Tree regeneration in models of forest dynamics: Protocol for a multi-model simulations and results from a PROCLIAS workshop

WG 2: IMPACT ATTRIBUTION AND UNCERTAINTY ASSESSMENTS
TASK GROUP 2.3: NOVEL APPROACHES TO MODEL UNCERTAINTY ASSESSMENT

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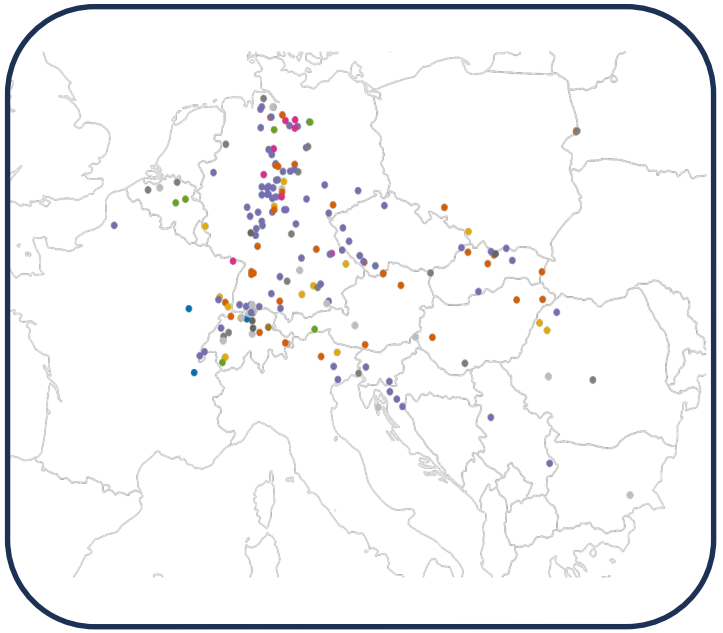
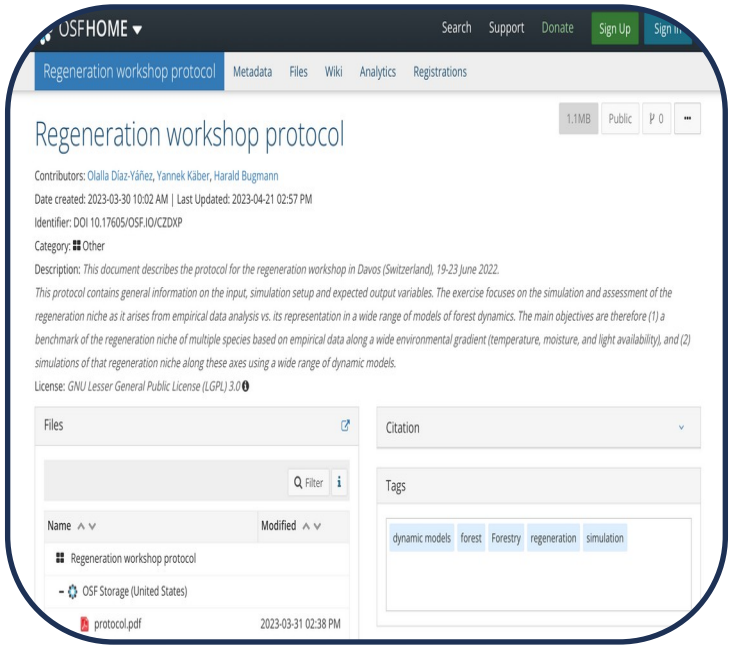
Are models of forest dynamics capturing accurately tree regeneration levels across environmental gradients?

Can we link their behaviour with the model structure, design or complexity?

Each modeling team was provided with a detailed protocol with instructions on how to perform the simulations.



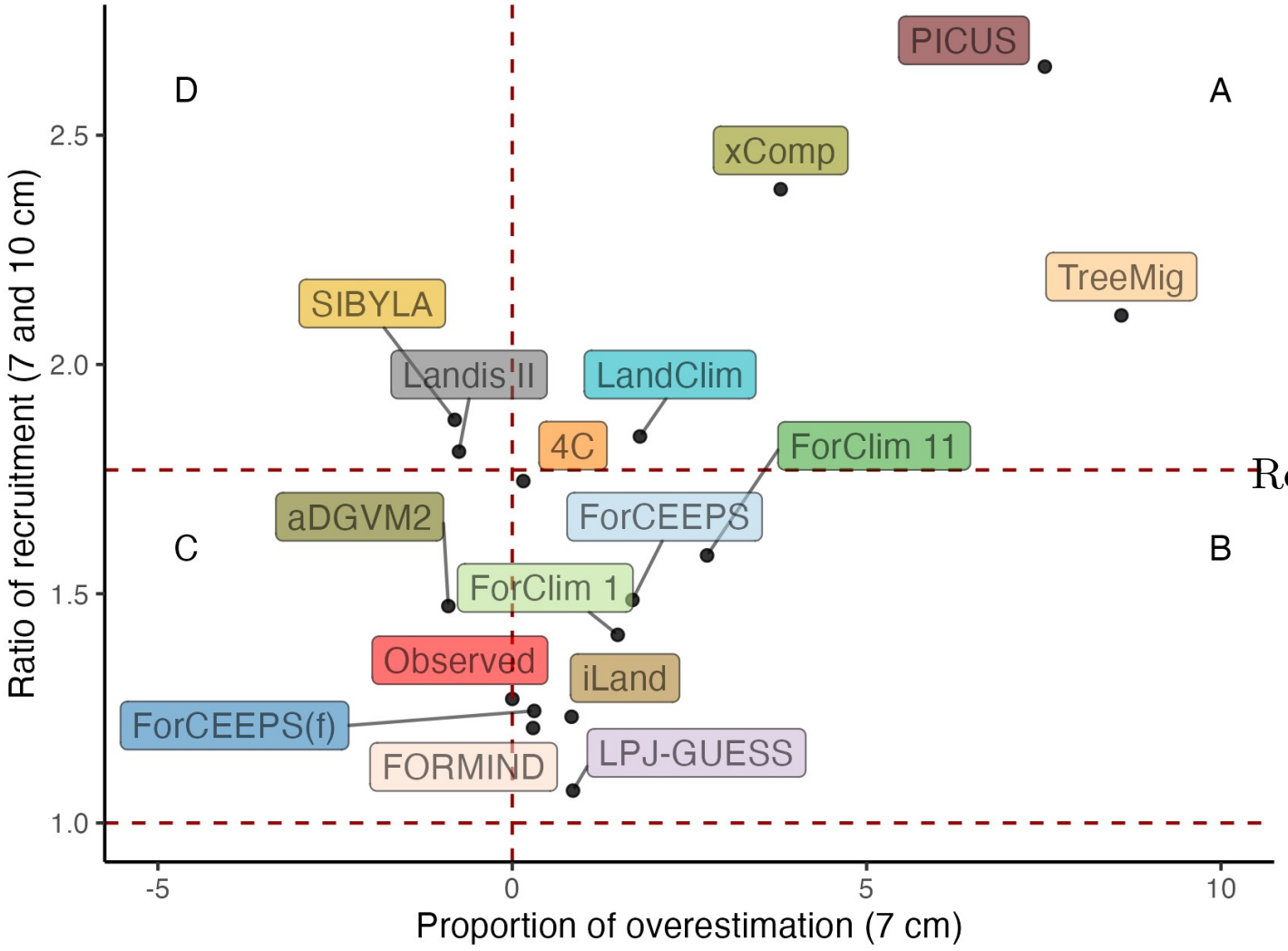
200 plots across environmental gradients (forest reserves)



Protocol and data analysis.
“Blind-flight” mode.

Workshop

Most of the models overestimate regeneration rates, but this is not always compensated by high mortality rates.



Reineke's self-thinning rule

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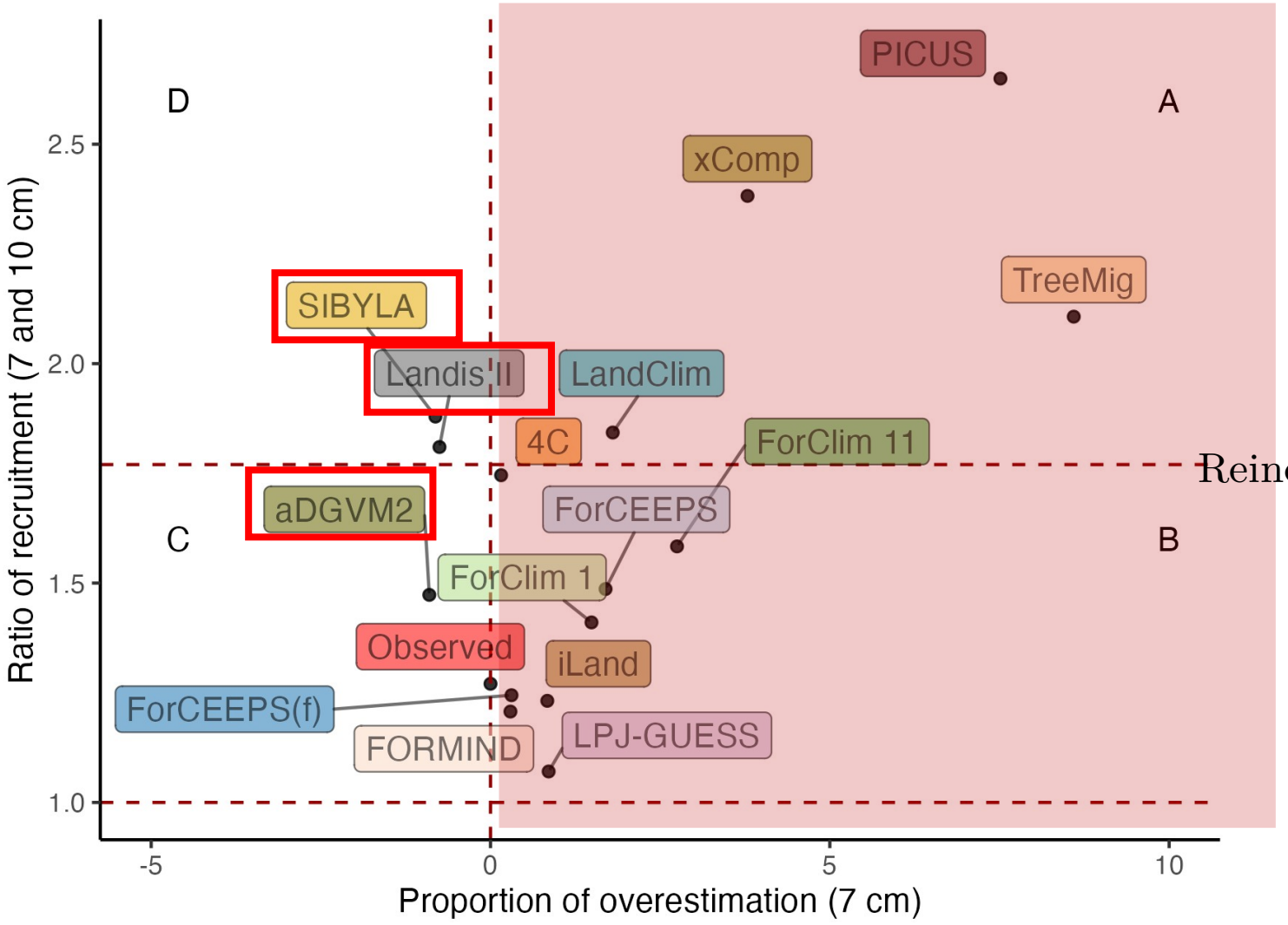

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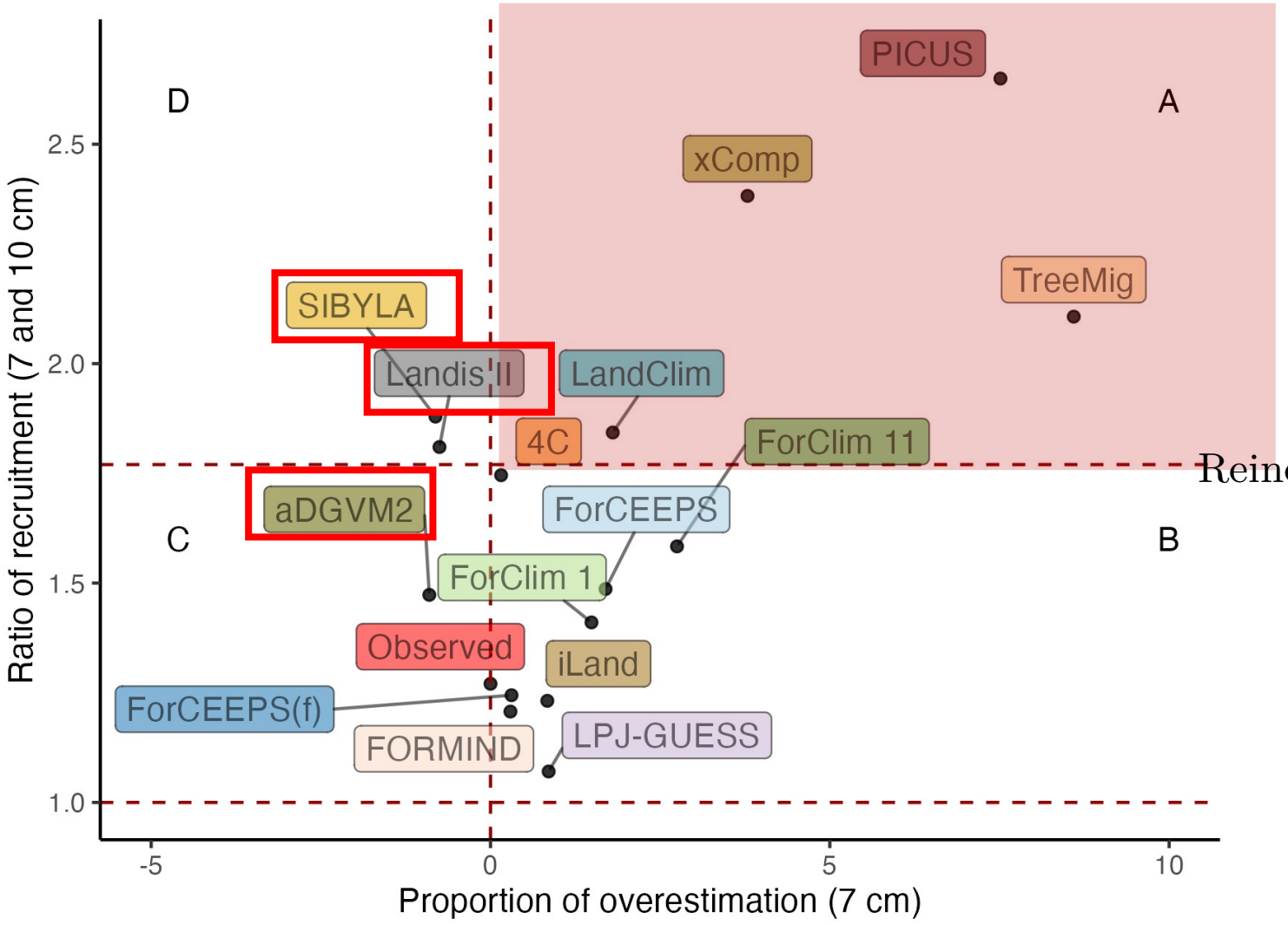
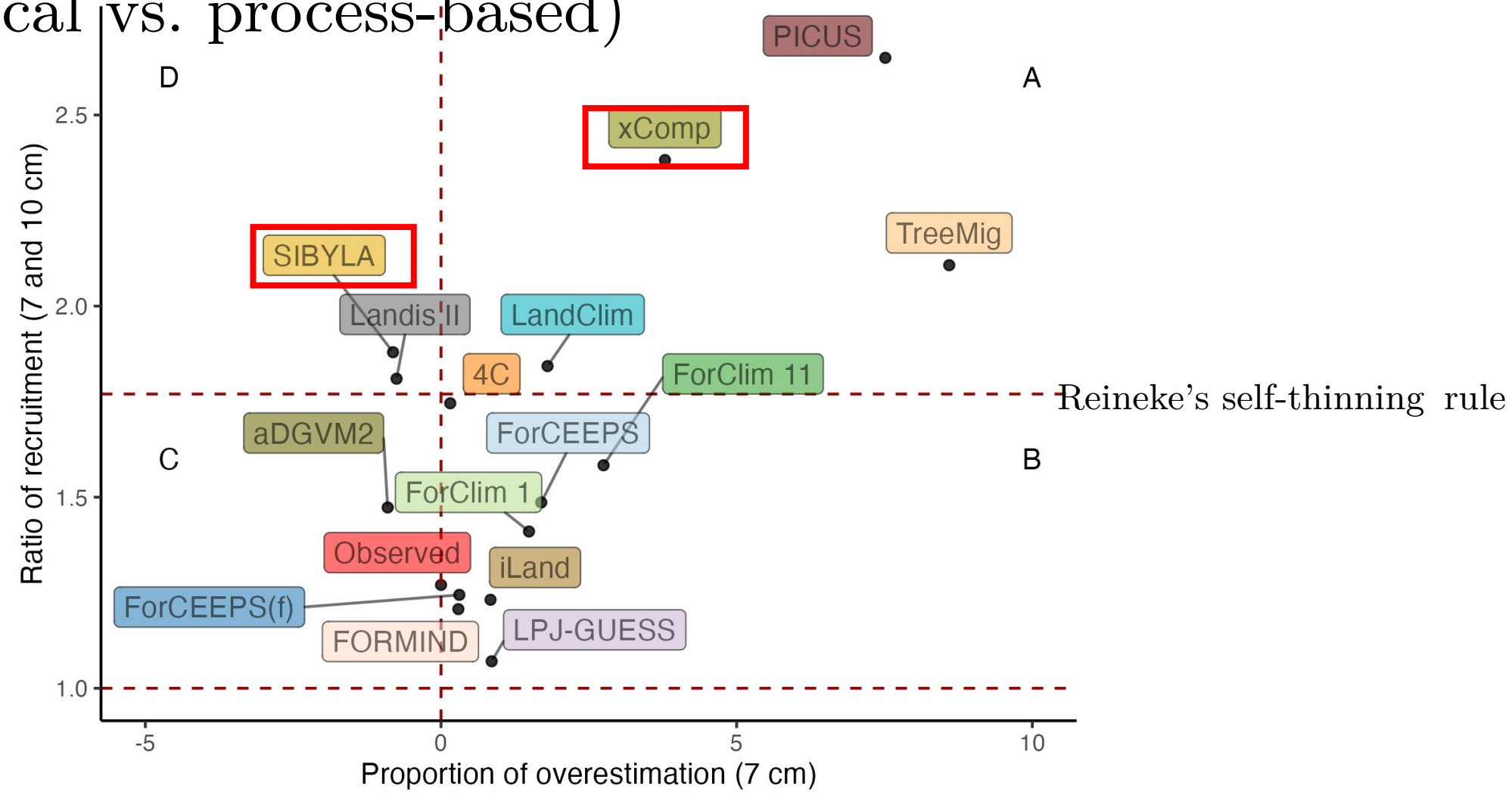


Reineke's self-thinning rule

The design of the regeneration modules is more important for its behaviour (accuracy) than the models scale (stand, landscape, global) or background (empirical vs. process-based)



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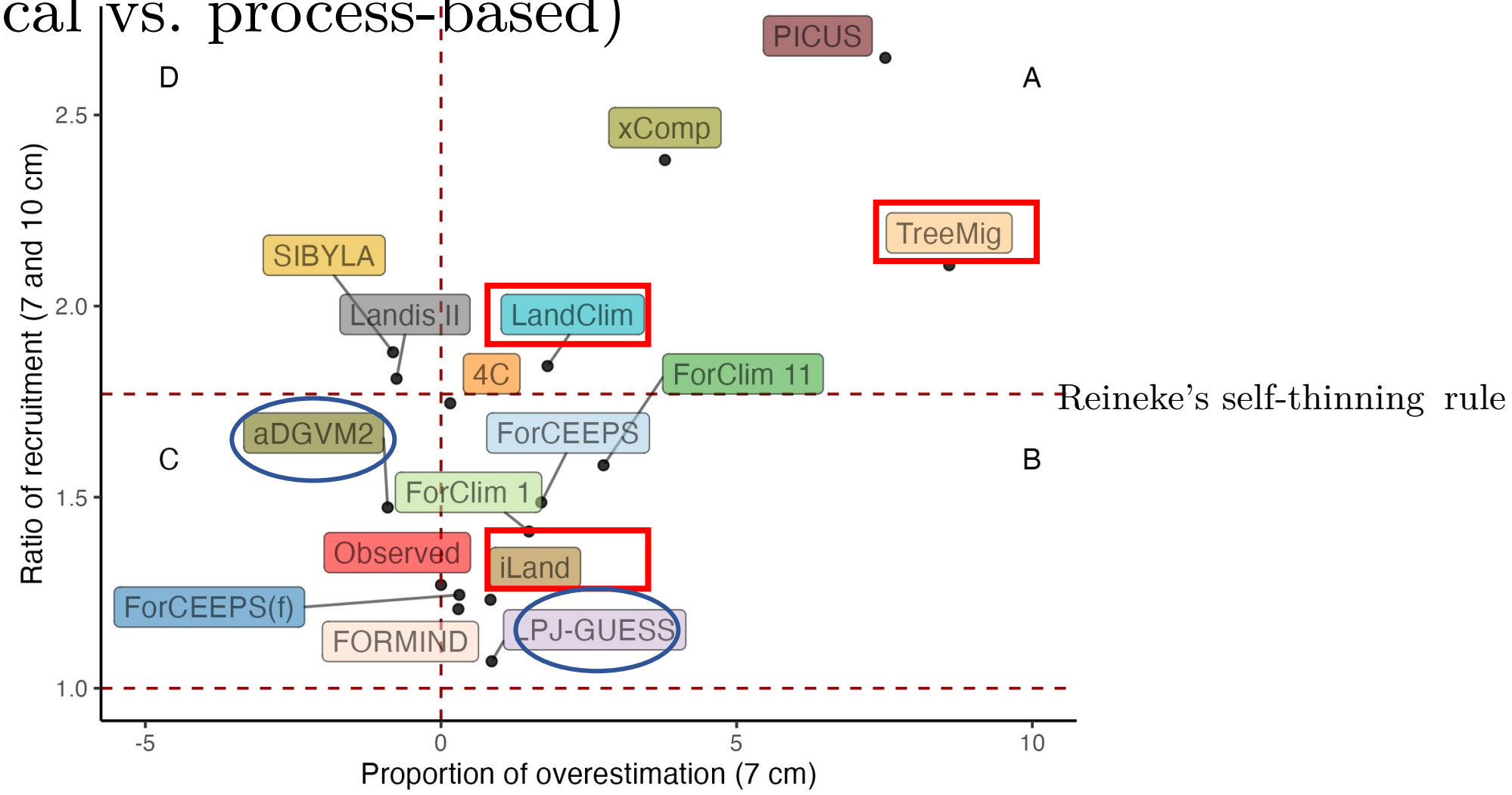
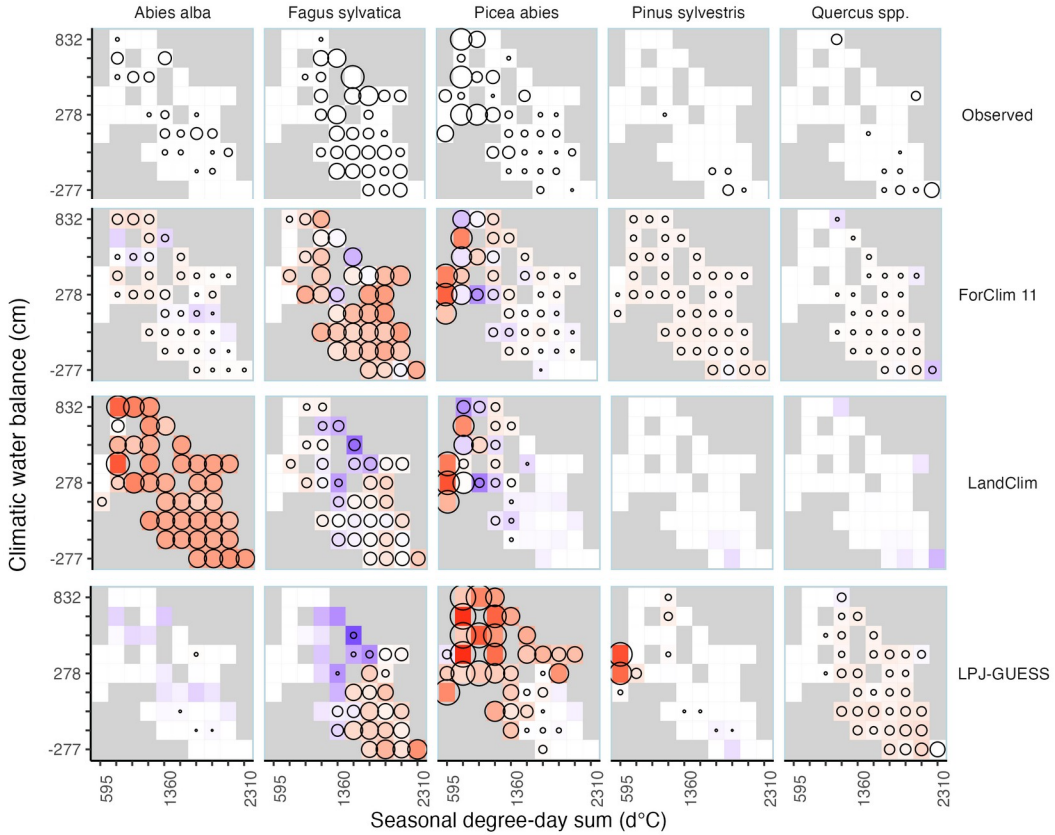
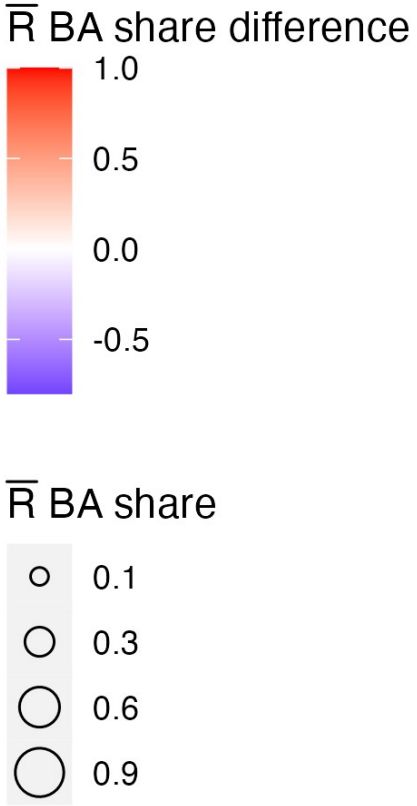
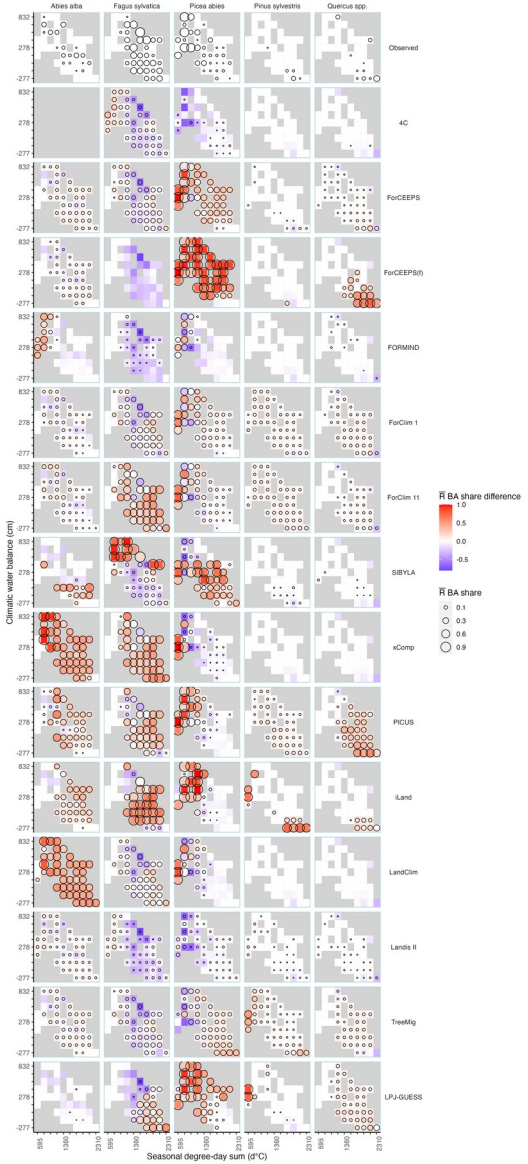


The regeneration of Abies alba is well captured across temperature and soil moisture gradients, whereas Fagus sylvatica is generally underestimated.





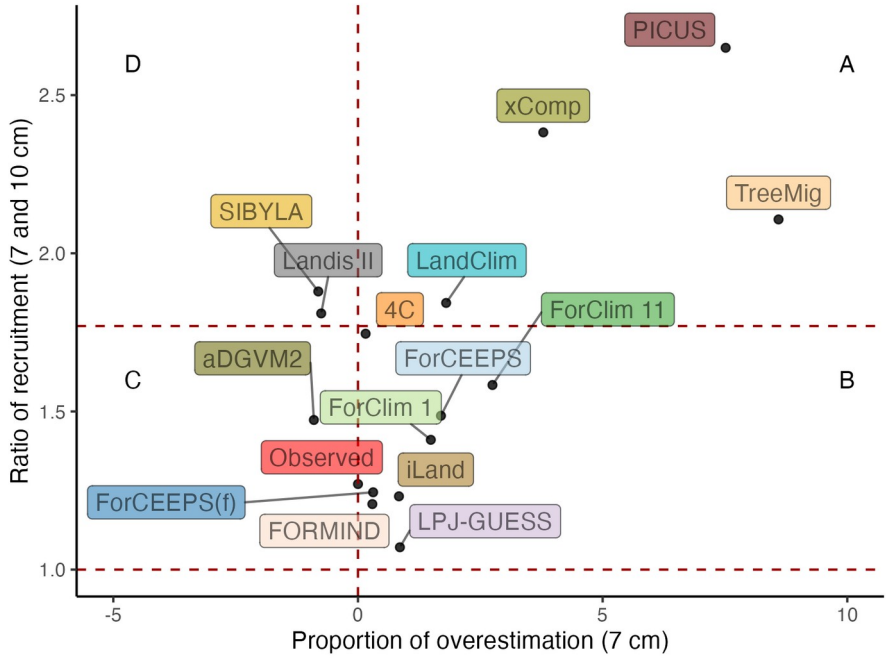


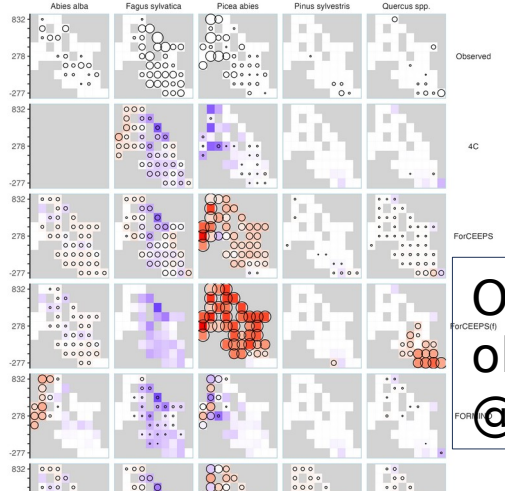
Conclusions

1-Most of the models overestimate regeneration rates, but this is not always compensated by high mortality

2-The design of the regeneration modules is more important for its behavior (accuracy) than the models scale (stand, landscape, global), background (empirical vs. process-based), and complexity.

3- The regeneration projections are not overly off. This indicates that a lot can be gained by a focus on the modeling of establishment processes.





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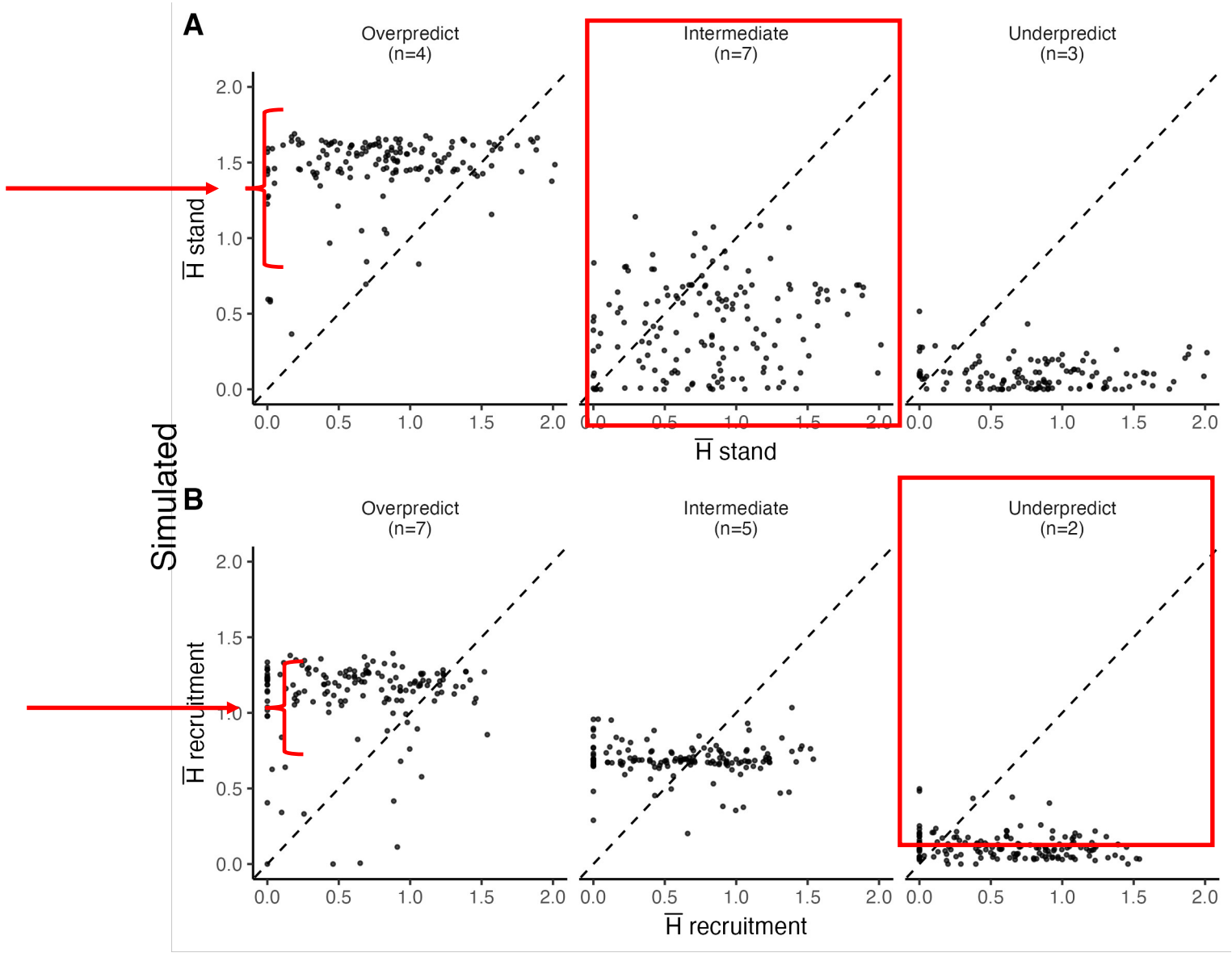
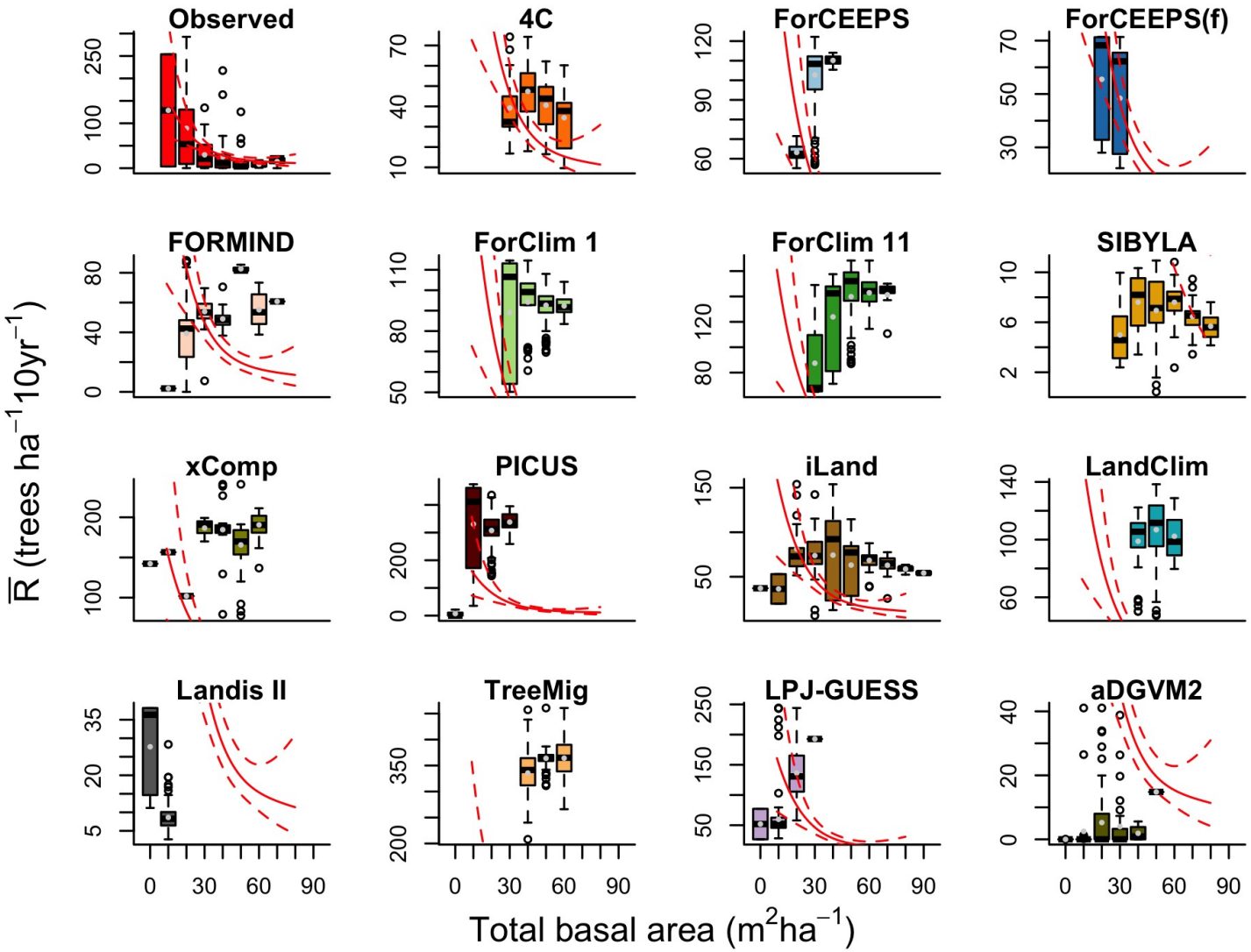
Supplementary

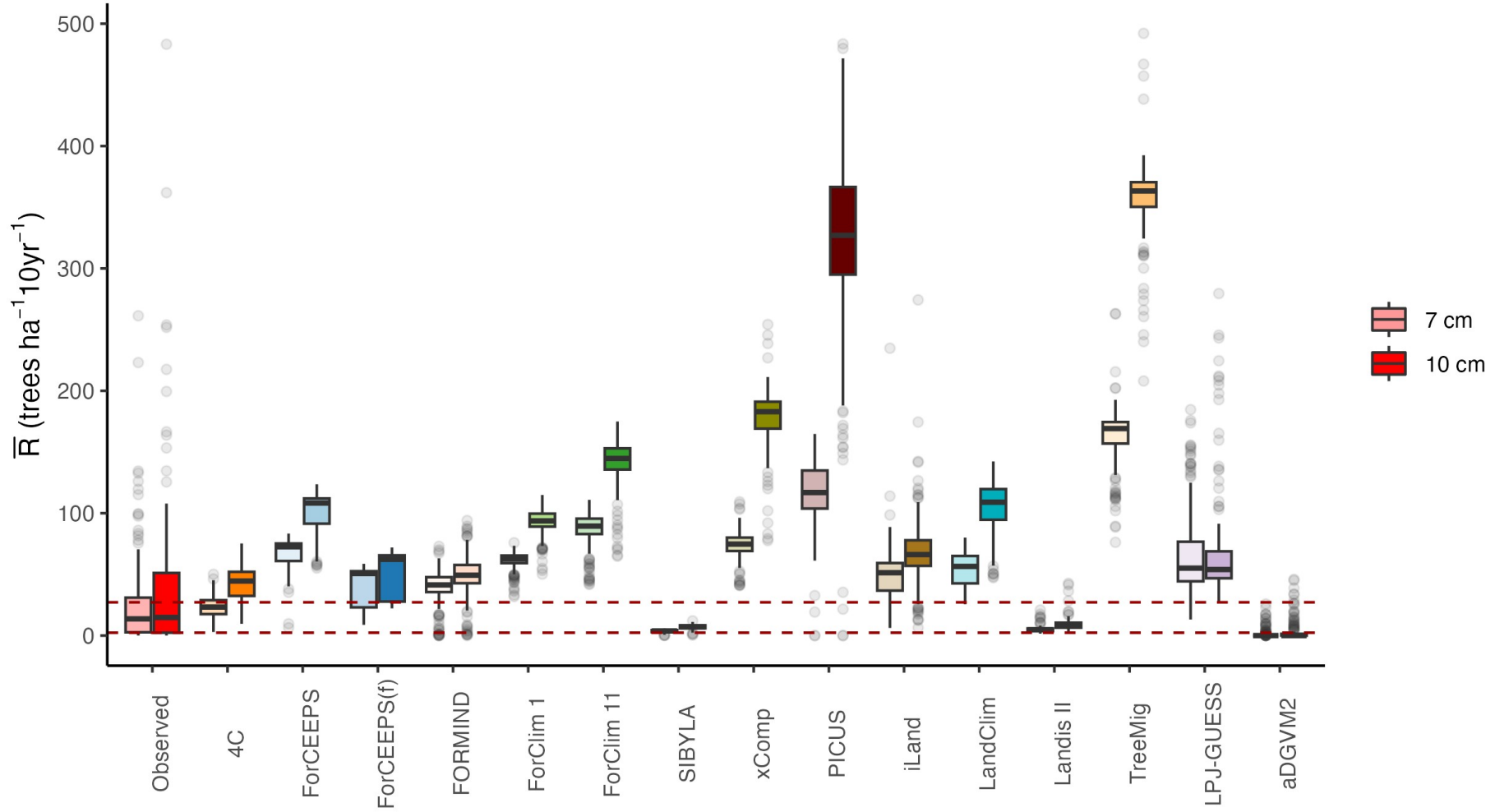
Models with feedback and without feedback from the adult trees to ingrowth (via seed production) underestimated ingrowth species diversity compared to the observations



In the models, the effect of light availability on ingrowth rates is captured better than the effect of temperature and soil moisture, but the patterns are not consistent across models.



Overestimation at 7 and 10 cm threshold



Species diversity in recruitment

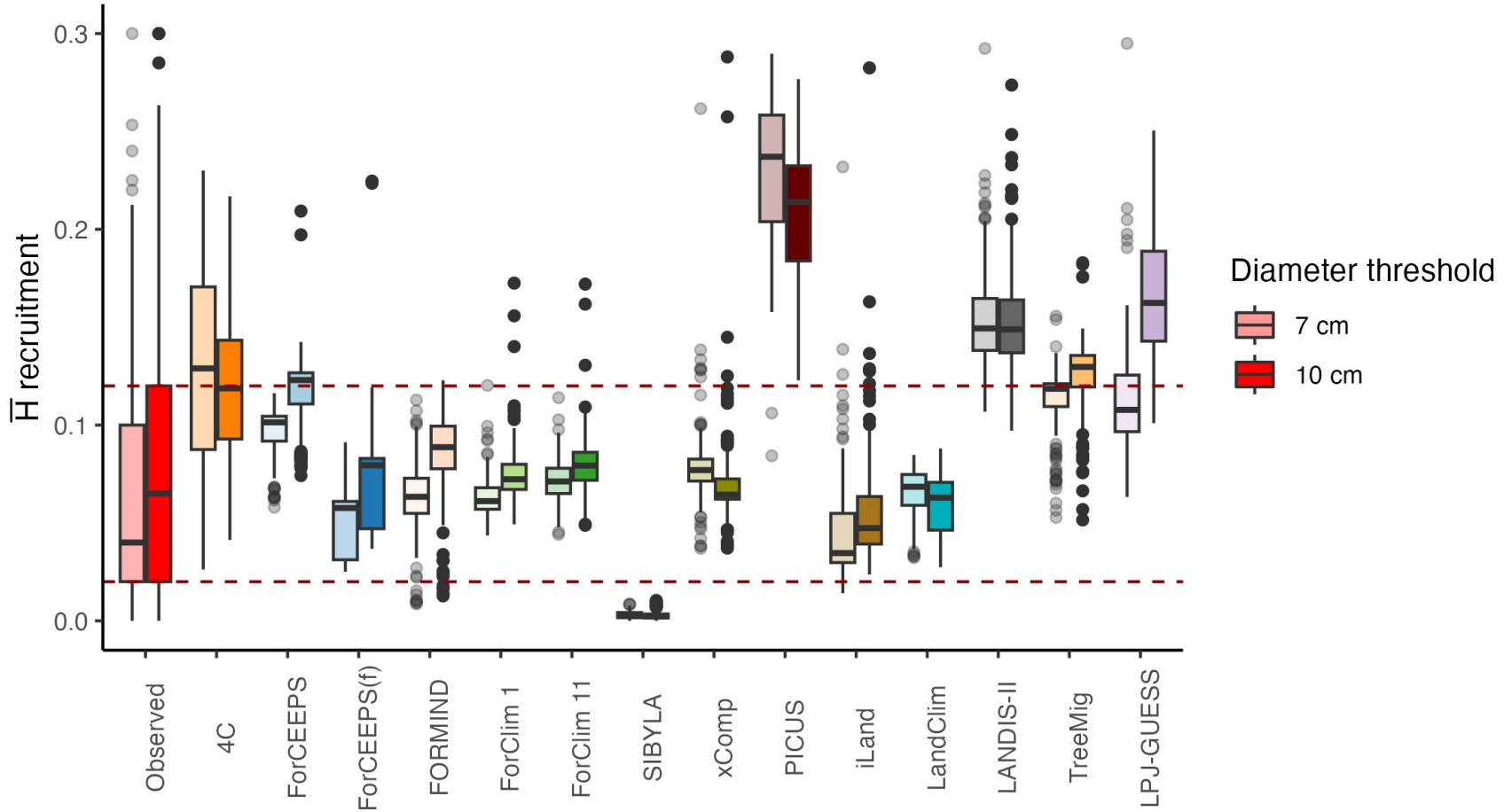


Table 1: List of models included.

Model	Scale(a)	Type(b)	Spatial structure(c)	Tree establishment module type(d)	Feedback(e)	Start from	Mean establishment formulation complexity (Bugmann & Seidl 2022)	Species simulated	Runtime for sampling (spin up) [years]	Climate data type (use of years)(f)	Reference
4C	S	PB	C	RG	N	saplings	-0.04	F. sylvatica, P. sylvestris, P. abies, A. alba	2000 (500)	D (loop)	Reyer et al. (2014)
ForClim	S	PB	C	RG	N	??	0.28 (ForClim 4.0.1)	All	200 (1000)	M (weather generator)	Bugmann (1996)
ForCEEPS	S	PB	C	RG	N	??	0.43	All	2000 (2000)	M (random)	Morin et al. (2021)
FORMIND	S	PB	I	RG	N	ingrowth	-0.57	All	? (1000)	D (random)	Bohn et al. (2014)
PICUS	S	PB	I	RG	Y	??	0.81	All	2000 (600)	M (random)	Lexer & Hönninger (2001)
SIBYLA	S	EM	I	RG	Y	seeds	NA	All	2500 (500)	M (weather generator)	Fabrika (2005)
xComp	S	EM	I	RG	Y	seedlings (age $<$ 1 year)	NA	All (-F. excelsior, -A. glutinosa)	2000 (750)	M (random)	Mette (2014)
iLand	L	PB	I	RG	Y	seeds	1.08	All	510 (1500)	D (random)	Seidl et al. (2012)
LandClim	L	PB	C	RC	Y	ingrowth	0.5	All	2000(2000)	M (random)	Schumacher et al (2006)
Landis-II	L	PB	C	RC	Y	saplings (age $>$ 1 year)	-0.1	All	1280 (700)	M (random)	Scheller & Mladenoff (2004)
TreeMig	L	PB	C	RG	Y	seedbank	0.12 (Landis II NECN 6.0)	All (-B. pendula)	100 (900)	M (random)	Lischke et al. (2006)
LPJ-GUESS	G	PB	I	RC	??	??	0.35	All (-A. pseuoplatanus, A. glutinosa)	37 (500)	D (loop)	Smith et al. (2001)
aDGVM2	G	PB	I	RC	Y	seedbank	-0.08	Tropical PFTs	? (600)	D (loop)	Scheiter & Higgins (2009)

[a] S-Stand, L-Landscape, G-Global
[b] PB-Process based, EM-Empirical
[c] C-Cohort, I-Individual
[d] RG-Regeneration, RC-Recruitment
[e] Y-Yes, N-No
[f] D-Daily, M-Monthly