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Tree regeneration in models of forest dynamics:
A key priority for further research

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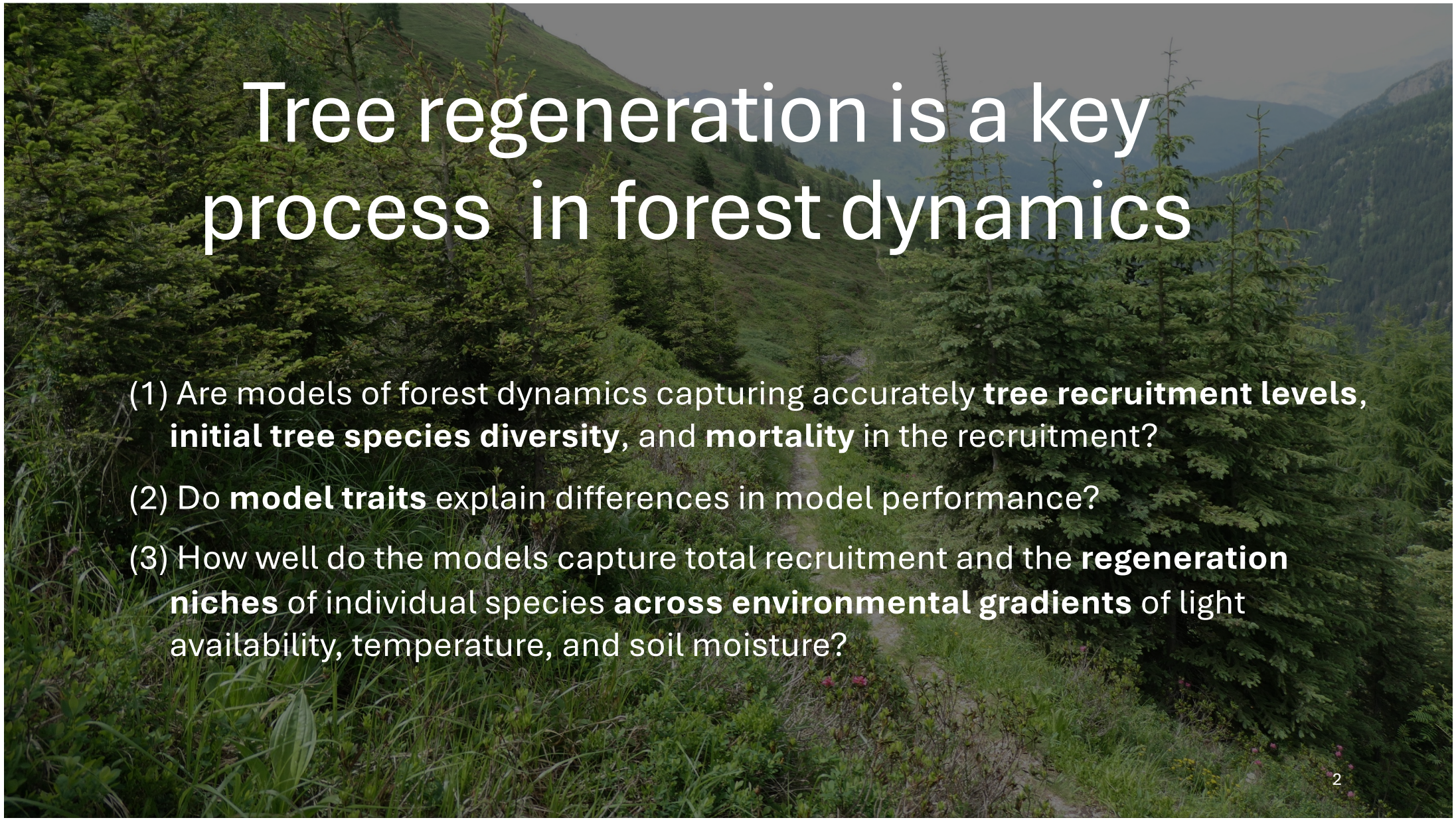


Tree regeneration is a key process in forest dynamics

(1) Are models of forest dynamics capturing accurately **tree recruitment levels**, **initial tree species diversity**, and **mortality** in the recruitment?

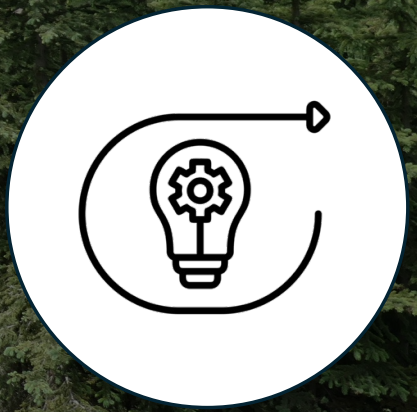
(2) Do **model traits** explain differences in model performance?

(3) How well do the models capture total recruitment and the **regeneration niches** of individual species **across environmental gradients** of light availability, temperature, and soil moisture?

Tree regeneration is a key process in forest dynamics

Methodology

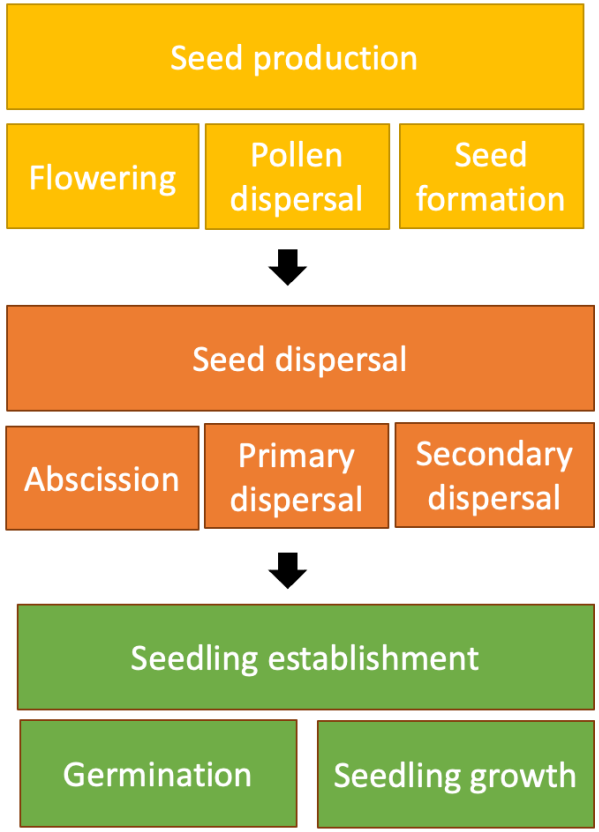
Main results



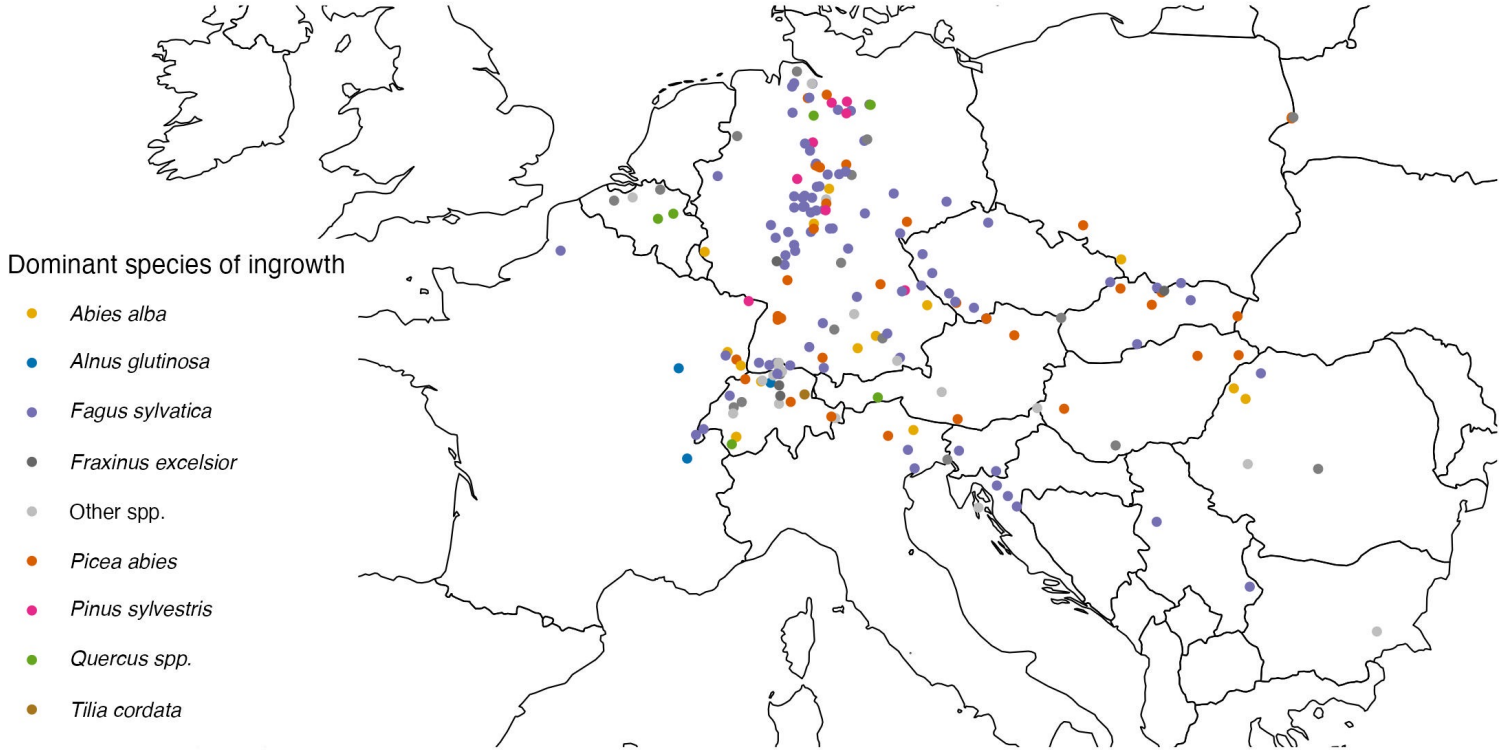
Recommendations

Tree regeneration processes in dynamic forest models are handled in a multitude of ways

- Entirely ignoring them
- The use of a few simple environmental filters
- Complex approaches that incorporate local feedback from the canopy, multiple ecological processes, and often also short time steps
- Field-based statistical parameterizations, which however are not easy to extrapolate in space and time



Data on forest regeneration are often fragmented, which constitutes a major problem for model building



EUPHORIA network
EuFoRIa, 2019; Käber et al., 2023

The goal of the simulation experiments was to assess tree recruitment in a wide range of models of forest dynamics.

Detailed Protocol

osf.io/czdxp/

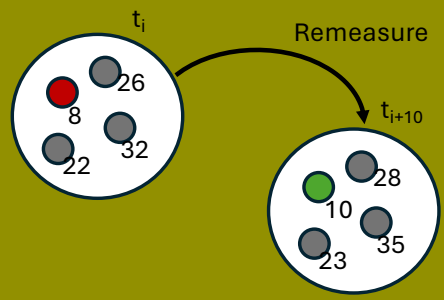
Potential Natural Vegetation

- No disturbances
- No management

Species mixture

Fagus sylvatica
Picea abies
Abies alba
Carpinus betulus
Tilia cordata
Acer pseudoplatanus
Betula spp.
Fraxinus excelsior
Quercus spp.
Alnus glutinosa
Pinus sylvestris

”Ingrowth”

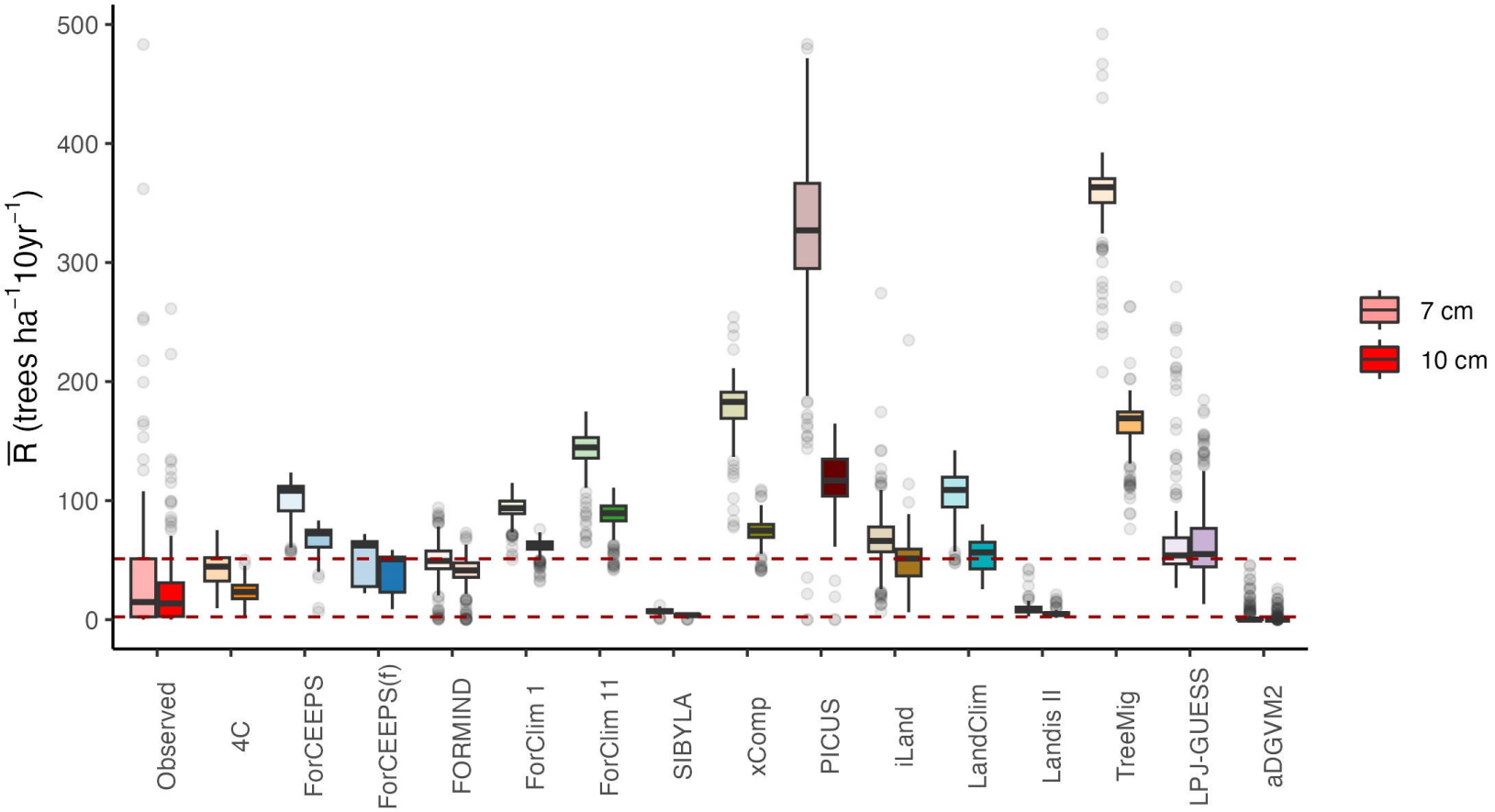


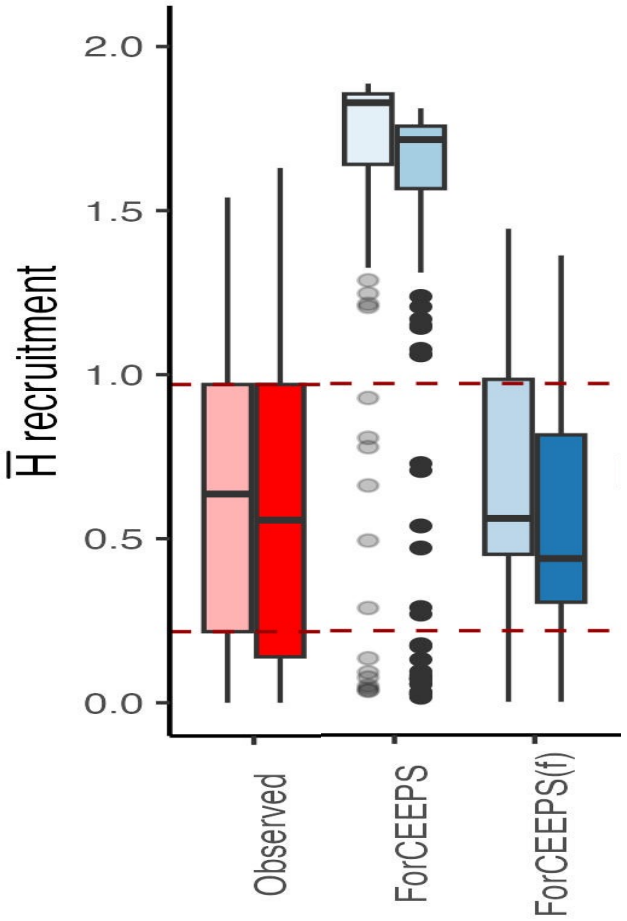
- 7 and 10 cm
- 200 sites
- 200 samples
- 10-year interval per ha

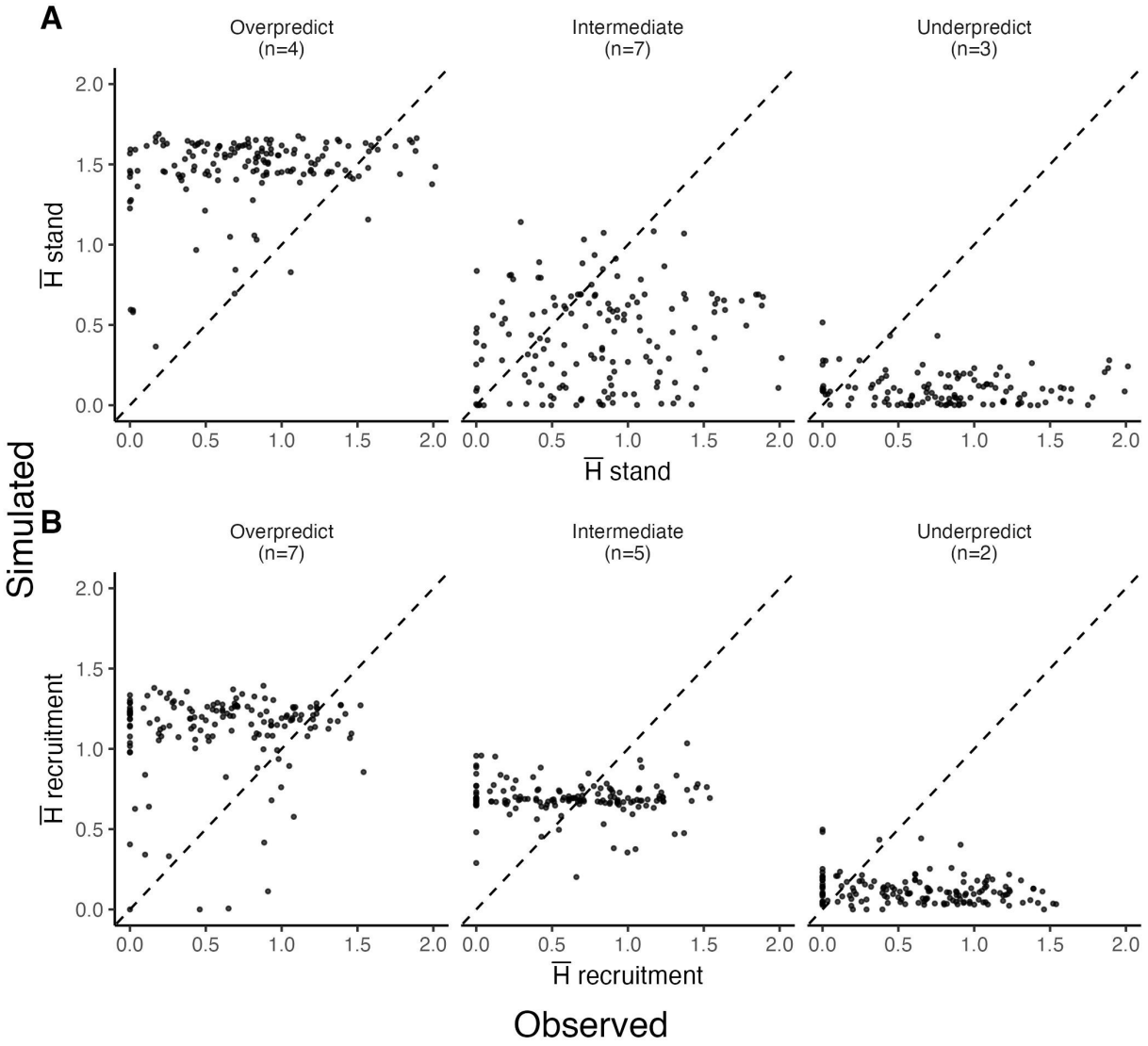
A workshop started the discussions on the main findings

June 2022, Davos Switzerland.

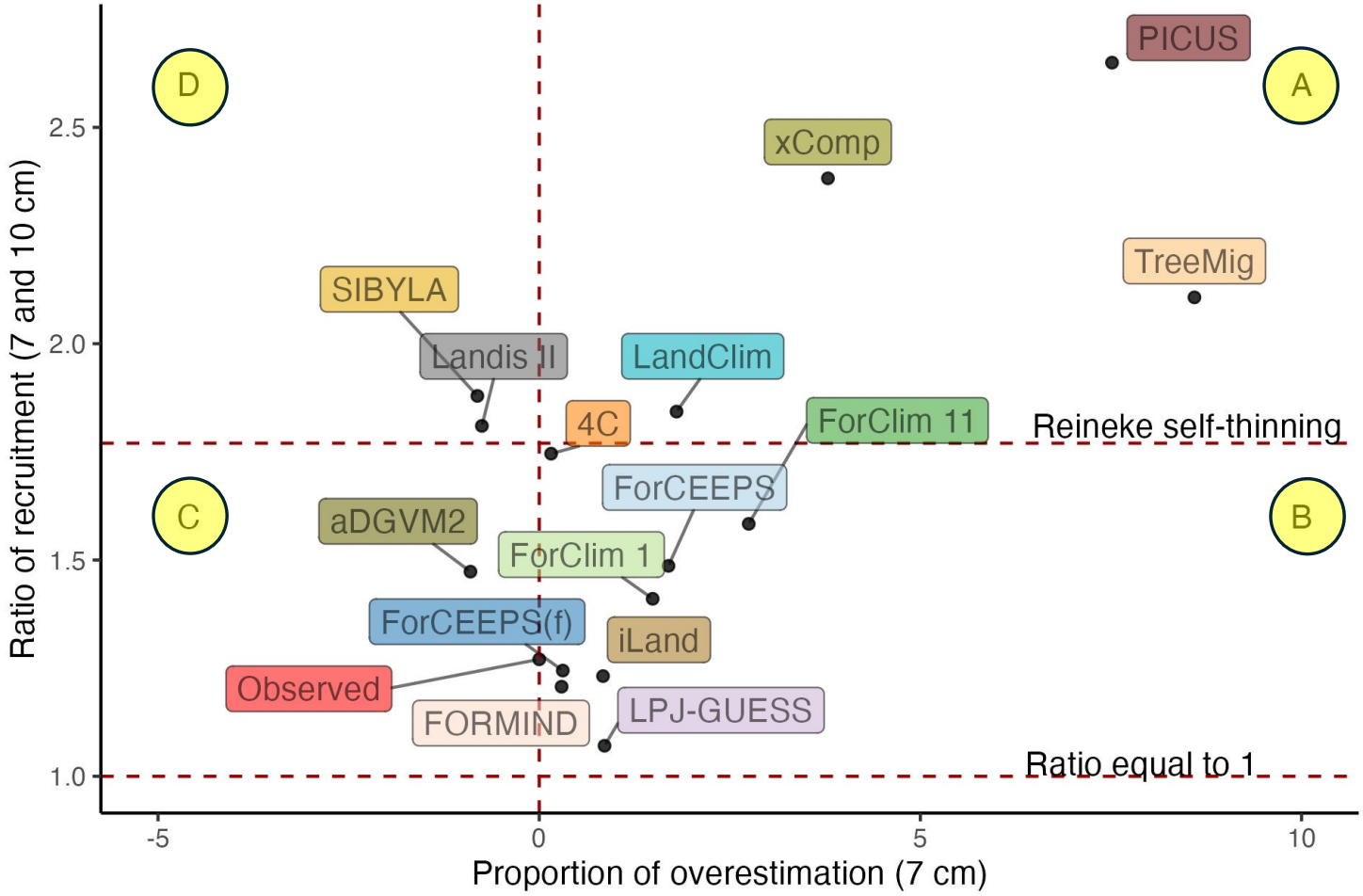
Most of the models overestimated tree recruitment levels



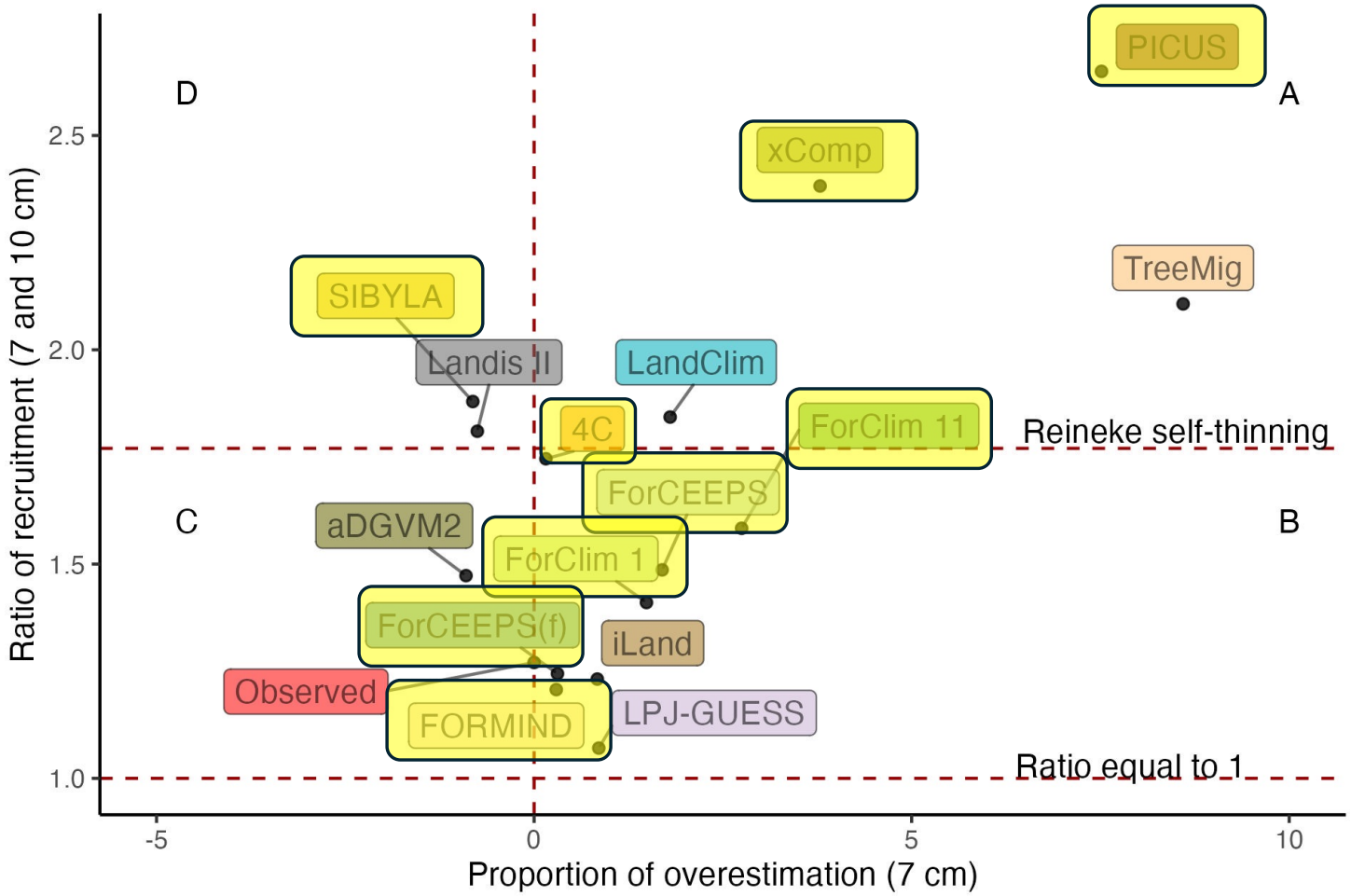

H̄ recruitment
2.0
1.5
1.0
0.5
0.0
Observed
ForCEEPS
ForCEEPS(f)


A
Overpredict
(n=4)
Intermediate
(n=7)
Underpredict
(n=3)
H̄ stand
H̄ stand
B
Overpredict
(n=7)
Intermediate
(n=5)
Underpredict
(n=2)
H̄ recruitment
H̄ recruitment
Simulated
Observed

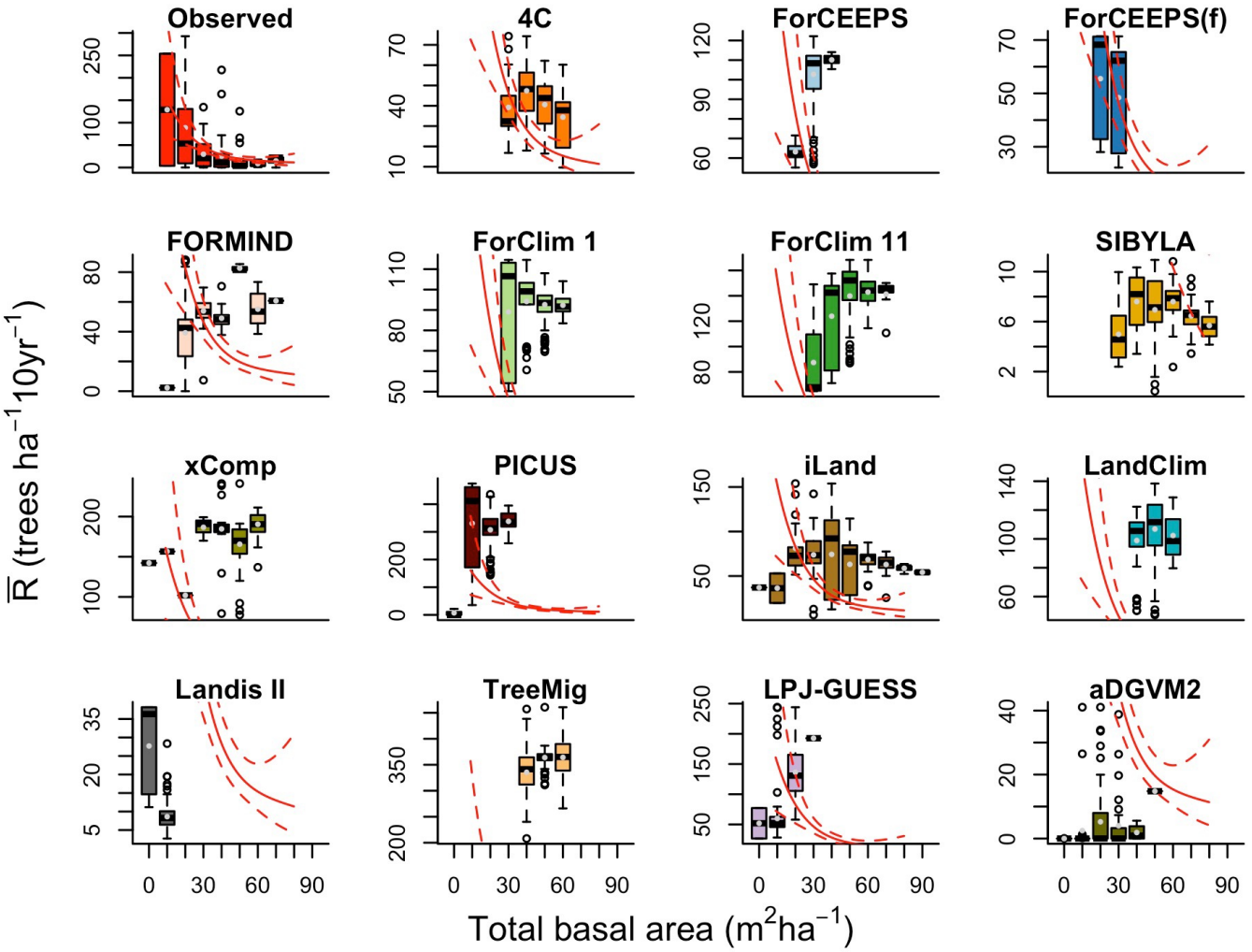
Most of the models featured a mortality rate significantly larger than the observed data



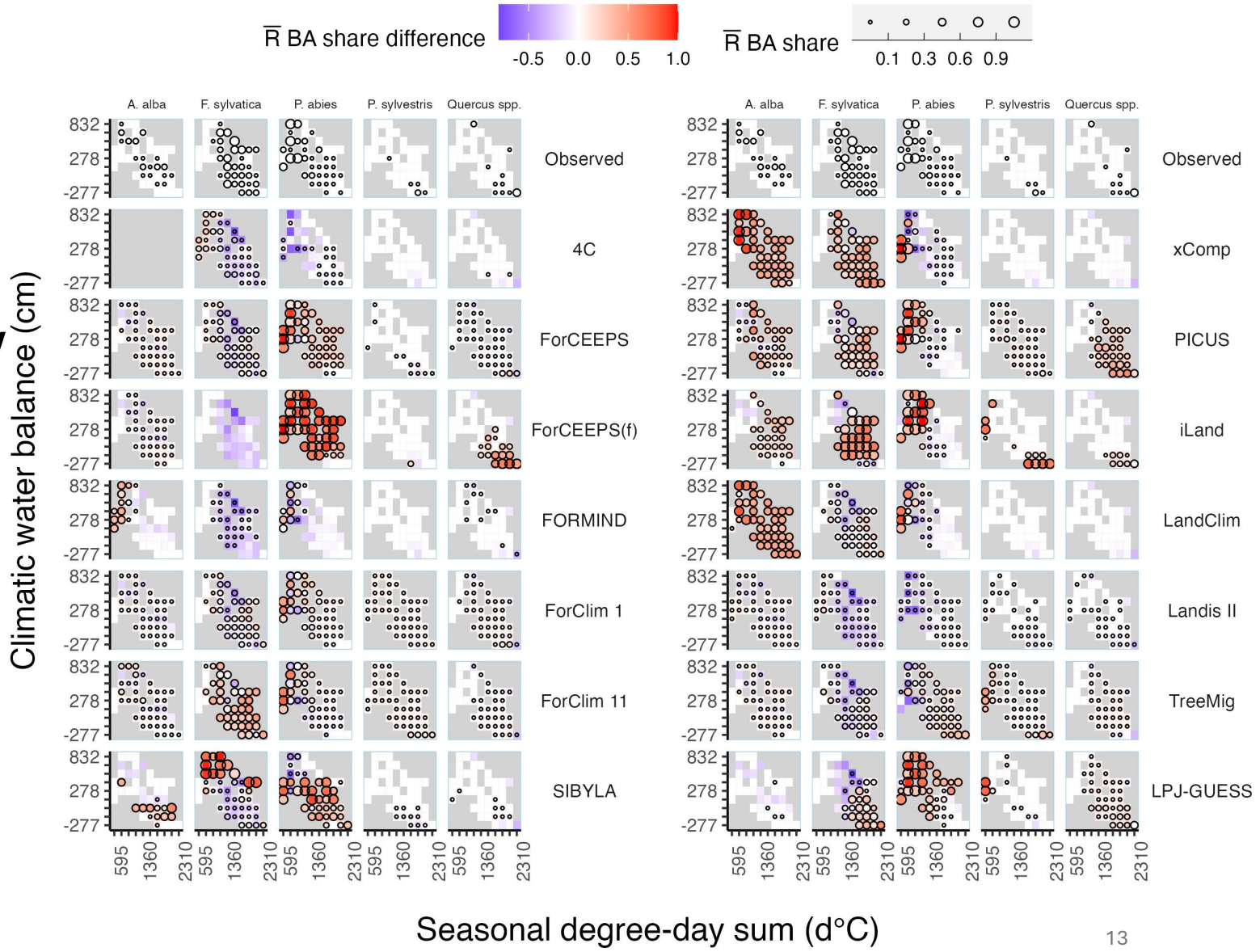
There was no significant relationship between the mean complexity of the regeneration module and the overestimation proportion

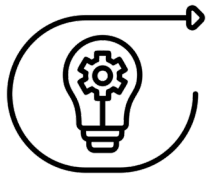


It is difficult to assess tree recruitment levels along gradients of light availability (basal area)



There were pronounced differences in how the main tree species were represented by the models along the environmental gradients





Research recommendations

1 We have demonstrated that models of forest dynamics need a **focus on their regeneration modules** to make them more robust.

2 It is still uncertain what **level of detail** is required to model tree regeneration, and this must be addressed in future research.

3 The improvement of the regeneration modules should be implemented as **additional features** that can be traced back

4 We should focus on collecting **harmonized datasets** in a site-specific manner covering the different aspects leading to tree regeneration.

This study is fully reproducible

Protocol

A protocol for simulating and evaluating tree regeneration using a diverse range of forest dynamic models

osf.io/czdxp/

Data

Tree recruitment in Central Europe: observed and simulated data

doi.org/10.3929/ethz-b-000643426

Analysis

Code from Tree regeneration in models of forest dynamics: a key priority for further research

zenodo.org/records/10665790

Conclusions

Díaz-Yáñez, O., et al. 2024.
"Tree Regeneration in Models of Forest Dynamics: A Key Priority for Further Research." Ecosphere 15(3): e4807
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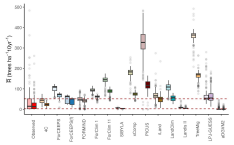
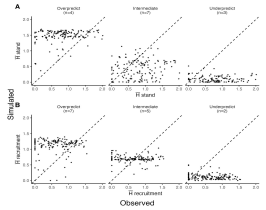
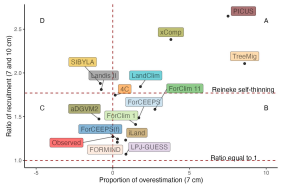


Models generally **overestimate** tree recruitment levels, and the simulated **regeneration niche** is not always captured accurately as a function of biotic (light) and abiotic (temperature and moisture) factors.



Most models properly capture **the diversity** of the initial tree community, and differences between model formulations, for example, the **presence or absence of feedback** from the adult trees did not have a strong effect.



Regarding **mortality** in the early phase of tree life, many models that feature a particularly high overestimation of recruitment levels compensate for this by a larger tree mortality.

The specific **design decisions** taken in the development of any model are more important for its behavior (accuracy) than scale (stand, landscape, and global), modeling approach (empirical vs. process-based), and complexity.

Remarkably, most models capture the essential features of tree regenerations while **not having been parametrized with such data**.