Dynamics of food-prey-predator systems and agricultural practices

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EXTENDED ABSTRACT
Crop fields are complex systems where the basic crop interacts with species that feed from it, and are, in turn, depredated or parasited by other species. These relations create a dynamic system with several counterintuitive behaviours. On the other hand agricultural practices based on pesticide application have been subject to debate and the economic benefits of chemical pesticides and their externalities are questioned (Cowan and Gunby 1996, Tjomhom1998, Widawsky 1998, Wilson 2001). This paper presents a food-prey-predator model of an agricultural system. The singular dynamics of this system and the effects of pesticide application on it are studied. There are many examples of agricultural plagues subject to predation, each one having its particular dynamics, but the model presented in this paper is a general one that aims to capture the most general features of pests dynamics. The results show that the prey-predator dynamics is an important fact to take into account if pesticides are applied, the effects of several agricultural practices concerning pesticide application and the development of pesticide resistances are investigated.

Food-prey model. The simplest model developed is the food-prey model (figure 1). The food is harvested every season. Growth rates, carrying capacity and food per prey parameters can only be chosen within a restricted set, otherwise the prey would extinct (figure 2).

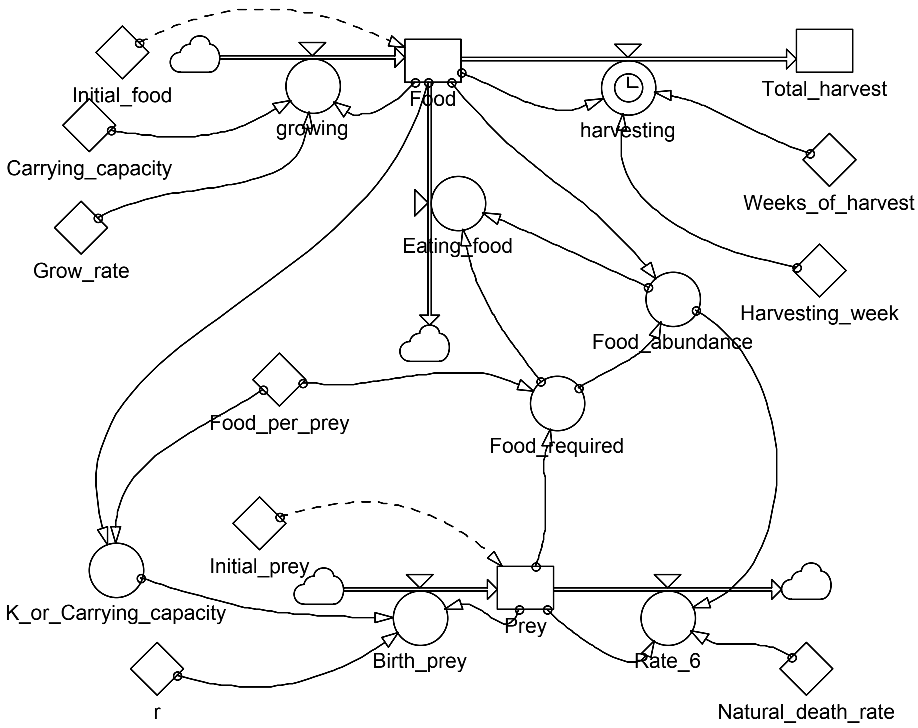

Figure 1. Food-prey model

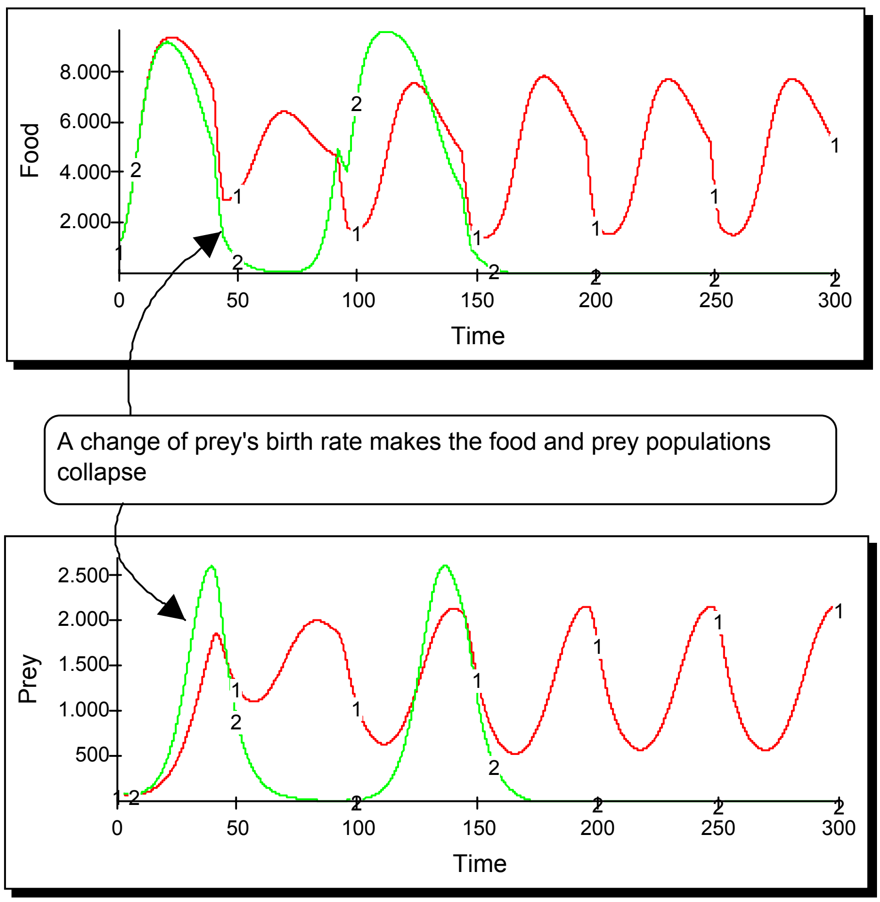

Figure 2. Results of food-prey model.

Food-prey-predator system. Only certain parameters lead to a system where the prey and predator do not extinguish (Figures 3 and 4). The results show the clear delays in the growth of the three species. The functional response of the predator is an important factor that stabilises the system.

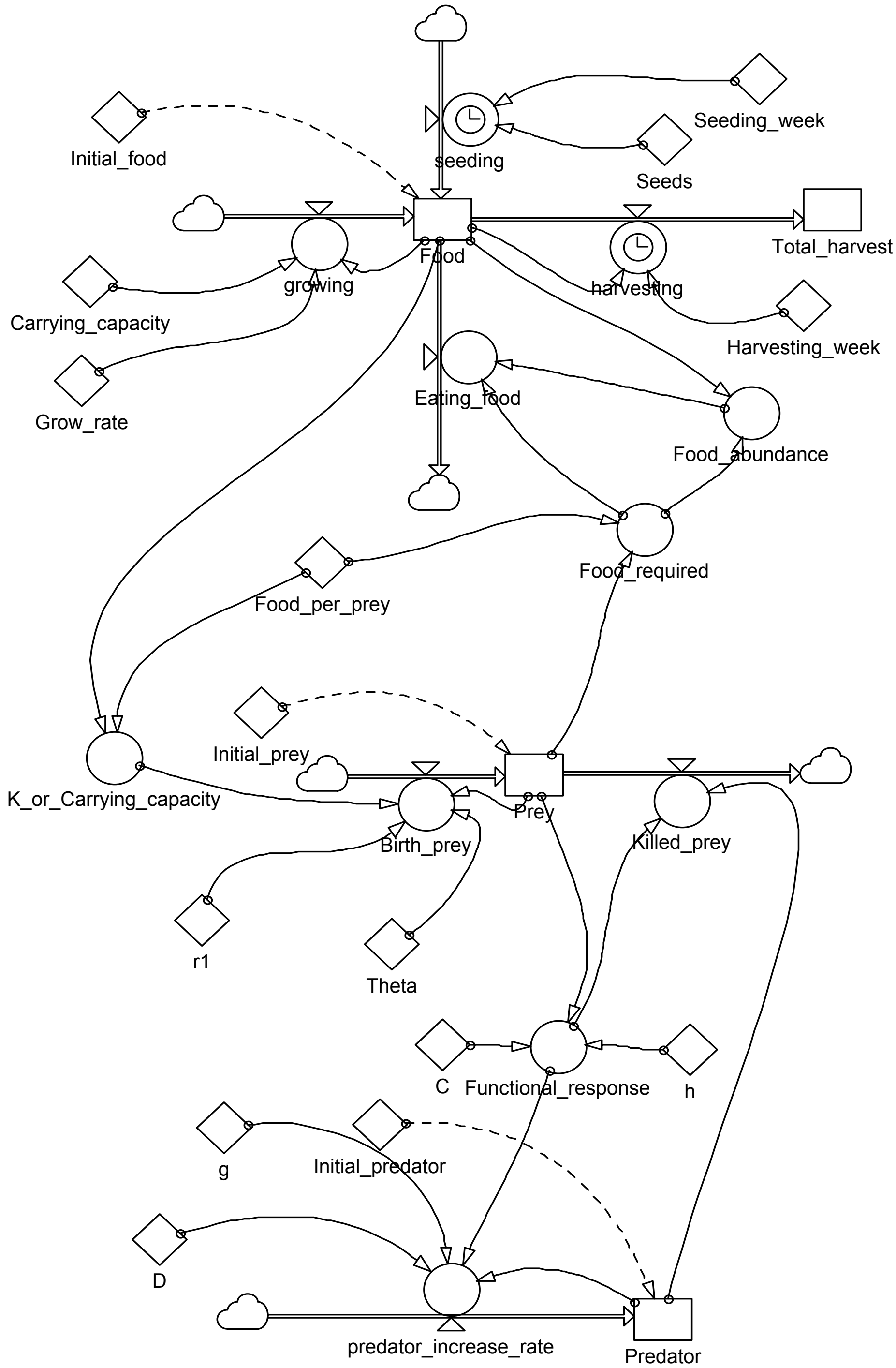

Figure 3. Food-prey-predator system

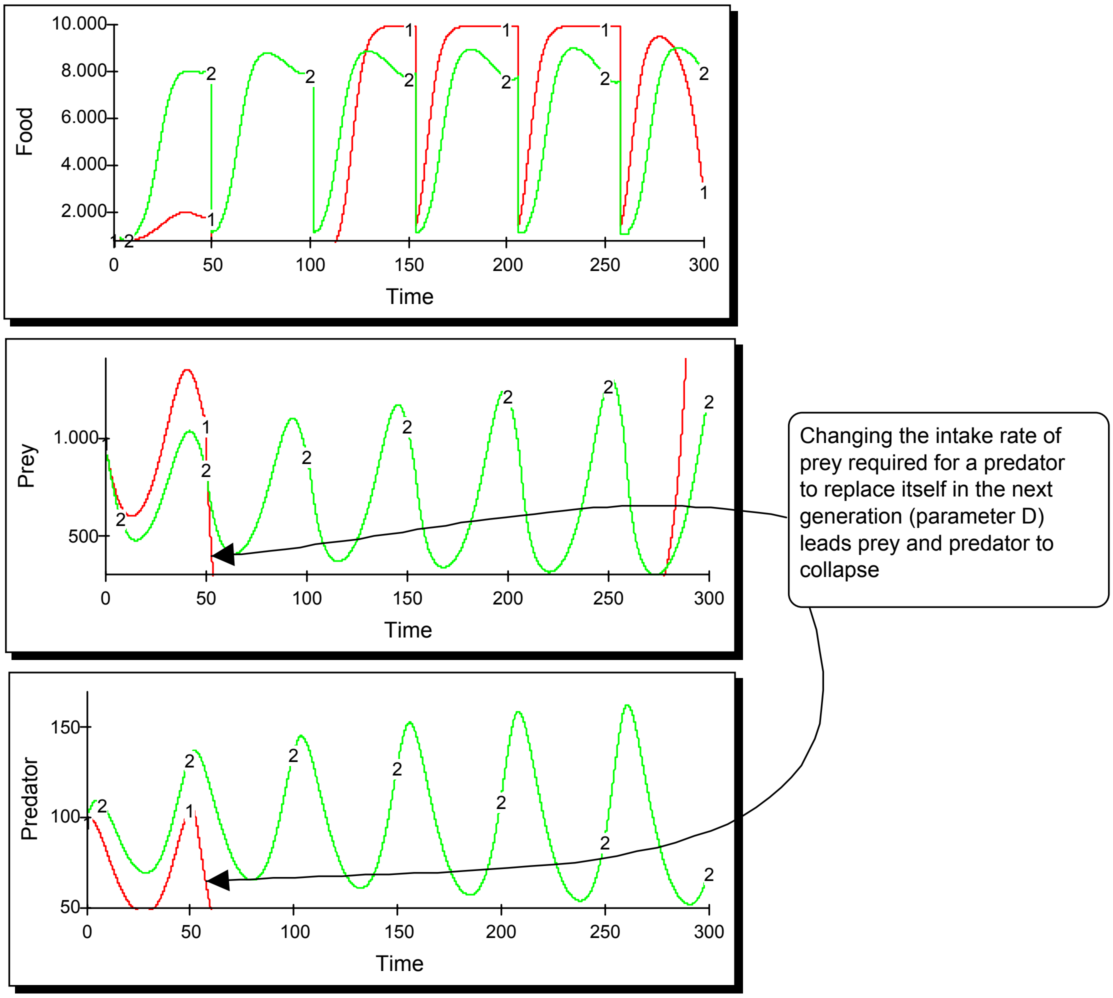

Figure 4. Results of food-prey-predator system.

Food-prey-predator and pesticide. The complete model includes the pesticide, the decision system concerning the application of the pesticide and the growth of a pesticide-resistant plague (prey). Two types of decision systems have been tried. One based on a fixed threshold: when the amount of prey reaches a fixed threshold the pesticide is applied. The second one is based on the concept of *economic injury level*. The pesticide is applied only if the cost of the loss of harvest (caused by the plague) is greater than the cost of the pesticide that has to be applied to eliminate the plague. (figures 5, 6 and 7)

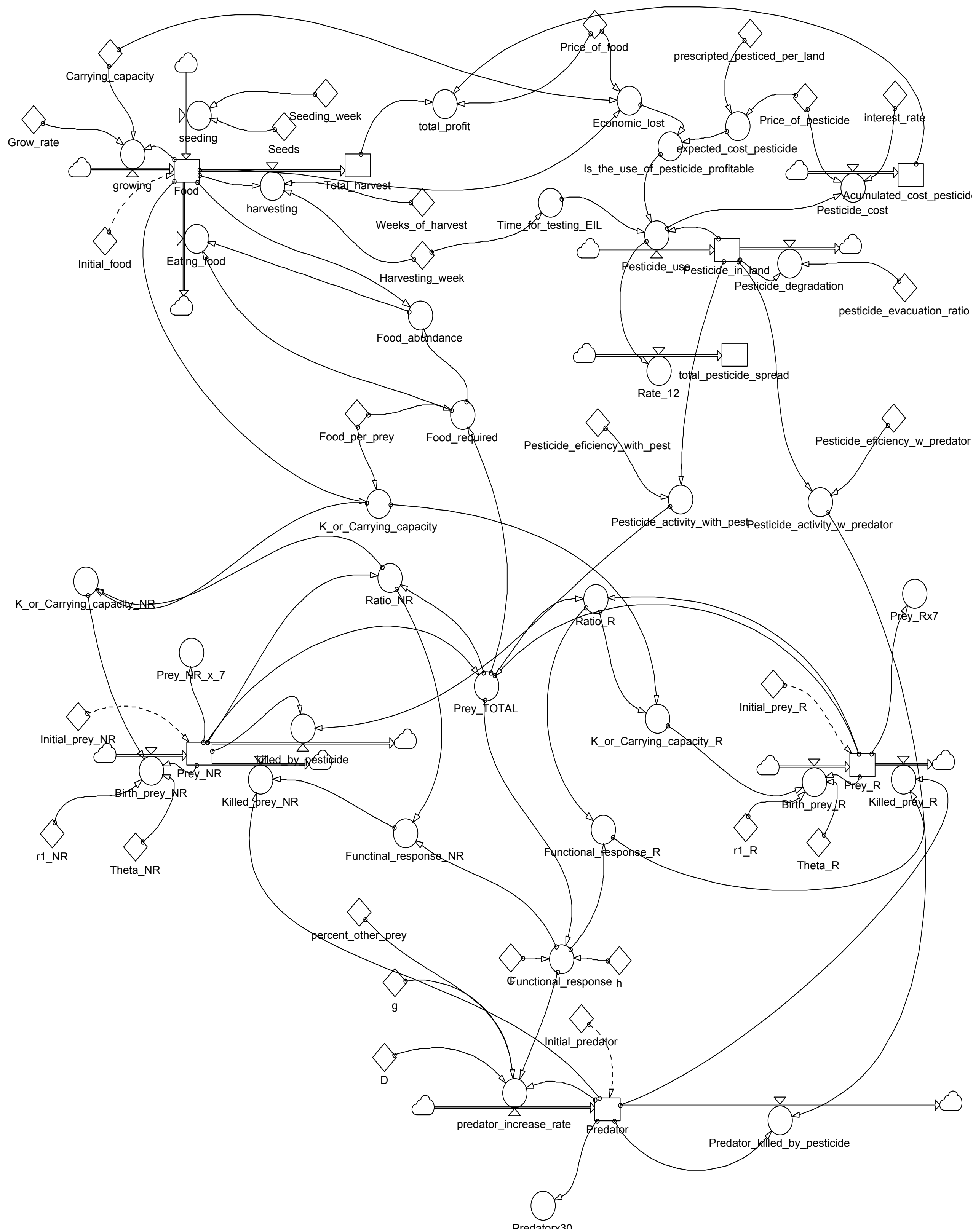

Figure 5. Complete model.

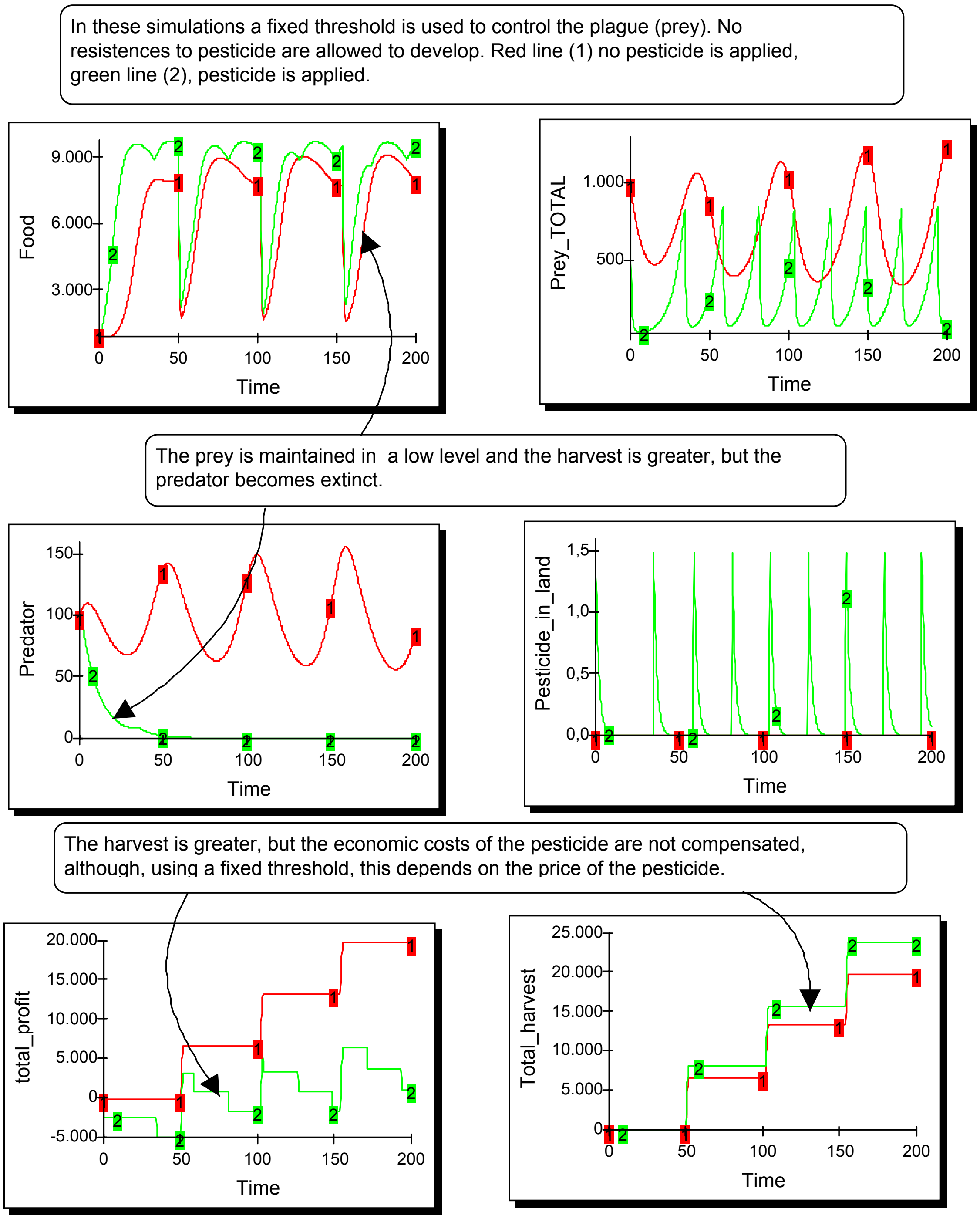

Figure 6. Fixed threshold to apply pesticide. No resistances allowed to developp.

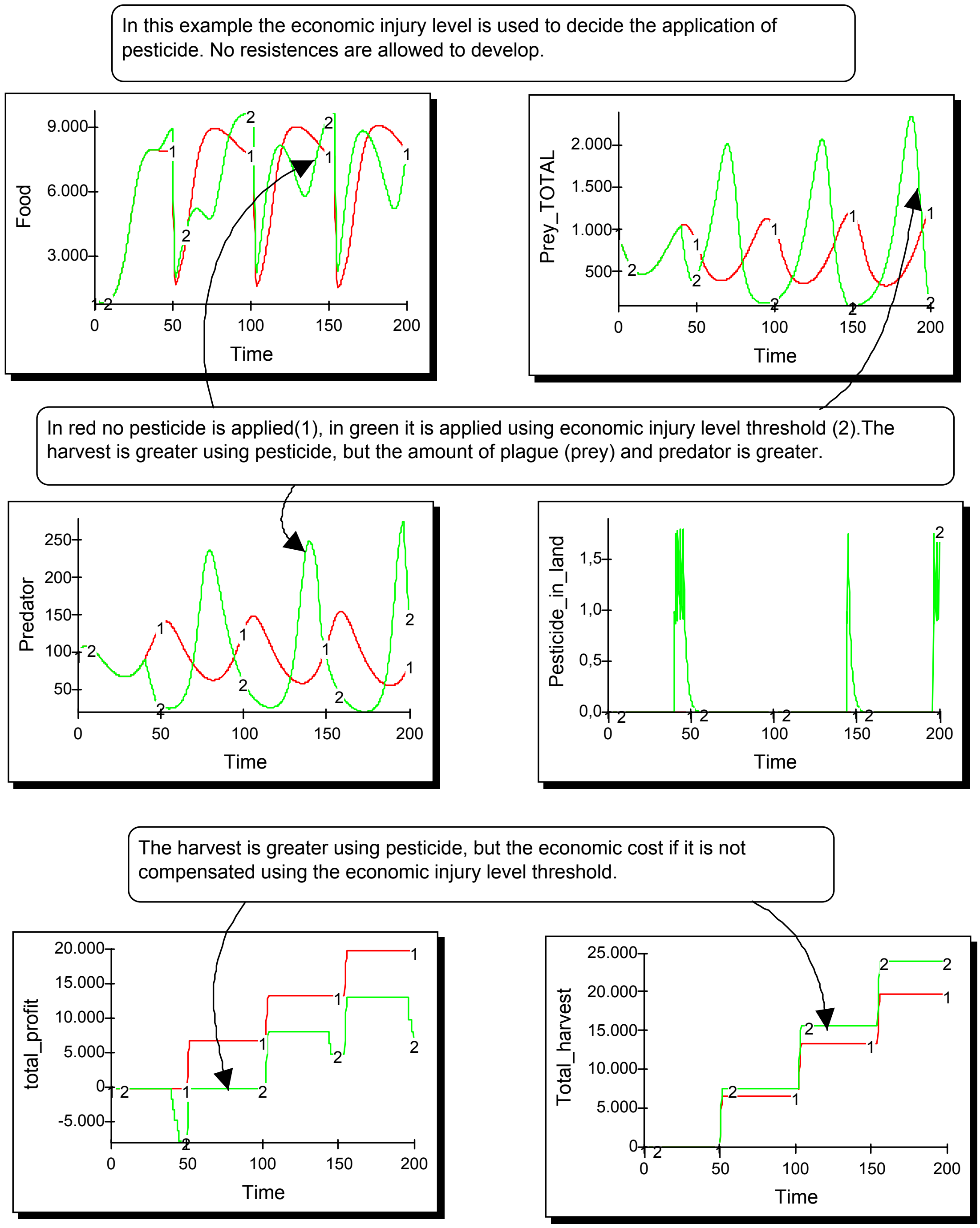

Figure 7. Economic injury level threshold. No resistances allowed to develop.

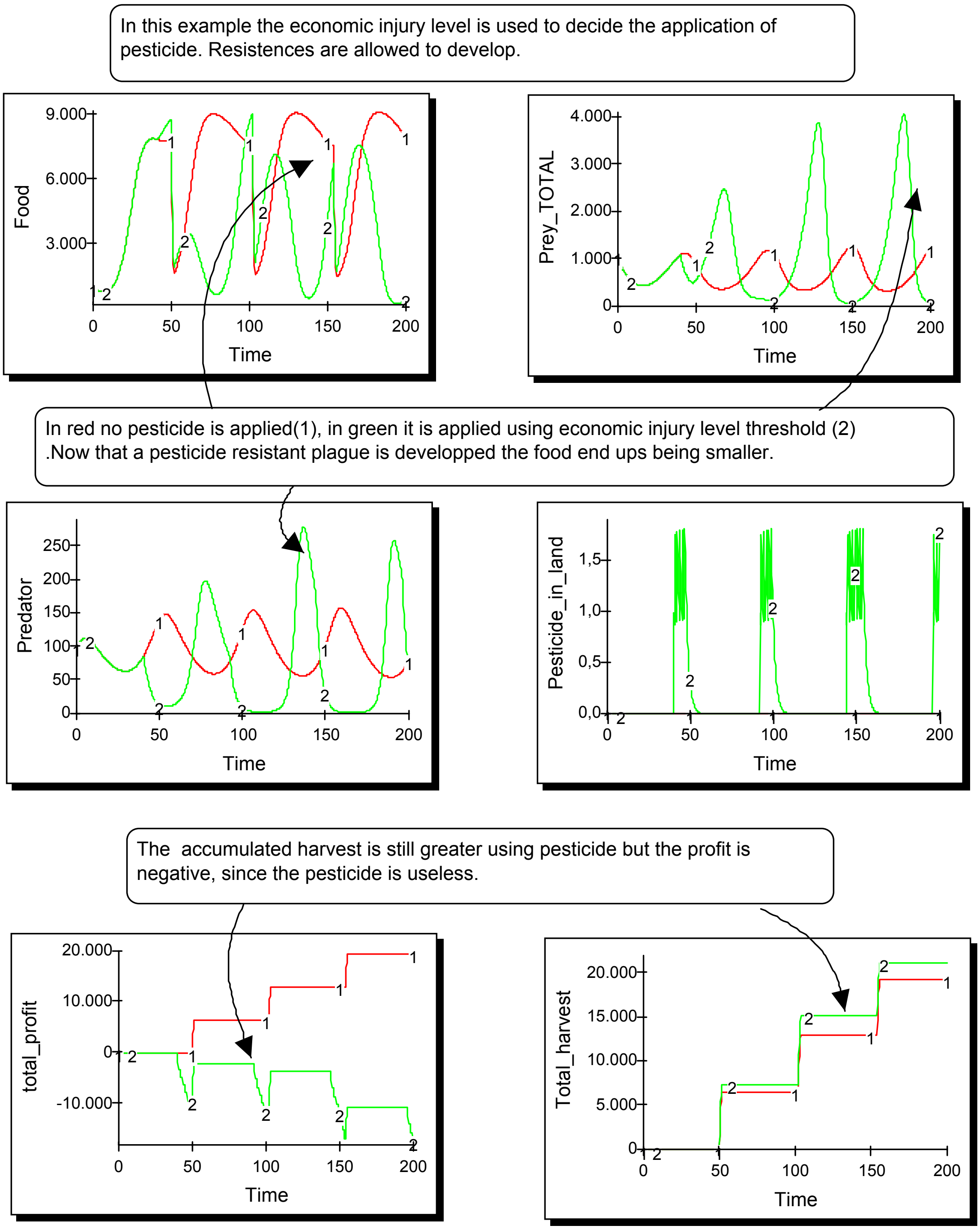

Figure 8. Economic injury level threshold. Resistances are allowed to develop.

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