Getting back to the basics: Museum collections and satellite imagery are critical to analyzing species diversity.

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Getting Back to the Basics: Museum Collections and Satellite Imagery Are Critical to Analyzing Species Diversity

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The world's tropics harbor the highest species richness and phylogenetic diversity of many groups, including both mammals and amphibians (Schipper et al. 2008, Pérez-Ponce de León and Poulin 2016); they are also home to the greatest number of newly described species, despite the highest level of data deficiency (Schipper et al. 2008). Miraldo and colleagues (2016) extended these patterns of richness and sampling gaps to interspecific genetic diversity. These patterns were then associated with synthesized anthromes and human density patterns (Ellis et al. 2010). Some of the limitations of the study by Miraldo and colleagues (2016) have been outlined by Pereira (2016). We commend the effort by Miraldo and colleagues (2016), because it mobilizes the best available data set to connect the relationships between diversity and anthropogenic-driven habitat change. Moving forward, we feel that now is an opportune time to highlight data challenges associated with biodiversity, museum-collections data sets, and land-cover change.

These recent analyses highlight some of the challenges and limitations of exploiting data sets of intrinsically different scales, as well as how the analyses of such data sets can create potential artifacts. In order to make large-scale models relevant, we need to analyze land-cover change using satellite imagery of appropriate geographic (global to site-specific) and temporal scales, which are then coupled with museum-collection data sets and natural history. Readily available genomic data sets have improved data sharing but often lack detailed geospatial information regarding the sample's habitat, which is sometimes as low as approximately 50 percent for some vertebrate groups (PHE 2016), thereby complicating associations between biodiversity and habitat types.

Among the potential remedies

First, there is a need for continued field collections and surveys (Rocha et al. 2014): The most detailed global databases represent only one percent of described species (Hudson et al. 2014). It is important to identify and monitor how species are adapting (or not) to landscape changes, including both habitat and climate. New collections are valuable, particularly for new genomic techniques that require high-quality DNA, but many current collections were amassed before tissue samples were routinely collected. Additional sampling offers opportunities for highly accurate georeferenced localities and habitat descriptions, either from microhabitat analyses or high-precision remote sensing. Furthermore, interspecific biodiversity assessments (Miraldo et al. 2016) require large sample sizes. Therefore, large samples are important, even if the sample is from a single site and includes "common" species. Such data are informative for population-level questions on species diversity.

Second, there is a need for increased funding of museum collections and basic inventories. Over the past two decades, there has been a decrease in museum-science and National Science Foundation funding (Pyke and Ehrlich 2010) and in basic natural-history curricula (Tewksbury et al. 2014). Natural-history repositories have steadily declined in staffing and financial support, which in turn limits basic science (Kemp 2015). In academia, there has been a shift from teaching the basic -ologies (e.g., mammalogy, herpetology, ichthyology, and entomology) to teaching genomics, bioinformatics, and modeling (Tewksbury et al. 2014), but those "basic" field- and collections-based data sets and training are crucial to the analyses of Miraldo and colleagues (2016).

Field biologists must devote major time and resources to assembling reliable species inventories, but these data can be difficult to publish because they are basic or regional. Metanalyses of inventories, such as Miraldo and colleagues' (2016), depend on such studies. There are limited employment and funding opportunities for scientists pursuing basic inventories, systematics, and natural-history careers, and this is particularly acute for early-career scientists (Maher and Sureda Anfres 2016, Powell 2016).

Third, species records should be coupled with date-specified habitat data. In Miraldo and colleagues (2016), study species were put in bins of anthromes. However, recent changes in regions such as South America's Chaco and Atlantic Forest, among many more, have occurred so rapidly (see supplemental figure S1) that using one land-cover map to assign data from multiple years or decades (and often at different spatial scales) to a particular anthrome might misrepresent the response of biodiversity to land-cover change. Local assemblages can be greatly affected by habitat changes, but impacts vary by scale and taxa (Laurance et al. 2011, de la Sancha et al. 2014, Newbold et al. 2015). Therefore, there is a need for high-resolution models with shorter temporal intervals, which would permit more robust correlative power between land cover and specimen data.

Vouchers with habitat data are important, but more and more, we're losing the natural-history components that used to accompany such data. Natural-history information often remains unpublished, but we need this information to validate the large-scale, biogeographical models. Ideally, vouchered specimen records can be coupled with contemporaneous satellite imagery, but such associations are rare. Reliance on low-resolution satellite imagery (more than 30 meters per pixel) can produce overly coarse habitat classifications that mask landscape connectivity (Boyle et al. 2014). Access to affordable high-resolution imagery (5 meters or less) could dramatically improve landscape modeling at all scales, a much-needed infrastructural development for understanding biodiversity changes in the rapidly changing Anthropocene.

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