

Species distributions are limited by interactions between organisms and their environment

Created by: Tiffany Doan, New College of Florida; Tanya Dewey, Colorado State University; John Carroll, Georgia Southern University; Liz Alter, California State University Monterey Bay

BACKGROUND

Species are typically found within a geographic range that is determined by a combination of physical tolerances and biological interactions. For example, the red mangrove tree *Rhizophora mangle* is a common species found along intertidal coastlines in the tropics and subtropics. It is usually restricted to areas below the 20°C isotherm. This limit to poleward distribution is due to intolerance to freezing and near freezing temperatures (Cavanaugh et al., 2014). However, temperature alone does not tell the whole story of the distribution of red mangroves. This species is also usually restricted to a thin band of trees immediately adjacent to the sea, and this landward distribution is driven mainly by biotic interactions such as competition with other tree species and predation by numerous invertebrate species. In this way, a combination of factors coalesce to restrict species within geographic ranges.

However, the geographic range for a species may change over time as local conditions become unfavorable or new areas become more favorable. For example, red mangroves are encroaching farther northward in the Gulf of Mexico and along the east coast of Florida as climate change decreases the incidence and intensity of freezing events in these regions (Cavanaugh et al., 2014, Kennedy et al., 2016). This is known as a range expansion - when a species moves into an area where it did not exist previously. This has been demonstrated across multiple terrestrial and marine species, where species have been shifting poleward or higher in latitude in response to changes in global climate (Lenoir and Svenning, 2015). For example, in an analysis of 56 bird species in North America, the northern limit of the species distribution migrated on average 2.35 km per year northward, with no similar expansion to the south (Hitch and Leberg, 2007). Likewise, two species of reef-building corals - the staghorn (*Acropora cervicornis*) and elkhorn (*Acropora palmata*) corals - have seen their distributions shifting northward along the Atlantic coast of Florida and into the northern Gulf of Mexico as a result of rising sea temperatures (Precht and Aronson, 2004). The rate of expansion tends to be highest in areas where more rapid warming is occurring (Chen et al., 2011).

Range expansions do not always occur via natural dispersive processes in response to changing environments. In many instances, range expansions occur through accidental or intentional introductions of species to new areas by human activities. These species may be termed non-indigenous, introduced, exotic or invasive, usually depending on the impact to local communities and ecosystems. The lionfish, *Pterois volitans*, is a piscivorous fish species with toxic spines that is native to the tropical western Pacific Ocean, and a popular fish in the aquarium hobby. It was accidentally introduced to the Atlantic Ocean near south Florida, possibly the result of Hurricane Andrew in 1992. This species has since spread throughout the Caribbean Sea, up the Atlantic US coast, into the Gulf of Mexico and also along the coast of Brazil (Bercantur-R et al., 2011). Another example of an invasive species with an expanding range is kudzu, *Pueraria montana*. Introduced from Japan as a rotational plant species to prevent topsoil erosion on croplands, it quickly spread throughout the southeastern United States (Forseth and Innis, 2010). Rapid expansion of the geographic ranges of invasive species is facilitated by high dispersal and

reproduction, allowing them to quickly colonize areas with favorable abiotic conditions and limited biotic limitations due to a lack of natural competitors and predators. As these species spread into new regions, which will also occur as a result of climate change, they can wreak havoc on native species in these new regions.

Additionally, human activities associated with urbanization and urban growth can also affect geographic ranges of species. Land use changes increasingly fragment habitats, altering species interactions and leading to localized extirpation (Biamonte et al., 2011). Reducing habitat available for wildlife can constrict geographic distributions, limit movements, and prevent mixing between populations. Further, urbanization can act as a barrier to range expansion and act as a pathway for new species introductions. However, in some instances, species may extend their ranges into urban areas. Food resources may actually attract fauna to urban areas, such as flying-foxes (Williams et al., 2006) and black bears (Baruch-Mordo et al., 2014), while urbanization might actually increase habitat availability for some species (Li et al., 2014).

In sum, many anthropogenic activities can interact to impact wildlife and lead to distributional shifts in populations and species. Understanding which species distributions are changing in relation to human influences is critical to exploring mechanisms for change, and ultimately, wildlife and resource management. In which species are you interested? How might their range be changing?

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