

Elsevier L^AT_EX template[☆]

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Radarweg 29, Amsterdam

Elsevier Inc^{a,b}, Global Customer Service^{b,}*

^a1600 John F Kennedy Boulevard, Philadelphia

^b360 Park Avenue South, New York

Abstract

Keywords: `elsarticle.cls`, L^AT_EX, Elsevier, template

2010 MSC: 00-01, 99-00

1. Introduction

One of the main challenges of community ecology has been to explain the observed diversity despite few theoretical supports to high coexistence, as know as the "plankton paradox". During the last 25 years, our theoretical understanding
5 of this apparent paradox is nourished by empirical and modelling work. This progress partly arose from a shift between approaches focusing on species to the use of functional traits. Functional traits allows the investigation of broader patterns and mechanisms shaping natural communities. Traits emerged s a great tool to link theoretical concepts to empirical studies. The rise of large trait
10 datasets and online trait data repositories favour the investigation of broad general patterns of response to climate, trade-offs, community composition. This shift also introduced the concept on functional diversity that focused more on the functional role of the species in the ecosystem than on their identity.

Despite the advances made in community ecology by the use of functional

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^{*}Corresponding author

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¹Since 1880.

15 trait, certain mechanisms are still misunderstood and the mysteries of coex-
 istence are not yet resolved. This limitation of the approach may lie in the
 use of the species average traits of species. According to Violle and al. (check
 the ref) intra-specific trait variability (ITV)... Intra-specific trait variability
 arises from three main mechanisms (see box 1 for details). Incorporating this
 20 intra-specific variability in community models is necessary to enhance our un-
 derstanding of community assemblage rules and community responses to biotic
 and abiotic drivers. ITV has been shown to have contrasted effects on con-
 clusions we can make from community models. Jung et al. demonstrated the
 positive effect of intra-specific variability on coexistence by mitigating the abi-
 25 otic filtering effect and improving the niche partitioning effect (check that). In
 the other hand the ITV are supposed to reduce predicted coexistence through
 Jensen inequality effect (on both XXX function and competitive effects, see for
 details), despite a light positive impact of released intra-specific competition of
 low density species. The relative impact of these stabilizing (better niche parti-
 30 tioning, lower intra-specific competition at low density, etc...) and destabilizing
 () effects of intra-specific variations cannot be resolved by the use of theoret-
 ical models only. Empirical works show interesting correlations between shoot
 plasticity and diversity, but this relationship is only explained by an increase
 in ramet density and not a increase in diversity per ramet (sign of increased
 35 niche partitioning). Disentangle effects, complexity, tractable, generalization...
 Differences of response Between the complexity of natural systems and the over-
 simplification of theoretical models, there is a gap to fill if we want to better
 understand the role of phenotypic plasticity as a regulator of plant responses to
 climate drivers and biological interactions.

40

To attempt to fill the gap between empirical approaches and theoretical we
 try to address the following questions: Can a simple shared plasticity func-
 tioning explain the diversity of plant plastic allocation strategies ? How the
 phenotypic plasticity alter species potential niches and species interactions ?
 45 What is the impact of plasticity costs on the plant strategies and interactions ?

In order to tackle these questions we developed a generic process-based model of mountain grasslands. This model rely on a generic framework of plant functioning based on multidimensional strategies and allocation trade-offs, extended
50 with phenotypic plasticity. The model is mostly in this paper at the individual scale to settle a good understanding of phenotypic plasticity at the lowest scale. Work at the higher scale will be able to extend from this basis thanks to community scale simulations. Hopefully this ensemble of work will nourish the discussion about the role of intra-specific variation and phenotypic plasticity on
55 community dynamics, response to global changes and evolution.

2. Methods

2.1. Purpose

The model ***MountGrass*** is designed to investigate the effect of phenotypic plasticity on coexistence mechanisms in response to climatic and management
60 drivers on mountain grasslands individual plants and communities. Its generic structure allows the representation of numerous species with diverse strategies. Its design also let us use it both as a toy model for plants in controlled conditions (main use case in this paper) or as a community model.

65 2.2. Structure

The model is an individual, spatially explicit, process-based model. Plants in ***MountGrass*** are represented as two cylinders: one for shoot and one of fix depth (soil depth) for roots. These basic shapes are used in the calculation of resource gathering. Individuals are defined by an ensemble of species specific
70 traits (see table) and state variables (table). Plant phenotype can be derived from model parameters, species specific traits and size of the different carbon pools. The plant phenotype is completed by an ensemble of variables that describe its internal state and strategy. The carbon pool decomposition relies

on the general patterns of the Leaf Economic Spectrum and other large scale
75 studies. The limits of the use of general patterns at the local scale is discussed
further in this paper. Statistical modelling approach by Shipley supports the
role of one particular trade-off to explain the LES: the proportion of cell tissue
(related to cell size and number) to cell-wall tissue (cell-wall thickness). This
assumption that the allocation between structural (cell-wall) and active (cell)
80 tissues can explain main trade-offs is at the center on the model carbon pool
decomposition described in figure . Other carbon pools are: stem, storage and
reproduction. Plants : multiple strategies, 2 cylinders, 4 carbon pools.
Environment : soil (water parameters, depth), atmosphere (temp, humidity,
light)
85 scales and processes.

2.3. Representation of processes

Resources gathering and competition
Resource allocation
Plasticity (and costs).
90 (reproduction ?)

2.4. Initialisation and inputs

Because of implementation limitations running sensitivity analysis and full
calibration is not possible. The model was used with fixed parameter values
95 unless explicitly said (e.g. for plasticity costs analysis) (see appendix for details).
The model was mostly used in the following set-ups:

Pot simulation:

Double pot simulation:

Greenhouse simulation:

100 In the rest of this paper we will use the terms "pot simulation", "double pot
simulation" and "greenhouse simulation" to refer to these set-ups.

If not specified or varying the default precipitation and radiance levels where as follow: 2mm per day and 300 Watt per day (10/12 hours). Species traits are default traits (see appendix for details)

105 **3. Simulation experiments**

3.1. Benefits of plasticity on single plant growth

The effect of plasticity on single plant growth is explore with pot simulations

3.2. Strategic differentiation and convergence

3.3. Potential and realised niche

110 **4. Results**

4.1. Individual plant growth and phenotypic plasticity benefits

4.2. Strategic differentiation and convergence

4.3. Potential and realised niche

References

115 [1]

[1] P. Dirac, The lorentz transformation and absolute time, Physica 19 (1-12) (1953) 888–896. doi:10.1016/S0031-8914(53)80099-6.

Appendices

5. *MountGrass* description

120 **6. State variables, traits and parameters**

6.1. State variables

6.2. Species specific traits

6.3. Parameters

7. Simulations