```
LLMY2.K=TABHL(LLMY2T,LY.K/ILF,0,9,1)                    115, A
LLMY2T=1.2/1/.63/.36/.16/.055/.04/.025/.015/.01         115.1, T
    LLMY2  - LLMY, VALUE AFTER TIME=PYEAR
             (DIMENSIONLESS)
    TABHL  - A FUNCTION WITH VALUES SPECIFIED BY A TABLE
    LLMY2T - LLMY2 TABLE
    LY     - LAND YIELD (VEGETABLE-EQUIVALENT KILOGRAMS/
             HECTARE-YEAR)
    ILF    - INHERENT LAND FERTILITY (VEGETABLE-
             EQUIVALENT KILOGRAMS/HECTARE-YEAR)
```

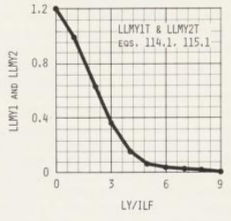

Figure 4-57 Land life multiplier from yield table

The average life of land ALL is assumed to decrease by a factor of 1/100 (to 60 years) as the land yield LY is forced up to nine times the natural inherent land fertility ILF of 600 vegetable-equivalent kilograms per hectare-year. Again, the importance of this curve lies in its negative slope rather than in the exact values it generates, which are only hypothetical. The sensitivity of the model to changes in the curve is demonstrated in section 4.6.

Land Erosion Rate LER The rate at which arable land is lost through erosion —the land erosion rate LER—is finally calculated as the level of arable land AL divided by the average life of land ALL:

```
LER.KL=AL.K/ALL.K                                       116, R
    LER    - LAND EROSION RATE (HECTARES/YEAR)
    AL     - ARABLE LAND (HECTARES)
    ALL    - AVERAGE LIFE OF LAND (YEARS)
```

This equation, given the postulated land life multiplier from yield LLMY curve of Figure 4-57, generates an erosion rate that would reduce the level of arable land to one-half (one-tenth) of its initial value in about 1,400 (4,600) years at the current average global land yield—roughly 2,000 vegetable-equivalent kilograms per hectare-year.

Urban-Industrial Land per Capita UILPC Large areas of land, including arable and potentially arable land, are being covered every year by expanding human settlements. Arable land is lost to dwellings and industrial plants; to roads, waste-disposal sites, and airports; to strip mines and power lines; and to recreational use of land (sports fields, golf courses, and parks). In World3 this urban-industrial use of land is assumed to be caused by the pressures of large populations and high industrial activity. Thus it occurs in both industrialized and nonindustrialized nations, but more in the former than in the latter.

In a study of California land usage, it was found "that by 1960, 3 million acres (1.2 million hectares) of arable land has been converted to non-agricultural use, which amounted to about 0.2 acres per person (0.08 hectares per person)" (Arkley 1969). "If this rate were to remain constant, half the state's productive farmland would be destroyed within 30 years. If it continues to accelerate as it has in recent years, 80 percent of the farmland will be gone" (Prestbo 1971). California is an extreme example, but it very clearly demonstrates the implications of an accelerating urban-industrial land use.

According to estimates of the U.S. Department of Agriculture, the United States, whose land area per capita almost exactly equals the world's average, is losing about 0.6 million hectares of farmland per year by housing subdivisions, factories, highways, and other forms of urban sprawl. That loss is equivalent to only about 0.3 percent of the total land area per year (Prestbo 1971), giving the impression that very large expansions of the urban area can still take place without serious impact. But the removal of land for urban-industrial use is accelerating and may create farmland shortages even in the United States within 50 to 100 years if the present growth rates continue.

Figure 4-58 shows the past growth trends of U.S. population and urban areas and their projections to the year 2000. Urban land in 1900 amounted to only about 1 percent of the agricultural area of the United States. It is expected to increase to approximately 8 percent in the year 2000 (Clawson, Held, and Stoddard 1965).

Figure 4-58 also indicates that urban land *per capita* increased from 0.04 hectares per person in 1920 to 0.05 hectare per person in 1970; it is projected to reach 0.06 hectare per person in the year 2000. The land taken from agriculture is more than twice as great if areas for highways, road systems, railroads, airports, sport fields, and parks are included, as in Figure 4-59.

The use of arable land for urban-industrial purposes is not only an American problem. In England and Wales arable land was lost to urban and industrial development at an approximate rate of 16,000 hectares per year between 1945 and 1966. Between the two world wars, this rate was even higher (Ministry of Agriculture, Fisheries, and Food 1968). The amount of urban land per capita increased from 0.024 hectare per person in 1925 to 0.035 hectare per person in 1960 (Best and Coppock 1962).