Environmental Systems – Dynamic Systems, Simulation and Modelling

A. Schupp, J. Schwalb & Schönberg, A.

1. Introduction

The goal of this work is to simulate a biological invasion of a superior species in a stable ecosystem. Ecosystems are complex, dynamical, non-linear and multilevel system with many feedbacks due to the co-operation of positive and negative loops (Awrejcewicz et al 2015, p.267).

An appropriate way to model and analyse the dynamics of ecosystems is the method of “Dynamic Systems” which was developed by Jay W. Forrester in the late 1950's (Awrejcewicz et al 2015, p.267). The open access Software VENSIM (Venata Systems Inc 2015: VENSIM) will be used to simulate a predator pray system with two predators in a food competition.

2. Model scenario „Invasive Species“

Since the increasing transport and exchange caused by globalisation (Perrings et al. 2005, p.212) ecosystems are threatened by invasive species (Meyerson & Mooney 2007, p. 199). If a foreign species reaches a new ecosystem there is a chance that it can establish in the new habitat (e.g. a niche). A successful reproduction can lead to an invasion of the native ecosystem with a probable risk of displacement to native species. (Nentwig 2010, p.16ff).

An actual example is *harmonia axyridis* (Asian Ladybug) which was introduced in many countries as a biological control agent (Majerus et al. 2006, p.210f., after Gordon 1985) but has negative influences on the native Ladybugs (*Coccinellidae*) populations. *H. axyridis* has some superiorities over native species like a higher reproduction rate, a fast dispersion (Majerus et al. 2006, p.210) and improved overwintering abilities (Labrie 2008, p.860f). The model simulates the arrival of *h. axyridis* as a superior predator in a stable system with native *Coccinellidae* as native predator feeding on *sternorrhyncha* (aphids) as prey. We assume that the superior *h. Axyridis* will outcompete the native species due to its advantages.

3. Model capability

The model is based on the Lotka-Volterra predator prey model (zitieren) with a second predator as the invasive species. The model is capable of simulating the food competition between both predators feeding on the same prey. The prey has a constant birth-rate while the predators birth-rate is dependent on the population of prey (amount of food supply) and a reproduction-rate (individualy). Both predators have a constant death-rate while the prey death-rate is depend of the population of both predators. With normalized initial values (1) and rates (0.1) the system is stable. The main adjustment to simulate the superiority of the Asian Ladybugis an increased reproduction-rate and a decreased death-rate.

4. Discussion

5. Literature

Awrejcewicz, J., Kazmierczak, M., Mrozowski, J. & P. Olejnik (2015): Dynamical Systems – Mathematical and Numerical Approaches.

Nentwig, N. (2010): Invasive Arten. Göttingen.

Meyerson, L.A. & Mooney, H.A.MEYERSON (2007): Invasive alien species in an era of globalization. Frontiers in Ecology and the Environment, 5, 199–208.

Perrings, C., Dehnen-Schmutz, K., Touza, J. & M. Williamson (2005): How to manage biological invasions under globalization. Trends in Ecology & Evolution, 20, 212–215.

Labrie, G. Coderre, D. & E. Lucas (2008): Overwintering Strategy of multicolored Asian Lady Beetle (Coleoptera: Coccinellidae): Cold-Free Space As a Factor of Invasvie Success. InAnn. Entomol. Soc. Am. 101(5): p. 860-866.

Majerus M., Strawson, V. & H. Roy (2006): The potential impacts of the arrival of the Harlequin ladybird, Harmonia axyridis (Pallas) (Coleoptera: Coccinellidae), Britain. Ecol Ent 31,  207–215.

Venkat, K. (2005): Predator-Prey Dynamics and Wildfile Management: A System Dynamics Model.

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