Ecosystem Loss and its Implications for Greenhouse Gas Concentration Stabilisation

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The UNFCCC Objective

- Says that atmospheric concentrations should be stabilised at a level the would "prevent dangerous anthropogenic interference with the climate system".
- However, defining "dangerous interference" has proved hard and "political".
- Second sentence of the objective says that "such a [concentration stabilisation] level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change …".
- Evidence of impacts of climate change upon both ecosystems and species is fairly clear-cut. Likely to be less prone to subjective judgement than defining "dangerous".

Species responses

- A host of evidence shows a very strong correlation between changes in species behaviour and climate change.
- Recent meta-analyses by Parmesan and Yohe and by Root *et al* tested whether a coherent pattern of species/climate change correlations exists.
- First study covering 587 species showed significant changes: 82% had shifted in the direction expected if they were climate change-induced, i.e. towards higher latitudes or altitudes, or earlier spring events.
- Second analysis of more than 1,700 species had similar results: 87% of shifts in phenology and 81% of range shifts were in the direction expected from climate change.

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Does this matter?

- Simply because species are affected by climate change does not mean that the effects will be adverse.
- A particular concern is climate change-induced alteration of species ranges.
- Species are threatened when their"climate space" moves to an area where they are unable to go or that is fundamentally unsuitable.
- Ecosystem loss is likely because species will not all move to the same extent or at the same rate as their climate space changes.

Ecosystem loss

- An ecosystem is an assemblage of species, some are near the edges of their ranges, others that are not.
- Those at their range edges will tend to move as their climate space changes, those nearer their range centres need not.
- This differential movement will be exaggerated by opportunistic, robust species moving more rapidly and faring better when they do.
- Also, movement may be impeded by habitat fragmentation or differences in the underlying geology of the area across which species move.
- The composition of ecosystems, and hence the ecosystems themselves, will thus change with climate.

Ecosystem change: an example

- Because species do not act in isolation, changes in one particular species or group of species can affect many others, often in unpredictable ways.
- For example, seabirds on the North Sea coast of Britain suffered a large-scale breeding failure in 2004. In Shetland, Orkney and Fair Isle, tens of thousands of seabirds failed to raise any young.
- Most likely cause is loss of food: sandeels.
- Sandeel numbers have crashed.
- Plankton regime has changed.

Ecosystem change in the Northeast Atlantic: birds

- In 2004, the total Shetland population of nearly 7000 pairs of great skuas produced only a handful of chicks, and the 1000 or more pairs of arctic skuas none at all.
- Shetland's 24,000 pairs of arctic terns and more than 16,000 pairs of kittiwakes have also probably suffered near total breeding failure.
- Similar failures occurred in other seabird colonies.
- Strongly indicates a widespread food shortage, especially of sandeels, a small fish, the staple diet of many UK seabirds.

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Ecosystem change in the Northeast Atlantic: fish

- The Danish sandeel fishery, accounts for about 90% of the North Sea catch.
- Recently, the fishery has had quotas of 800,000 to 900,000 tonnes, of which 600,000 to 700,000 tonnes taken.
- In 2003, they caught only 300,000 tonnes. This year's catch is apparently similar.
- This does not appear to result solely from overfishing, in at least some of areas where sea birds' breeding failures have occurred.
- Shetland has operated a seabird-friendly sandeel fishing regime for several years. In 2004, the waters south of Shetland were closed to sandeel fishing and a reduced 'Total Allowable Catch' was introduced to the north.

Ecosystem change in the Northeast Atlantic: fish

- However, sea surface temperatures in the North Sea in 2003 and 2004 were significantly higher than the 30-year (1961 to 1990) average.
- Research into sandeels in the North Sea indicates that their numbers are inversely proportional to sea temperature during the egg and larval stages.
- There is further evidence that sandeel numbers are linked to plankton abundance around the time of egg hatching, which we come to in a moment.
- The study also indicated that the adverse effect of rising sea temperatures is most marked in the southern North Sea where the lesser sandeel is near the southern limit of its range.

Ecosystem change in the Northeast Atlantic: plankton

- Research over more than four decades, has identified a "regime shift" in the plankton composition of the North Sea since about 1986, caused by an increased influx of warm Atlantic water.
- Indeed, across the entire the Northeast Atlantic sea surface temperature change is accompanied by increased phytoplankton abundance in cooler regions and decreased abundance in warmer regions.
- The researchers conclude: "Future warming is likely to alter the spatial distribution of primary and secondary pelagic production, affecting ecosystem services and placing additional stress on already-depleted fish and mammal populations".

Ecosystem change in the Northeast Atlantic: summary

- It appears that a major ecosystem change is occurring in the North Sea, in which climate change plays a major role.
- The base of the food chain, the plankton populations, have certainly changed, almost certainly as a result of climate change.
- Sandeel numbers have declined and a change in sea temperature coupled with a change in the plankton population (also induced by temperature change) seems a very likely explanation.
- Sea bird breeding success was certainly low in 2004, most probably due to the fall in sandeel numbers.

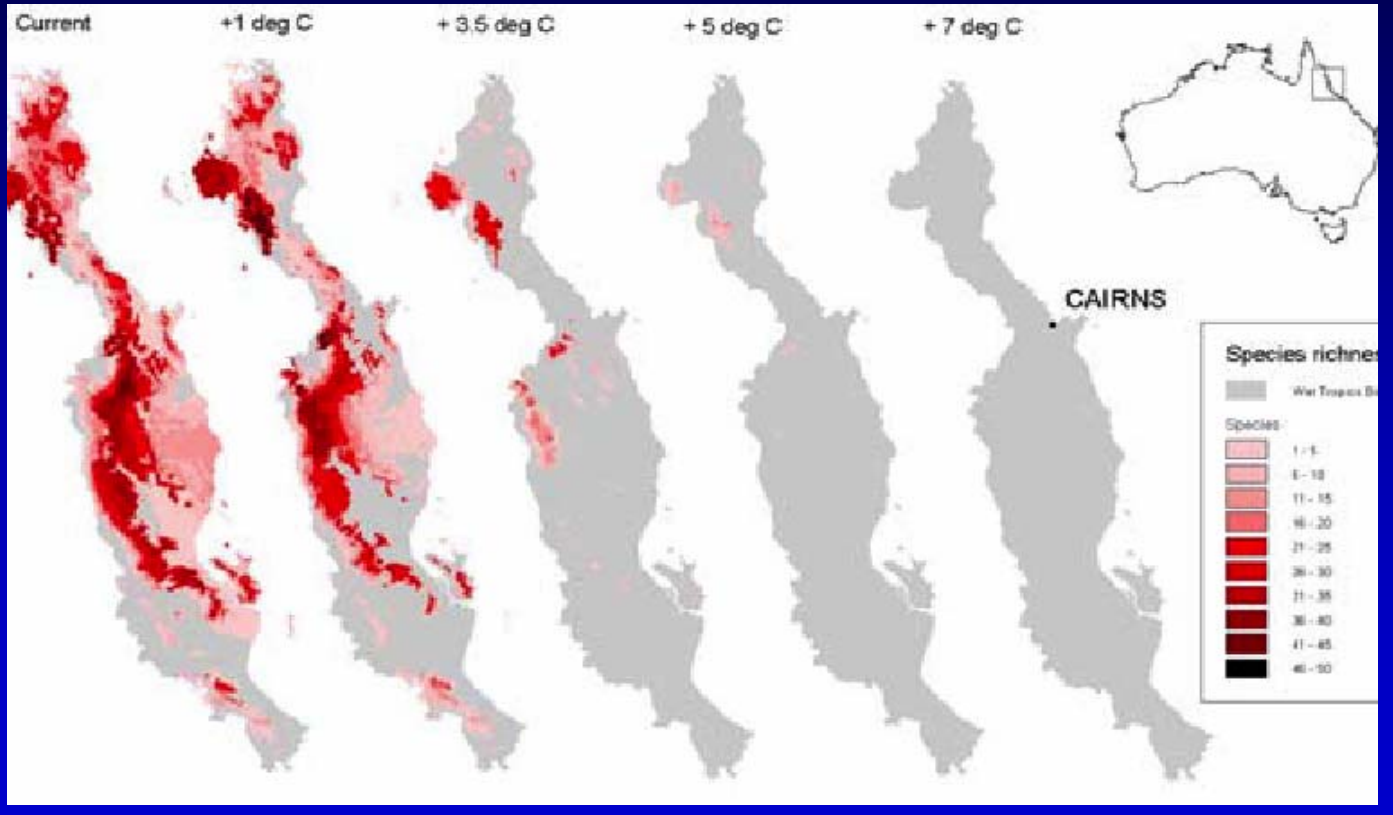
Forecast species and ecosystem change

- Many workers have modelled species responses to future climate change.
- Such models typically work on the basis of defining the "climate space" for particular species and then employing climate models to forecast where that space will be in the future.
- Whilst species will not necessarily move to fill their future climate space, the models give a good picture of possible future movement and hence of where movement might be difficult, for example where the climate space for a land-based species moves entirely to a marine area.

A modelled example

- Williams *et al* conducted a study of the Australian Wet Tropics World Heritage Area.
- They assessed the effects of increases in temperature of between 1°C and 7°C on species distribution.
- Estimates were made of the change in the core range of each species under different climate scenarios.
- Models for 62 endemic montane species indicated that
  1°C warming results in 40% loss of potential core range,
  3.5°C warming a 90% loss,
  5°C warming a 97% loss.
  7°C results in the loss of all potential core range
  for all species.

Endemic montane vertebrates in northern Queensland wet tropics



Conclusions

- There is substantial and compelling evidence that the degree of climate change which has already occurred has affected both species and ecosystems, in many cases adversely.
- Indeed, there is evidence that at least one species has become extinct due to climate change: the golden toad of Costa Rica.
- It appears very likely that species will increasingly become extinct and ecosystems will be lost with little further change in the climate.
- In terms of the ultimate objective of the Climate Change Convention, it can thus be reasonably argued that some ecosystems are not "adapting naturally" to climate change and that atmospheric concentrations of greenhouse gases are already too high.

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Recommendations

- Given that further climate change will inevitably occur, a realistic aim would be to keep mean global temperature rise to less than 2°Celsius above pre-industrial levels.
- The concentration stabilisation level corresponding to this goal is debatable, in light of increasing indications that climate sensitivities are higher than previously thought.
- It would seem advisable to keep atmospheric concentrations of greenhouse gases at less than 450ppmv.