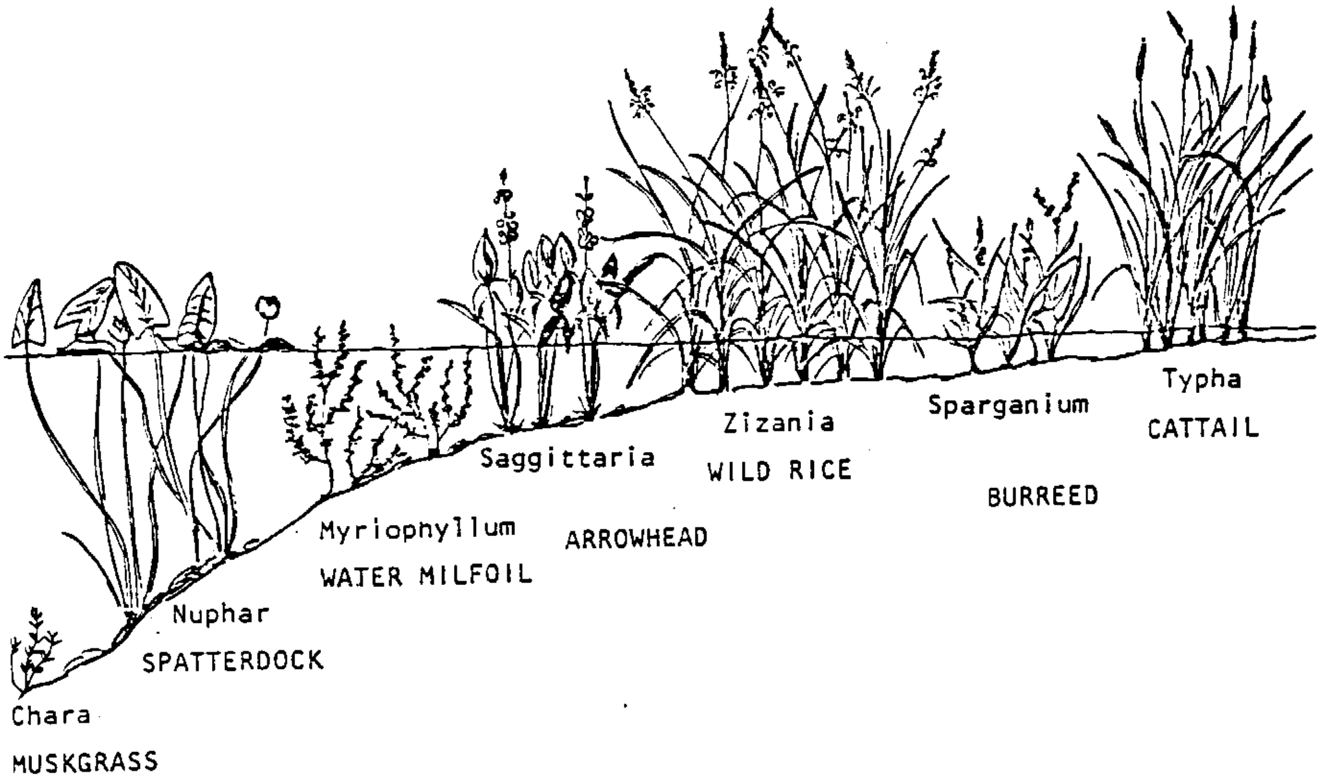

THE MORPHOLOGY OF A WILD RICE PLANT DURING THE LIFE CYCLE

FIGURE 2.2




LIFE CYCLE AND SOME HAZARDS AFFECTING THE GROWTH OF WILD RICE IN NATURAL STANDS.

FIGURE 2.3




Generalized zonation of aquatic vegetation in lakes and along riverbanks in Northwestern Ontario. Note the approximate position of wild rice with respect to water depth and associated plant species.

GENERALIZED ZONATION OF AQUATIC VEGETATION

FIGURE 2.4

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CHAPTER 3

# WILD RICE IN THE STUDY AREA

## 3.1 AREA OF STUDY

The study area comprises several lakes and rivers in the Winnipeg River drainage system all of which is tributary to the Nelson River. Specifically the study area includes Lake of the Woods, Rainy Lake, Namakan Lake, Lac La Croix, the Winnipeg River above the Manitoba border, English River below Lac Seul and the Rainy River below Lac La Croix. Streamflows are naturally regulated by the large lakes on the principal rivers and the many smaller lakes of the tributary system. The flows are also artificially regulated, mainly for electric power production by dams at the outlet of Lac Seul, Lake of the Woods, Rainy Lake and Namakan Lake.

Management of water levels and releases are governed by the International Boundary Waters Treaty of 1909, the International Lake of the Woods Control Board, and Canadian federal and provincial governments under the Lake of the Woods Control Board Act.

Management of these lakes and streams is directed toward the enhancement and protection of the interests of various water users, both on the lakes and streams themselves and downstream of the study area. Except when extremes of levels or flow occur or threaten, the water management is directed principally toward hydro-electric generation requirements. Because these requirements may not always be compatible with protection and enhancement of the wild rice crop, the study described by this report was initiated. Therefore, with the exception of Lac La Croix, the area of study includes only those rice producing lakes and streams whose water levels are artificially regulated.

For the purposes of the study, the area has been divided into water bodies each of which is affected in a different way by regulation. These are:

Winnipeg River

English River below Lac Seul

Lake of the Woods (including Shoal Lake)

Rainy Lake

Namakan Lake

Lac La Croix

Lac Seul is not included in the study of rice production since it produces practically no rice, although its regulation is included in the hydrological system. The portion of the Rainy River between Lake of the Woods and Rainy Lake is included with Lake of the Woods since nearly all of its rice producing area is located in its lower reaches where water levels respond mainly to Lake of the Woods levels.

For purposes of management and licensing of the rice harvest, the major producing areas have been divided into rice harvest areas.[1] The location of these is indicated on Figure 3.1. In addition, the 1:50,000 scale maps entitled Wild Rice Habitat Classification, drawing no. 355-01,

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[1] MNR, 1960 Map of Harvest Areas.

which forms Appendix E of this report, show the designated harvest area boundaries.

### 3.1.1 Harvest Areas

The study area includes parts of Northwestern and North Central administrative regions of the Ontario Ministry of Natural Resources. Kenora and Fort Frances Districts within Northwestern region cover most of the study area, although parts of the English River are in Red Lake District and Lac La Croix is in North Central Region.

There are eight wild rice harvest areas in Kenora District. These areas were etablished in 1960 along with two others now included in Dryden district. Table 3.1 shows Kenora District harvest areas and the Indian Bands to which they are allocated. Harvest areas numbered 3 through 8 cover mainly Lake of the Woods. Harvest area #1 covers the Winnipeg River, and the western portion of the English River. Harvest area #2 covers the eastern portion of the English River.

Fort Frances District has not been divided into harvest areas in large blocks the same way Kenora District has been. Table 3.2 shows the Fort Frances Harvest Areas by number and the Indian Bands who harvest them. There are several harvest areas licensed to individuals in the district, and these are also listed in Table 3.2.

Fort Frances district harvest areas numbers 1, 3, 4, and 5 are on Lake of the Woods. Harvest area numbers 6, 7, 8, 9, 12, 14, 18, 19 and 20 are on Rainy Lake, and the others are outside the study area boundaries.

TABLE 3.1

| Kenora District Harvest Area | Band |
|---|---|
| 1 | Islington (Whitedog) |
| 2 | Grassy Narrows |
| 3 | Rat Portage & Dalles |
| 4 | Shoal Lake 39 & 40 |
| 5 | N.W. Angle 33 & 37 |
| 6 | Big Island |
| 7 | Sabaskong & Big Grassy (Morson) |
| 8 | Whitefish Bay |

TABLE 3.2

| Fort Frances District Harvest Area | Band/Harvester |
|---|---|
| 1 | Manitou Rapids |
| 2 | Manitou Rapids |
| 3 | Big Grassy |
| 4 | Manitou Rapids |
| 5 | Manitou Rapids |
| 6 | Northwest Bay |
| 7 | Northwest Bay |
| 8 | Stanjikoming |
| 10 (portion in Rainy L. district) | Couchiching |
| 10 (portion in Dryden district) | Wabigoon |
| 12 | Couchiching |
| 13 | Seine River |
| 14 | Seine River |
| 18 | Redgut |
| 19 | Seine River |
| 20 | Couchiching |
| 21 | Northwest Bay |
| 22 | Northwest Bay |
| 142,A,B,C | Adam Troy Parks (individual) |
| Bear River | Cliff Slowe (individual) |
| NW Cherry Island | Donna Marie Howells (individual) |

## 3.2 WILD RICE MAPPING

### 3.2.1 Data and Presentation

The study area is covered by 30 National Topographic Series map sheets at the scale 1:50,000. Emergent vegetation was identified by airphoto interpretation and plotted on 1:50,000 scale National Topographic base sheets. These maps, entitled Wild Rice Habitat Classification, drawing number 355-01, 30 sheets, form Appendix E of this report. Maps at the same scale were used in the Band Surveys to identify past and present rice producing areas. This information and Ministry of Natural Resources and Department of Indian Affairs rice area maps were used as a cross-check with the airphoto mapping.

The maps produced show the potential rice producing areas within the study area. These areas are interpreted as having a cover of emergent vegetation at the time photographed and probably include species other than wild rice. Spot checks against interpretation from large scale photo indicated that nonrice species might occupy approximately 20% of the mapped area. All the plotted areas essentially represent wild rice habitat whether or not wild rice currently grows in that habitat. The boundaries of these areas change over time with changing water levels, competition from other species and sediment movement. The aerial extent shown is therefore based on boundaries in existence at the time of available photography.

By incorporating all emergents in the maps of wild rice habitat, historical rice producing areas are implicitly included. Separate maps of historical rice producing areas are not included because the band surveys indicated very few of these within the area of study that do not produce today. Also shown on the maps are rice area boundaries as observed by the Ontario Ministry of Natural Resources during the 1977 crop year or the 1980 crop year. These were large harvest years compared to those for which airphoto is available, and the consequent difference in the wild rice producing area is apparent.

### 3.2.2 Airphoto and Satellite Image Interpretation

The study objective included definition of existing natural wild rice producing areas to the extent possible from existing data. It was also desirable, for purposes of rice harvest modelling, to provide definition of wild rice area and classification of uniform conistency throughout the study area. The band surveys and agency data described in Section 3.2.1 provided general information and location of harvest areas, and, in certain areas for the years 1977 to 1980, reasonably accurate mapping. To provide area and classification of uniform consistency, remote sensing methods were used to define areas of wild rice habitat. The following three sources were used:

a) Earth resources satellite imagery at 1:1,000,000 scale.

b) Existing high level airphoto at 1:50,000 scale.

c) Existing intermediate level airphoto at 1:15,840 scale.

The results of the interpretation have been plotted on 1:50,000 scale National Topographic Series base plans (Appendix D). These are discussed further in Section 3.3.

Satellite imagery is available for Canada from 1972 to the present. The satellite has a repeat path and creates image data over the same point every seventeen days. When received by ground stations, the black and white satellite images can be processed to provide a true colour print or various combinations of false colours to enhance certain features.

Two major problems with satellite imagery for the mapping of emergent vegetation are:

a) high levels of light, primarily in the visible region of the spectrum, are required, therefore cloud cannot be penetrated. As a result, useful imagery can be obtained only on bright cloudless days. The total microfiche record of imagery obtained for the study area since 1972 was examined and three partially useable images were located, date 16-08-77, 12-08-78 and 07-08-79.

b) Scale is too small to identify most wild rice areas. A large bed of rice with an area of 160 acres would be represented by an area of only 1/32 inch square on the satellite image.

Available satellite imagery cannot be examined stereoscopically; it is therefore necessary to re-create images in such a form that a particular target, such as emergent vegetation, can be enhanced for examination. For this purpose, an electronic scanner available through the Manitoba Remote Sensing Centre, was utilized to examine and analyze the selected images. Approximately 150 of the scanner images were photographed covering various frequency bands and scales up to 1:10 enlargement, the maximum range of the scanner. Examination of these slides provided interesting but inconclusive results. In addition to the limitations described above, it was found that the shadows created by the solar angle caused shifts in colour band in near shore areas dependent on shoreline aspect. In consideration of these limitations, interpretative problems and inconclusive results, it was decided to abandon the use of satellite imagery to identify wild rice habitat.

Examination of flight indexes provided by the National Airphoto Library, Ottawa, indicated that the greater portion of the area south of Kenora, Ontario, is covered by 1:50,000 scale aerial photography of reasonable quality taken in 1952. This was flown during the summer and early autumn and was judged reasonable for the identification of areas of emergent vegetation. For those areas north of Kenora, photography of 1:50,000 scale taken at various times during the years 1970, 1974 and 1976 was available.

It should be noted that the map information presented must be considered in the context of the photography dates. They represent areas of emergent vegetation only at the time of photography. For example, since 1952, there have been changes in vegetation due to seeding of rice and natural changes in water level, competition, etc. Figure 3.2 shows, as an example, the wild rice area in Yellowgirl Bay for two different seasons. The difference in rice covered area is attributable mainly to a difference in water level. In order to check the 1:50,000 scale interpretation, 1:15,840 scale airphoto was obtained for two selected areas, Shoal Lake - Rush Bay and Seine River. This photography was examined stereoscopically and at this scale significant detail not observable on the 1:50,000 scale photo appears. Rice is more easily distinguished from other emergent species and small areas of rice less than one acre in size could be identified. Used as a check against the high level interpretation, the 1:15,480 scale interpretation indicated that possibly some 20% of the emergent species identified in the complete mapping may not have been wild rice.

Table 3.3 shows the dates of photography and corresponding water levels throughout the study areas.

## 3.3 WILD RICE HABITAT

### 3.3.1 Habitat Classification

The interpretation defined habitat boundaries and provided wild rice stand classification shown on the 1:50,000 maps (Appendix D). The habitat parameters included in the classification are: type of water body, slope of littoral zone, exposure, aspect and approximate size. Each parameter is represented by a single digit; each habitat area represented by a five-digit sequence. The habitat maps show this five-digit classification number adjacent to each wild rice stand location. This classification is described by the legend of the Wild Rice Habitat maps and by Table 3.4. The paragraphs following provide a more complete description of the classification system and its use.

The type of water body is important to the growth of wild rice

TABLE 3.3

NORTHWESTERN ONTARIO WATER LEVEL SUMMARY FOR YEARS OF AIR PHOTOGRAPHY

SHOAL LAKE - Converted To GSC

| Date | Water Level (metres) |
|---|---|
| April 1952 | 322.97 |
| May 1952 | 323.01 |
| June 1952 | 323.04 |
| July 1952 | 323.10 |
| August 1952 | 323.16 |
| September 1952 | 323.11 |
| October 1952 | 323.04 |

LAKE OF THE WOODS (Lake Of The Woods Datum)

| Date | Water Level (metres) |
|---|---|
| April 1952 | 322.92 |
| May 1952 | 323.01 |
| June 1952 | 322.98 |
| July 1952 | 323.17 |
| August 1952 | 323.35 |
| September 1952 | 323.16 |
| October 1952 | 323.01 |

RAINY LAKE (United States datum)

| Date | Water Level (metres) |
|---|---|
| April 1952 | 336.69 |
| May 1952 | 337.06 |
| June 1952 | 337.53 |
| July 1952 | 337.85 |
| August 1952 | 337.79 |
| September 1952 | 337.77 |
| October 1952 | 337.59 |

NAMAKAN LAKE - above Kettle Rapids

| Date | Water Level (metres) |
|---|---|
| April 1970 | 338.48 |
| May 1970 | 340.11 |
| June 1970 | 341.04 |
| July 1970 | 340.89 |
| August 1970 | 340.77 |
| September 1970 | 340.84 |
| October 1970 | 340.73 |

WINNIPEG RIVER - at Minaki

| Date | Water Level (metres) |
|---|---|
| April 1970 | 316.03 |
| May 1970 | 316.19 |
| June 1970 | 317.14 |
| July 1971 | 317.14 |
| August 1971 | 316.11 |
| September 1971 | 316.04 |
| October 1971 | 316.03 |

## TABLE 3.4

## WILD RICE HABITAT CLASSIFICATION

Water Body

1. Channel habitat - emergent vegetation affected by streamflow and/or wind induced currents.

2. Lake habitat - emergent vegetation not affected by streamflow and/or wind induced currents.

Littoral Zone

3. Ribbon growth - narrow littoral zone extending for some distance along a shoreline.

4. Extensive bed area - flat deltaic or gradually sloped littoral zone.

Exposure

5. Habitat exposed to greater than 1/2 mile fetch of open water.

6. Sheltered habitat with less than 1/2 mile fetch of open water.

Aspect

Shoreline with emergent vegetation facing:

1 - North
2 - Northeast
3 - East
4 - Southeast
5 - South
6 - Southwest
7 - West
8 - Northwest

Estimated Size

1. 1-10 acres
2. 11-30 acres
3. 31-100 acres
4. 101+ acres

e.g. 23512 = Exposed lake habitat, narrow littoral zone facing north 11 to 30 acres in size.

and other emergents. In a channel habitat, (indicated by a "1" in the first position of the five-digit sequence) emergent vegetation may be affected by streamflow and/or wind induced currents. Effects of streamflow include replenishment of nutrients by sediment agitation, possible changes in water temperature, clearing away of old straw. Currents can be created in a channel situation by the wind. These currents have effects similar to streamflow.

In a lake habitat, indicated by a "2" in the first position of the sequence, emergent vegetation is affected by lake currents but not to the same extent as an inflow/outflow situation in a channel. Depending on the exposure of the vegetative zone, waves may build up in a lake habitat. The old straw can accumulate in a lake habitat and conditions may favour competitive plants if sediments are not stirred sufficiently by lake currents.

The slope of the littoral zone determines the shape and extent of much of the wild rice habitat. If the slope is relatively steep, the rice will grow in a ribbon-like zone close to the edge of the water. If the littoral zone is relatively flat, or gradually sloped, there is a larger area at an appropriate water depth for emergent vegetation. The rice can therefore grow in a more extensive bed. Flat deltaic areas can also support an extensive bed of emergents. Steep sloped littoral zones change the location of wild rice habitat, but not necessarily the actual size of the vegetative zone, with seasonally changing water levels. The extent of growth in more gradually sloped zones, however, can be greatly affected by seasonal changes in the water level as illustrated by Figure 3.3. The classification indicates the type of littoral zone with a "3" in the second position denoting ribbon growth and a "4" extensive bed.

The exposure of emergent vegetation to open water is important to the effect that wind and waves have on the growing plants. For the wild rice habitat classification a sheltered area is defined as an area with less than 1/2 mile of fetch (distance of exposure to open water) indicated by a "5" in the third position of the classification number. Greater than 1/2 mile of fetch classifies an area as more susceptible to the effects of wind and waves and is indicated by a "6" in the third position.

The direction in which a zone of emergent vegetation faces is also important to the effects of wind. The aspect is divided into eight compass directions, as indicated in the fourth position of the classification number. The shoreline along which the emergent growth occurs is used to define the direction the growth is facing.

The size of the vegetation zones change over time. Instead of measuring the size of each area therefore, all the wild rice habitat areas plotted on the maps were divided into four size groups. An estimate of total area of wild rice habitat can then be approximated by using the midpoints of these size classes (for the largest class, 200 acres was used). The size is indicated in the fifth position of the classification number.

## 3.4 DISTRIBUTION OF WILD RICE HABITAT BY STUDY AREA

Table 3.5 shows the habitat classification by harvest area and by study area.

### 3.4.1 Winnipeg River

Kenora District Harvest Area #1 includes part of the English River and most of the Winnipeg River. The Islington Band harvests from this area. There are approximately 1,297 acres of wild rice habitat area identified in this harvest area. Most of this habitat area (55%) is in beds 1 to 10 acres in size. No areas are over 100 acres and only 10% are between 31 and 100 acres. More areas face northwest than any other single directon. Channel type growth accounts for 21% of the total acreage. This is a larger percentage than most of Lake of the Woods, but smaller than the English River, parts of southern Lake of the Woods and parts of Rainy Lake. Less than half (44%) of the wild rice habitat area is classified 'open', susceptible to wind and waves. Thirty-eight per cent of the habitat is found on steeply sloped littoral zones, indicated by ribbon-type growth of emergents. The English River (Kenora Harvest Area #2) and part of Rainy Lake (Fort Frances Harvest Area #4) are the only two harvest areas with a higher percentage classified as ribbon growth.

### 3.4.2 English River

Kenora District Harvest Area #2 covers most of the English River. The Grassy Narrows Band harvests this area. There are approxi-

TABLE 3.5

HABITAT CLASSIFICATION SUMMARY

| WATER BODY | | Habitat Area (Acres) | Predominent Aspect | % Of Total Area Size 1 | Size 2 | Size 3 | Size 4 | Open | Channel | Ribbon |
|---|---|---|---|---|---|---|---|---|---|---|
| WINNIPEG RIVER | | | | | | | | | | |
| Kenora Harvest Area | 1 | 1,297 | NE | 55 | 35 | 10 | 0 | 44 | 21 | 38 |
| ENGLISH RIVER | | | | | | | | | | |
| Kenora Harvest Area | 2 | 1,051 | NE | 59 | 35 | 6 | 0 | 64 | 28 | 48 |
| LAKE OF THE WOODS | | | | | | | | | | |
| Kenora Harvest Area | 3 | 3,349 | NE | 39 | 43 | 18 | 0 | 35 | 10 | 26 |
| | 4 | 2,476 | W | 48 | 23 | 21 | 8 | 65 | 3 | 37 |
| | 5 | 1,770 | NE | 23 | 44 | 33 | 0 | 54 | 2 | 15 |
| | 6 | 1,938 | S | 42 | 34 | 14 | 10 | 64 | 7 | 29 |
| | 7 | 2,414 | S | 29 | 32 | 22 | 17 | 56 | 2 | 19 |
| | 8 | 2,972 | NE | 28 | 34 | 24 | 13 | 44 | 8 | 21 |
| Fort Frances Harvest Area | 1 | 229 | E | 17 | 26 | 57 | 0 | 71 | 9 | 10 |
| | 3 | 484 | NW | 7 | 25 | 68 | 0 | 54 | 53 | 8 |
| | 4 | 576 | N | 21 | 21 | 23 | 35 | 27 | 72 | 3 |
| | 5 | 192 | NE | 23 | 43 | 34 | 0 | 30 | 83 | 9 |
| TOTAL | | 16,400 | NE | 33 | 34 | 24 | 8 | 49 | 10 | 23 |
| RAINY LAKE | | | | | | | | | | |
| Fort Frances Harvest Area | 6 | 114 | SW | 82 | 18 | 0 | 0 | 24 | 5 | 14 |
| | 7 | 1.392 | S | 17 | 31 | 38 | 14 | 53 | 25 | 8 |
| | 8 | 1,603 | NE | 16 | 22 | 37 | 25 | 72 | 4 | 21 |
| | 9 | 871 | S | 42 | 28 | 30 | 0 | 72 | 4 | 37 |
| | 12 | 827 | SE | 17 | 35 | 24 | 24 | 76 | 2 | 10 |
| | 14 | 275 | S | 70 | 30 | 0 | 0 | 82 | 36 | 46 |
| | 18 | 357 | N | 23 | 40 | 37 | 0 | 75 | 45 | 21 |
| | 19 | 317 | SE | 42 | 58 | 0 | 0 | 65 | 23 | 34 |
| | 20 | 281 | SW | 25 | 51 | 23 | 0 | 57 | 18 | 25 |
| Other | | 807 | N | 37 | 38 | 24 | 0 | 55 | 36 | 21 |
| TOTAL | | 6,844 | S | 28 | 32 | 27 | 12 | 65 | 17 | 21 |
| NAMAKAN LAKE | | 887 | SE | 40 | 30 | 30 | 0 | 31 | 5 | 60 |
| LAC LA CROIX | | 87 | E | 76 | 24 | 0 | 0 | 55 | 13 | 70 |

mately 1,051 acres of wild rice habitat identified. Most of this habitat occurs in beds 1 to 10 acres in size. Like the Winnipeg River, there are no areas greater than 100 acres in size. Only 6% of the area is in beds 31 to 100 acres in size. More of the area is situated on shorelines facing northeast than any other single direction. More than half (64%) of the area is classified 'open'. This harvest area is more susceptible to wind and waves than Harvest Area #1, but not as susceptible as Fort Frances Harvest Area #1 on the Rainy River or most of Rainy Lake. The English River has more channel growth than most of Lake of the Woods and Winnipeg River. Approximately half (48%) of the growth occurs on relatively steeply sloped littoral zones in ribbon-type beds. This area has one of the highest percentages of ribbon growth in the study area. Only Namakan Lake has a greater percentage.

### 3.4.3 Lake of the Woods

Kenora District Harvest Areas #3 to #8, and Fort Frances District Harvest Areas #1, #3, #4 and #5 cover Lake of the Woods and Shoal Lake. The Fort Frances harvest areas are much smaller than Kenora areas on Lake of the Woods, ranging in size from area #5 at approximately 192 acres to area #4 at approximately 576 acres of wild rice habitat. Kenora District harvest areas on Lake of the Woods range from approximately 1,770 acres of habitat in area #5 to 3,349 acres in Area #3.

Approximately 16,400 acres of emergent vegetation was identified on Lake of the Woods. Most areas are between 1 and 30 acres in size. Only 8% of the area is in beds larger than 100 acres and 24% in beds between 30 and 100 acres in size. More area faces northeast than any other single direction for all of the lake. Individual harvest areas have predominant aspects of north northeast, south, west and northwest, as shown in Table 3.4. Approximately half of the area is open (49%), susceptible to wind and wave action. Only 10% of the total wild rice habitat area is classified as channel; most growth being lake type, not affected by wind induced currents or streamflow. However, specific harvest areas within Lake of the Woods, such as Fort Frances Harvest Area #4 and #5 have a much greater percentage of area in channel type habitats. The emergents in these two harvest areas occur in rivers and streams in the southern part of Lake of the Woods. Most habitat area occurs on gradually sloped or flat littoral zones. Only 23% of the emergents are classified ribbon growth.

### 3.4.4 Rainy Lake

Fort Frances Harvest Areas #6, #7, #8, #9, #12, #14, #18, #19 and #20 are all on Rainy Lake, but do not include all the areas of wild rice habitat identified. Areas identified on the maps outside of these registered harvest areas are either included with the harvest area closest, or tabulated under "other" in the table. Approximately 6,844 acres of wild rice habitat were identified as shown on the maps provided. Most area (60%) occurs in beds between 1 and 30 acres in size. There is slightly more area in larger beds (between 30 and 100, and over 100 acres) than in Lake of the Woods or the Winnipeg and English Rivers. The predominant aspect is south, but varies between harvest areas as shown in Table 3.5. In Rainy Lake, 27% of total habitat is in beds between 30 and 100 acres and 12% is in beds greater than 100 acres. More than half the habitat (65%) is classified 'open', susceptible to wind and waves. This is a higher percentage than Lake of the Woods or Winnipeg River, comparable to the English River (64%). The percentage of area in channel habitat (17%) is slightly greater than in Lake of the Woods (10%) but is still less than Winnipeg (21%) and English Rivers (28%). As in Lake of the Woods, most areas occur on gradually sloped or flat littoral zones. The percentage of ribbon growth showing a relatively steep slope is only 21%.

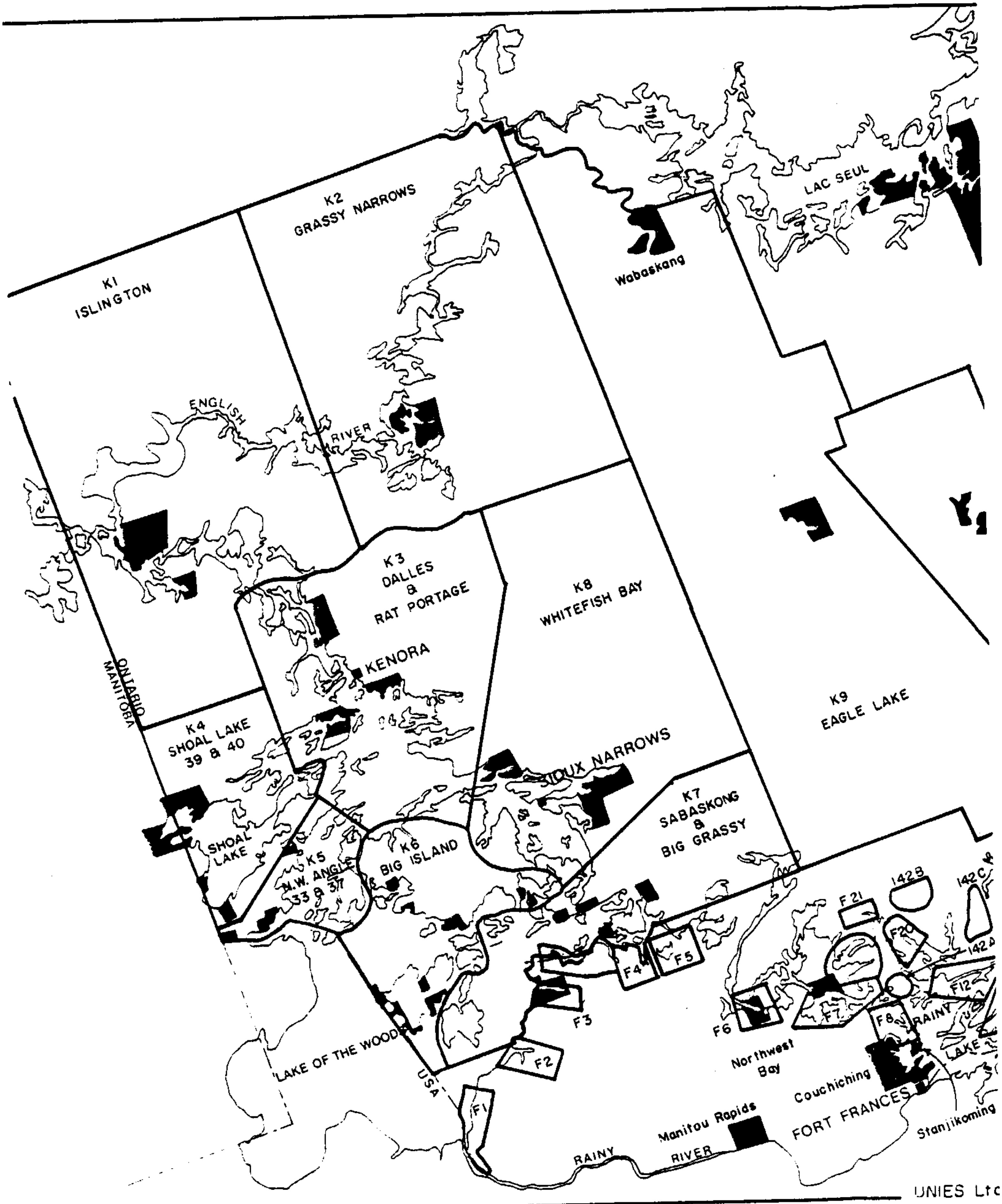
### 3.4.5 Namakan Lake

Approximately 887 acres of wild rice habitat were identified on the airphotos. The predominant aspect is southeast. Of the total area, 70% is located in beds between 1 and 30 acres in size. There are no large beds of 100 acres or more. Thirty per cent of the total area is in beds 30 to 100 acres in size. Only 31% of the total habitat area is classified open. This is lower than any other part of the study area. Only 5% of the emergent vegetation is found in channel habitat. This percentage is also lower than any other water body of the study area. Most (60%) of the emergent vegetation is found in ribbon development, on relatively steep littoral zones. Namakan Lake has more ribbon growth, more sheltered and more lake type habitat than the Winnipeg River, English River, Lake of the Woods, or Rainy Lake. Lac La Croix has a slightly higher percentage of ribbon growth.

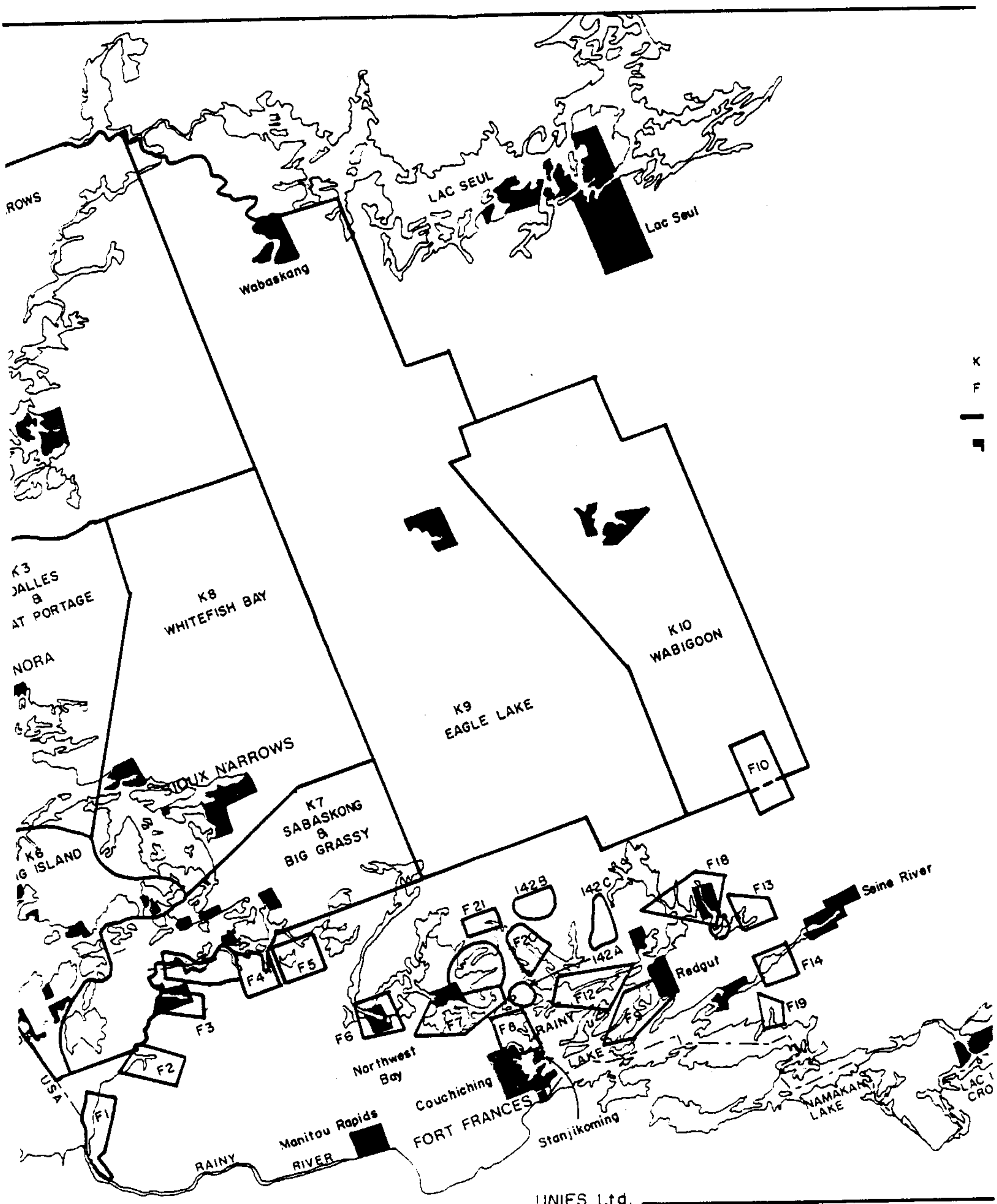
### 3.4.6 Lac La Croix

There is only a small amount of wild rice habitat area in the Canadian part of Lac La Croix, mostly on shorelines facing east. From the photos, 87 acres have been estimated. Seventy-six per cent of this area is in beds 1 to 10 acres in size. There are no areas of more than 30 acres in size. The habitat is 55% open, a higher percentage than Namakan, Rainy Lake, Lake of the Woods or Winnipeg River. Only 13% of the habitat is channel and 70% is ribbon. Most of the emergent vegetation is found in lake habitat on relatively steep slopes.

FIGURES


K1
ISLINGTON
K2
GRASSY NARROWS
Wabaskang
LAC SEUL
ENGLISH
RIVER
K3
DALLES
&
RAT PORTAGE
K8
WHITEFISH BAY
KENORA
ONTARIO
MANITOBA
K4
SHOAL LAKE
39 & 40
SIOUX NARROWS
K9
EAGLE LAKE
K7
SABASKONG
&
BIG GRASSY
SHOAL
LAKE
K5
N.W. ANGLE
33 & 37
K6
BIG ISLAND
F 21
142B
142C
142A
F20
F4
F5
F12
F3
F6
F7
F8
RAINY
LAKE
Northwest
Bay
LAKE OF THE WOODS
F2
USA
F1
Couchiching
FORT FRANCES
Stanjikoming
Manitou Rapids
RAINY
RIVER

UNIES Ltc



LAC SEUL
Lac Seul
Wabaskang
ROWS
K3
DALLES
&
AT PORTAGE
NORA
K8
WHITEFISH BAY
K9
EAGLE LAKE
K10
WABIGOON
F10
SIOUX NARROWS
K7
SABASKONG
&
BIG GRASSY
K6
G ISLAND
F18
142B
142C
F13
Seine River
F21
F20
142A
Redgut
F14
F4
F5
F12
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F6
F7
F8
RAINY
F9
LAKE
F2
Northwest
Bay
Couchiching
USA
F1
FORT FRANCES
Stanjikoming
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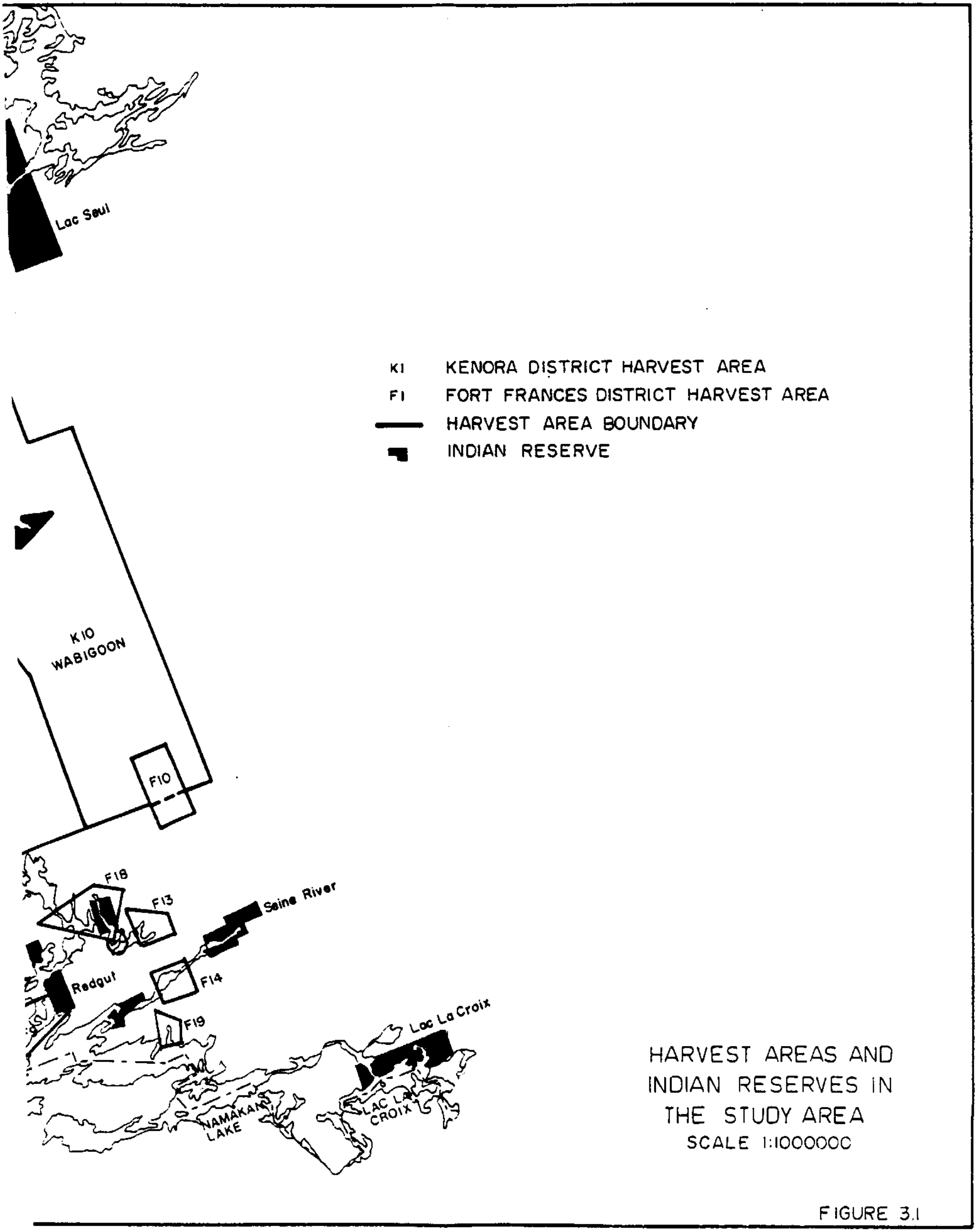
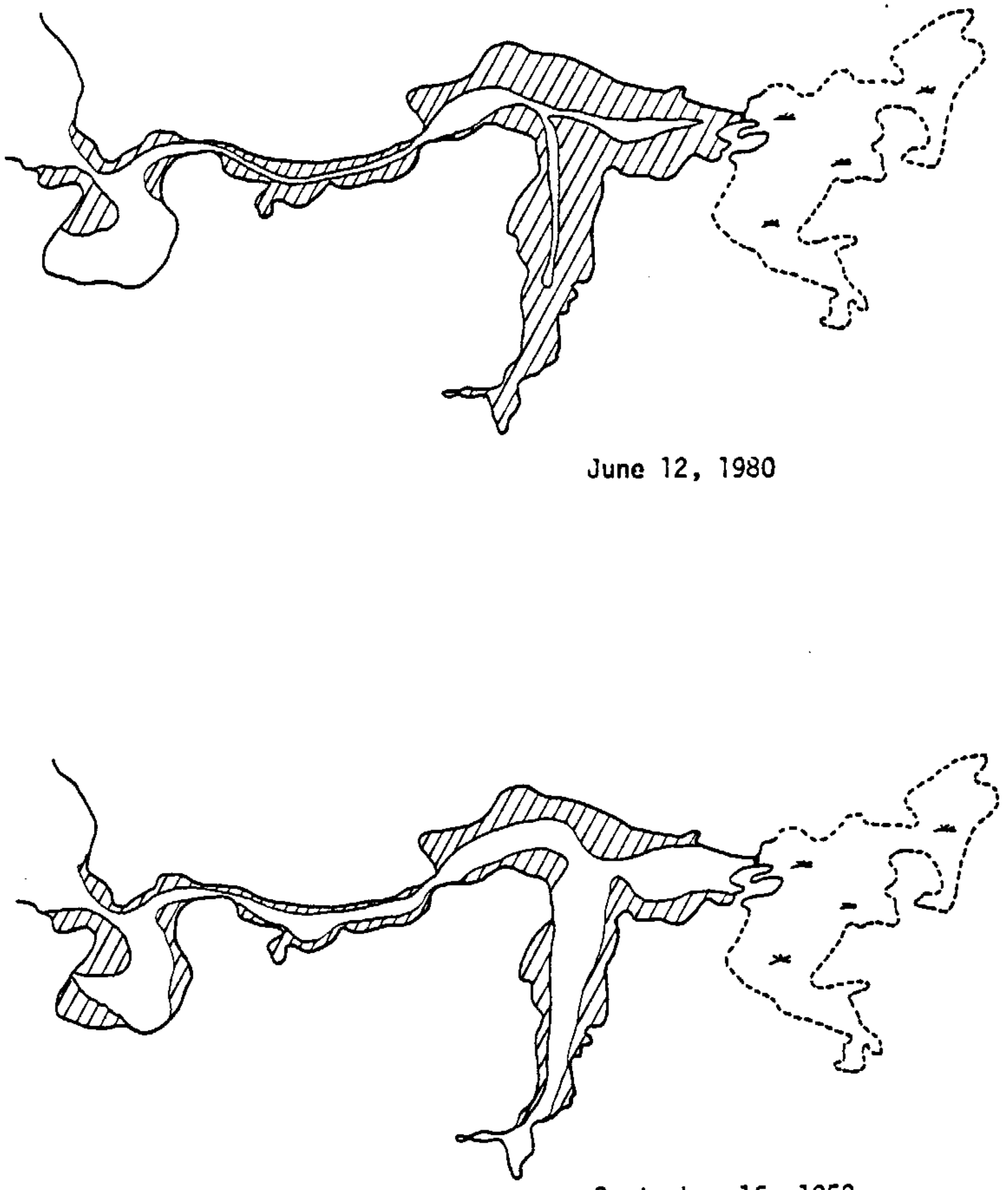



HARVEST AREAS AND INDIAN RESERVES IN THE STUDY AREA

SCALE 1:1000000

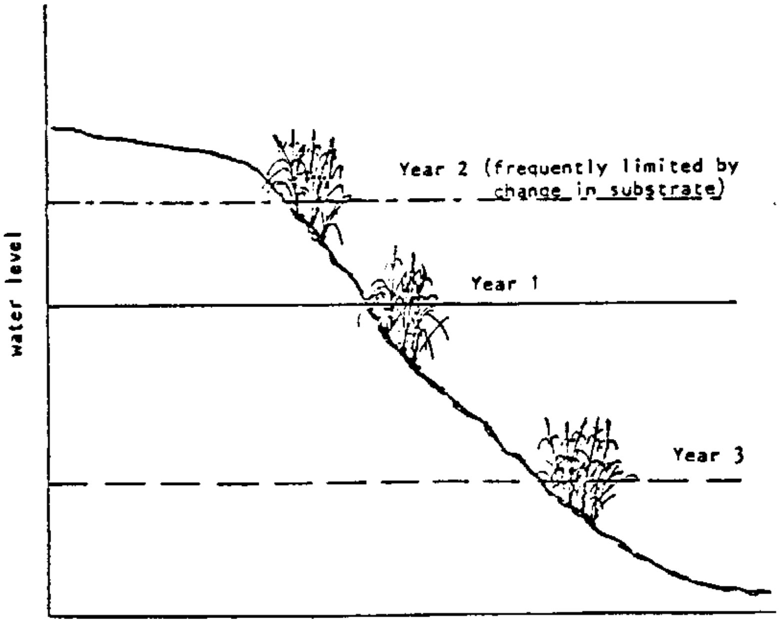
FIGURE 3.1



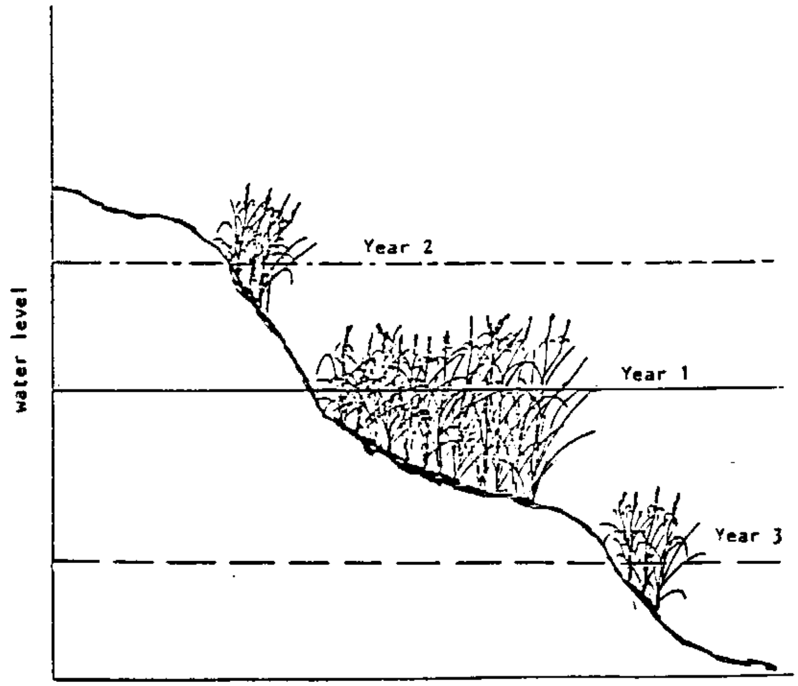

shoreline
wild rice area

YELLOWGIRL BAY
CHANGES IN WILD RICE AREA

FIGURE 3.2




A. Areas with steep littoral zone.




B. Areas with gradually sloped or flat littoral zone.

Problems with habitat location changes due to changing water levels:

1) other plants may be established at higher levels,
2) availability of seed,
3) flooding of unsuitable soils, e.g. granular or rock.

GENERALIZED RESPONSE OF WILD RICE POPULATION TO CHANGES IN THE LITTORAL SLOPE.

FIGURE 3.3

CHAPTER 4

# MARKET, ECONOMIC AND SOCIAL CONSIDERATIONS

## 4.1 RELATION OF WILD RICE MARKET TO HARVEST

The year 1980 proved to be a bumper crop year for wild rice, both in terms of lake wild rice and paddy wild rice. Recorded production in the four major growing areas, Minnesota, Manitoba, Ontario and Saskatchewan was 10,971,000 lbs. of green wild rice. Depending on the recovery rate[1] this amount of green rice would process into 4.3 million to 4.9 million lbs. of finished rice ready for market. At the retail level with prices ranging from $5.00 to $7.00 (U.S. funds) this represents a market value of $21 to $34 million in U.S. funds or $25 to $40 million in Canadian funds.

### 4.1.1 Production Aspects

The production of wild rice is characterized by two very different sets of conditions. Lake wild rice is harvested from natural stands and is therefore much more susceptible to the vagaries of the natural environment, whereas paddy wild rice is grown under more controlled conditions.

Lake wild rice is harvested in Manitoba, Ontario and Saskat-

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1 Green wild rice is processed by parching the rice until very little moisture is retained in the kernel. In the process, the moisture driven off results in weight loss of the rice. A 40% to 45% recovery rate will be used.

chewan, using either a canoe and flail or mechanical harvesters. The latter are usually airboats equipped with a speedhead which collect the ripened wild rice as the airboat is driven through the stand. The State of Minnesota, however, does not allow the use of mechanical harvesters[2] at all. One of the reasons stated for this policy is the apprehension that the use of mechanical harvesters will result in the income generated from the wild rice harvest to accrue to only a few individuals or companies. The chief benefit of mechanical harvesters is the greatly reduced manpower requirement and economic efficiency in harvesting wild rice, assuming, of course, that alternate income is available to the manpower replaced.

In most instances, natural wild rice stands receive very little attention from harvesters until the crop is ready for picking. There are places, however, where natural stands are thinned, water levels controlled, and wild rice seeded in order to increase the harvest. To date, this has been the exception rather than the rule. In order to increase productivity, these and other techniques will become more prevalent over time.

The production of paddy wild rice, on the other hand, is a purely agricultural enterprise. Water levels are strictly controlled, nonshattering rice strains are used to increase harvestable yields and fungicides, pesticides and fertilizers are used extensively. The control

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2 Minnesota Department of Natural Resources 1980, Minnesota Wild Rice Harvesting Regulations. "No wild rice shall be harvested with the use of any machine or mechanical device or implement except a round, smooth, wooden flail of not over 30 inches in length nor more than one pound in weight, held and operated by hand".

of these factors greatly enhances the probability of getting high and consistent yields of wild rice. The price of improving vagaries of nature is the capital expenditure in constructing and maintaining the paddies, the equipment needed such as rice combines, thinning equipment, etc., as well as the yearly investment in fertilizers, fungicides and pesticides.

Due to the fact that lake wild rice is harvested as a natural resource, whereas paddy wild rice is harvested as an agricultural crop, the number of participants in the harvest are vastly dissimilar. From Table 4.1, it can be seen that the lake wild rice harvest involves literally thousands of people in both the U.S.A. and Canada, whereas paddy wild rice production only involves approximately 65 farm units. Considering that paddy wild rice usually accounts for at least 50% of total wild rice production, it is obvious that revenues generated by the sale of lake wild rice are much more widely distributed than those generated by the sale of paddy wild rice. This factor affects the distribution of profits but not necessarily their scale.

## 4.2 MARKET ASPECTS

### 4.2.1 Product Differentiation

It is usually acknowledged that the long grain wild rice produced in the natural stands is of superior quality in the sense that the kernels are longer and plumper. There is considerable debate, however, as to whether this superior quality in length and width of kernel in

TABLE 4.1

PARTICIPANTS IN WILD RICE HARVEST

| | Lake Wild Rice | Paddy Wild Rice |
|---|---|---|
| Minnesota | 8,430[1] | 65 farm units[5] |
| Manitoba | 1,115 - 1,545[2] | 1 farm unit |
| Ontario | 1,500[3] | 1 farm unit |
| Saskatchewan | 213[4] | -- |

1 1979 Figure - Minnesota, Department of Natural Resources.

2 1980 Range - Manitoba, Department of Natural Resources.

3 1977 Figure, most recent estimate, Ontario, Ministry of Natural Resources.

4 1980 Figure, Saskatchewan, Economic Development Branch, Northern Saskatchewan.

5 Minnesota Wild Rice Council.

fact, translates into more flavourful wild rice than the leaner and shorter paddy rice. This characteristic of paddy wild rice also ensures it a spot in the marketplace. Because it is similar in size and shape to white rice, it is mixed with white rice and sold as a rice and wild rice mix. This is a significant portion of the market and one in which long-grained wild rice cannot readily compete. Because of its smaller overall size, there are more paddy wild rice kernels than lake wild rice kernels for any given weight. In the mix, it looks as if there is more wild rice if paddy wild rice, rather than lake wild rice, is used.

For the gourmet market, the long-grained lake wild rice is preferred. However, because large companies such as Uncle Ben's, do not have as large a vested interest in this side of the market the impetus for growth in the markets is certainly in the smaller sized wild rice produced in paddies. The issue of product differentiation has come to a head recently in Minnesota. Legislation has been passed through the House and Senate which will require the labelling of wild rice to differentiate between lake and paddy grown wild rice. The bill still requires the governor's signature but this is viewed as just a formality.

The potential effect of this labelling requirement in the marketplace is unknown, but the only major opposition to the bill came from the Minnesota Wild Rice Growers' Association. The Association may be apprehensive in that the distinction may result in a larger price differential than already exists between lake and paddy grown wild rice.

### 4.2.2 Buyers, Processors, Wholesalers and Retailers

Wild rice is bought and sold in many forms. During the harvest season lake wild rice is sold green and unprocessed by many of the harvesters. Once processed, it may be sold ungraded, graded but unpackaged or graded and packaged.

The individuals who are involved in the market cover the spectrum from being solely buyers, processors, wholesalers and retailers to any combination of the aforementioned.

The vast majority of the participants in the wild rice market operate on too small a scale to affect the market to any extent. However, there are some notable exceptions at the wholesale level. It is estimated that Uncle Ben's, a large food manufacturer and distributor, purchases approximately 1/3 to 1/2 of the wild rice crop in any given years for producing their rice and wild rice mix. Paddy wild rice growers are also a major influence on the market in the form of a growers' cooperative called United Wild Rice Incorporated. It is alleged that by 1979, United controlled more than 2/3's of the world supply of wild rice. A rival company also comprised of paddy rice growers, called M.R.G. (Minnesota Rice Growers) sells directly to Uncle Ben's. Unlike United, M.R.G. does not process its wild rice, but has it processed through Gibbs Wild Rice Co. Inc. Gibbs is a major processor of wild rice and a major purchaser of lake wild rice.

At the retail level, some food stores in the Minneapolis-St. Paul area, for example, Lund's and Byerlis, sell wild rice almost at cost and use it as a loss leader. In January 1981, a lb. of wild rice through this outlet retailed at U.S. $3.89 or $4.65 Canadian. Such pricing structures, however, are the exception rather than the rule.

## 4.3 PRODUCTION AND PRICES

### 4.3.1 Production from 1970-80

The four major wild rice producing areas at present are Minnesota, Manitoba, Ontario and Saskatchewan. Minor amounts of wild rice are harvested in Wisconsin, Nova Scotia, New Brunswick and Prince Edward Island. It is estimated that the latter three provinces, in total, produce approximately 100,000 lbs. of green wild rice per year. Sources in the trade indicate that some paddy wild rice production is taking place in California but no harvest estimates are available.

Tables 4.2 and 4.3 show the estimated production and percent distribution of green or unprocessed wild rice in Ontario, Manitoba, Saskatchewan and Minnesota for the years 1970 to 1980. Figure 4.1 shows the major producing area and the potential producing area of North America. The data presented are based on information from various government agencies and, at best, are an indication of the minimum level of harvest in each year. The degree of accuracy of the figures is unknown. These data, however, are probably indicative of the quantity of wild rice that reaches the commercial market. The year 1980 proved to be a bumper crop year, both for lake and paddy grown wild rice. The lake wild rice harvest in Minnesota for 1980 represented 22.8% of total production compared to 52.4% for paddy wild rice. The remaining produc-

TABLE 4.2

MAJOR PRODUCING AREAS OF WILD RICE
(LBS. OF UNPROCESSED RICE)

| | Ontario | Manitoba | Saskatchewan | Minnesota Lake | Minnesota Paddy | Total |
|---|---|---|---|---|---|---|
| 1970 | 60,354 | 148,950 | 2,310 | 1,223,713 | 842,500 | 2,277,827 |
| 1971 | 275,096 | 499,826 | 22,938 | 1,217,414 | 1,405,000 | 3,420,274 |
| 1972 | 1,092,823 | 600,969 | 55,337 | 1,033,800 | 3,460,000 | 6,242,929 |
| 1973 | 1,289,568 | 627,184 | 12,614 | 1,014,607 | 2,775,000 | 5,718,973 |
| 1974 | 9,934 | 137,194 | 22,524 | 1,000,000 | 2,590,398 | 3,760,050 |
| 1975 | 93,264 | 142,466 | 41,858 | 500,000 | 3,081,838 | 3,859,426 |
| 1976 | 1,137,801 | 351,353 | 96,432 | 2,000,000 | 4,523,052 | 8,108,638 |
| 1977 | 860,098 | 1,154,360 | 85,538 | 1,091,462 | 2,472,158 | 5,663,616 |
| 1978 | 155,015 | 474,037 | 60,504 | 549,154 | 2,903,473 | 4,142,183 |
| 1979 | 299,259 | 597,575 | 160,000 | 759,881 | 5,428,435 | 7,245,150 |
| 1980 | 1,000,000 | 1,400,000 | 321,000 | 2,500,000 | 5,750,000 | 10,971,000 |

NOTE: Small amounts of lake wild rice are produced in Wisconsin, Nova Scotia, New Brunswick and Prince Edward Island. It is estimated to be not more than 200,000 lbs. of green wild rice for all four areas. Some paddy wild rice is grown in Manitoba but the amount is not known.

SOURCES: Ontario Ministry of Natural Resources.
Manitoba Department of Natural Resources.
Saskatchewan Economic Development Branch, Northern Saskatchewan.
Minnesota Department of Natural Resources.
1970-73 data from the University of Minnesota.
1974-80 data from Wild Rice Growers Association.
Original data was in terms of processed lbs. and translated into green using a recovery rate of 40%.

TABLE 4.3

DISTRIBUTION OF PRODUCTION
BY MAJOR PRODUCING AREA
(PERCENT)

| | | | | Minnesota | | |
|---|---|---|---|---|---|---|
| | Ontario | Manitoba | Saskatchewan | Lake | Paddy | Total |
| 1970 | 2.7 | 6.5 | 0.1 | 53.7 | 37.0 | 100.0 |
| 1971 | 8.0 | 14.6 | 0.7 | 35.6 | 41.1 | 100.0 |
| 1972 | 17.5 | 9.6 | 0.9 | 16.6 | 55.4 | 100.0 |
| 1973 | 22.6 | 11.0 | 0.2 | 17.7 | 48.5 | 100.0 |
| 1974 | 0.3 | 3.6 | 0.6 | 26.6 | 68.9 | 100.0 |
| 1975 | 2.4 | 3.7 | 1.1 | 13.0 | 79.8 | 100.0 |
| 1976 | 14.0 | 4.3 | 1.2 | 24.7 | 55.8 | 100.0 |
| 1977 | 15.2 | 20.4 | 1.5 | 19.3 | 43.6 | 100.0 |
| 1978 | 3.7 | 11.4 | 1.5 | 13.3 | 70.1 | 100.0 |
| 1979 | 4.1 | 8.3 | 2.2 | 10.5 | 74.9 | 100.0 |
| 1980 | 9.1 | 12.8 | 2.9 | 22.8 | 52.4 | 100.0 |

SOURCE: Table 4.2.

tion, 24.8%, occurred in Canada. Prior to 1980, however, Canadian production represented anywhere from 4.5% to 36.9% of total production.

Table 4.4 provides data based on three-year averages in order to smooth out the data. Canada's proportion of total production seems to be falling from an average of 24.5% in the 1972-74 average to 20.0% in the 1978-80 average. Concomitantly, the average production of paddy wild rice has increased from 56.1% of total production in the 1972-74 average to 63.0% in the 1978-80 average.

Comparing growth rates from the 1972-74 average to the 1978-80 average, it can be seen that paddy wild rice production has increased by 59.6% in contrast to a 25.0% increase in Minnesota lake production and a 16.1% increase in Canadian lake production. The best performer in Canadian lake wild rice production increases is Saskatchewan with a three-year average that increased by 498.5% compared to 81.0% for Manitoba and a decrease of 39.2% in Ontario. Saskatchewan started from a lower base, but at the present rate of increase, may match production figures in Manitoba or Ontario within the next five years.

Of greater interest, data based on information provided by the University of Minnesota on the yields and acreages of paddy-grown wild rice is presented in Table 4.5. The acreage used by Minnesota paddy wild rice growers peaked in the years 1972 and 1973 at 17,000 and 18,000 acres respectively. Since then, acreage has dropped to 13,500 acres in 1980. Yields per acre, however, have increased dramatically over the 12-year period by 329.7% or 12.9% compounded yearly.

The average yield per acre for the three-year period 1978-80 is 397 lbs. of green wild rice per acre. Such a yield as an average

TABLE 4.4

THREE-YEAR AVERAGES OF
WILD RICE PRODUCTION
(LBS.)

| Three Year Period | Ontario | Manitoba | Saskatchewan | Total Canada | Minnesota Lake | Minnesota Paddy | Total |
|---|---|---|---|---|---|---|---|
| 1972-'74 | 797,442<br>(62.2) | 455,116<br>(35.5) | 30,158<br>( 2.3) | 1,282,716<br>(100.0)<br>( 24.5) | 1,016,136<br>(19.4) | 2,941,799<br>(56.1) | 5,240,652<br>(100.0) |
| 1975-'77 | 697,055<br>(52.8) | 549,393<br>(41.6) | 74,609<br>( 5.6) | 1,321,057<br>(100.0)<br>( 22.4) | 1,197,154<br>(20.4) | 3,359,016<br>(57.2) | 5,077,227<br>(100.0) |
| 1978-'80 | 484,759<br>(32.5) | 823,871<br>(55.3) | 180,501<br>(12.1) | 1,489,131<br>(100.0)<br>( 20.0) | 1,269,678<br>(17.0) | 4,693,969<br>(63.0) | 7,452,778<br>(100.0) |
| **Total Period** | | | **Average Increases Percent** | | | | |
| 75-77/72-74 | -12.6% | 20.7% | 147.4% | 3.0% | 17.8% | 14.2% | 3.1% |
| 78-80/75-77 | -30.5% | 50.0% | 141.9% | 12.7% | 6.1% | 39.7% | 46.8% |
| 78-80/72-74 | -39.2% | 81.0% | 498.5% | 16.1% | 25.0% | 59.6% | 42.2% |

SOURCE: See Table 4.2

TABLE 4.5

WILD RICE HARVESTED FROM MINNESOTA
CULTIVATED FIELDS

| Year | Acreage | Production Per Acre Processed (in lbs.) | Production Per Acre Green* (in lbs.) |
|---|---|---|---|
| 1968 | 900 | 37 | 92 |
| 1969 | 2,650 | 56 | 140 |
| 1970 | 5,200 | 65 | 162 |
| 1971 | 8,700 | 65 | 162 |
| 1972 | 17,000 | 81 | 204 |
| 1973 | 18,000 | 62 | 154 |
| 1974 | 13,000 | 77 | 192 |
| 1975 | 13,000 | 92 | 230 |
| 1976 | 12,500 | 120 | 300 |
| 1977 | 10,000 | 90 | 225 |
| 1978 | 11,500 | 139 | 348 |
| 1979 | 12,500 | 176 | 440 |
| 1980 | 13,500 | 159 | 398 |
| % Change: | | | |
| 1968-'71 | 866.7% | 75.7% | |
| 1971-'74 | 49.4% | 18.5% | |
| 1974-'77 | -23.1% | 16.9% | |
| 1977-'80 | 35.0% | 76.7% | |
| 1968-'80 | 1,400.0% | 329.7% | |

* Based on a recovery rate of 40% of processed wild rice to green wild rice.

SOURCE: University of Minnesota.

means that some growers are getting less than 400 lbs. of green wild rice per acre while some are getting considerably more. Nonshattering wild rice is used extensively in the paddy operations but there are still some paddies with shattering seed. These paddies with shattering seed lower the average yields for the whole industry. Therefore, it is quite reasonable that some growers have yields as high as 900 lbs. green per acre with the use of nonshattering seed. With a gradual changeover to the new strains of nonshattering wild rice, the total paddy wild rice harvest has a potential to increase significantly over the next 5 years, unless a substantial number of paddies are taken out of production.

### 4.3.2 Exports of Canadian Wild Rice

Data on the Canadian import and export of wild rice can be used as an indicator of what percentage of the Canadian harvest of wild rice is exported from Canada. Export statistics, however, do not delineate whether the wild rice is processed or unprocessed. However, by examining the data on a monthly basis, one can assume that wild rice exported in August and September is usually green or unprocessed, especially if the price per lb. is substantially lower than in the remainder of the year. Import data available on a yearly basis from 1976 onward are mostly for processed wild rice, when one examines and finds relatively high prices are associated with the imports. By converting the processed lbs. into unprocessed lbs. using a recovery rate of 50%, green weight may be estimated. The difference then, between exports and imports, becomes net exports of wild rice out of Canada.

Examination of Table 4.6 shows that Canada exports a large quantity of wild rice in any given year. The imports of wild rice, also shown on Table 4.6, are most probably due to Canadian wild rice being shipped to the U.S.A. for processing, then returned to Canada. Table 4.7 provides a comparison of net exports for a four-year period from 1976 to 1979. In that time period, net exports represented 88.6% of total Canadian production. Therefore it can be assumed that 90% of the recorded Canadian harvest is exported to the U.S.A. and other countries, with the U.S.A. being by far the largest importer.

Table 4.6 shows that from August 1978 to July 1979, Canada had net exports of 1,169,600 lbs. of green wild rice, but only harvested 689,556 lbs. of green wild rice. The net difference of 480,044 lbs. was probably due to commitment to the market of inventories accumulated during the previous years in response to high export prices which, from December 1978 to April 1979 rose from $4.50 to $6.67 per lb. of processed wild rice (see Table 4.8).

## 4.4 PRICES OF WILD RICE

### 4.4.1 Historical Review of Harvester Prices

Examination of Table 4.9 shows historical prices per lb. of green wild rice paid to harvesters as far back as 1940 for Minnesota, 1970 for Ontario, and 1975 for Manitoba. As may be expected, prices in the three regions are roughly comparable because the U.S.A. is both the prime producer and consumer of wild rice.

TABLE 4.6

HARVEST, EXPORTS AND IMPORTS OF CANADIAN WILD RICE
(IN LBS. OF UNPROCESSED OR GREEN WILD RICE)

| August 1 - July 31 | Canadian Harvest [1] | Exports [2] | Imports [3] | Net Exports | Harvest Net Exports | Cumulative Net Exports |
|---|---|---|---|---|---|---|
| 1970 - '71 | 211,614 | 671,100 | N/A | | | |
| 1971 - '72 | 797,860 | 1,010,600 | N/A | | | |
| 1972 - '73 | 1,749,129 | 1,877,000 | N/A | | | |
| 1973 - '74 | 1,929,366 | 1,322,900 | N/A | | | |
| 1974 - '75 | 169,652 | 447,600 | N/A | | | |
| 1975 - '76 | 277,588 | 422,400 | N/A | | | |
| 1976 - '77 | 1,585,585 | 1,286,400 | 216,600 | 1,069,800 | 515,785 | 515,785 |
| 1977 - '78 | 2,099,996 | 2,123,900 | 432,000 | 1,691,900 | 408,096 | 923,881 |
| 1978 - '79 | 689,556 | 1,314,400 | 144,800 | 1,169,600 | -480,044 | 443,837 |
| 1979 - '80 | 1,056,834 | 1,102,500 | 223,000 | 879,500 | 177,334 | 621,171 |
| 1980 - '81 | 2,721,000 | N/A | N/A | | | |

1 Harvest for Ontario, Manitoba & Saskatchewan.

2 Statistics Canada, Cat. 65-004 - Exports by Commodities - Exports are recorded by Customs in both processed & unprocessed lbs. Processed lbs. of wild rice were converted into unprocessed by using a recovery rate of 50%. Exports were recorded from August 1 to July 31 of the following year.

3 Statistics Canada, Cat. 65-207 - Imports. Merchandise Trade Commodity Detail. Data recorded in processed lbs. was converted to unprocessed by using a recovery rate of 50%. Import data is for the calendar year.

TABLE 4.7

CANADIAN WILD RICE HARVEST
AND NET EXPORTS 1976 - 1979
(LBS.)

| | Canadian Harvest | Net Exports |
|---|---|---|
| 1976 - '77 | 1,585,585 | 1,069,800 |
| 1977 - '78 | 2,099,996 | 1,691,900 |
| 1978 - '79 | 689,556 | 1,169,600 |
| 1979 - '80 | 1,056,834 | 879,500 |
| TOTAL 1976 - '79 | 5,431,968 (100.0%) | 4,810,800 (88.6%) |

SOURCE: See Table 4.6.

TABLE 4.8

MONTHLY PRICES OF CANADIAN
WILD RICE EXPORTED TO
THE U.S.A.
($/LB.)

| | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|
| January | -- | $3.14 | $4.24 | $6.67 | -- |
| February | $2.40 | 3.00 | 5.00 | 6.40 | 6.42 |
| March | -- | 2.57 | -- | 5.73 | 8.00 |
| April | 2.86 | 4.00 | 4.07 | 4.83 | -- |
| May | -- | -- | 4.55 | -- | -- |
| June | -- | 4.00 | 6.00 | 1.54 | 7.33 |
| July | 3.00 | 1.73 | -- | -- | 4.71 |
| August | .67 | 1.28 | -- | 1.40 | .55 |
| September | .97 | 1.67 | 1.43 | 2.61 | .86 |
| October | 2.08 | 3.55 | 4.59 | 4.46 | 1.61 |
| November | 2.11 | 3.81 | 1.77 | 5.55 | 2.95 |
| December | 2.22 | 3.46 | 4.50 | 4.83 | 2.97 |

SOURCE: Statistics Canada - Cat. 65-004.

TABLE 4.9

HARVESTER PRICES OF WILD RICE
(LBS. OF GREEN WILD RICE)

| | Manitoba | Ontario | Minnesota |
|---|---|---|---|
| 1940 - '49 | -- | -- | $.10 - .35 |
| 1950 - '59 | -- | -- | .30 - .60 |
| 1960 - '69 | -- | -- | .30 - 1.50 |
| 1970 | N/A | $ .58 | .40 - .60 |
| 1971 | N/A | .56 | .40 - .60 |
| 1972 | N/A | .57 | .40 - .60 |
| 1973 | N/A | .50 | .40 - .60 |
| 1974 | N/A | .69 | .40 - .60 |
| 1975 | .90 | .90 | 1.00 (1.02 Cdn.$) |
| 1976 | 1.00 | .71 | 1.00 ( .99 Cdn.$) |
| 1977 | 1.31 | 1.35 | 1.00 (1.06 Cdn.$) |
| 1978 | 2.26 | 2.50 | 2.00 - 2.50 ($2.28-2.85 Cdn$) |
| 1979 | 2.13 | 2.00 | 1.60 ($1.87 Cdn.$) |
| 1980 | .65 | .70 | .50 ($0.60 Cdn.$) |

N/A = Not Available.

SOURCE: Data for 1940-'69 - A.D. Little Inc. "The Feasibility of Paddy Production of Wild Rice in Manitoba" - Sept., 1968.

Manitoba Government, Dept. of Natural Resources.
Ontario Government, Ministry of Natural Resources.
Minnesota Government, Dept. of Natural Resources.

The price paid to the harvester slowly increased from an average of $0.21 per lb. in the 1940's, to an average of $0.40 per lb. in the 1950's, to an average of $0.74 during the 1960's. During the early '70's, prices hovered between $.40 to $.60 per lb. until 1974, then jumped to $1.00 to $1.35 per lb. from 1975-77. A major price increase occurred however, in 1978-79 when prices ranged from $2.00 to $2.50 per lb., only to fall dramatically in 1980 to $.60 to $.70 per lb.

The events which precipitated major increases in prices from 1977 to early 1980 will be investigated in a later section. It will be seen that major accumulations of inventories resulted in artificially high prices paid to the harvester.

4.4.2 Prices At Various Marketing Levels

To state that there is a single retail price of wild rice is, of course, a generalization. There are, in fact, a whole series of prices dependent upon the quality of the wild rice, the distance between grower and processor and the type of retail outlet where it is sold. However, an average price can be derived based on estimates of the price paid to the harvester, the buyers' commission, the cost of processing and the recovery rate, the ratio of processed wild rice to green wild rice. It is usually estimated that it takes 3 lbs. of paddy-grown wild rice to make 1 lb. of processed or finished rice, a recovery rate of 33.3%. Lake wild rice, however, usually requires only 2 lbs. of green wild rice to make 1 lb. of finished rice for a recovery rate of 50%. For the purposes of estimating the price of wild rice, at the various marketing levels, a recovery rate of 40% is used which is the figure aimed for by paddy wild rice growers when determining whether their crop should be harvested in order to achieve the maximum return.

Information provided in Table 4.10 shows what prices could be expected at the various marketing levels based on harvester prices, buyers' commission, processing costs, a 40% recovery rate and standard wholesale and retail markups. Following record high prices paid to harvesters in 1977, 1978 and 1979, prices in 1980 at retail levels after the harvest were down to 1975 levels. The retail price range of $7.18 to $8.20 per lb. (Canadian) is close to the selling price for wild rice in Winnipeg, Minnesota and in Northwest Ontario in the first quarter of 1981. Retail prices of long-grained wild rice in Minnesota at retail outlets in the middle of the wild rice producing area ranged from $4.50 to $6.95 per lb. (U.S.) or $5.50 to $8.40 (Canadian). In Winnipeg, similar wild rice was selling from $6.80 to $7.50 per lb. (Canadian).

Table 4.11 provides a comparison of prices at various marketing levels for 1979 and 1980. Harvester prices went from an all-time high to a very low level in 1980. The retail price of wild rice as compared to the price paid to the harvester for green wild rice, might be thought to support the conclusion that someone in the handling stream is making an inordinate profit. In 1979 for instance, the harvester received $2.00 per lb. (Canadian) green and the retail price would have been around $17.50 (Canadian) for a difference of $15.50. However, $2.00 per lb. for green wild rice is equivalent to $5.00 per lb. for finished wild rice. Adding in a buyers' commission of $0.875 and processing cost of

TABLE 4.10

WILD RICE PRICES AT VARIOUS MARKETING LEVELS (CDN. $'S)

| | Harvester Prices | | Price After Processing[2] | Wholesale Price 40% MU[3] | Retail Prices 75-100% MU |
|---|---|---|---|---|---|
| | Green | Processed[1] | | | |
| 1970 | .58 | $1.45 | $2.08 | $2.91 | $5.09 - $5.82 |
| 1971 | .56 | 1.40 | 2.03 | 2.84 | 4.97 - 5.68 |
| 1972 | .57 | 1.43 | 2.10 | 2.94 | 5.15 - 5.88 |
| 1973 | .50 | 1.25 | 1.93 | 2.70 | 4.73 - 5.40 |
| 1974 | .69 | 1.73 | 2.05 | 2.87 | 5.02 - 5.74 |
| 1975 | .90 | 2.25 | 3.20 | 4.48 | 7.84 - 8.96 |
| 1976 | 1.00 | 2.50 | 3.60 | 5.04 | 8.82 - 10.08 |
| 1977 | 1.31 | 3.28 | 4.50 | 6.30 | 11.03 - 12.60 |
| 1978 | 2.26 | 5.65 | 6.90 | 9.66 | 16.91 - 19.32 |
| 1979 | 2.00 | 5.00 | 6.25 | 8.75 | 15.31 - 17.50 |
| 1980 | .65 | 1.63 | 2.93 | 4.10 | 7.18 - 8.20 |

1 Based on a 40% recovery rate of processed wild rice to green or unprocessed wild rice.

2 This includes a buyer's commission and processing costs. Based on the following estimates of buyers' commissions and processing costs per lb. of green wild rice.

| | Buyers' Commission | Processing Costs |
|---|---|---|
| 1970-'71 | .15 | .10 |
| 1972-'73 | .15 | .12 |
| 1974-'75 | .20-.25 | .13 |
| 1976-'77 | .30-.35 | .14 |
| 1978-'79 | .35 | .15 |
| 1980 | .35 | .17 |

3 MU = Mark-up.

TABLE 4.11

DISTRIBUTION OF RETAIL PRICES
IN THE MARKETING SEQUENCE
(CDN. $ PER LB.)

| | Green $ | 1979 Processed $ | Percent of Total Price | Green $ | 1980 Processed $ | Percent of Total Price |
|---|---|---|---|---|---|---|
| Harvester | 2.00 | 5.00 | 28.6 | .65 | 1.625 | 19.8 |
| Buyer | .35 | .875 | 5.0 | .35 | .875 | 10.7 |
| Processing | .15 | .375 | 2.1 | .17 | .425 | 5.2 |
| SUBTOTAL | 2.50 | 6.25 | | 1.17 | 2.93 | |
| Wholesaler 40% MU | | 2.50 | 14.3 | | 1.17 | 14.3 |
| SUBTOTAL | | 8.75 | | | 4.10 | |
| Retailer 100% MU | | 8.75 | 50.0 | | 4.10 | 50.0 |
| TOTAL | | 17.50 | 100.0 | | 8.20 | 100.0 |

NOTE: Based on a 40% recovery rate.

$0.375 per finished lb., this represents a processed cost of $6.25. With standard mark-ups of 40% and 100% for the wholesaler and retailer respectively, the retail price becomes $17.50 (Canadian). These gross profit margins are required in order to pay for handling, carrying charges, packaging, cartons, recipes, office supplies and operating costs.

Because wild rice is not a high turnover item, the retailer makes a profit based on a high mark-up. If wild rice had a higher turnover, similar to other regular food products, such a high mark-up would not be justified. Until the volume of wild rice increases significantly, these relatively high mark-ups are likely to persist.

In terms of the percentage of the retail price received by any marketing level, the harvester is second only to the retailer. For instance, in 1979, the harvester received the equivalent of 28.6% of the retail price. In 1980 however, this had fallen to 19.8%. The difference in price paid to the harvester for green wild rice and the retail price paid by the consumer, contains a rather large element of "illusory" profits.

## 4.5 ECONOMICS OF PRODUCTION

### 4.5.1 Estimated Production Costs of Paddy Wild Rice

The sizeable gains made in the average yields of paddy-grown wild rice in the past several years (see Table 4.5) influence the average production cost per lb. of paddy wild rice. The University of Minnesota's Agricultural Extension Service in cooperation with some paddy wild rice growers, has assembled data on the costs of paddy wild rice production. The original information presented was based on a 3-year cycle where every third year, the paddies were left in fallow. However, discussions with people in the industry have indicated that a 4-year cycle would be a better representation of existing procedure. Therefore the following analysis is based on the data provided by the University of Minnesota but extended to a 4-year cycle. Detailed information on the cost data presented in Tables 4.12 and 4.13 is provided in Appendix B.

Tables 4.12 and 4.13 show the breakdown of costs on a yearly basis for the various activities involved in the production of paddy wild rice. "Total Cost" data is based on all costs including cash costs, overhead and depreciation on equipment. Cash costs, however, represent only those costs incurred with the actual production of the crop and are estimates of out-of-pocket cash operating expenses such as fuel, oil, repairs, fertilizers, seed, chemicals, labour and land taxes.

Returns above cash costs are positive in all years except for the noncrop year based on a yield of 150 lbs. of processed wild rice per acre. Returns above total costs are negative in two years and are marginally positive at $0.81 (U.S.) per acre when summed across all four years.

Production cost data is analyzed in Table 4.14 based on per acre yields of 150 lbs. of processed paddy wild rice. The range of costs per processed lb. varies from $2.79 to $3.49 (U.S.) for total costs and a minimum of $1.88 (U.S.) for cash costs only. Translated into equi-

TABLE 4.12

TOTAL COSTS PER ACRE OF PADDY
WILD RICE PRODUCTION
(U.S. FUNDS)

| | Cycle Year 1 | 2 | 3 | 4 | Total | Average Per Acre |
|---|---|---|---|---|---|---|
| Revenue[1] | $ 525.00 | $ 525.00 | $ 525.00 | -- | $1,575.00 | $ 393.75 |
| Costs: | | | | | | |
| Seeding & Management | | | | | | |
| 1. Flood | 30.00 | 30.00 | 30.00 | -- | 90.00 | $ 22.50 |
| 2. Aerial Seed Application | 19.25 | -- | -- | -- | 19.25 | 4.81 |
| 3. Seed | 90.00 | -- | -- | -- | 90.00 | 22.50 |
| 4. Malathion (midge) | 5.63 | -- | -- | -- | 5.63 | 1.41 |
| 5. Topdress Nitrogen | 6.25 | 6.25 | 6.25 | -- | 18.75 | 4.69 |
| 6. Dithane | 12.00 | 12.00 | 12.00 | -- | 36.00 | 9.00 |
| 7. Malathion (worm) | 5.63 | 5.63 | 5.63 | -- | 16.89 | 4.22 |
| 8. Black Bird | 4.00 | 4.00 | 4.00 | -- | 12.00 | 3.00 |
| 9. Dike Main | 20.00 | 15.00 | 15.00 | -- | 50.00 | 12.50 |
| 10. Labor, Main.& Checking | 8.75 | 8.75 | 8.75 | -- | 26.25 | 6.56 |
| *Sub-Total* | $ 201.51 | $ 81.63 | $ 81.63 | -- | $ 364.77 | $ 91.19 |
| Harvesting: | | | | | | |
| 11. Combine | 64.00 | 64.00 | 64.00 | -- | $ 192.00 | $ 48.00 |
| 12. Tractor & Dumping | 3.41 | 3.41 | 3.41 | -- | 10.23 | 2.56 |
| 13. Processing | 67.50 | 67.50 | 67.50 | -- | 202.50 | 50.63 |
| 14. Truck (medium) | 14.56 | 14.56 | 14.56 | -- | 43.68 | 10.92 |
| 15. Rotovate | 61.22 | 61.22 | -- | $ 102.03 | 224.47 | 56.12 |
| 16. Nitrogen | 3.75 | 3.75 | -- | 3.75 | 11.25 | 2.81 |
| 17. $P_2O_5$(Phosphate) | 14.40 | 14.40 | -- | 14.40 | 43.20 | 10.80 |
| 18. $K_2O_5$(Potassium) | 9.90 | 9.90 | -- | 9.90 | 29.70 | 7.42 |
| *Sub-Total* | $ 238.74 | $ 238.74 | $ 149.47 | $ 130.08 | $ 757.03 | $ 189.26 |
| Other Costs: | | | | | | |
| 19. Land Costs | 40.00 | 40.00 | 40.00 | 40.00 | 160.00 | 40.00 |
| 20. Land Taxes | 5.00 | 5.00 | 5.00 | 5.00 | 20.00 | 5.00 |
| 21. Crop Insurance | 13.13 | 13.13 | 13.13 | -- | 39.39 | 9.85 |
| 22. Irrigation Overhead | 16.90 | 16.90 | 16.90 | 16.90 | 67.60 | 16.90 |
| 23. Interest On Crop* | 48.50 | 32.13 | 24.87 | 12.89 | 118.39 | 29.60 |
| 24. Weed Control | -- | .44 | .44 | -- | .88 | .22 |
| 25. Field Maintenance | -- | -- | -- | 30.00 | 30.00 | 7.50 |
| 26. Disk | -- | -- | -- | 13.68 | 13.68 | 3.42 |
| *Sub-Total* | $ 123.53 | $ 107.60 | $ 100.34 | $ 118.47 | $ 449.94 | $ 112.49 |
| *TOTAL COSTS* | $ 563.78 | $ 427.97 | $ 331.44 | $ 248.55 | $1,571.74 | $ 392.94 |
| Returns above Total Cost: | <38.78> | 97.03 | 193.56 | <248.55> | 3.26 | 0.81 |

* See Table 4.13, "Total Cash Costs". Interest charges on cash carrying costs at 14% per year.

1 Based on 150 lbs. of processed wild rice @ $3.50/lb. (U.S.).

# TABLE 4.13

## CASH COSTS PER ACRE OF PADDY WILD RICE PRODUCTION (U.S. FUNDS)

| | Cycle Year 1 | 2 | 3 | 4 | Total | Average Per Acre |
|---|---|---|---|---|---|---|
| Revenue[1] | $ 525.00 | $ 525.00 | $ 525.00 | -- | $1,575.00 | $ 393.75 |
| Costs: | | | | | | |
| Seeding & Management | | | | | | |
| 1. Flood | 30.00 | 30.00 | 30.00 | -- | 90.00 | 22.50 |
| 2. Aerial Application | 19.25 | -- | -- | -- | 19.25 | 4.81 |
| 3. Seed | 90.00 | -- | -- | -- | 90.00 | 22.50 |
| 4. Malathion (midge) | 5.63 | -- | -- | -- | 5.63 | 1.41 |
| 5. Topdress Nitrogen | 6.25 | 6.25 | 6.25 | -- | 18.75 | 4.69 |
| 6. Dithane | 12.00 | 12.00 | 12.00 | -- | 36.00 | 9.00 |
| 7. Malathion (worm) | 5.63 | 5.63 | 5.63 | -- | 16.89 | 4.22 |
| 8. Black Bird Control | 4.00 | 4.00 | 4.00 | -- | 12.00 | 3.00 |
| 9. Dike Maintenance | 10.00 | 7.50 | 7.50 | -- | 25.00 | 6.25 |
| 10. Labor, Main. & Checking | -- | -- | -- | -- | -- | -- |
| *Sub-Total* | $ 182.76 | $ 65.38 | $ 65.38 | -- | $ 313.52 | $ 78.38 |
| Harvesting: | | | | | | |
| 11. Combine | $ 30.00 | $ 30.00 | $ 30.00 | -- | $ 90.00 | $ 22.50 |
| 12. Tractor & Dump | .77 | .77 | .77 | -- | 2.31 | .58 |
| 13. Processing | 67.50 | 67.50 | 67.50 | -- | 202.50 | 50.63 |
| 14. Truck | 8.52 | 8.52 | 8.52 | -- | 25.56 | 6.39 |
| 15. Rotovate | 23.82 | 23.82 | -- | $ 39.70 | 87.34 | 21.84 |
| 16. Nitrogen | 3.75 | 3.75 | -- | 3.75 | 11.25 | 2.81 |
| 17. $P_2O_5$(Phosphate) | 14.40 | 14.40 | -- | 14.40 | 43.20 | 10.80 |
| 18. $K_2O_5$(Potassium) | 9.90 | 9.90 | -- | 9.90 | 29.70 | 7.42 |
| *Sub-Total* | $ 158.66 | $ 158.66 | $ 106.79 | $ 67.75 | $ 491.86 | $ 122.97 |
| Other Costs: | | | | | | |
| 19. Land Costs | -- | -- | -- | -- | -- | -- |
| 20. Land Taxes | 5.00 | 5.00 | 5.00 | 5.00 | 20.00 | 5.00 |
| 21. Crop Insurance | -- | -- | -- | -- | -- | -- |
| 22. Irrigation Overhead | -- | -- | -- | -- | -- | -- |
| 23. Interest On Crop | -- | -- | -- | -- | -- | -- |
| 24. Weed Control | -- | .44 | .44 | -- | .88 | .22 |
| 25. Field Maintenance | -- | -- | -- | 15.00 | 15.00 | 3.75 |
| 26. Disk | -- | -- | -- | 4.32 | 4.32 | 1.08 |
| *Sub-Total* | $ 5.00 | $ 5.44 | $ 5.44 | $ 24.32 | $ 40.20 | $ 10.05 |
| *TOTAL CASH COSTS* | $ 346.42 | $ 229.48 | $ 177.61 | $ 92.07 | $ 845.58 | $ 211.40 |
| Returns above Cash Cost: | $ 178.58 | $ 295.52 | $ 347.39 | <92.07> | $ 729.42 | $ 182.35 |

[1] Based on 150 lbs. of processed wild rice @ $3.50/lb. (U.S.).

TABLE 4.14

PADDY WILD RICE PRODUCTION
COSTS PER ACRE
(U.S. FUNDS)

| | Full Cost Scenario | | Cash Cost[1] Scenario | |
|---|---|---|---|---|
| Year | Total Costs | Cash Costs | Total Costs | Harvest [2] |
| 1 | $ 563.78 | $ 346.42 | $ 462.15 | 150 lbs. |
| 2 | 427.97 | 229.48 | 342.71 | 150 lbs. |
| 3 | 331.94 | 177.61 | 253.44 | 150 lbs. |
| 4 | 248.55 | 92.07 | 195.66 | -- |
| TOTAL | $ 1,571.74 | $ 845.58 | $1,253.96 | 450 lbs. |
| Per Lb. Processed | $ 3.49 | $ 1.88 | $ 2.79 | |
| -Processing Costs | .45 | .45 | .45 | |
| | $ 3.04 | $ 1.43 | $ 2.34 | |
| Equivalent[3] in green lbs. | $ 1.28 | $ .60 | $ .98 | |
| Canadian funds[4] | $ 1.56 | $ .73 | $ 1.20 | |

[1] Excludes the following items:
19. Land Costs
21. Crop Insurance
23. Interest on crop costs

[2] In processed lbs.

[3] Based on 42% recovery rate for paddy wild rice.

[4] Based on an exchange rate of $1 Cdn. = $.82 U.S.

valent green lbs., it can be seen that costs per lb. vary from $.98 to $1.28 (U.S.) for total costs and are $0.60 (U.S.) for cash costs.

These figures suggest that, for a yield of 150 lbs. per acre of processed wild rice, the long-term breakeven costs for paddy production is $.98 to $1.28 (U.S.) funds or $1.20 to $1.56 (Canadian) per lb. of green wild rice. The short-term breakeven point on the cash costs of production per green lb. are estimated at $.60 (U.S.) or $0.73 (Canadian). This cash cost of production is almost identical to the price that was paid at the lakeside for lake wild rice in Canada and the U.S.A. during the 1980 harvest (see Table 4.9).

As previously stated, the figure of 150 lbs. of processed wild rice per acre is an average based on the total production of paddy wild rice in Minnesota in 1980. However, wild rice growers fortunate enough to have higher yielding varieties have lower production costs and could more readily compete even if prices fell lower than the 1980 level. Growers of newer shatter-resistant strains of wild rice have stated that they have harvested in excess of 900 lbs. of green wild rice per acre. Assuming yields of even 700 lbs. of green wild rice or 300 lbs. in equivalent processed wild rice, the production costs are cut in half and the approximate breakeven points shift from $1.20 to $1.56 (Canadian) to $0.60 to $.78 in the long-term and from $.73 to $.37 (Canadian) cash costs per green lb. in the short-term. Such increases in yield coupled with land costs and paddy development costs incurred in the late '60's by most major paddy wild rice growers in Minnesota indicate that most paddy wild rice growers can easily weather sustained periods of extremely low prices.

### 4.5.2 Estimated Production Costs of Machine Harvested Lake Wild Rice

In the harvest of lake grown wild rice, there are probably as many production cost figures as there are harvesters. However, in order to determine the competitiveness of lake wild rice production versus paddy wild rice production, an estimate of the probable costs of lake wild rice production is required. Information in Table 4.15 provides an estimate of these production costs based on the use of an airboat type of mechanical harvester. For these cost figures, it is estimated that, in a 12-hour day, a machine can harvest 1,000 lbs. of wild rice taking into account down time due to repairs, maintenance and refueling.

From Table 4.15, it can be seen that the production costs are estimated to be $0.40 per lb. (Canadian). This estimate, if anything, is biased on the high side and in many instances, harvesters would face lower costs than this.

The cost of producing lake wild rice at $.40 per lb. (Canadian) compares favourably with paddy production costs from $0.60 to $.78 per lb. (Canadian) to $1.20 to $1.56 per lb. (Canadian) of green wild rice depending on the yields of paddy growers.

## 4.6 MARKET FORCES FROM 1977 TO 1980

In previous sections, it was noted that the price of green wild rice paid to the harvester took a rather dramatic jump from $1.00 to $1.35 (Canadian) in 1977 to $2.00 to $2.50 (Canadian) in 1978 followed by a slight decline to $1.85 to $2.13 (Canadian) in 1979 followed by a

TABLE 4.15

MACHINE HARVESTED LAKE
WILD RICE PRODUCTION COSTS
(CDN. $'S)

| | | | |
|---|---|---|---|
| Harvest: | 1 machine at 1,000 lbs. green per day for 20 days | | 20,000 lbs. |
| Costs: | | | |
| | Mechanical Harvester<br>Cost of $6,000 depreciated over 5 years | $ 1,200 | |
| | Truck<br>Cost of $10,000 depreciated over 5 years | $ 2,000 | |
| | Harvester fuel costs<br>12 gals/day x 20 days x $1.50/gal. | $ 360 | |
| | Truck operating costs<br>100 miles/day x 20 days ÷ 10 miles/gal x $1.50 | $ 300 | |
| | Harvester maintenance & repairs<br>$6,000 x 10% | $ 600 | |
| | Labour<br>2 men x 20 days x 12 hrs/day x $7.50 per hour | $ 3,600 | |
| | TOTAL COSTS | $ 8,060 | |

Cost per lb. $\frac{\$8,060}{20,000 \text{ lbs.}}$ = $ 0.40/lb.

rapid descent to $0.60 to $.70 (Canadian) in 1980. Rumours abounded and were later confirmed that a large paddy wild rice growers' cooperative in Minnesota had been buying large quantities of lake wild rice and maintaining large inventories with the view to maintaining high prices for wild rice.

According to industry sources and newspaper accounts[3] the strategy for higher wild rice prices originated in 1977 with a Minnesota growers co-op called United Wild Rice, the largest processor and marketer of wild rice in the U.S.A. and Canada. The objective of the strategy was to get Uncle Ben's Inc. to pay substantially higher prices for the wild rice used in their popular brands of wild rice and rice mixes. In order to do so, United required a greater control on the inventory of wild rice available to the market. As a result, United started bidding up prices paid to lake wild rice pickers from $0.40 to $.60 (U.S.) to a $1.00 to $1.50 (U.S.) per lb. hoping to sell the finished wild rice at wholesale prices of approximately $4.00 (U.S.) per lb. It was estimated that, in 1977, United purchased a little less than 1/2 of the total Canadian and U.S.A. lake wild rice crop. Unknown to United, Uncle Ben's had foreseen their vulnerability in the marketplace and had bought wild rice from the previous bumper crop year in 1976 and stopped buying from United.

In 1978, United continued to buy lake wild rice and offered the lake wild rice pickers $2.00 to $2.50 (U.S.) per lb. It was estimated

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3 Minneapolis Tribune, "Scheme To Set Wild Rice Prices Falls Apart", Sunday, December 21, 1980, Volume CXIV, Number 170.

that United had bought 2/3 of the lake wild rice harvest in Canada and the U.S.A. in 1978, but had suffered a sales slump from 1,000,000 lbs. sold in 1977 to 500,000 lbs. sold in 1978. A major reason for the sale slump was the loss of their major customer, Uncle Ben's Inc.

The higher price scenario in 1978 was further complicated by the State of Minnesota withdrawing from their normal strict regulation of the lake crop, and allowing the harvest date to be set as early as July 15th. The theory behind this lack of regulation was based on the premise that no one would pick unripened wild rice just as no one would pick green blueberries. The theory was quickly disproved when buyers for some of the processors were offering $2.50 (U.S.) per lb. for all the wild rice they could buy irrespective of its quality. Allegedly, such high prices were being offered with the hope that the rice beds would be battered and the lake wild rice crop destroyed.[4]

By 1979, because of United's aggressive purchasing of wild rice, it was alleged that it controlled 2/3 of the wild rice supply in the U.S.A. and Canada. During 1979 United was offering $2.00 (U.S.) per lb. to lake wild rice pickers and had accumulated an inventory in the order of 3 million lbs. of finished wild rice.

United's strategy for the 1980 harvest was to behave as they had in the past but to withdraw from buying any lake wild rice at the last moment. Since competitors would have little time to arrange financing and purchase the lake crops, most of it would not have been har-

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[4] Ibid.

vested. However, before their strategy could be implemented, United's bank would no longer finance their acquisition of more lake wild rice presumably due to inventories of 3,000,000 lbs. and a debt of $11,000,000. With United not purchasing wild rice during the 1980 harvest, compounded with a bumper lake crop, prices to the harvester fell to $.60 to $.70 (U.S.) per lb. for green wild rice.

An anti-trust suit was filed by the State of Minnesota against United Wild Rice Inc. The complaint filed stated that beginning as early as 1977, United Wild Rice Inc. had attempted to monopolize and had monopolized the trade and commerce in wild rice. The methods used were the purchasing of unreasonable quantities of green wild rice from non-members and storing and withholding unreasonable amounts from the market.

The complaint further stated that the actions by the United Wild Rice Inc. had:

a) attempted to monopolize and had monopolized the wild rice market and submarkets;

b) restrained actual and potential competition in the growing, processing and sale of wild rice, and;

c) raised the price of green and finished wild rice above the levels that would have prevailed in a competitive market.

On February 27th, 1981 United Wild Rice agreed to pay a $25,000 penalty as part of the settlement in the anti-trust suit but did not admit to any wrongdoing. As part of the settlement, United Wild Rice Inc. agreed to the following conditions:

a) to restrain from monopolizing the market for wild rice,

b) to send its members a written notice on an option to withdraw within 10 days of the order,
   - this option would be open for 60 days from receipt of the notice.
   - a member who elected to withdraw could
     - leave his inventory to be sold by United, or
     - have it returned to him and pay United for the costs of holding the inventory.

c) that agreements in the future would last a maximum of two years,

d) that current members who had signed for longer than two years would have 30 days to limit the duration of their contract to two years,

e) from July 1, 1981 - June 30, 1982, United cannot purchase more than 500,000 lbs. of green wild rice from non-members and from July 1, 1980 - June 30, 1983, it cannot purchase more than 1,200,000 lbs. of green wild rice from non-members,

f) by October 31, 1983, the month-end inventory of finished wild rice equivalent inventory has to be less than the greater of either -
   - 150% of their sales for the prior fiscal year
     OR
   - 2.2 million lbs. of finished wild rice

g) for three years from October 1983, United's total month-end finished wild rice equivalent inventory in pounds for any month shall not exceed the greater of either.
   - 150% of their sales for the prior fiscal year
     OR
   - 2.2 million lbs. of finished wild rice.

h) the Minnesota Attorney General's Office can review United's, books, ledgers, accounts, correspondence, memoranda, and other records relating to the order;

i) United has to furnish to the Antitrust Division of the Office of the Attorney General, reports on May 15 and November 15 for 5 years from the date of entry of the order on the following;

- month-end inventory levels, in pounds, for each of the prior six months for;
    - finished wild rice equivalent
    - member wild rice and
    - nonmember wild rice
- total purchases, in dollars and pounds, of nonmember green rice for the prior six-month period and
- total sales, in dollars and pounds, of finished wild rice for the prior six-month period.

The above-mentioned court order against United Wild Rice clearly shows that such activity will not be tolerated by U.S. courts and that for the next five years, the market for wild rice will be much more competitive than in the past.

## 4.7 FUTURE OUTLOOK FOR WILD RICE SUPPLY AND PRICES

### 4.7.1 Supply of Wild Rice in the Next Five Years

Developments in the United States and Canada over the next several years all point to greater production in both lake wild rice and paddy wild rice. Examination of data presented in Table 4.4 shows that the average recorded production of all wild rice in Canada and in the U.S.A. has increased by 42.2% from the 3-year average for 1972-74 to 1978-80. This growth has occurred mainly in paddy production at 59.6% versus 25.0% for Minnesota lake wild rice and 16.1% for Canadian lake wild rice. Of the Canadian lake production, Saskatchewan's has increased dramatically in the same time period by 498.5%, Manitoba's production has increased by 81.0%, but Ontario's has decreased by 39.2%.

Increases in production are caused by increases in total production area, increases in the production per acre or both. Discussions with industry sources indicate that several areas in the United States, namely California, Idaho, Washington, and Florida, could be potential producers of paddy wild rice. By far the most likely area to consider growing paddy wild rice on a commercial basis is Calfornia where white rice paddies already exist. It was estimated that 500 acres of paddy wild rice were under cultivation in 1980 and that an estimated 1,000 acres would be cultivated in 1981. The advantages to growing paddy wild rice in California are numerous. The climate inhibits the spread of insects and diseases and the cool evenings, considered to be a factor, are similar to those in Minnesota. Because the warmer climate does not provide a dormancy period, the paddies have to be reseeded each year. This increases costs but it also ensures that the latest nonshattering varieties of wild rice can be used. Other cost factors are also higher, namely water costs and land taxes, but it appears that two crops a year can be grown; one of wild rice and one of white rice. Total acreage in paddy wild rice in Minnesota has been decreasing since 1972 and has stabilized at around 14,000 acres with no major increases in paddies under cultivation foreseeable in the near future. Whether California acreage will expand greatly in the near future, will depend entirely on the results achieved by those experimenting with growing wild rice at present.

Interviews with researchers[5] at the University of Minnesota indicate that advances in paddy wild rice strains have resulted in more

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5 Dr. E.A. Oelke, University of Minnesota, Department of Agronomy and Plant Genetics.

shatter-resistant varieties and therefore higher yields of paddy wild rice to the extent that production of 150 to 300 lbs. of finished wild rice are possible and in some cases, exceeded. However, it appears that the major achievement during the '70's was a more consistent yield of wild rice which means that the average production per acre has increased and will increase in the future.

Future research work will continue in the areas of more shatter-resistant varieties; varieties that produce more grain and less straw as well as being more resistant to leaf blight. Earlier maturing varieties are being sought in order that a grower could plant different paddies with different maturing varieties in a manner which would allow him to harvest in a sequence rather than all in the same time period. This would result in lower capital costs because of improved utilization of harvesting equipment. This research work should result in greater yields of paddy wild rice over the next several years.

Whereas the United States is focussing on paddy wild rice Canada has been exploring the possibilities of increasing lake wild rice production. As previously noted the province that has significantly increased its production in the past several years is Saskatchewan. From a harvest of 321,000 lbs. of green wild rice in 1980, they expect a harvest in excess of 700,000 lbs. for 1981 based on an extensive seeding program. Over 3,000 acres were harvested in 1980 and over 5,000 additional acres were seeded during the year.

Production in Canada should continue increasing with the continued introduction of mechanical harvesters in Ontario which greatly increase the amount of wild rice harvested per acre when compared to the more traditional canoe and flail technique.

Interest has also been shown by various Canadian harvesters in trying to use some techniques applied in paddy wild rice, such as thinning the wild rice to increase yield.

Also, research is taking place at Lakehead University under Peter Lee which should provide further information on improving the lake wild rice harvest. To date, most of the research being done on wild rice has taken place in the United States and is aimed entirely at improving paddy wild rice production.

### 4.7.2 Harvester Prices in the Next Five Years

In order to arrive at a forecast for the price of wild rice at the harvester level over the next several years, an assessment of the demand and supply conditions that are expected to prevail is required. Increases in demand with stable supply tends to increase prices whereas increases in supply with stable demand tends to lower prices.

The demand conditions for wild rice are such that no major increase in per capita consumption is expected in the near future. Consumption will continue to grow as in the past, but this consumption increase is expected to be a gradual one. National advertising by large food processors is unlikely, given the size of the total crop at present. Such expenditures would greatly outweigh any expected returns to these companies. As well, with a limited supply, these companies could not assure their clients of a stable supply at reasonable prices.

On the supply side, however, there are, as previously noted, major influences which indicate that there should be an ample supply of wild rice. The supply of wild rice can increase due to several factors such as an increase in new areas of production, an increase in yields on existing wild rice stands or both. The lake wild rice harvest in Canada is being subjected to all these influences that should increase its production. New areas of production are taking place through extensive seeding programs in Saskatchewan and on a smaller scale in Ontario. As well, an increasing use of mechanical harvesters and water level control in selected areas over time will increase the yields of wild rice in all areas. These factors should result in a substantially larger lake wild rice crop in Canada than presently exists.

In the United States, dramatic increases in lake wild rice production will probably not occur given the fact that mechanical harvesters are not allowed and will probably not be allowed in the foreseeable future. Production of paddy wild rice, however, should continue increasing due to new growers in California and an increasing yield due to more shatter-resistant strains.

Increasing production as outlined above coupled with a large inventory overhang estimated at 1.5 to 2.0 million lbs. of finished wild rice in United Wild Rice's warehouse as well as a court restriction on their purchase of lake wild rice from nonmembers are all indicators that point to stable prices for wild rice barring major crop or harvest failures.

Given the above scenario, it can be expected that the price being paid to the harvester should remain within the range of $0.50 to $1.25 per lb. (Canadian) with a very high probability of prices remaining between $.50 to $1.00 (Canadian) for green wild rice at lakeside.

## 4.8 SOCIAL AND ECONOMIC SIGNIFICANCE OF WILD RICE

### 4.8.1 History of Use

According to early records wild rice has been used for food by man for thousands of years. Direct evidence of prehistoric use comes from the recovery of charred wild rice grains from excavations in known Chippewa harvest sites.

The survival of the southern Ojibwa people has been attributed by some, to the ready availability of the large rice stands. The Indian population in the wild rice belt of Northwestern Ontario and Minnesota was 50 times as large as the population in the plains. According to Jenks, the people were stronger, bigger and healthier because of the nutritional value of wild rice.

Because of its importance to survival during the long, harsh winters, wild rice became the subject of legends. For example, in the legends of the Menomini, Manabush, a mythical half god half animal, gave the first Indian "Skekatchekna", wild rice, a supply of food found growing in the shallows of rivers and lakes.

The harvesting and curing of the wild rice was a traditional activity, closely tied to religious beliefs. Feasts and rituals are associated with the harvest. "The Ojibwa believed that rice had been given to them, along with other types of foods, for their welfare by the Indian god, Kijie Manito, the Great Spirit. Thus, the ricing season was concluded with a feast in Thanksgiving for this gift and prayers were offered to Manito."[6]

The nutritional qualities and the ease of transporting and storing wild rice helped make possible the northern expeditions of fur traders and explorers.

"The early European explorers, traders, missionaries and settlers quickly learned the value of wild rice from the Indians resulting in the first commercial use of the resource. In 1776, Carver (Jenks, 1898) recognized the use of wild rice to infant colonies, for supporting them until other types of food supplies were produced."[7]

Wild rice became important for commercial trade as well as a food staple. Today this resource is still important as food and also, like the historical trade value, as a source of income and employment.

### 4.8.2 Band Survey

The Band Survey was carried out for several purposes, including survey of attitudes of the Indian people toward wild rice, factors affecting attitude and the processing and marketing methods used.

There are a total of 25 bands in the Treaty 3 area of which 20 are part of the study area. Twenty-three of the bands were completely

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6 Schreiner C., Senior Honours Essay, University of Waterloo, 1979, p. 19.

7 Ibid., p. 16.

surveyed but two bands, Lac des Milles Lacs, which is a great distance from the water system under study and Wabauskang, a small band, not living on the reserve at present, were not interviewed.

In carrying out the survey, the usual procedure was that the Chief of a band was contacted by telephone or in person in order to explain the purpose of the survey. The Chief then recommended who in the band should be interviewed whether it be the band Administrator, the Wild Rice Buyer, band council members, elders, or anyone respected for their knowledge and experience in harvesting, marketing or processing. A detailed list of the bands surveyed and the dates on which they were surveyed can be seen in Appendix C.

The band representatives interviewed as part of this survey had an average family size of 4.6 persons. The adults, all persons over 14 years of age, represented 2.8 persons and there was an average of 1.8 children. In the majority of households, (68.6%) there were 1 or 2 members of the family actively engaged in the wild rice harvest. Assuming that it was mostly adults (i.e. people over 14 years of age) who participated in the harvest, then it can be estimated that 81.7% of the adults in the households interviewed participated in the harvest. This estimate is probably biased on the high side since the people interviewed were usually particularly selected for their involvement in the wild rice harvest.

All of the people interviewed had harvested wild rice and, in the majority of cases, were still involved in the harvest. The most common harvesting team was comprised of a husband and wife combination.

Other teams usually were comprised of relatives such as brothers, aunts and nephews, or fathers and sons, and sometimes friends, but generally family members tended to harvest together. Children are taught to harvest by their parents or grandparents but usually do not participate actively in the harvest until after the age of 14. A high percentage (92.1%) of the interviewees, stated that the same family members harvested every year.

Only a small percentage of those interviewed stated that their families harvested less than 5 days. Slightly more than 2/3 harvested for more than 10 days and 40% harvested for more than 15 days. Considering that the total length of the harvest is usually 30 to 40 days and that some days are not suitable for harvesting due to adverse weather conditions, this represents a serious commitment to the harvest by a substantial number of the people.

Once the wild rice has been harvested, a substantial portion is sold green directly to buyers from Ontario, Minnesota and Manitoba. Two bands had some wild rice custom processed. All bands surveyed kept some of the wild rice for traditional processing for personal consumption and for sale. Estimates of total wild rice kept for personal consumption are unavailable but the amount withheld varied from 40 lbs. to 700 lbs. green per person depending if some was kept for private sale as well. Not everyone who harvests wild rice keeps a quantity for personal use. As well, the amount kept for personal consumption varies from year to year, and area to area depending on such factors as quality, price and the size of the harvest. Fifty per cent of those interviewed stated that their families ate wild rice more than once a week and the other 50% less than once a month.

The importance of wild rice as a source of income varied within bands and between bands but the general response was that, irrespective of wild rice's importance to a family's income, it was always considered important in a traditional and cultural way. Of those interviewed, 61.5% stated that wild rice was a very important source of family income, 10.3% stated that it was somewhat important and 28.2% stated it was not very important. Wild rice's lack of importance in terms of income as viewed by 28.2% of those interviewed should not be construed however, as a lack of interest in wild rice by those people. Amongst the elders, the income potential of the wild rice is secondary but what is of importance is the sacredness of the plant and the seed itself. However, the younger harvesters, though aware of the cultural importance of wild rice, are more concerned with the income that can be derived from its harvest. Their main concern, however, is the possibility of losing the resource or having its control pass from the Indian people.

When questioned as to which factors they considered had an adverse effect on the wild rice crop, the most frequently mentioned factor was water levels, followed by rain storms, wind, hail and the wild rice worm. Water level was perceived as more of a problem at harvest time. If the water level is too low and makes it impossible to use a canoe or boat, then all of the wild rice cannot be harvested. If the water level is too high, the problem becomes one of not being able to bend the plant over the canoe in order to strike off the ripened grain. Water levels at other times, say in the spring, that could adversely affect the crop, were perceived as less of a problem because the wild rice will be there another year. But water levels that create harvesting problems cause greater frustration because a good crop can be seen but cannot be harvested.

Attitudes of the people interviewed varied greatly when asked their opinion on the mechanization of wild rice through the use of control structures (dams, etc.) and airboats. Unless a band had some control structures in operation, the general attitude was one of caution. Where the rice beds are not located in areas suitable to the development of such structures, the people were generally neutral in their attitude. This ambivalence as to the usefulness of control structures is reflected in the 18.9% who were neutral, the 16.2% who were undecided and the 16.2% who were opposed, compared to the 48.6% who were in favour of control structures.

The use of airboats proved to be much more controversial than more passive methods of improving the wild rice harvest such as control structures. Opposition to airboats was more prevalent in the Fort Frances district than in other areas of Northwestern Ontario. The main concerns were for traditional harvest areas, the effects on the plant itself and the threat to pickers in terms of income and availability of wild rice for personal consumption. Many who have seen the machines operate are in favour of their use whereas others are still undecided but would like to see strict controls on their use as well as their use restricted to newly seeded areas.

In analyzing the attitudes to airboats with other responses, it was found that 86.7% of the people who favoured airboats stated that wild rice was very important to family income versus 50.0% for those who did not favour airboats. Also 60.0% of the people who favoured airboats spent more than 15 days harvesting versus 27.3% for those who did not favour airboats. As was expected, there was a correlation between those who favour airboats and those who favour control structures with 66.7% of those who favour control structures also favouring airboats. In contrast, of those who do not favour airboats, 36.4% do not favour control structures. This further indicates that control structures are felt to be less of a threat than airboats.

Broadly speaking, one can say that those people who spend relatively more time harvesting and view wild rice as a very important source of income are more inclined toward the mechanization of the growing and harvesting of wild rice.

4.8.3 <u>Wild Rice Revenues</u>

Revenues generated by all wild rice harvesters in Northwestern Ontario, as shown in Table 4.16 have ranged from a low of $6,854 in 1974 to a high of $1,161,132 in 1977 based on the recorded harvest. Such divergences in revenue do not allow wild rice pickers to depend on wild rice income as anything other than a supplement to other incomes.

Data provided in Table 4.17 which is based on the Kenora and Dryden districts, shows that the average annual revenue per picker varied from a low of $84.00 in 1969 to a high of $882.00 in 1967. No estimates

TABLE 4.16

VALUE OF GREEN WILD RICE
IN NORTHWESTERN ONTARIO

| | Recorded Harvest (LBS.) | Average Prices $/LB. | Estimated Revenues $ |
|---|---|---|---|
| 1967 | 512,633 | $1.15 | $ 589,528 |
| 1968 | 285,478 | .65 | 185,561 |
| 1969 | 142,393 | .46 | 65,501 |
| 1970 | 60,354 | .58 | 35,005 |
| 1971 | 275,096 | .56 | 154,054 |
| 1972 | 1,092,824 | .57 | 622,910 |
| 1973 | 1,289,569 | .50 | 644,785 |
| 1974 | 9,934 | .69 | 6,854 |
| 1975 | 93,264 | .80 | 74,611 |
| 1976 | 1,137,801 | .71 | 807,839 |
| 1977 | 860,098 | 1.35 | 1,161,132 |
| 1978 | 155,015 | 2.50 | 387,538 |
| 1979 | 299,259 | 2.00 | 598,518 |

SOURCE: Ministry of Natural Resources, Ontario.

TABLE 4.17

KENORA AND DRYDEN
DISTRICTS
WILD RICE REVENUES

| | Total Harvest lbs. | Total Revenue $ | Price $/lb. | Number Of Pickers | Revenue per Picker $ |
|---|---|---|---|---|---|
| 1967 | 456,046 | 525,847 | 1.15 | 596 | 882 |
| 1968 | 272,250 | 176,888 | 0.65 | 838 | 211 |
| 1969 | 117,122 | 54,354 | 0.46 | 645 | 84 |
| 1970 | 53,854 | 32,144 | 0.61 | 300 | 107 |
| 1971 | 209,823 | 116,830 | 0.56 | 748 | 156 |
| 1972 | 891,498 | 508,154 | 0.57 | 740 | 687 |
| 1973 | 1,188,402 | 594,201 | 0.50 | 777 | 765 |
| 1974 | 9,938 | 6,854 | 0.69 | - | - |
| 1975 | - | - | NO HARVEST | - | - |
| 1976 | 830,195 | 589,438 | 0.71 | 958 | 615 |
| 1977 | 686,254 | 926,443 | 1.35 | 1,520 | 610 |
| 1978 | 84,158 | 210,395 | 2.50 | - | - |
| 1979 | 157,202 | 314,404 | 2.00 | - | - |

SOURCE: Ministry of Natural Resources, Ontario.

of numbers of pickers were available for the 1978 and 1979 harvests but if a range of 500 to 1,500 pickers is used, the average revenue per picker in 1979 would have ranged from $210.00 to $630.00.

The survey results indicated that 60% of families harvested for fewer than 15 days and that 40% harvested for more than 15 days. Given that the effort put into the harvest varies from family to family, it is estimated that some families can generate 2 to 3 times the average income or $630.00 to $1,890.00 from the harvest of wild rice. If this is supplementary to another source of income, say $4.00 per hour for a 40-hour work week or $8,000.00 per annum, this represents from 8% to 24% of average yearly income.

### 4.8.4 Wild Rice Harvest by District and Band

Information provided in Table 4.18 on the recorded wild rice harvest shows wide fluctuations in harvest from 1967 to 1979. These fluctuations are not restricted to one or two districts but occur in all districts though not in unison. Table 4.19 shows that in the years 1967, 1972, 1973, 1976 and 1977, when the harvest was in excess of 500,000 lbs., the Kenora district accounted for 66.5% to 75.2% of the recorded harvest. Tables 4.20, 4.21 and 4.22 show similar wide and inconsistent fluctuations in harvest between bands.

In spite of the apparently low and unreliable income to individuals from wild rice, over 70.0% of those interviewed were of the opinion that income derived from the harvest of wild rice was somewhat to very important to band members.

## TABLE 4.18

## WILD RICE HARVEST BY DISTRICT IN NORTHERN ONTARIO (GREEN LBS.)

| | Kenora | Dryden | Fort Frances | Sioux Lookout | Red Lake | Ignace | TOTAL |
|---|---|---|---|---|---|---|---|
| 1967 | 374,280 | 81,766 | 36,667 | 19,920 | -- | -- | 512,633 |
| 1968 | 189,124 | 83,126 | 3,804 | 9,424 | -- | -- | 285,478 |
| 1969 | 99,925 | 17,197 | 25,271 | N/A | -- | -- | * 142,393 |
| 1970 | 15,817 | 37,037 | 7,500 | N/A | -- | -- | * 60,354 |
| 1971 | 171,636 | 38,187 | 30,405 | 34,868 | -- | -- | 275,096 |
| 1972 | 821,622 | 69,876 | 122,053 | 79,273 | -- | -- | 1,092,824 |
| 1973 | 1,127,004 | 61,398 | 61,401 | 39,765 | N/A | N/A | *1,289,568 |
| 1974 | 9,934 | N/A | N/A | N/A | N/A | N/A | * 9,934 |
| 1975 | N/A | N/A | 30,458 | 62,806 | N/A | N/A | * 93,264 |
| 1976 | 757,120 | 73,075 | 142,403 | 126,392 | 30,181 | 8,630 | 1,137,801 |
| 1977 | 580,643 | 105,611 | N/A | 143,322 | 25,696 | 4,826 | * 860,098 |
| 1978 | 25,201 | 58,957 | N/A | 54,597 | 1,095 | 15,165 | * 155,015 |
| 1979 | 44,216 | 112,986 | 47,848 | 21,830 | 46,797 | 25,582 | 299,259 |

* Incomplete Data    N/A = Not Available

NOTE: Data for Kenora and Dryden were disaggregated for years prior to 1973.
The harvest data for Ignace and Red Lake prior to 1973 are included with the data of the old Fort Frances and Sioux Lookout administrative districts respectively.

SOURCE: Ministry of Natural Resources, Ontario.

TABLE 4.19

DISTRIBUTION OF THE WILD RICE HARVEST
BY DISTRICT IN NORTHWESTERN ONTARIO
(PERCENT)

| | Kenora | Dryden | Fort Frances | Sioux Lookout | Red Lake | Ignace | Total |
|---|---|---|---|---|---|---|---|
| 1967 | 73.0 | 16.0 | 7.2 | 3.9 | -- | -- | 100.0% |
| 1968 | 66.2 | 29.1 | 1.3 | 3.3 | -- | -- | 100.0 |
| 1969 | 70.2 | 12.1 | 17.7 | -- | -- | -- | 100.0 |
| 1970 | 26.2 | 61.4 | 12.4 | -- | -- | -- | 100.0 |
| 1971 | 62.4 | 13.9 | 11.1 | 12.7 | -- | -- | 100.0 |
| 1972 | 75.2 | 6.4 | 11.2 | 7.3 | -- | -- | 100.0 |
| 1973 | 87.4 | 4.8 | 4.8 | 3.1 | -- | -- | 100.0 |
| 1974 | 100.0 | -- | -- | -- | -- | -- | 100.0 |
| 1975 | -- | -- | 32.7 | 67.3 | -- | -- | 100.0 |
| 1976 | 66.5 | 6.4 | 12.5 | 11.1 | 2.7 | 0.8 | 100.0 |
| 1977 | 67.5 | 12.3 | -- | 16.7 | 3.0 | 0.6 | 100.0 |
| 1978 | 16.3 | 38.0 | -- | 35.2 | 0.7 | 9.8 | 100.0 |
| 1979 | 14.8 | 37.8 | 16.0 | 7.3 | 15.6 | 8.5 | 100.0 |

NOTE: Data for Kenora and Dryden were disaggregated for years prior to 1973. The harvest data for Ignace and Red Lake prior to 1973 are included with the data of the old Fort Frances, and Sioux Lookout administrative districts respectively.

SOURCE: See Table 4.9.4.

# TABLE 4.20

## WILD RICE HARVEST BY BAND
## KENORA DISTRICT
## (LBS. OF GREEN WILD RICE)

| | Whitedog (Islington) | Grassy Narrows | Rat Portage Dalles & Washagamis | Shoal Lake 39 & 40 | N.W. Angle 33 & 37 | Big Island | Sabaskong & Big Grassy | Whitefish Bay | Un-designated | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 26,713 | 22,856 | -- | 225,000 | 22,610 | 18,509 | 27,434 | 31,158 | -- | 374,280 |
| 1968 | 39,346 | 14,971 | 40 | 38,150 | 6,850 | -- | 59,695 | 11,594 | 18,478 | 189,124 |
| 1969 | 7,468 | 1,650 | 1,242 | 10,644 | 1,687 | | 73,898 | | 3,336 | 99,925 |
| 1970 | 4,908 | 4,694 | nil | 3,378 | Nil | Nil | 2,837 | Nil | -- | 15,817 |
| 1971 | 14,454 | 1,020 | 11,550 | 2,649 | 8,788 | 22,507 | 41,161 | 69,507 | -- | 171,636 |
| 1972 | 154,834 | 109,340 | 60,967 | 48,334 | 46,981 | 96,176 | 192,763 | 112,227 | -- | 821,622 |
| 1973 | 187,472 | 19,739 | 45,095 | 73,457 | 46,283 | 229,526 | 432,820 | 92,612 | -- | 1,127,004 |
| 1974 | 1,669 | No Report | 813 | 7,452 | | | No report | | | 9,934 |
| 1975 | -- | -- | -- | -- | -- | -- | -- | -- | -- | No report |
| 1976 | 290,996 | 86,603 | 40,972 | 57,694 | 7,562 | 130,564 | 115,636 | 27,093 | -- | 757,120 |
| 1977 | 94,969 | 34,000 | 84,610 | 49,758 | 25,535 | 91,401 | 106,836 | 93,534 | -- | 580,643 |
| 1978 | 4,000 | 20,917 | 284 | | | No Report | | | -- | 25,201 |
| 1979 | 2,043 | 39,563 | 507 | 1,603 | 500 | | No report | | -- | 44,216 |

TABLE 4.21

WILD RICE HARVEST BY BAND
DRYDEN DISTRICT
(IN LBS. OF GREEN WILD RICE)

| | Eagle Lake | Wabigoon | Total |
|---|---|---|---|
| 1967 | 13,888 | 67,878 | 81,766 |
| 1968 | 32,183 | 50,943 | 83,126 |
| 1969 | 8,766 | 8,431 | 17,197 |
| 1970 | 5,400 | 31,637 | 37,137 |
| 1971 | 11,373 | 26,814 | 38,187 |
| 1972 | 37,203 | 32,673 | 69,876 |
| 1973 | NA | NA | 61,398 |
| 1974 | -- | -- | Nil |
| 1975 | No Report | | |
| 1976 | NA | NA | 73,075 |
| 1977 | NA | NA | 105,611 |
| 1978 | NA | NA | 58,957 |
| 1979 | NA | NA | 112,986 |

## TABLE 4.22

### WILD RICE HARVEST BY BAND
### FORT FRANCES DISTRICT
### (IN LBS. OF GREEN WILD RICE)

| | Manitou Rapids | Big Grassy | N.W. Bay | Stanjikoning | Couchiching | Seine River | Redgut | Un-designated | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1967 | | | | | | | | | 36,667 |
| 1968 | | | | | | | | | 3,804 |
| 1969 | | | | | | | | | 25,271 |
| 1970 | | | | | | | | | 7,500 |
| 1971 | | | | | | | | | 30,405 |
| 1972 | | | | | | | | | 122,053 |
| 1973 | | | | | | | | | 61,401 |
| 1974 | | | | | | | | | -- |
| 1975 | | | | | | | | | 30,405 |
| 1976 | 84,630 | 33,458 | 2,512 | 5,384 | 8,092 | 5,935 | 2,255 | 137 | 142,403 |
| 1977 | No Report | | | | | | | | -- |
| 1978 | No Report | | | | | | | | -- |
| 1979 | 5,489 | Nil | 8,672 | 1,800 | 145 | 18,474 | -- | 13,268 | 47,848 |

FIGURES

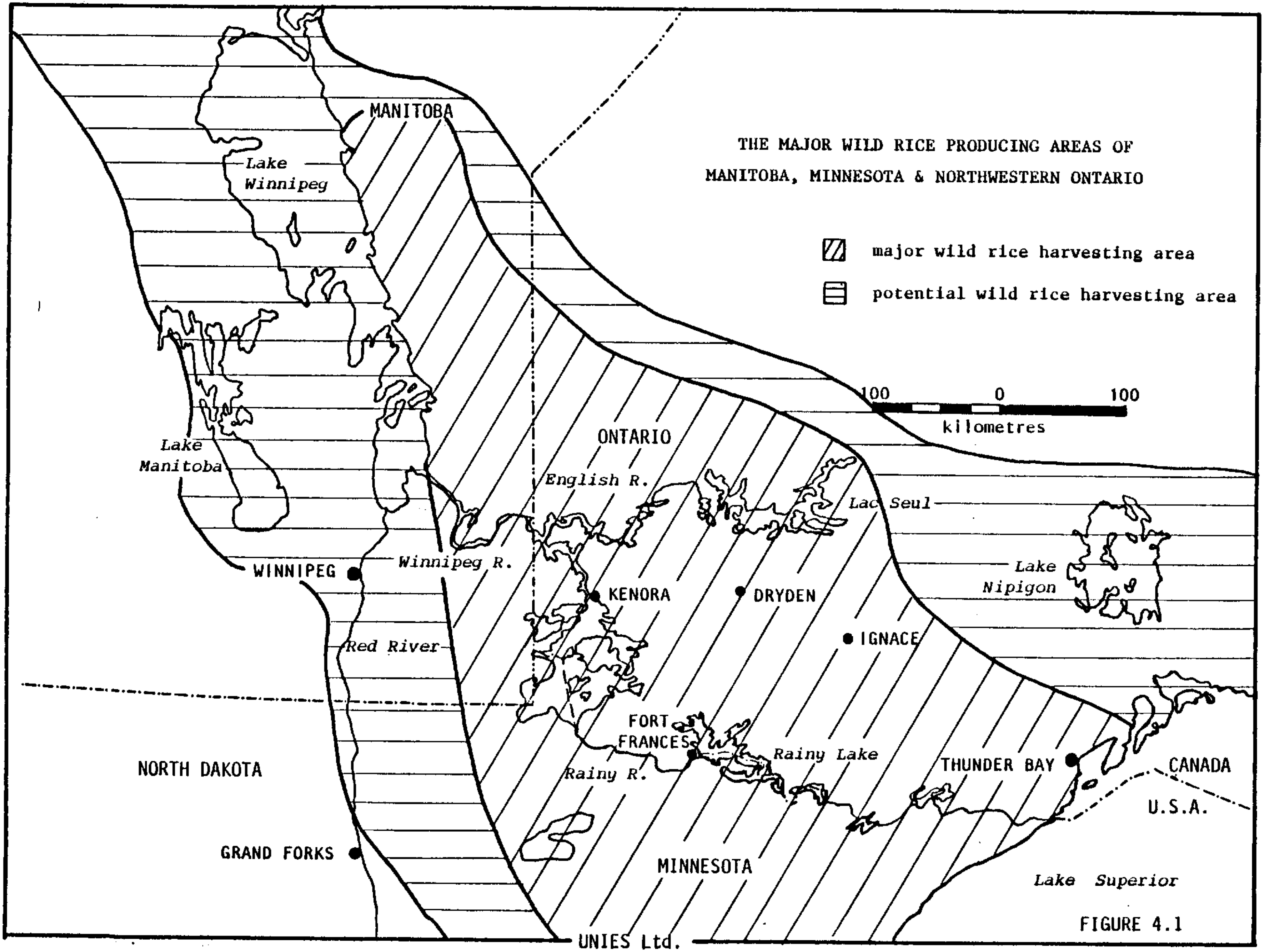

THE MAJOR WILD RICE PRODUCING AREAS OF
MANITOBA, MINNESOTA & NORTHWESTERN ONTARIO
major wild rice harvesting area
potential wild rice harvesting area
100
0
100
kilometres
MANITOBA
Lake Winnipeg
Lake Manitoba
WINNIPEG
Winnipeg R.
Red River
NORTH DAKOTA
GRAND FORKS
ONTARIO
English R.
KENORA
DRYDEN
IGNACE
Lac Seul
Lake Nipigon
FORT FRANCES
Rainy R.
Rainy Lake
MINNESOTA
THUNDER BAY
CANADA
U.S.A.
Lake Superior
UNIES Ltd.

FIGURE 4.1

# CHAPTER 5

## SIMULATION OF RICE GROWTH AND HARVEST

### 5.1 PURPOSE OF SIMULATION MODEL

A major objective in the study is to define the relationship between wild rice production and water level regime and to determine practical modifications to water level regime that may enhance wild rice production. The records of wild rice production are not adequate in either length or areal extent, to establish the relationship directly. Therefore a simulation model was developed which could make use of existing data to first establish the relationship between wild rice production and certain physical processes, and then, using this model, to extend a synthetic history of production over a longer period of time using the more extensive records of these physical processes. The simulation model can then be used to establish a comparative record of wild rice production on the assumption that one or more of the governing processes has been changed. In this case the physical process changed is that of water level regime.

A simulation model was developed which used existing records of solar radiation, air temperature, precipitation, river flows and water levels to simulate the annual growth and harvest of wild rice in the study area over the period 1918 to 1979. From the resulting 60-year synthetic record a statistical comparison was made of the harvest obtainable, assuming several variations of water level regulation pattern.

## 5.2 PERIOD OF SIMULATION

The longer the period of simulation the better the definition of statistical properties of the wild rice harvest. The simulation model developed for the study is driven by climate, streamflow and water level data. Therefore, it can simulate wild rice growth and harvest for only that period when an adequate supply of these data is available.

Climate data used in the simulation model consist of the following records:

- Daily precipitation at three weather stations in the study area (Figure 1.1).
- Daily temperatures at three weather stations in the study area.
- Daily radiation at the Kenora weather station from 1953 to 1979 and, prior to 1953, substitution of daily hours of sunshine at Winnipeg.

Hydrological data used consisted of the following records:

- Mean monthly Winnipeg River flows at Slave Falls.
- Mean monthly English River flows at Caribou Falls or Manitou.
- Mean monthly English River flows at Ear Falls.
- Mean daily Lac Seul water levels.
- Mean monthly Winnipeg River flows at Fort Frances.
- Mean daily Lake of the Woods levels.
- Mean daily Shoal Lake levels.
- Mean monthly Rainy River flows at Fort Frances.
- Mean daily Rainy Lake levels.

These records have been kept for various lengths of time, not all of them continuously. Certain climate records and Lake of the Woods water level records extend back to the late 1880's. However, other records used have been kept for a much shorter period of time. It was assumed that, using some substitution and correlation of noncontinuous data, a data base adequate to drive the simulation model through the period 1918 to 1979 could be assembled. In particular, hydrological data for the English River and Lac Seul prior to 1918 are lacking.

## 5.3 SIGNIFICANT PARAMETERS AFFECTING GROWTH AND HARVEST

Wild rice growing under natural conditions exists in a state of dynamic equilibrium with its environment. This environment is an interactive complex of physical and biological processes not entirely understood by man and certainly not fully measured and calibrated. A simulation model of growth and harvest of wild rice can be developed using mathematical relationships between only those few processes for which data have been collected.

Data available for the simulation model, in the case of this study of wild rice, are harvest date and volume collected for a part of the study area over a period of about 20 years. Over a longer period, 1918 to 1979, data useable to represent the major physical processes influencing wild rice growth and harvest throughout the study area have been collected. These principal physical processes are climate and hydrology and, within limits, it may be assumed that they govern variations in biological processes which, in turn, govern changes in growth and harvest occurring from year to year. It is recognized that cyclical changes in nutrient balance and plant succession independent of physical processes occur. In the zone occupied by wild rice, water and sediment movement constantly redistribute nutrients dampening these cyclical changes. Therefore their impact on the rice harvest from year to year is believed to be small relative to that caused by variations in the physical processes.

For the above reasons the simulation model developed is driven by the physical processes of climate and hydrology as defined by available data. These processes have been represented in the model by parameters which are converted by simple mathematical functions into growth and harvest volume for each season's wild rice crop. The mathematical functions represent, in the model's terms, all of the biological processes which go into the growth and production of a rice crop and the harvesting process by which that crop is converted to delivered green wild rice. The mathematical functions and the factors used to adjust the parameters representing physical processes, have been adjusted by calibration of the simulated wild rice harvest from Lake of the Woods with that actually recorded during the period 1960 to 1979.

Several climate parameters are of importance. Plant growth is contingent on the rate at which solar energy is received and on the temperature of both air and water in which the rice grows. The parameter used in the model to represent solar energy was solar radiation estimated for Kenora, and since the Kenora record did not cover the entire period of simulation, a conversion of hours of sunshine measured at Winnipeg was used for the earlier record. Air temperature is recorded at three stations in the study area and these records were used for the simulation. A short period of recorded water temperatures for Shoal Lake indicated a reasonable correlation with air temperature. Therefore it was assumed that growth attributable to both air and water temperature would be correlated with air temperature only.

Climate factors which retard growth are wind, heavy precipitation and hail. These factors also stress the growing plants so that the seed yield is reduced, and if they occur at harvest time may render all or part of the crop unharvestable. In the model they are represented only as storms as recognized at the weather stations in the area by the rate and duration of precipitation. The impact of these storms on growth and harvest, in nature and as modelled, are dependent on their time of occurrence.

Hydrological parameters affecting wild rice growth and harvest are water level and water movement. However only water level is used in the simulation model, although the impact of storms represent the wind generated component of water movement.

Water levels in each division of the study area vary in a complex pattern and influence wild rice growth and harvest in several ways. The static water level between the time of germination and growth of the first aerial leaves is particularly important. It has been explained that wild rice growth is located mainly in the lower part of the littoral zone. For example, in Lake of the Woods, the establishment of competing species seems to prevent the growth of rice where littoral zone sediments lie above approximately elevation 322.8 meters (1059 ft.). Further, wild rice does not grow in water depth greater than about 2.5 meters. Therefore, assuming a uniform bottom slope in the littoral zone, the area in which rice can grow in Lake of the Woods, would decrease as static water levels are increased above elevation 322.8 meters (1059 ft.). The simulation model includes terms which decrease harvest as mean lake level during the growth season increases.

Changes in water level during the growth and harvest seasons also affect the harvest obtainable. A changing water level during germination, submerged and floating leaf stages reduces the potential harvest through several impacts. If a rise in water level is experienced wild rice plants growing at the deep edge of the bed will be flooded out and lost. This loss will be compensated if seed is available in the newly flooded areas but the rate of compensation is retarded as competing species become established. A falling water level, such as may occur in the floating and aerial stage, may result in a loss of rice bed area through drying. Rising water levels stress the wild rice plants, particularly in the submerged and floating stages, and divert energy that would otherwise go into seed production. A change in water level near harvest time may reduce the harvest by making a part of the bed inaccessible in the case of a falling level, or submerging the stalks so that collection is hampered in the case of a rising level. The simulation model includes terms which decrease harvest as a result of changing water level during critical parts of the growth and harvest season.

Changes in water level from one season to the next also have an impact on the wild rice harvest. In addition, the volume of the crop in preceding years affects the availability of seed for the current year's crop. Both water levels and crop during the preceding season were included as parameters in the simulation model influencing the current year's harvest. The impact of the antecedent harvest is generally positive, that is, a large crop in the preceding year will provide ample seed for the current year's crop. However, a change from antecedent growing season water levels may be either positive or negative, depending on whether it is an increase or a decrease, and on its magnitude, since both wild rice and competing species must adjust to the change.

The selection of physical parameters has been based on the reasoning outlined above. The coefficients and mathematical relationships governing their impact on wild rice growth and harvest were refined in the simulation model calibration. Details of the calibration process and of the parameters used in the model are discussed in the sections of this report that follow.

## 5.4 RICE GROWTH SIMULATION

### 5.4.1 Growth Model

Each stage in the growth of wild rice is affected in varying degrees by a number of environmenal factors, as discussed in Chapter 2. For the purpose of modelling, the index used to measure plant growth was normalized dry weight per plant. Figure 5.1 was derived from Figure 2.1. The data in this figure were based on field measurements of actual wild rice growth, and the duration of each stage shown is representative of average growing conditions. The length of the growing season varies from year to year, depending upon weather and water level conditions. Annual MNR rice harvest reports for the period 1960 to 1979 provided the only data available for calibration of the growth model, i.e. the date of the beginning of the rice harvest each year.

A mathematical model of rice growth was formulated as follows. It was assumed that at each particular stage i, in the growth cycle, the variation in growth rate for each factor j was of the form

$$\frac{dg_{ij}}{dt} = K_{ij}\ (P_j - A_{ij})^{\hat{A}} N_{ij} + g_{ij} \tag{5.1}$$

where $K_{ij}$, $A_{ij}$, $N_{ij}$ and $g_{ij}$ are constants. In general, at different stages, the number of factors included, and the form of the rate equation for each factor may be different. If m factors are included for stage i, the total growth rate is given by

$$\frac{dG_i}{dt} = \sum_{j=1}^{M} \frac{dg_{ij}}{dt} \tag{5.2}$$

The growth of the plant is thus determined by integration of the rate equation,

$$G_i(t) = \int_0^{T_i} \left(\frac{dG_{ij}}{dt}\right) \cdot dt \tag{5.3}$$

Transitions from one stage to another are defined by the normalized growth curve (Figure 5.1). For example, the aerial stage is completed on the day that the value of the growth function exceeds a value of 0.7. The next day, the simulation model would select the functions defined for the next stage (flower), and the integrations would proceed. The date of completion of the last growth stage is interpreted as the beginning of the harvest.

Daily values of the following parameters were available for use in modelling the rice growth.

a) Air temperature

b) Solar radiation

c) Precipitation

d) Water level

In order to maximize the flexibility of the model, the functions defining growth rates for each parameter were allowed to vary as illustrated in Figure 5.2. Parameter values less than $P_{min}$ would result in partial growth rate $\dot{g}_{min}$, and parameter values greater than $P_{max}$ would yield a growth rate of $\dot{g}_{max}$. Intermediate values, $P_{min} \leq P \leq P_{max}$ would result in growth rates defined by equation (5.1).

### 5.4.2 Growth Model Calibration

The parameters selected for each stage in the growth model are shown in Table 5.1. Constants for the growth rate equations were chosen by iteration. The average slope of the growth curve during each stage, and historical monthly average of the parameters were used as a starting point for defining specific function values. Initial values were then refined by repeated simulations over the period 1960 to 1979, with the objective of minimizing the average error in predicting the harvest date. At first glance, this appears to be an almost impossible task due to the large number of unknowns. However, in the 20-year record, there is considerable variation in the combination weather and water level parameters. After several trials, it became apparent that adjustment of any

TABLE 5.1

PARAMETERS USED IN GROWTH MODEL

| | Germination | Submerged Leaf | Floating Leaf | Aerial Leaf | Flower | Immature Seed | Mature Seed |
|---|---|---|---|---|---|---|---|
| PARAMETERS | Air Temperature | Air Temperature | Air Temperature | Air Temperature | Air Temperature | Air Temperature | Air Temperature |
| | | + | + | + | + | + | + |
| | | Solar Radiation | Solar Radiation | Solar Radiation | Solar Radiation | Solar Radiation | Solar Radiation |
| | | + | + | + | + | + | + |
| | | Precipitation | Lake Level | Lake Level | Precipitation | Precipitation | Precipitation |

particular rate equation was necessarily limited in order to obtain reasonable model predictions in all 20 years. In most cases, over-adjustment of a given rate equation would "fix" a problem during some years, but cause different problems during other years simulated.

The set of growth rate functions developed after a number of trials is illustrated in Figure 5.3. Model predictions of estimated date of beginning of harvest obtained using these functions are given in Table 5.2, and a plot of the predicted versus reported start of harvest dates is presented in Figure 5.4. Computed growth curves for the years 1960 to 1979 are presented in Figure 5.5.

## 5.5 RICE HARVEST MODEL DEVELOPMENT

Previous studies by many workers have shown that many factors influence the amount of wild rice available for harvest. Annual rice harvest reports compiled by the Ontario MNR frequently contain references to the effects of water levels on the annual rice crops. A study by P.F. Lee in 1975 attempted to relate rice harvest to average summer water level on Lake of the Woods.

In the present study, the effects of various water level and climatic factors were examined using a multiple linear regression program. Reported annual rice harvests for the period 1960 to 1979, adjusted to include only those rice harvest areas on Lake of the Woods, were used in developing the statistical models. Other data used in the models included lake levels, solar radiation, air temperature, precipitation, and an antecedent conditions index. Multiple linear regression models of

TABLE 5.2

COMPARISON OF REPORTED AND MODELLED
RICE HARVEST AND START OF HARVEST DATES
LAKE OF THE WOODS

| | BEGINNING OF HARVEST | | RICE HARVEST (lbs.) | |
|---|---|---|---|---|
| Year | MNR Records Prediction | Model | Reported | Modelled |
| 1960 | 19/8 | 17/8 | 350,000 | 372,000 |
| 1961 | 18/8 | 9/8 | 471,000 | 409,000 |
| 1962 | 1/9 | 12/9 | 45,000 | 85,000 |
| 1963 | 21/8 | 20/8 | 20,000 | 41,000 |
| 1964 | 1/9 | 17/8 | 20,000 | 72,000 |
| 1965 | 5/9 | 3/9 | 0 | 77,000 |
| 1966 | 28/8 | 5/9 | 0 | -16,000 |
| 1967 | 27/8 | 31/8 | 325,000 | 215,000 |
| 1968 | 27/8 | 7/9 | 116,000 | 101,000 |
| 1969 | 25/8 | 2/9 | 87,000 | 49,000 |
| 1970 | 28/8 | 30/8 | 6,000 | -119,000 |
| 1971 | 21/8 | 14/8 | 156,000 | 233,000 |
| 1972 | 21/8 | 13/8 | 537,000 | 480,000 |
| 1973 | 15/8 | 18/8 | 920,000 | 879,000 |
| 1974 | 1/9 | 25/8 | 8,000 | 67,000 |
| 1975 | No Report | 13/8 | 0 | -17,000 |
| 1976 | 3/8 | 1/8 | 380,000 | 496,000 |
| 1977 | 5/8 | 2/8 | 452,000 | 446,000 |
| 1978 | 20/8 * or later | 20/8 | 29,000 | -15,000 |
| 1979 | 20/8 * or later | 27/8 | 34,000 | 120,000 |

* Personal communication, DIA.

the form

$$R = A_o + \sum_{j=1}^{n} A_j P_j \qquad (5.4)$$

where R is the annual rice harvest, the A's are constants determined by the regression, and the $P_j$ are parameter values, were used. Various definitions for the parameters $P_j$ were investigated in order to obtain the best possible fit to the observed rice harvest data. After considerable experimentation, the following set of parameters were developed.

$P_1$ - Mean lake level

$$P_1 = \frac{(h_{June} + h_{July})}{2} - h_o \qquad (5.5)$$

where $h_o$ = 320 m was chosen as a convenient datum for the Lake of the Woods model.

$P_2$ - "Mean" Square lake level

$$P_2 = \sum_{j=4}^{9} (h_j - h_o)^2 \qquad (5.6)$$

$P_3$ - Level Change Index

This parameter is equal to the sum of lake level changes exceeding $\pm$ 0.2 meters during the months of April, May and September.

$P_4$ - Solar Radiation:

The total solar radiation for the months of April through September (mega joules per square meter).

$P_5$ - Air Temperature:

The sum of air temperatures for the months of April through September (degrees celsius)

$P_6$ - Precipitation Index:

The total recorded precipitation in July, August, September in excess of 300 mm.

$P_7$ - Antecedent Conditions Index:

This parameter was used in an attempt to account for the influence of last year's conditions on the harvest in the current year.

$$P_7 = R_{LY} + 1/2 \left(h_{LY} - h_{TY}\right) \quad (5.7)$$

where $R_{LY}$ is the harvest last year, $h_{LY}$ is the summer lake level last year, and $h_{TY}$ is the summer lake level in the current year. The value of coefficient in the level term, 1/2 was determined by doing a series of runs using different values to select the optimum value.

Using these definitions, the following regression model was developed.

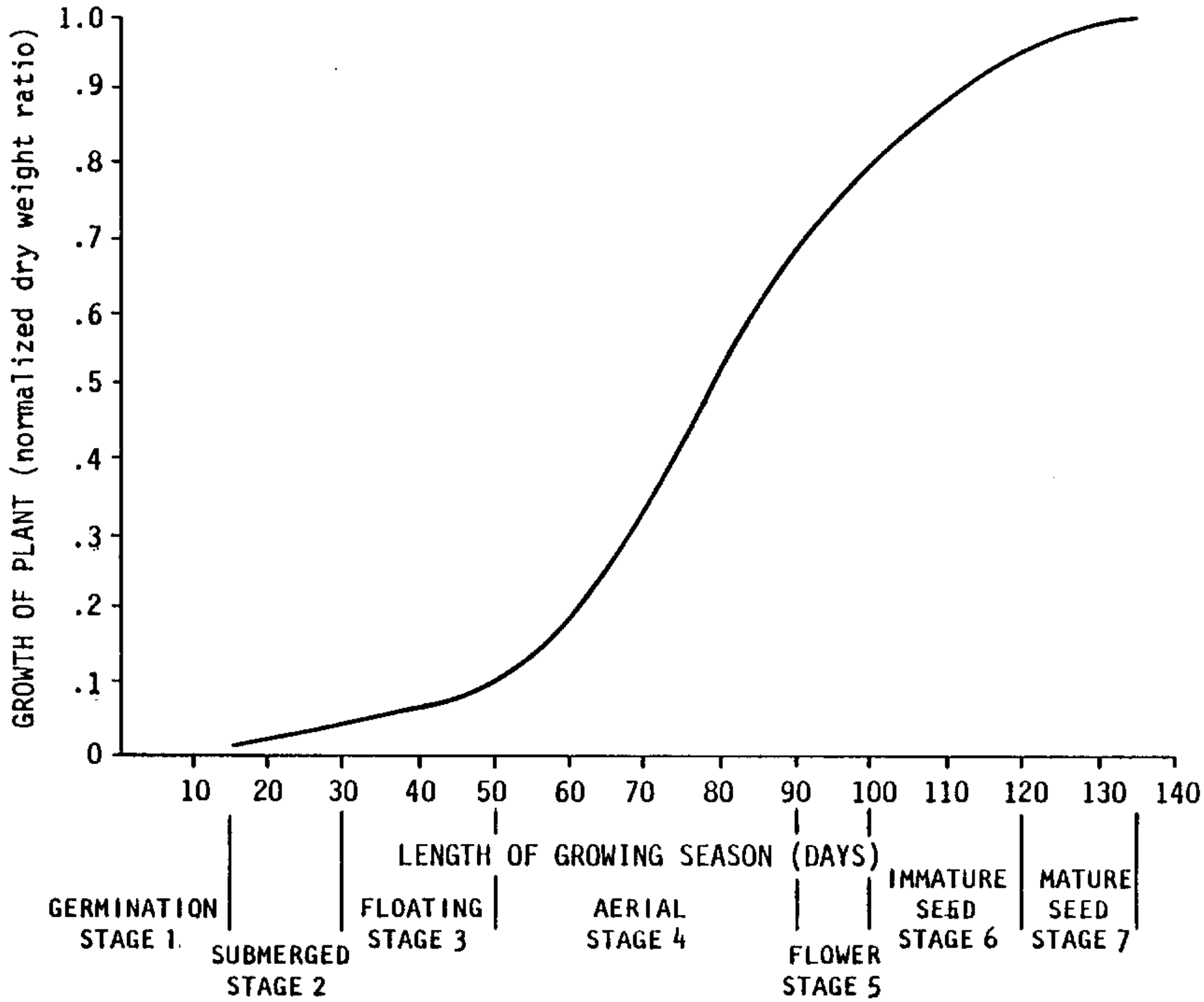
$$\begin{aligned} R = {} & 1.49346 - 0.814359 * P_1 + 1.0156516 \times 10^{-2} * P_2 \\ & - 8.74502 \times 10^{-2} * P_3 + 5.195111 \times 10^{-4} * P_4 \\ & - 1.246594 \times 10^{-3} * P_5 + 3.17836 \times 10^{-3} * P_6 \\ & + 7.30266 \times 10^{-2} * P_7 \end{aligned}$$

where R is the rice harvest in millions of pounds. A comparison of reported and predicted harvests is given in Table 5.2 and Figure 5.6. The correlation coefficient of the fit obtained using this model was 0.964, i.e. the model "explains" 93% of the variation in annual rice harvest. The rms (root-mean square) error in a single estimate of a rice harvest was approximately $\pm$85,000 pounds. Negative harvests indicated in Table 5.2 result from statistical uncertainty in predicting the harvest using the regression model.

Another model investigated used the same parameters as the above model, but the terms $P_1$ and $P_2$ which use absolute lake levels were dropped out. This model thus only uses changes in water level in the parameters $P_3$ and $P_7$. The six parameter model obtained a correlation coefficient of 0.906, accounting for 82% of the variation in rice crops.

Both the 8 and 6 parameter models have negative coefficients on the lake levels change term, $P_3$. In effect, the statistical models indicate that large changes in water level during the summer decrease the amount of rice available for the harvest. This is in agreement with conclusions reached in other studies of wild rice. The model would indicate that low lake levels might result in large rice harvests, except that it is physically impossible to maintain these levels during median and high inflow years. Even if achievable, repeated low levels could be expected to precipitate a change in species distribution in the littoral zone, probably at the expense of the area producing rice.

FIGURES




WILD RICE GROWTH CURVE FOR SIMULATION MODEL

FIGURE 5.1

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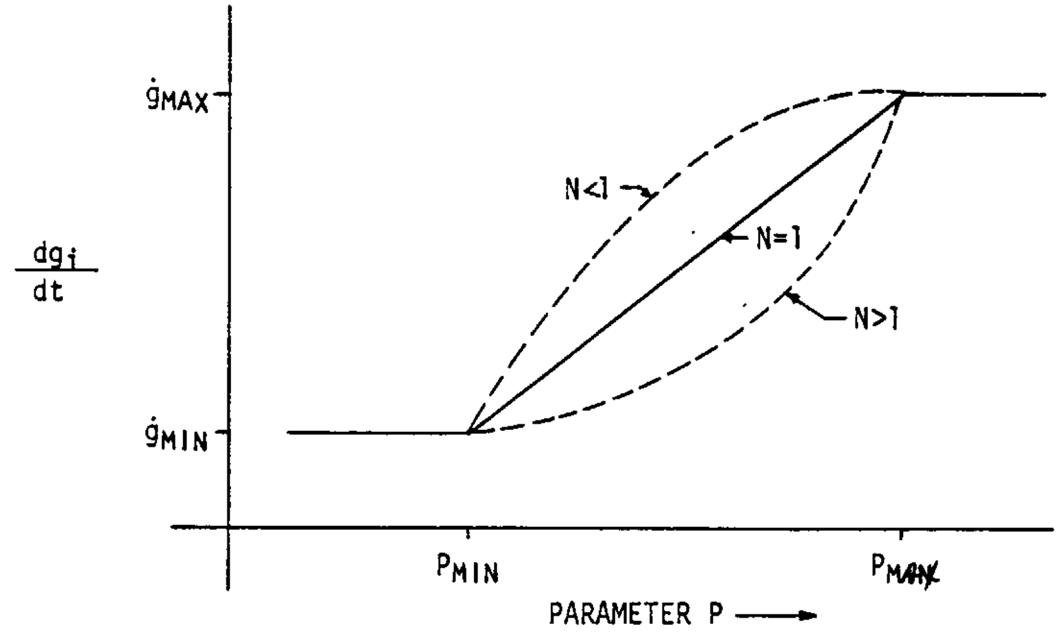


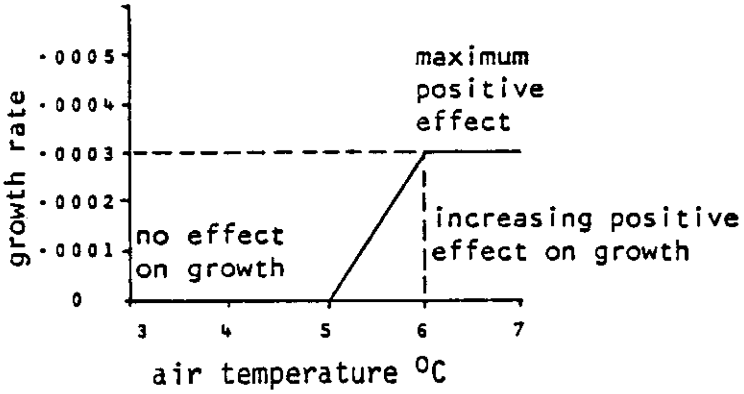

TYPICAL GROWTH RATE FUNCTION

FIGURE 5.2

## STAGE 1 - GERMINATION

Growth at end of stage = .005
Factors affecting growth = Air Temperature

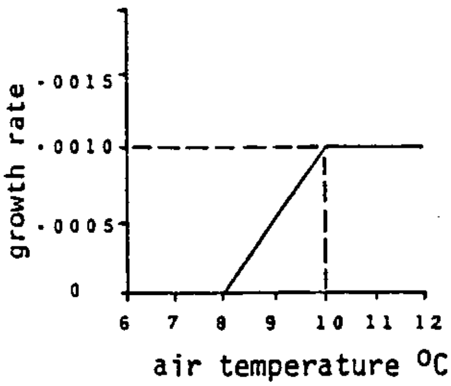
AIR TEMPERATURE
vs.
DAILY GROWTH RATE



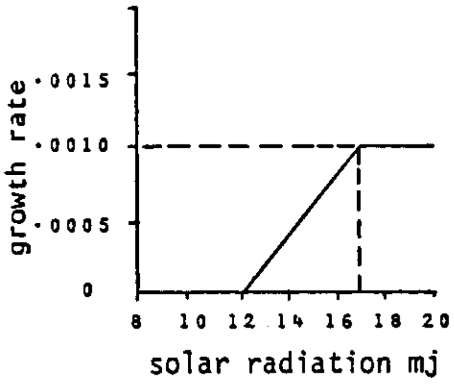

## STAGE 2 - SUBMERGED

Growth at end of stage = .02
Factors affecting growth = Air Temperature
Solar Radiation
Precipitation

AIR TEMPERATURE
vs.
DAILY GROWTH RATE




SOLAR RADIATION
vs.
DAILY GROWTH RATE




PRECIPITATION
vs.
DAILY GROWTH RATE

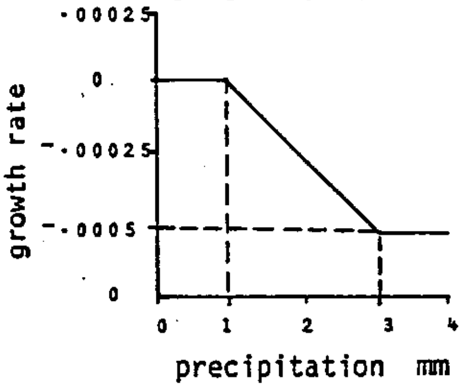
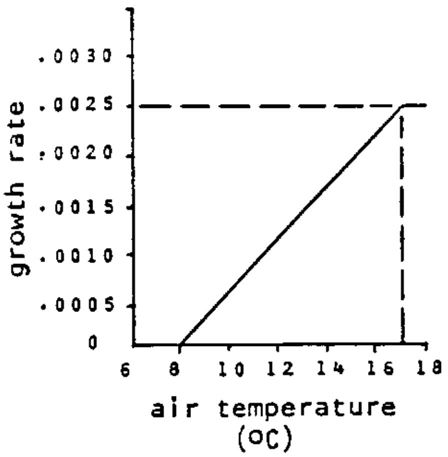



FIGURE 5.3, SHEET 1 OF 4

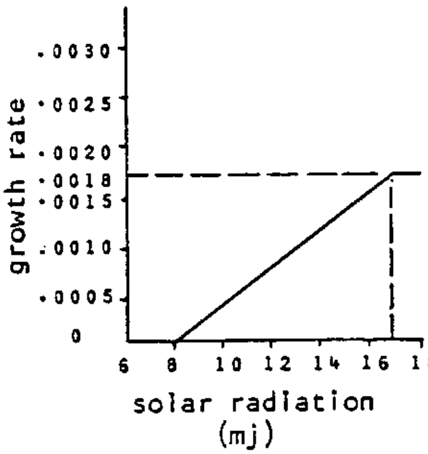
## STAGE 3 - FLOATING

Growth at end of stage = .08
Factors affecting growth = Air Temperature
Solar Radiation
Lake Level

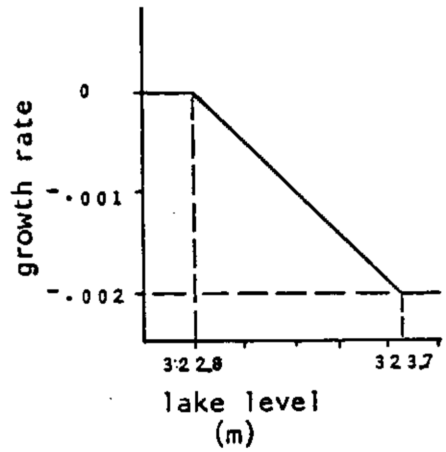
AIR TEMPERATURE vs. DAILY GROWTH RATE




SOLAR RADIATION vs. DAILY GROWTH RATE



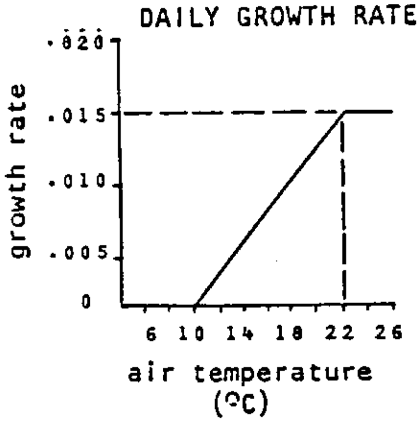

LAKE LEVEL vs. DAILY GROWTH RATE



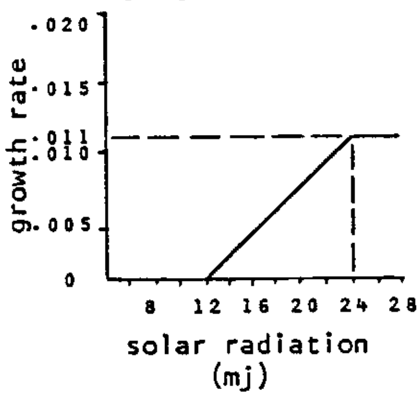

## STAGE 4 - AERIAL

Growth at end of stage = .7
Factors affecting growth = Air Temperature
Solar Radiation
Lake Level

AIR TEMPERATURE VS. DAILY GROWTH RATE




SOLAR RADIATION vs. DAILY GROWTH RATE




LAKE LEVEL vs. DAILY GROWTH RATE

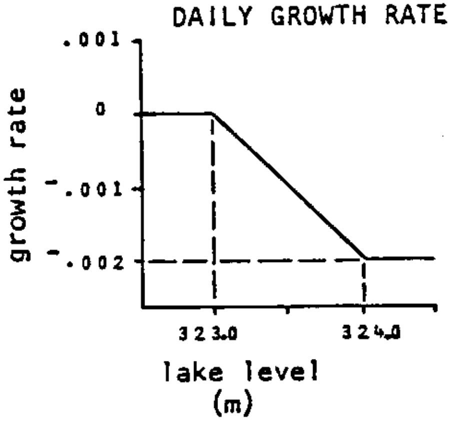
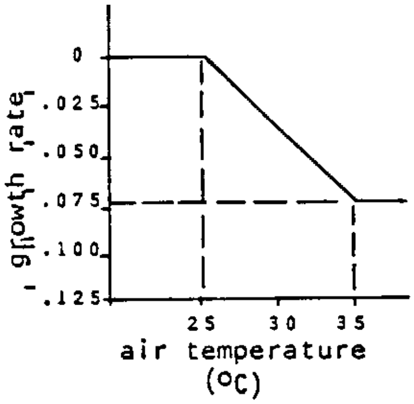



FIGURE 5.3, SHEET 2 OF 4

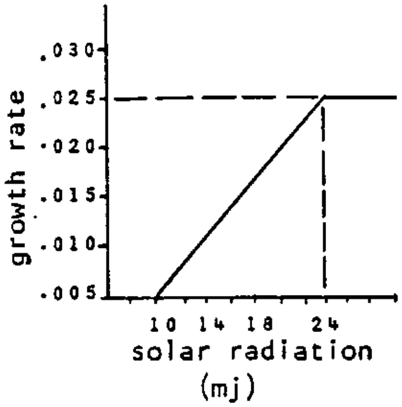
STAGE 5 - FLOWER

Growth at end of stage = .8
Factors affecting growth = Air Temperature
Solar Radiation
Precipitation

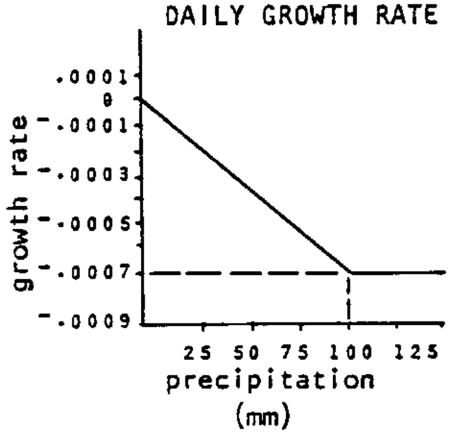
AIR TEMPERATURE
vs.
DAILY GROWTH RATE




SOLAR RADIATION
vs.
DAILY GROWTH RATE



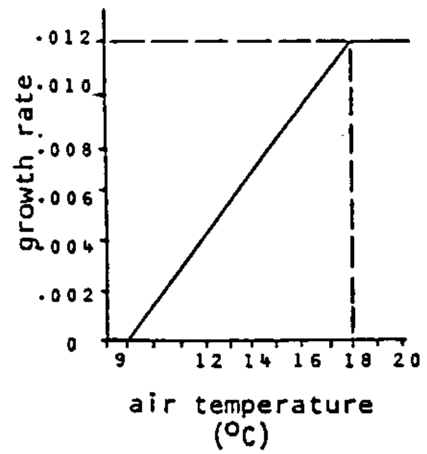

PRECIPITATION
vs.
DAILY GROWTH RATE



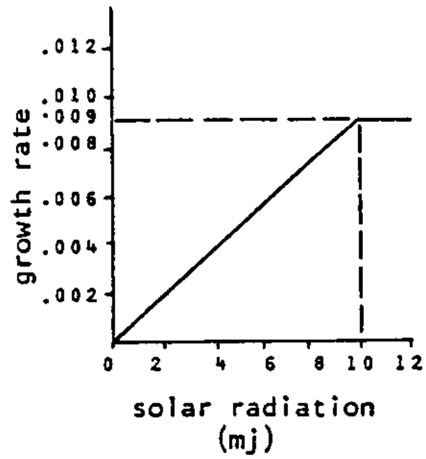

STAGE 6 - SEED

Growth at end of stage = .94
Factors affecting growth = Air Temperature
Solar Radiation
Precipitation

AIR TEMPERATURE
vs.
DAILY GROWTH RATE




SOLAR RADIATION
vs.
DAILY GROWTH RATE




PRECIPITATION
vs.
DAILY GROWTH RATE

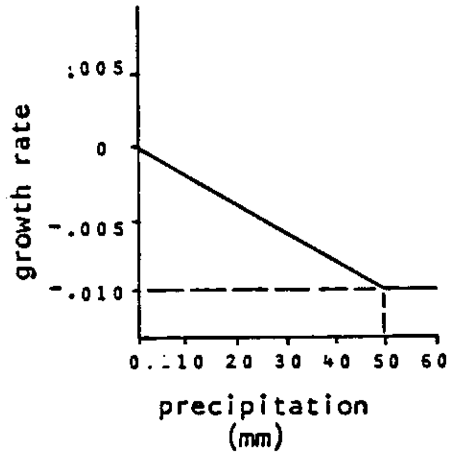



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FIGURE 5.3,SHEET 3 OF 4

STAGE 7 - SEED 2

Growth at end of stage = .0
Factors affecting growth = Air Temperature
Solar Radiation
Precipitation

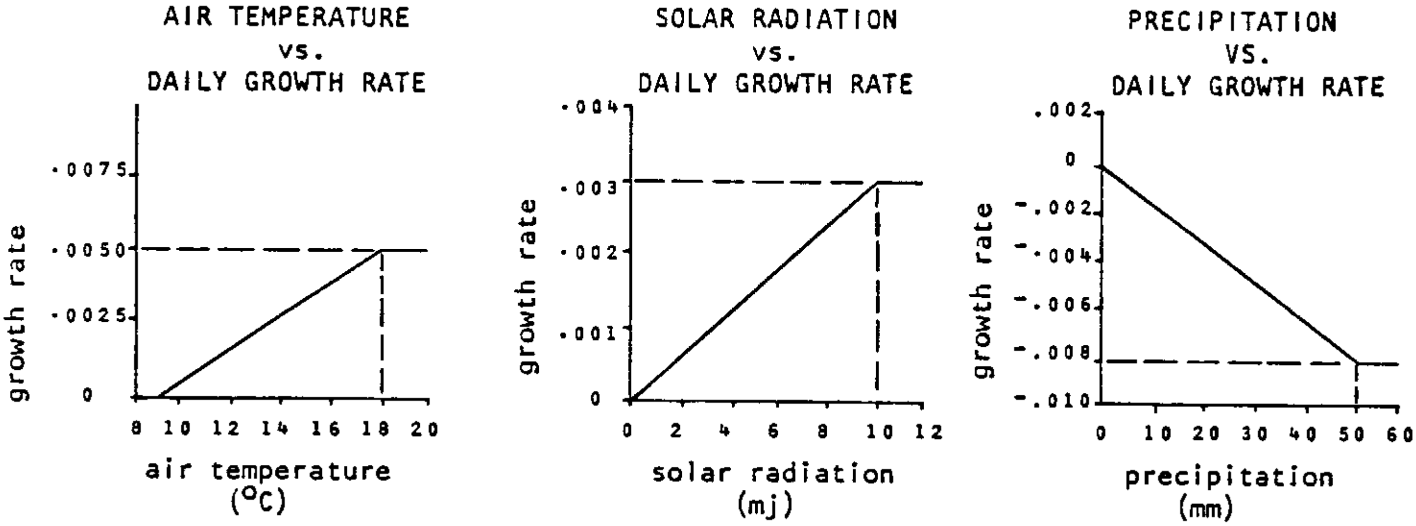
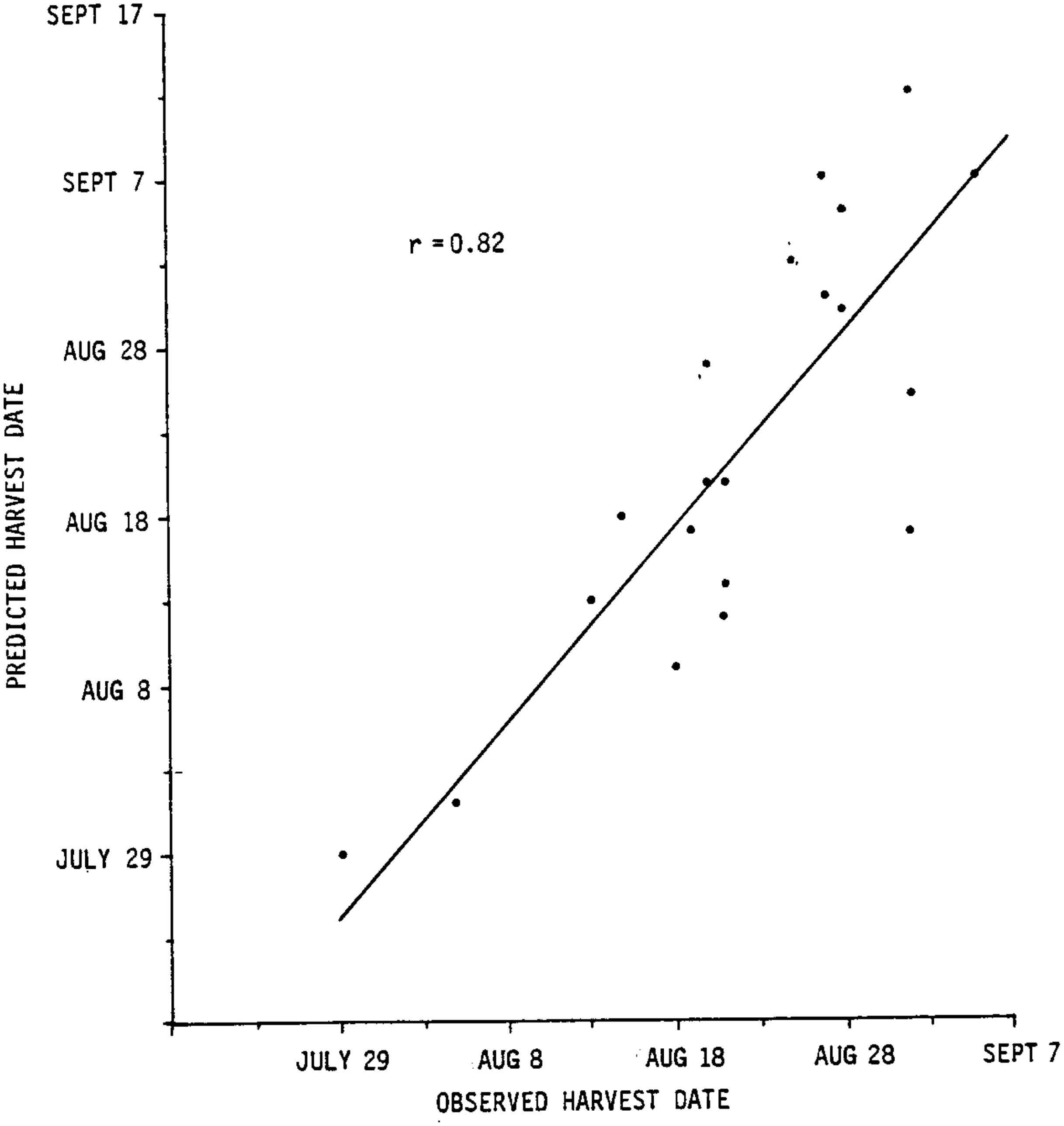
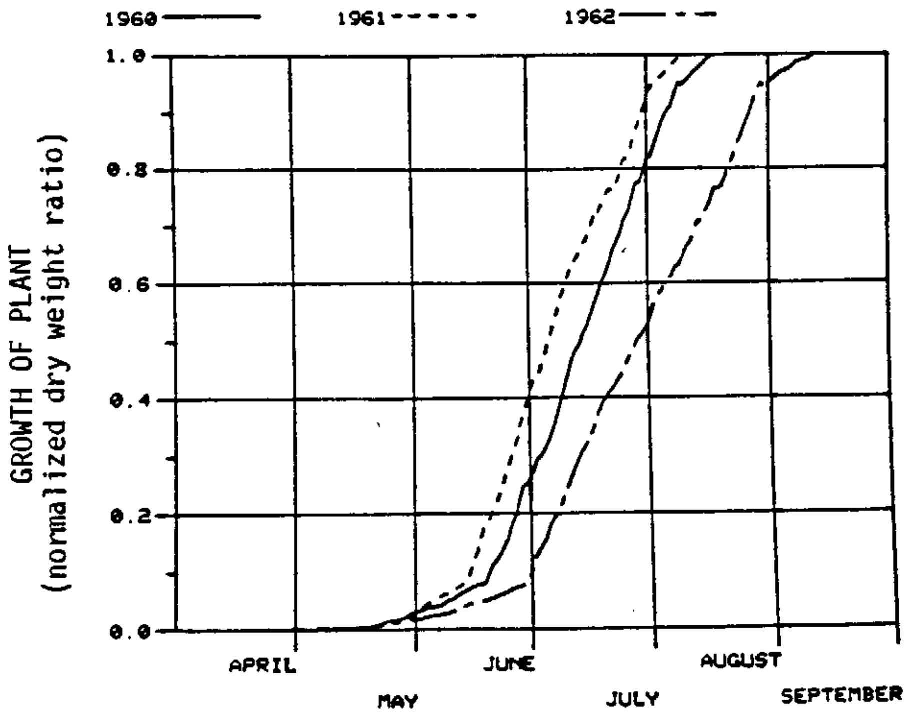


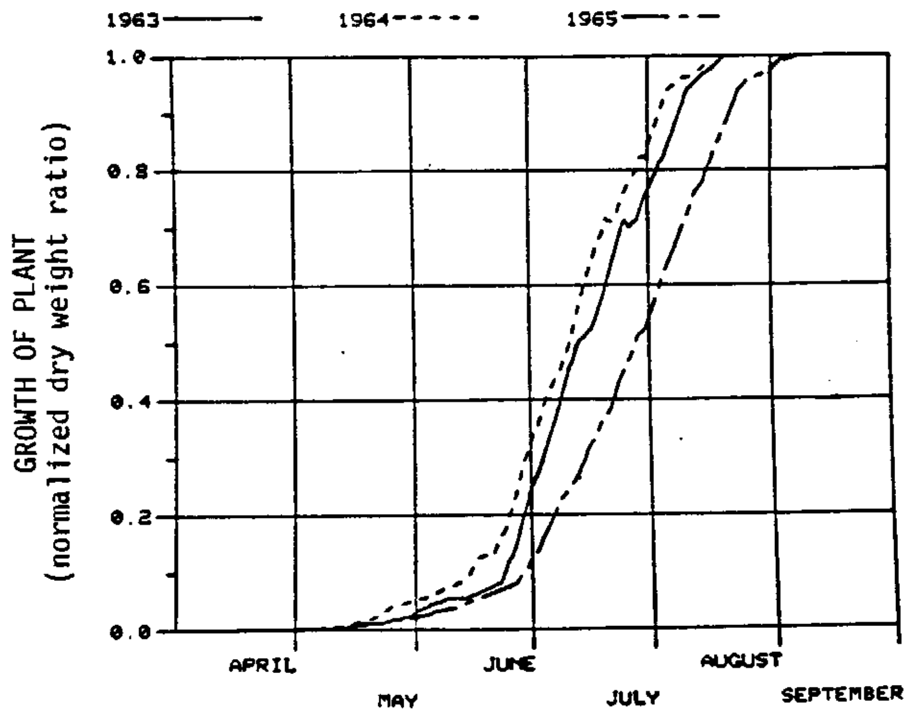

FIGURE 5.3, SHEET 4 OF 4




OBSERVED vs PREDICTED
START OF HARVEST DATES

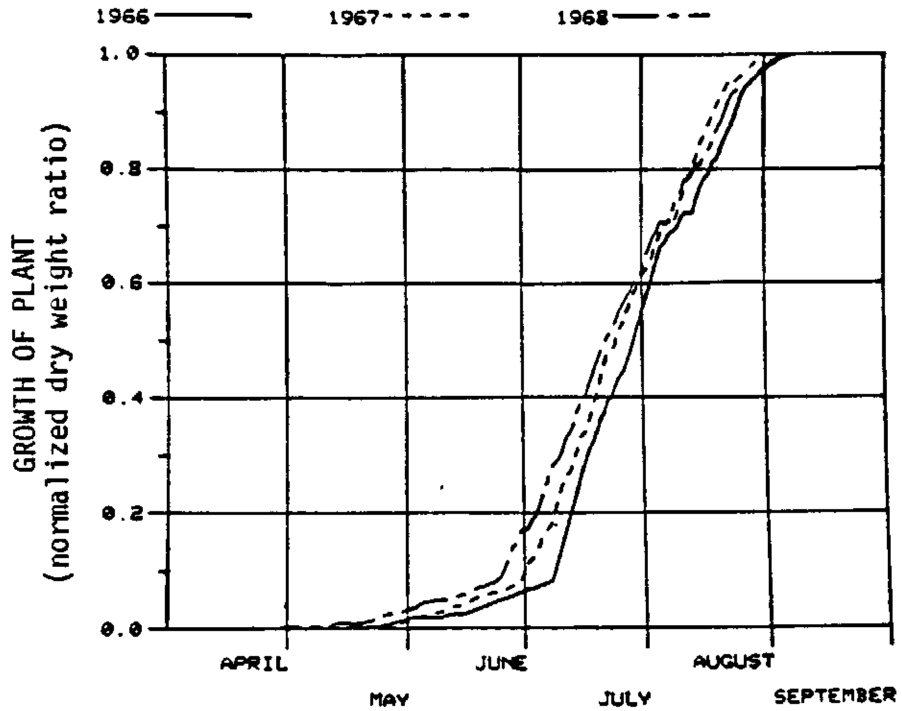
FIGURE 5.4

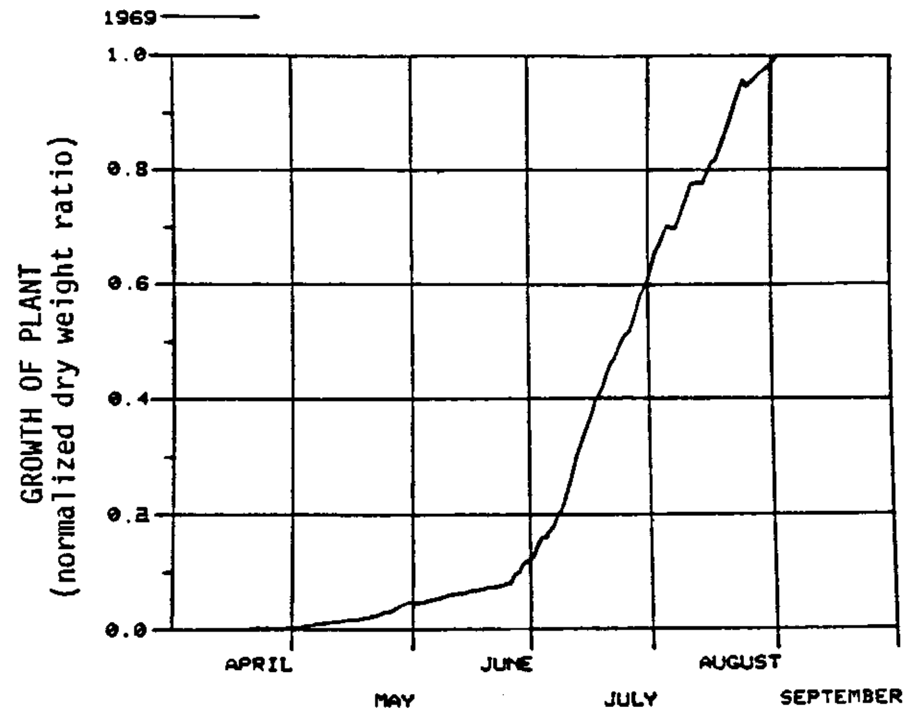



SIMULATED WILD RICE GROWTH CURVES
1960 - 1965

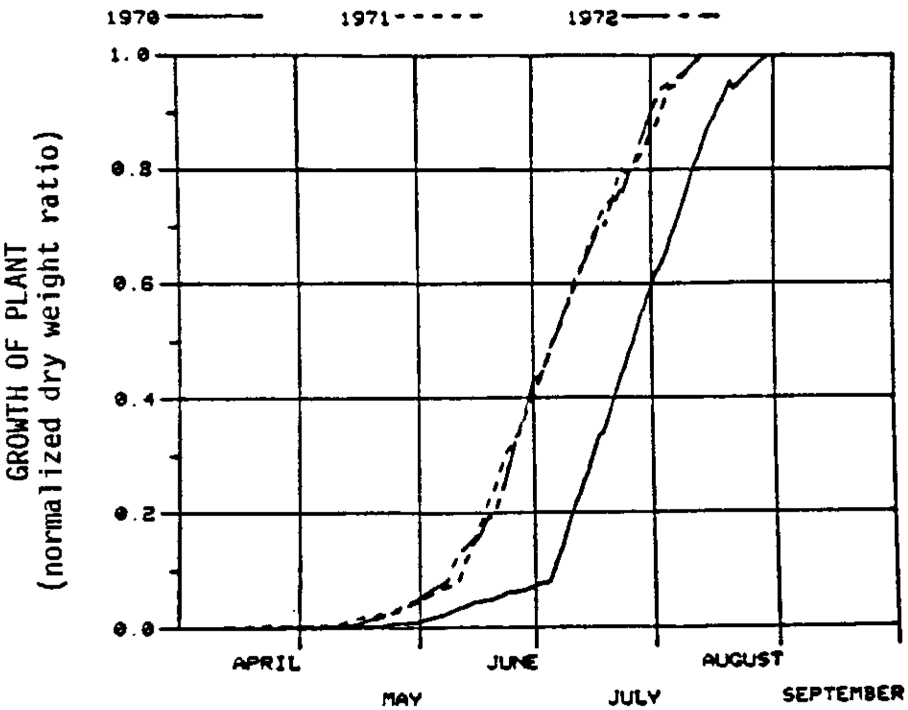
FIGURE 5.5, SHEET 1 OF 4

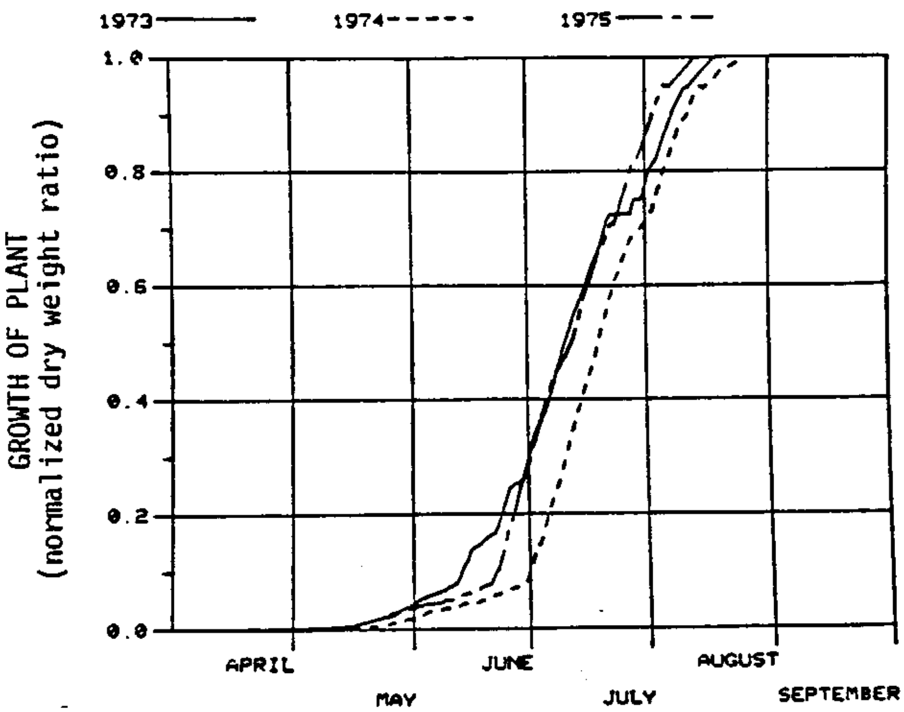



SIMULATED WILD RICE GROWTH CURVES
1966 - 1969

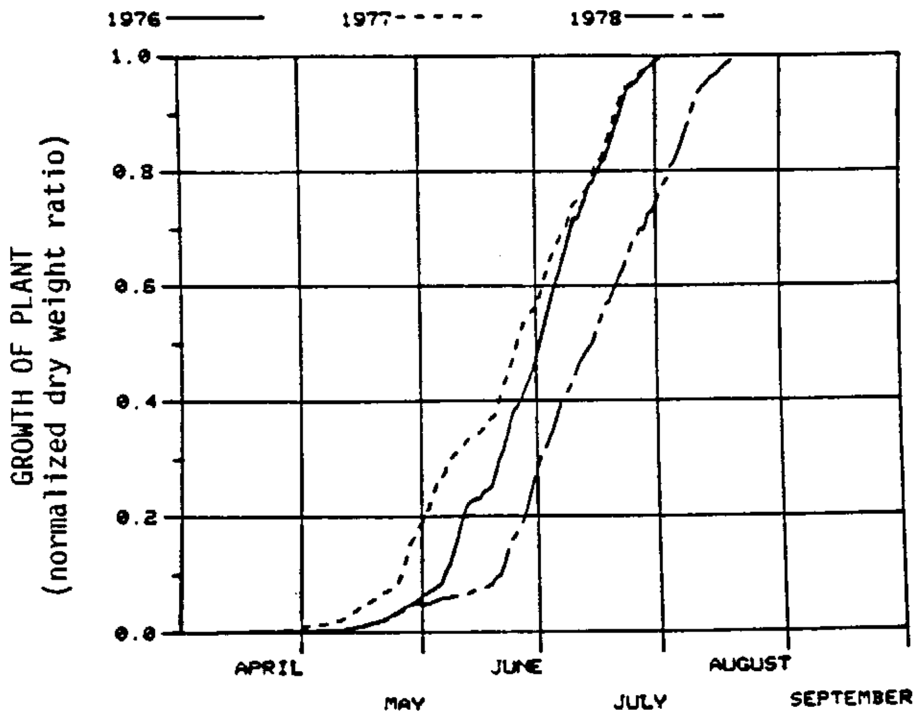
FIGURE 5.5, SHEET 2 OF 4

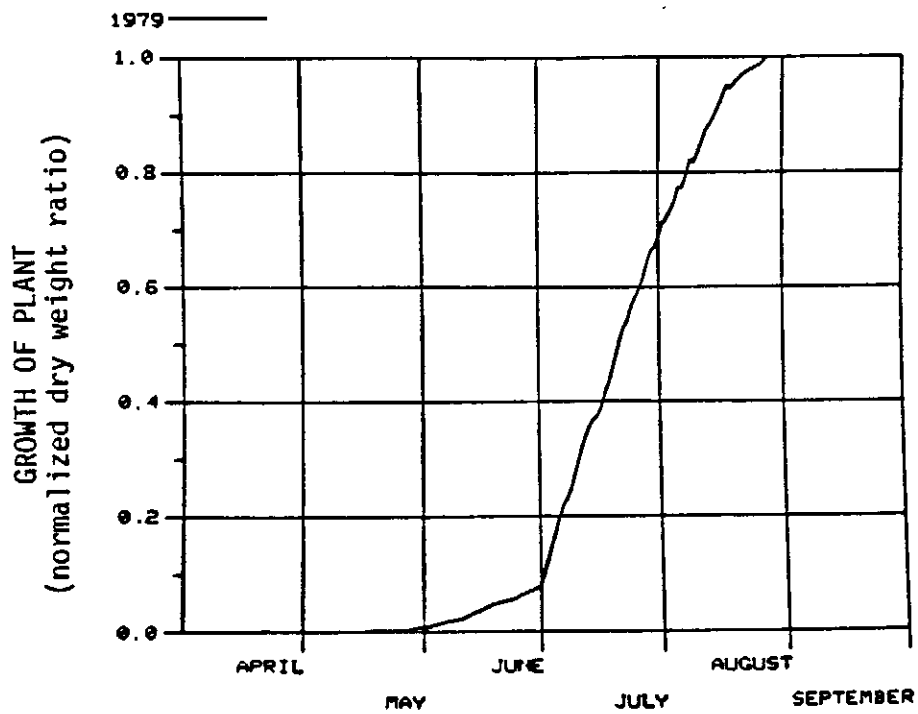



SIMULATED WILD RICE GROWTH CURVES
1970 - 1975

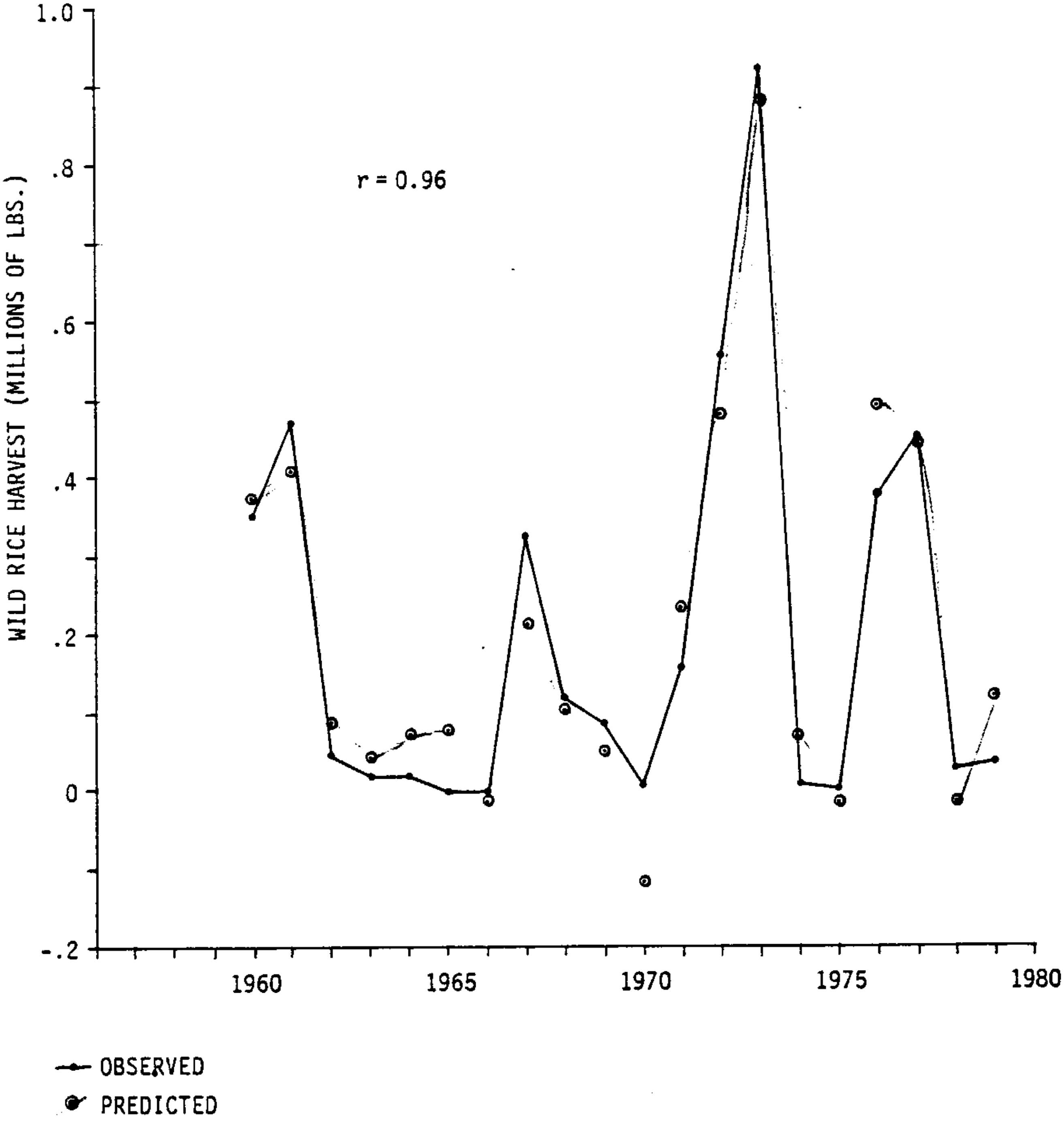
FIGURE 5.5, SHEET 3 OF 4




SIMULATED WILD RICE GROWTH CURVES
1976 - 1979

FIGURE 5.5, SHEET 4 OF 4




OBSERVED vs PREDICTED
VOLUME OF HARVEST

FIGURE 5.6

CHAPTER 6

# SIMULATION OF WATER LEVELS

## 6.1 SIMULATION MODEL FOR LAKE REGULATION

Analysis shows that the annual patterns of lake levels and flows in the English and Winnipeg River systems have changed over time. The changes exhibited in the historical record indicate an evolution of the regulation objectives rather than changes in the hydrological processes involved. For example, mean monthly outflows from Lake of the Woods, (Figure 6.1) have been modified over time to increase the flows in the winter months. Similar changes have occurred in the pattern of outflows from Rainy Lake and Lac Seul.

In order to provide sets of lake levels and flow data which approximate what would have happened if the operating rules did not change through time, a monthly simulation program was developed. The program simulates the operation of Rainy Lake, Lake of the Woods, and Lac Seul, computes month-end lake elevations and outflows, and estimates potential hydro-electric generation at all plants on the English-Winnipeg River system down to Lake Winnipeg, as illustrated in Figure 6.2. The model is based on three main assumptions as follows:

1. The inflow to each lake is known one month in advance,
2. The effects of channel storage and travel time between lakes are not taken into account,
3. Hydro-electric stations operate at the maximum efficiency

possible for the conditions which are simulated to occur.

For each lake, a set of rule curves are used to define the maximum, minimum, and target elevation for the end of each month. The objective is to reach the target elevation at the end of each month. However, when the outflow to reach target is less than the desired minimum monthly outflow, the lake level is reduced when feasible. Minimum outflows are limited in order to minimize the occurrence of levels below the lower rule curve, and high outflows are limited due to flow restrictions at the lake outlets. These "operating rules" for each lake are defined by input data to the program so that they can easily be changed to suit different requirements. Details on program operation and hydrological and other data input are outlined in Appendix D. Available data permitted simulation for the period of 1918 to 1979. Since data for Namakan Lake was available only for the period 1962 to 1979, the operation of this lake was not included in the simulation. As a result, all simulations assume the historic operation of Namakan Lake.

## 6.2 SIMULATED OPERATION WITH PRESENT OPERATING RULES

Present operating rules for the English-Winnipeg River system in terms of rule curves and minimum flows were not provided by the Lake of the Woods Control Board. For Rainy Lake, upper and lower rule curves have been set by the International Joint Commission (IJC) in 1970. From these data, a monthly target level was defined as the average of the upper and lower rule curves. However, there were no monthly rule curves available for the operation of Lac Seul or Lake of the Woods.

Approximate rule curves for Lac Seul were developed on the assumption that the period 1970 to 1979 could be taken as representative of "present" operating rules. Smoothed monthly mean, minimum and maximum month-end levels were used as initial rule curves. Monthly minimum outflows were chosen by running the simulation model and adjusting these values until the simulated outflows and lake levels were in reasonably good agreement with those recorded through 1970 to 1979.

Regulation of Lake of the Woods is governed by an international treaty ratified by Canada and the United States in 1925. Article 4 of the Lake of the Woods Convention and Protocol states that "The level of Lake of the Woods shall ordinarily be maintained between elevation 1056 ft. (321.869 m) and 1061.25 ft. (323.469 m) sea level datum, and between these two elevations the regulations shall be such as to ensure the highest continuous uniform discharge of water from the lake ...". The phrases "continuous uniform discharge" and "securing . . . the most advantageous use of the waters . . . for power . . . purposes" (Article 2) can lead to some ambiguities in formulating a consistent set of operating rules.

Monthly operating rules to approximate present objectives for regulation of Lake of the Woods were developed in a manner similar to the method used for Lac Seul. Adjustments were made in target levels and minimum outflows to reproduce as nearly as possible, flows on the Winnipeg River at Slave Falls. Since no formal optimization procedure was applied, it is possible that further adjustments could be made to the set of rules finally adopted.

The operating rules used to simulate present water control objectives are summarized in Table 6.1, and Figure 6.3 shows comparative target levels for present and preferred operating rules on Lake of the Woods, Rainy Lake and Lac Seul. In order to achieve an overall water balance, it was necessary to run the model twice. The first run was used to determine the final (December, 1979) water surface elevation at each lake. For the second run, these final elevations were used as starting elevations for each lake. This method insured that the simulations of the system had exactly the same amount of water available for hydro-electric generation. Errors in the order of 5 GWH could have resulted if this procedure had not been followed.

## 6.3 SIMULATION OF HISTORIC OPERATING RULES

The flows and lake levels which actually occurred in the period 1918 to 1979 resulted from a changing set of criteria which are referred to as "historic" operating rules. For this case, simulation was required only to provide an estimate of the potential energy generation over the period of record. Most of the hydro stations in the system were not in existence in 1918. As in all other simulations done, it was assumed that all hydro stations have been in full operation over the complete period of simulation.

A second run, labelled "Modified Historic" was done in order to provide estimates of energy generation assuming that the Lake St. Joseph diversion had been in operation throughout the period of record. These results are more comparable with the "present" and "preferred" simula-

TABLE 6.1

WINNIPEG RIVER SYSTEM -
"PRESENT" OPERATING RULES

| Month | Lower | Target | Upper | Minimum Outflow |
|---|---|---|---|---|
| | | Rainy Lake | | |
| Jan. | 337.05 | 337.17 | 337.29 | 90.0 |
| Feb. | 336.86 | 337.02 | 337.17 | 90.0 |
| Mar. | 336.68 | 336.83 | 336.99 | 90.0 |
| Apr. | 336.82 | 337.05 | 337.28 | 90.0 |
| May | 337.29 | 337.44 | 337.60 | 90.0 |
| Jun. | 337.54 | 337.65 | 337.75 | 90.0 |
| Jul. | 337.54 | 337.65 | 337.75 | 90.0 |
| Aug. | 337.54 | 337.65 | 337.75 | 90.0 |
| Sep. | 337.54 | 337.65 | 337.75 | 90.0 |
| Oct. | 337.46 | 337.61 | 337.75 | 90.0 |
| Nov. | 337.35 | 337.48 | 337.61 | 90.0 |
| Dec. | 337.23 | 337.33 | 337.44 | 90.0 |
| | | Lake of the Woods | | |
| Jan. | 322.10 | 322.74 | 323.10 | 400.0 |
| Feb. | 322.00 | 322.57 | 323.00 | 350.0 |
| Mar. | 322.00 | 322.40 | 322.90 | 300.0 |
| Apr. | 322.10 | 322.67 | 323.10 | 200.0 |
| May | 322.50 | 323.13 | 323.50 | 150.0 |
| Jun. | 322.60 | 323.20 | 323.60 | 150.0 |
| Jul. | 322.60 | 323.20 | 323.60 | 150.0 |
| Aug. | 322.60 | 323.20 | 323.60 | 150.0 |
| Sep. | 322.50 | 323.13 | 323.50 | 150.0 |
| Oct. | 322.40 | 323.08 | 323.40 | 200.0 |
| Nov. | 322.30 | 322.98 | 323.30 | 300.0 |
| Dec. | 322.20 | 322.86 | 323.20 | 350.0 |
| | | Lac Seul | | |
| Jan. | 353.70 | 355.40 | 356.60 | 350.0 |
| Feb. | 353.40 | 355.00 | 356.30 | 320.0 |
| Mar. | 353.30 | 354.70 | 356.00 | 250.0 |
| Apr. | 353.60 | 354.90 | 356.00 | 150.0 |
| May | 354.20 | 355.40 | 356.70 | 100.0 |
| Jun. | 354.60 | 356.10 | 357.20 | 100.0 |
| Jul. | 354.90 | 356.30 | 357.20 | 100.0 |
| Aug. | 355.10 | 356.40 | 357.20 | 150.0 |
| Sep. | 355.20 | 356.40 | 357.20 | 200.0 |
| Oct. | 354.90 | 356.20 | 357.20 | 250.0 |
| Nov. | 354.50 | 356.00 | 357.20 | 300.0 |
| Dec. | 354.10 | 355.70 | 357.20 | 320.0 |

tions than actual historic since the long-term average flows are the same in all cases.

## 6.4 SIMULATION WITH PREFERRED OPERATING CRITERIA

The set of operating rules presently used for regulation generally tend to give priority to hydro-electric generation, and in many years result in water level conditions which reduce the potential rice harvest. Alternative operating rules could be formulated in such a way that rice production would be maximized. Unfortunately, such policies would also be detrimental to energy generation and would result in significant economic penalties to the utilities and consumers of Ontario and Manitoba.

A more balanced approach was developed by revising the "present" summer operating rules on Lake of the Woods to improve rice production. The operating rules for Lac Seul and Rainy Lake were then adjusted in order to compensate for energy generation losses resulting from the decreased storage range and lower average levels on Lake of the Woods. Operating rules which tend to favour rice production result in slightly more frequent spills and some reduction in head at the downstream hydro-electric plants, i.e. utilization of the available water for electrical generation is somewhat decreased.

After a number of trial runs, a set of operating rules was developed which provided for significant improvements in wild rice production while minimizing the impact on hydro-electric generation. These results are discussed in the following sections and the operating rules finally selected as preferred are shown in Table 6.2 and on Figure 6.3.

TABLE 6.2

WINNIPEG RIVER SYSTEM -
"PREFERRED" OPERATING RULES

| Month | Lower | Target | Upper | Minimum Outflow |
|---|---|---|---|---|
| | | Rainy Lake | | |
| Jan. | 337.05 | 337.15 | 337.29 | 90.0 |
| Feb. | 336.86 | 336.96 | 337.17 | 90.0 |
| Mar. | 336.68 | 336.75 | 336.99 | 90.0 |
| Apr. | 336.82 | 337.07 | 337.28 | 90.0 |
| May | 337.29 | 337.40 | 337.60 | 90.0 |
| Jun. | 337.54 | 337.70 | 337.75 | 90.0 |
| Jul. | 337.54 | 337.70 | 337.75 | 90.0 |
| Aug. | 337.54 | 337.70 | 337.75 | 90.0 |
| Sep. | 337.54 | 337.70 | 337.75 | 90.0 |
| Oct. | 337.46 | 337.70 | 337.75 | 90.0 |
| Nov. | 337.35 | 337.58 | 337.61 | 90.0 |
| Dec. | 337.23 | 337.40 | 337.44 | 90.0 |
| | | Lake of the Woods | | |
| Jan. | 322.10 | 322.62 | 323.10 | 400.0 |
| Feb. | 322.00 | 322.46 | 323.00 | 350.0 |
| Mar. | 322.00 | 322.32 | 322.90 | 300.0 |
| Apr. | 322.10 | 322.57 | 323.10 | 200.0 |
| May | 322.50 | 322.93 | 323.50 | 150.0 |
| Jun. | 322.60 | 323.00 | 323.60 | 150.0 |
| Jul. | 322.60 | 323.04 | 323.60 | 150.0 |
| Aug. | 322.60 | 323.04 | 323.60 | 150.0 |
| Sep. | 322.50 | 323.00 | 323.50 | 150.0 |
| Oct. | 322.40 | 322.95 | 323.40 | 200.0 |
| Nov. | 322.30 | 322.85 | 323.30 | 300.0 |
| Dec. | 322.20 | 322.73 | 323.20 | 350.0 |
| | | Lac Seul | | |
| Jan. | 353.70 | 355.55 | 356.60 | 350.0 |
| Feb. | 353.40 | 355.15 | 356.30 | 320.0 |
| Mar. | 353.30 | 354.70 | 356.00 | 250.0 |
| Apr. | 353.60 | 354.90 | 356.00 | 150.0 |
| May | 354.20 | 355.50 | 356.70 | 100.0 |
| Jun. | 354.60 | 356.20 | 357.20 | 100.0 |
| Jul. | 354.90 | 356.45 | 357.20 | 100.0 |
| Aug. | 355.10 | 356.55 | 357.20 | 150.0 |
| Sep. | 355.20 | 356.55 | 357.20 | 200.0 |
| Oct. | 354.90 | 356.35 | 357.20 | 250.0 |
| Nov. | 354.50 | 356.15 | 357.20 | 300.0 |
| Dec. | 354.10 | 355.85 | 357.20 | 320.0 |

## 6.5 IMPACT OF OPERATING RULES ON WILD RICE PRODUCTION

The simulations discussed in the previous sections produced records of monthly flows, water levels and energy generation as they would have occurred for each set of assumed operating criteria. Monthly water levels thus obtained were then input to the wild rice harvest model in order to provide an estimate of the potential rice harvest for each of the years simulated. A frequency analysis of the predicted rice harvests for Lake of the Woods is presented in Figure 6.4. These results indicate that the "preferred" operating rules improve both the reliability and the average yield of wild rice harvests.

The model predicts that for historical conditions, crop failures (less than 50,000 lbs.) would have occurred on the average of once every three years. If the "present" operating rules had been in effect since 1918, crop failures would have occurred approximately once every five years, but "preferred" operating rules would have reduced the frequency of crop failures to approximately once in twelve years. For historical (actual) conditions, the model predicts an average annual harvest of 211,000 lbs. of green rice. Simulated present operating rules would have reduced this to 199,000 lbs., and the preferred operating rules would yield an average of 265,000 lbs. of green rice. These values apply to Lake of the Woods only.

It is interesting to note that the preferred operating rules have no significant effect on the size or frequency of bumper crops. Although present operating rules are predicted to yield less wild rice on the average, the reliability of the annual rice harvest has been significantly improved over historic conditions.

Estimates of the rice harvests which would have occurred on Lake of the Woods under natural (unregulated) conditions are also shown in Figure 6.4. Month-end lake levels used for this analysis were taken from charts provided by the Lake of the Woods Control Board. In this case, a datum of 319.008 m was used in the 8 parameter model. The average harvest predicted for natural conditions was 250,000 lbs. The frequency analysis indicates that under natural conditions, the number of years in which harvests are in the range of 200,000 to 600,000 lbs. is greater than have occurred historically, but that the frequency of crop failures is slightly increased also.

Models for rice production on Rainy Lake and the English River (Figures 6.5, 6.6 and 6.7) were also prepared based on the 8 parameter model developed for Lake of the Woods. In these cases, the predicted rice harvests were adjusted by a factor equal to the ratio of the mean harvest observed to the mean harvest predicted in order to "calibrate" the model for these areas. Correlations of these models with observed harvests were not good ($r^2$ less than 0.5). This is mainly due to the fact that the rice production records include a large proportion of waters whose levels are not directly related to those in the water bodies under study. Considerably more detailed field data would be required to provide a calibration of the modelled rice production in water bodies to the same level of accuracy as the Lake of the Woods model.

The model for Rainy Lake, after adjustment to match the appropriate proportions of the Fort Frances harvest area record, predicts that average harvests would decrease from 38,000 lbs. for simulated present conditions to approximately 33,000 lbs. under preferred operating conditions. On the Winipeg River, average annual rice harvests are predicted to increase from 54,000 lbs. under simulated present operating conditions to 58,000 lbs. if the preferred operating rules were adopted, while on the English River, they would increase from 21,000 to 23,000 lbs. These predictions are uncertain since recorded harvest for these water bodies cannot be isolated for model calibrations.

As shown in Table 6.3, the models indicate that adoption of "preferred" operating rules would increase the total annual rice harvests by more than 65,000 lbs. This increase would be realized in all of the study area with the exception of Rainy Lake, which would be slightly decreased as a result of the adoption of "preferred" operating rules. Most of the improvement would occur on Lake of the Woods, by far the largest producing unit of the study area.

## 6.6 IMPACT OF OPERATING RULES ON LAKE LEVELS, FLOWS AND ENERGY GENERATION

Mean month-end lake elevations and monthly outflows for the simulations outlined in the previous sections are presented in Figures 6.8 through 6.11. Reductions in summer levels on Lake of the Woods under "preferred" operating rules are partially compensated for by slight increases in storage on Rainy Lake and Lac Seul. These changes are also indicated in the frequency analysis of lake levels and flows, Figures 6.12 through 6.15. The differences in flows between the "pre-

TABLE 6.3

IMPACT OF OPERATING RULES
ON WILD RICE PRODUCTION

| | Average Annual Harvest (Thousands of lbs.) | | |
|---|---|---|---|
| | Historic | Present | Preferred |
| Lake of the Woods | 211 | 199 | 265 |
| Winnipeg River | 62 | 54 | 58 |
| Fort Frances | 52 | 38 | 33 |
| English River | 21 | 21 | 23 |
| TOTAL | 346 | 312 | 379 |

sent" and "preferred" cases are generally quite small.

Computed monthly energy generation for the three cases is presented in Figures 6.16 and 6.17, and frequency analyses of monthly energy generation for some selected generating units are presented in Figures 6.18 through 6.22. The results for the Kenora units show that the reduction in monthly energy generation is distributed throughout most months. The greatest differences occur at the extremes. During the high flow months, there is a greater probability of spills in preferred operation, and during low flow months, there is a greater probability of reduced flows. Both of these occurrences result from the lowered operating range on Lake of the Woods.

Average annual energy generation at each of the units simulated are presented in Table 6.4. These results indicate that "preferred" operation would cause an average net loss in generation capability of approximately 7 GWH per year. A seasonal analysis of energy generation, Table 6.5 shows that adoption of the "preferred" operating rules would result in an average net loss of 17.5 GWH per year in summer generation, and an average net gain of approximately 10.5 GWH per year in winter.

TABLE 6.4

AVERAGE ANNUAL ENERGY GENERATION (GWH)
ENGLISH-WINNIPEG RIVER SYSTEM 1918-1979

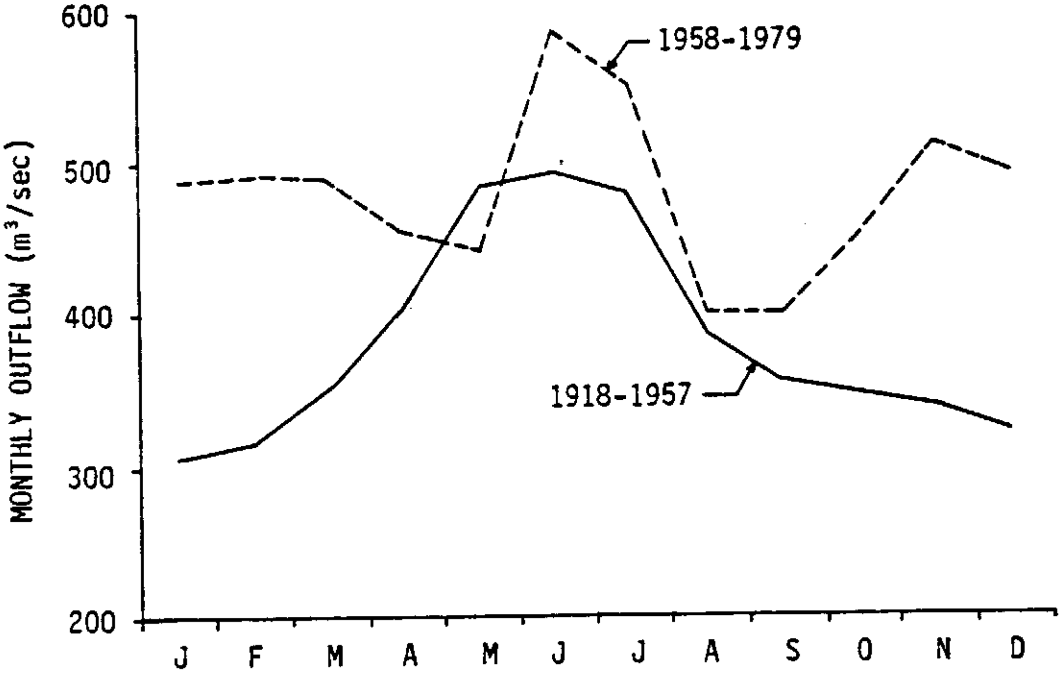
| Generating Unit | Historic | Modified Historic | "Present" Rules | "Preferred" Rules |
|---|---|---|---|---|
| Ear Falls | 110.0 | 126.1 | 126.8 | 127.2 |
| Manitou | 341.7 | 391.5 | 389.3 | 390.4 |
| Caribou | 469.9 | 524.0 | 523.1 | 523.7 |
| TOTAL - English River | 921.7 | 1041.6 | 1039.2 | 1041.3 |
| Fort Frances | 133.4 | 133.8 | 131.7 | 132.5 |
| Kenora | 112.1 | 112.0 | 102.7 | 99.8 |
| Whitedog | 392.9 | 392.4 | 378.7 | 378.2 |
| Winnipeg River Plants | 3711.0 | 3896.4 | 3873.8 | 3867.1 |
| TOTAL - Winnipeg River | 4349.4 | 4534.6 | 4486.9 | 4477.6 |
| TOTAL GENERATION | 5271.1 | 5576.2 | 5526.1 | 5518.9 |

TABLE 6.5

SEASONAL ANALYSIS OF ENERGY GENERATION (GWH)

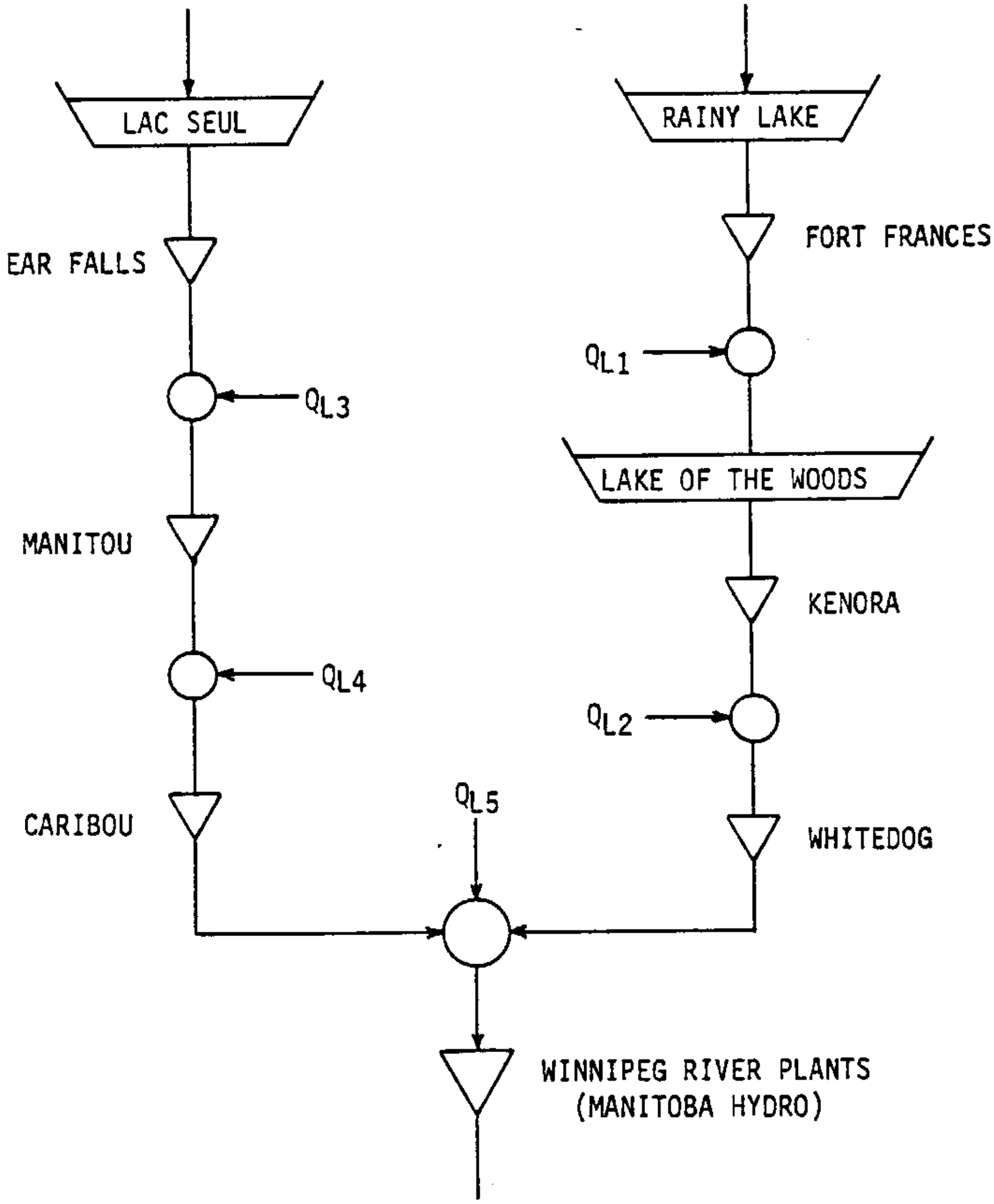
| | Historic | | Present | | Preferred | |
|---|---|---|---|---|---|---|
| | Summer | Winter | Summer | Winter | Summer | Winter |
| Winnipeg River | 2204.6 | 2144.6 | 2008.6 | 2478.0 | 1996.1 | 2481.4 |
| English River | 460.7 | 461.2 | 471.7 | 567.5 | 466.9 | 574.5 |
| TOTAL | 2665.4 | 2605.8 | 2480.5 | 3045.5 | 2463.0 | 3056.0 |

FIGURES




MEAN MONTHLY OUTFLOW
LAKE OF THE WOODS

FIGURE 6.1



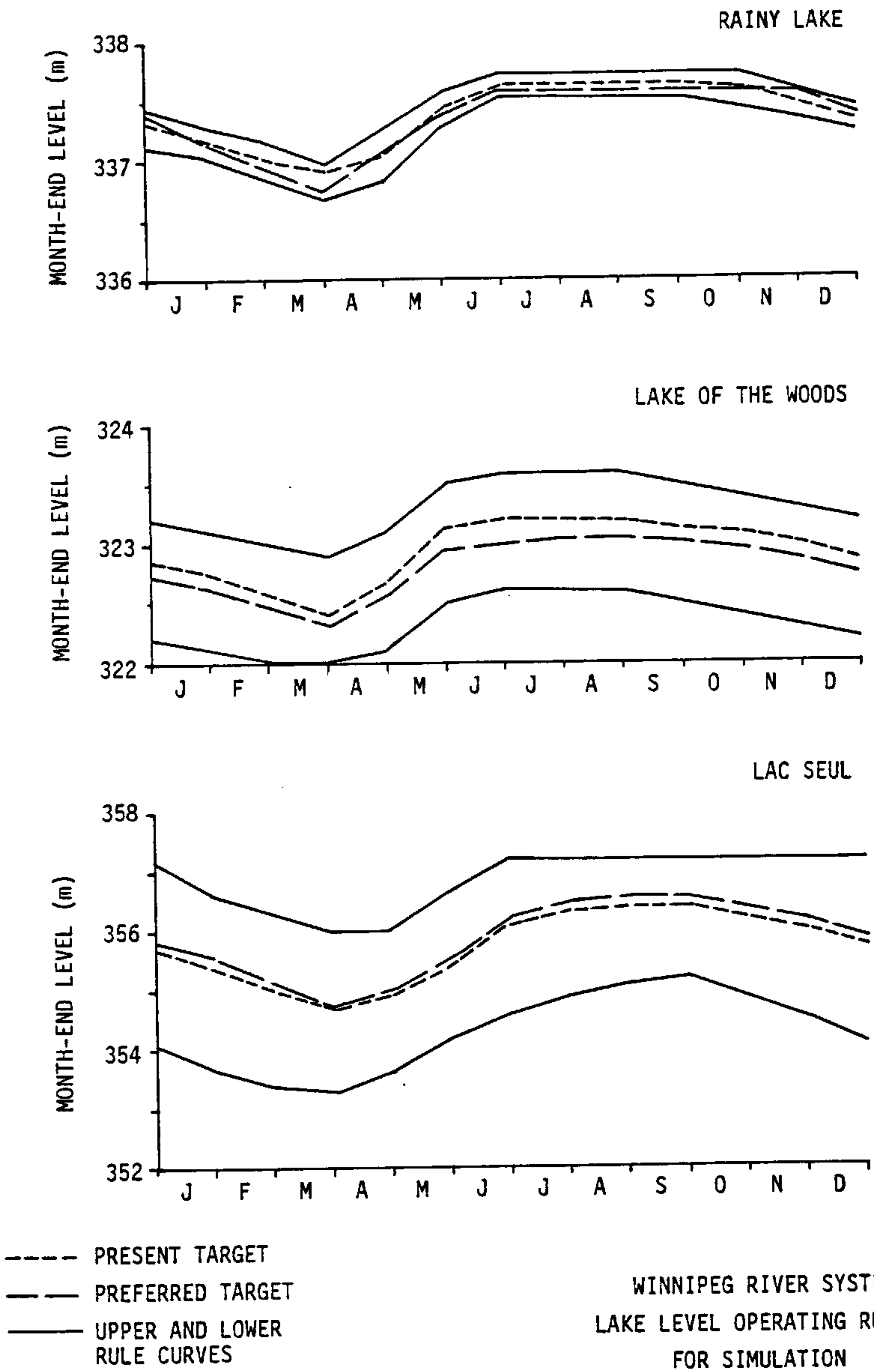

▽ HYDRO GENERATING UNIT

$Q_{L3}$ LOCAL INFLOW

REGULATED LAKE

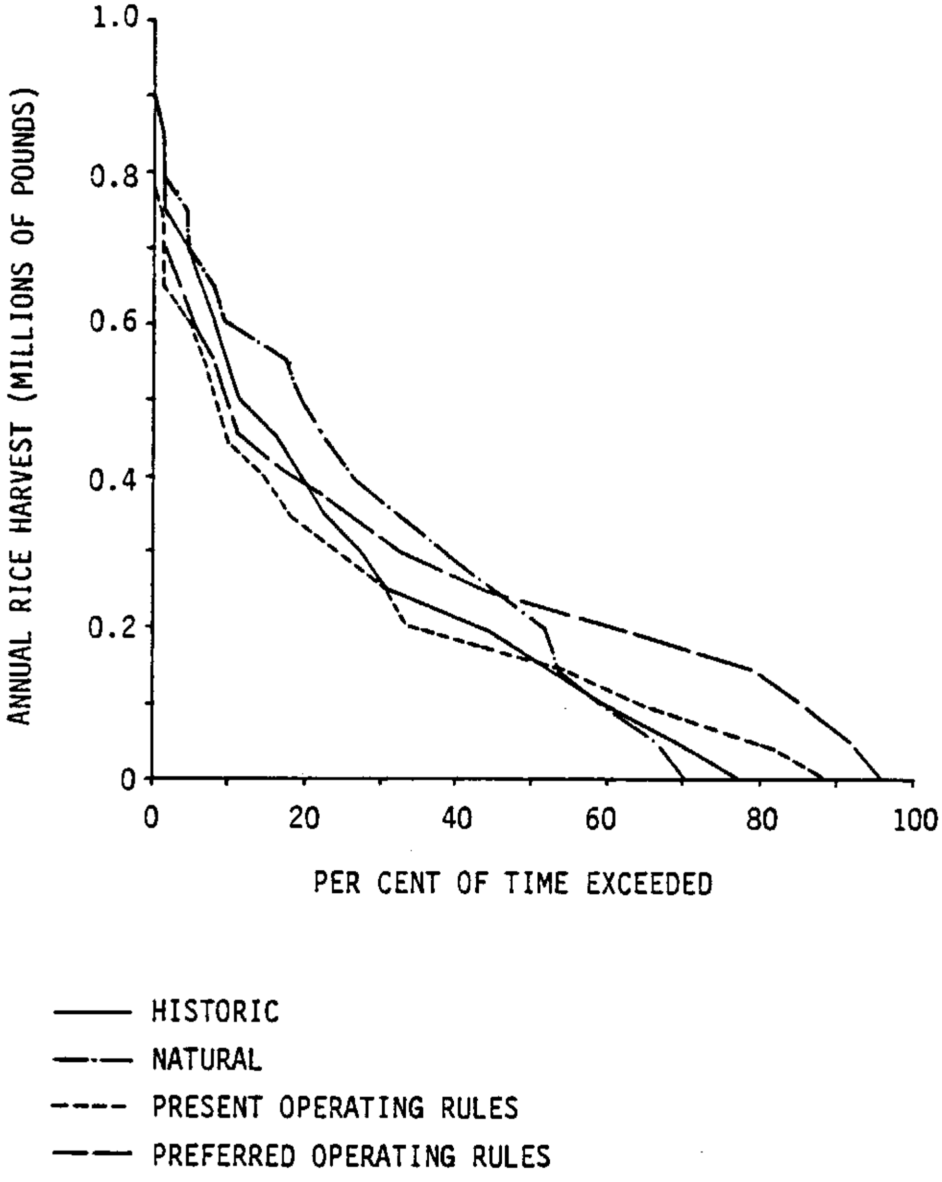
SIMULATION MODEL OF
WINNIPEG RIVER SYSTEM

FIGURE 6.2




WINNIPEG RIVER SYSTEM
LAKE LEVEL OPERATING RULES
FOR SIMULATION

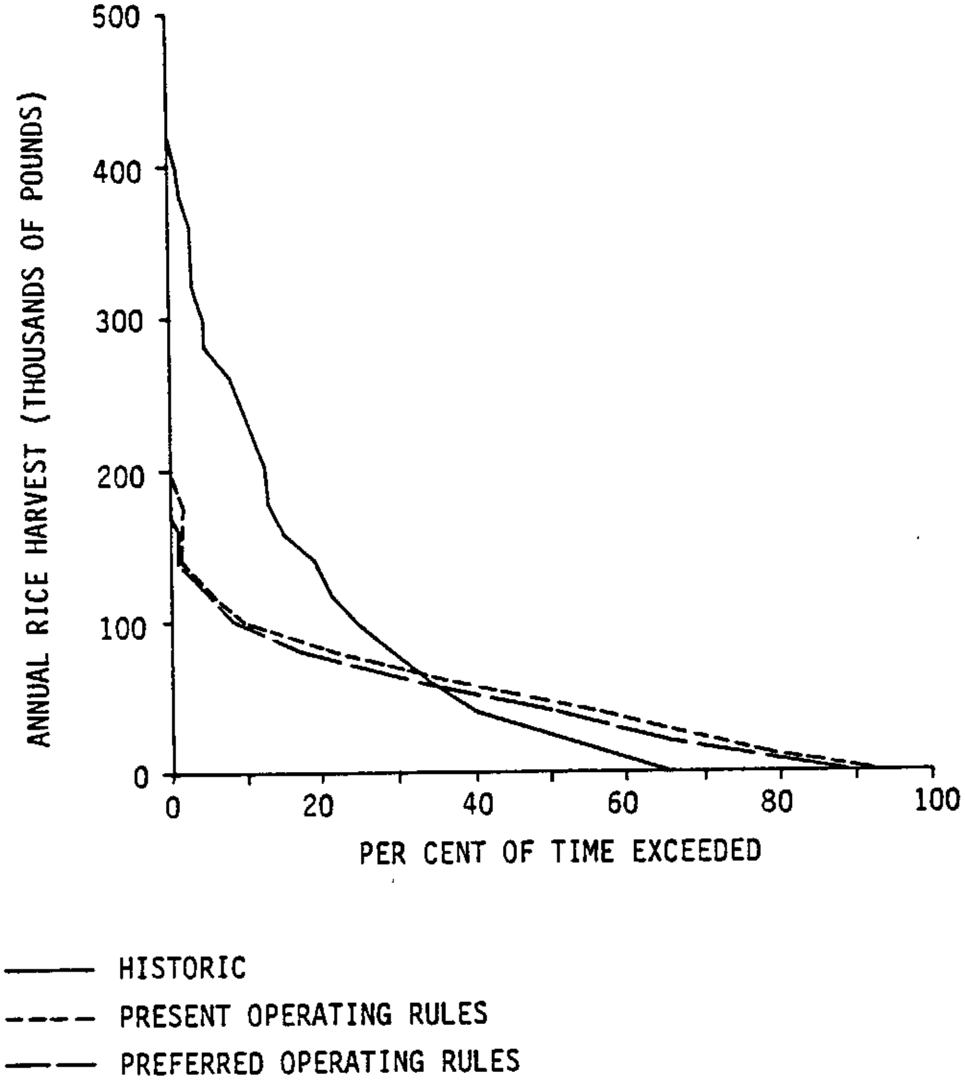
FIGURE 6.3




PROBABILITY DISTRIBUTION OF
ANNUAL RICE HARVESTS
LAKE OF THE WOODS

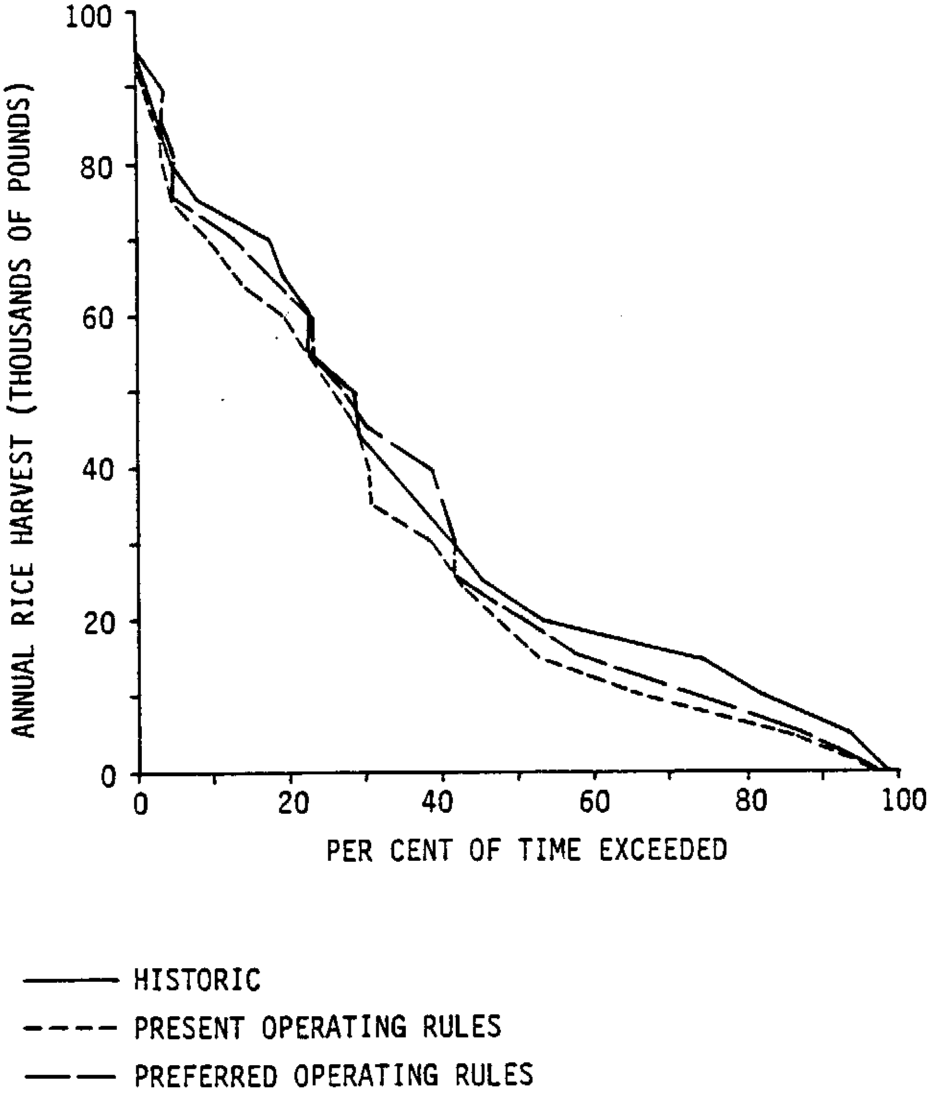
FIGURE 6.4

UNIES Ltd.



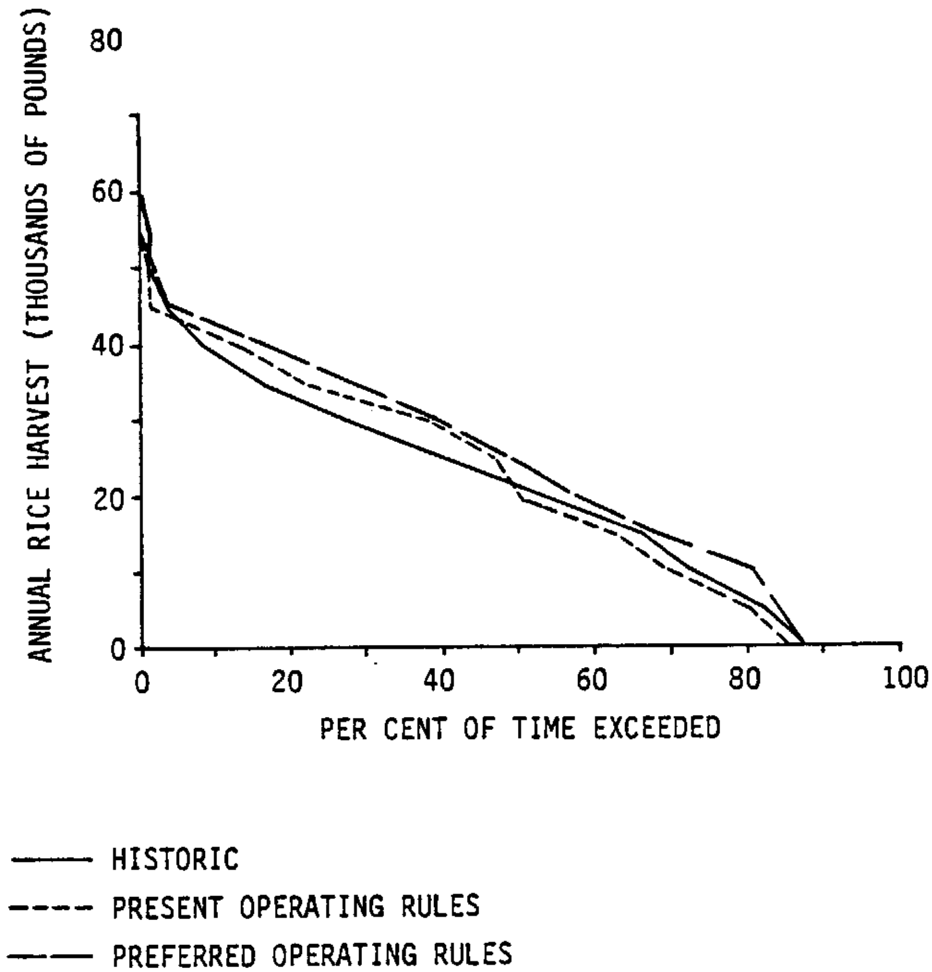

PROBABILITY DISTRIBUTION OF
ANNUAL RICE HARVESTS
FORT FRANCES (RAINY LAKE)

FIGURE 6.5



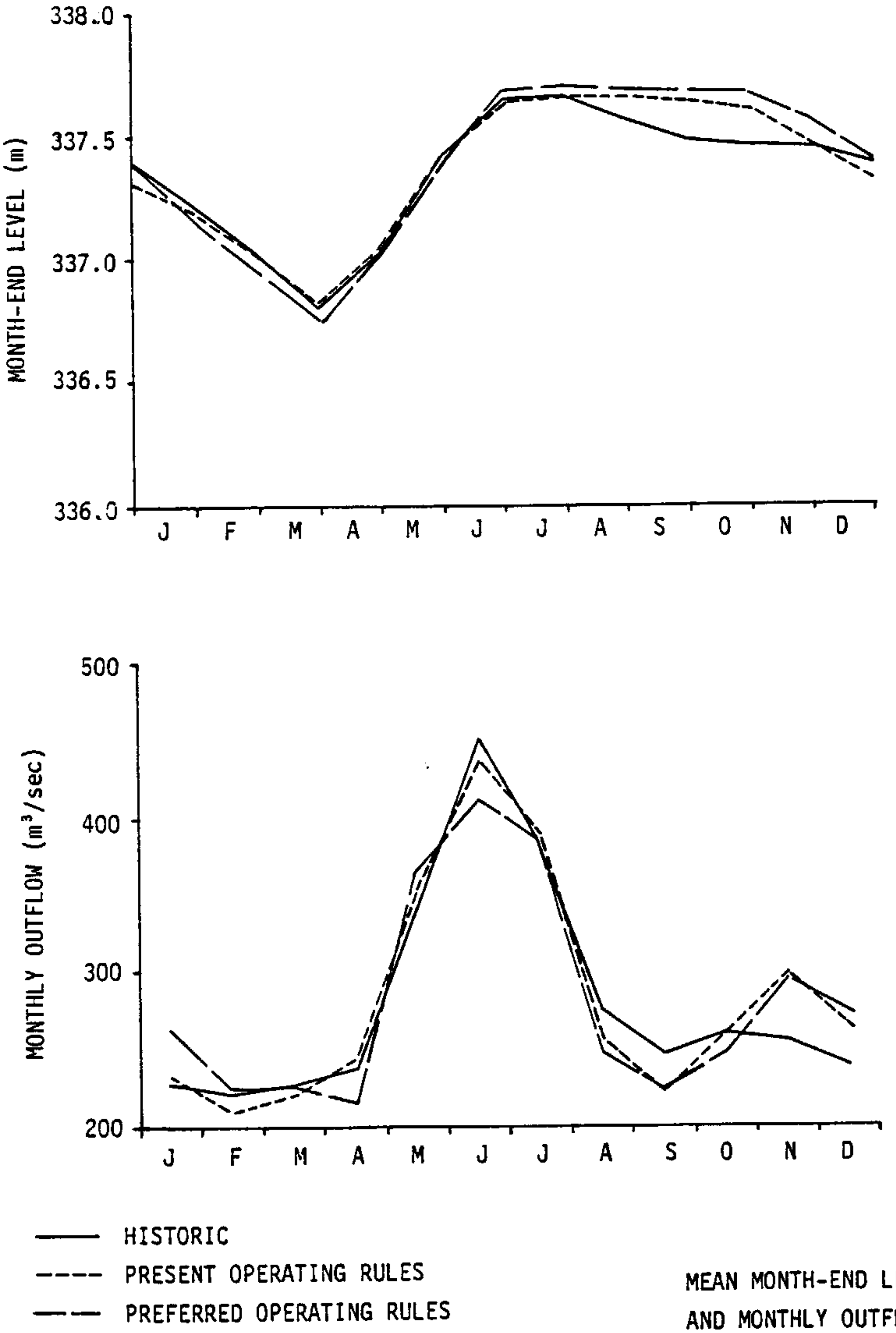

PROBABILITY DISTRIBUTION OF
ANNUAL RICE HARVESTS
WINNIPEG RIVER

FIGURE 6.6



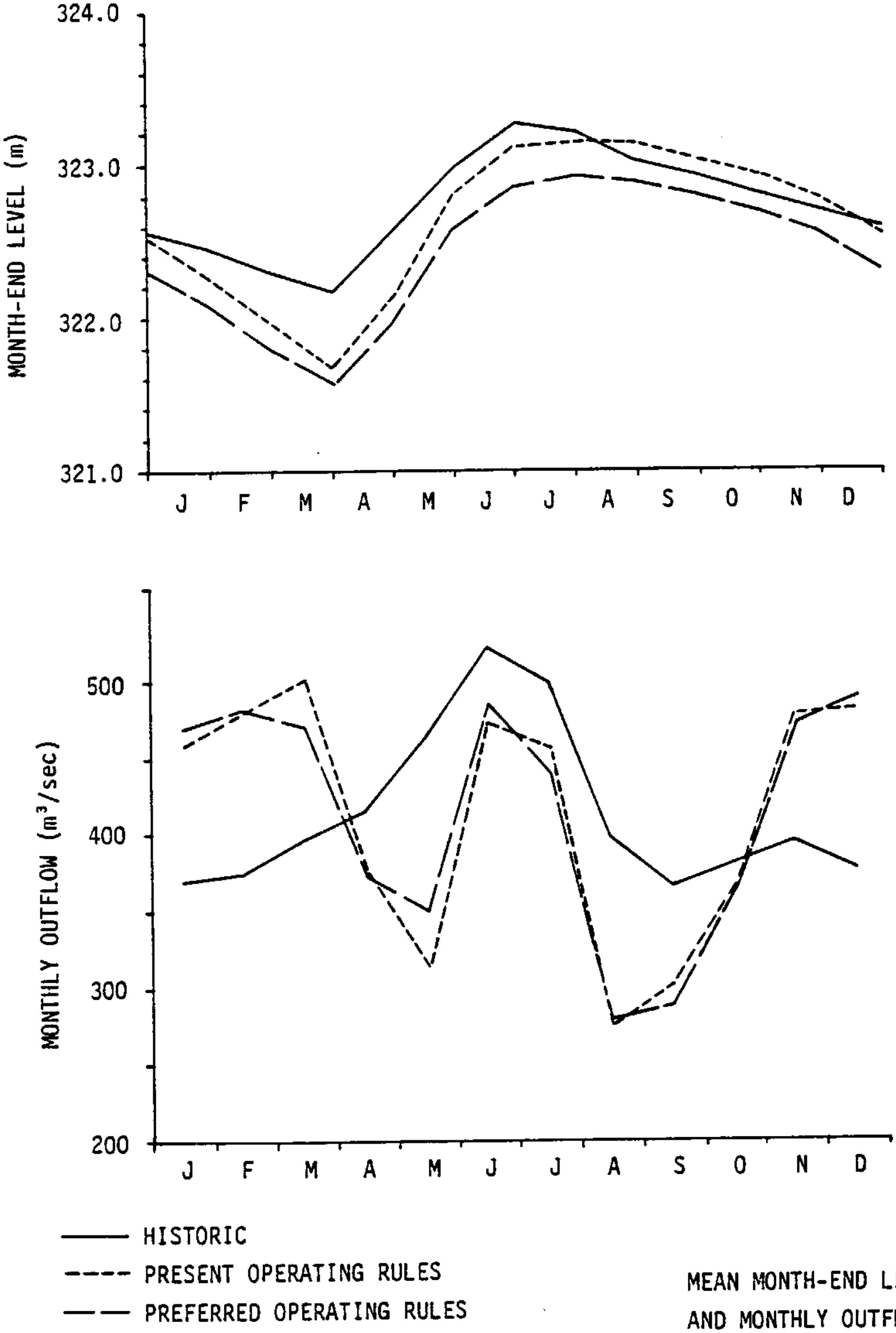

PROBABILITY DISTRIBUTION OF
ANNUAL RICE HARVESTS
ENGLISH RIVER

FIGURE 6.7



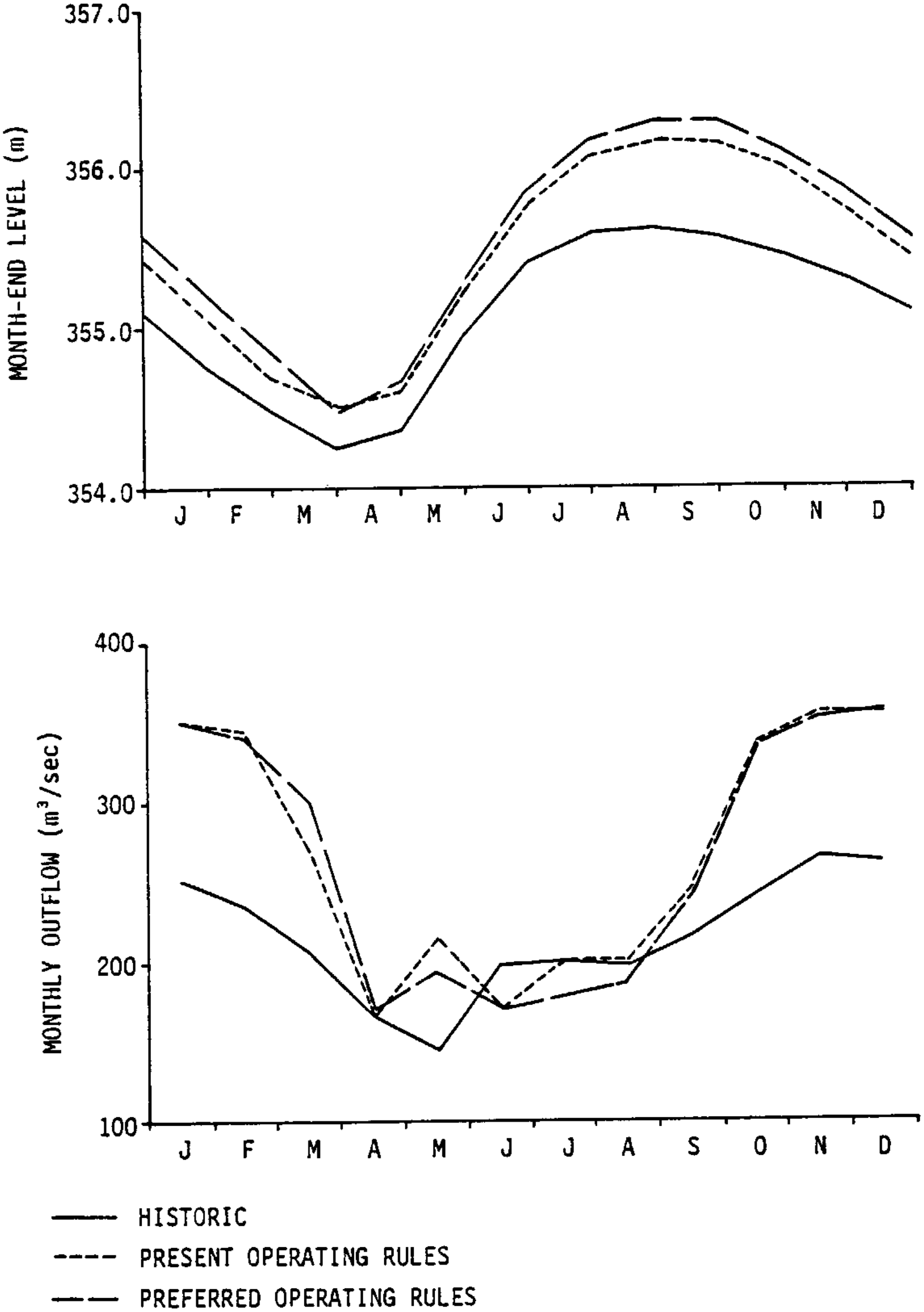

MEAN MONTH-END LEVELS
AND MONTHLY OUTFLOWS
RAINY LAKE

FIGURE 6.8



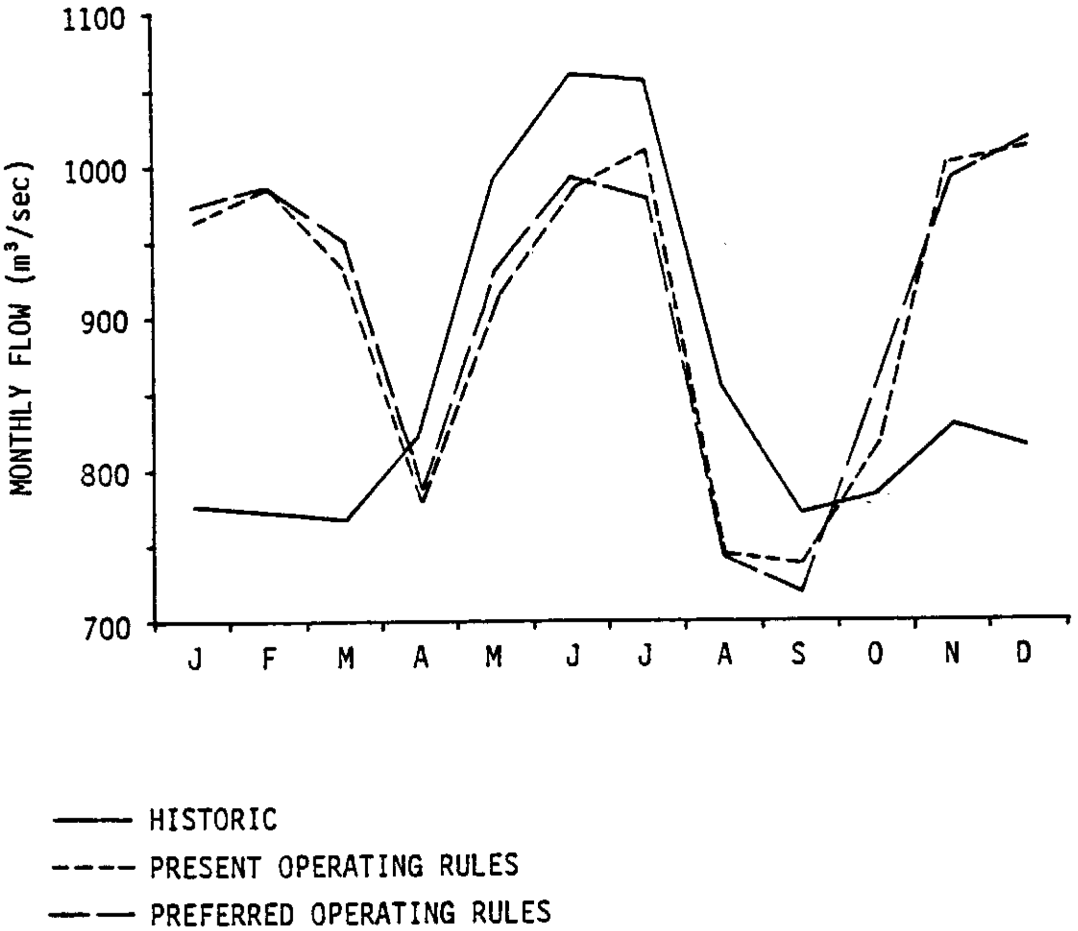

MEAN MONTH-END LEVELS
AND MONTHLY OUTFLOWS
LAKE OF THE WOODS

FIGURE 6.9



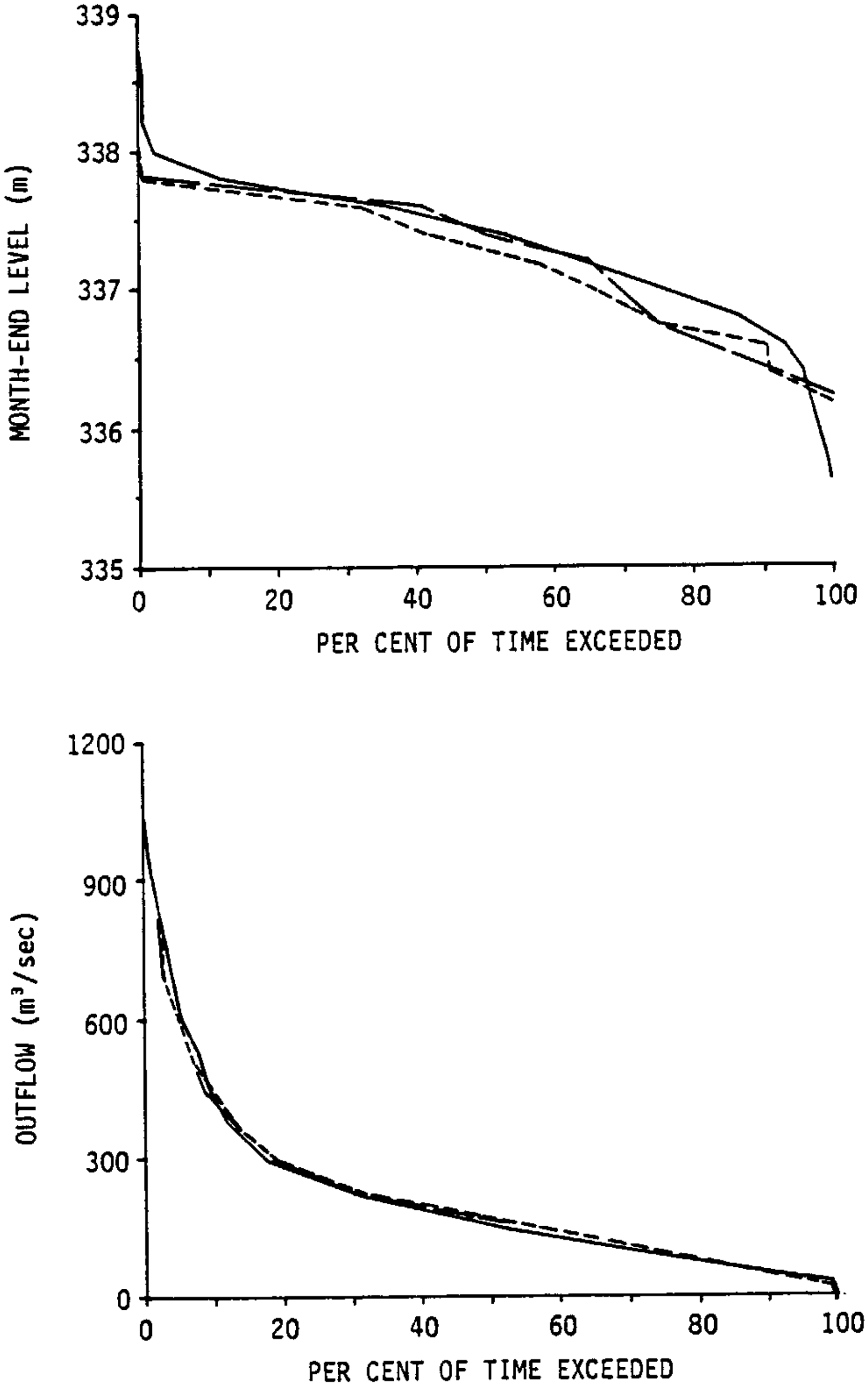

MEAN MONTH-END LEVELS
AND MONTHLY OUTFLOWS
LAC SEUL

FIGURE 6.10




MEAN MONTHLY FLOWS
WINNIPEG RIVER AT SLAVE FALLS

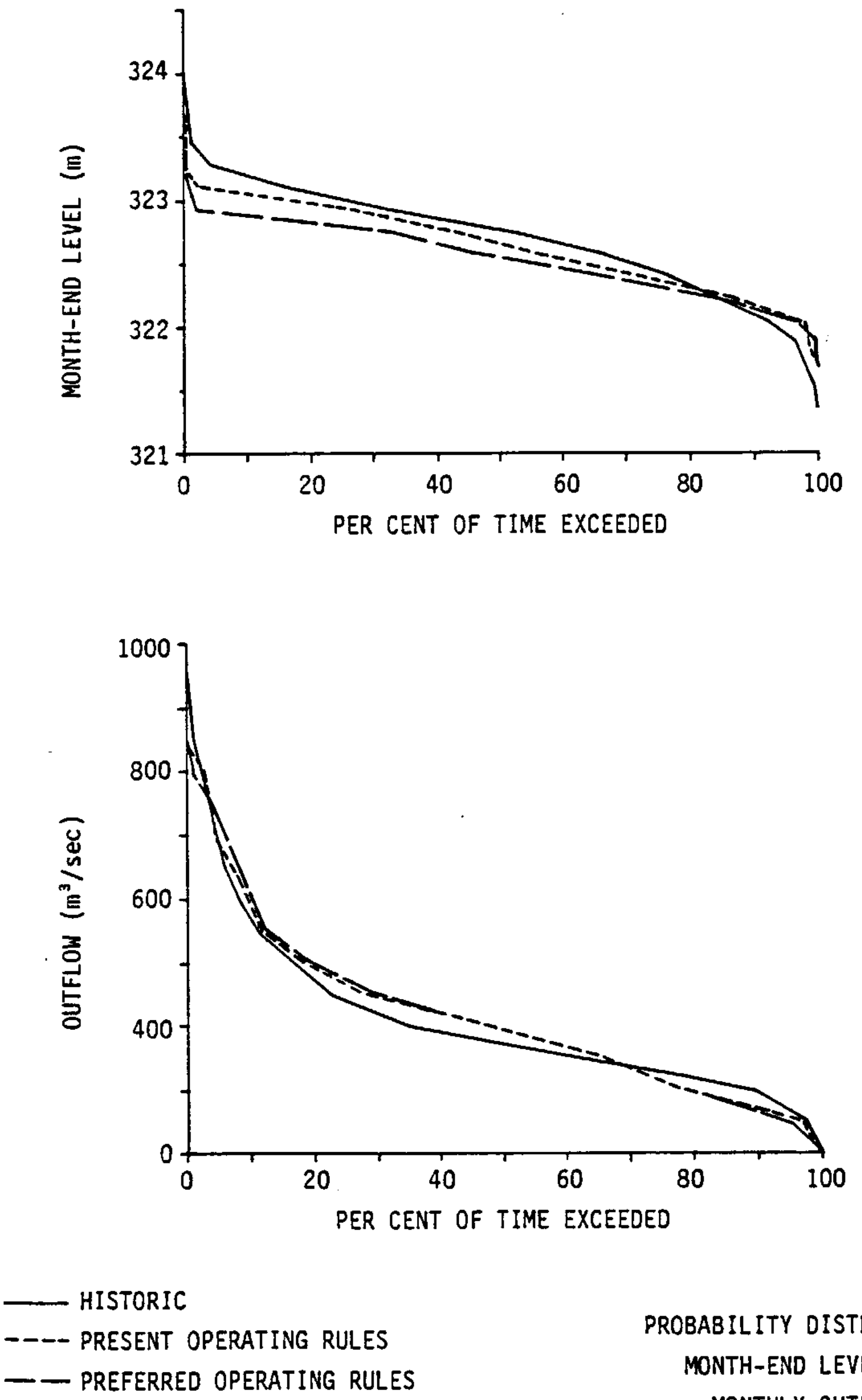
FIGURE 6.11




——— HISTORIC
- - - - PRESENT OPERATING RULES
— — — PREFERRED OPERATING RULES

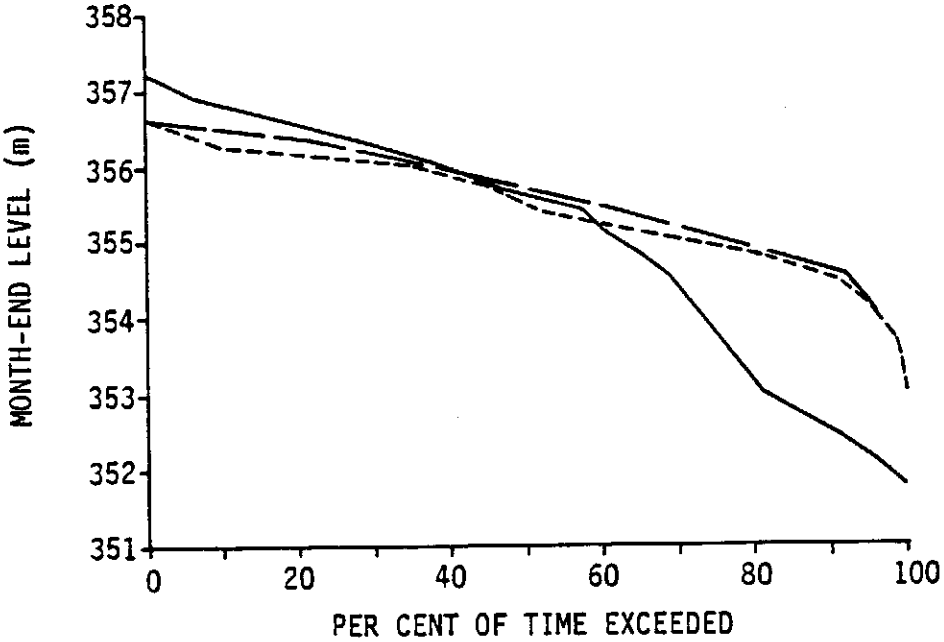
PROBABILITY DISTRIBUTION OF
MONTH-END LEVELS AND
MONTHLY OUTFLOWS
RAINY LAKE

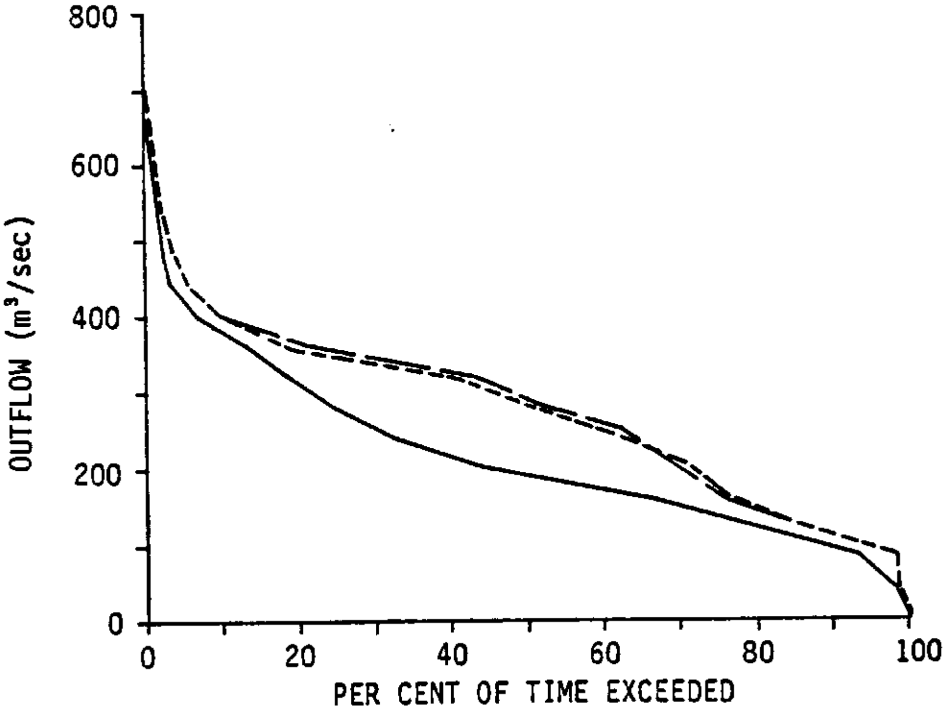
FIGURE 6.12

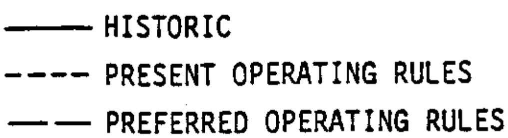



PROBABILITY DISTRIBUTION OF
MONTH-END LEVELS AND
MONTHLY OUTFLOWS
LAKE OF THE WOODS

FIGURE 6.13



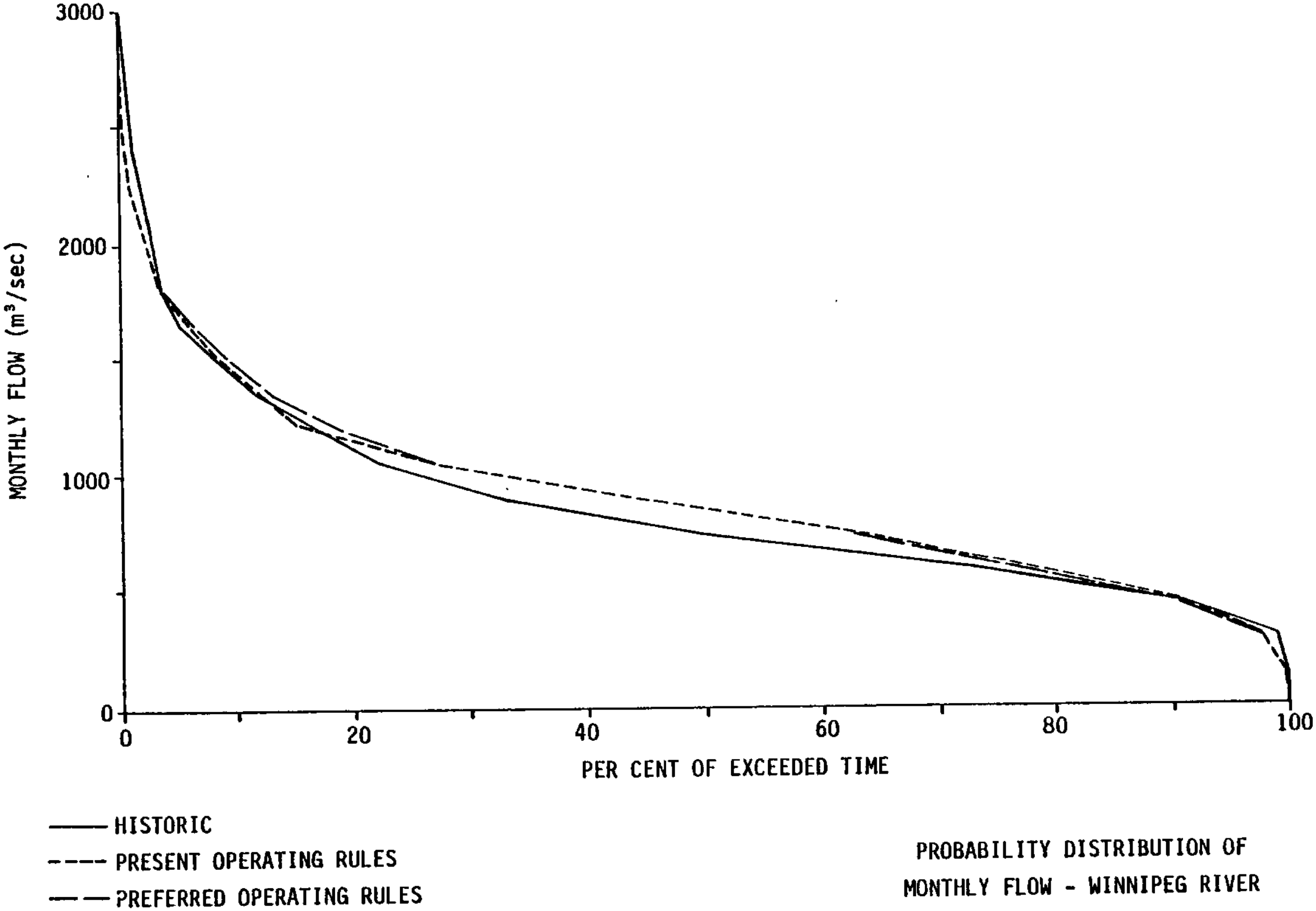




PROBABILITY DISTRIBUTION OF MONTH-END LEVELS AND MONTHLY OUTFLOWS LAC SEUL

FIGURE 6.14

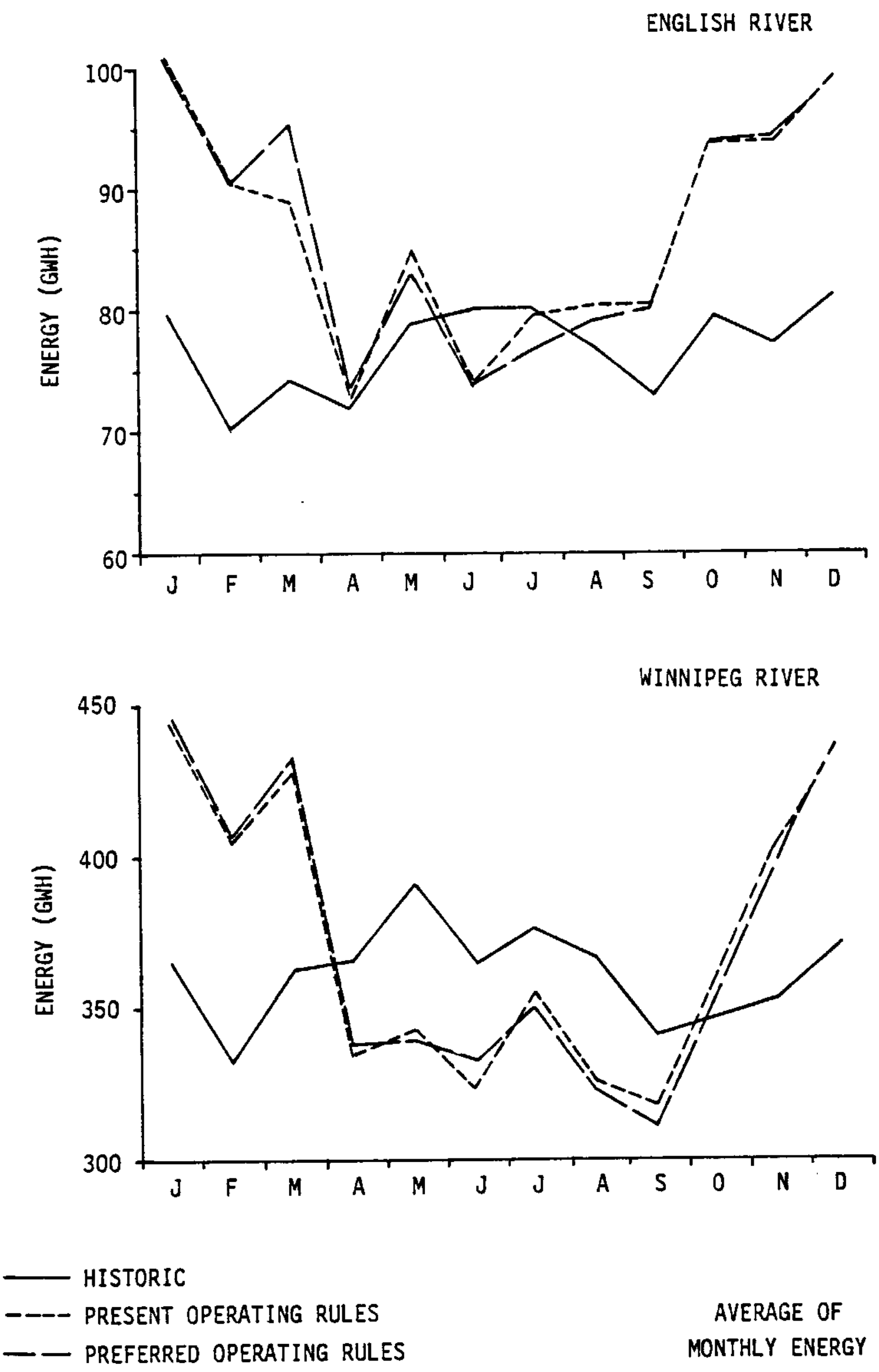
UNIES Ltd.




PROBABILITY DISTRIBUTION OF
MONTHLY FLOW - WINNIPEG RIVER
AT SLAVE FALLS

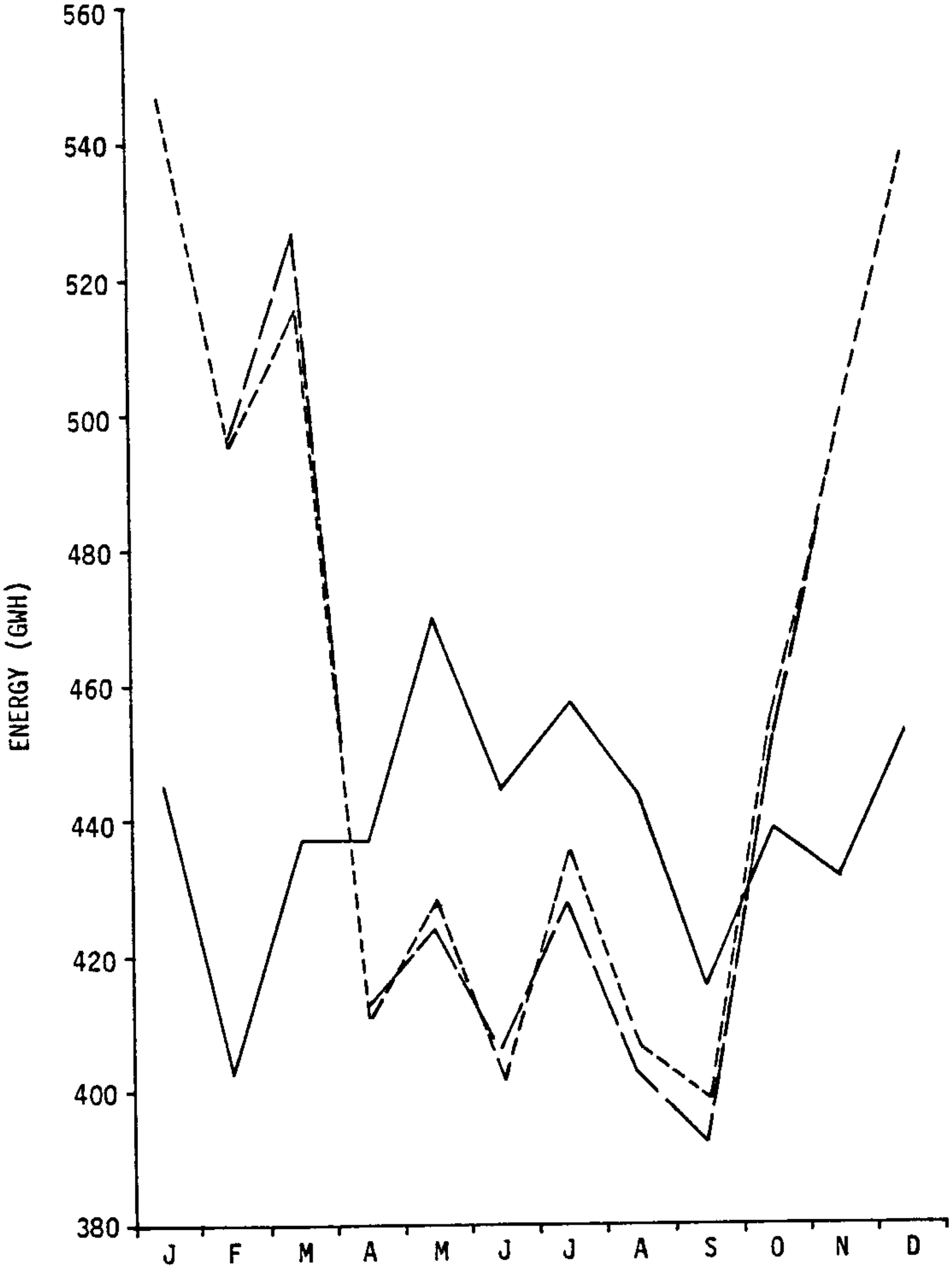
FIGURE 6.15

UNIES Ltd.




AVERAGE OF
MONTHLY ENERGY
GENERATION 1918-1979

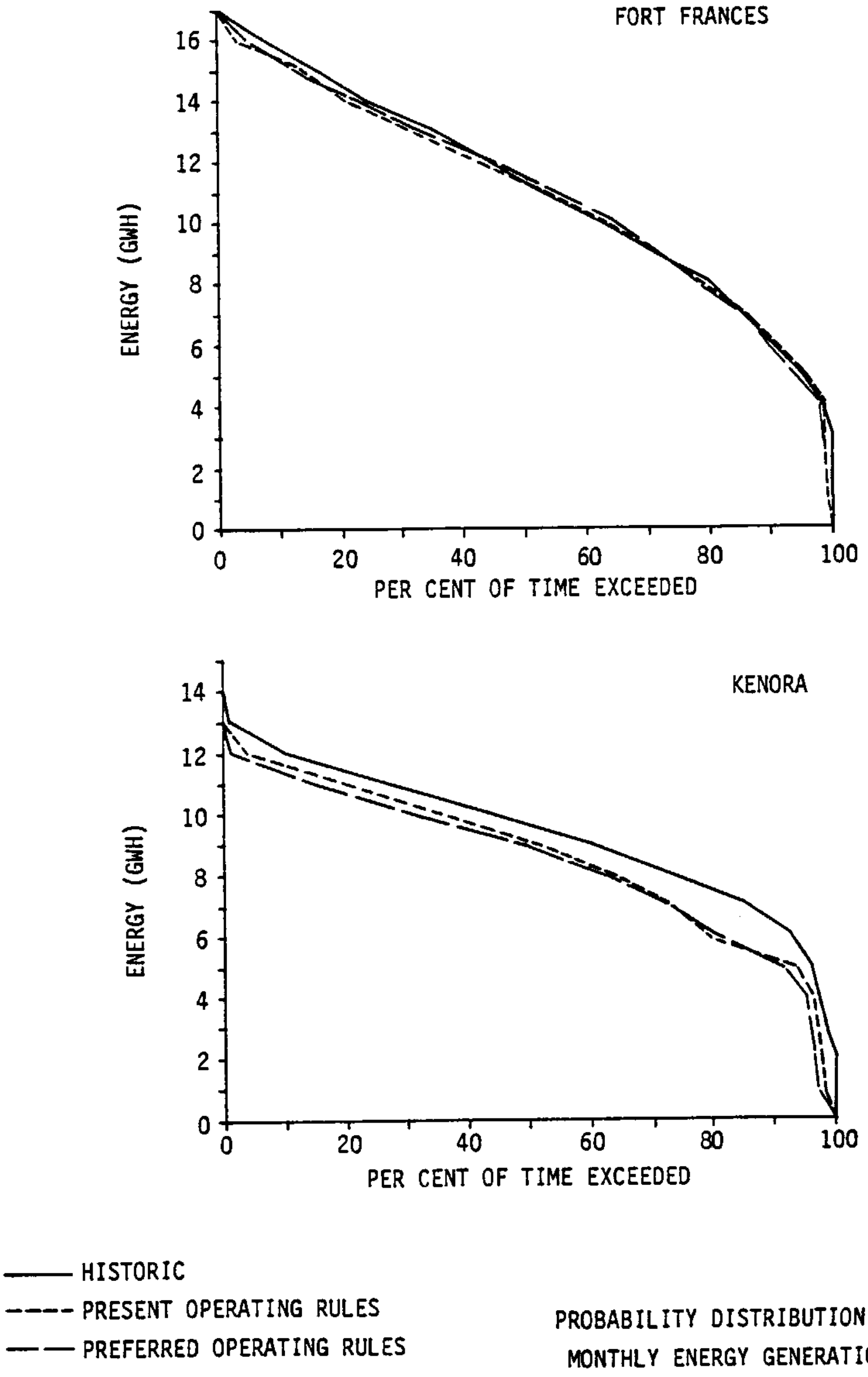
FIGURE 6.16




——— HISTORIC
- - - - PRESENT OPERATING RULES
— — PREFERRED OPERATING RULES

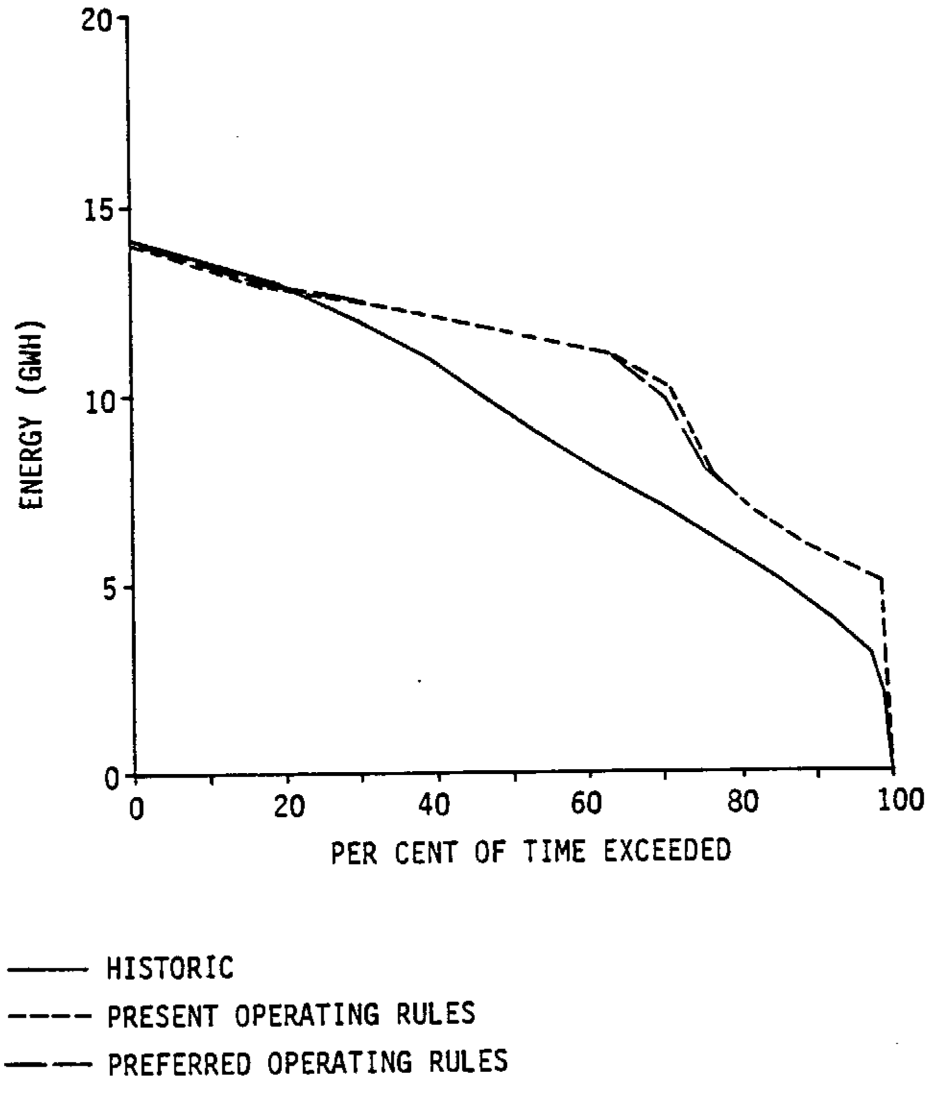
AVERAGE OF
TOTAL MONTHLY
ENERGY GENERATION

FIGURE 6.17



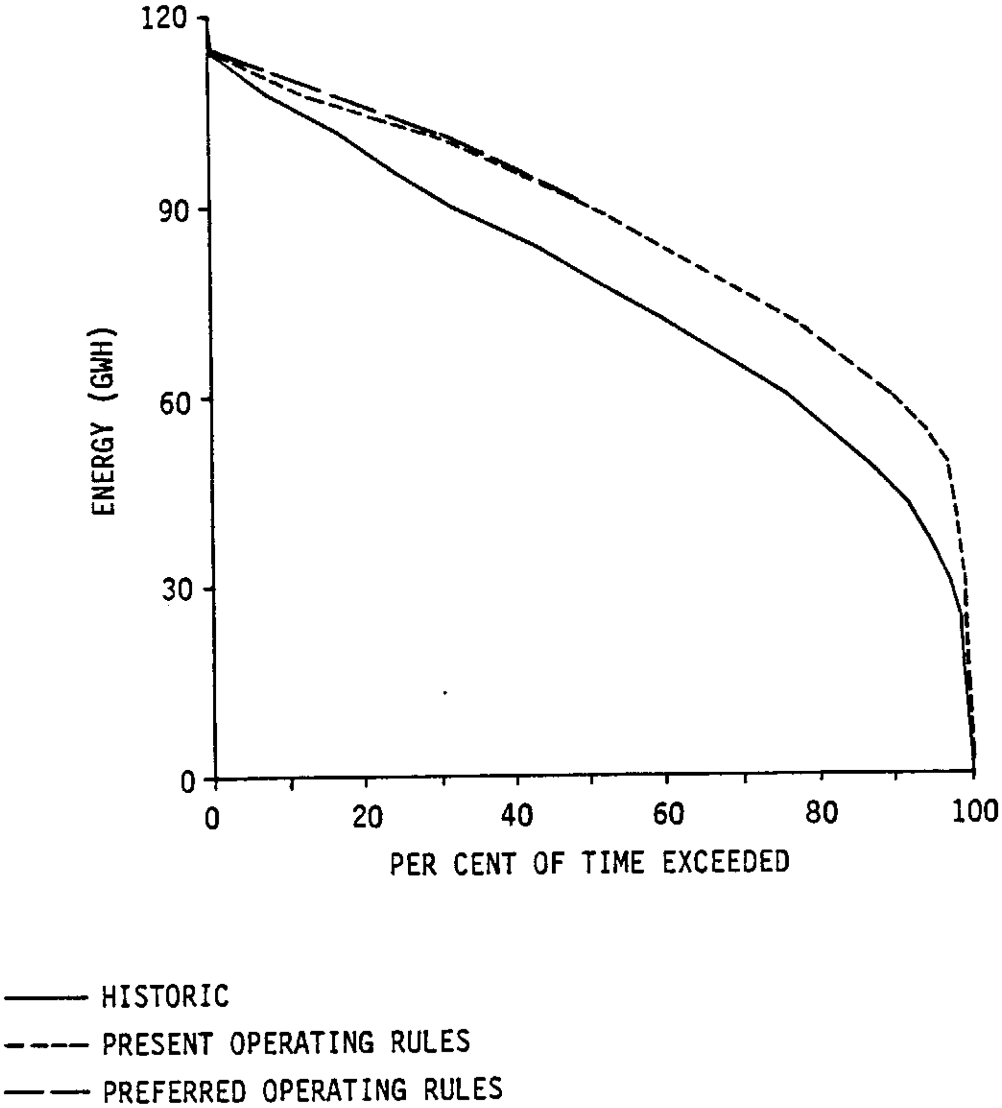

PROBABILITY DISTRIBUTION OF MONTHLY ENERGY GENERATION

FIGURE 6.18



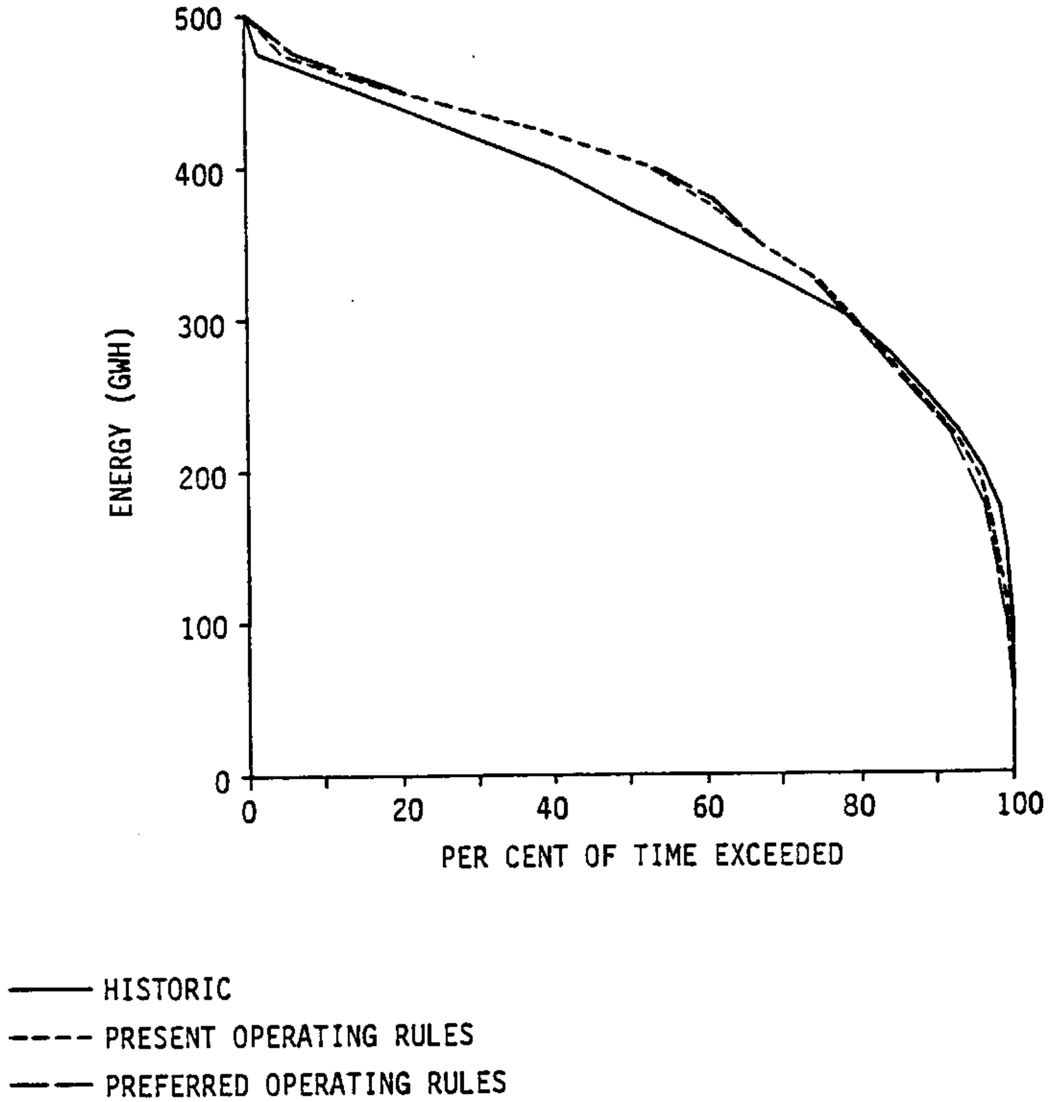

PROBABILITY DISTRIBUTION OF
MONTHLY ENERGY GENERATION
EAR FALLS

FIGURE 6.19



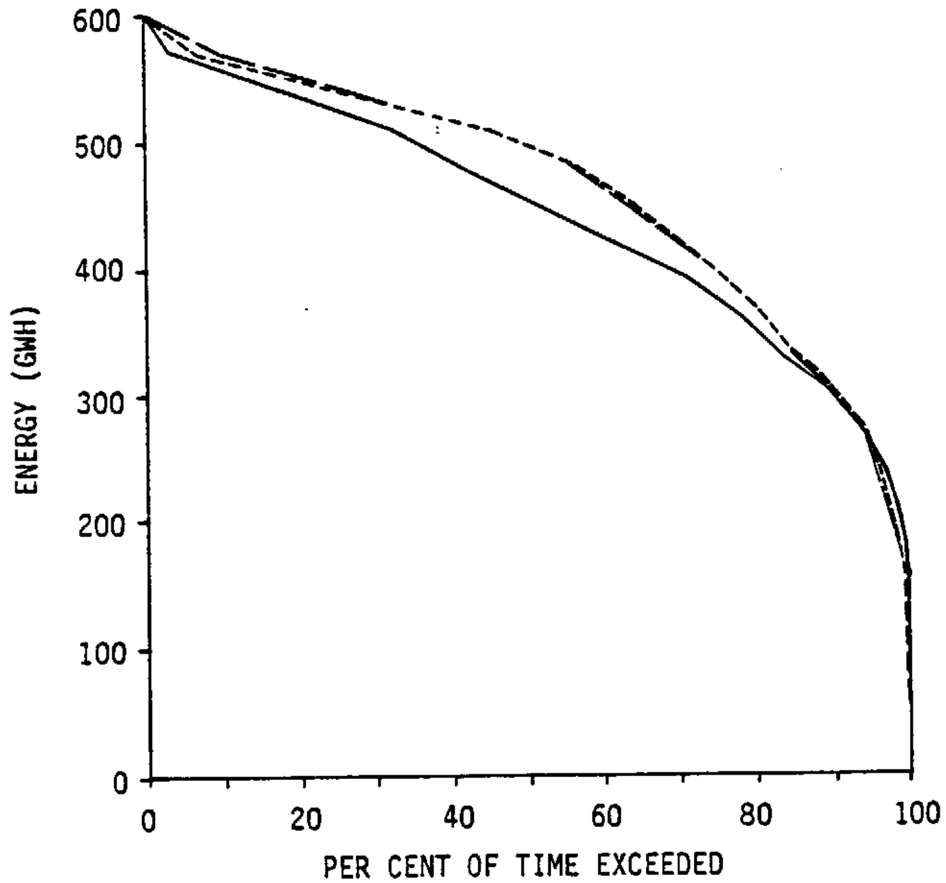

PROBABILITY DISTRIBUTION OF
MONTHLY ENERGY GENERATION
ENGLISH RIVER

FIGURE 6.20




PROBABILITY DISTRIBUTION OF
MONTHLY ENERGY GENERATION
WINNIPEG RIVER

FIGURE 6.21




PROBABILITY DISTRIBUTION OF
TOTAL MONTHLY ENERGY GENERATION

FIGURE 6.22

## CHAPTER 7

### SOCIAL AND ECONOMIC SIGNIFICANCE OF ALTERED RICE HARVEST

Changes in the regulation of water levels in the study area will impact on the wild rice harvest as well as on hydro-electric generation. As previously stated the preferred operating rules which result in an increase of 66,000 lbs. (Table 7.1) in the annual average wild rice harvest have the effect of lowering the average lake level of Lake of the Woods by .16 meters (6.3 inches) and raising Lac Seul by .09 meters (3.5 inches). The combined effect of the preferred operating rules on hydro-electric generation on the Winnipeg and English Rivers is a decrease of 7.0 GWH (Table 7.3).

Determination of the net economic impact of increased wild rice production and a decrease in energy generation requires that prices be assigned to the physical units involved. In Table 7.1 it can be seen that the total direct income generated by an increase in wild rice production is $86,465. This figure is based on a harvester price of $1.00 per lb. at lakeside, a 40% recovery rate and exports of 88.6% of the Canadian harvest.

In any economy an increase in the value of production of an industry not only has a direct income effect but also an indirect and induced effect as the monies generated filter through the economy. As can be seen in Table 7.2, the total income multiplier for Ontario in Agriculture is 2.62, in Forestry it is 2.21, and in Fishing, Hunting and

TABLE 7.1

SIMULATED WILD RICE
HARVEST UNDER PRESENT
AND PREFERRED OPERATING RULES

| | Preferred Operating Rules | Present Operating Rules | Increase In Harvest |
|---|---|---|---|
| Average Wild Rice Harvest (green lbs.) | 265,000 | 199,000 | 66,000 |

Value of Increased Harvest:

Exported Wild Rice:[1]

66,000 x .886 x $1.00 = $58,476

Domestically Consumed:[2]

40% x 66,000 x (1 - .886) x $9.30 = $27,989

| | |
|---|---|
| Total Direct Income = | $86,465 |
| Total Income Multiplier for Ontario (see Table 7.2) | 2.02 |
| Indirect, Direct & Induced Total Income in Ontario | $174,659 |

(1) 88.6% of Cdn. wild rice is exported (see Table 4.7).
Average price per lb. green is estimated @ $1.00 for 1981 harvest.

(2) 40% x 66,000 = 26,400 lbs. of processed wild rice.
(1 - .886) = .114 is proportion that is domestically consumed.
[($1.00 + .17 + .35) ÷ 40%] (1.40) (1.75) = $9.30 retail price.
See Table 4.11 for methodology.

TABLE 7.2

TOTAL INCOME[1]
MULTIPLIERS BY
PRIMARY INDUSTRY

| Industry | Domestic Total Income Multiplier | Ontario Total Income Multiplier | % of Induced Total Domestic Income Retained in Ontario |
|---|---|---|---|
| Agriculture | 2.92 | 2.62 | 89.7 |
| Forestry | 2.43 | 2.21 | 90.9 |
| Fishing, Hunting and Trapping | 2.23 | 2.02 | 90.6 |

(1) Total income consists of wages, salaries, and net income of incorporated business as well as total primary factors such as commodity taxes, surplus, etc.

Source: Tables 2.1, 2.3 and 2.6.
Dept. of Regional Economic Expansion "An Interprovincial Input-Output Model - Version III", May, 1976.

Trapping it is 2.02. For every $1.00 increase in output in the Fishing, Hunting and Trapping industry, $2.02 is generated in terms of direct, indirect and induced total income in the province of Ontario whereas for all of Canada $2.23 is generated. Using the Fishing, Hunting and Trapping industry as a proxy for the impact of increased wild rice production it can be seen that the indirect, direct and induced total income that would be generated in Ontario is estimated at approximately $175,000 (see Table 7.1).

The electrical power generation that would be lost would have to be produced elsewhere in the systems affected. In Table 7.3 it can be seen that the impact of regulating the lake levels in order to increase the average wild rice harvest results in an annual loss of 7 GWH of which 4 GWH would be lost in Manitoba and 3 GWH in Ontario. The value of this energy is the incremental cost of producing electrical energy elsewhere in the systems to counteract this loss of generation. For Manitoba, it is estimated that the cost of generating energy at an alternative site is $.020 per kWh and in Ontario, it is estimated at $.025 per kWh. The total cost of generating 7.0 GWH in alternative sites is thus $155,000 and represents the increased cost of electrical energy resulting from an increased wild rice harvest.

The average annual benefit of increased wild rice production outweighs the average loss in energy generation by some $20,000. The benefits and disbenefits however, accrue to different interest groups. The benefits of increased wild rice production accrue mainly to the native people and other residents of Northwestern Ontario, whereas the

TABLE 7.3

ANNUAL AVERAGE
SIMULATED ELECTRICAL ENERGY
GENERATION UNDER PRESENT
AND PREFERRED OPERATING RULES
(GWH)

| | Preferred Operating Rules | Present Operating Rules | Difference |
|---|---|---|---|
| Winnipeg River: | | | |
| Summer | 1996.1 | 2008.6 | -12.5 |
| Winter | 2481.4 | 2478.0 | 3.4 |
| English River: | | | |
| Summer | 466.9 | 471.7 | - 4.8 |
| Winter | 574.5 | 567.5 | 7.0 |
| Total: | | | |
| Summer | 2463.0 | 2480.5 | -17.5 |
| Winter | 3056.0 | 3045.5 | 10.5 |

Total decrease in energy generation - 7.0 GWH

| Value of Decreased Energy Generation | Decrease in Energy | | Incremental Cost Of Alternative Generation | | |
|---|---|---|---|---|---|
| Manitoba generation | 4 GWH | x | 20 mills/kWh | = | $ 80,000 |
| Ontario generation | 3 GWH | x | 25 mills/kWh | = | 75,000 |
| Total Cost of Alternative Energy Generation | | | | = | $155,000 |

increased costs of alternative electrical energy generation is spread among the total population of Ontario and Manitoba.

Secondary benefits that stem from the preferred operating rules are the diminished probability of a crop failure and a reduction in the range of fluctuations in the harvests. These factors coupled with an average increase of 66,000 lbs. of wild rice could affect the economic feasibility of introducing a new processing plant in the future.

The disbenefits that arise from these preferred operating rules in regard to electrical generation have to be viewed in a temporal sense as well. As shown in Table 7.3, average annual summer generation is down 17.5 GWH but winter generation is up 10.5 GWH for a net loss of 7.0 GWH. Since electrical demands are greater in the winter months, this shift of increased electrical generation is preferable to the reverse situation.

The dual effect of minimizing crop failures and widely fluctuating harvests and increasing average harvests will have favourable impact on the incomes of native people in the study area. Such measures will tend to stabilize and increase the income to native people from the wild rice harvest.

CHAPTER 8

## PRINCIPAL FINDINGS AND CONCLUSIONS

In relation to the purpose of the study, the following observations and findings are significant:

1. A strong correlation has been found between water level regime and the volume of the annual wild rice harvest in the study area. The wild rice harvest is sensitive to the mean growing season level, the amount by which water level changes over the growing season, and the change in water level from one season to the next. Mean growing season levels near the top of the normal water level range and rising water levels in the early part of the growing season have a particularly adverse impact on the harvest. The modelled results are somewhat obscurred by the climate parameters but it appears that harvest reduction becomes appreciable when water levels increase at 0.2 m or more per month. This is particularly critical in that part of the growing season before the aerial plant is fully formed. The critical growth period usually occurs between May 1st and June 30th, however, a particularly late or early growing season may extend the critical period into July or April respectively.

   In the case of Lake of the Woods, which has by far the largest part of the wild rice production in the study area, the start of season water level places a constraint on the rate of water level rise during the critical growth period. This is because, under normal or high inflow conditions, the lake outlet capacity is not sufficient to prevent an excessive rate of rise in level. Good crops in the past have often been associated with below normal mean summer season water levels. This appears to be the result of the correlation between low summer level and spring runoff low enough not to cause rapid increases in water level.

2. Average annual wild rice harvest in the study area can be substantially improved by modification of the present operating criteria for Lake of the Woods, Lac Seul and Rainy Lake. Of several operating criteria modifications tested in the model, the best indicated an increase in annual average harvest of approximately 67,000 lbs. of green rice. It also indicated a decrease in the frequency of crop failure and an improvement in the harvest volume in the below average crop years.

   The improvement in the wild rice harvest for the best operating case tested would not be uniformly distributed throughout the study area. This case indicated a substantial increase in the Lake of the Woods harvest, minor increases in the Winnipeg and English River harvest, and a minor decrease in the Rainy Lake harvest. No change in the Namakan Lake harvest is inferred, because, due to insufficient hydrometric records, regulation of Namakan Lake levels was not modified in the model.

The modelling also indicated an annual average historic harvest (1918 to 1979) 34,000 lbs., green, greater than obtained with the present operation, but 33,000 lbs. less than the preferred or best case tested. Crop failures for the historic case were indicated to be more frequent than with either the present or preferred operating criteria. Average annual harvest, broken down into each principal water body of the study area, is indicated in Table 6.3. The frequency distributions of annual harvest are shown on Figures 6.4 to 6.7.

3. The simulation of rice harvest, on Lake of the Woods only, assuming the reconstructed natural levels, indicated an average annual harvest of 250,000 lbs. green. This is 15,000 lbs. less than indicated for preferred operation, 51,000 lbs. more than for present operation and 39,000 lbs. more than the simulated historic average. The model also indicates that the frequency of crop failure under natural conditions would be appreciably greater than for the historic, present or preferred operating cases (Figure 6.4). Examination of the results indicates that this relatively high frequency of failure is due to the frequency with which Lake of the Woods, in a state of nature, would fall to low winter levels followed by a rapid rise due to median or high spring inflows. Large harvests could generally be associated with seasons of below normal inflow or those with inflows approaching the median but with reasonably high water levels in the preceding winter.

4. The restrictions on water levels and water level changes required to improve the modelled rice harvest also resulted in a decrease of approximately 7 million kWh's in the average annual electric energy production from hydro-electric plants on the Winnipeg River system above Lake Winnipeg. The energy generated during winter was actually increased by the operation preferred for rice but this increase was more than compensated by a decrease in average summer generation. A breakdown of energy production for the preferred, present and historic operations are provided in Tables 6.4 and 6.5. The estimated change in energy generation is relatively small, approximately 0.15 percent of total average generation of the Winnipeg River system plants.

5. The modifications to reservoir operating criteria preferred for rice production result in changes in water levels and streamflows too small to have an appreciable impact on resources other than wild rice and electrical energy.

6. The benefits and disbenefits of increased wild rice production resulting from the preferred operating criteria accrue to different interest groups. The economic benefits of increased wild rice production accrue to the native and other residents of Northwestern Ontario. The economic disbenefits of producing electricity at alternative sites accrue to the total population of Manitoba and Ontario. In essence this represents a redistribution of income from a very large population to a

small population in Northwestern Ontario. The financial impact on the customers of Manitoba Hydro and Ontario Hydro however, would be minimal. For the residents of Northwestern Ontario the financial impact would be of some significance and would be favourable to the local economy.

7. The results of the modelling also indicate that, under natural conditions, the production of wild rice on Lake of the Woods would have been greater than under historic water level conditions. The implication of these results is that there has been a redistribution of income taking place in Ontario from the native and other residents of Northwestern Ontario to the residents of Ontario and Manitoba who use electricity. The inferred difference in income between natural and historic conditions is not necessarily proportional to the difference in average harvest since the model also indicates a greater probability of crop failure under natural than under historic conditions (Figure 6.4).

8. Restriction of the trade practices of the largest wholesaler of wild rice in Canada and the U.S.A. by the U.S. courts will result in increased price competition in the market place. However, due to the low costs of lake wild rice production, compared to paddy production, lake producers should be able to maintain and expand their traditional share of the market.

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