Supplementary Information

Supplementary tables

Add a table with species and their group

Table S1. List of R packages used.

Packages	Main functions	Uses	References
msm	msm	Multi-state Markov models in continuous time	Jackson (2011)
	lrtest.msm	Likelihood ratio test	
	pmatrix.msm	Transition probability matrix	
	hazard.msm	Calculate tables of hazard ratios for covariates on transition intensities	
	pnext.msm	Probability of each state being next	
	sojourn.msm	Mean sojourn times from a multi-state model	
sf		Manipulation and mapping of spatial data	Pebesma (2018)
pROC	multiclass.roc	Compute multi-class AUC	Robin et al. (2011)
scoring	logscore	Compute logarithmic score	Merkle & Steyvers (2013)

Table S2. Frequency of all observed transitions between the four forest states during the study period. Transitions are from rows to columns.

From/To	Boreal	Mixed	Pioneer	Temperate	Total
Boreal	9632	210	1171	17	11030
Mixed	131	2121	188	656	3096
Pioneer	1484	345	4839	281	6949
Temperate	11	383	215	6019	6628
Total	11258	3059	6413	6973	27703

Table S3. Frequency of observed transitions between the four forest states from the first to the final survey of each plot. Transitions are from rows to columns.

	Boreal	Mixed	Pioneer	Temperate	Total at t_0
Boreal	3637	181	716	33	4567
Mixed	72	528	97	446	1143
Pioneer	1064	211	1285	152	2712
Temperate	22	186	78	1680	1966
Total at t_{final}	4795	1106	2176	2311	10388

Table S4. Table of risk ratios + CI

Supplementary figures

References

Jackson, C. H. (2011). Multi-State Models for Panel Data: The msm Package for R. *Journal of Statistical Software*, *38*(8), 28. https://doi.org/10.18637/jss.v038.i08

Merkle, E. C., & Steyvers, M. (2013). Choosing a Strictly Proper Scoring Rule. *Decision Analysis*, *10*, 292–304.

Pebesma, E. (2018). Simple Features for R: Standardized Support for Spatial Vector Data. *The R Journal*. Retrieved from https://journal.r-project.org/archive/2018/RJ-2018-009/index.html

Robin, X., Turck, N., Hainard, A., Tiberti, N., Lisacek, F., Sanchez, J.-C., & Müller, M. (2011). pROC: An open-source package for R and S+ to analyze and compare ROC curves. *BMC Bioinformatics*, *12*, 77.

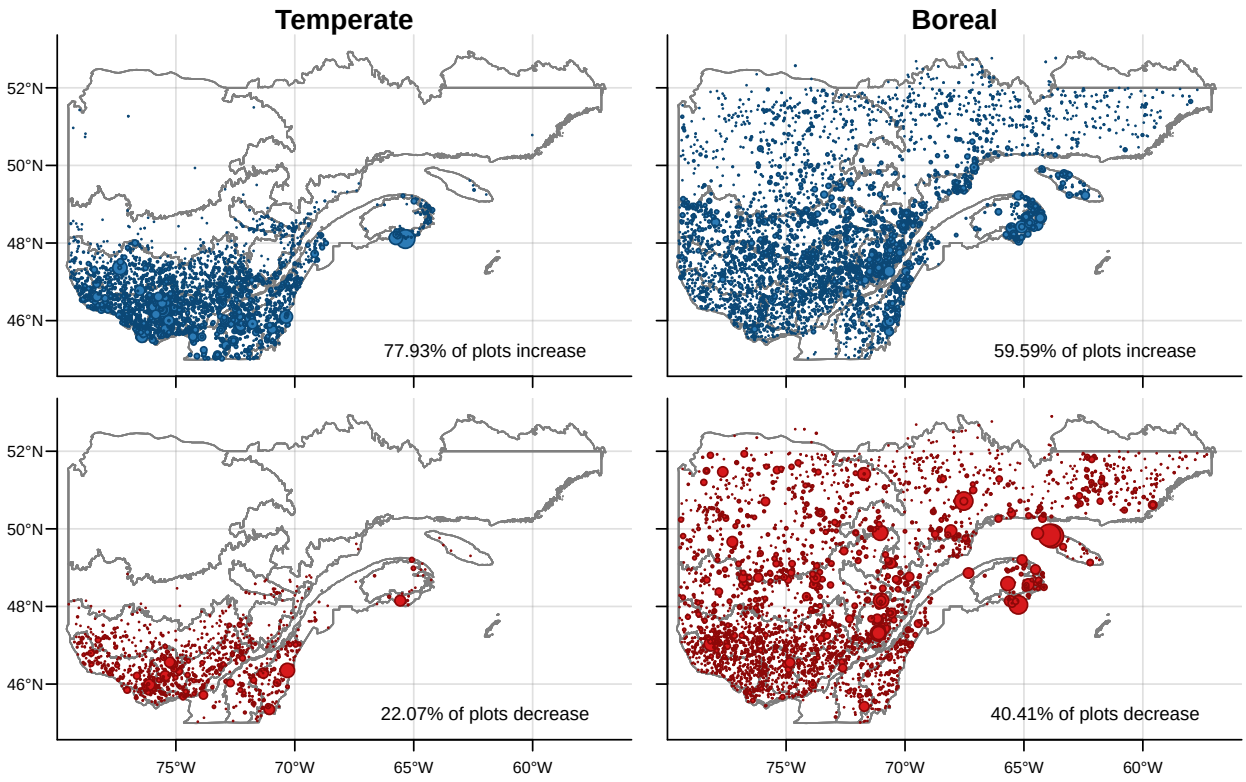

Figure 1: Spatial distribution of observed change in tree basal area for temperate (left) and boreal (right) species. Forest plots in blue (top) have seen an increase in the basal area of one of the two groups, whereas forest plots in red (bottom) have seen a decrease in basal area.

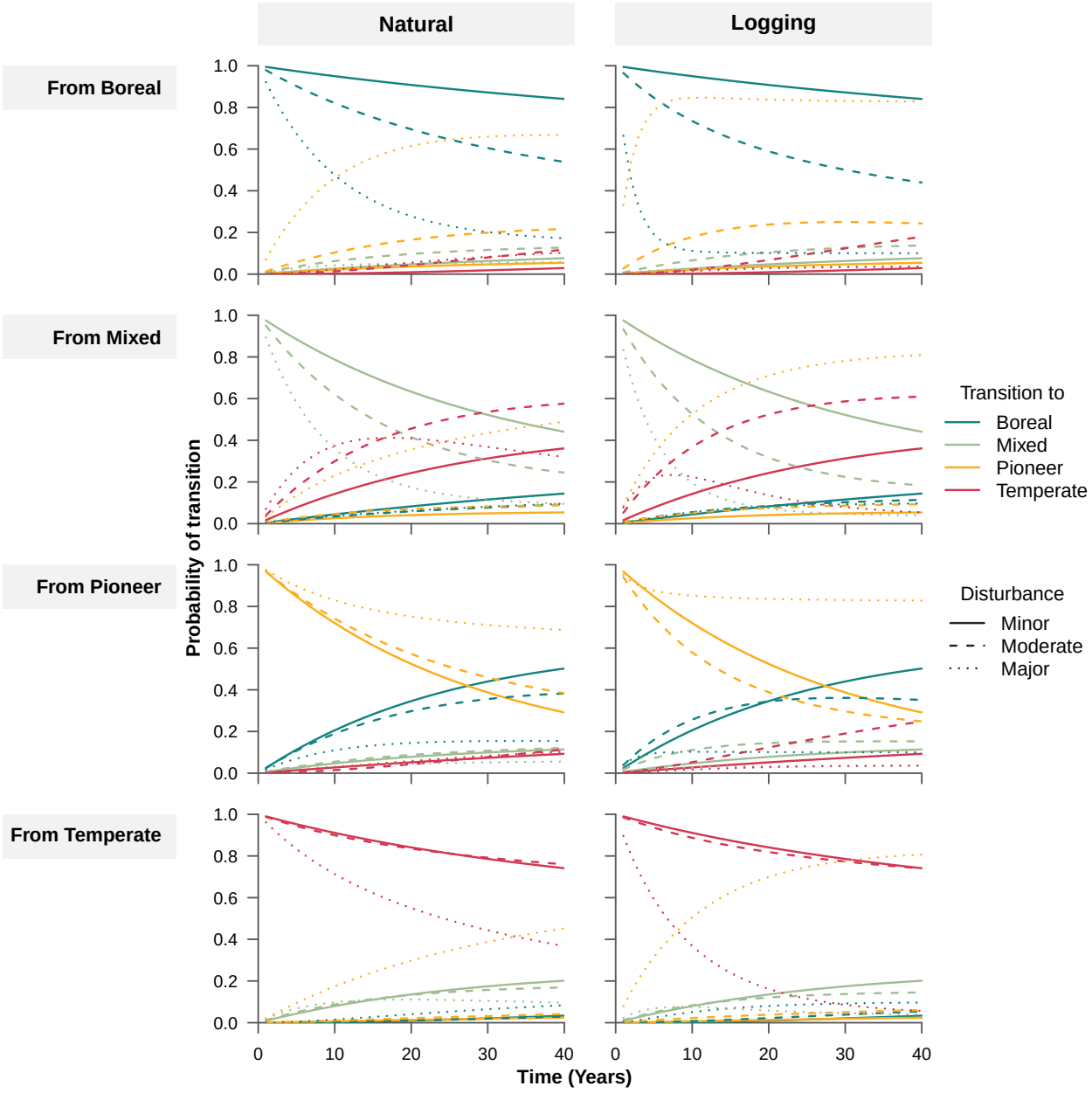

Figure 2: Probability of transition between forest states through time for natural disturbances (left) and logging (right) and for different levels (line type) as predicted by the best multi-state model. All other covariates are fixed at the average conditions found in the ecotone, i.e. the balsam fir-yellow birch domain.

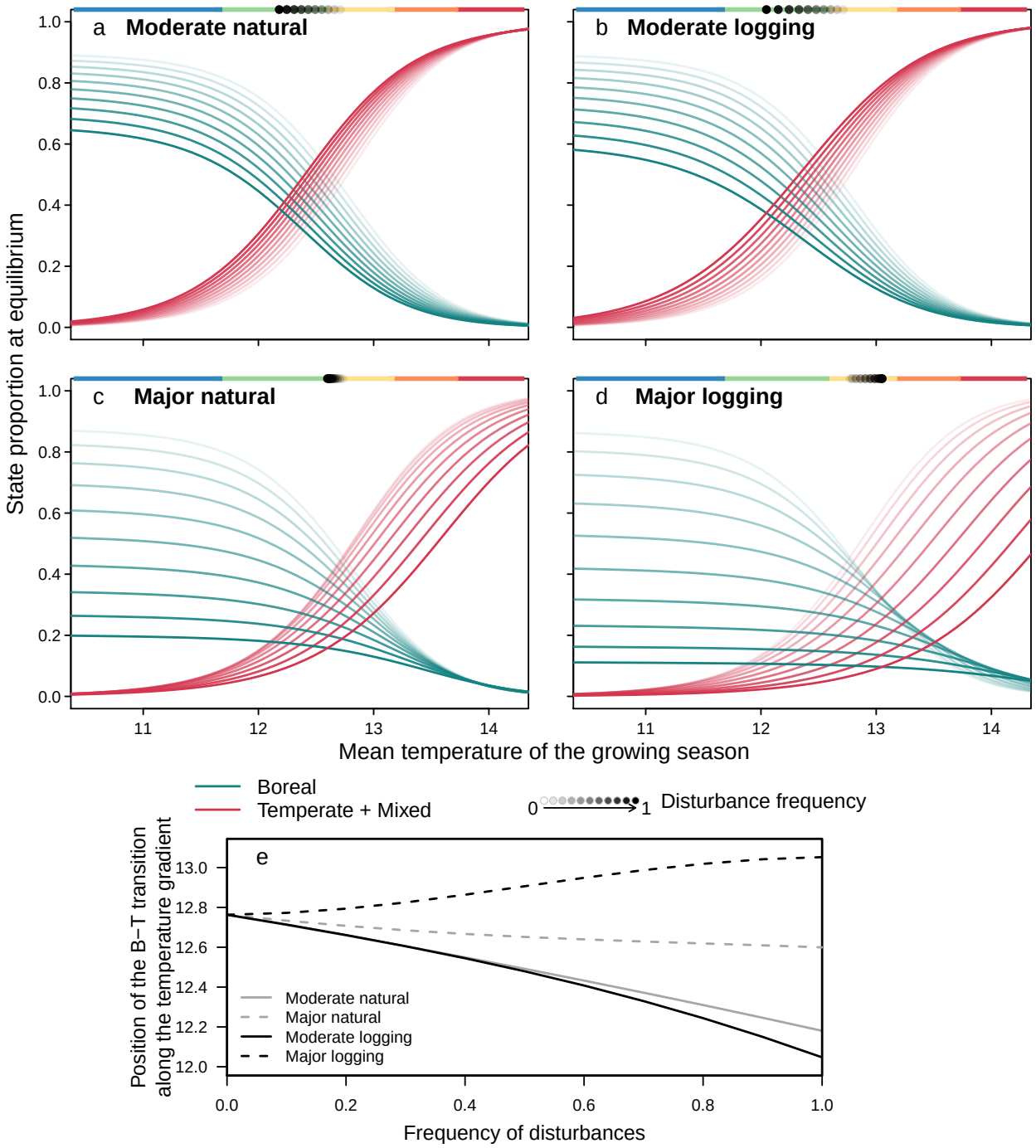

Figure 3: Changes in forest state proportion at equilibrium (a-d) as well as change in the position of the Boreal-Temperate transition (e) along the temperature (latitudinal) gradient for different disturbance scenarios . Proportion of Boreal (blue) and Temperate + Mixed forests (red) for increasing frequency of natural disturbances (a,c) and logging (b,d). Increasing frequency of disturbances is illustrated as increasing color intensity (from pale, low intensity, to dark, high intensity). The circles at the top of each plot (a-d) indicate the position of the boundary between dominance of Boreal forests and dominance of Temperate and Mixed forests (i.e. the advancing front). The change in the position of these circles along increasing frequency of each disturbance type and intensity are illustrated in (e). All other covariates are fixed at the average conditions found in the ecotone, i.e. the balsam fir-yellow birch domain, to focus solely on the effect of disturbances along the temperature gradient. The colors at the top of the plots approximate the position of the bioclimatic domains along the temperature gradient.

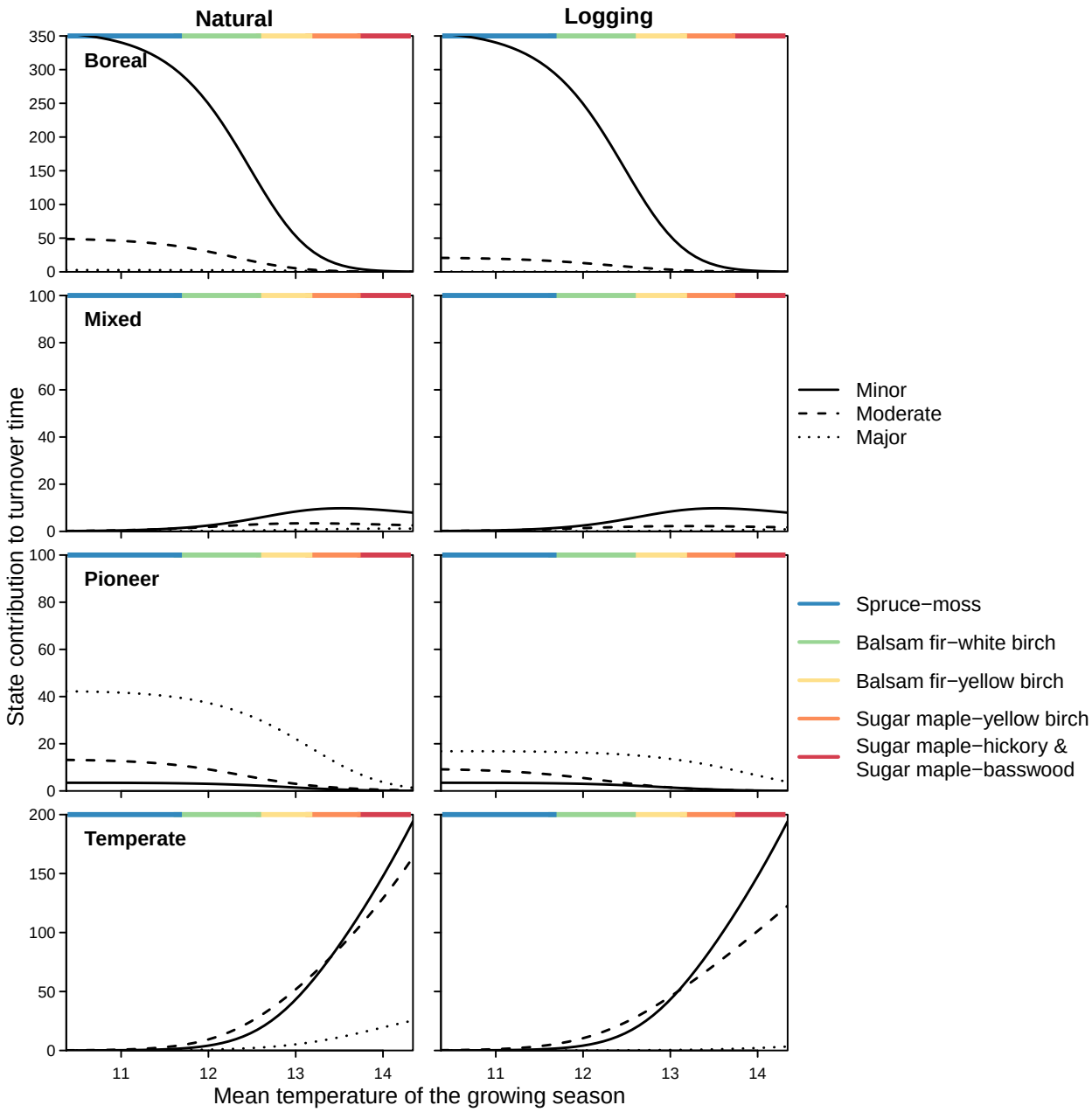

Figure 4: State contribution to forest turnover (see Fig. 7a,b in main text) along the temperature (latitudinal) gradient for different disturbance scenarios: minor (solid), moderate (dashed) and major (dotted) disturbances for both natural (a,c,e) and logging (b,d,f). All other covariates are fixed at the average conditions found in the ecotone, i.e. the balsam fir-yellow birch domain, to focus solely on the effect of disturbances along the temperature gradient. The turnover time of a state (or sojourn time) measures the time spent in this state before transitioning to the next. Long turnover time can translate to large resistance. Here, at any point along the gradient, state turnover time is scaled by the steady state distribution and the sum of all scaled state turnover gives the the turnover time of the transition matrix. The colors at the top of the plots approximate the position of the bioclimatic domains.

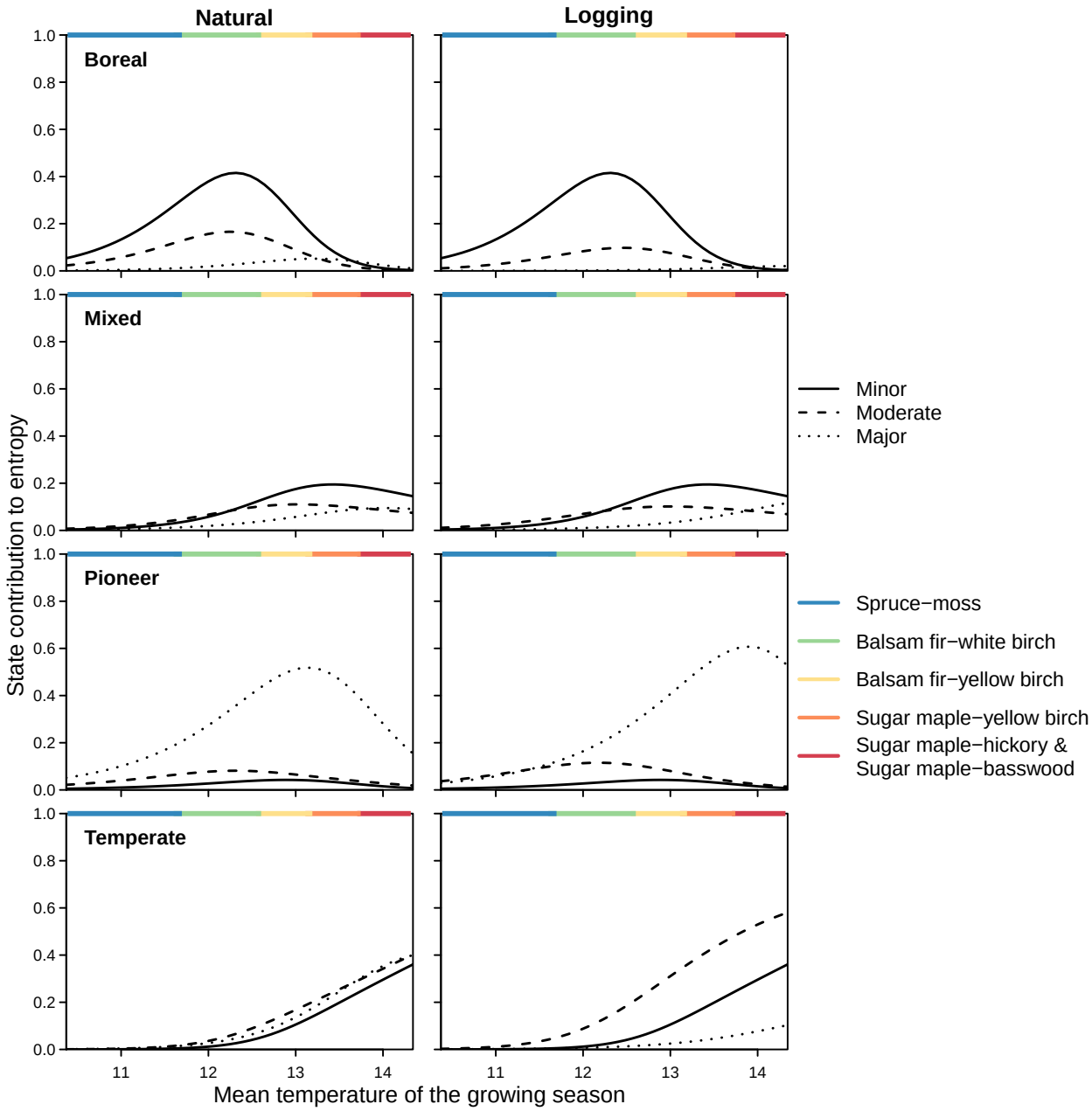

Figure 5: State contribution to forest entropy (see Fig. 7c,d in main text) along the temperature (latitudinal) gradient for different disturbance scenarios: minor (solid), moderate (dashed) and major (dotted) disturbances for both natural (a,c,e) and logging (b,d,f). All other covariates are fixed at the average conditions found in the ecotone, i.e. the balsam fir-yellow birch domain, to focus solely on the effect of disturbances along the temperature gradient. The entropy of a state measures the incertitude of its next transition. Here, at any point along the gradient, state entropy is scaled by the steady state distribution and the sum of all scaled state entropy gives the the entropy of the transition matrix. The colors at the top of the plots approximate the position of the bioclimatic domains.