Species' responses to climate change

Implications for resilient biodiversity management

Key messages

There is a strong business case for effective biodiversity management by the private sector. However this is complicated by climate change. It is important to consider climate change impacts on biodiversity to build resilience at all stages of the mitigation hierarchy.

This briefing note highlights species' responses to climate change that require consideration with respect to biodiversity management strategies:

- **Changes in distributions**
    - Species range shifts occur due to climate-driven changes in habitat suitability i.e. the optimal conditions for species survival. Considering these responses at the design phase of a project may prevent developments from impeding these shifts.
- **Changes in behaviour**
    - Climate change modifies the timing of seasonal events such as breeding, feeding and migration. Mitigation measures associated with avoiding or minimising impact through the timing of operations need to consider these changes.

The location and timing of operations may need to alter in response to these changes, creating a need for ongoing biodiversity monitoring and adaptive management throughout the project life cycle. Changes in distributions and behaviour can also lead to changes in local threat status which will need to be considered in biodiversity assessments. While few datasets are available at present on the impacts of climate change on biodiversity and ecosystem services, some datasets exist, such as those described in this briefing note, which may inform adaptive management.

Extractive projects are a driver of growth in other sectors. Given their long life span they are well-positioned to input into landscape-level planning to address cumulative impacts on biodiversity and support the long-term conservation of species under a changing climate.

Climate change considerations for a resilient mitigation hierarchy:

Mitigation hierarchy stage	Climate change considerations
Avoidance	• Can areas where species are vulnerable to climate change be avoided? • Are priority species likely to disappear from or move into selected avoidance and/or operational sites? • Do areas for proposed development impede predicted species range shifts? • Can processes be re-scheduled to avoid impacts on changed seasonal events?
Minimisation	• Is there potential to minimise impediments to species range shifts? • Can processes be re-scheduled to minimise impacts on changed seasonal events? • Can impacts on species threatened by climate change be minimised?
Restoration	• Are there opportunities to restore feeding or nesting resources for species to allow for predicted range shifts? • Can restoration support recovery of species threatened by climate change? • Are restoration methods climate-resilient?
Offsetting	• Are priority species likely to disappear from or change the way they use proposed offset sites? • Do proposed offset sites consider altered feeding or nesting resources? • Can proposed offset sites be selected to protect species threatened by climate change?

Introduction

It is well established that changes in climate pose a significant risk to biodiversity. Impacts may alter the composition of ecosystems, affecting ecosystem function and resilience. At a species level, increased climate variability and more frequent extreme events can lead to changes in distributions and behaviour, and result in changes in threat status.

Furthermore, climate change impacts will compound other stressors such as land use change and habitat degradation. This may result in species range contractions and increased likelihood of extinction.

Climate change is already a consideration in project finance. The International Finance Corporation (IFC) Performance Standard 6, states that:

- "*Both avoidance and habitat restoration are especially important in high carbon forested areas as well as in marine and coastal habitats that are vulnerable to the effects of climate change or which contribute to climate-change mitigation*." GN51.

- "*Other recognised high biodiversity values might also support a critical habitat designation… Examples are as follows: Ecosystems of known special significance to EN or CR species for climate adaptation…*" GN56.

If not addressed, climate change could undermine biodiversity management plans. Failing to address climate change could have potential negative consequences, including disruption to production and services associated with unforeseen biodiversity impacts, and increased operational costs. Climate resilient biodiversity management reduces these risks.

Risks and opportunities for the extractives sector

The extractives industry operates in a wide variety of environments and habitats, including forests, wetlands, polar regions and deserts, which include ecosystems particularly vulnerable to climate change, such as coral reefs, mangroves, and cloud forests.

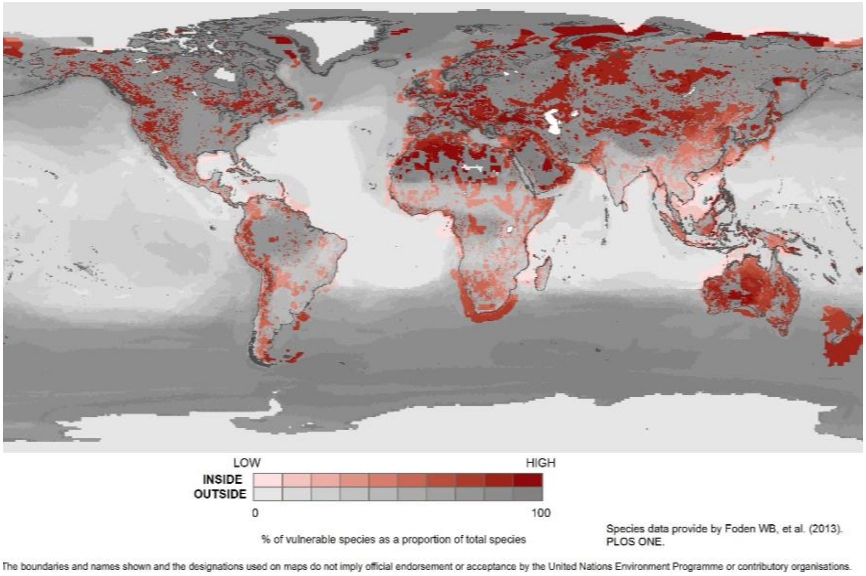


Figure 1. Percentage of amphibian, bird and coral species vulnerable to climate change, as a proportion of all species, within 10km of extractive operations (red) and further than 10km from extractive operations (grey). Species vulnerability data, published in Foden *et al*. 2013, were provided by IUCN.

Extractives operations involve large investments and liabilities throughout a long life cycle, usually at least 30 to 40 years, exposing the industry to changes in the environment over a time period in which climate change effects are predicted to be very significant. Industry impacts within the landscape are also likely to change over this period as a result of climate change.

Extractive projects are a driver of growth in other sectors and given their long life span, are well-positioned to input into landscape-level planning to address cumulative impacts on biodiversity. They hold the potential to be a driver of positive environmental change, supporting long-term conservation of species in a changing climate.

Based on an overlap analysis with oil, gas and mining data from IHS and SNL, 83% of the Earth's surface holds at least one climate change vulnerable species[1], and 14% of this area is within 10km of existing extractive operations (see Figure 1). There is therefore considerable scope for this sector to adopt climate resilient biodiversity management for new and existing operations and drive positive environmental change.

Climate resilient biodiversity management

Climate change has the potential to impair the effectiveness of biodiversity management strategies at all stages of the mitigation hierarchy. There are essentially two types of species responses to climate change which might impact on the success of proposed mitigation measures:

- changes in distributions;
- and changes in behaviour.

Changes in distributions

Climate change has already led to changes in species distributions and this is expected to continue in the future (Parmesan & Yohe, 2003). Elevational and latitudinal shifts occur due to climate driven changes in the location of suitable habitat. They have been recorded for a number of species across various taxa (Loarie et al. 2009), and shifts of up to 115 km have been recorded for a number of bird species over a 20 year period (Maclean et al. 2008).

Climate change can also alter the migratory pathways of species by changing their routes or preventing

[1] Climate change vulnerability is comprised of three dimensions: sensitivity (lack of potential to persist), exposure (extent to which environment will change) and adaptive capacity (ability to avoid impacts of climate change through dispersal and/or micro-evolutionary change; Foden et al. 2013).

migration altogether (Harvell et al. 2009).

These species responses are particularly important for the design phase of a project to ensure that developments do not impede this shift and render a population unviable in the long term. In such cases, mitigation can consider wildlife corridors to minimise these impacts.

Impact mitigation measures in areas identified as important for biodiversity also need to consider any potential shifts in the species of concern. This allows for appropriate selection of avoidance and offsetting sites that account for both current and long-term biodiversity values.

While present restoration efforts tend to focus on returning ecosystems to their prior composition, there is also a need to take account of how species are shifting under climate change to ensure the long term viability of restored areas. For example, by exploring whether restoration can support the recovery of species threatened by climate change, or if there are opportunities to restore nesting or feeding resources for species to allow for predicted range shifts.

It is also important to consider whether restoration methods take account of climate change, for example the use of climate-resilient seedlings, and storm barriers to protect against increasing frequency of extreme events.

Table 1. Changes in habitat suitability of climate change vulnerable amphibian, bird and mammal species in Nimba West protected area, Liberia, as identified by the PARCC project. Please refer to Case Study 1 for further information.

Protected area		Total species	Climate change vulnerable	↑ habitat suitable	↓ habitat suitable	No change
Nimba West	**Amphibians**	55	2	2	0	0
	Birds	394	95	51	24	20
	Mammals	153	15	4	7	4

Examples of how existing impact mitigation measures could consider changes in distribution are provided in Box 1 below.

Case Study 1:

The Protected Areas Resilient to Climate Change (PARCC) project in West Africa aimed to increase the resilience of protected area networks to the impacts of climate change. Trait-based vulnerability assessments identified climate change vulnerable species and distribution models were used to assess potential impacts of climate change on habitat suitability.

Table 1 shows the changes in habitat suitability for climate change vulnerable amphibians, birds and mammals in Nimba West protected area in Liberia. The habitat suitability within this protected area for amphibians and half of birds is predicted to increase under future climate conditions, but will decrease for a number of birds and mammals. This information will be important to consider in spatial avoidance and offsetting strategies.

Changes in behaviour

Climate change is also causing changes in the timing of seasonal events such as breeding, feeding and migration, and can lead to changes in food composition and foraging behaviour. In an assessment of 677 species from six taxa, 71% showed changes in the timing of spring events, such as flowering and migration (Parmesan and Yohe 2003).

Mitigation measures associated with avoiding or minimising impact through the timing of operations will therefore need to take these changes into account. This highlights the need for ongoing biodiversity monitoring and adaptive management throughout the project life cycle to alter the timing of operations in response to these changes.

Examples of how existing impact mitigation measures could consider changes in behaviour are provided in Box 1 below.

Case Study 2:

There have been significant shifts in the egg laying dates of pied flycatchers across parts of Europe (Figure 2). If an operation were based in the orange area of Figure 2, which indicates temperature increases of 4°C in the last 25 years and an associated earlier laying date of pied flycatchers by 5-7 days, the timing of operations would need to adapt

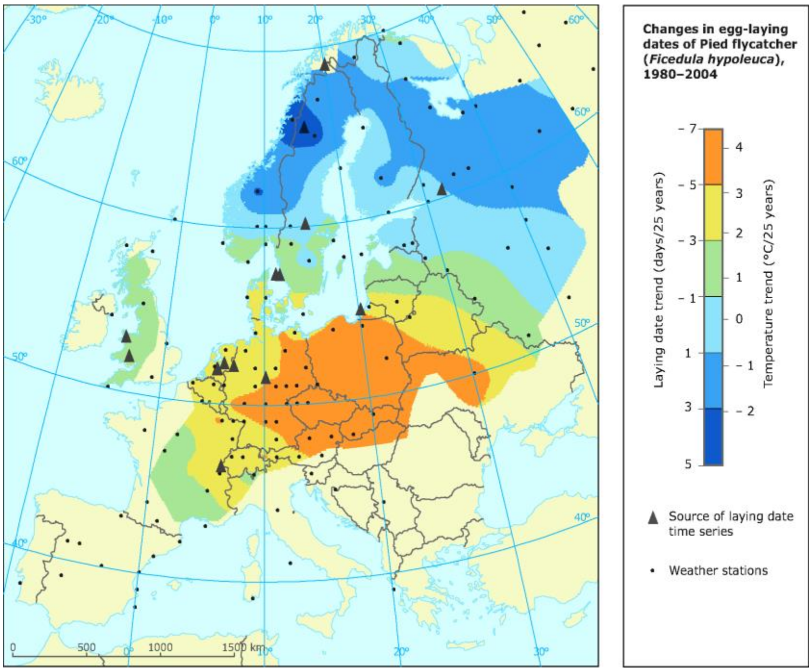


Figure 2. Trend in egg-laying dates of the pied flycatcher across Europe. Orange indicates an increased temperature in the last 25 years and an earlier laying date by 5-7 days. Please refer to Case Study 2 for further information.

accordingly. Timings would also need to be adjusted for blue areas, which indicate temperature decreases and a later laying date (EEA, 2009).

Changes in threat status

Many species are showing an increase in extinction risk as a result of changes in distributions or behaviour due to climate change. This occurs when species are unable to shift to suitable habitat or adapt to the changing conditions.

Changes in threat status will vary according to the severity of predicted changes in climate and according to biological traits, like sensitivity to environmental change or dispersal ability (Foden, et al 2013).

Biodiversity assessments at or close to project sites therefore need to take account of climate change when understanding the local threat status of species. For example, as ranges contract, the threat to species increases as does the relative importance of local species populations. Ignoring possible changes in threat status from the outset may accumulate stakeholder concerns later on when activities are perceived as impacting species that are now unable to adapt to climatic changes.

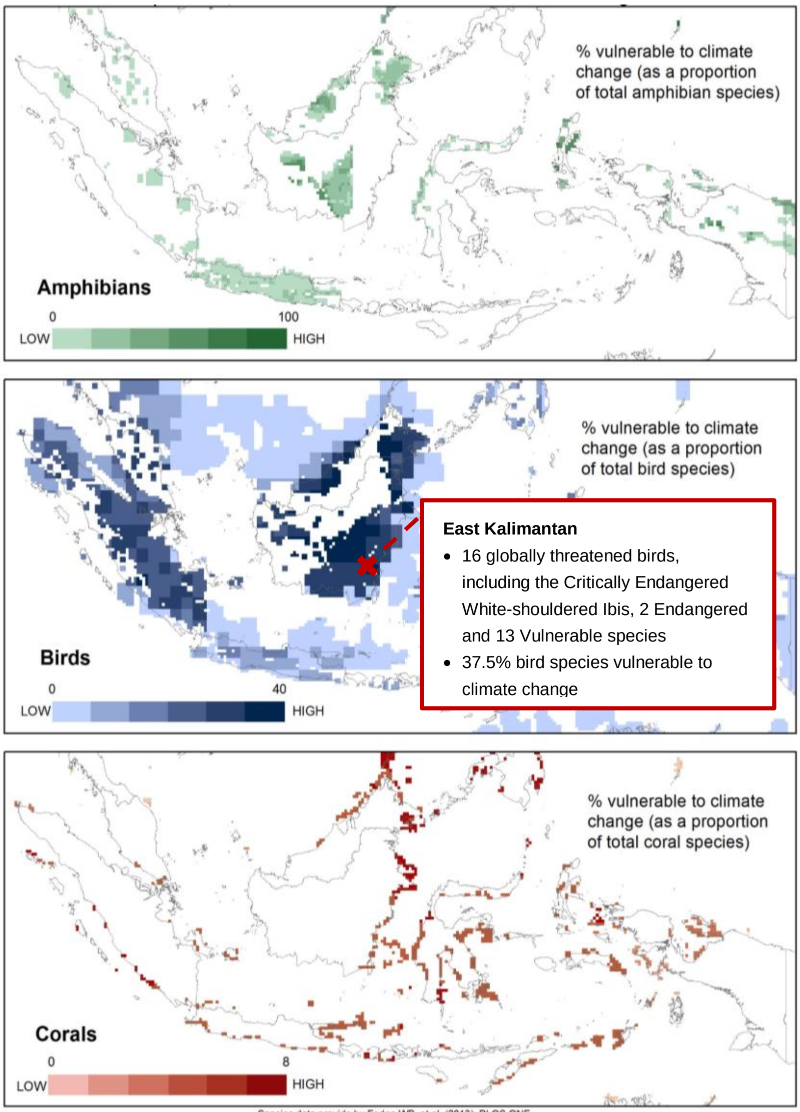
If project development proceeds, avoidance zones and offsets provide an opportunity to safeguard sites for those vulnerable species. It may also be possible to support species recovery or dispersal through restoration activities, depending on the time lag associated with this measure.

Case Study 3:

Figure 3 shows the results of an overlap analysis in Indonesia between extractive activity (based on IHS and SNL spatial data for oil, gas and mining operations) and climate change vulnerable species from Foden *et al.* (2013).

This gives an indication of the degree of impact that climate change may have on biodiversity management strategies within this region for each taxonomic group. In Indonesia, up to 40% of bird species are vulnerable to climate change and also occur within 10km of existing extractives activity.

It also highlights where there may be opportunities to support conservation over longer time frames by providing or protecting the last remaining habitat for species threatened by climate change.



Species data provide by Foden WB, et al. (2013). PLOS ONE.
Valid Contract Blocks, Bidding and Application Blocks data from IHS Energy. Data extracted from the EDIN interface, 14th November 2016.
Global Mining Data from SNL Metals and Mining's Metals Economics Group. Data extracted 14th November 2016.
Boundaries: United Nations Cartographic Section (UNGIWG), 2016.

The boundaries and names shown and the designations used on maps do not imply official endorsement or acceptance by the United Nations Environment Programme or contributory organisations

Figure 3. Percentage of amphibian, bird and coral species vulnerable to climate change, as a proportion of all species, and within 10km of extractives activity. Spatial data on oil and gas, and mining operations were provided by IHS and SNL respectively. Species data, published in Foden *et al*. 2013, were provided by IUCN. Near Threatened and Least Concern species are also available within the Integrated Biodiversity Assessment Tool (IBAT), but are not included in this figure. Please refer to Case Study 3 for further information.

The figure describes species-level information available in an example 20 x 20 km grid cell, using results of the overlap analysis in conjunction with data included in the Integrated Biodiversity Assessment Tool (IBAT). This level of information allows companies to identify species that are globally threatened as well as those that are vulnerable to climate change.

Data challenges and gaps

Data on predicted changes in spatial distribution, behaviour and threat status would be a valuable tool for companies to inform mitigation strategies.

While few datasets are available at present on the impacts of climate change on biodiversity and ecosystem services, those described in this briefing note may inform adaptive management.

Raw global climate data on changes in temperature, precipitation etc. are available, as well as projections using IPCC future climate change scenarios. These are not readily amenable to business use. However if combined with other datasets available via IBAT they could be useful for informing decisions.

Uncertainty in projecting future climate change and identifying risks can be overcome by exploring a range of scenarios, for example business-as-usual or worst case scenarios, to formulate management plans, and by having information on confidence intervals. Data uncertainty may lead to costly impact mitigation, so confidence in the data used is vital.

While data are increasingly available to support climate resilient biodiversity management, there are limitations in availability and accessibility which may prevent uptake by the private sector. Further work and consultation between the private sector and the scientific community is needed to identify and collate relevant datasets, and to improve access to expertise for this purpose.

Examples of climate change considerations

Box 1 provides examples of impact mitigation strategies at different stages of the mitigation hierarchy, and the types of considerations required to account for climatic changes. This table is not comprehensive. Some of the considerations are answerable with existing data, while others require significant further information.

Species responses to climate change need to be considered in every decision across the project development timeline, and particularly in decisions around offsets as these are costly and long-term interventions that need to be resilient to climate change.

It may not be possible to meet conservation objectives for species severely threatened by climate change, and in these cases total avoidance of impacts may be the only viable option.

Box 1. Examples of climate change considerations across the different stages of the mitigation hierarchy. This table presents examples from the Cross Sector Biodiversity Initiative (CSBI, 2015) and a Cambridge Conservation Initiative project on avoidance (CCI, 2015).

Mitigation hierarchy stage	Example	Climate change considerations
Avoidance	**Shell (Sakhalin):** Avoided key rivers for rare migratory salmon, re-routed pipelines to avoid Western Gray Whale populations, and timed construction according to Steller's sea eagle nesting and migration.	• Could Western Gray Whales shift their distributions under future climate scenarios? • Could other important species shift near the development in the future? • Could the timing of Steller sea eagle nesting change? • Could the threat to migratory salmon change?
Minimisation	**Total (Yemen LNG):** Minimised impacts on coral reefs, including coral translocation and in-situ mitigation measures to reduce sedimentation impacts.	• Are proposed coral translocation areas viable under future climate change scenarios? • Could the threat to these coral reefs change?
Restoration	**Eni (Agri River Valley):** Targeted biodiversity action plan for restoration of priority habitats for grazers, largely upland grassland and natural/planted forests.	• Could climate change impact the grasslands or forests? • Are restoration efforts viable under future climate change? • Could grazers feed in different areas in the future due to changing vegetation? • Are the correct species being planted for the climate conditions in the future? • Could the restoration plan address actions to support recovery?
Offsets	**BHP Billiton (Hay Point Coal Terminal):** Developed and implemented the Marine Plant Restoration project as a marine fish habitat offset to compensate for impacts on mangroves and intertidal areas.	• Could future climate change lead to shifts in marine fish habitat and breeding sites that affect offset site selection? • Are the mangroves vulnerable to climate change?

References

Cambridge Conservation Initiative – Collaborative Fund Project Report (2015) Strengthening implementation of the mitigation hierarchy: managing biodiversity risk for conservation gains. Compiled by: BirdLife International, UNEP-WCMC, RSPB, FFI and the University of Cambridge. Link to case studies.

CSBI (2015) A cross-sector guide for implementing the mitigation hierarchy. Prepared by the Biodiversity Consultancy on behalf of IPIECA, ICMM and the Equator Principles Association: Cambridge UK.

European Environment Agency (2009) Trend in egg-laying dates of the Pied flycatcher across Europe. Link.

Foden, W.B. et al. (2013) Identifying the World's Most Climate Change Vulnerable Species: A Systematic Trait-Based Assessment of all Birds, Amphibians and Corals. PLoS ONE, 8, e65427.

Harvell, D. et al. (2009) Climate change and wildlife diseases: when does the host matter the most? Ecology, 90, 912-920.

Loarie, S.R. et al. (2009) The velocity of climate change. Nature, 462, 1052-1055.

Maclean, I. et al (2008) Climate change causes rapid changes in the distribution and site abundance of birds in winter. Global Change Biology, 14, 2489-2500.

Parmesan, C & Yohe, G (2003) A globally coherent fingerprint of climate change impacts across natural systems. Nature, 421, 37-42.

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