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Shifting habitats in the Alps and potential future consequences for birds

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Climate change has resulted in upward elevational shifts in the distribution of animals and plants in many high-altitude areas. The extent to which this will have negative impacts for high-altitude species will depend on sufficient areas of high elevation to enable upwards range expansion, and also on the response of different habitat types to temperature rise; in particular, habitat loss may be exacerbated if different habitats respond differentially. These processes are illustrated graphically in Figure 1, which shows the distribution of the Northern Wheatear *Oenanthe oenanthe* in relation altitude, and also the preferred open habitats (mainly grassland) and those habitats largely avoided (forest at lower elevations and unvegetated rocky habitat at higher elevations) above 1700 m in the Italian Alps. Figure 1(A) shows the current situation. If climate change resulted in a shift in vegetation zones, and all zones responded at the same rate, then there should be little loss of habitat for grassland species such as the Wheatear (Fig. 1B), so long as there is an adequate altitudinal range to enable the grass zone to expand into former unvegetated high-altitude areas. However, if zones respond at different rates, then habitat loss may be more marked. For example, the formation of soils and the existing soil quality may be adversely affected by temperature increases at high altitude (Edwards *et al*. 2007), which may constrain the colonization of the rock zone by grass, hence increasing tree and shrub zones at lower altitudes. A lack of increase in the grass zone at higher altitudes would lead to a decrease in suitable Wheatear habitat (Fig. 1C).

The potential consequences of such changes for alpine bird communities were assessed by modelling data on breeding bird distributions estimated from point counts along altitudinal gradients at relatively high altitude (*c*. 1700–3100 m) in the Alps of the Province of Turin, Italy, in relation to habitat, topography and temperature. These models were used to assess the sensitivity of species to potential future environmental change by estimating distributions under a range of scenarios of habitat and climate change by 2080. There were nine scenarios in total, all based on a moderate degree of climate change (IPCC scenario B2A), which varied in terms of the rate of response of forest and grassland zones, the sensitivity of species to habitat change and their sensitivity to climate change *per se*. This included a scenario of change in climate but no change in habitat, thus simulating active management to maintain current habitat distributions (full details in Chamberlain *et al*. 2013). Model performance was good for the majority of species studied, with the exceptions of Black Redstart *Phoenicurus ochruros*, Common Chiffchaff *Phylloscopus collybita* and Bonelli's Warbler *P. bonelli*, the scenario outcomes of which should be treated with caution.

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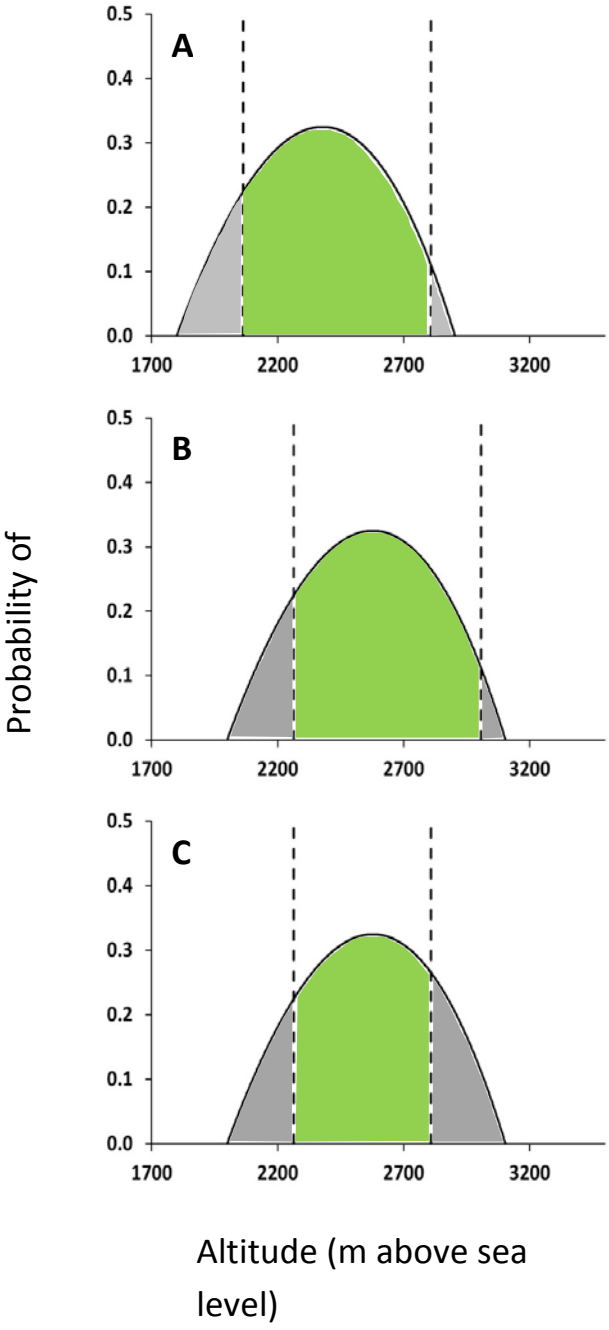

Figure 1. An illustration of the effects of differential elevational shifts in habitat zones on the distribution of Wheatear along an altitudinal gradient, showing potentially suitable (green shading) and unsuitable (grey shading) areas (defined according to both habitat and climate).
(A) The probability of occurrence of Wheatear along an altitudinal gradient (fitted from a quadratic logistic regression model), and the mean altitude below which forest was the dominant habitat type (dashed line, left) and above which unvegetated substrate was the predominant habitat type (dashed line, right).
(B) The same distribution under a hypothetical scenario of climate change which results in an elevational shift of 200 m in all habitat zones. In (C) it is assumed that, under the same scenario, tree lines show an elevational shift in response to climate change, but the rock zone does not move due to constraints on soil processes. Estimates of the probability of occurrence, and of the altitudes of the dominant habitat types, were derived from the data in Chamberlain *et al*. (2013).

Distributions of the majority of forest or shrub-nesting species (Tree Pipit *Anthus trivialis*, Dunnock *Prunella modularis*, Eurasian Wren *Troglodytes troglodytes*, Chiffchaff, Bonelli's Warbler, Willow Tit *Poecile montanus*, Coal Tit *Periparus ater*, Common Chaffinch *Fringilla coelebs*) remained stable or increased in response to climate change according to most scenarios as a result of elevational shifts in suitable habitats, with an average increase

in distribution of 102% considered over all models. There were, however, some species (Tree Pipit, Dunnock, Wren and Willow Tit) that decreased in distribution under scenarios of little or no forest increase and a high sensitivity to a warmer climate. Conversely, open habitat species (Eurasian Skylark *Alauda arvensis*, Water Pipit *Anthus spinoletta*, Black Redstart and Wheatear) mostly showed declines, with an average loss of 29% considered over all models, although all species except Water Pipit increased under scenarios of warming coupled with slow or no increase in the extent of forest. Therefore, open habitat species may face a severe decrease in distribution as grasslands are colonized by forest and shrubs, because much of the area considered is not at a sufficient altitude to accommodate further elevational shifts. This will be exacerbated if upward shifts in vegetation are constrained at high altitudes, due to negative impacts of loss of snow cover on soil properties, leading to a habitat 'squeeze' caused by an asymmetric response of vegetation zones to climate change at higher altitudes (Fig. 1C).

Model outcomes suggested that management to maintain open habitats may be of benefit to some species, but it may not be sufficient for those species for which climate change results in a mismatch between the distribution of suitable climates and suitable habitats. Water Pipit in particular is likely to be highly sensitive to such changes, as it is a high mountain specialist associated with colder conditions and is strictly linked to open habitats. Open habitat bird species illustrate the potential threat to wider biodiversity of alpine grasslands which are likely to host a high diversity of a number of groups, such as flowers, carabid beetles, dung beetles and butterflies, not to mention other high-altitude specialist bird species which were recorded too infrequently for analysis (e.g. Ptarmigan *Lagopus muta*, Alpine Accentor *Prunella collaris*, Snow Finch *Fringilla montifringilla*). The loss of alpine grasslands may therefore present a serious conservation problem in the future, not only for birds, but for the many other species associated with this habitat. Continued monitoring and research should be prioritized for this potentially threatened habitat, in particular at the interface between the grassland and bare rock habitats at higher altitudes where soil responses may be crucial for vegetation communities and consequently possible distributional shifts of alpine fauna.

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