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The Spatial Treeline-Ecotone Model (STEM) as a tool for understanding pattern-process relationships in alpine-treeline ecotones

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Spatial patterns in alpine-treeline ecotones reflect the ecological processes that have shaped and probably continue to shape these transition zones. Understanding these processes is essential for predicting treeline responses to global-change factors. To connect treeline-ecotone patterns and processes, we developed a spatially-explicit individual-based model. The first version of this Spatial Treeline Ecotone Model (STEM 1.0) represents the growth, mortality and dieback (biomass loss leading to stunted trees or krummholz) of all individual trees within a treeline transect, and uses variation in these demographic rates, imposed along elevation gradients or emerging as a result of neighbor interactions, to create treeline ecotones with different spatial patterns. The model could reproduce many of the expected treeline types, but some types required very particular parameter combinations. These results helped to identify missing elements in the model and thus to sharpen our conceptual model of treeline-forming processes. The next mayor development step for the model is to let demographic rates emerge from the interaction of environmental influences, modified by plant-plant interactions, rather than being imposed. However, this first version is a very important first step to formalizing and developing our conceptual model of pattern-process relationships in alpine-treeline ecotones.