ISEI 7

7th International Conference on Ecological Informatics

13 – 16 December 2010

Ghent University
Ghent, Belgium

How agricultural matrix intensification may affect understory passerines that inhabit forest patches?

Fernando Goulart, Paulo Salles and Ricardo Bomfim Machado

goulart.ff@gmail.com, psalles@unb.br, rbmac@unb.br
Institute of Biological Sciences, University of Brasilia
Campus Darcy Ribeiro, Brasilia, 70.910-900, Brazil

Session: Qualitative reasoning (Chair: B. Bredeweg (The Netherlands)

Timing: 14 December 2010, Blancquaert room, 14h40-15h00 (Code QR 9)

Abstract

Most studies about habitat fragmentation tend to consider the landscapes as binary scenarios because “natural areas” embedded in a “hostile matrix” compose them. This black-and-white view is dominant in biology education books, research and management practices and has its theoretical basis on the Island Theory. Despite of this, terrestrial landscapes often fall off this insular pattern, mostly because terrestrial matrix is often a heterogeneous mosaic in which human communities interact and interfere on landscape’s quality for biodiversity. Therefore, understanding how different managed matrix affects organisms that inhabit patches seems to be crucial for biological conservation.

Considering that most of the tropical area is composed by agricultural land and that most of this land is either intensified or in the way to, we have asked the following questions: How agricultural intensification of the landscape matrix of an Atlantic Forest region (a biodiversity hotspot) may affect the dynamic of populations of understory endemic passerines? Secondly, how can we communicate these results to decision makers and local stakeholders? Focal species in this study are *Sclerurus scansor*, *Pyriglena leucoptera*, *Conopophaga lineata, Chiroxiphia caudata*, *Xiphorhynchus fuscus, Lepidocolates squamatus*.

We built a qualitative model using the Theory of Qualitative Process, which is based in a compositional approach that combines model fragments to obtain simulation models. The model is implemented in GARP3, a software that express causal relationship either by direct influences (I+ and I-), that represents processes, or qualitative proportionalities (P+ and P-), that propagate the effects of processes.

The model has nine entities: Agricultural intensification, Agricultural matrix, Species source, Target patch, *Sclerurus scansor*, *Pyriglena leucoptera*, *Conopophaga lineata, Chiroxiphia caudata*, *Xiphorhynchus fuscus/Lepidocolates squamatus* (these two last entities were considered as one single entity due to their ecological and phylogenetic similarity). Two external agents are modeled: Emigration and Local Extinctions. Entities and agents are associated to quantities. Matrix has *structural permeability*, *light incidence*, *arboreal component*, *heterogeneity between farm-plots*, *arthropod abundance*, *vertical complexity*, *fruit availability*, *pesticide*. Species entities have *sub-population numbers* and *sub-population variation rate*. Species source has *propagules quantity*; Emigration has *migration rate* and Local extinction has *random extinction rate*.

Structural permeability captures the matrix structure in rendering or facilitating the flux of propagules through it, so different species will respond differently to it. For example, *C. caudata*

is a very vagile species, so that propagules from source will always reach the target patch, no matter of the structural permeability value. Differently *S. scansor* was considered here as the lesser vagile species, so that structural permeability has a minimum effect on its ability to disperse and colonization capacity. The other species are considered to have intermediate response (structural permeability threshold equal to medium value).

In the model, *agricultural intensification rate* acts upon agricultural matrix decreasing (I-) *heterogeneity between farm-plots*, *vertical complexity*, *fruit availability* and increasing (I+) *pesticide* use. All these variables affect *agricultural intensification rate* via feed-back loops that stabilize the system. For species that forage in the matrix, such as *P. leucoptera* and *C. caudata*, *arthropod abundance* and *fruit availability* affect positively *sub-population variation rate*, which leads to an increase in the *sub-population number* in the target fragment.

The model assumes that local extinction in the target patch is a random variable that goes from zero to maximum, so that, for less sensitive species (*C. caudata, P. leucoptera, C. lineata),* if *random extinction rate* is greater than medium values, it affects negatively *sub-population variation rate*. For moderate sensitive species (*Xiphorhynchus fuscus/Lepidocolates squamatus*), negative influence of random extinction rate is active if its value is greater or equal to medium. Finally, *S. scansor*, a very sensitivity species, is always negatively affected by random extinction rate, despite of its values. Random extinctions affect all species, suggesting an inter-species dependence dynamics. Fire occurrence, storm, droughts, predator introduction or population increase, parasite outbreaks, epidemics and human pressure would be good examples of these unpredictable events.

Simulations show that agriculture intensification should, from the causal point of view, lead to instability of understory species populations at different scales. Species were affected by low immigration, caused by decline of farmed matrix permeability reducing arrival of new individuals form the source and reducing rescue effect. For species that forage in the farmed matrix (*C. caudata* and *P. leucoptera*), the decrease of arthropod and food abundance caused by pesticide use and simplification (decrease of heterogeneity, vertical complexity and arboreal component), respectively, negatively affected population variation rate and thus, population numbers. Simulation showed cycles that stabilize the systems maintaining populations at different levels. This seems to represent how intensification could lead to instability in the colonization-extinction ratio. Therefore sub-populations could increase, decrease or remain stable in zero, low or high levels. Bird persistence was greater in non-intensified scenarios especially for species that have low dispersal ability. Even for better dispersal species, such as *C. caudata*, decrease on fruit availability due to intensification may cause population decline. Therefore, conservation and implementation of non-intensified agricultural practices such as organic farming and agroforestry may spur forest bird conservation.

Our model reinforces the burgeoning literature that suggests that matrix quality really does matter to population dynamics so that colonization is possible in balancing random local extinction. If agriculture intensification is implemented in the Atlantic Forest, these species shall present a decline locally, regionally and globally (as they are endemic, regional extinction is also global).

The model also explores important theories of animal movement. For instance, photophobia, or a psychological predisposition to avoid open country habitat that may constrain movement trough the opened matrix. In the model this is captured by the assumption that changes in light incidence causes an opposite effect on structural permeability, so that when the former is increasing, permeability is decreasing.

Our model can be used by graduate and undergraduate students to support understanding of some ecological concepts, such as source-sink-dynamics, rescue effect, matrix permeability, random extinction, landscape connectivity. It also could be used by stakeholders and researchers in order to go further beyond the use of common sense about causal relations involved in ecological systems.

This work is co-funded by the EC within FP7, Project no. 231526. For further information, visit http://www.DynaLearn.eu