

economic and social impacts, three scenarios can be envisaged. One possibility is that goods transport is at capacity, and any lengthening of the shipping season will correspondingly increase demand for shipping and/or the price of shipments. Although this is unlikely given the present situation, with increased exploration and development activity, demand for shipping could increase significantly. The second, and more likely, scenario is that the demand for shipping is inelastic and a longer season does not generate higher demand. Rather, it results in lower costs, as shipments are spread over a longer period, using less capital (and labour). If these savings are passed on to consumers, regional economic impacts could be transmitted to the population at large. A third scenario is

that the transportation company would extend the shipping season, using less capital and labour, but retaining any cost savings. In this case there would be little economic impact.

In view of the monopolistic competition present in the transportation industry and the existence of substantial surplus capacity, our preliminary view is that the third scenario is most likely. Cost savings arising from the extended ice-free season will not be passed on to consumers. Few benefits are expected to trickle down to the local economy and the economic impact might even be negative, should the company decide to lay off employees with attendant social consequences.

IMPLICATIONS OF GLOBAL WARMING FOR AGRICULTURE IN ONTARIO

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This paper summarizes an assessment of implications of possible climatic changes for agriculture in Ontario. The research is based on scenarios reflecting average thermal conditions and a range of moisture regimes for current and altered climates. The changed climate scenarios are derived from GCM experiments (GISS and GFDL) assuming a doubling of CO₂ or its equivalent. Under the altered climate scenarios the frost-free season would be extended throughout Ontario, growing season mean temperatures would increase, and because of the longer season, precipitation over the growing period would also increase. However, increases in potential evapotranspiration would more than offset increases in rainfall, resulting in a climate characterized by a longer, warmer, drier growing season.

Superimposed on the spatially coarse GCM output are the current regional variations in climate, which are assumed to persist. Temporal variability is considered by including scenarios representing average, wet, and dry years, the latter two reflecting the 95 percentile and 5 percentile precipitation levels, respectively. For each scenario, crop yields are estimated for 8 principal grain, oilseed, and forage crops on 7 land types available within

6 macro-climatic regions of Ontario. This information on yields is then used for a series of analyses dealing with different attributes of the agricultural system. Details on the analytical methods, data sources, and results are presented in LEG (1985; 1986), Smit et al. (1989), and Brklacich and Smit (1992). The results illustrated in this paper relate to the GISS-based scenarios.

Crop Yields and Production

Crop yields are calculated via a series of models, based on photosynthetic, agroclimatic, and edaphic relationships (Smit et al. 1989). Yields are estimated as a function of each crop's climatic requirements for growth relative to the thermal and moisture conditions under each climatic scenario. Figure 3 illustrates the results for one crop (soybeans) in 2 regions on 3 land types, for the current and GISS-derived scenarios. Overall, crop prospects in northern regions are enhanced. In the more southerly parts of Ontario moisture stress reduces yields for many field crops. Lands currently considered prime because of their good drainage often suffer yield declines under the altered

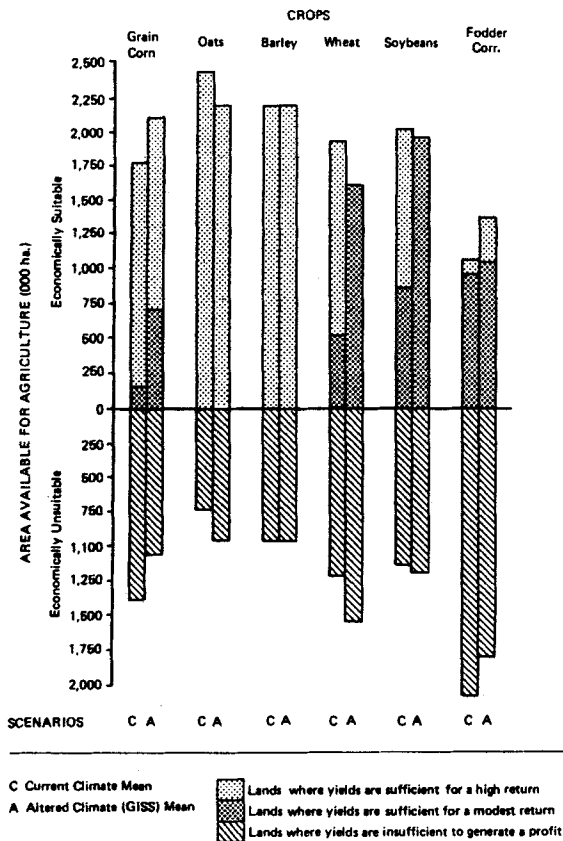


Figure 4
Suitability of Ontario's land resources for crops under two climate scenarios

were undertaken to assess implications for agriculture in Ontario.

Land Resource Suitability

For each climate scenario and region, information on crop yields by land type is combined with data on the availability of each land type to calculate the total area for which each crop is economically viable (Smit et al. 1989). Northern regions experience significant proportional increases in the areas of land suitable for the various crops, but the total areas involved are relatively small. By contrast, there are vast agricultural areas in southern regions, and it is here that land suitability for many crops declines. Figure 4 presents results aggregated to the provincial level for 6 crops and 2 (average) scenarios. Provincial production prospects under the altered climate are enhanced for fodder corn, unchanged for barley, and reduced for oats, wheat, and soybeans. While the area of land economi-

cally unsuitable for grain corn would decrease, so too would the area for which yields would generate a high return. A larger area of the province, mainly in southwestern Ontario, would have yields falling in the modest returns category.

Farm Level Assessment

A farm business model is used to assess implications for resource allocation, product mix, sales and profits for a 'typical' cash grain farm in southwestern Ontario (Brklacich and Smit 1992). By holding all other conditions constant, the analysis addresses the degree to which changes in climatic norms and variability in precipitation pose risks to the farm operation. The model is run for the two average scenarios (current and altered), assuming farm decisions are made on the basis of prevailing average conditions. Then grain yields are adjusted to reflect those expected for the precipitation extremes under both current and altered thermal regimes. Changes in average conditions would allow increased profits but would require greater crop specialization. However, the range in profits associated with variations in precipitation would increase under the altered climate, with implications for cash flow, debt load, and security of the farm sector.

Provincial Food Production Potential

A land use allocation model is employed to assess aggregate provincial potential for food production under current and altered climate scenarios. The model maximizes the proportion by which current production levels can be exceeded, simultaneously for all crops, given the land base and yields (LEG 1986). Results indicate that under current average climate the provincial land base can produce at least an additional 66 per cent of each and every crop product considered. Under the altered average climate this 'surplus capacity' drops to 60 per cent. Furthermore, the range in surplus capacity associated with deviations in precipitation is greater under the altered scenarios than under current conditions. Thus, even allowing for adaptation, risks to crop production in Ontario would be greater under the altered climate, especially in years with low precipitation.

Other Perspectives on Climate Change and Agriculture

The studies briefly summarized here provide rather crude estimates of the sensitivity of agriculture to global warming. They are based on a small set of GCM outputs. The enrichment effect of CO₂ on crop yields has not been consid-

ered. Impacts of social, economic, technological, and policy changes may dwarf those of climatic change. Implications for interregional and international comparative production opportunities have been examined only superficially (Smit 1989). There is also the question of adjustments to incremental change. It is often argued that agriculture is an activity that can readily adapt to changes in environmental conditions, by switching crops, developing new hybrids, irrigation, and so on. Yet there is

evidence that, in practice, agriculture is slow to reduce vulnerability to climatic conditions. Technological developments, economic structures and government support policies often reinforce this inertia (Smit 1988). Agricultural systems may adapt, but without an improved understanding of implications and options under changing and persistently variable climates, this adaptation may be at considerable social and environmental cost.

GLOBAL 'WARMING,' THE ARCTIC AND INUIT: SOME SOCIOCULTURAL IMPLICATIONS

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Although future environment change in the Arctic, mainly as a result of global warming, is receiving attention (Abelson 1989), its potential impact on Inuit of northern Canada has not been extensively or specifically discussed. A primary reason is that another kind of 'warming,' in the way that western Europeans and North Americans perceive the relationship of man to the Arctic ecosystem, already affects the well-being of Inuit and all northern aboriginal people.

Inuit Culture and Past Global Warming

Past climatic and cultural episodes in the Arctic have had large-scale effect on Inuit. The last time the polar world experienced anything physically comparable to what is currently being forecast was ca. A.D. 1000 (Barry et al. 1977) when the Neo-Atlantic altered the physical and cultural parameters of Arctic life. The key ecological impact of this warming event was a radical change in the North's annual sea-ice regime, especially longer periods of ice-free summer open water, and the consequent opening of new habitat areas for bowhead whales along Canada's Arctic coast.

The Neo-Atlantic time period also had a far-reaching cultural impact on Inuit. Foremost was the replacement of almost 2000 years of *in situ* Palaeoeskimo cultural development by archaic Inupiat migrants from northwest Alaska. This new societal tradition, Thule Culture, spread eastward, ultimately to Greenland, because the large whales that formed the cornerstone resource of the Thule hunting economy were now able to enter Canadian Arctic

waters previously blocked by ice (McGhee 1978). And while Classic Thule whaling lasted only a few centuries (ending ca. A.D. 1450 because of a return to intense cold (Andrews and Miller 1979), the technological innovations introduced by Thule hunters at the start of this millennium form the adaptive foundation of contemporary Canadian Inuit society.

The Impact of the Present Warming

Just as the Neo-Atlantic phase led to a cultural shift in the Inuit world a thousand years ago, the latest physical warming in the Arctic coincides with a new set of changes in the Inuit sociocultural environment. What is different is that rather than relating to the direct occupation of the region, this latest change is the result of extensive environmental re-evaluation of the Arctic and the ecological role of Inuit within it by our industrialized culture. This new way of thinking is an outgrowth of, first, a new, if incomplete, awareness that the Arctic is as environmental sensitive as any other part of the world ecosystem and, second, the 'discovery' that the Arctic has become as accessible and therefore as 'knowable,' as any other part of the earth.

A change in southern attitudes about the environmental health of the North is obviously positive, but this shift remains rooted in our own definition of environmental well-being and harm, sometimes to the detriment of Inuit. That this is the case is suggested by the two important Arctic environmental events of the 1980s involving Inuit: the 1988 stranding of three Gray whales in northern