Development of a grassland simulation model to support decision-making on grassland use

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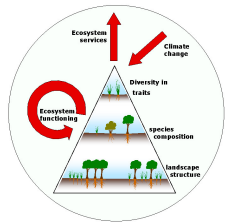

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About me

I ...

- studied Landscape Ecology and Ecology (Greifswald and Potsdam, Germany)

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About me

I ...

- studied Landscape Ecology and Ecology (Greifswald and Potsdam, Germany)
- have knowledge in plant ecology (plants & bryophytes), simulation modelling and in (Bayesian) statistics
- am a doctoral student at the FU Berlin
- teach statistics with R, individual-based modelling, and a botany & ecology module

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Research questions

- How can the taxonomic and functional diversity of plants in grasslands be promoted and, at the same time, the loss of yield (forage production) be minimised?

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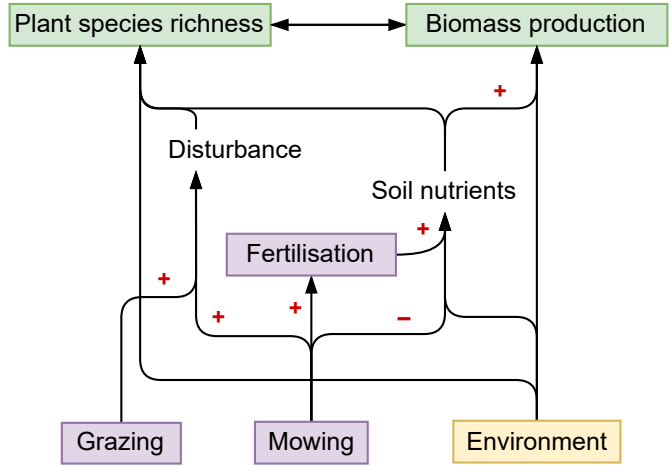
- How can the taxonomic and functional diversity of plants in grasslands be promoted and, at the same time, the loss of yield (forage production) be minimised?
- Does a higher functional plant diversity lead to a higher temporal stability of the forage production?

Plant species richness and biomass production



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Model overview

- community model of grassland plant species
- implementation with difference equations

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- spatial resolution: per grassland (patch)

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State variables

- biomass of species
- soil water content

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Traits

- Specific leaf area
- Plant height
- Root surface area / aboveground biomass
- Mycorrhizal colonisation
- Leaf nitrogen content

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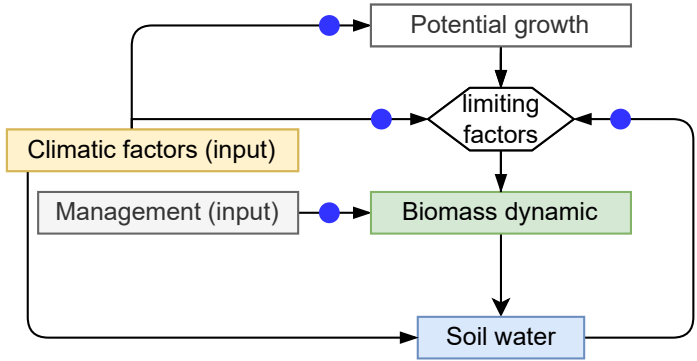
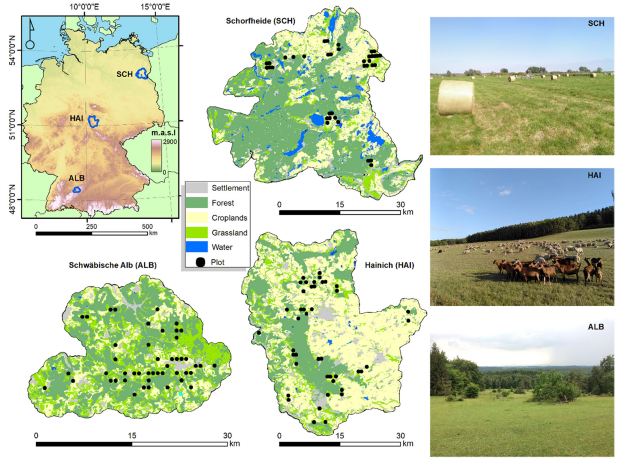
Model overview

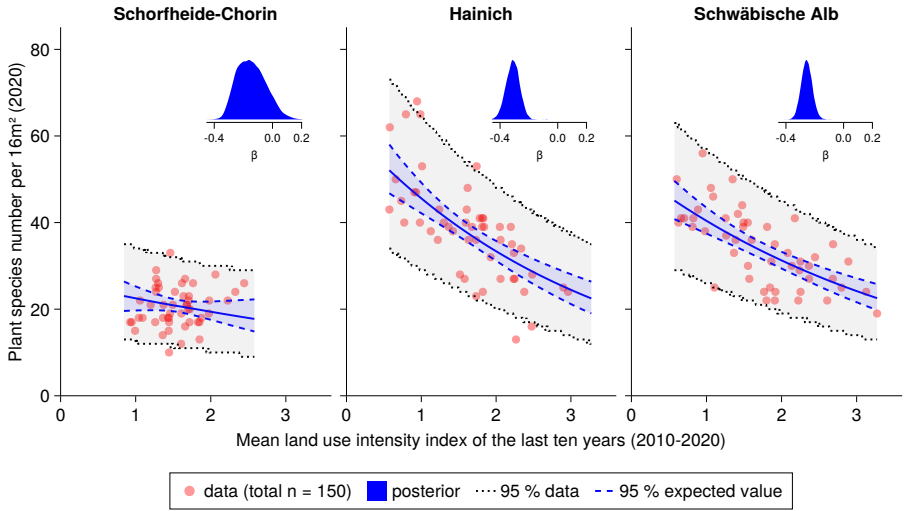


Study site - Biodiversity exploratories



Muro et al. (2022)

Study site - Biodiversity exploratories



Species-specific response - Plant traits

Radiation use efficiency

- Specific leaf area ↑
- Plant height ↑

Water and nutrient use efficiency

- Specific leaf area ↓
- Root surface area / aboveground biomass ↑
- Mycorrhizal colonisation ↑

Species-specific response - Plant traits

Radiation use efficiency

- Specific leaf area ↑
- Plant height ↑

Water and nutrient use efficiency

- Specific leaf area ↓
- Root surface area / aboveground biomass ↑
- Mycorrhizal colonisation ↑

Senescence rate

- Specific leaf area ↓

Grazing and trampling

- Leaf nitrogen content ↓
- Plant height ↓

Mowing

- Plant height ↓

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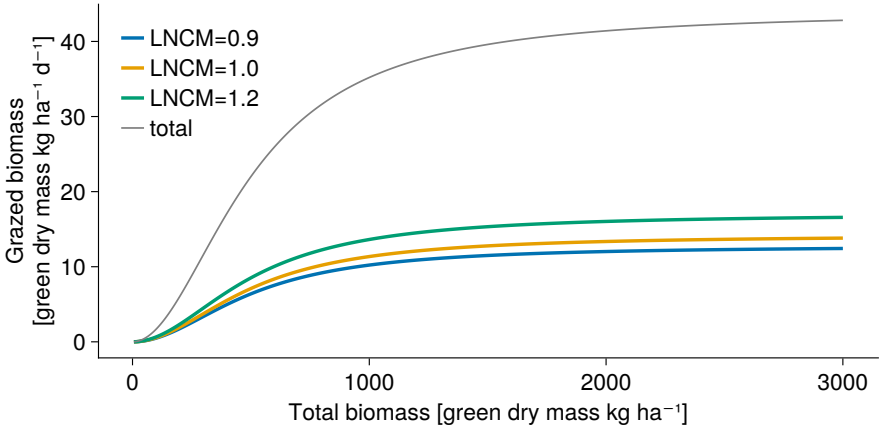
Species-specific response - Example



Model parametrisation and Scenarios

for fitting internal parameters:

- input: observed time series of climatic and management variables (2006/2009 - 2021/2022)

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Model parametrisation and Scenarios

for fitting internal parameters:

- input: observed time series of climatic and management variables (2006/2009 - 2021/2022)
- output: biomass, trait mean, trait variance, and soil moisture

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- initialisation: equal biomass among generated species

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Model parametrisation and Scenarios

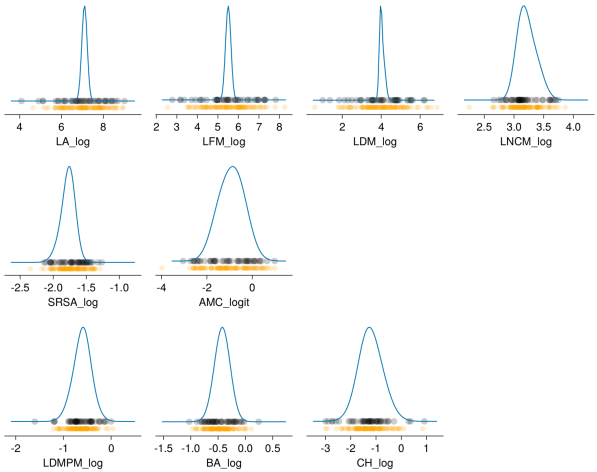
for fitting internal parameters:

- input: observed time series of climatic and management variables (2006/2009 - 2021/2022)
- output: biomass, trait mean, trait variance, and soil moisture
- initialisation: equal biomass among generated species

for running scenarios:

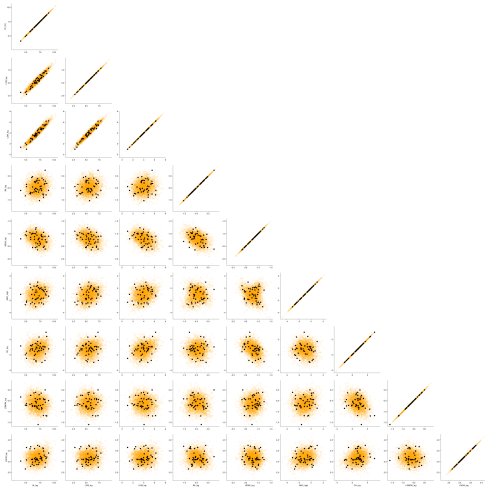
- random samples from fitted time series models of the climate data
- management options can be varied

Plant traits - Gaussian mixture model



- 46 species with values for all traits (out of 138 of the three exploratories)
- Gaussian mixture model with full covariance matrix and transformed data
  - black: data
  - orange: generated samples
  - blue line: marginal likelihood

Plant traits - Gaussian mixture model



- correlation structure between the traits
  - black: data
  - orange: generated samples

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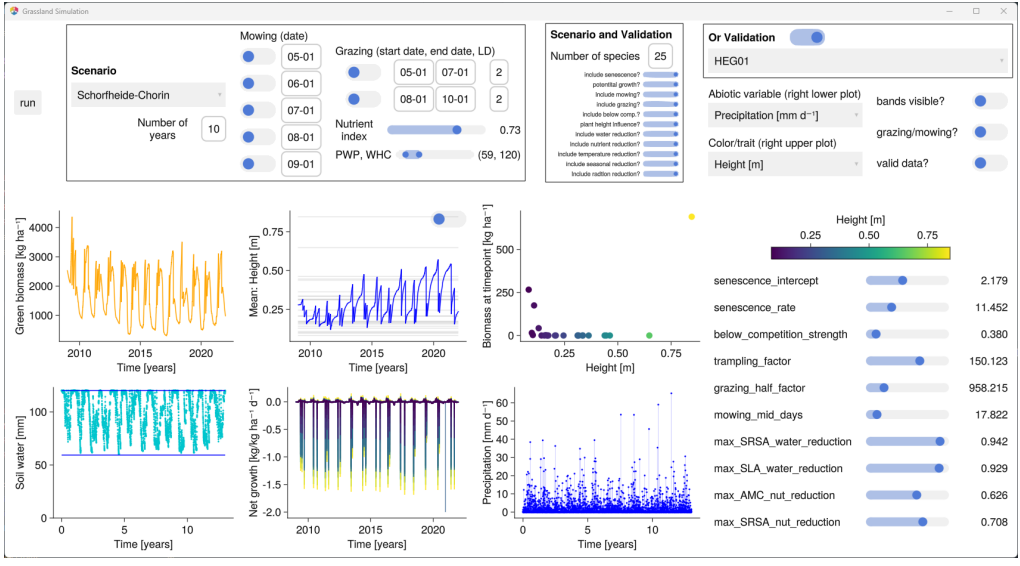
Model

- Model is developed as a *Julia* package:
  `https://github.com/FelixNoessler/RegionalGrasslandSim.jl`
- documentation (WIP):
  `https://felixnoessler.github.io/RegionalGrasslandSim.jl`


Grassland Simulation
run
Scenario
Schorfheide-Chorin
Number of years
10
Mowing (date)
05-01
06-01
07-01
08-01
09-01
Grazing (start date, end date, LD)
05-01
07-01
2
08-01
10-01
2
Nutrient index
0.73
PWP, WHC
(59, 120)
Scenario and Validation
Number of species
25
include senescence?
potential growth?
include mowing?
include grazing?
include below comp.?
plant height influence?
include water reduction?
include nutrient reduction?
include temperature reduction?
include seasonal reduction?
include radition reduction?
Or Validation
HEG01
Abiotic variable (right lower plot)
Precipitation [mm d⁻¹]
Color/trait (right upper plot)
Height [m]
bands visible?
grazing/mowing?
valid data?
Green biomass [kg ha⁻¹]
Time [years]
Mean: Height [m]
Time [years]
Biomass at timepoint [kg ha⁻¹]
Height [m]
Height [m]
0.25
0.50
0.75
senescence_intercept
2.179
senescence_rate
11.452
below_competition_strength
0.380
trampling_factor
150.123
grazing_half_factor
958.215
mowing_mid_days
17.822
max_SRSA_water_reduction
0.942
max_SLA_water_reduction
0.929
max_AMC_nut_reduction
0.626
max_SRSA_nut_reduction
0.708
Soil water [mm]
Time [years]
Net growth [kg/kg ha⁻¹ d⁻¹]
Time [years]
Precipitation [mm d⁻¹]
Time [years]

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Questions?

Thanks for listening! Do you have questions or remarks?

References

Muro, J., A. Linstädter, P. Magdon, S. Wöllauer, F. A. Männer, L.-M. Schwarz, G. Ghazaryan, J. Schultz, Z. Malenovský, and O. Dubovyk (2022). "Predicting plant biomass and species richness in temperate grasslands across regions, time, and land management with remote sensing and deep learning". In: *Remote Sensing of Environment* 282, p. 113262. DOI: 10.1016/j.rse.2022.113262.