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Contact:
emilienkuhn@gmail.com

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Early warnings: climate change may force plant ranges to split, threatening genetic diversity

Signs that the ranges of sub-mountainous forest plants in France have contracted in response to global warming have been detected in a new study. This pattern is likely to induce a splitting of these species' ranges across Europe under future climate change, which could have serious consequences for plant genetic diversity and the capacity of plant populations to adapt to warming climates, say the researchers.

Climate change is driving a rise in global temperatures and triggering changes in habitats, wildlife and natural processes. Such disturbances will likely alter the distribution of species around the world, potentially leading to biodiversity loss. In the northern hemisphere, warming temperatures are expected to drive plants further northwards and upwards, as they seek the cooler temperatures found at higher latitudes and altitudes.

Researchers in France have speculated that, as plants migrate under warming temperatures, plant ranges could also become split in Europe because the arrangement of the continent's mountainous areas and temperate lowlands causes climate gradations between the two types of environments.

To see whether there is already evidence for early signs of such splitting, the researchers investigated the historical and current distribution of sub-mountainous forest plants in France. Temperate lowlands cover much of northern France, where the annual average temperature is between 6 and 10 °C, and the mountain ranges of the Pyrenees and Alps dominate the southern landscape, resulting in locally colder areas in the south of the country, compared with the north. Sub-mountainous forest plants grow predominantly further north than 45 °N, with the cold edge of their distribution in mountains and the warm edge in the temperate lowlands.

Using French floral databases and climate data from French meteorological stations, the researchers compared the historical (1914–1987) and recent (1997–2013) distributions of 97 sub-mountainous forest plants found in France. The researchers also used species distribution models to predict how the range of these species might have shifted between these two periods, for comparison with the observational data.

The researchers found that the average annual temperature in France has increased by approximately 1 °C over the last century and is obvious since 1988. Coinciding with this, both observational changes and model predictions revealed a consistent pattern which showed plants had migrated higher up the mountains at the southern edge of their distribution.

There was also a 6% decrease in the observed frequency of these plant species in the lowlands between these two periods. The changes in frequency as well as range indicate that these plants species are already showing signs of retreating from the warmer lowlands at their warm edge and migrating southwards towards the colder, southern mountains. This contradicts expectations that, globally, plants will shift polewards under climate warming and highlights the potential for plant ranges to also shift in other directions at regional and local scales, say the researchers.

These shifts clearly indicate a retraction of these species from temperate lowlands in France which could, the researchers suggest, also indicate the beginning of their disappearance in European temperate lowlands more widely. Considered at the European scale, under future warming, these plant populations could become separated into those retreating to the cold, southern mountains and those migrating polewards in the northern lowlands.

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Early warnings: climate change may force plant ranges to split, threatening genetic diversity *(continued)*

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Twenty-five of the 97 forest plants are also found with distributions ranging between southern and northern Europe. The researchers modelled how the latitudinal distribution ranges of these 25 plants would change across Europe under a future (2061–2080) climate compared with the contemporary (1950–2000) climate. They assumed a range of future climate warming based on four scenarios, representing the best case with the lowest greenhouse gas (GHG) concentrations in the atmosphere by 2100 and three other scenarios corresponding to increasing GHG atmospheric concentrations.

For the worst case scenario, 12 out of the 25 species were predicted to have their ranges split, with species separated into two distinct populations, one in northern Europe and the other in the southern mountainous area.

The researchers point out that the investigated plant species are not threatened with extinction over the next 100 years. Nevertheless, the genetic diversity needed for populations to survive could be lost as ranges are divided and gene pools are isolated in distinct populations too far apart for long-range species dispersal to be possible.

The researchers say the agreement between observed and modelled range shifts of sub-mountainous plants in France strengthens the significance of their results and gives them increased confidence about the model's predictions for future distributions of these plants across Europe under climate change.

The range retraction of sub-mountainous plants already detected in France acts as an early warning of possible future range fragmentations for these species across Europe. Under a warming climate, this pattern could occur in any parts of the world where two areas with similar climatic conditions are separated by a much warmer area. The warm edge of species falling into this area would likely retreat, inducing a pattern of fragmentation and division.

The researchers say the consequent biodiversity loss could be mitigated by conservation efforts to protect populations containing plants with a highly diverse gene pool, especially southern European plants' populations. Limiting habitat fragmentation as a result of land-use change could help to maintain gene flux between separated populations and prevent the loss of adaptation ability.