Applied Evolutionary Ecology Part 6: Ecological and Evolutionary Responses to Recent Climate Change II

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Biol 417: Evolutionary Ecology

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Review

Last lecture we revisited the concept that large, fast change is always maladaptive and CC is both large and fast and breaks the association between species' niches and their local climate.

Our focus was on adaptations that allowed species to respond *in situ* by adjusting the **timing** of their phenologies to become better matched to novel conditions.

... but no two species are likely to respond to CC in the same way and at the same rate and community-level asynchrony is an important threat to species' survival.

Today we will focus on how species track their shifting ecological niches in **space**.

Range Shifts

Range Shifts

Globally, species have been shifting their geographic range to track their bioclimatic niche in space.

E.g.: The northward expansion of the red fox (*Vulpes vulpes*) range and simultaneous retreat of the Arctic fox (*Alopex lagopus*).

Source: Canadian Geographic

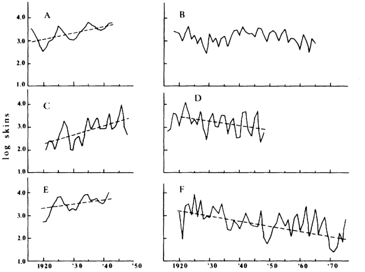


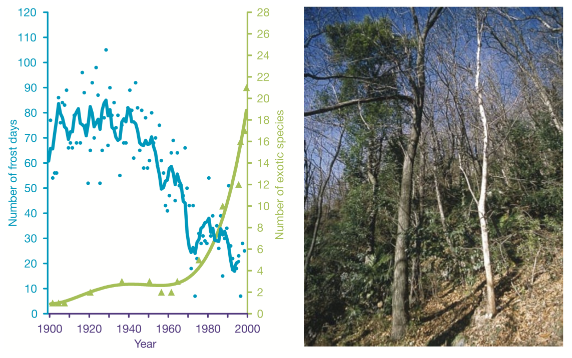
Fig. 7. Diagrams of the number ($\log_{10}$) of foxes traded in three different areas of Canada: A) red fox and B) arctic fox in NWT; C) red fox and D) arctic fox in Ungava; E) red fox and F) arctic fox in Manitoba.

(Hersteinsson & Macdonald, 1992)

Range Shifts

Globally, species have been shifting their geographic range to track their bioclimatic niche in space.

E.g.: Vegetation shift from indigenous deciduous to exotic evergreen broad-leaved in southern Switzerland.

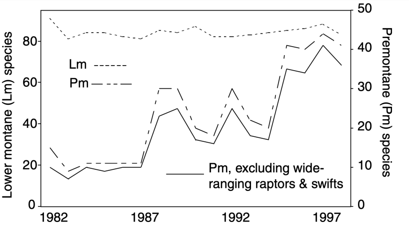


(Walther *et al.*, 2002)

Range Shifts

Globally, species have been shifting their geographic range to track their bioclimatic niche in space.

E.g.: Lowland bird species in Costa Rica expanded their distribution from lower mountain slopes to higher areas.



(Pounds *et al.*, 1999)

Global Range Shifts

Parmesan & Yohe (2003) reviewed data on the distributions and phenologies of 1598 globally distributed species over the past 20-140 years.

They found that, in the Northern Hemisphere, boundaries increased by 6.1km per decade northward on average.

Range shifts represent one of the most immediate responses as they do not require any adaptive response.

Note: This trend also prevalent in the fossil record and not unique to human induced CC (Fernández & Peláez Campomanes, 2005).

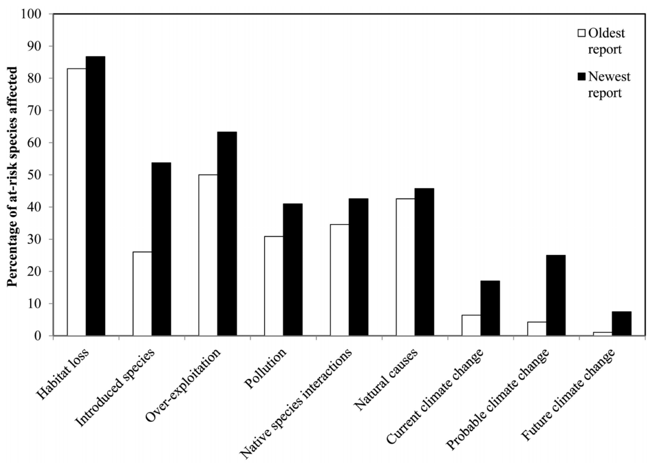
Scope of Climate Change as a Threat

The IUCN (2007) recognises six major threats to biodiversity: habitat degradation, over-exploitation, pollution, disease, introduced species, and climate change.

Woo-Durand *et al.* (2020) reviewed COSEWIC reports to identify the relative importance of these threats to Canadian species.

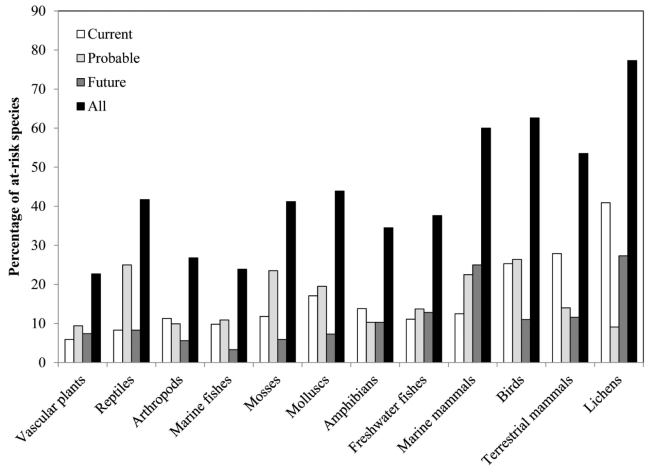
Expectations?

CC is the least prevalent



Woo-Durand *et al.* (2020)

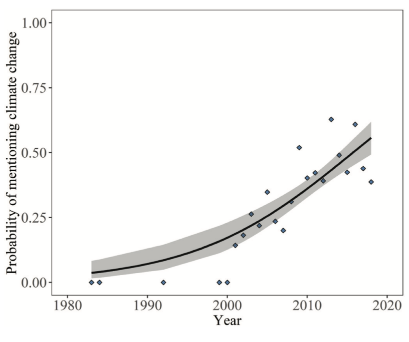
...but differs between taxa.



Woo-Durand *et al.* (2020)

Climate change is not currently the most universal threat, but its prevalence is increasing.

The probability of CC being mentioned as a threat to Canadian species increased over time from 0% in the late 1990s to about 55.6% by 2020.



Woo-Durand *et al.* (2020)

Climate Change & Compounding Effects

Compounding effects

Species are responding to CC and rapid rates of natural climate change are not unprecedented in the paleo record (Dansgaard *et al.*, 1993)

... but species are threatened by other numerous factors (habitat loss, fragmentation, loss of ecosystem biodiversity, pollution, over harvesting, etc...), impacting their capacity to respond to CC.

The interactions between pressures from multiple sources of Human-Induced Rapid Environmental Change (HIREC) can be more important than any single threat on its own (Sih *et al.*, 2011)

... and ecological responses are typically non-linear with disproportionately severe 'tipping points' (Doak & Morris, 2010).

Ethiopian wolves (*Canis simensis*) live in the high altitude plateaus of the Ethiopian Highlands.

Source: Wikipedia

Threatened by farming induced habitat loss, persecution, and disease (distemper; Gottelli & Sillero-Zubiri, 1992).

Source: Wikipedia

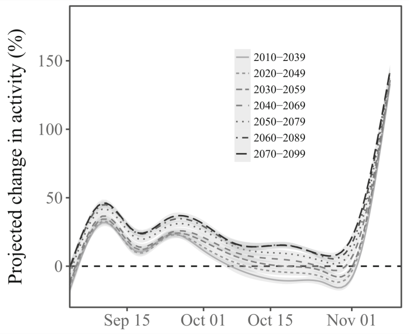
Climate change?

Ethiopian wolves cont.

CC has been allowing for farming to encroach into higher altitudes, exacerbating other threats and leaving the wolves nowhere to go.

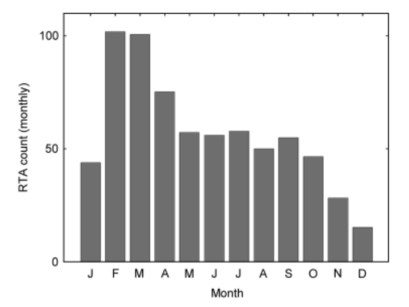
Source: Wikipedia

Models suggest that CC will result in an increase in activity in European badgers.



(Noonan *et al.*, 2018)

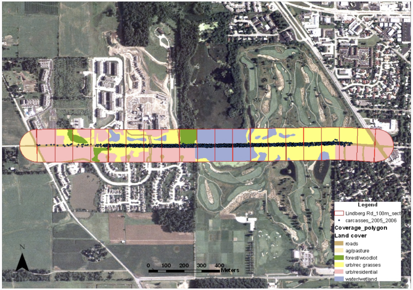
Badger road-mortalities are tightly linked to weather patterns, so the increased activity will likely lead to more road-killed animals (Macdonald *et al.*, 2010).



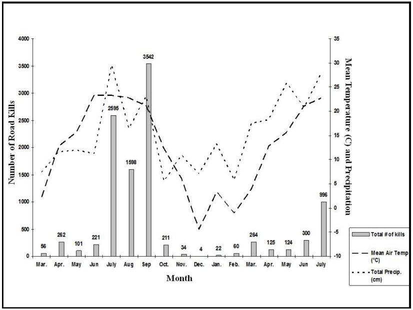
(Macdonald *et al.*, 2010)

Temperature roadkills

Glista & DeVault (2008) analysed records on >10,000 road mortalities and found that temperature was the primary predictor of roadkill rates.



(Glista & DeVault, 2008)



(Glista & DeVault, 2008)

Population monitoring

Climate change is ‘noisy’ and responses to climate change can be just as noisy (over short timescales extreme events can obscure trends).

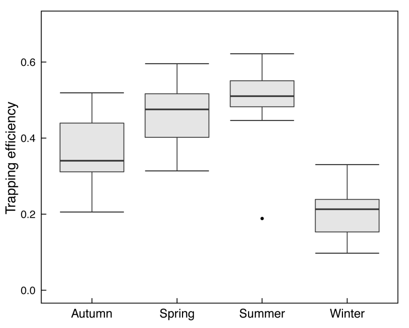
Our job is to cut through this noise by carefully monitor populations.

The ability to trap, observe, or photograph and to recapture study individuals consistently and reliably is central to accurate population monitoring.

... but we know that individuals adjust their behaviour in response to climate change and only $\frac{1}{5}$ of ecological studies account for imperfect detection (Kellner & Swihart, 2014).

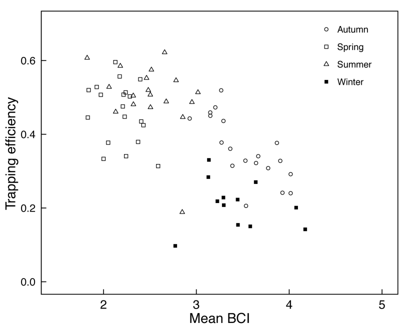
Population monitoring cont.

Weather generates a ∼10% difference in badger trapping efficiency.



(Noonan *et al.*, 2015)

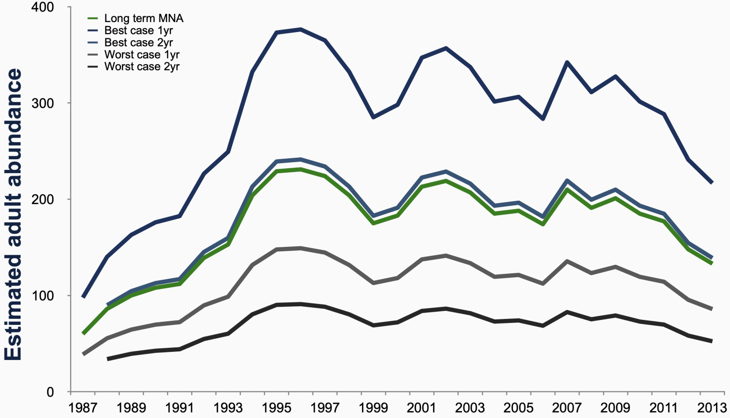
Individuals adjust their risk taking behaviour based on their body condition.



(Noonan *et al.*, 2015)

Population monitoring cont.

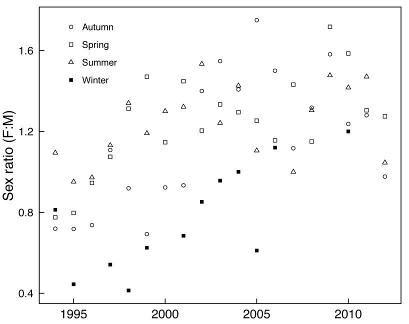
Without accounting for imperfect detection, short term population monitoring can be highly skewed.



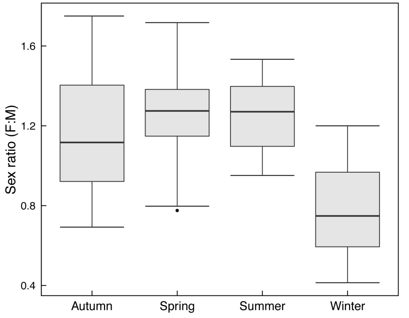
(Noonan *et al.*, 2015)

Population monitoring cont.

Differences in behaviour between ages, sexes, etc... can also skew estimates of demographic structure.



(Noonan *et al.*, 2015)



(Noonan *et al.*, 2015)

CC Take Homes

Species have well-defined niches that have been shaped by interactions between individuals and their environment over generations.

Range shifts are one of the most immediately accessible responses and have been documented in the majority of taxa.

CC is presently not the most important threat to spp. survival but it risks compounding other threats and tipping points can have dramatic outcomes.

Properly assessing responses to CC necessarily requires long-term monitoring to parse the signal from the noise.

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