Collaboration for Environmental Evidence

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Plain Language Summary
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Systematic Review
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Changes in species distributions in response to climate change are highly variable

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Average range shift rates for many taxa demonstrate significant movement to higher elevations and latitudes as expected with a warming climate, yet most species are not shifting in the expected directions. Shift rates and directions differ across range shift dimensions (i.e., latitude, elevation, and depth), range positions, and taxonomic groups. Despite growing evidence that species are shifting their ranges in response to climate change, substantial variation exists in the extent to which empirical observations confirm general expectations.

Why is this Evidence Synthesis Needed?

Geographic range shifts are among the most widely predicted climate change-related impacts on biodiversity. These involve species shifting their spatial distribution to track their preferred climate. Species range shifts have the potential to restructure ecosystems, with implications for biodiversity conservation, ecosystem functioning, economic development, and human health and well-being. Common hypotheses have emerged in the scientific literature suggesting species are expected to shift their distributions to higher latitudes, greater elevations, and (for aquatic species) deeper depths in response to rising temperatures associated with climate change. However, many species are not shifting at all or are shifting in the opposite direction than expected. We reviewed studies evaluating the impact of anthropogenic climate change (specifically, changes in temperature and precipitation) on species' ranges by looking at the direction and rate of species movements over time, and assessed whether expected range shifts are supported by the body of empirical evidence.

This systematic review examines whether the rate and direction of species' range shifts supports common hypotheses about how species will move in response to climate change. The review summarizes evidence from 315 studies of over 12,000 species.

Main Findings

What studies are included?

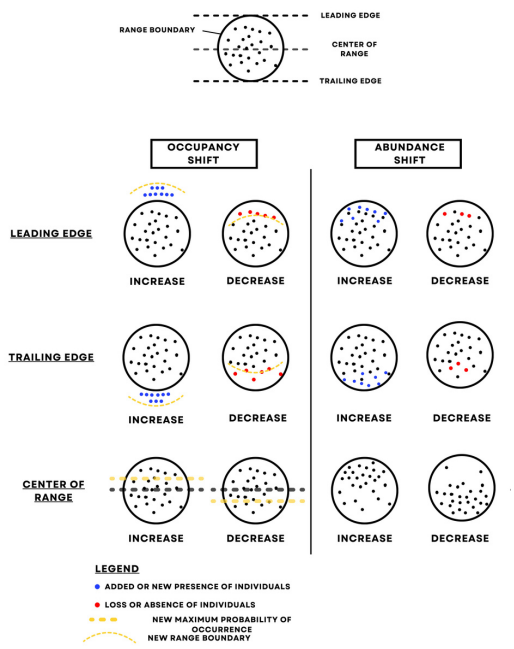
This review includes studies that looked for plant or animal species range shifts in response to temperature or precipitation changes. A total of 315 studies published before 2021 provided sufficient evidence to be included in our review. Study duration ranged from 10 to 211 years. From these studies, we obtained over 32,000 range shift observations from over 12,000 species. Although studies are included from all over the world, the majority were conducted in North America and Europe.

Are commonly expected species range shifts supported by the evidence?

Less than half of all range-shift observations documented[2] shifts towards higher latitudes, higher elevations, or greater marine depths (each assessed separately), demonstrating significant variability in the empirical evidence for general range shift expectations. For the subset of studies looking at range shift rates (n=203), we find that species demonstrated statistically significant average shifts towards higher latitudes and higher elevations, although we do not find significant evidence for shifts to greater marine depths. Methodological factors in individual range-shift studies have an impact on the reported direction and magnitude of shifts. We identify significant variation in shift directions and rates across dimensions of range shifts (e.g., greater support for latitude and elevation shifts than depth), range position (e.g., high latitude range edges shifted faster than low latitude range edges), and taxonomic groups (e.g., faster latitudinal shifts for insects than plants).

What are the Implications of the Review Findings?

Understanding how species will move in response to climate change is a key concern for managers. As species move outside of their current ranges, current management practices may no longer be effective. For example, existing fisheries management is based on assumptions of stationarity—that population ranges are generally stable over time. However, given the substantial variation in range shifts among animal and plant species, additional modeling and monitoring to anticipate and detect species shifts may be warranted to assess when these species may need to be integrated into management plans. Incorporating additional factors such as the level of climate change exposure, species traits, and other disturbances like land use change may improve our ability to predict which species will shift and by how much.



Typology of range shifts. Leading edge or center of range increases and trailing edge decreases were considered to support our temperature-related range shift hypotheses. Lack of shifts in any parameter; decreases on the leading edge or in the mean/optimum; and increases on the trailing edge were considered "fail to support".

Synthesis Time Frame

The review authors searched for studies published before June 2021. This CEE Systematic Review was published in April 2023.

Full Citation

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