Indicators and trends

Monitoring climate change adaptation

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Indicator name				Version
NB4 Proportion of ancient woodlands with declining overall suitability for lichen epiphytes				**31/03/16**

Indicator type:	**Risk/opportunity**	**Impact**	**Action**
	X		

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Natural Environment	N2 Support a healthy and diverse natural environment with capacity to adapt	BD5 Species unable to track changing climate space

At a glance
• There is good evidence that species are shifting their range in response to climate change (Brown et al., 2012). • Lichen epiphytes are diverse, functionally important in ecosystems and used as indicators of environmental health. • Certain lichen epiphytes are associated with Scotland's fragmented but undisturbed 'ancient woodland'. • This restricted distribution makes them excellent indicators for investigating the impact of climate change on species that are unable to easily track changing climatic space (climatically suitable areas).

Latest Figure	Trend
Western region: 41% (1292 sites/3172 sites) **Eastern region: 68% (2124 sites/3133 sites)**	No trend available.

Why is this indicator important?
Scientific (bioclimatic) models (Pearson & Dawson, 2003) have been used to investigate the exposure of species to climate change, i.e. the degree to which suitable bioclimatic conditions may change for a certain region over a given time-period. Bioclimatic models compare a species' known distribution to the present-day 'baseline' climate, to establish a predictive model, and then project the location and extent of suitable climate space using climate change scenarios. A species' exposure can be determined as the degree to which suitable climate space is gained/lost, or the degree to which it shifts spatially, requiring rates of migration to track bioclimatic space. Often bioclimatic models do not include information on species dispersal, and therefore the extent to

which species are actually at risk under a changing climate remains equivocal. In many cases, species dispersal rates are inadequately known and they cannot be included as a reliable component in assessing risk. However, it is generally accepted that climate change poses a particular threat to species which occur in fragmented habitats (Travis, 2003); it is possible that such species may not be able to migrate between isolated habitat patches in order to track their suitable bioclimatic conditions.

One solution in addressing the effect of dispersal-limitation is to focus on species that are indicators of ancient woodlands. Numerous studies have demonstrated that these species share a particular set of traits making them both habitat specialists, and dispersal-limited (Hermy et al, 1999 and Kimberley et al, 2013). As a consequence, they tend to be restricted to ancient woodlands with long ecological continuity (i.e. stable habitat conditions over multiple generations of trees), and have limited colonisation into regenerated woodland, even after 100s years. Given the relatively rapid pace of human-induced climate change (Diffenbaugh & Field, 2013), it is a reasonable assumption that these dispersal limited species represent biodiversity which will struggle to track shifts in suitable climate, via migration between woodland patches in Britain's landscape.

What is happening now?

Bioclimatic modelling has indicated that lichen epiphytes in the continental north-east of Scotland (referred to as the 'eastern region') may be particularly exposed to climate warming, leading to large projected losses of suitable climate space (Fig. 1 and Fig. 2). In contrast, there have been mixed results in the gain/loss of climate space for Scotland's internationally important Atlantic rainforest epiphytic lichens which are found further to the west (referred to as the 'western region'), with species appearing to gain or lose climate space in an unpredictable manner. The magnitude of the shift towards unfavourable bioclimatic conditions also tended to be greater within the eastern region and there was striking local variation with high to low risk sites being mixed in occurrence throughout this region (Fig. 2).

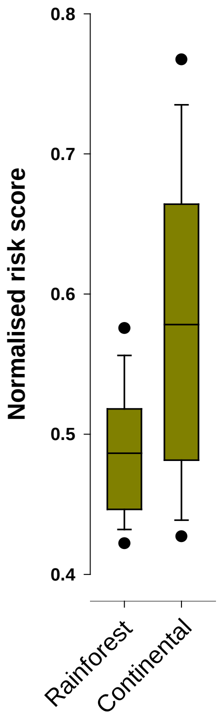

Figure 1. Risk scores for ancient woodland sites combining the change in environmental suitability, and woodland extent. 0 = low risk; 1 = high risk
It can be seen that ancient woodland sites in Scotland's eastern continental region had higher risk scores compared to those in Scotland's western rainforest region.

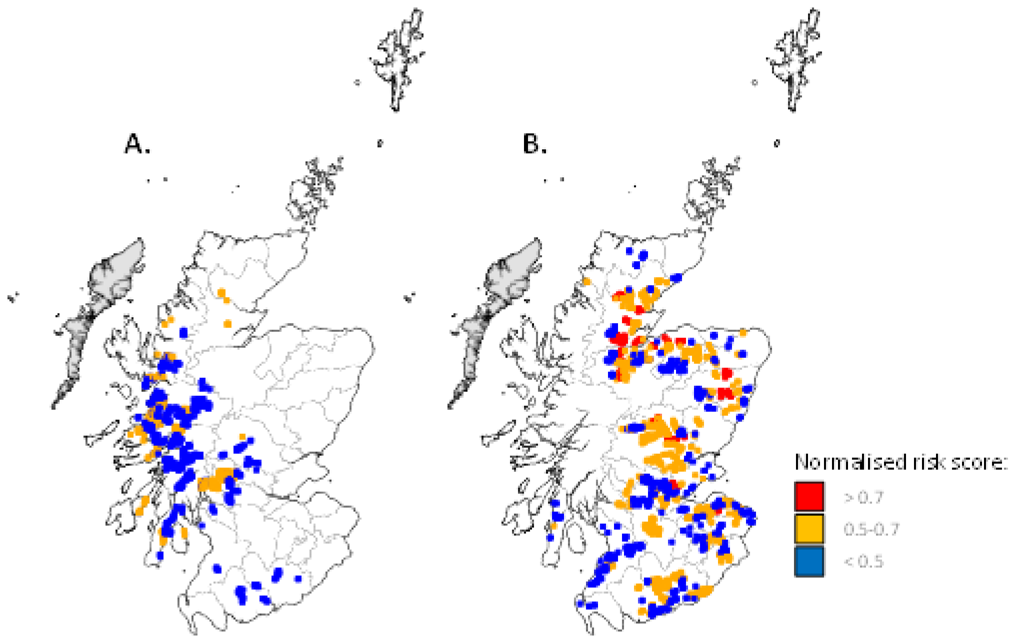

Figure 2. Distribution of the risk posed by climate change for ancient woodland sites in the western (A.) and eastern (B.) regions

What has happened in the past?

N/A

What is projected to happen in the future?
N/A

Patterns of change

See above for trends in eastern and western regions of Scotland.

Interpretation of indicator trends

The vulnerability of ancient woodland lichen epiphytes to climate change is linked to the size (and connectivity) of ancient woodland sites. The number of different microhabitats within sites and the long term continuity of these microhabitats, upon which the survival of ancient woodland epiphytes depends, have been found to increase in larger sites. The size of woodland sites was similar in both eastern and western regions (see Figure 3), as such it is the magnitude of the shift towards unfavourable bioclimatic conditions in the eastern region which drives the higher risk to lichens in this area (see Figure 3).
The considerable local variation in risk levels between sites in the eastern region reflects individual site extent and local climate variability related to Scotland's mountainous topography.

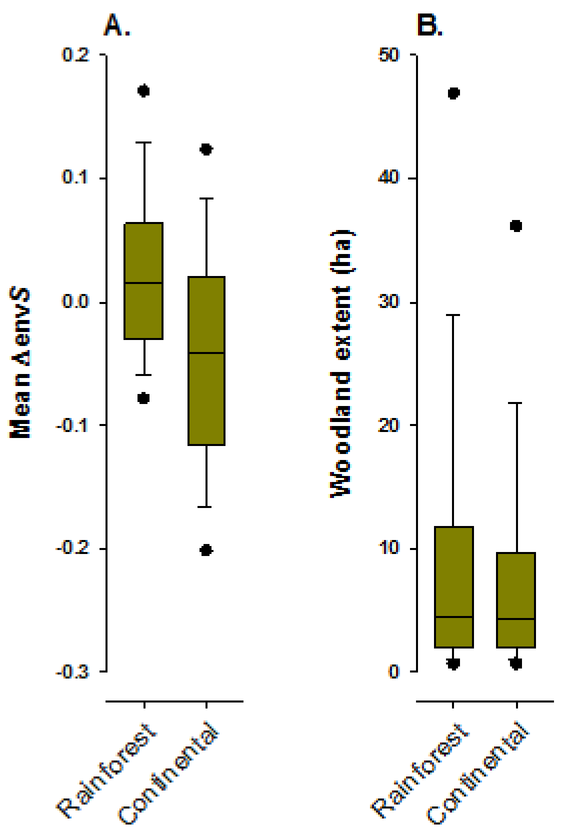

Figure 3. Boxplots for: A. The shift in modelled environmental suitability (baseline v. 2050s) calculated for indicator species within the western and eastern bioclimatic groups; B. Extent of ancient woodlands compared among biogeographic regions.

Limitations
The uncertainty in this indicator is relatively low. The most important factors in this uncertainty are: • Incomplete records of where lichens can be found • Any errors in the Ancient Woodland Inventory mapping • Using climate data that are estimated and/or projected using models

References
Brown, I et al (2012) *UK Climate Change risk Assessment 2012. Climate Change Risk Assessment for the biodiversity and ecosystem services sector*. Defra, London. https://www.gov.uk/government/policies/adapting-to-climate-change (Accessed February 2015) Diffenbaugh, N.S. & Field, C.B. (2013) Changes in ecologically critical terrestrial climate conditions. *Science*, 341: 486-492. Hermy, M., Honnay, O., Firbank, L., Grashof-Bokdam, C. & Lawesson, J.E. (1999) An ecological comparison between ancient and other forest plant species of Europe, and the implications for forest conservation. *Biological Conservation*, 91: 9-22. Kimberley, A., Blackburn, G.A., Whyatt, J.D., Kirby, K. & Smart, S.M. (2013) Identifying the trait syndromes of conservation indicator species: how distinct are British ancient woodland indicator plants from other woodland species? *Applied Vegetation Science*, 16: 667-675. Pearson, R.G. & Dawson, T.P. (2003) Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology & Biogeography*, 12: 361-371. Travis, J.M.J. (2003) Climate change and habitat destruction: a deadly anthropogenic cocktail. *Proceedings of the Royal Society B*, 270: 467-473.

Further information

Acknowledgements
Chris Ellis, Royal Botanic Garden Edinburgh, conducted the analysis underpinning this indicator template.

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	Proportion of ancient woodlands with declining overall suitability for lichens
Indicator contact: Organisation or individual/s responsible for the indicator	Ruth Monfries (Royal Botanic Garden Edinburgh/CXC)
Indicator data source	Chris Ellis (RBGE)
Data link: URL for retrieving the indicator primary indicator data.	N/A

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	Baseline (1961-2006) and projection for 2050s
Frequency of updates: Planned or potential updates	No updates planned. Potential for updating if climate projections or other underpinning knowledge changes.
Spatial coverage: Maximum area for which data is available	Scotland
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	Incomplete distribution records; interpolated and projected modelled climate; potential errors in Ancient Woodland Inventory mapping.
Spatial resolution: Scale/unit for which data is collected	Site level
Categorical resolution: Potential for disaggregation of data into categories	Bioclimatic zones e.g. rainforest zone and Continental zone; by species trait groups
Data accessibility: Restrictions on usage, relevant terms & conditions	Available on request from Chris Ellis, RBGE. Unlicensed. No charge.

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
British Lichen Society (mapping data for bioclimatic modelling).

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Chi-square association analysis and Indicator Species Analysis. Further details available in the Methodology Statement http://www.climatexchange.org.uk/files/1514/0326/9235/Methodology_Statement_ancient_woodland_lichens.pdf