SECTION 2

The Effects on the Agroclimatic Environment

In Section 1 several scenarios were selected that were based on instrumentally observed historical climatic data (HIST) and on results from a general circulation model (GISS). In this section we employ indices or models to analyze the impacts associated with these scenarios on the thermal climate (growing degree-days), the moisture climate (precipitation effectiveness), the combined thermal–moisture effects (climatic index of agricultural potential which reflects biomass potential), and on drought frequency.

This section of the case study differs from Sections 3, 4 and 5 in that it does not examine specific processes (e.g., wind erosion), crops (e.g., spring wheat), or the impacts on the economy. Instead it considers more general effects on the agroclimatic environment. In a changed climate, crops and processes may be altered so much that results of applying a particular model may be misleading when considered by themselves. Section 2 not only provides a useful prelude to the subsequent parts by describing the changes in the agroclimatic environment, but it also provides some general indications, for instance, with respect to biomass productivity and drought frequency, that are useful in the interpretation of the more specific results.

The GISS model results provided were on a grid point basis. The following are the latitudes and longitudes of the six points used to represent southern Saskatchewan in this part of the study: 50°N 100°W, 50°N 105°W, 50°N 110°W, 54°N 100°W, 54°N 105°W, 54°N 110°W (*see Figure 1.11*). The temperature differences for obtaining the 2 × CO_2 scenario temperatures for stations in southern Saskatchewan were obtained by interpolating to the station locations from the values for these six grid points, using a Gaussian filter procedure (as described in Part I, Section 3). The same method was used to obtain the ratios for adjusting precipitation to the 2 × CO_2 scenarios. For Uranium City, the adjustment increments and ratios were obtained by manual interpolation from nearby grid points.

2.1. Effects on Growing Degree-Days

Growing degree-days (GDD) have long been in use in Canada for characterizing the thermal climate for crops. GDD have sometimes been referred to as "day-degrees", or "accumulated temperatures" (Unstead, 1912). Other terms that have been applied include "heat units" and "effective growth-heat"; and the quantity required for a crop to reach maturity has been called the "summation constant" or the "remainder index" (Holmes and Robertson, 1959). The term "growing degree-days", which has been commonly used in recent work such as that by Edey (1977), will be employed in this case study. Elsewhere in this volume, however, the measure is termed "effective temperature sum".

Growing degree-days are the accumulation of temperature above some threshold or base temperature, b. For $b = 5\,^{\circ}\mathrm{C}$, on a day with mean temperature of 19 °C there are $t - b = 14$ degree-days above b, where $t =$ the mean temperature for the day = (maximum + minimum for day)/2. To compute GDD for a month, these excesses above the base are summed: that is, GDD for the month = the sum of $(t - b)$ for every day in the month for which t is greater than b. Each plant species would have a different threshold, but 5 °C is widely used for such calculations (and is quite close to the 42 °F base most often used for growing degree calculations in the United States).

The longer the growing season and the higher the temperatures, the greater the annual GDD. Thus GDD provides an indication of the combined effects of growing season length and temperature (Chapman and Brown, 1978). Degree-days are ordinarily computed each day and accumulated through the season. Computation of long-term degree-day normals can be performed with the daily data, but if one wants to compute monthly normals of degree-days from monthly temperature normals, some adjustment is desirable to obtain comparable values, particularly for those months where the base temperature is close to the monthly mean. For example, a monthly mean just below the base would give zero degree-days without such adjustment, but such a month would normally include days where the mean temperature exceeded the base temperature, thus contributing to the degree-day summation. The method of Thom (1954a,b) for computing degree-days from monthly mean temperature normals and standard deviations of monthly mean temperatures overcomes this problem. This method was therefore used with both the simulated 2 × CO_2 (GISS) and instrumentally based (HIST) scenarios. Holmes and Robertson (1959) have demonstrated the application of Thom's methods to growing degree-days. Standard deviations were derived from those published for stations in the area for 1951–1980 (Environment Canada, 1982).

It should be noted that the use of standard deviations for 1951–1980 mean monthly temperatures in the degree-day computations implies that we are asking the question: What is the impact on the thermal climate of the scenario temperature changes if the temperature variability remains unchanged? It seems likely that the sensitivity of annual GDD to changes in the standard deviation would be quite low, particularly for assessments of the effects of a warmer climate. In future research this sensitivity could be tested, and scenarios of changed variability could also be assessed.