IMPACT OF CLIMATIC VARIATION ON BOREAL FOREST BIOMASS PRODUCTION

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INTRODUCTION

Climate has a direct and pronounced effect on forest vegetation. However, there is a need to establish the impact of climate, especially climatic fluctuations, on forest biomass productivity. Little is known about the effect of climatic factors on biomass and how climatic fluctuations effect forest growth and yield. Renewed interest in the use of forest products and wastes for energy supplements as liquid fuels, and in using certain forest products for food, especially animal fodders and supplements, demonstrate there is a need to develop long-term inventories of biomass in forested areas and to establish projected annual yields. Such inventories and projections must take climatic factors into account. The rate of biomass renewal under a wide range of environmental, site and growing stock conditions is unknown.

Present day forests and their associated vegetation did not evolve under constant or uniform climatic conditions. Different regions of our forests are subjected to widely contrasting temperature and precipitation regimes. Weather patterns are highly variable from year to year. Today's forests reflect past climates. Their origins in time and space, growth rates, species composition, longevity and total biomass are largely dictated by past and present climates.

Predictions relating to future forest vegetation or biomass must include a consideration of climatic change. Some climatologists believe that North American climate is unlikely to remain as amenable in the near future as during several recent decades - a period of relatively stable climate (Hare 1979; Science Council of Canada 1976). Some predict a significant cooling, others a warming, but most indicate there will be a return to increased climatic variability with subsequent impact on energy, food and other resources (National Academy of Sciences 1976; Norwine 1977; Science Council of Canada 1976).

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Past decisions concerning the use of Boreal Forest and adjacent areas have involved little thought as to the impact of changing climate on long-term productivity of the resource. Continuing disregard to climatic variations could, therefore, have severe social and economic implications.

Clearly, we need more information on climatic fluctuations that have occurred in the Boreal Forest zone. However, there are few long-term weather stations in this zone, and none with a record of 100 years. Some proxy data* indicate that important climatic fluctuations occurred in the past, and that the position of the Boreal Forest zone and northern tree line has shifted also (Kay 1978, 1979; Larsen 1965, 1974; Nichols 1967, 1969, 1975, 1976; Ritchie 1976; Ritchie and Hare 1971; Ritchie and Yarranton 1978; Sorenson 1977; Sorenson and Knox 1974). The Boreal Forest presently occupies a zone with a summer temperature range of only 2°C. Any long-term cooling, even of 0.5°C, would adversely affect this zone and its biomass productivity. Therefore, information is needed in two specific areas: (1) impact of climate on forest biomass production; and (2) past climates in the Boreal Forest region.

OBJECTIVES AND APPROACHES

Objectives

The two overall objectives of the study are to determine:
(1) extent and degree of past short- and long-term climatic variation in selected regions of the Boreal Forest to assess impact of climatic change upon tree and forest growth;
(2) quantitative and qualitative relationships between key climatic parameters/climatic variations, and measures of forest biomass growth and production in selected regions of the Boreal Forest.

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* Data drawn from biological, chemical and physical characteristics of the earth's environment that respond to climate, and that are useful in the reconstruction of past climates.

Approaches

All long-term instrumental climatic records available for the central Boreal Forest zone (Yukon to northwestern Ontario) will be analyzed to establish regional climatic (particularly temperature and precipitation) trends and fluctuations. In addition, proxy data relating to the Boreal Forest zone will be used (e.g. data from dendrochronology, paleobotany, lake sediments including foraminifera, speleothems, isotopes, archaeology and historical documents). This will help to establish climatic variation over a longer period.

To assist with this review, a two-year contract has been awarded to Western Ecological Services Ltd. to carry out an extensive literature survey of growth, yield and biomass of different tree species and other vegetation in the Boreal Forest zone, with particular emphasis on North America. The effect of temperature, precipitation, etc. on growth and yield of biomass will be noted. The survey will include references to dendrochronology (dendroclimatology) and other proxy data which may be useful in establishing relationships between biomass (phytomass) productivity and climatic variations. A preliminary evaluation of qualitative and quantitative relationships between key climatic parameters and measures of biomass productivity in the Boreal Forest will also be included.

Tree-ring analysis can provide answers in both areas indicated at the end of the Introduction. Tree-ring chronologies have long been known to be useful in gathering information on past climates and dateable phenomena, providing normal tree growth trends are considered. This type of analysis can also help identify various climatic factors that have played a major role in forest growth and biomass production. Ring-width and density profiles can also provide year-to-year biomass data.

Dendroclimatological techniques have been successfully applied in western Canada by Parker and his colleagues (Parker 1976; Parker and Jozsa 1973, 1977; Parker and Kennedy 1973; Parker, Schoorlemmer and Carver 1973; Parker, Bruce and Jozsa 1977). Parker has shown that on an altitudinal transect in the Columbia River valley of southeastern British Columbia, temperature/tree-ring correlations were more significant at higher elevations, and precipitation/tree-ring correlations at lower elevations (Western Forest Products Laboratory 1979, pp. 23-24). A similar relationship may occur on a latitudinal transect of the Boreal Forest zone. If this can be shown, it is relevant to any dendroclimatological studies undertaken in the Interior Plains and elsewhere in North America.

A two-year contract has been awarded to Parker and his group at Forintek Canada Corporation to undertake a pilot study of tree-ring chronologies and the impact of climatic change on Boreal Forest biomass productivity. Field work will include the selection of five or more sampling sites along two north-south transects, from near the northern tree-line through the Boreal Forest zone to the Aspen Parkland, using white spruce *(Picea glauca)* as the sample species. One transect would be in the Alberta/Northwest Territories area near longitude 115°W, and the other near the Saskatchewan/Manitoba boundary. In September 1979, 300-year-old tree samples were obtained from the Swan Hills area of Alberta; in March 1980, 300-year-old samples were obtained from near Fort Resolution in the Northwest Territories. In August 1980, 200 + -year-old samples were collected from west of Sundre and north of Hinton, Alberta, and in September 1980 from west of Fort Vermilion, Alberta and from just north of Lake Claire in Wood Buffalo National Park. In September, 200 + year-old samples were also collected from the Cameron Hills southwest of Hay River, and at Prelude Lake east of Yellowknife in the Northwest Territories.

Sampling along the second transect will be undertaken in 1981. Disks are being obtained from 10 to 15 trees at each site on the transect and at various heights on the trees. Two average radii from each disk will be prepared for x-ray densitometry analysis to derive ring-density chronologies and biomass data. The data will be placed on tape using various programs, so that all data can be subsequently analyzed for various climatic factors from which growth trends have been removed. This will result in a record of processed tree-ring widths and densities suitable for climatic and biomass analyses.

Presumably these north-south transects through the Boreal Forest will tie in with studies by G.C. Jacoby* and others near the northern tree-line, providing a network which could lead to more comprehensive climatic analyses of large areas of central Canada. This, in turn, could add to the value of isolated, local reconstructions of past climate based on various proxy sources.

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* See papers by Jacoby and Ulan, and by Parker et al. in this publication.

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It is with great regret that the death of Gordon Manley, the outstanding English paleoclimatologist and geographer, is noted. The editor is grateful to The Royal Geographical Society for permission to reprint his obituary at the end of this volume.

CLIMATIC CHANGE IN CANADA - 2

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