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commentary

Mapping species distributions: living with uncertainty

A recent paper by Jetz et al. (2012) presents the ‘Map of Life’, a web-based tool that aims to provide a representation of the distribution of every species on Earth[1]. This database, if it is fully realized, would provide an invaluable resource for the advancement of biogeographical research, in addition to its potential utility for conservation planning. As most biogeographers, we would give almost unconditional support to any initiatives that may improve the quantity, quality and availability of species distribution data – such as the Map of Life, GBIF[2], Encyclopedia of Life[3], etc. (see review in Riddle et al. 2010). We are certain that they will provide a deeper and wider knowledge about life on Earth through the uprising field of biodiversity informatics (see Soberón & Peterson 2004). Even so, it is important to bear in mind that there are intrinsic limitations to the quality, longevity and coverage of biodiversity data.

There are at least three factors that compromise the quality of our knowledge of species distributions at any given spatial scale: survey completeness, and the decay of information with time and space. First, as any field ecologist knows, many taxa are difficult to detect because of their phenotype (cryptic coloration and behavior, high mobility, phenology, etc.) and the characteristics of the habitat. Thus, most biological surveys on which species distribution maps are based are unavoidably incomplete, even when a range of sampling methodologies is utilized (Colwell & Coddington 1994). In other words, it is normally impossible to record the entire assemblage for a defined area at a given moment of time. Moreover, the completeness of a sample will typically decrease with increasing extent of the survey area (see Chiarucci et al. 2011).

Second, knowledge about species distributions and the composition of local assemblages is in a constant state of information decay. The reliability of the information provided by any survey decreases with time because of range changes associated with factors such as climate and land-use change, habitat degradation, biological invasions, etc. Moreover, changes in taxonomic status resulting from reclassifications (Hey et al. 2003) may mean that even if the assemblage remains unchanged, the quality of the information degrades. Thus, the utility and accuracy of information about species occurrences to describe current distributions depends upon when the database is consulted. This process of information decay also applies to data based on expert assessments, such as range maps, which are ultimately based on knowledge coming from surveys and observations.

Finally, the decay in community similarity with increasing geographic distances is a well known pattern in biogeography (Nekola & White 1999). The main drivers of this pattern are environmental gradients (e.g. climate, soil chemistry, etc.), spatial configuration of habitats and population aggregation (Morlon et al. 2008). Species distribution maps are typically based on the spatial extrapolation of survey data through expert assessment or species distribution modeling (Rocchini et al. 2011). It follows that their accuracy for unsurveyed regions will decrease with distance from the original samples, and (in the absence of comprehensive coverage of the study area) our knowledge about the actual distribution of the species may be poor.

The proposed Map of Life project aspires to create a type of omniscient GIS for all the Earth’s living species – such as the one imagined by Colwell & Coddington (1994). This is a wonderful target, with the potential to dramatically improve the spatial and temporal resolution of biodiversity data. Nevertheless, the biodiversity data that underpin any such enterprise have intrinsic and unavoidable limitations that result in loss of knowledge over both time and space. This is well known

1 http://www.mappinglife.org/
2 http://www.gbif.org/
3 http://eol.org/

– Jetz et al. (2012), among many others, cover several of the issues that we raise above. Rather, what is lacking is a nuanced discussion of how to most effectively communicate biogeographical uncertainty and, more importantly, how to practically incorporate lack of knowledge -into applied research.

One possible solution would be the parallel development of 'maps of ignorance' that provide information on where the mapped distributions are reliable and where they are uncertain (Rocchini et al. 2011) – such maps could potentially be integrated into biodiversity information systems, allowing users to quickly identify overlap between priority areas for conservation and areas of high uncertainty. Moreover, regularly updated 'maps of ignorance' would provide scientists with the information required to explicitly deal with biogeographical uncertainty, either through the design and implementation of new surveys (Hortal & Lobo 2005) or by incorporating spatially explicit estimates of uncertainty into species distribution modeling (Beale & Lennon 2012).

Uncertainty casts a long shadow over biogeographical research. Although it can never be completely eliminated, through careful analysis and inventive visualization ignorance may be incorporated into biodiversity planning and controlled for in distribution modeling. In the words of Daniel J. Boorstin, "The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge[4]."

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4 http://en.wikiquote.org/wiki/Daniel_J._Boorstin

