Glacier retreat reorganises river habitats leaving refugia for Alpine invertebrate biodiversity poorly protected

BACKGROUND

Alpine regions are warming at a faster rate than the global average. High levels of endemism make alpine biodiversity particularly vulnerable to climate change because geographical barriers restrict opportunities for poleward range shifts. Alpine species populations are therefore expected to shift to higher elevations under climate change.

By coupling models of future ice extent, glacial influence on downstream river habitats, and species' ecological niches, **we present a new method for identifying potential future refugia for cold-adapted aquatic species**.

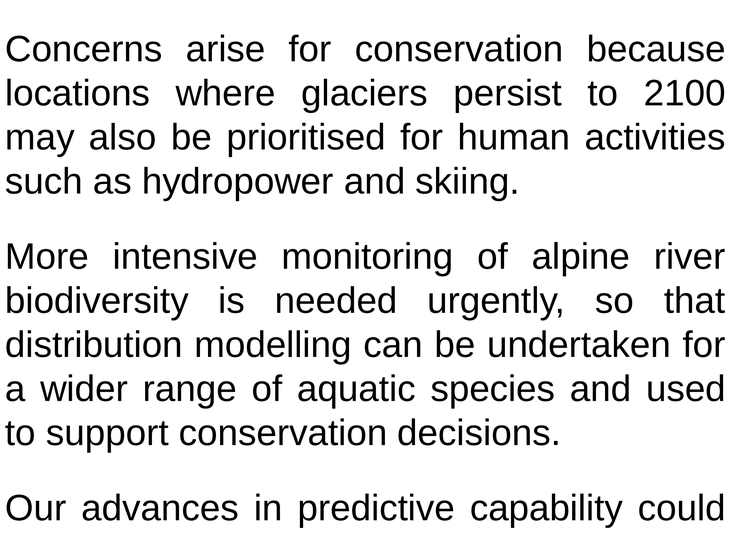
These advances can now be used to predict future alpine biodiversity, and then use this information to ensure that protected areas evolve to provide greater conservation potential.

METHODS

Projections of river invertebrate distributions were developed for all glaciated sub-catchments of the Alps > 2000 masl, at decadal intervals (2020-2100), for 10x10 m river "segments".

Projections were driven by a glacial influence model that determines the % upstream catchment with glacial ice cover for each river segment. Future glacier extent was predicted from the Global Glacier Evolution Model.

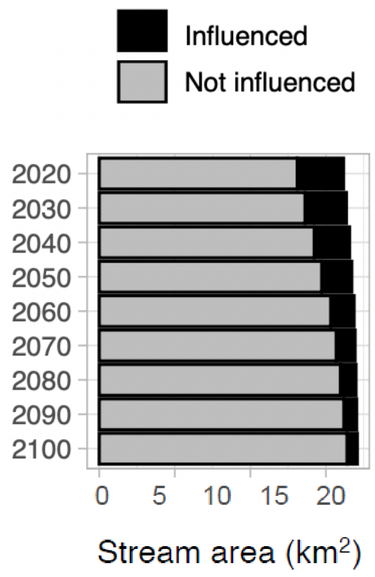
Projections for 15 species were developed using species distribution models by integrating 656 biological samples with a set of river environmental characteristics composed of glacial influence, hydrological, hydraulic and hydrochemical controls.



MAIN FINDINGS

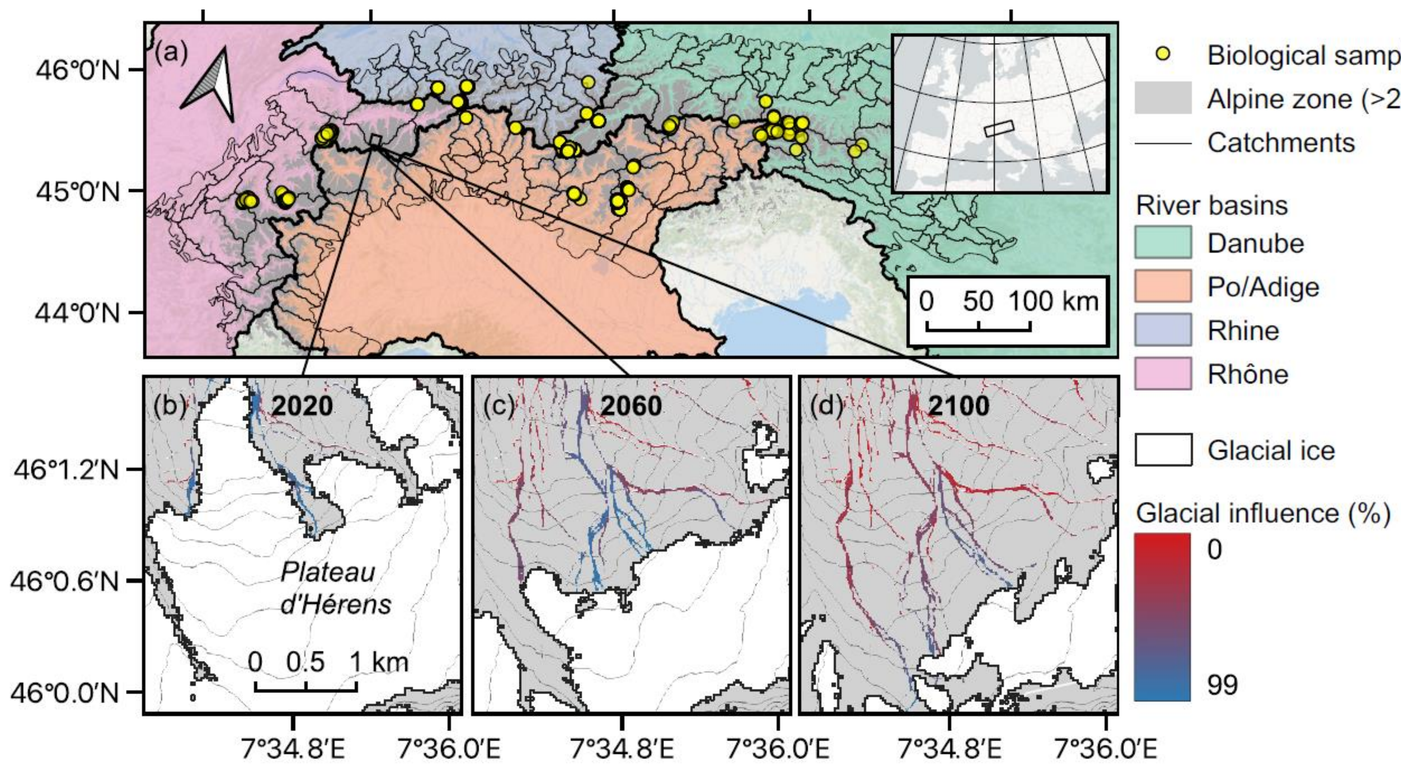
Glacial influence on river ecosystems is projected to diminish to the end of the 21st century in all European Alps river basins.

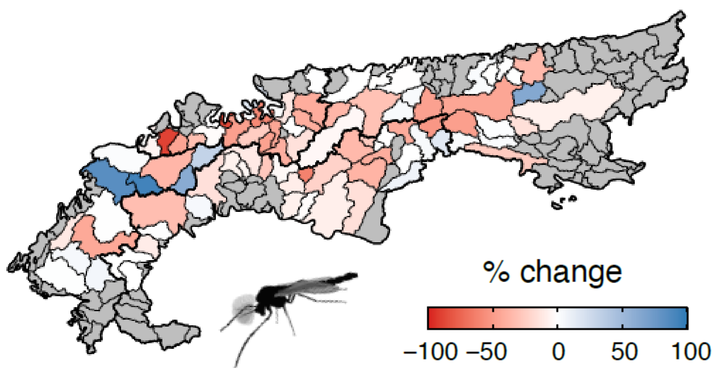
Example shows decadal projections for Danube basin headwaters →



Projected river network structure and glacial influence on river habitat are now available for the whole of the European Alps from 2020 to 2100.

↓ *Example shows how retreat of the Plateau d'Hérens, Valais, Switzerland, leads to the formation of new streams, many of which develop to have low or zero glacier influence by 2100*



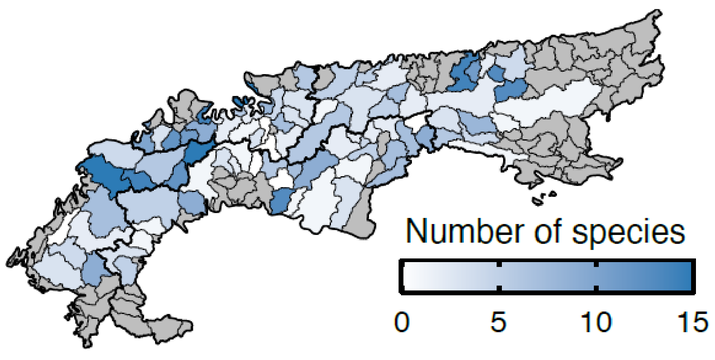


For each species, the % change in suitable habitat area for river sub-catchments is predicted from 2020 to 2100. Sub-catchments with no glacial influence in 2020 are shown in grey.

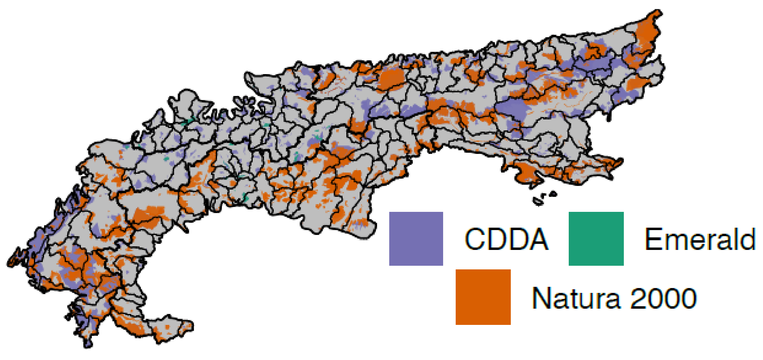
Most alpine species are predicted to suffer decreases in suitable habitat area across the European Alps by 2100.

←*This example shows losses for the cold-adapted, non-biting midge Diamesa steinboecki*

↓ Sub-catchments identified as offering refugia retain higher levels of glacial influence in 2100, and these tend to be in the Western Alps.



↓ Protected areas cover only 12% of areas predicted to be refugia for all 15 species. This is less than the protected area coverage of the wider Alps landscape (25%)



SUMMARY

In 2100, many of the most effective areas for cold-water invertebrates will fall outside of existing protected area networks.

Concerns arise for conservation because locations where glaciers persist to 2100 may also be prioritised for human activities such as hydropower and skiing.

More intensive monitoring of alpine river biodiversity is needed urgently, so that distribution modelling can be undertaken for a wider range of aquatic species and used to support conservation decisions.

Our advances in predictive capability could now be used in other mountain ranges, where local-scale predictions are available for only a small number of species.

This work was undertaken by scientists from the UK, Austria, France, Italy and Switzerland, building on multiple studies dating back to the 1990s.
The full report is available online: https://www.nature.com/articles/s41559-023-02061-5
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