BOOK REVIEW

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How the fraying fabric was woven: a pocket guide to the changing world

Biogeography: a very short introduction, by Mark V. Lomolino, 2020, Oxford University Press, 176 pp., ISBN 9780198850069
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The *Very Short Introductions* series, which now includes Mark Lomolino's new book *Biogeography*, aims to give "anyone … a stimulating and accessible way into a new subject" (p. ii). In such an holistic discipline as biogeography, in such a short book, finding the hooks to engage a diverse audience and represent the field seems like an impossible task. But having co-authored a, if not *the* discipline's preeminent, full-size biogeography text (Lomolino et al. 2016), probably few are as well positioned as Lomolino to distil biogeography's essence.

The book's main message is that human interdependence with biodiversity spans space and time and has been—and still is—shaped by geology, environment, and organisms. As Lomolino puts it, "ancient civilizations[']… very existence depended on knowledge of how food plants, game animals, and other natural resources were distributed across the landscapes and seascapes that comprised their homelands" (p. 1). Now, in the Anthropocene epoch (Crutzen and Steffen 2003), it is clear that our dependency upon natural resources has grown from a local to a global scale. And, amidst the megafaunal and 6th Mass extinctions (Barnosky et al. 2011), which Lomolino attributes to humans spreading around the globe (pp. 50–52), it also is clear that biodiversity's existence is now more precariously than ever dependent on us. Lomolino's message is that, ancient or modern, what we know (and don't know), how we know it, and how we use it, are central to our place in the Earth system.

Lomolino's narrative weaves together how Earth processes shape life and how the ways we study biogeography shape our understanding of those processes. The first figure—Humboldt's holistic 'Tableau physique' of Mount Chimborazo—is his pivotal example of a critical juncture when a series of facts—knowledge of how plants were distributed across the mountainscape—were metamorphosed by theory into both a synthesis of existing information and a prediction about patterns in yet to be collected data. Lomolino quickly parlays this into the time-tested visual for summarizing and predicting biogeographic patterns: maps, which constitute two-thirds of the figures in the book (five others feature organisms and a half-dozen-or-so are mostly conceptual diagrams). The first map—William Smith's 1815 British geological "map that changed the world" (Gould 2001)—integrates time and space; the second map, dating to 1876, is Alfred Russel Wallace's proposed zoogeographic regions of the world. The geological and climatological processes that underwrite such spatial (and temporal) variation across scales on a dynamic planet are summarized in a (relatively) long second chapter, in which a key question is raised: are these still the dominant processes? Through the remaining five chapters, Lomolino pulls on these three threads — the interplay of knowledge and theory, space and time, and various drivers of change — to examine how the fabric of life is made, maintained, and cut by "biogeography's fundamental processes": evolution, immigration, and extinction (p.15).

Lomolino primarily chooses to illustrate patterns in the tapestry of life using islands—particularly the Galápagos and Hawai'i archipelagos plus Madagascar—for the joint reasons that "they include some of the world's most spectacular … adaptive radiations" and "compelling illustrations of the [interdependencies of] geography [and] diversification" (Chapter 3; p.53). While there may be debate about what constitutes an adaptive radiation (Gillespie et al. 2020), the merits of this choice for this short book are clear: life's complexity is simplified, captivating, and already familiar examples—such as finch adaptations, honeycreeper–bromeliad co-evolution, lemur richness, and predator paucity—can be amplified. The similarities and differences of islands may illuminate the interacting roles of environment, isolation, and time. The demerits also are clear: small sample sizes, imperfect comparisons that leave room for alternative interpretations, and the need for anecdotes to illustrate exceptions (such as Lake Baikal), which invariably are used to demonstrate the rule (that radiations happen in the tropics). Lomolino concludes that the patterns are self-evident: more isolation, area, and antiquity lead to more biodiversity and endemicity … especially in the tropics, and particularly on land. Of little consequence, then, counter-examples such as the cryonotothenioid fish that radiated in the Antarctic (Near et al. 2015) after ice sheets had already started forming (Hansen et al. 2013)?

Employing conceptual thinking (from theological supposition to non-equilibrium theory) to reconstruct the details of how (we think) such patterns form, takes center stage by the middle of the book (chapters 4 and 5) with a focus on historical (phylogenetic) and island biogeographic theory, including the sources of 'hotspots'. An uncharacteristically long (for this book)

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dive into phylogenetic methods and terminology (p.78–81) may be as difficult for some audiences to read as even the simplest 'geophylogeny' (Novick and Catley 2013), a tool that has not taken off in the literature. Nonetheless, Lomolino's embrace of an expansive definition of phylogeography—ranging from deep time that reveals how species' histories predate the modern Hawaiian islands they now inhabit, to the shallow temporal scales of population genetics—offers a powerful integration that emphasizes continuity of processes through time and space (Marske et al. 2013). Lomolino deploys three devices to make this point. One is island biogeography theory; building on the examples already core to the book, he charts a direct path from the descriptive equilibrium theory (p.103) and artificial experimental islands of the 1960s (p.106) to their 'natural experimental' counterparts, real islands, and the General Dynamic Model (p.111). The second is the macroscope "which provide[s] multi-scale windows into the complex structure of the natural world" (p.117). A bit of a swiss army knife, the macroscope is variously Humboldt's concept of Mt. Chimborazo, an imaginary flying observatory able to remotely sense all biodiversity simultaneously at any detail and scale, a graph of body mass versus geographic range size, and more. The third is our sense of wonder and the idea of biophilia—a long-selected human trait tied to our dependence on knowing what could feed or hurt us and where it can be found—which Lomolino incongruously equates to "an instinctive attraction to the most rare" (p.93); to us and others, what is close and abundant seemed at least equally important. These sections thus started to show how what we know has progressed: presenting evolutionary updates of Wallace's map, which now differentiate Hawai'i from other Pacific islands and Madagascar from other regions (p.89), and heightening the alarms about the loss of endemic diversity from such hotspots (p.115) through extinction and homogenization.

The ecological-evolutionary synthesis is also apparent in the discussion of macroecology, the conceptual framework for the macroscope and the focus of Lomolino's penultimate chapter. Applied to continents as well as to islands, Lomolino uses macroecology to emphasize the continuity of process and scaling in life on Earth, but that things at one level (e.g. traits) may non-linearly generate emergent patterns at higher levels (species or community). This brings the reader almost full-circle to the start of the book and the idea that by observing broad-scale patterns we may posit hypotheses about 'rules' that govern the distribution and diversity of life on Earth. Our ability to do this requires we make measurements of great detail over vast distances and expanse of time. The complexity and continuity of process itself is a problem for which we do not yet have solutions on continental scales (or in the seas), so the book returns one final time to the 'natural experiments' of islands, to the phenomenon of the 'island syndrome' explained by the absence of eco-evolutionary drivers that allow 'relaxation' toward intermediate body size, the "great anomaly" of birds that do not fly (p.126), and the loss of dispersal ability in island descendants of once-continental ancestors that travelled so far, which have all become particularly susceptible to extinction.

Thus, the book concludes with its most powerful observation: that humans, like other organisms, are subject to the 'rules' of biogeography (chapter 7). Humans too are shaped by the land and by time. As environments change spatially and temporally, as we are isolated on islands, migrate along coastlines, and adapt to high elevations; as the world changes us, we change the world on ever-increasing scales. In a sometimes seemingly endless cycle, the saving grace, perhaps, is that our ability to use data and theory to predict the consequences have also grown, and the emergence of studies such as conservation biogeography could shape a different future. As powerful as this idea is, Lomolino suggests that it may not be knowledge that makes the difference, but rather the need to fill in gaps in understanding, to complete 'maps of ignorance' of, for example, species distributions (the Wallacean shortfall [Hortal et al. 2015]). Lomolino's poignant example of elephants becoming tame tuskless forms limited to a few small areas, suggests an eighth gap — the McClintockian shortfall — in our understanding: how genes are distributed and modulated to link form and function as environments vary across space and through time.

And so we return to the start of this review, to ask how the book stacks up against its goal to give "anyone … a stimulating and accessible way into [biogeography]" (p. ii)? There may be as many answers as there are readers, but we can perhaps start by considering three audiences: the public, undergraduates, and graduates. For the public, the book makes sense: it introduces what experienced biogeographers in general consider key aspects of the discipline (e.g. islands, radiations, historical biogeography, macroecology, etc) and some of the best-known examples. But we wonder whether this might slightly miss the mark? Where are the beautiful images of the amazing radiations? (Figures in the paperback are greyscale!) Following Lomolino's initial logic for why humans care about biodiversity (p.1), might people be motivated more by the biogeography of species with which they interact than by his later invocation of what we might term xenobiophilia (p.93)? And did that miss an opportunity to consider alternate perspectives on what is 'remote' (Baker et al. 2019), to draw on standpoint theory and strong objectivity (Harding 1992), and to decolonize biogeography just a little (Eichhorn et al. 2020)? Might the quick dives into scientific details and jargon be too much, especially in absence of a glossary? For undergraduates – a key audience for Lomolino's broader endeavors (Lomolino 2018) – the book may provide a framework and key examples that can be embellished by the instructor; for sure it is less daunting, cheaper, and more flexible than the classical Biogeography text (Lomolino et al. 2016; see also Marske 2017). Considering public and undergraduate audiences together raised the question of whether one might write a very different book if starting from scratch: if it weren't woven

from the same thread as the major text, what would this book be? For graduates, ourselves, we found it at first frustrating: it jumped in too quickly for those new to the discipline, lacked details for those more experienced, and was at other times incongruous. Doesn't continuity of process suggest the fundamental drivers of biogeography are not evolution, immigration, and extinction but rather drift, migration, mutation, and selection (Roughgarden 2009, Vellend and Geber 2005, Dawson 2016)? Are there systems, such as the isolated drainages of eastern Brazil, that could act as intermediaries from island to continental processes (Guimarães et al. 2021, Lima et al. 2021)? Given this is a "blue planet" (p. 98) could marine biogeography be better integrated? But over the course of a semester, a couple of readings, and presentations by remotely visiting biogeographers, we grew to appreciate the framework and space that Lomolino's very short introduction provided for our own discussions and exploration.

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