Climate change will soon threaten many more species with extinction

Climate change will reduce, and force shifts in, the ranges of many species. Many will not be able to move fast enough, or in concert with other species. This will result in extinctions. Whether we lose a few species or huge numbers will depend critically on the degree of warming. We must act now to minimise this.

Many species will suffer from range shifts and losses

Modelling studies show that the ranges occupied by many species will become unsuitable for them as climate changes. The climate space that is suitable for particular species may shift (in latitude or altitude: see **box 1**), contract (**boxes 2 and 3**), or even disappear (**box 4**). Species whose climate space both contracts and shifts substantially will be of particular concern (**box 5**).

1 In Mexico, climate change may lead to habitat becoming unsuitable in large parts of the range of Worthen's Sparrow

Worthen's Sparrow *Spizella wortheni* is currently listed as Endangered because it has an extremely small and declining range and population in north-east Mexico, threatened by continued degradation of its open shrub-grassland habitat by agriculture and grazing. Climate change modelling shows that much of the remaining habitat may become unsuitable in just 50 years. This was determined by modelling the relationship between known localities[1,2] (see figure a) and various climatic variables to generate a predicted potential distribution[3] (figure b). This was then combined with global climate change models to generate a predicted potential distribution in 2055[4,5] (figure c). The modelled distributions for present and future were brought together to determine areas that are suitable now and likely to remain so (figure d). Many of the sites from which the species is currently known are predicted to become unsuitable in future due to climate change. Assuming that Worthen's Sparrow has minimal dispersal ability, this analysis points to the populations at the south-western edge of the species's distribution as the most viable in the long term.

(a) Historic distribution of Worthen's Sparrow based on specimen localities

(b) Current potential distribution of the species based on modelling of its 'ecological niche'

(c) Potential distribution in 2055, based on modelled current distribution and global climate change models

(d) Potential present and future distribution of the species

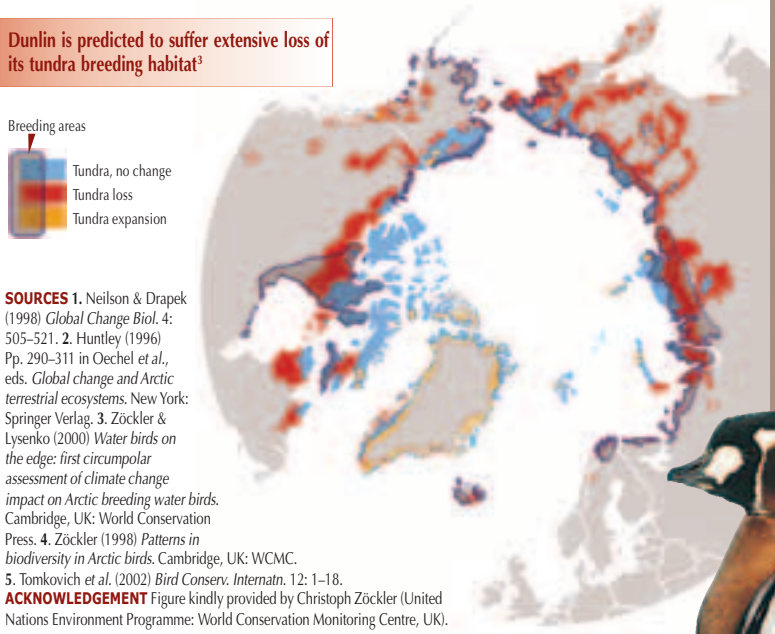
SOURCES 1. Navarro-Sigüenza *et al.* (2002) *CODATA J.* 1: 45–53. 2. Navarro-Sigüenza *et al.* (2003) *Bull. Brit. Orn. Club* 123A. 3. Peterson *et al.* (2002) Pp. 617–623 in Scott *et al.* eds, *Predicting species occurrences: issues of scale and accuracy.* Washington, DC: Island Press. 4. Peterson *et al.* (2002) *Nature* 416: 626–629. 5. Peterson *et al.* (2001) *Ecol. Model.* 144: 21–30.
ACKNOWLEDGEMENTS Data and figures kindly provided by A. Townsend Peterson (University of Kansas Natural History Museum and Biodiversity Research Center, USA), Adolfo G. Navarro-Sigüenza (Universidad Nacional Autónoma de México), and Enrique Martínez-Meyer (Universidad Nacional Autónoma de México).

2 In the Arctic tundra, climate change will cause dramatic losses in waterbird breeding habitat

The Arctic region showed the most pronounced warming of any part of the globe in the last century. This trend is set to continue, with warming of up to 5°C in the next 50–80 years predicted by some models[1]. Considerable changes in vegetation cover are predicted by all models: boreal forests are likely to spread northwards, perhaps at a rate of 0.2–2 km/year[2]. As there are few areas where tundra is expected to expand, there will be a consequent net loss of 45–71% of the area of tundra if CO_2 levels double, a scenario that is predicted to occur by 2070–2099[3].

The Arctic tundra is the main breeding habitat for many migratory waterbird species, comprising 23–27 million individual geese and waders[4]. Many species will be severely impacted by the loss of tundra habitat. A study of 23 Arctic waterbirds showed that, on average, they may lose 35–51% of their breeding range[3]. For example, Dunlin *Calidris alpina* could lose up to 58% of its breeding habitat in this time-frame (see figure), Red-breasted Goose *Branta ruficollis* (already classified as Vulnerable) may lose up to 85% and Spoon-billed Sandpiper *Eurynorhynchus pygmeus* (Endangered) could lose up to 57%[4,5]. Such results show how climate change may impact species that are distributed at the polar edges of continents, and which may therefore have limited opportunities for dispersing to new areas of suitable habitat.

Dunlin is predicted to suffer extensive loss of its tundra breeding habitat[3]



SOURCES 1. Neilson & Drapek (1998) *Global Change Biol.* 4: 505–521. **2.** Huntley (1996) Pp. 290–311 in Oechel *et al.*, eds. *Global change and Arctic terrestrial ecosystems.* New York: Springer Verlag. **3.** Zöckler & Lysenko (2000) *Water birds on the edge: first circumpolar assessment of climate change impact on Arctic breeding water birds.* Cambridge, UK: World Conservation Press. **4.** Zöckler (1998) *Patterns in biodiversity in Arctic birds.* Cambridge, UK: WCMC. **5.** Tomkovich *et al.* (2002) *Bird Conserv. Internatn.* 12: 1–18.
ACKNOWLEDGEMENT Figure kindly provided by Christoph Zöckler (United Nations Environment Programme: World Conservation Monitoring Centre, UK).

P. 49: Golden Bowerbird © IAN MONTGOMERY/birdway.com.au
Red-breasted Goose © TONY MARTIN

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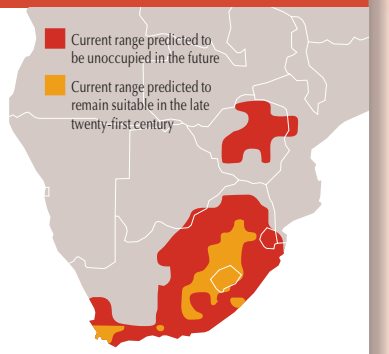
3 In southern Africa, the range of Cape Longclaw is predicted to retreat to upland areas

Cape Longclaw *Macronyx capensis* is endemic to southern Africa, occurring in a variety of grassland habitats from the coast to highlands[1]. Over much of its range it is a fairly common breeding resident. To assess the potential effect of climate change on its distribution, a 'climate envelope' was modelled using the current known distribution of the species and a number of climatic variables. These included a measure of moisture availability and of summer and winter temperature. The resultant model was then applied to a future climate scenario[2] to indicate the future distribution of suitable climate. This shows that towards the end of the twenty-first century the range is predicted to retreat south and contract considerably. Cape Longclaw will become extinct in Botswana and will be largely confined to regions of higher ground in South Africa (see figure). Any management necessary to safeguard the species should be concentrated in those upland areas predicted to remain suitable.



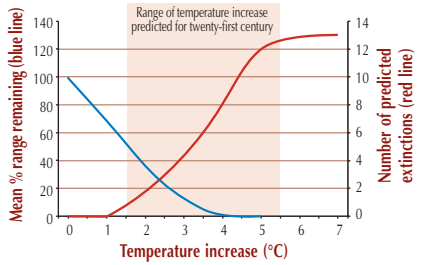
By 2070–2099 the range of Cape Longclaw is predicted to contract considerably

SOURCES 1. Harrison *et al.* (1997) *The atlas of South African birds. Volume 2: the passerines.* Johannesburg: BirdLife South Africa. 2. Gordon *et al.* (2000) *Clim. Dynam.* 16: 147–168. **ACKNOWLEDGEMENTS** Data and figure kindly supplied by Steve Willis, Yvonne Collingham and Brian Huntley (University of Durham, UK), Geoff Hilton (Royal Society for the Protection of Birds, UK), Rhys Green (Royal Society for the Protection of Birds and Conservation Biology Group, University of Cambridge, UK) and Carsten Rahbek (University of Copenhagen, Denmark).

4 The number of montane endemic birds that go extinct in Australia will depend on the degree of warming from climate change

The montane tropical rainforests of north-eastern Australia support 13 endemic bird species. Under global climate change, these forests are expected to shrink considerably. An increase of just 1°C (considered inevitable within the next few decades) will reduce the mean range of endemic birds by over 30%, as suitable climate space retreats to higher altitudes up mountain sides. The reduction will be as much as 96% if temperatures rise 3.5°C. Assuming that the complete loss of a species's suitable range results in its extinction (because there will be no areas of new suitable habitat to disperse to), the number of extinctions will increase dramatically if temperatures rise by more than 2°C, and almost all species will go extinct if temperatures rise by 5.8°C[1] (the upper end of the predicted range of temperature increases[2]; see figure). These results are mirrored for other endemic vertebrates[3], and dramatically illustrate the need for action to ensure that temperature rises do not exceed c.2°C. If they do, the results for biodiversity will be catastrophic.

With larger temperature rises, the percentage of suitable range predicted to remain for 13 endemic birds decreases rapidly to zero (blue) while the number of extinctions increases rapidly (red)[1]



SOURCES 1. S. Williams *in litt.* (2003) 2. Houghton *et al.* (2001) *IPCC third assessment report.* Cambridge, UK: Cambridge University Press. 3. Williams *et al.* (2003) *Proc. Royal Soc. Lond.* B 270:1887–1892. **ACKNOWLEDGEMENT** Data kindly provided by Stephen Williams (James Cook University, Australia).

Climate change will result in many extinctions

Studies suggest that many species will not be able to keep up with their changing climate space. As species move at different rates, the community structure of ecosystems will also become disrupted. Both local and global extinctions are likely, even of species currently considered safe. One recent global study estimated that 15–37% of species could be committed to extinction by 2050 as a consequence of climate change. The most susceptible species will be those with restricted ranges, bounded distributions (on the edges of continents, mountain-tops or small islands), specialised habitat requirements, poor dispersal abilities or small populations. While bird species differ greatly in dispersal abilities, most are relatively mobile compared to other organisms—which will be impacted even more severely.

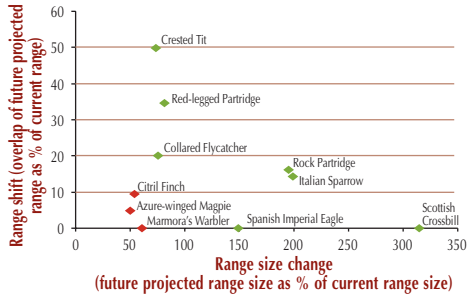
The extent of warming will be critical

The size of the extinction crisis caused by climate change will be directly related to the degree of global warming (**box 4**). A global average temperature rise of 2°C in the next century will lead to numerous extinctions, but leave open some practical management options for the conservation of biodiversity. Temperature rises beyond this level are predicted to lead to catastrophic extinction rates, with few management options and a bleak future for both biodiversity and people.

5 In Europe, species with ranges that both contract and shift are likely to be most at risk

For ten landbirds endemic to Europe, the potential impact of climate change was assessed by modelling their recent (1980s) geographical distribution in terms of three climatic variables. This model was used to simulate their recent ranges, usually with good agreement between the observed and simulated ranges. The model was then used to map the area in which the climate is likely to be suitable for the species in the late twenty-first century under a future climate scenario[1]. The graph shows how well the projected and current modelled ranges match up in overlap (y axis) and extent (x axis). For six species, the area where climate is suitable will decrease (x axis values less than 100). Even where this does not occur, the climate space associated with the species may shift so much that there is little overlap between future and current modelled ranges. For eight species, less than 20% overlap is predicted and for three species there is no predicted overlap at all. Species with low values on either axis might be at risk, but those with low values on both axes—those marked in red on the graph—may be of particular conservation concern.

The percentage overlap and size change of the potential future ranges of ten bird species endemic to Europe, under a climate change scenario



SOURCE 1. Gordon *et al.* (2000) *Clim. Dynam.* 16: 147–168. **ACKNOWLEDGEMENTS** Data and figure kindly supplied by Rhys Green (Royal Society for the Protection of Birds and Conservation Biology Group, University of Cambridge, UK), Yvonne Collingham and Brian Huntley (University of Durham, UK).