POTENTIAL IMPACTS OF CLIMATIC CI

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limatic change due to enhanced CO_2 levels is ≪ely to have many impacts on forestry, some of ıich will be discussed below. The nature of the ıpacts themselves often suggests methods by ıich these effects may be measured.

ɔw to deal effectively with these impacts on ɾestry and related resources is not a simple atter. Even the impacts created by the current ɛar-to-year climatic variability pose difficult oblems, which are further aggravated by the time ale of forest management plans (usually one tation). The total impacts of forestry operations ıd practices often last for a period more than a ɛrson's lifetime.

easuring forestry impacts accurately is an sential prerequisite to determining the many ıplications of climatic change. Impacts analysis ay be looked upon as a change in 1) level of risk, frequency of extreme events, 3) and range of ıtions, and may be examined through the spatial ift of isopleths and the matching of "scales of ɔplanation, process, and pattern". Some of the ost significant potential impacts of climatic ıange on forest resources are discussed below.

Displacement of Ecosystems: Global warming due to increased CO_2 levels will have a significant effect on natural ecosystems. Such systems have evolved over long periods of time, and are in dynamic equilibrium with the many factors of their environment. A change in any of these factors will trigger changes in others; the net effect of these changes on habitat and fauna will be seen in a spatial displacement of ecosystems. Recent studies suggest possible shifts in the northern and southern boundaries of the boreal forest, as delimited by the 600 and 1300 growing degree-day isolines. The shift northwards for the southern boundary of the boreal forest could range from 470 to 920 km according to the model of the Goddard Institute for Space Studies, and 250 to 900 km for the model of the Geophysical Fluid Dynamics Laboratory. Further research should be focussed on this important impact of climatic change; the actual shift in ecosystem boundaries needs to be predicted more precisely as a function of change in important climatic and site factors.

Change in Land Use: Land use changes will occur due to climatic warming. Agricultural operations will extend further to the north and replace most of the grassland-forest transition near the southern boundaries of the boreal forest. Such land use alterations will in turn cause changes in the reflectivity of large tracts of land (e.g. exposed soil versus agricultural crop versus tree cover, etc.), which will affect radiation balances and further affect local climates. Changes in land use will be relatively easy to observe using standard land use monitoring techniques.

3. **Forest Fires:** The impact on the frequency and intensity of forest fires will likely be quite significant, due mainly to a rise in the range of summer temperatures experienced over an area, and also to the increased frequency of drought occurrences. The vegetation changes involved will provide extra fuel for fires, their sustenance, and intensities. Fire, along with agricultural extension and the related movement of populations, will be a main mechanism for shift in ecosystem boundaries.

4. **Insect and Disease Infestations:** Insect and disease organisms are significantly affected by climatic change. Various tree species will have reduced resistance to insects and diseases which they host under the stress caused by the impending shift in climate. Also, changes in species composition and plant cover will cause shift in insect and disease populations, and influence the likelihood of their occurrence over a particular site. The intensity of such impacts can be measured by the incidence, duration, and areal extent of old and new infestations.

5. **Treeline:** A shift in the upper limit of tree growth can be readily monitored and determined with the help of air photos, forestry maps, and land survey records dating back to the time when these were first done. The rate of change in the areal advance of timberline will indicate the intensity of impact of the impending climatic change on the elevational shifts in forest vegetation in a specific location.

6. **Snow Accumulation and Melt Patterns:** Climatic warming will have significant impacts on forest hydrology, such as changes in snow accumulation and melt patterns, which are likely to result in redistribution of major bodies of fresh water. The change in snow patterns will affect the regimen of streams and rivers, and modify the moisture status of forest soils.

7. **Droughts:** Climatic warming and altered precipitation amounts will lead to increased rates of evaporation and evapotranspiration and a higher risk of drought and soil moisture stress, which can affect survival and growth rates of trees during the various stages of their life.

8. **Regeneration and Survival:** The possible climatic impacts on species composition, ecosystem processes, and seedling survival and growth are likely to affect forestry operations relating to regeneration and establishment of commercial species. This will create stress on the resources needed for restocking efforts, and will determine success/failure of such operations in harvested and burnt areas.

9. **Growth and Yield:** Growth rates (and related yield curves) will generally improve because of the significant increase in degree days and length of growing season; however, southern areas may be adversely affected because of decreased soil moisture and consequent effect on growth. The potential impacts may be negative or positive, depending on the presence or absence of critical or limiting factors. Modified rates of growth will have impacts on the yield curves of main species.

10. **Wood Density and Timber Quality:** Wood density, which is a good indicator of wood quality, is related to rate of growth of a commercial tree species. As the growth rates are likely to be positively affected by climatic warming, especially in northern areas of the boreal forest where excessive moisture currently impedes growth, the impact will be noticed in the gradual changes occurring in wood density and quality of such species.

The above-mentioned impacts of climatic change will directly and indirectly affect all major areas of forest research and management. Suitable strategies for dealing effectively with the forestry-related aspects of climatic warming will need to be formulated and developed. The potential changes mentioned in this paper will have significant impact on forest industry and economics. Because of the slow annual rate of change, long-term studies must be undertaken to monitor climatic impacts and formulate policy implications. On a short-term basis, impact models need to be explored and derived to maximize beneficial impacts and minimize adverse effects of climatic warming.

SOCIETAL IMPLICATIONS OF CLIMATIC CHANGE IN CANADA[1]

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The consensus of the scientific community is that there will be a significant warming of the world climate in the next century. This paper addresses some of the recent changes with respect to the elements and processes of human social systems. From this point onward, the term "climatic change" will have the fuller meaning of change and variability. The interpretation of social impacts for this paper is intentionally generic. Society is defined as a system that evolves from the interaction of the human and ecological conditions (the "environment") to provide the mechanisms and institutions for achieving a common purpose. The societal consequences of environmental change are examined with respect to human individuals, their activities, communities, and institutions. Some specific examples of social impacts are provided.

The Canadian Climate Program (CCP) was established in 1978 to coordinate climate studies across the nation to develop better understanding of climate, and to foster greater awareness of the value of climate information. The Atmospheric Environment Service (AES) of Environment Canada was designated as the lead agency for the CCP. One of the first activities of the CCP was to organize a series of workshops and meetings focussed on identifying the effects of climatic change on various sectors of the economy. The results of this initiative established an important momentum for subsequent research in Canada concerning the societal implications of climatic change. Also significant, from the political perspective, was the official endorsement of the CCP in 1981 by the Canadian Council of Resource and Environment Ministers (CCREM) and the CCREM sponsorship of a "Climate Change Seminar", held the same year in Regina. Systematic CCP support of socio-economic studies is largely responsible for the recent acceleration of the Canadian social science research effort concerning climatic change (Table 1).

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1 The unabridged version of this paper will be published in the December 1988 issue of the Operational Geographer.

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IN THIS ISSUE: CLIMATIC CHANGE