Abies alba

Description of model and ensemble projections

The current distribution model of *Abies alba* is predicted to cover most of the Northern Pre-Alps, the Jura mountains, and those areas of the Swiss Plateau that are not located too low. It is also predicted to occur at mid- to high altitudes South of the Alps. In addition, the species is modeled in some inner-alpine valleys, notably the region between Disentis and Chur. The modeled distribution does not capture some of the lower altitudes on the Swiss Plateau and all locations in the dry inner-alpine Valais, where the species was measured in the LFI. The species naturally inhabits primarily the subalpine and upper montane regions. The fact that some (the warmest) parts of the Plateau and Valais are not modeled to be suitable reflects the fact that the model does not find sufficient evidence for *Abies* being present in these regions consistently according to the model data from across the Alps (MANFRED project).

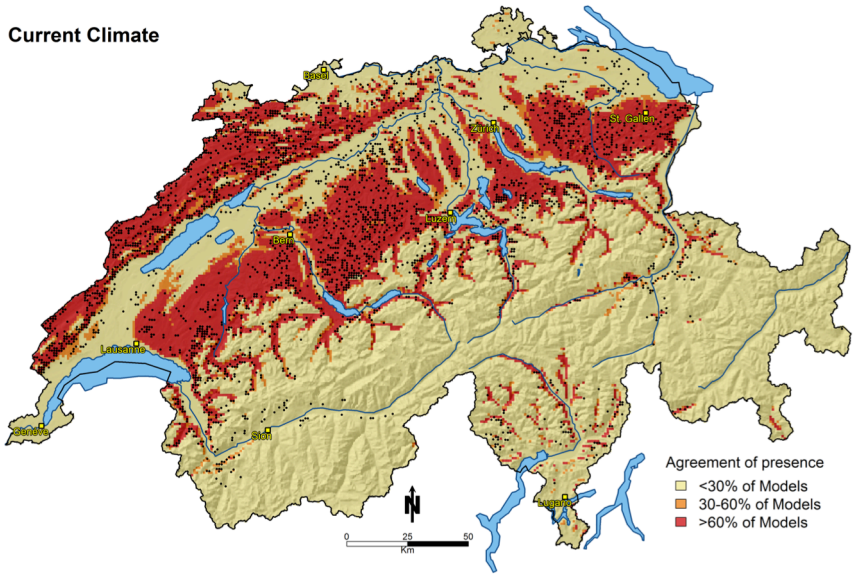

Figure 1. Current distribution (black dots) from the Swiss National Forest inventory (LFI 1) and simulated habitat suitability under current climate as calibrated from forest inventory data across the Alps (MANFRED project).

Under expected climate change using the A1B scenario, most combinations of statistical and regional climate models predict a rapid disappearance of *Abies* on the plateau and a retreat to Jura and higher Pre-Alps, and Insubrian mountains, meaning that these abandoned regions represent soon climate conditions, under which no presence of *Abies* is currently being observed given the many absence observations there. It is currently unclear as to how long Abies might still grow well on the Plateau despite finding unsuitable habitats soon. Growth analyses suggest that Abies can tolerate warmer climates, and even somewhat drier climates. This uncertainty cannot be resolved from SDM models, and likely by no other modelling approach.

Synthesis and Conclusions

The modelled distribution of *Abies alba* tends to underestimate the wide ecological amplitude of the species, although it fits the core of its current distribution well. As a tendency, the warm end of the species distribution is underrepresented, which means that it doesn't consistently occur under such conditions, but sometimes.

Range change statistics

	CH	Europe
Current range size [km²]	10'749	44'880
Future (2080) range size	3'952	16'673
Range Change 2080/2000 [%]	36.8%	37.1%
Overlap 2000/2080 [km²]	1'128	14'354
Overlap/current range [%]	10.5%	31.9%

There is growing evidence (Maiorano *et al.* 2013; Tinner *et al.* 2013) that the species has a much wider ecological amplitude, spanning a temperature amplitude that ranges from Mediterranean climates to treeline conditions, given that a minimum annual rainfall of ca. 700-800mm are met. Given these numbers, *Abies alba* could serve well as an alternative to *Picea abies* as a future timber tree on the Plateau under A1B scenario conditions. Uncertain is currently the full reason for the lack of covering this large gradient, especially at the warm end. Reasons likely include the long history of human interventions in European forests, and the fact, that *Abies* has a very slow response to disturbance. It therefore might be a more natural component under even Submediterranean and Mediterranean conditions, but only, if disturbance rates and intensity remain low.

The predicted overlap between current and future range is low (10%) in Switzerland but at least higher at the European scale (32%), meaning that within Europe, there remain significant areas, where the species is not threatened in the future due to sufficient range overlap. In addition, the view that *Abies alba* is more tolerant to heating and even a moderately drying climate means that the species might serve as an important future timber tree on the Plateau. Unclear is, however, how an increasing rate of climatic (e.g. drought) events and other disturbances (e.g. pests) might affect the future coping of *Abies* with the ongoing climate change.

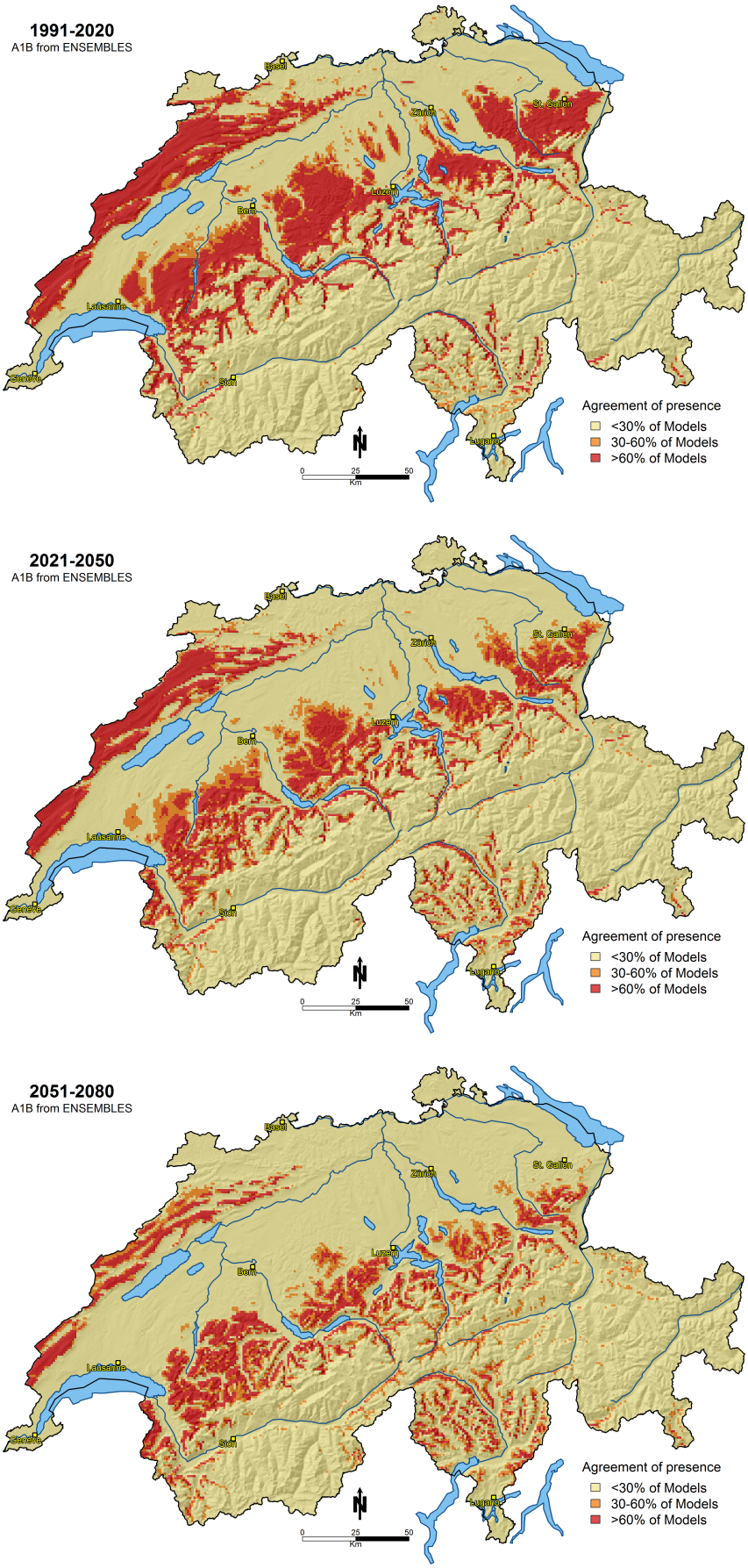

Figure 2: Ensemble of projected future ranges of suitable habitat as modeled from six RCMs and six statistical models. Light yellow colors indicate that all climate & statistical model combinations project absence of the species, while dark red colors indicate presence. Orange colors indicate uncertainty regarding habitat suitability.

It remains therefore uncertain to promote *Abies* to a high degree; yet, it should remain on the agenda of future forest planning north of the Alps, even at low altitudes. The growth analyses (Appendix S2) do not contradict this statement, and predict a comparably good growth even under dry and warm conditions as long as average monthly summer precipitation doesn't fall below 75mm (totaling ca. 400mm in summer, or 700-800mm annually).

References

Maiorano L, Cheddadi R, Zimmermann NE, *et al.* (2013) Building the niche through time: using 13,000 years of data to predict the effects of climate change on three tree species in Europe. *Global Ecology and Biogeography* **22**, 302-317.

Tinner W, Colombaroli D, Heiri O, *et al.* (2013) The past ecology of Abies alba provides new perspectives on future responses of silver fir forests to global warming. *Ecological Monographs* **83**, 419-439.