```
      NRUF   - NONRENEWABLE RESOURCE USAGE FACTOR
                 (DIMENSIONLESS)

NRUF.K=CLIP(NRUF2,NRUF1,TIME.K,PYEAR)                    131, A
NRUF1=1                                                  131.1, C
NRUF2=1                                                  131.2, C
      NRUF   - NONRENEWABLE RESOURCE USAGE FACTOR
                 (DIMENSIONLESS)
      CLIP   - A FUNCTION SWITCHED DURING THE RUN
      NRUF2  - NRUF, VALUE AFTER TIME=PYEAR
                 (DIMENSIONLESS)
      NRUF1  - NRUF, VALUE BEFORE TIME=PYEAR
                 (DIMENSIONLESS)
      TIME   - CURRENT TIME IN THE SIMULATION RUN
      PYEAR  - YEAR NEW POLICY IS IMPLEMENTED (YEAR)
```

The level of nonrenewable resources NR is depleted by the nonrenewable resource usage rate NRUR, which is defined as the product of current population and current per capita consumption. In the model it was assumed that the level of industrial output per capita IOPC determines the level of per capita resource use through the per capita resource usage multiplier PCRUM. This multiplier is normalized so that when NRUF is set equal to 1.0 the per capita usage is equal to the 1970 world average per capita resource usage. In several runs, NRUF was decreased to simulate the impact of technological advances that are resource conserving, such as increases in product lifetimes or reductions in the quantity of resources used per product.

Per Capita Resource Utilization Multiplier PCRUM

```
PCRUM.K=TABHL(PCRUMT,IOPC.K,0,1600,200)                  132, A
PCRUMT=0/.85/2.6/4.4/5.4/6.2/6.8/7/7                     132.1, T
      PCRUM  - PER CAPITA RESOURCE USAGE MULTIPLIER
                 (RESOURCE UNITS/PERSON-YEAR)
      TABHL  - A FUNCTION WITH VALUES SPECIFIED BY A TABLE
      PCRUMT - PCRUM TABLE
      IOPC   - INDUSTRIAL OUTPUT PER CAPITA (DOLLARS/
                 PERSON-YEAR)
```

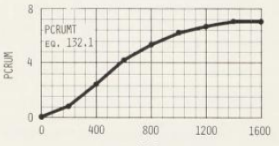

Figure 5-14 Per capita resource usage multiplier table

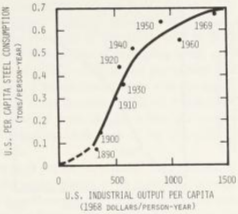

Figure 5-15 Per capita steel consumption in the United States as a function of industrial output per capita, 1890–1969
Sources: Steel production from AMM 1970; IOPC derived from GNP data in U.S.D.C. 1969.

Per capita resource usage is assumed to be a nonlinear function of industrial output per capita IOPC, the measure of industrial development used in the model. At low levels of IOPC, much of the industrial output is devoted to agricultural activities, which consume fewer nonrenewable resources than do industrial activities. At very high levels of IOPC, a large fraction is devoted to services, which also consume fewer resources. The combination of these two characteristics of industrial development produces the S-shaped relationship illustrated in Figure 5-14. The units of per capita resource usage were normalized to 1.0 at 1970 per capita usage levels.

This relationship can be supported empirically by examining the per capita consumption of materials in different countries at one point in time and in a single country over time. The original data cited in this section relate per capita usage to GNP per capita; we have converted GNP per capita to industrial output per capita IOPC according to the development patterns recorded in Chapter 3. Figure 5-15 plots time-series data of per capita steel consumption in the United States versus IOPC. The curve shows not only the rising per capita consumption at low levels of IOPC but also that steel consumption per capita begins to level off as IOPC reaches very high values. Figure 5-16, a similar curve drawn for per capita copper consumption in the United States (time-series data), shows a similar trend.

It is possible that the leveling off of the per capita consumption of steel at the higher values of industrial output per capita may be caused by a time trend toward the substitution of other materials for steel in industrial production. This is probably not the case, however, for the cross-sectional data reveal a similar relationship (Figure 5-17). If, in fact, the substitution of other materials and not a shift to service-oriented output causes the steel consumption curve to level off, then the hypothesized per capita resource usage multiplier PCRUM relationship should reflect a continuing increase of per capita consumption as a function of IOPC. If we should assume that the per capita resource demand does not level off as industrialization proceeds, the