5.1   INTRODUCTION

This chapter describes the effects of an assumed finite supply of nonrenewable resources on the World3 economy. A nonrenewable resource is defined here as a mineral or fossil-fuel commodity that (1) is essential to industrial production processes and (2) is regenerated on a time scale that is long compared with the 200-year time horizon of the model. For example, coal and oil are included as nonrenewable resources, while wood pulp and wool are renewable resources that are not considered in this sector. Nineteen examples of nonrenewable resources are listed in Figure 5-1. Our aim in this sector is to specify a set of model relationships that (1) represent the basic factors controlling the use of nonrenewable resources, and (2) relate the cost of extracting and processing them to the productive efficiency of the industrial sector of World3.

The second section of this chapter (5.2) describes the real-world historical behavior exhibited by the important variables in the nonrenewable resource sector. Next, the underlying theory and assumptions used to formulate the model structure are described in the section on basic concepts (5.3). The specific relationships assumed in the sector are then brought together into a causal structure (5.4). The model equations are given in section 5.5, which also explains the individual parameter values chosen for the equations. The final section (5.6) presents a series of simulation runs of the nonrenewable resource sector that illustrate the dynamic behavior resulting from the assumptions in the sector, test the sensitivity of behavior to changes in parameter values, and explore the effects of various policies on this behavior.

5.2   HISTORICAL BEHAVIOR MODES

Exponential growth in the production and usage of nonrenewable resources has been the most prominent long-term historical behavior mode of importance to the sector. Figure 5-2 shows the historical growth in the rate of production of six critical nonrenewable resources. Although the historical rate of growth varies for each resource, it is clear from this figure that exponential growth in resource production has been a general historical characteristic of the world economy. In fact, aggregate world production and usage of nonrenewable resources increased by 4.1 percent per year between 1950 and 1970 (NCMP 1972). The U.S. Bureau of Mines forecasts that the total world demand for resources will grow at an annual rate of 3.6–5.5 percent per year to the year 2000 (Bureau of Mines 1970, p. 3).

Over the long term, the grade, or concentration in ore, of a mined resource tends to decrease as more reserves are mined. For the fossil fuels, the parallel to the decline in the grade of ore mined is the decline in discoveries per foot of exploration. Figure 5-3 shows the time trends for copper ore mined and for crude oil discoveries. From these trends, one would expect the unit costs of obtaining resources to increase over time. Yet for most nonrenewable resources, the dollar cost per resource unit has remained relatively constant or has even declined (Potter and Christy 1962, Barnett