# Adapting our lochs to uncertain climate futures: management in the conservation interest.


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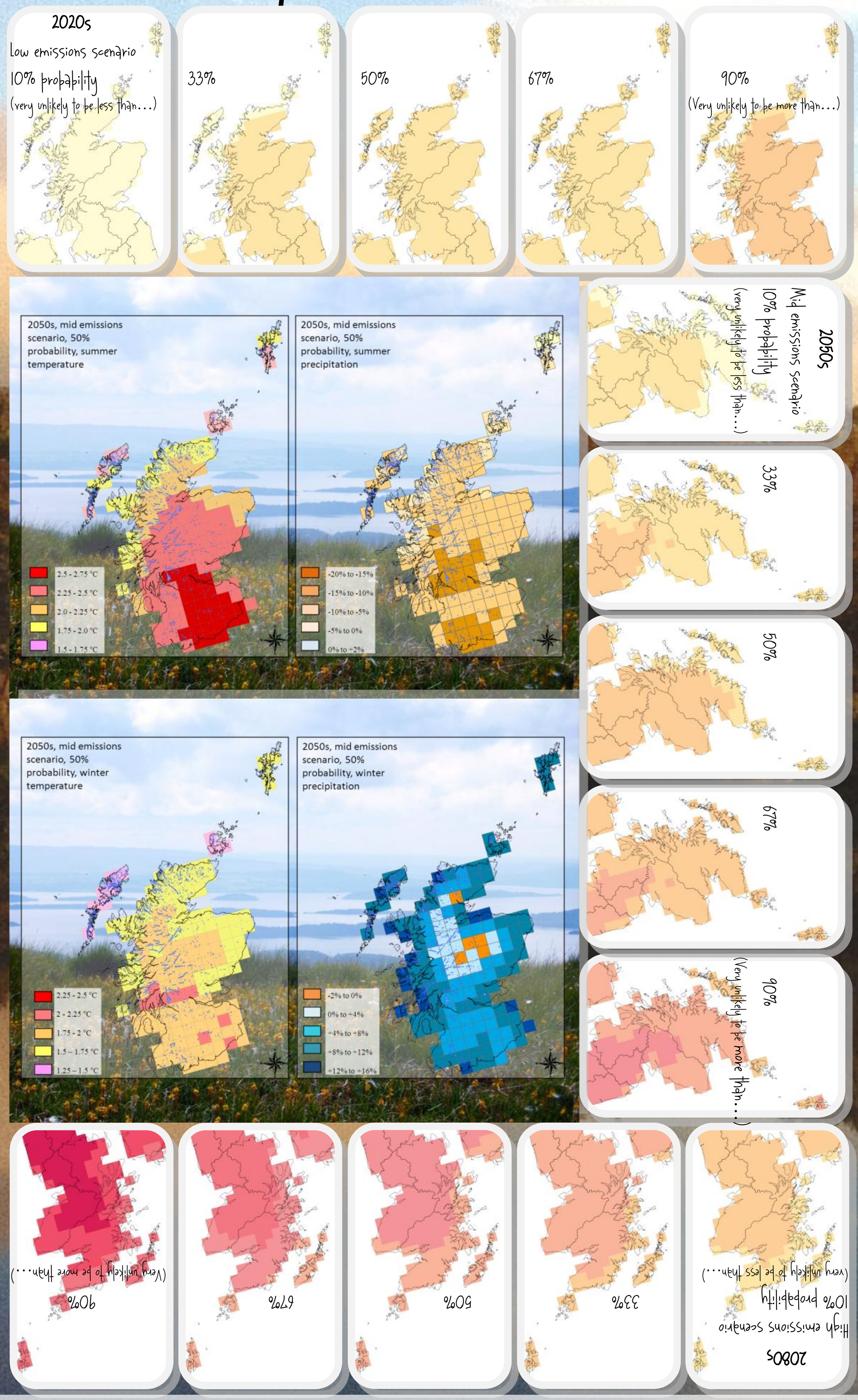
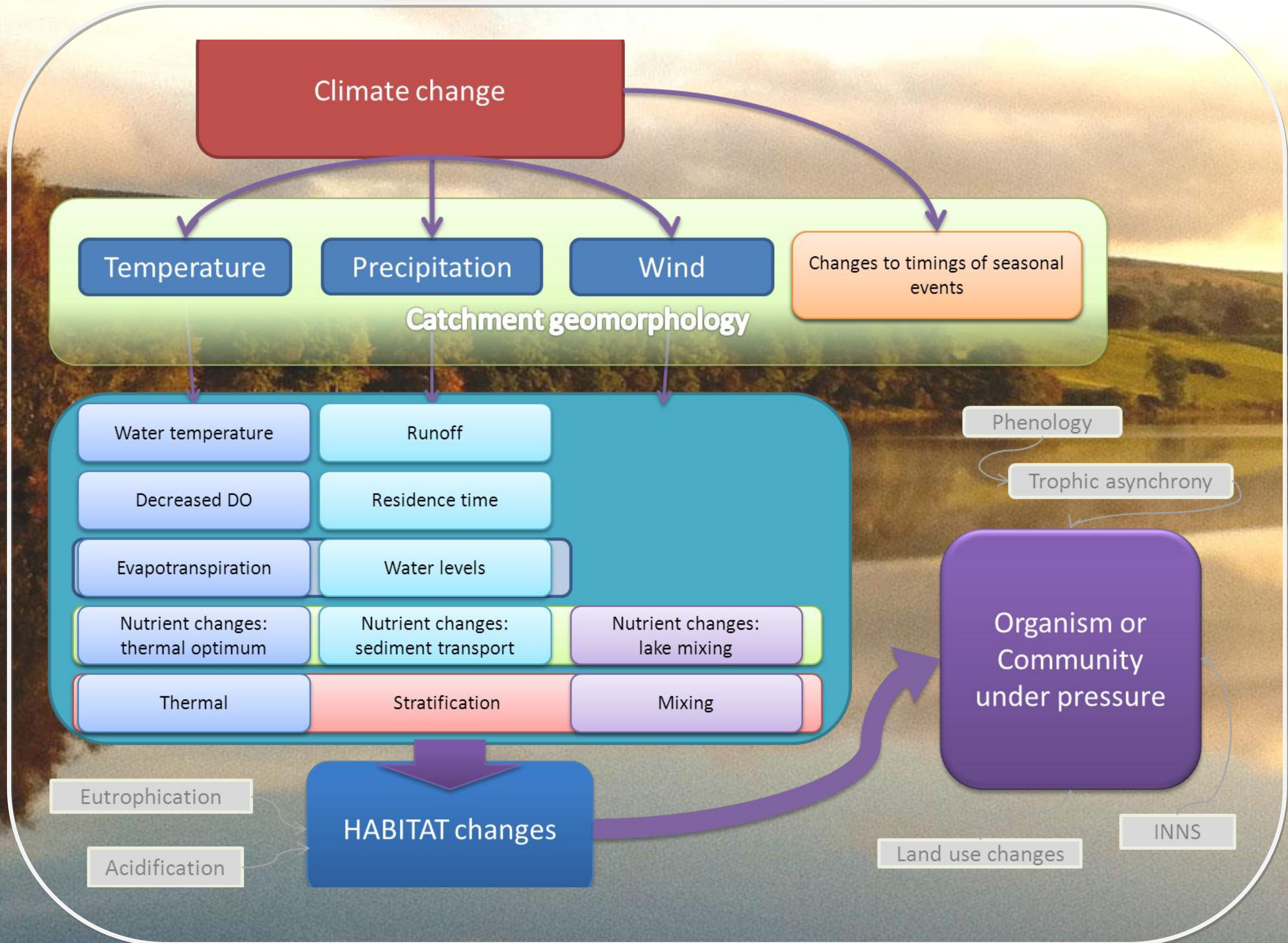
## Climate futures in Scotland




Scotland is a country blessed with outstanding freshwater ecosystems providing multiple social, economic and cultural functions as well as providing ecosystem services of global importance. Scotland's lochs occupy approximately 3% of the country's land mass and contain more than 90% of Great Britain's total freshwater resource. With over 25,000 lochs with areas greater than 0.1hectare standing freshwaters are an iconic part of Scotland's landscape and they come in a myriad of forms and sizes contributing outstanding geodiversity as well as habitats of international importance for numerous species of conservation interest.

There is undoubtedly a need to protect the conservation interests of designated sites in the face of changing loch and catchment pressures – which include diffuse pollutants, morphological modification, recreation and invasive species. Climate change, and uncertainty surrounding projected future scenarios, presents a new set of challenges with potential impacts across the entire standing water resource base.

## What ecohydrological change might we expect?

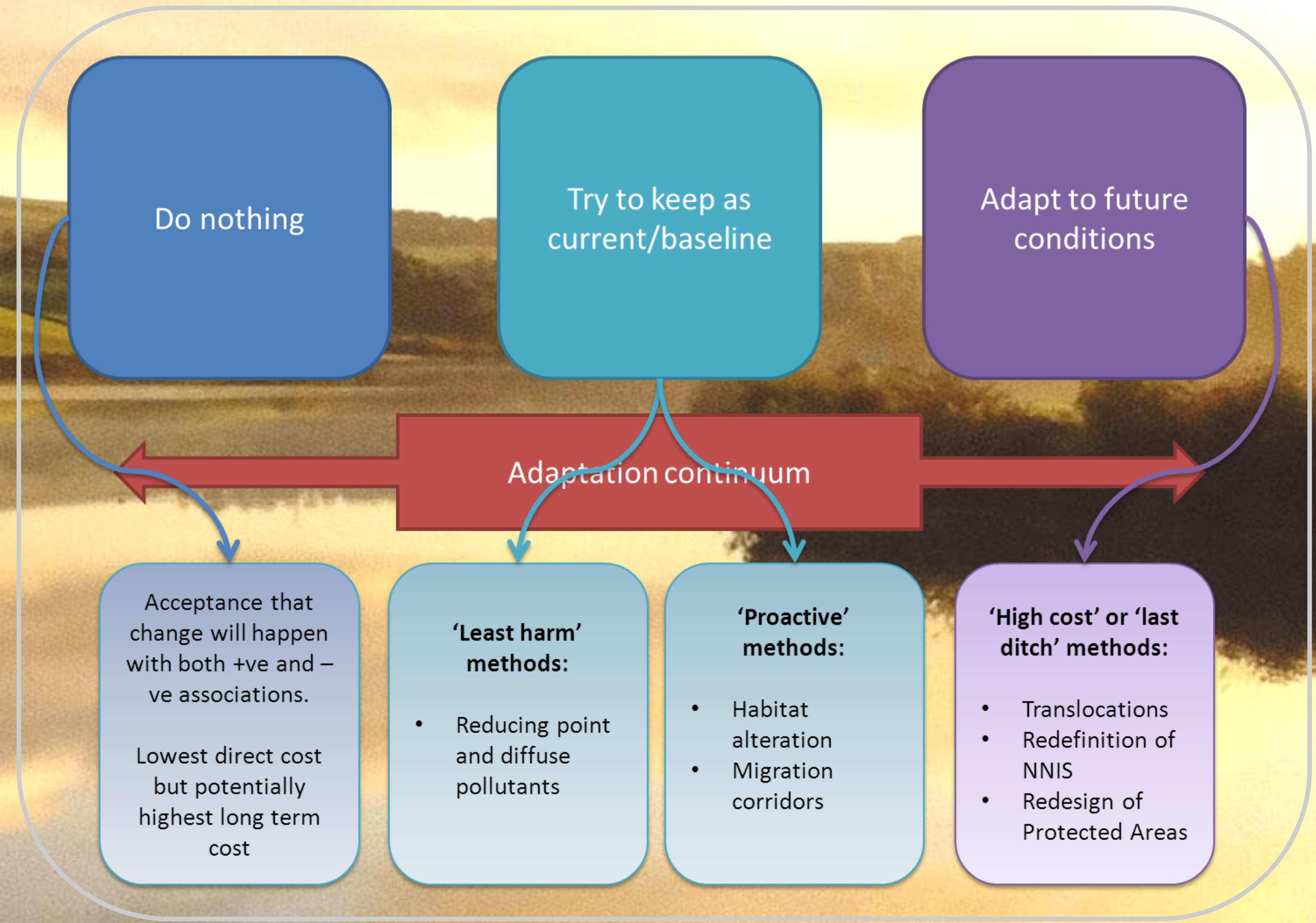



Global climate change is predicted to be a major cause of change across all ecosystems and there are particular concerns about impacts on freshwater systems due to the coupling of impacts to both hydrology and ecology (Bates *et al.*, 2008; Ormerod, 2009; Wilby *et al.*, 2010).

Climate change is likely to affect the hydrological cycle in a number of ways, most significantly through changing temperature and precipitation patterns, intensities and extremes (IPCC, 2007; Bates *et al.*, 2008). These changes, coupled with reduced snow and ice cover, frequency and duration, will lead to changes in soil moisture conditions and subsequently runoff (Bates *et al.*, 2008). This is turn will impact on river flow, loch water levels, epilimnic temperatures, nutrient availability and, subsequently, the ecological structure and function of the entire standing water system (Carvalho and Kirika, 2003; Whitehead *et al.*, 2009; Kernan *et al.*, 2010; Wantzen *et al.*, 2010 ).

Ecological responses are predicted too with a deal of evidence of phenological shifts in relation to earlier season warming potentially leading to trophic asynchrony (Winder and Schindler, 2004; Heino *et al.*, 2009; Dijkstra *et al.*, 2010; Jeppesen *et al.*, 2010; Thackeray *et al.*, 2010). Some species ranges are already documented to be changing, with species 'climate envelopes' (the geographic ranges with conditions suitable for species life) (Dawson *et al.*, 2003) showing latitudinal moves North and altitudinal movement up gradients (Durance and Ormerod, 2007). These changes will have a serious effect on species composition and for those species in Scotland currently at their latitudinal/altitudinal limits could lead to local extinctions.

## What can (or should) we do about it?




Geographically static reserves, species and indeed standing water systems themselves (i.e. those with fixed physical roots or boundaries) are more vulnerable to change than systems where biotic movement is possible. Traditional management practises (reserves) may no longer be sufficient or adequate if habitat conditions change beyond historic ranges or in ways that favour invasives (Dockerty *et al.*, 2003; Brooks *et al.*, 2004). Habitat corridors will become more important to allow native species to move with their climate envelope (Dawson *et al.*, 2003; Hagerman *et al.*, 2010) however these may also function as invasion pathways so there will need to be careful consideration of risks and close monitoring of any new networks.

In the first instance adaptive management of priority areas should to make use of low-regret, evidence based adaptation techniques which are synergistic with reducing other anthropogenic pressures on the catchment – an approach increasingly termed multiple objective management (Ormerod, 2009; Wilby *et al.*, 2010). Managers will be confronted with choices between building resistance or resilience to climate change and whether to be proactive or reactive. If more active 'actionable' (Heller and Zavaleta, 2008) adaptation policies are to be pursued, such as riparian planting to increase shade and reduce water temperatures or the creation of thermal refugia, channel modifications or cool water discharges (Hallegate, 2008, Wilby *et al.*, 2010) these need to done with a great deal of care and the understanding that not all policies will be suitable for all locations. If resilience, rather than adaptability is to be promoted attitudes to what is an acceptable 'standard' ecosystem must be changed (Hopkins *et al.*, 2007, Wilby *et al.*, 2010) and definitions of native and invasive species may also need to be revisited. Further research is needed to inform policy formation and management options surrounding these issues.