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Editorial: Predicting and Managing Climate-Driven Range Shifts in Plants

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Editorial on the Research Topic

Predicting and Managing Climate-Driven Range Shifts in Plants

Plants' geographic ranges will shift in response to climate change; already some shifts have been documented (Lenoir et al., 2008; Parmesan and Hanley, 2015; Zu et al., 2021). Plants face a number of challenges to tracking climate, including dispersal (e.g., seed number, dispersal distance, etc.) and establishment limitations (i.e., unsuitable soil or competition from existing vegetation) (Van Grunsven et al., 2010; Svenning et al., 2014; Lustenhouwer et al., 2017; Thuiller et al., 2019; Sharma et al., 2022). It is also challenging to predict where suitable future habitats will be, given uncertainties in biodiversity models (Thuiller et al., 2019) and climate projections (IPCC, 2013). Inter- and intra-specific variation in climate sensitivity (Angert et al., 2011; Benito Garzón et al., 2019; DeMarche et al., 2019) and the possibility of evolutionary responses (Bush et al., 2016; Cotto et al., 2017; Moran, 2020) particularly complicate the latter. The goal of this Research Topic was to highlight the importance of understanding plant range shifts, to review what is known, and to identify key knowledge gaps.

Several studies used species distribution modeling (SDM) to examine potential range shifts. Zhang et al. found that while suitable area worldwide for the vine *Akebia quinata* might increase up to 50% by 2080, this was mostly driven by increased suitability where the species is introduced; suitable native habitat in Asia was projected to decline. Brodie et al. modeled the range of the succulent tree *Aloidendron dichotomum*. The species likely expanded poleward after the last glacial maximum, consistent with observed genetic variation. Suitable habitat could shift eastward toward the summer-rainfall areas of South Africa by 2070, but range shift rates needed to track habitat were substantial and many species are dispersal-limited. Moeller et al. found that there is a 100–150 km gap in suitable habitat between the Appalachian and Allegheny mountains both for four species endemic to the Southern Appalachians and for four more widely-distributed species. However, the endemic species never crossed this gap and thus have unfilled suitable habitat to the north. Since these endemics are projected to have declining habitat suitability in their native range, assisted migration across the gap might be necessary to conserve them. Similarly, Semenchuk et al. found that the representation of Austrian endemic plant species in protected areas was projected to decline to 1/3 by 2080 in both RCP 4.5 and RCP 8.5 scenarios, with 20–30% of the species studied having zero range representation in protected areas by that date.

While SDMs are relatively simple to implement, concerns have been raised regarding the inherent assumption that species are well-adapted to current conditions (Ibanez et al., 2006; Browne et al., 2019), omission of species interactions (Davis et al., 1998), and ability to project habitat suitability outside the current range of conditions (Williams and Jackson, 2007; Merow et al., 2014). Charney et al. tested 11 algorithms using subsets of forest inventory data for 108 North American tree species. When extrapolating from one region to another, a substantial proportion of algorithms performed worse than random. Data integration approaches that draw from the full

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species range often improve performance of SDMs (Chevalier et al., 2021) but novel future climate space or climate-edaphic combinations cannot be included in the initial model fitting. As Charney et al. noted, the use of more process-based or hybrid models might help to address this issue.

Petit et al. used a process-based model simulating physiological climate responses in five European tree species to estimate mortality risk. They found that, despite positive effects of higher CO₂ on carbon assimilation and water use efficiency, risks of extinction for “genetic conservation units” are similar to or higher than those calculated from SDMs. Qiu et al. used a combination of forest inventory data and demographic data from the MASTIF network to examine demographic sensitivity to climatic factors and forest structure. They found that many life stages, especially fecundity, were sensitive to temperature, but that responses to other factors varied substantially. The niche estimated from adult distributions likely reflects past recruitment conditions rather than current ones. A shift in the distribution of life stages was also observed by White et al. who found that reduced stream-flow in an Australian watershed was linked to fewer juveniles relative to adult riparian trees in low-rainfall areas but more juveniles in high-rainfall areas, where more exposed sediment may have allowed more seedling recruitment.

Experiments that measure growth responses to different climate conditions can also provide important information regarding the sensitivity of locally adapted populations to climate change (Angert et al., 2011; Leites et al., 2012; Moran et al., 2017b; Arnold et al., 2019). Hallingbäck et al. used Scots pine provenance experiments to examine sensitivity of growth to climate at its northern and southern range limits. They found that factors strongly affecting growth differ and that, while moderate transfer distances have little effect on growth, local seed-sources can exhibit lower growth than non-local sources. Growth was predicted to increase at Nordic sites and in northern Spain, but decrease in southern Spain. However, a shorter tree is not necessarily less fit, as conservative growth strategies can be adaptive (Moran et al., 2017a).

The two final papers in the collection synthesized broad-scale patterns. Zettlemoyer and Peterson examined how plasticity

in phenology is likely to affect species’ adjustment to climate change. They found that plasticity is usually adaptive, and that while plasticity did not generally differ with range position, when it did edge populations tended to be more plastic. This suggests that plasticity is more likely to promote than hinder range shifts, though direct tests are needed. Shay et al. reviewed rules governing plant species ranges and what this might tell us about climate responses. Five potential rules were supported by multiple studies, including “range limits often coincide with [abiotic] niche limits,” “biotic interactions often set range limits,” and “smaller ranges tend to be more vulnerable.” These rules suggested corresponding conservation actions.

While much attention has been paid to direct climate impacts on species ranges, these papers and others indicate other important factors. Biotic interactions will likely affect both local persistence and colonization, as will physical barriers to dispersal. Life-stages may also be affected differently by climate shifts. A particularly important issue in research evident both in this collection and overall is the northern temperate zone bias; highly biodiverse equatorial regions including tropical rainforests have received much less attention regarding how climate change impacts on species’ ranges (Feeley et al., 2017; Sheldon, 2019). Non-seed plants are also seldom studied. All these topics are deserving of further research effort, and studies integrating approaches to test impacts of multiple factors are particularly needed.

AUTHOR CONTRIBUTIONS

EVM wrote the initial draft of this manuscript. All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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