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|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| <p>Climate change</p> <p><b>Anthropogenic causes of climate change</b></p>               | <p>Climate change</p> <p><b>Five positive feedback cycles in global warming</b></p> |
| <p>Climate change</p> <p><b>How does loss of snow and ice cause further warming?</b></p> | <p>Climate change</p> <p><b>Legacy carbon</b></p>                                   |
| <p>Climate change</p> <p><b>Why could boreal forests become a net carbon source?</b></p> | <p>Climate change</p> <p><b>Threat to emperor penguins</b></p>                      |
| <p>Climate change</p> <p><b>Threat to walruses</b></p>                                   | <p>Climate change</p> <p><b>Effect of warmer surface water on upwelling</b></p>     |

CO<sub>2</sub> from deep ocean; loss of reflective ice; decomposition of peat and permafrost; methane from permafrost; droughts and forest fires.

Human increases in atmospheric CO<sub>2</sub> (fossil fuels, deforestation) and methane (livestock, rice fields, landfill).

Old organic carbon in deep boreal forest soils that survived earlier fires; burned by more intense fires.

Darker land and sea absorb more solar radiation than reflective ice.

Early breakout of landfast ice before chicks fledge destroys breeding grounds.

Warmer, less snowy winters cause drought, lower primary production, forest browning and more intense fires.

Prevents nutrient upwelling, decreasing ocean primary production and energy flow through marine food chains.

Loss of Arctic sea ice used for resting and nursing between feeding dives.

Climate change

## **Ocean acidification and corals**

Climate change

## **Coral bleaching**

Climate change

## **Upslope range shift example**

Climate change

## **Range shifts in North American trees**

Climate change

## **Why are mountain-top species at risk?**

Climate change

## **Three approaches to carbon sequestration**

Climate change

## **Why does peat store carbon?**

Climate change

## **The debate over tree planting for carbon**

Higher water temperature makes corals expel symbiotic algae; prolonged bleaching kills corals and the reef ecosystem collapses.

More dissolved CO<sub>2</sub> lowers pH and carbonate availability, suppressing calcification.

Range contraction at the warm southern edge and northward spread at the cool edge.

Tropical-zone montane bird species in New Guinea now live higher up mountains.

Afforestation, forest regeneration, restoration of peat-forming wetlands.

As ranges shift upslope they have nowhere higher to move.

Non-native plantations absorb CO<sub>2</sub> fast but have low biodiversity; native rewilding is more biodiverse and resilient.

Waterlogged soil is anaerobic, so dead plant matter decomposes very slowly and accumulates.

Climate change **HL only**

## Phenology

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## Two variables that cue phenological events

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## Chickweed and reindeer mismatch

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## Spruce bark beetle and climate change

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## Tawny owl colour variants and climate change

Photoperiod and temperature patterns.

Research into the timing of biological events, e.g. flowering, budburst, bud set, migration, nesting.

Warming allows two or more generations a year instead of one, causing outbreaks that kill spruce.

Chickweed growth is cued by temperature and now earlier; reindeer arrive by photoperiod, so calves miss peak food.

With less snow cover, brown owls' fitness has risen relative to grey owls, so brown has become more common.