Linking forest management and species distribution models: a theoretical approach under climate change

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Abstract

Abstract section

Ecology may provide many of the answers — but only if it is holistic enough to incorporate the human element as part and parcel of the ecosystem.

(Pfister, 1993, p. 231)

1 What is going on?

I can use the section in the Robert's project

Climate change is an increasing trending topic both in non-scientific (Capstick et al., 2015) and scientific environment (Figure 1), transforming our world as a metamorphosis of practice and acting (Beck, 2016). According to IPCC (Cubasch et al., 2013), humans activities are contributing to increase the concentration of greenhouse gases, which can lead to increase the mean temperature and the strength of extreme climate events. This global change has an impact in different biological processes, from local species constraints (e.g. low regeneration Treyger and Nowak, 2011) to shift in species' range (Boisvert-Marsh et al., 2014; Monleon and Lintz, 2015) and in community composition (Dieleman et al., 2015), impacting biodiversity at different scales (Peñuelas et al., 2013).

Species distribution models (SDM; defined in section 5) has predicted tree species' range shift under climate change, providing a wide range of applications, as in biodiversity conservation and management (Guisan and Thuiller, 2005; Guisan et al., 2013). However, these models are generally phenomenological and distributed at equilibrium with climate (e.g. Pigot and Tobias, 2013). Hence, they do not consider important determinants of range limits as demography (Louthan et al., 2015), biotic constraints (Wisz et al., 2013; Pigot and Tobias, 2013) and species absences data (Koshkina et al., 2017), inducing non-accurately projection of the future spatial distribution of a species. Considering then ecological constraints, trees' migration rate following climate change will
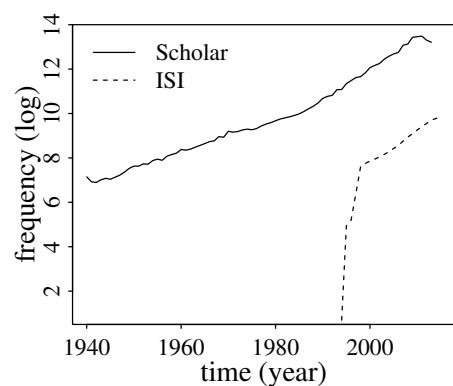

Figure 1: Frequency of the keyword "Climate change" used in research papers indexed on Google Scholar (1940 - 2013) and Web of Science (1994 - 2015)

be slower than predicted (Bertrand et al., 2011; Sittaro et al., 2017), increasing the climatic debt (Bertrand et al., 2016).

The climatic debt is a measure of the lag (or disequilibrium) of plant communities with climate change, integrated in an environmental context (Bertrand et al., 2016). Essl et al. (2015) has listed twelve mechanisms that contribute to delayed biodiversity responses, among them, changes appears at ecosystem (loss and degradation), community (secessional, biotic interaction, species removal and invasion) and population (evolutionary and adaptive) levels. Disturbance regime was also listed but it may not by related to climate debt (Bertrand et al., 2016). Hence, this lag under climate change promotes extinction debt, being a challenging for biodiversity conservation (Kuussaari et al., 2009) and productivity (Lasch et al., 2002). Then identify the mechanisms shaping delayed biotic response to environment is crucial to access the vulnerability of biodiversity to climate change and improve forecasts and biodiversity management (Essl et al., 2015; Bertrand et al., 2016).

2   What should we do?

Increase forest resilience! **(i)** But what is it exactly? (paper: Building evolutionary resilience for conserving biodiversity under climate change) Try and discuss this aspect in different perspectives. **(ii)** Why resilience?

Forest management

Present some motivations, advantages and disadvantages in considering forest management.

Interesting argument about who should peak do winners from Webster et al. (2017). They say that *Predict-and-prescribe management may erode diversity by focusing on 'winners'*.

Forest management in a theoretical view was actually not very much explored and so I consider it a kind of gap we should better explore. Read Becknell et al. (2015) for an overview.

3   Study case: the Quebec forest resource

Explain here where I am going to work and also why I am choosing this area.

4   Theoretical approach

Read the section *recent developments in predicting changes in species distribution* from Ehrlen and Morris (2015)

Disturbance

Pass through the main disturbance theories basing mainly in Pulsford et al. (2016) (verify with Dom if this section is necessary)

Resilience

(iii) But how to calculate it in a analytical way? Before introduce the method to calculate resilience, we must have an idea of what is the equilibrium (Box 1) and stability (Box 2) of a

model. Now introduce the calculus of λ by Jacobian matrix.

Box 1. Equilibrium

$$E = mc^2 \qquad \text{Formula of the universe} \qquad (1)$$

Box 2. Stability

$$E = mc^2 \qquad \text{Formula of the universe} \qquad (2)$$

Range dynamics theory

What theories can help us to describe species range under climate change?
How to integrate forest management in this theory?
-> Matapopulation dynamics theory <-

Transition period

Species Interaction: why is it important?

Explain the role species interaction can play on its distribution range. http://www.sciencedirect.com/science/art
The perceived threat of climate change is often evaluated from species distribution models that
are fitted to many species independently and then added together. This approach ignores the
fact that species are jointly distributed and limit one another (Clark et al., 2014).

Joint species distribution?

Interactions between land-use and climate also can underestimate species resilience in distribution models (Goring and Williams, 2017).

5 How to do it?

Here we see a briefly presentation of possible methods will be used in the thesis.

Modeling

Why and how modeling?
Morin et thuiller 2009:What then are the best strategies for obtaining accurate predictions for
changes in the distributions of deciduous temperate trees? At the scale of the geographic distribution of species, no experiments in situ can be reasonably carried out to predict possible
range shifts (Woodward 1987). Modeling therefore appears the most feasible and efficient way
to establish useful predictions (Lovejoy and Hannah 2005, Thuiller 2007), and several kinds of
models have been developed during the previous decade for this purpose. As reviewed by Midgley
et al. (2007), these models fall into two main classes: vegetation-type models (dynamic global
vegetation models [DGVMs]) and species-specific models (niche-based and process-based).

Species Distribution Models

Nice resume about SDM in Morán-Ordóñez et al. (2016).

Integral Projection Models

I should be writing and not playing with LaTeX

Bayesian approach

I should be writing and not playing with LaTeX

6   Thesis structure

The first part of the thesis will be a general introduction in French where I will probably use a part of this document and present the big picutre of my thesis.

The first chapter will try to answer the question *Can forest management increase forest resilience to climate change?*. The paper will work with an analytical and sensitivity analysis in a metapopulation dynamics model to understand the impact of forest management on increasing forest resilience.

In the second chapter I am going to build a landscape model that will consider both forest management and species interaction.

The third chapter I am going to build another model but in a local scale. *I have to find a good biological reason for that.*

The fourth chapter will then integrate both landscape and local model into one. Here I will also track the uncertainty of the model by bayesian approach.

TODO:
- Automate box labels
- Short reference style

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