Pinus sylvestris

Description of model and ensemble projections

The current distribution of *Pinus sylvestris* is simulated to cover most of the Swiss Plateau, the North-Eastern Jura range and the Northern Pre-Alps and lower altitudes of the interior dry valleys (Valais, Posterior Rhine valley incl. Landwasser and Bergün region, Lower Engadin. The valleys North and South of the Gotthard massive (Upper Reuss valley, Hasli valley, Leventina) are harboring significant populations of *P. sylvestris*. Yet, these populations are not modelled well with the existing model. Neither are some of the highest populations in the Jura and North-Eastern Pre-Alps.

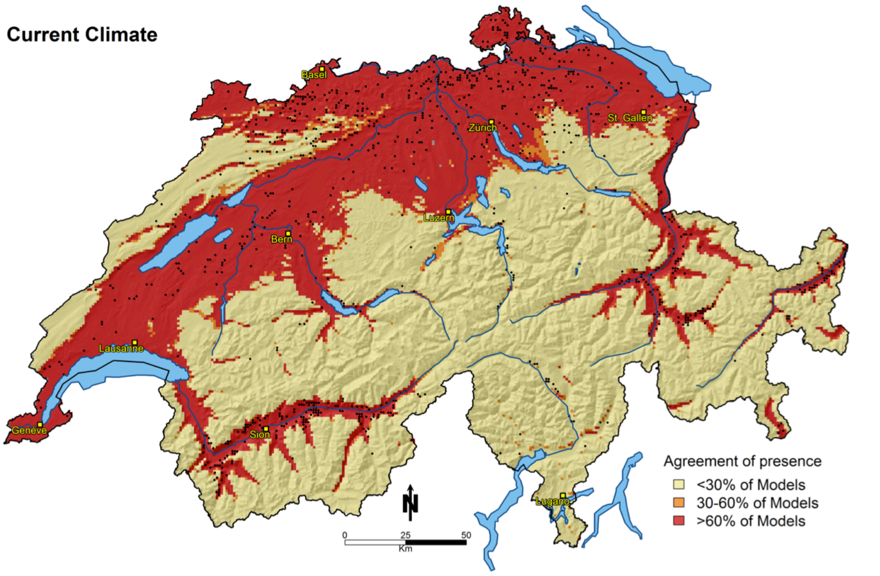

Figure 1. Current distribution (black dots) from the Swiss National Forest inventory (LFI 1) and simulated habitat suitability under current climate as calibrated from LFI forest inventory data of Switzerland.

Under projected climate change using the A1B scenario, most combinations of statistical and regional climate models predict a rapid spread of *P. sylvestris* to higher altitudes and specifically also into the regions that were said to have false negative (predicted absence, where presence is observed). The species "escapes" to higher altitudes and invades into more valleys than it is currently distributed. On the other hand, the species doesn't really lose much suitable habitat at lowest altitudes, except in the Ticino. There, it is projected to no longer find suitable habitats.

Synthesis and Conclusions

The model fits the distribution of *Pinus sylvestris* very well, and can be considered a credible model to project the future habitat suitability of *P. sylvestris*. Only the some "Foen" (=chinook) regions are not modelled well, since this predictor is not easily available in map form. The ensemble models project a 99% overlap between the current and the future range in Switzerland and still a high overlap (59%) in Europe. This is a much higher overlap than previously modeled (2.9%, Zimmermann *et al.* 2006). The difference mostly originates from using less extreme climate scenarios in this report. Here we used the A1B scenario, which is a moderate warming scenario from the fourth IPCC assessment report (IPCC 2007). The previous simulations were based on the 3^{rd} assessment report (IPCC 2001), where the A1FI scenario was much more extreme compared to the current A1B scenario. In addition, we used soil information (soil depth) and an assessment of calcareous/non-calcareous soil types. In addition, the species is projected to increase its range of suitable habitats in Switzerland (+44%), and in Europe, it will lose a fraction of its comparably large range, shrinking by ca. 40%.

Range change statistics

	CH	**Europe**
Current range size [km^2]	15'302	207'621
Future (2080) range size	22'095	122'934
Range Change 2080/2000 [%]	144.3%	59.2%
Overlap 2000/2080 [km^2]	15'159	122'062
Overlap/current range [%]	99.1%	58.8%

This species will not be in difficulties with on-going climate change. On the one hand, it is rather a pioneer species that grows fast and doesn't tolerate much shade. It can grow to maturity within 10-15 years, and the wind-dispersed seeds allow for comparably rapid migration (Meier *et al.* 2012). This, together with the high overlap, suggests that the species will do well in the future. However, it has difficulties, currently, in the warmest regions of the Valais. In these warmest regions, the species is observed to undergo severe mortality events in years following severe droughts. This effect is not well modelled by the current model ensemble. It is therefore likely, that on some of the warmest regions, specifically on shallow soils, the species will not do well in the future. It is, on the other hand, not so clear, how the species will do on deeper soils. Currently, it can only grow on deep soils early during a succession, or at forest edges, thus escaping the competition by more shade tolerant, late successional species. In a warmer and dryer climate, it might expand its survival on deeper soils, but will face pathogens at such locations. Only on very dry (but usually not too hot) sites, the species can be considered a late successional species, meaning that no other species can tolerate these conditions and outcompete *P. sylvestris*

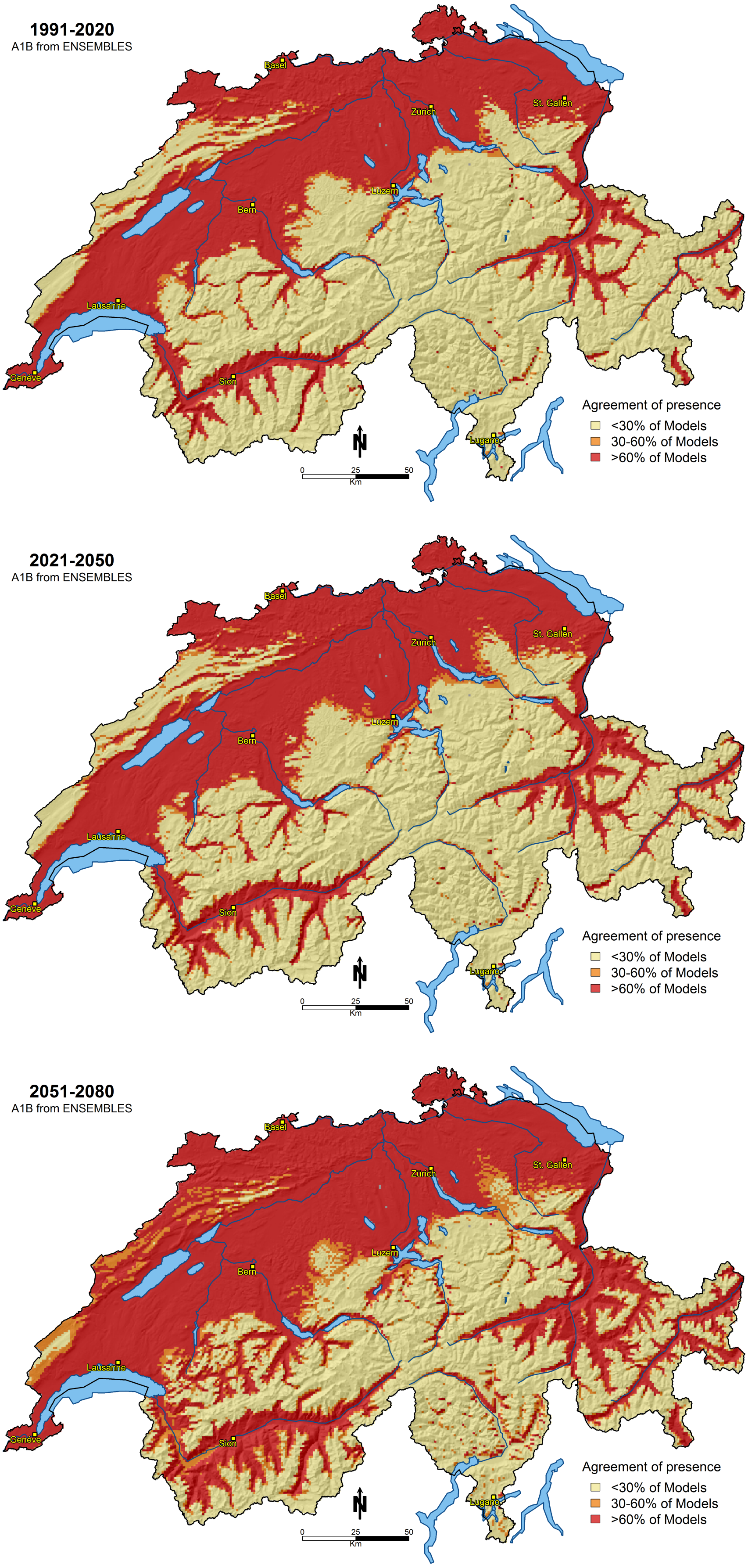

Figure 2: Ensemble of projected future ranges of suitable habitat as modeled from six RCMs and six statistical models. Light yellow colors indicate that all climate & statistical model combinations project absence of the species, while dark red colors indicate presence. Orange colors indicate uncertainty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

The species profits from two different types of seed dispersal. On the one hand it distributes the seeds by wind, using its seed wings. There is a short-winged form that can distribute seeds up to 150m away from the source. The long-winged form reaches seed dispersal distances up to 1000m, which can be considered very far. On the other hand, there is significant secondary distribution by small rodents, birds or by water transport.

Among all 113 pine species described, it is the one with the largest geographic distribution. It has spread throughout Northern Eurasia, but has also become invasive in several parts of North America and South Africa, specifically.

References

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