CLÉMENT VIGUIER

PhD Thesis

Contents

INTRODUCTION

1 MOUNTAIN GRASSLANDS

Mountain grasslands have an unique beauty drawn by the diversity of flowers colours, the strong contrast between the luxurious green vegetation and the roughness of the naked rocks, and the feeling that living in such places, at the edge of living conditions, is a fight worth fighting. I could illustrate this beauty with thousands pictures and words, and it would certainly convince you that these ecosystems worth spending time studying them to better understand and protect them. I could also describe their role in the economy of alpine regions, currently subject of great modification, and greater to come. But you would not see these rich systems as I see them: as an intricate network of interaction living creatures, with their own characteristics, strategy and experience, forming a dynamic system... Capturing this beauty is one challenge of this modelling PhD.
I must now give you an overview on the mountain grasslands

The idea is to go from context, to services to ecology. At the entd of this part, it is obvious that ecosystem services can be derived from traits and that we need tools for prediction of MG dynamics.

1.1 Geography, climate and managements: les drivers

1.2 Mountain grasslands under climate change

1.3 Mountain grasslands, source of services

2

Modelling ecological systems

The message here should be that: we know how to model vegetation systems, but we need finer resolution (from species and com, to traits, to individual responses) and bigger (higher number of species) scale -> generic framework and individual response.
Based on two particular similar models: taubert, and Lohier.

2.1 Models as understanding and testing tools

"Physicien de la biologie"
Justify the modelling approach - what's a model ? simplification of reality
Long subject refer to models in ecosystem sciences. Different classes of model, and different objectives. Mechanistic models: understanding and testing hypothesis.
Model as understanding tools: how does modelling help us understanding the system we are modelling.
The need for mechanistic model and emergent properties of models. Process-based models vs statistical model (what happen outside the data (example of flickering tails of regression models), similar to bayesian approach, the model is constrained by our understanding of processes.)
mechanistic models: risks of lack of mechanisms, complex calibration, lot of parameters. Statistical model have the advantage of parcymony: minimum number of parameters to reproduce a pattern.

2.2 Modelling plant communities

2.2.1 Different levels of modelling: from communities to individuals

community approaches, CWM to importance of individuals.

2.2.2 Processes

2.2.3 Agent-based models

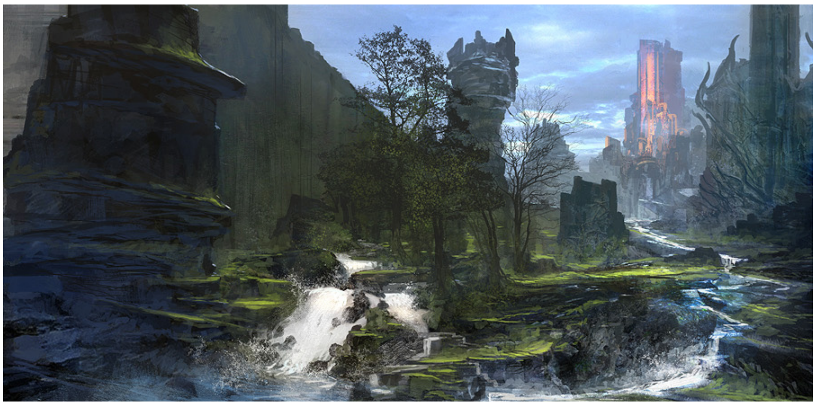
Review of existing models (grasslands and forest)
Comparison of two existing models
How to build aroung/from that.

2.3 Modelling coexistence

Message: modelling coexistence is a challenge because 1) do not know/understand all mechanisms, 2) challenging to incorporate enough mechanisms, 3) costly computation and data wise. -> need for more generic and complete (multiple mechanisms approaches.

2.3.1 What is diversity and why model it?

On why model coxistence: better understanding of mechanisms, tool to evaluate and predict changes in coexistence.



2.3.2 The concept of niche

2.3.3 Coexistence mechanisms

2.4 Breaking the resolution-specificity trade-off

use of generic species
still a trade-off with scale.

3

PHENOTYPIC PLASTICITY OF ORGANISMS

Message here ?

3.1 Stability and plasticity

3.2 Costs and limits of plasticity

3.3 Plasticity and coexistence

SCIENTIFIC QUESTIONS

How to model vegetation system with higher resolution at bigger scale?
How does plasticity work in plants?
Effect of plasticity of plant interactions (and coexistence)?
Effect of plasticity on resistance/resilience to climatic events?
Effect of this mechanism on overall services provision?

I

EXTEND MOUNTGRASS

This section is meant to include thoughts and ideas on how to extend mountgrassbut that could not be included in the first versions of the model for various reasons. Despite not being included, these extensions are interesting from a scientific or technical point of view, and I hope these notes can be useful to anyone interested in mountgrassor individual based vegetation modelling.

1 INCLUDE NITROGEN: SOURCE OF TRADE-OFF

As seen previously in chapter , the emergence of trade-off in growth strategy in the actual framework actually rely on a strong genetic constraint over plant plasticity. Indeed, without plasticity cost and low reactivity there would be a high rate of phenotypic convergence of individuals from different species. This is explained by the existence of optimum carbon partitioning (for a given size) in a stable environment. The coexistence of different resource use strategies (exploitative vs conservative) is allowed only through temporal variations and non equilibrium state. This is quite common since a lot of models will predict rapid dominance of one entity in case of equilibrium (need references here).
Multiple questions arise from this observation: are the conclusions of this work still interesting in the understanding of the coexistence mechanisms? (I hope I did convince you in the dedicated part of this document, see .. for more details), is it possible to see coexistence of multiple strategies in a temporally stable environment? how can we produce trade-off by including only one more resource?

In the following paragraphs I try to answer these questions with theoretical arguments and suggestions on how to integrate them in MOUNTGRASS.

1.1 Stable coexistence: the need for a resource dependent tissue efficiency

Coexistence mechanisms are listed and detailed in the introduction of this thesis (see chapter **??**). Here I focus on the efficiency of tissues... Nitrogen based, why coexistence ? different phenotype correspond to different limiting resources and for different resource availabilities, different phenotype will optimize the return cost of tissues.Nitrogen also allow the model to have an extra dimension into strategy: WUE (local scale) versus NUE (global scale) (element of reflexion in Maire's thesis).
Its also can be related to

2

SPECIFIC RESISTANCE CARBON POOLS: DIVERSIFY STRATEGIES (AND MEMORY)

Original idea was to have specific carbon pools for different function, and weight the relative allocation based on gain projections.

3

Land-use: a important driver

3.1 Proto-model of management

Mapping, digestibility and selectivity (smoothing). Grazing and mowing. Height correction.

3.2 Individual and collective response

Response could be to grow thinner, more fragile leaves to go back on tracks (and take advantages of nutrients and lower competition) or grow bigger leaves and invest in predation resistance/avoidance.

3.3 Remaining questions

Calibration of herbivory pressure.

4

LOCAL ADAPTATION AND EPIGENETIC: BETWEEN SPECIES AND INDIVIDUAL MEMORY