Forest Biodiversity and Carbon Sequestration as a Function of Past and Future Climate Changes

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Objective

The aim of the study was to assess quantitatively the impacts of past and future climatic changes (cc) on forest biodiversity and carbon (C) sequestration for forests in Switzerland using latest transient downscaled scenarios, and to determine the variable that is most impacted by cc.

Approach

Simulations were done with the forest patch model FORCLIM (vers. 2.6-4.1) at 12 sites representing the main climatic zones of Switzerland.
Past climate data (1864-2003, [1]) were divided in 5 time windows.
Future climate scenarios combine:

- 450 ppm (low cc) [2]
- 1000 ppm (medium cc) stabilization scenarios [2]
- extended IPCC SRES A2 (high cc)

Site-specific climate data were gained using statistical downscaling (CSIRO GCM using IPCC SRES A2).

Results

Past climate changes

- No significant changes in C stocks
- No significant changes in species number
- Climate of last time window (1976-2003) has a significant effect on the species composition ($P < 0.001$, fig. 2)

Future climate changes

- Almost no changes in C stocks for low cc, but medium or strong cc lead to new forests or diebacks at some sites (cf. fig. 3)
- Species number generally increases with climate change
- Species composition changes up to 100% under the extended A2 scenario, 50% under the 1000 ppm scenario
- 5 types of response considering both biomass and species number (fig. 3) [after 3]

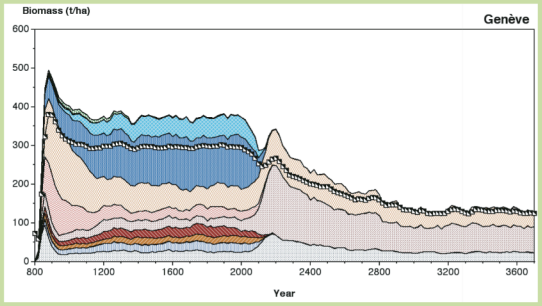

Fig. 1: Simulated transient forest response to transient climate change (extended IPCC SRES A2 scenario) for site Geneva. Black line: carbon stocks; coloured areas: species specific biomass (cf. fig. 3).

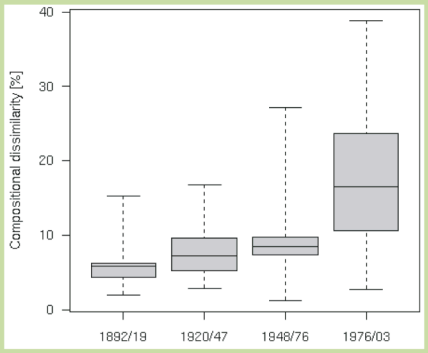

Fig. 2: Boxplots of dissimilarities of simulted forest compositions (in %) (FORCLIM vers. 2.6-4.1) showing the equilibrium forests under the climates of the second to the fifth time window compared with that of the first time window (1864-1891) at 12 Swiss sites (dissimilarity index represents the fraction of the biomass with a complete change in species abundance). Climate data from [1].

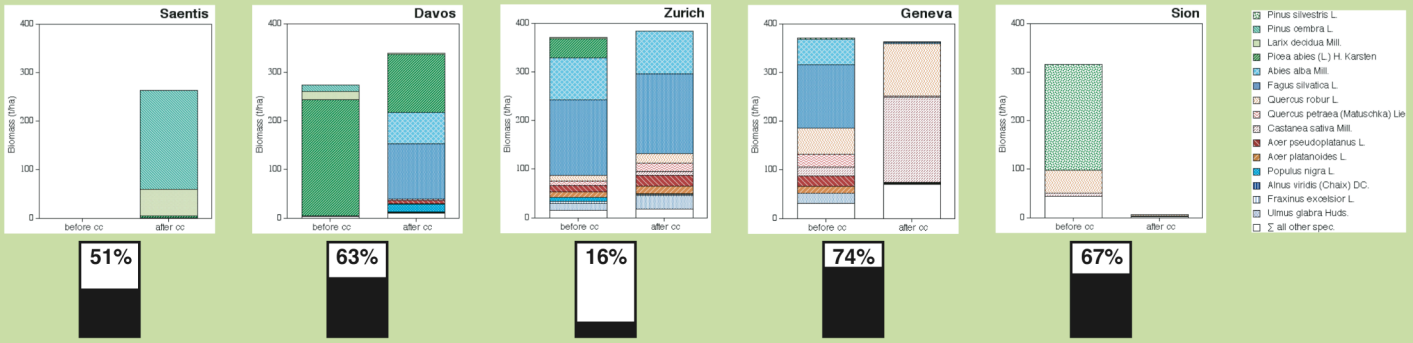

Fig. 3: Effect of cc on forest equilibrium tree-species compositions at five selected sites representing the five types of forest responses to cc. Left: compositions before significant climate change (1864-91); right: after a medium climate change (1000 ppm CO_2 stabilization scenario), as well as the dissimilarity indices in the row below. Saentis: increasing biomass and species number (newly afforested Alpine site); Davos: increasing biomass and species number (sub Alpine site - shift from spruce to mixed forest); Zurich: almost no response of biomass or species number (Swiss plateau site); Geneva: decreasing biomass and increasing species number (low altitude site); Sion: decreasing biomass and species number (central Alpine site - forest dieback due to drought).

Conclusions

As yet, forests have not responded much to observed past climatic changes. For some sites, forest productivity might not even change much under future climatic changes. However, species composition will in most cases change significantly, albeit delayed, which means a shift in forest types. Moreover, changes in species composition might affect forest structure and hence understorey biodiversity.

References

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