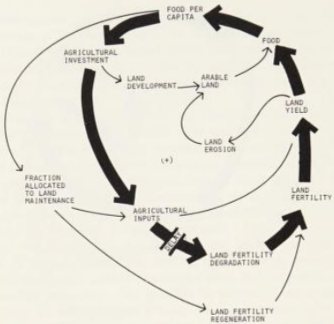

Figure 4-13 Loop 4: land fertility impairment

the microorganisms in the soil, to salinization, and to soil compaction, respectively—all of which we assumed to have unfavorable impacts on inherent land fertility. We also assumed in World3 that land fertility degradation can arise from a high level of industrial pollutants (heavy metals, radiation). A common characteristic of land fertility degradation due to agricultural inputs and industrial pollutants is that the effects do not occur until after a certain delay; the undesirable effects are not obvious immediately after the first use of the input or the first emission of a pollutant. Loop 4 (Figure 4-13) represents the assumed fertility degradation process. Food pressures result in higher investment in agricultural inputs as before. However, after a delay—assumed in the model to be twenty years—these inputs result in a reduction in land fertility and hence, ceteris paribus, in a lower land yield and less food.

Loop 4, like loop 3, is a positive feedback loop that will drive food output toward zero. However, the fertility degradation process is assumed to be much faster than the land erosion process; with no investment in soil maintenance, we assumed that it is possible to decrease the land fertility significantly in a few decades. On the other hand, soil fertility reductions are not irreversible, and land fertility regeneration can be speeded up by proper land maintenance techniques.

Loops 2 and 4 together explain why agricultural inputs are used despite their possible undesirable long-term effects. In the short run, the single result of increasing agricultural inputs is to increase land yield (through loop 2); it is only after a significant delay that the reduction in land fertility may ultimately depress land yield (through loop 4). Thus increases in agricultural inputs appear to have only beneficial effects in the short run.

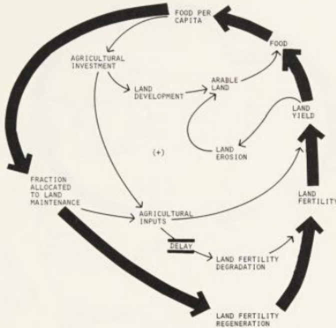

Figure 4-14 Loop 5: land fertility regeneration

Loop 5: Land Fertility Regeneration

When left fallow, land will recover lost fertility through the action of natural processes. The natural growth of grass and new forests on the soil will ultimately restore its content of nutrients, organic material, and useful microorganisms. These restorative processes normally go on continuously and can be enhanced by man-induced means, such as fertilization, mulching, proper irrigation and drainage, or planting leguminous green manures. This enhancement of the normal land fertility regeneration process is routinely undertaken by any farmer to prevent his land from losing its fertility.

Loop 5 (Figure 4-14) represents this process in World3. As long as the food available to the population is adequate, we assumed that a certain fraction of the annual agricultural investment will be devoted to land maintenance, even though that expenditure has no immediate visible return. This investment is assumed to be capable of enhancing the land fertility regeneration process to such an extent that normal rates of land fertility degradation can be counteracted and land fertility can remain at high levels.

Loop 6: Immediate Food Increase from Discontinuing Land Maintenance

If the food supply becomes very inadequate over several years, so that mass starvation and death are likely to result, we hypothesized that long-term investments in soil maintenance programs would no longer be made. In the short run, more agricultural inputs would thereby become directly available for producing more