

A global change-induced biome shift in the Montseny mountains (NE Spain)

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Abstract

Shifts in plant species and biome distribution in response to warming have been described in past climate changes. However, reported evidence of such shifts under current climate change is still scarce. By comparing current and 1945 vegetation distribution in the Montseny mountains (Catalonia, NE Spain), we report here a progressive replacement of cold-temperate ecosystems by Mediterranean ecosystems. Beech (*Fagus sylvatica*) forest has shifted altitudinally upwards by ca. 70 m at the highest altitudes (1600–1700 m). Both the beech forests and the heather (*Calluna vulgaris*) heathlands are being replaced by holm oak (*Quercus ilex*) forest at medium altitudes (800–1400 m). This beech replacement has been observed to occur through a progressive isolation and degradation of beech stands. In 'isolated' (small and surrounded by holm oaks) beech stands, beech trees are 30% more defoliated, beech recruitment is 41% lower, and holm oak recruitment is three times higher than in 'continental' (large and continuous) beech stands. The progressively warmer conditions, complemented by the land use changes (mainly the cessation of traditional land management) are the apparent causes, providing a paradigmatic example of global change affecting distributions of plant species and biomes.

Keywords: altitudinal shift, biome replacement, *Calluna* heathland, climate change, defoliation status, *Fagus sylvatica*, land use change, Mediterranean forest, Montseny mountains, *Quercus ilex*, recruitment, temperate forest

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Introduction

Climatic regimes determine species distributions through species-specific physiological thresholds of temperature and water availability (Woodward, 1987). Shifts in plant species and biome distribution towards the poles or higher altitudes in response to warming have been described in past climate changes (Gates, 1993) and it is considered clear now that poleward and altitudinal upward shifts of species ranges have also occurred across a wide range of taxonomic groups and geographical locations during the 20th century in response to current climate warming (IPCC, 2001a; Walther *et al.*, 2002). However, in fact, actual evidence of plant species

altitudinal shifts is still scarce (Wardle & Coleman, 1992; Grabherr *et al.*, 1994; Kullman, 2001) despite such shifts being easier to discern in plants than in animals, which may exhibit large fluctuations from year to year. Plant shifts follow from the slow processes of population extinctions and colonizations, and therefore it is easier to detect true geographical shifts than in animals since change is more methodical and missing data is less important.

The medium and highest altitudes (800–1700 m a.s.l) of the Montseny mountains in Catalonia (NE Spain) constitute one of the ecotonic southern distribution areas of *Fagus sylvatica* (beech) forest and *Calluna vulgaris* (heather) heathlands in western Europe (Bolòs & Vigo, 1990). At lower altitudes of Montseny mountains (less than ca. 800 m a.s.l) the vegetation is typically Mediterranean, with dominance of the *Quercus ilex* (holm oak) forests. As Montseny beech forests and heather heathlands represent quite an extreme of their distribution area (Fig. 1), they are

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