Peer Community In Ecology

A meaningful application of species distribution models and functional traits to understand invasion dynamics

Joaquín Hortal based on reviews by Peter Convey and Paula Matos

A recommendation of:

Manuele Bazzichetto, François Massol, Marta Carboni, Jonathan Lenoir, Jonas Johan Lembrechts, Rémi Joly, David Renault. **Once upon a time in the far south: Influence of local drivers and functional traits on plant invasion in the harsh sub-Antarctic islands** *(2020), bioRxiv, 2020.07.19.210880, ver. 3 peer-reviewed and recommended by Peer Community in Ecology.* 10.1101/2020.07.19.210880

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Polar and subpolar regions are fragile environments, where the introduction of alien species may completely change ecosystem dynamics if the alien species become keystone species (e.g. Croll, 2005). The increasing number of human visits, together with climate change, are favouring the introduction and settling of new invaders to these regions, particularly in Antarctica (Hughes et al. 2015). Within this context, the joint use of Species Distribution Models (SDM) –to assess the areas potentially suitable for the aliens– with other measures of the potential to become successful invaders can inform on the need for devoting specific efforts to eradicate these new species before they become naturalized (e.g. Pertierra et al. 2016).

Bazzichetto et al. (2020) use data from a detailed inventory, SDMs and trait data altogether to assess the drivers of invasion success of six alien plants on Possession Island, in the remote sub-Antarctic archipelago of Crozet. SDMs have inherent limitations to describe different aspects of species distributions, including the fundamental niche and, with it, the areas that could host viable populations (Hortal et al. 2012). Therefore, their utility to predict future biological invasions is limited (Jiménez-Valverde et al. 2011). However, they can be powerful tools to describe species range dynamics if they are thoughtfully used by adopting conscious decisions about the techniques and data used, and interpreting carefully the actual implications of their results.

This is what Bazzichetto et al. (2020) do, using General Linear Models (GLM) –a technique well rooted in the original niche-based SDM theory (e.g. Austin 1990)– that can provide a meaningful description of the realized niche within the limits of an adequately sampled region. Further, as alien species share and are similarly affected by several steps of the invasion process (Richardson et al. 2000), these authors model the

realized distribution of the six species altogether. This can be done through the recently developed joint-SDM, a group of techniques where the co-occurrence of the modelled species is explicitly taken into account during modelling (e.g. Pollock et al. 2014). Here, the addition of species traits has been identified as a key step to understand the associations of species in space (see Dormann et al. 2018). Bazzichetto et al. (2020) combine their GLM-based SDM for each species with a so-called multi-SDM approach, where they assess together the consistency in the interactions between both species and topographically-driven climate variations, and several plant traits and two key anthropic factors –accessibility from human settlements and distance to hiking paths.

This work is a good example on how a theoretically meaningful SDM approach can provide useful –though perhaps not deep– insights on biological invasions for remote landscapes threatened by biotic homogenization. By combining climate and topographic variables as proxies for the spatial variations in the abiotic conditions regulating plant growth, measures of accessibility, and traits of the plant invaders, Bazzichetto et al. (2020) are able to identify the different effects that the interactions between the potential intensity of propagule dissemination by humans, and the ecological characteristics of the invaders themselves, may have on their invasion success.

The innovation of modelling together species responses is important because it allows dissecting the spatial dynamics of spread of the invaders, which indeed vary according to a handful of their traits. For example, their results show that no all old residents have profited from the larger time of residence in the island, as Poa pratensis is seemingly as dependent of a higher intensity of human activity as the newcomer invaders in general are. According to Bazzichetto et al. trait-based analyses, these differences are apparently related with plant height, as smaller plants disperse more easily. Further, being perennial also provides an advantage for the persistence in areas with less human influence. This puts name, shame and fame to the known influence of plant life history on their dispersal success (Beckman et al. 2018), at least for the particular case of plant invasions in Possession Island.

Of course this approach has limitations, as data on the texture, chemistry and temperature of the soil are not available, and thus were not considered in the analyses. These factors may be critical for both establishment and persistence of small plants in the harsh Antarctic environments, as Bazzichetto et al. (2020) recognize. But all in all, their results provide key insights on which traits may confer alien plants with a higher likelihood of becoming successful invaders in the fragile Antarctic and sub-Antarctic ecosystems. This opens a way for rapid assessments of invasibility, which will help identifying which species in the process of naturalizing may require active contention measures to prevent them from becoming ecological game changers and cause disastrous cascade effects that shift the dynamics of native ecosystems.

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Revision round #1

2020-10-06
Dear authors

Thanks for sending this nice text to PCI, and sorry for the time taken to get a first decision on it; summer holidays and the difficulties we all are struggling with this year of confinations delayed the process of getting two sound reviews and reviewing the text myself.

Both the two reviewers and myself believe that it is a solid piece of work, and is in general well written. The reviewers highlight some minor problems with yhe understandability of certain parts of the text, including the need for specific clarifications and presenting further information on data and traits. Among these, I would like to highlight the need to be a bit more critical with the limitations of SDM approaches to model invasions. They certainly are one of the best tools we have to forecast the potential areas of impact of invaders, but as one of the reviewers states, their accuracy depends on the quality of the original data (on both species occurrence and climate). Besides that, for many (if not most) species the environmental conditions they occupy now do not comprehend the whole range of conditions where their populations could present positive growth rates (i.e. their potential distributions). This difficults forecasting all the conditions where these species could thrive and become succesfully naturalized during the process of invasion. This limitation does not diminish the value of your study, specially in the extreme conditions of the seldom studied archipelagos you work with. But calls for being cautious about the limitations of the results you obtain. Please try to make clear for the reader these limitations, in the paragraph of the introduction indicated by the reviewer, and also in the discussion, (around current lines 380-400), where you can also indicate the gains of having been able to develop a more mechanistic model using high-quality data on species abundances, as indicated by the other reviewer. You can take a look to Jiménez-Valverde et al (2011) Biological Invasions 13, 2785–2797 or Srivasta et al (2019) CAB Reviews Perspectives in Agriculture Veterinary Science Nutrition and Natural Resources 14:1-13 for a more critical view on the use of SDM to model invasions.

Once these moderate changes are accounted for, I am certain that I will be able to recommend your text for publication on behalf of the PCI Ecology community. Please let us know when you have a revised version of your preprint, to prepare a final recommendation for your work. I'm looking forward to it.

All the best,

Joaquín.

Additional requirements of the managing board:
As indicated in the 'How does it work?' section and in the code of conduct, please make sure that:
-Data are available to readers, either in the text or through an open data repository such as Zenodo (free), Dryad or some other institutional repository. Data must be reusable, thus metadata or accompanying text must carefully describe the data.
-Details on quantitative analyses (e.g., data treatment and statistical scripts in R, bioinformatic pipeline scripts, etc.) and details concerning simulations (scripts, codes) are available to readers in the text, as appendices, or through an open data repository, such as Zenodo, Dryad or some other institutional repository. The scripts or codes must be carefully described so that they can be reused.
-Details on experimental procedures are available to readers in the text or as appendices.
-Authors have no financial conflict of interest relating to the article. The article must contain a "Conflict of interest disclosure" paragraph before the reference section containing this sentence: "The authors of this preprint declare that they have no financial conflict of interest with the content of this article." If appropriate, this disclosure may be completed by a sentence indicating that some of the authors are PCI recommenders: "XXX is one of the PCI XXX recommenders."

Preprint DOI: 10.1101/2020.07.19.210880

Reviewed by Paula Matos, 2020-09-30 15:19

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Reviewed by Peter Convey, 2020-09-25 12:18

Once upon a time in the south: local drivers of plant invasion in the harsh sub-Antarctic islands
Bazzichetto et al.

The threat and impacts of biological invasions have justifiably received much increased attention in recent years across the entire Antarctic region, but in particular in the sub-Antarctic islands, across which over 90% of known non-natives in Antarctica are recorded from. Of these, around half of the known species are of 'higher' (flowering/vascular) plants, with the largest numbers recorded from the extensively impacted Kerguelen archipelago in the Indian Ocean. This study focuses on the Crozet archipelago, a separate (also French-administered) island group also in the Indian Ocean which closely shares human historical and biological features with Kerguelen. This is the first detailed analysis of this type that I am aware of for drivers of plant invasions in these (or other sub-Antarctic) island groups, although a number of more general studies and reviews are available. The results described provide important information that will be helpful to those responsible for risk management and conservation in this region.
The paper is generally clearly written and appropriately and thoroughly referenced; very minor language editing would be helpful throughout. My comments are generally minor and offered more to stimulate discussion than being critical.
L44-46 – this is an inevitably brief reference to the impacts of climate change in this region, but is in danger of being a bit simplistic….warming trends have been identified in some sub-Antarctic islands, although perhaps more important are some quite drastic changes in precipitation and drying regimes, while studies have also noted that some of these changes can have serious negative impacts on various native plant species (especially I think on Marion and Macquarie Islands). The very widespread impacts of non-native vertebrates on most of the sub-Antarctic islands also deserve mention. Taken together, these points highlight

the potentially very complex interactions between several major factors, which may have both positive and negative impacts on both native and non-native biota.
L48 – I believe the Molina-Montenegro et al study refers to the South Shetland Islands and Antarctic Peninsula, in the maritime Antarctic. Perhaps there should be a line early in the paper defining what is included in the term 'sub-Antarctic' for the purposes of this paper.
L85 – I do strongly accept the usefulness and increasing application of SDM approaches for modelling non-native species distributions. Perhaps one caution I would raise is that a regular feature of some biological invasions in the wider invasion literature is that at least some such non-native species appear capable of making 'jumps' that take them beyond what would be expected to be a suitable/viable habitat based on the available ecophysiological and physical climatic characteristics of their native ecosystems. One example of this is the global pest moth species Plutella xylostella which has been introduced to and spread quite widely on sub-Antarctic Marion Island. In the early 2000s, when this was first reported, the annual climatic characteristics of Marion Island appeared to place it beyond the capabilities (in the published literature) of this moth to survive year-round and establish there. This highlights that modelling approaches such as SDM may only be as 'good' as the data available to input to them (this is further to the caveats recognised at l95-97). For completeness in the use of citations to the use of this approach in the Antarctic Peninsula region, two further recent studies on, respectively, invading and native invertebrates are pertinent: Pertierra et al 2019 J Biogoeg on the invading midge Eretmoptera murphyi and Contador et al 2020 Sci Rep on the maritime Antarctic native Parochlus steinenii.
L120 – it would seem appropriate to have explicit reference to a good map figure in this subsection.
L123 – what is 'EPSG'?
L137 – perhaps be explicit and name the herbivores that impacted Possession.
L141 – although a weblink is given, and not knowing this journals' policy with supplementary material, I suspect many readers would appreciate having direct access to a list of these recorded species directly linked to this paper, including the subsets that are persistent and invasive.
L182 – if 'flowering' includes mechanisms of non-insect fertilisation (wind pollination, self fertility) then is it appropriate to exclude all these traits? With reference to seed characteristics, are any of the selected species known to have seeds that can facilitate dispersal either within vertebrate guts or attached to their fur/feathers? 194 – could some explicit examples be given of such areas?
L307 – I certainly don't question the finding, but is there any surprise that J. bufonius shows this negative relationship with precipitation? I would have assumed members of this genus would be positively associated with wet habitats? Is high precipitation associated with lower temperature?
L380 (para) – a couple of thoughts that might be added to discussion in this para: first, would it pertinent to draw analogy with the way P. annua on King George Island (maritime Antarctic) appears to have escaped from local human influence in its rapid recent expansion from its original introduction site at the Polish research station there? And partly drawing on that example, it would be appropriate to mention the potential role of some species being able to establish seed banks which ensure some level of extended viability even if it were possible to eradicate a proportion of the visible plants.
L394 – a similar point is emphasised generally for terrestrial studies in both Arctic and Antarctic regions by Convey et al. 2018 (Polar Biol).
L441-443 – while this closing sentence is certainly true, it is also something of a motherhood statement – readers might be interested in the inclusion of a para in the paper (Introduction and/or Discussion) on whether control measures have been carried out or are planned directed towards such non-native plants – the statement of 'they might be', on its own, is rather irrelevant if they are not!

Author's reply:

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