Island Biology

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Introduction

This article focuses on the ecology, evolutionary biology, and conservation of biotas on islands surrounded by ocean. These include oceanic islands in a strict sense (i.e., volcanic islands), atolls, islands on a continental shelf, and continental fragments (i.e., islands that originated from a continental plate but are now isolated in the ocean). This article treats only the terrestrial ecology of islands, and it does not cover islands in freshwater bodies, or islandlike isolated habitats on land such as mountaintops or landscape fragments. Islands can be found in all oceans of the planet and at all latitudes and consequently in all climate zones. They are characterized by their small area and isolation from other land, although both isolation and land area vary very widely. In this article we focus mostly on islands that are fully and continuously detached from the mainland and especially treat land-bridge islands (e.g., British Isles) only marginally. Islands are often part of island groups or chains, but they can also be completely isolated. Some islands reach an elevation of several thousand meters above sea level and then share many characteristics with mountains, including elevational vegetation zonation and often strongly contrasting leeward and windward climates. There are at least twenty thousand islands more than one square kilometer in area and millions if all sizes are considered. Together they make up nearly 5.3 percent of the earth's land area. Island biodiversity is of huge importance for global biodiversity because of its high endemism. For instance, about one quarter of vascular plant diversity is endemic to islands. Oceanic islands have long been used as model systems for research in biogeography, ecology, evolution, and conservation. Islands were crucial for the formulation of Charles Darwin's and Alfred Russel Wallace's evolutionary theory and later for the observation of evolution in action. The relevance of processes such as biological invasions and demographic stochasticity for conservation were first recognized through examples from islands. In biogeography, the theory of island biogeography by MacArthur and Wilson is by far the most widely cited and discussed theory. Islands are also hotspots of biodiversity loss, where conservation strategies are being tested that might save some threatened species despite the dramatic degradation of most island ecosystems.

General Overviews

Despite the great importance of islands for ecology, relatively few general scientific treatises exist. The most comprehensive up-to-date overview on islands in general is Gillespie and Clague 2009. Whittaker and Fernández-Palacios 2007, although primarily a textbook about biogeography, is an excellent starting point for many aspects of island biology. The classical work Carlquist 1974 is still an indispensable reference, and Gorman 1979 is also still a useful, short, but dense introduction to the topic. Fernández-Palacios and Morici 2004 introduces some of the key issues in Spanish. For recent developments in island biology, Kueffer, et al. 2014 can serve as an entry point. Royle 2014 is a good starting point for exploring social, political, and economic aspects of insularity and how they interact with island biology.

Carlquist, Sherwin. 1974. *Island biology*. New York: Columbia Univ. Press.

This seminal book, by an icon of island biology, proposes twenty-four hypotheses about island biotas then examines them using island floras and faunas worldwide: there is a particular focus on long-distance dispersal, functional traits, and adaptive radiation of island plants. It inspired many researchers to further investigate island species from new ecological and evolutionary perspectives and is still a source of important information on island biology and plants.

Fernández-Palacios, José María, and Carlo Morici, eds. 2004. *Ecología insular/Island Ecology*. Santa Cruz de La Palma, Spain: Cabildo Insular de La Palma.

Bilingual (Spanish and English) compilation of the fifteen contributions presented at the Island Ecology Symposium held in La Palma (Canaries) in 2002. The chapters included topics such as island biogeography, metapopulation dynamics, fragmentation, mutualistic networks, and extinction on islands, among others. This is one of the few Spanish texts in this field.

Gillespie, Rosemary G., and David A. Clague, eds. 2009. *Encyclopedia of islands*. Berkeley: Univ. of California Press.

This encyclopedia is a monumental effort that collects the existing geological and biological knowledge on all aspects of island biology, including separate entries on most important island groups and oceanic regions worldwide. With the participation of more than a hundred specialists, this indispensable reference work is a must for every island researcher and a valuable starting point for information on virtually any topic in the field of island biology.

Gorman, Martin. 1979. *Island ecology*. London: Chapman & Hall.

Short but dense introduction to island ecology. The text touches briefly, but consistently, upon the more important aspects of island biogeography, ecology, and evolution and is a useful introductory text for students.

Kueffer, Christoph, Donald R. Drake, and José María Fernández-Palacios. 2014. Island biology: Looking towards the future. *Biology Letters* 10.10: 20140719.

Discusses recent developments in island biology and highlights in particular four recent developments: emergence of (1) a global, comprehensive research community incorporating previously neglected islands and taxa; (2) macroecology and big-data analyses yielding numerous global-scale synthetic studies and detailed multi-island comparisons, (3) use of modern methodologies in genomics, phylogenetic and functional ecology, and paleoecology, and (4) tight collaboration between basic research and conservation management, using islands to test new conservation solutions for the 21st century.

Royle, Stephen A. 2014. *Islands: Nature and culture*. London: Reaktion.

A small booklet illustrated with many photographs intended for a broad audience. Introduces island studies: the interdisciplinary study of islands. The main focus is on the human geography of islands. The author discusses general features of islands or insularity and how they determine, in particular, social, political, and economic life. A previous book by the same author, *Geography of Islands: Small Islands Insularity* (Routledge, London, and New York, 2008) provides a more systematic but less accessible introduction to island studies.

Whittaker, Robert J., and José María Fernández-Palacios. 2007. *Island biogeography: Ecology, evolution and conservation*. 2d ed. Oxford: Oxford Univ. Press.

This textbook has achieved the status of a key reference in its field, and it is the first comprehensive overview of island biogeography since the seminal work by MacArthur and Wilson in the 1960s. It is an appropriate text for both students and researchers and is divided into four parts: island environment, ecology, evolution, and conservation, plus a glossary.

Historical Accounts and Foundational Works

Islands have played a pivotal role for the development of biogeography, evolutionary biology, and ecology throughout the history of these fields. The 19th century was both a time of colonial exploration and scientific revolution in biology, and islands in particular inspired naturalists. Not surprisingly then, the formulation of modern evolutionary theory by Charles Darwin and Alfred Russel Wallace was strongly influenced by observations made on islands (Darwin 1859, Wallace 2013). Naturalists collected plant and animal samples on islands around the world and brought them home where they were classified, for instance, by the director of Kew Botanic Gardens, Joseph Dalton Hooker, who, through such a comprehensive sample of island plants, gained early on a thorough understanding of island life (Hooker 1866). Such naturalistic data from the world's islands also shaped the Evolutionary Synthesis of the mid-20th century through Mayr 1963. The most influential work in the history of island biology is MacArthur and Wilson 1967, which details a theory of island biogeography. However, as argued by Midway and Hodge 2012, Sherwin Carlquist's work from the same time provided an alternative and maybe somewhat neglected framework for island biology (see Carlquist 1974, cited under General Overviews, Sherwin Carlquist's webpage Sherwin Carlquist's Plant Discoveries, cited under Island Conservation Biology, Carlquist 1980, cited under Polynesia, Carlquist 1966 and Carlquist 1967, both cited under Long-Distance Dispersal, and Carlquist, et al. 2003, cited under Macroevolution: Phylogenetics and Adaptive Radiations). The range of research approaches inspired by MacArthur and Wilson's theory of island biogeography in the first decades after publication is nicely illustrated through a special issue published as Bengtson and Enckell 1983. Islands have become a laboratory for studying (adaptive) radiations over longer time periods and rapid evolutionary change happening over scientifically observable timescales; David Lack's studies on birds initiated such work (Lack 1976). Further historical texts are reviewed in other sections, especially work from the 1970s in the sections on island biogeography and community assembly. The entries on "Darwin and Geological History," "Exploration and Discovery," "Voyage of the *Beagle*," and "Wallace, Alfred Russel" in Gillespie and Clague 2009 (cited under General Overviews) give further information on these aspects of the history of island biology. *Oxford Bibliographies* also includes separate entries on Charles Darwin and Alfred Russel Wallace.

Bengtson, Sven-Axel, and Pehr H. Enckell, eds. 1983. *Special issue: Island ecology. Oikos* 41:293–547.

This special issue, produced for the 20th anniversary of the classical MacArthur and Wilson paper on evolution, documents island research done in the first decades after the publication of the paradigmatic work by MacArthur and Wilson. It encompassed twenty-four articles by many of the most important island researchers at the time.

Darwin, Charles. 1859. *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. London: John Murray.

In addition to its fundamental relevance for modern evolutionary theory, Darwin's book discusses many core questions of island biology, including long-distance dispersal, disharmony, biogeography, invasive species, and evolution on islands. It also provides specific, early examples of island phenomena, such as flightlessness, woodiness, gigantism, dwarfism, altered dispersal syndromes, and high endemism.

Hooker, Joseph Dalton. 1866. *Insular floras*. Lecture delivered before the British Association for the Advancement of Science at Nottingham, UK, 27 August.

Lecture given by Hooker—at the time director of Royal Botanic Gardens in Kew—soon after the publication of Darwin's seminal work and illustrating the breadth and depth of knowledge about the origin and characteristics of insular biotas in the 19th century. Should be read together with other early biogeographic and naturalists' treaties of island biotas. Subsequently reprinted in four issues of the *Gardeners' Chronicle* in January 1867, and in various pamphlets.

Lack, David. 1976. *Island biology, illustrated by the land birds of Jamaica*. Oxford: Blackwell.

Published posthumously, this is Lack's most important work. Lack was one of the early proponents of in-depth studies of evolutionary processes shaping island faunas including Darwin's finches in the Galápagos. In a first part, the author summarizes his deterministic perspective of island colonization, exemplifying it with his outstanding knowledge of Jamaican land birds. The second part is focuses on the biology of the Jamaican and Caribbean avifauna.

MacArthur, Robert H., and Edward O. Wilson. 1967. *The theory of island biogeography*. Princeton, NJ: Princeton Univ. Press.

This is the foundation book of island biogeography and by far the most cited reference in the whole field of biogeography: it turned this discipline from a descriptive into a predictive one. Despite the fact that time has shown that several of its postulates were partial or incomplete, this text constituted the base of a research program that has inspired for over fifty years an outstanding development of the knowledge of the assembly of island biotas.

Mayr, Ernst. 1963. *Populations, species and evolution: An abridgment of animal species and evolution*. Cambridge, MA: Belknap.

Good summary of Ernst Mayr's work, one of the fathers of Evolutionary Synthesis and the integration of evolutionary biology and biogeography, which is crucial for understanding evolutionary processes on islands. The book is full of pedagogic examples about the origin of island biotas, including the use of concepts coined or developed by him, such as founder events or geographic speciation.

Midway, Stephen R., and Anne-Marie C. Hodge. 2012. Carlquist revisited: History, success, and applicability of a natural history model. *Biology and Philosophy* 27:497–520.

The article summarizes the twenty-four hypotheses put forward by Sherwin Carlquist through his foundational works in the 1960s and reviews research on these hypotheses since then. The authors discuss the theoretical framework of Carlquist as an alternative to the island biogeography model of MacArthur and Wilson for structuring island biology research. They characterize Carlquist's approach as being rooted in natural history as opposed to the generalized and mathematical models of MacArthur and Wilson.

Wallace, Alfred Russel. 2013. *Island life or the phenomena and causes of insular faunas and floras, including a revision and attempted solution of the problem of geological climates.* Foreword by David Quammen and introduction with commentary by Lawrence R. Heany. Chicago: Univ. of Chicago Press.

Originally published in 1880. Seminal book based on the vast knowledge about islands (especially in Southeast Asia) of one of the fathers of biogeography, presenting a classification of island types and biogeographic regions. These classifications are still largely valid, even though the importance of glaciation events or continental drift was unknown when the text was published. Excellent introductory text for students. See also Wallace 1872, cited under Southeast Asia and Wallace's other writings.

Journals

All major ecological, evolutionary, systematic, biogeographical, macroecological, and conservation journals publish island biological research. Due to the importance of islands for biogeography the *Journal of Biogeography* regularly publishes island research. *Atoll Research Bulletin* is specialized in research on atolls but there is today no specialized, international island biology journal. *Island Studies Journal* is focused on integrative studies of island issues with a social sciences focus. There are many local and regional island journals and newsletters; among these *Pacific Science*, *Caribbean Journal of Science* and *Oceania* (although with a focus on the cultural sciences) are listed in Web of Science. *Micronesica* is a starting point for information on Micronesia.

***Atoll Research Bulletin*.**

The *Atoll Research Bulletin* is issued by the Smithsonian Institution to provide an outlet for information on the biota of tropical islands and reefs and on the environment that supports their biota.

***Caribbean Journal of Science*.**

Publishes articles, research notes, and book reviews pertinent to the Caribbean region. The emphasis is on botany, zoology, ecology, conservation biology and management, geology, archaeology, and paleontology.

***Island Studies Journal*.**

Multidisciplinary journal with a main focus on geography, social sciences, and interdisciplinary island studies. Regularly publishes reviews of books and special issues in all research fields including island biology. The official journal of the International Small Islands Studies Association (ISISA) and RETI: The Network of Island Universities.

***Journal of Biogeography*.**

Established in 1973 and possibly the journal publishing the most island biology research, *Journal of Biogeography* publishes such research both in regular issues and through special issues such as: Volume 28 (Issue 11–12, 2001), Volume 29 (Issue 5–6, 2002), Volume 35 (Issue 6, 2008), Volume 36 (Issue 6, 2009), Volume 37 (Issue 6, 2010), and Volume 39 (Issue 11, 2012).

***Micronesica*.**

For fifty years this journal has published articles on the anthropology, botany, and zoology of Micronesia. The journal is open access.

***Oceania*.**

Publishes contributions in the field of social and cultural anthropology. Its primary regional orientation is to the peoples of Australia, Melanesia, Polynesia, Micronesia, and insular Southeast Asia.

***Pacific Science*.**

A quarterly, interdisciplinary journal established in 1947 and reporting on biological and physical sciences in the Pacific Basin.

Databases and Other Information Sources

Regularly updated information on island biology and island issues is available through a number of online databases and webpages. These are presented below in two subsections: one focused on information about island and conservation biology and another representing different island partnerships, networking actors, and experts on islands.

Island Conservation Biology

Island ecoregions of high conservation priority are documented on the Biodiversity Hotspots, WWF Ecoregions, and UNESCO World Heritage Sites webpages. The Threatened Island Biodiversity and Database of Island Invasive Species Eradications databases provide comprehensive information on ongoing conservation action on islands. Global Island Conservation Network is a list server for the global island conservationist and ecologist community, and many oceanic regions have their regional list servers. Many islands or archipelagos have their own information portals: of particular scientific interest might be the webpage that documents the recently formed Surtsey island. Currently no webpage exists that is dedicated to island biology, but the Sherwin Carlquist’s Plant Discoveries site gives an excellent overview of the work of this island biology pioneer.

Biodiversity Hotspots.

The biodiversity hotspot concept of Conservation International identifies world regions with a particularly important representation of world biodiversity, which include many oceanic island regions. These biodiversity hotspot areas are portrayed on the webpage and also in a coffee-table book. See Russell Mittermeier's *Hotspots Revisited* (Mexico City: Cemex, 2004), and for the conceptual background see Myers, et al. 2000, cited under Island Biodiversity.

Database of Island Invasive Species Eradications.

Compiles information on historical and current invasive vertebrate eradications on islands and makes this information available via a GIS-based interface. Data from each project includes information on the island, methods used in the eradication, and contact information for people knowledgeable about the eradication.

Global Island Conservation Network.

A list server for the global island conservationist and ecologist community that is moderated by Christoph Kueffer (ETH Zurich) with the technical support of Botanic Gardens Conservation International (BGCI). The list server was initiated at the fourth Global Botanic Gardens Congress in Dublin in June 2010.

Sherwin Carlquist's Plant Discoveries.

This pedagogic webpage summarizes the outstanding contribution of the author to island biology. The website includes, among others, sections dedicated to dispersal to islands, loss of dispersability on islands, evolution of tarweeds and silverswords, plant reproductive systems on islands, and secondary woodiness.

Surtsey.

This is the official webpage of the Surtsey Research Society, available in English and Icelandic. The new island, Surtsey, formed in the 1960s and for the past fifty years allowed scientists to study initial colonization of a new island in real time. The webpage presents information on the geological origin and the colonization processes of the marine and terrestrial zones.

Threatened Island Biodiversity Database (TIB).

The Threatened Island Biodiversity database is a comprehensive global review of IUCN-listed threatened species on islands. The TIB database includes information for thousands of islands and threatened species and makes this information available via a GIS-based interface.

UNESCO World Heritage Sites.

Includes descriptions of the many UNESCO World Heritage sites that are situated on islands, including, among others, the Aeolian Islands, Aldabra Atoll, Gough and Inaccessible Islands, Heard and McDonald Islands, Henderson Island, Lord Howe Islands, Macquarie Island, Phoenix Islands, Surtsey, and areas in the Canary Islands, Cuba, Dominica, Hawaii, Indonesia, Japan, La Réunion, Madagascar, New Zealand, Palau, Philippines, Seychelles, and Sri Lanka. Currently thirty-two UNESCO World Heritage sites are found in small island development states, which can be found online.

WWF Ecoregions.

Includes descriptions of many unique island ecosystems around the world.

Island Partnerships

Global Island Partnership, Small Island Developing States Network, and Alliance of Small Island States are three global networks that connect experts and policymakers involved in conservation and sustainable development on islands. Global Islands Network provides a comprehensive link directory and news service for island-related information.

Alliance of Small Island States.

The Alliance of Small Island States (AOSIS) is a coalition of small islands and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change. It functions primarily as an ad hoc lobby and negotiating voice for small island developing states (SIDS) within the United Nations system.

Global Island Partnership.

GLISPA is a voluntary partnership for islands to conserve and sustainably utilize island natural resources that support people, cultures, and livelihoods.

Global Islands Network.

Provides a comprehensive link directory and news service for island-related information.

Small Island Developing States Network.

The aims of SIDSnet are to track international meetings related to Small Island Developing States (SIDS), to contribute to filling gaps in data availability on sustainable development in SIDS, and to facilitate partnerships and motivate action in support of the sustainable development of SIDS.

Island Types

This article focuses on islands surrounded by ocean. These include volcanic islands (i.e., oceanic islands in a strict sense that formed through the accumulation of submarine magma and were never connected to continents), atolls (the last stage of a former tropical volcanic island now represented by only a coral reef), land-bridge islands (continental peninsulas that due to interglacial sea-level rise lost their connection to continents; e.g., Borneo), other islands on a continental shelf, and continental fragments or micro-continents (originally continental areas but now isolated in the ocean through continental drift, e.g., Madagascar or Seychelles). Volcanic islands can be further divided according to the type of volcanism. Seamounts rise from the seabed but do not reach the ocean's surface. They are important habitats for sea life, and some of them emerge above the ocean's surface in times of lower sea levels (e.g., during glaciation periods) and are therefore important for understanding dispersal via stepping stones. This article does not cover islands in freshwater bodies, islandlike isolated habitats on land such as mountaintops, or landscape fragments—although these are an important research focus in island biogeography. Definitions of island types can be found in Gillespie and Clague 2009 and Whittaker and Fernández-Palacios 2007 (both cited under General Overviews). Two reference books for information on different types of islands and their geology are Menard 1986 and Nunn 1994. Woodroffe and Biribo 2011 and articles in the *Atoll Research Bulletin* (cited under Journals) give more information on atolls. For short overviews see also entries on “Atolls,” “Barrier Islands,” “Continental Islands,” “Ephemeral Islands,” “Granitic Islands,” “Island Arcs,” “Makatea Islands,” “Motu,” “Seamounts,” and “Volcanic Islands” in Gillespie and Clague 2009 (cited under General Overviews).

Menard, William. 1986. *Islands*. New York: Scientific American.

Written by a volcanologist, this is a well-illustrated but somewhat dated book about the origin, characteristics, and ontogenetic stages of oceanic islands.

Nunn, P. D. 1994. *Oceanic islands*. Oxford: Blackwell.

A richly illustrated treatment of the physical geography of oceanic islands. The main focus is on the geological origin and development of islands and island landscapes over geological timescales. Effects of climate and sea level change are specifically addressed.

Woodroffe, C. D., and N. Biribo. 2011. Atolls. In *Encyclopedia of modern coral reefs: Structure, form and process*. Edited by D. Hopley, 51–71. Dordrecht, The Netherlands: Springer.

Comprehensive encyclopedia entry on the distribution, types, morphology, geology, hydrology, vegetation, and ecosystems of atolls.

Geography

Islands occur in all oceanic regions and at all latitudes, and their geological origins are diverse. As a result, there are no general physical characteristics of the islands of the world. There have been attempts to assemble global databases of physical characteristics such as climate, size, and isolation (Weigelt, et al. 2013; Weigelt and Kreft 2013). It is important to keep in mind that the geography of islands has changed repeatedly and strongly over geological timescales, as exemplified for high-elevation habitat on islands in Fernández-Palacios, et al. 2014. An introduction to the geology of islands can be found in Island Types, and more information on the abiotic factors characterising particular islands can be found in Oceanic Regions of the World.

Fernández-Palacios, J. M., R. Otto, C. Thebaud, and J. P. Price. 2014. Overview of habitat history in subtropical oceanic island summit ecosystems. *Arctic, Antarctic and Alpine Research* 46:801–809.

Discusses how different geological (related to the island ontogeny) or climatic (related to glacial cycles) processes may create or destroy summit environmental conditions in subtropical oceanic islands worldwide, as well as the consequences for mountain biotas on islands.

Weigelt, P., W. Jetz, and H. Kreft. 2013. Bioclimatic and physical characterization of the world’s islands. *Proceedings of the National Academy of Sciences USA* 110:15307–15312.

Presents a standardized data set for 17,883 of the world’s islands of more than one square kilometer (98 percent of total island area). The compiled variables are: area, temperature, precipitation, seasonality in temperature and precipitation, past climate change velocity, elevation, isolation, and past connectivity to other landmasses.

Weigelt, P., and H. Kreft. 2013. Quantifying island isolation: Insights from global patterns of insular plant species richness. *Ecography* 36:417–429.

Presents and discusses seventeen different ways of measuring isolation of islands and presents such data for 453 islands worldwide.

Oceanic Regions of the World

Islands can be found in all oceans on the planet and at all latitudes—and consequently in all climate zones. There exists no universally accepted definition of the oceanic regions of the world. Here we distinguish between twelve regions that we discuss in separate sections: Mediterranean Sea, Macaronesia (islands west of northern Africa in the North Atlantic), Caribbean Sea, Central Atlantic Islands, Pacific (including Micronesia and Japanese Islands, Melanesia, Polynesia, and East Pacific), Southeast Asia, Indian Ocean, Arctic Islands, and Subantarctic Islands.

Mediterranean Sea

The islands in the Mediterranean Sea between Africa, Europe, and the Middle East are characterized by a Mediterranean climate and a complex geological and paleoclimatic history, and they are a biodiversity hotspot (see Biodiversity Hotspots, cited under Island Conservation Biology). Although long inhabited by humans (several millennia ago), these islands still represent outstanding biodiversity with a high endemicity. Most of the Mediterranean islands are continental fragments (e.g., Balearic archipelago [Spain], Corsica [France], Sardinia and Sicily [Italy], Crete [Greece] and Cyprus, which is a special case because it is the result of a tectonic uplift of the Mediterranean seafloor and was never connected to the mainland). There are also some volcanic islands (e.g., Eolie [Italy] or Santorini [Greece]) and land-bridge islands (e.g., Djerba [Tunis], the Croatian island group in the Adriatic Sea, and the Aegean Islands [Greece]). Blondel, et al. 2010 gives a broad overview of the biodiversity of the region, while Cardona Pons, et al. 2013 adds more detailed information for the floras of the different islands. Feliner 2014 is a recent review of plant phylogenies that highlights the complexity of the regional biogeography. For short overviews see also entries on Mediterranean region, Cyprus, and Greek Islands in Gillespie and Clague 2009 (cited under General Overviews).

Blondel, Jacques, James Aronson, Jean-Yves Bodiou, et al. 2010. *The Mediterranean region: Biological diversity in space and time*. 2d ed. Oxford: Oxford Univ. Press.

Well written and easy to read, this book provides a rigorous overview of the biological diversity in the Mediterranean region, from the ocean to the highest mountaintops and from the islands to the surrounding continents. Highly recommended for scholars, students, and educated tourists.

Cardona Pons, Eva, Irene Estaún Clarisó, Mireia Comas Casademont, Pere Fraga i Arguimbau, eds. 2013. *Islands and plants: Preservation and understanding of flora on Mediterranean islands*. Maó, Spain: Institut Menorquí d'Estudis.

The product of the Second Botanical Conference held in Menorca in 2011, this volume includes seventeen chapters that analyze the floras of different Western Mediterranean islands groups (Balearics, Ionian, Malta, Hyeres, Tuscany, Sicily, Habibas, etc.). Several general chapters covering the flora of the whole region focus mainly on conservation issues.

Feliner, Gonzalo Nieto. 2014. Patterns and processes in plant phylogeography in the Mediterranean Basin: A review. *Perspectives in Plant Ecology, Evolution and Systematics* 16:265–278.

A recent review of plant phylogenetic information that highlights the complex biogeography of the region.

Macaronesia

The name Macaronesia is rooted in the Greek words *makarios* (happy) and *nesoi* (islands). It stands for a group of volcanic archipelagos located in the northeast Atlantic Ocean: Azores (Forjaz 2004; Trota and Pereira 2013), Madeira and the tiny archipelago of Selvagens (Sziemer 2005), Canary Islands (Kunkel 1976; Fernández-Palacios and Esquivel 2001), and Cape Verde (its endemic flora is analyzed in Brochmann, et al. 1997). These archipelagos share many biogeographic affinities through their geographical location between Europe, Africa, and North and South America and are therefore considered a biogeographical region (Juan, et al. 2000; Serrano, et al. 2010). For short overviews see also entries on “Atlantic Region,” “Azores,” “Canary Islands,” “Cape Verde Islands,” and “Madeira Archipelago” in Gillespie and Clague 2009 (cited under General Overviews).

Brochmann, C., O. H. Rustan, W. Lobin, and N. Kilian. 1997. The endemic vascular plants of the Cape Verde Islands, W Africa. *Sommerfeltia* 24:1–356.

One of the few texts about the Cape Verdian natural history. It summarizes the knowledge about the endemic vascular plants of the archipelago, including their insular distribution pattern and biogeographical and ecological affinities. Includes plates and taxonomic keys.

Fernández-Palacios, José María, and José Luis Martín Esquivel, eds. 2001. *Naturaleza de las Islas Canarias: Ecología y conservación*. Santa Cruz de Tenerife. Spain: Editorial Turquesa.

Comprehensive book in Spanish, divided into fifty chapters written by seventy-two specialists. Presents the early-21st-century state of knowledge about Canarian natural history, including geology, climatology, taxonomy, ecology, evolution, human impact, and conservation. Although somewhat dated, it is a must for students and scholars of this paradigmatic archipelago.

Forjaz, Victor H., ed. 2004. *Atlas Básico dos Açores*. Ponta Delgada, Portugal: Observatório Vulcanológico e Geotérmico dos Açores.

Indispensable introduction on the Azorean archipelago for scholars and students, with more than a hundred color pages including geographical, geological, climatological, floristic, faunistic, ecological, and human demography sections. In Portuguese but accessible for non-Portuguese speakers thanks to its many graphics.

Juan, Carlos, Brent C. Emerson, Pedro Oromí, and Godfrey M. Hewitt. 2000. Colonization and diversification: Towards a phylogeographic synthesis for the Canary Islands. *Trends in Ecology and Evolution* 15:104–109.

Interesting synthesis of the phylogeographic evidence accumulated up to the turn of the century about the Canarian plant, vertebrate, and invertebrate lineages and their insular and ecosystem distribution pattern along the archipelago. The roles of colonization pathways, vicariance, niche shift, adaptations and radiation are discussed and exemplified.

Kunkel, Günther, ed. 1976. *Biogeography and ecology in the Canary Islands*. The Hague: Dr. Junk.

Classic treatise on what was known in the 1970s about the terrestrial biodiversity and ecosystems of the Canary Islands. With seventeen chapters (one in Spanish), including chapters about anthropology and geology. Although dated, this book was a milestone for Canarian natural history.

Serrano, Artur R. M., Paulo A. V. Borges, Mário Boieiro, and Pedro Oromí, eds. 2010. *Terrestrial arthropods of Macaronesia: Biodiversity, ecology and evolution*. Lisbon, Portugal: Sociedade Portuguesa de Entomología.

Comprises sixteen chapters authored by leading researchers in Macaronesian biogeography and entomology discussing the biodiversity, ecology, evolution, and conservation of the arthropods of the region. The introduction gives an interesting overview of the biogeographic region.

Sziemer, Peter. 2005. *Madeira's natural history in a nutshell*. Funchal, Portugal: Francisco Ribeiro & Filhos.

An excellent introduction to the Madeiran natural history. Written in a pedagogic style and with plenty of color photographs illustrating the Madeiran and Selvagens archipelagos' geological origin, climate, biota, ecosystems, and protected areas. A German edition is also available.

Trota, Antonio Neves, and María Joao Pereira. 2013. *História Natural dos Açores*. 2d ed. Ponta Delgada, Portugal: Universidade dos Açores.

This recent book, written in Portuguese, is a nice introductory text to the Azorean archipelago. It is divided into two main parts, the first one dedicated to the geologic setting and origin of the islands and the second to the biotic colonization, in situ evolution and human settlement and its impact. Includes a glossary and the checklist of Azorean native plants and animals.

Caribbean Sea

The biogeographic region of the Caribbean Basin—stretching from North to South America east of Central America—consists essentially of three regions (together also called the West Indies or sometimes Antilles): the Greater Antilles (mostly continental fragment islands including the very large islands of Cuba and Hispaniola, and also Jamaica and Puerto Rico), Bahamas Banks (low-lying islands north of the Greater Antilles), and the Lesser Antilles (mostly volcanic islands; islands east of Puerto Rico that can be further divided into Leeward Islands and Windward Islands (e.g., Anguilla, Guadeloupe, Dominica, Martinique, and Grenada). Other islands in the Caribbean Basin include the Netherland Antilles and Trinidad and Tobago off the coast of Venezuela. A condensed introduction to the complex geology and biogeography of the region is given in Woods and Sergile 2001, Ricklefs and Bermingham 2008, Hedges 2006 and the entries on Antilles, and Trinidad and Tobago in Gillespie and Clague 2009 (cited under General Overviews). Brokaw, et al. 2012 provides an in-depth overview of the ecology of a tropical island forest ecosystem.

Brokaw, N., T. Crowl, A. Lugo, W. McDowell, F. Scatena, R. Waide, and M. Willig. 2012. *A Caribbean forest tapestry: The multidimensional nature of disturbance and response*. Oxford: Oxford Univ. Press.

Synthesizes over fifty years of intensive ecological research in the Luquillo Mountains of Puerto Rico. Provides a comprehensive description of the ecology of a tropical forest island ecosystem and focuses in particular on the role of disturbances, with some of them, such as hurricanes, of special importance to Caribbean island systems.

Hedges, S. B. 2006. Paleogeography of the Antilles and origin of West Indian terrestrial vertebrates. *Annals of the Missouri Botanical Garden* 93:231–244.

Overview of the biogeography of the terrestrial vertebrates of the Caribbean region.

Ricklefs, R., and E. Bermingham. 2008. The West Indies as a laboratory of biogeography and evolution. *Philosophical Transactions of the Royal Society of London B—Biological Sciences* 363:2393–2413.

Condensed but comprehensive overview of the geography, biogeography, and human history of the Caribbean region relating empirical patterns to theoretical concepts such as adaptive radiation or species-area relationships.

Woods, C. A., and F. E. Sergile. 2001. *Biogeography of the West Indies: Patterns and perspectives*. 2d ed. Boca Raton, FL: CRC.

The first four chapters give broad overviews of the biodiversity and biogeography of the Caribbean region. Subsequent chapters are mostly restricted to particular island groups or taxonomic groups.

Central Atlantic Islands

This section discusses islands that are scattered across the central Atlantic Ocean from east of the Caribbean Sea to the coast of

Africa, and from south of the Macaronesian region to north of the Subantarctic islands (i.e., north of Tristan da Cunha). Islands of particular importance for island biology are the two isolated British islands Ascension and St. Helena (Ashmole and Ashmole 2000), and the Gulf of Guinea archipelago that includes Sao Tomé and Príncipe (an independent republic) and Bioko and Annobón (belonging to Equatorial Guinea) (Fa and Juste 1994). This island group belongs to the Mount Cameroun biodiversity hotspot (see Biodiversity Hotspots, cited under Island Conservation Biology). Bioko was connected to mainland Africa during the last glacial maximum, which explains its richer biota. An interesting but lesser known island group is Martín Vaz and Trindade islands belonging to Brasil (Válka Alves 1998). For short overviews see also entries on Atlantic Region, Ascension, Bermuda, Fernando de Noronha, St. Helena, and Sao Tomé, Principe, and Annobon in Gillespie and Clague 2009 (cited under General Overviews).

Ashmole, and Ashmole. 2000. *St. Helena and Ascension islands: A natural history*. Oswestry, UK: Anthony Nelson.

A splendid introduction to the natural history of these two British dependencies with information on their physical environments, major habitats, biota, human history, and conservation challenges.

Fa, John, and Javier B. Juste, eds. 1994. *Special issue: Biodiversity conservation in the Gulf of Guinea Islands*. *Biodiversity and Conservation* 3:757–968.

Compiles sixteen contributions from a workshop held at the Jersey Wildlife Preservation Trust in June 1993. The workshop reviewed the state of knowledge on species richness and endemism in the islands and identified issues that threaten the conservation of the islands' unique fauna and flora.

Válka Alves, Ruy José. 1998. *Ilha da Trindade & Arquipélago Martin Vaz: Um Ensaio Geobotânico*. Río de Janeiro: Servico de Documentacão da Marinha.

Geobotanical approach to the knowledge of this interesting Brazilian oceanic group located in the middle of the Atlantic Ocean. The chapters cover geography, climate, geology, soils, pristine and current vegetation, as well as an annotated checklist of the vascular plants and fauna. In Portuguese.

Wilkinson, D. M. 2004. The parable of Green Mountain: Ascension Island, ecosystem construction and ecological fitting. *Journal of Biogeography* 31:1–4.

Introduces secondary cloud forest on Green Mountain (Ascension Island) as an example of a man-made but self-organized ("wild") ecosystem. One of the first articles that discussed ideas that are now often subsumed under the keyword "novel ecosystem."

Pacific

The Pacific is the largest ocean, has tens of thousands of islands, and has played a key role in island biology research. Pacific-based studies can be found under virtually all general entries in this document. Concise information on Pacific-focused topics can also be found in Gillespie and Clague 2009 (cited under General Overviews) (e.g., for Polynesian voyaging and ethnobotany). Mueller-Dombois and Fosberg 1998 (cited under Vegetation Zonation) is a valuable background reference that provides tremendous detail on the plant communities and physical environments of all the Pacific islands, with much of the information being drawn from original sources that are not otherwise readily available. Keast and Miller 1996 and Trewick and Cowie 2008 give excellent and wide-ranging overviews of patterns of biogeographic and evolutionary diversity across a wide range of taxa and islands in the Pacific. Gillespie, et al. 2013 is an example of a comparative, multi-archipelago study that stretches across several of the Pacific Ocean's regions. Finally, the BBC documentary *Wild Pacific* is an excellent visual exploration of the geography, biodiversity, and ecological and evolutionary processes that have shaped the biota of the Pacific islands. Subsections review more specific literature about different regions of the Pacific: Micronesia and Japanese islands, Melanesia, Polynesia, and East Pacific.

BBC. 2009. *South Pacific*. DVD. London: BBC.

Exceptional collection of six TV episodes available in several languages and accessible to viewers of all backgrounds. Deals with the volcanic origin, biotic colonization, bizarre life forms, and human settlement of the South Pacific islands, from Macquarie to Hawaii.

Gillespie, Thomas W., Gunnar Keppel, Stephanie Pau, Jonathan P. Price, Tanguy Jaffre, and Kristin O'Neill. 2013. Scaling species richness and endemism of tropical dry forests on oceanic islands. *Diversity and Distributions* 19:896–906.

Of interest to researchers and conservation managers. This study is exemplary for its use of consistent field methodology to collect data on dry forests from New Caledonia, Fiji, Marquesas, Marianas, and Hawaii, which are then compared on the basis of features such as species richness, endemism, and rarity.

Keast, A., and S. E. Miller, eds. 1996. *The origin and evolution of Pacific Island biotas, New Guinea to eastern Polynesia: Patterns and processes*. Amsterdam: SPB Academic.

A compilation of twenty-eight review papers directed at professionals. Geology, biogeography, and evolution are examined across a broad diversity of islands. A balanced range of taxa, including plants, invertebrates, and vertebrates are treated.

Trewick, Stephen A., and Robert H. Cowie, eds. 2008. *Special issue: Evolution on Pacific islands: Darwin's legacy*. *Philosophical Transactions of the Royal Society B* 363:3287–3465.

A compilation of fifteen review papers and primary research of use to professionals. A broad diversity of islands and taxa are examined, with invertebrates, especially terrestrial mollusks and arthropods, particularly well represented.

Micronesia and Japanese Islands

Under this heading the islands of the western rim of the Pacific Ocean, south of Japan, east of the Philippines and north of New Guinea are included. Aside from the main Japanese islands, these archipelagos are characterized by the small land areas of their islands (*micro* meaning small and *nesos* meaning islands in ancient Greek, although some atolls can be large), among them outlying Japanese islands such as Bonin (Ogasawara), the Marianas (split into the volcanic northern Marianas and the andesitic southern ones, including Guam, a US dependence), and the independent states of Palau, Carolinas (today the Federated States of Micronesia), the Marshall Islands (a set of large atolls), the Gilbert Islands (belonging to Kiribati), Nauru, and Tuvalu. Vegetation on Micronesian islands is described in Mueller-Dombois and Fosberg 1998 (cited under Vegetation Zonation). The natural history of Guam is documented in Cunningham and Beaty 2001. The Ogasawara (Bonin) islands have received considerable attention both from research and management perspectives (Kawakami and Okochi 2010). A good starting point for information on the region is the journal Micronesica, cited under Journals. For short overviews see also the entries "Caroline Islands," "Japan's Islands," "Marianas," "Marshall Islands," "Palau," and "Taiwan" in Gillespie and Clague 2009 (cited under General Overviews).

Cunningham, Lawrence, and Janice J. Beaty. 2001. *Guam: A natural history: A thorough introduction to the land, resources, and communities of Guam and Micronesia*. Honolulu, HI: Bess.

Written for elementary school students, the book provides a general introduction to the geography and human history of Guam and other islands in Micronesia.

Kawakami, Kazuto, and Isamu Okochi, eds. 2010. *Restoring the Oceanic Island ecosystem: Impact and management of invasive alien species in the Bonin Islands*. Berlin: Springer.

The edited book mostly focuses on invasive species management in the Bonin Islands, but an introductory chapter gives a general overview of the geography, biology, and human history of the islands.

Melanesia

Stemming from the ancient Greek words *melas* for black and *nesos* for islands, the term “Melanesia” refers to the West Pacific Islands inhabited by the Melanesian people. Among them are New Guinea (shared between Indonesia and Papua New Guinea, it is the largest island of the world if Greenland, actually formed by several islands united by an ice cap, is not considered), New Britain and New Ireland and its satellites (all part of Papua New Guinea), the Solomons, Vanuatu and Fiji (all independent countries), and New Caledonia, which is a French territory. During the Last Glacial Maximum (LGM) New Guinea was connected to Australia and together with Australia and Tasmania formed part of the Sahul Pleistocene continent. New Guinea is putatively the island with the best-preserved natural environment (Marshall and Beehler 2007), and it is still poorly studied. In contrast, New Caledonia, a Gondwanan fragment, has been widely studied (Grandcolas, et al. 2008). For Fiji (Ryan 2000) and the largest island of Vanuatu, Espiritu Santo (Bouchet, et al. 2011), natural histories have also been published. Although not belonging to Melanesia, the Australian dependencies of Norfolk and Lord Howe are included here. Lord Howe has become a model system for studying sympatric speciation (see Savolainen, et al. 2006, cited under Microevolution: Evolution in Action). For short overviews see also entries on Fiji, Lord Howe Island, New Caledonia, New Guinea, Solomon Islands, and Vanuatu in Gillespie and Clague 2009 (cited under General Overviews).

Bouchet, P., H. Le Guyader, and E. Pascal, eds. 2011. *The natural history of Santo*. Paris: Muséum National d’Histoire Naturelle.

Espiritu Santo is the largest and highest island in Vanuatu and is an extraordinary geographical and cultural microcosm, combining reefs, caves, mountains, satellite islands, and a history of human habitation going back three thousand years. With contributions by more than a hundred authors, *The Natural History of Santo* is an illustrated homage to the biodiversity of this unique island.

Grandcolas, P., J. Murienne, T. Robillard, L. Desutter-Grandcolas, H. Jourdan, E. Guilbert, and L. Deharveng. 2008. New Caledonia: A very old Darwinian island? *Philosophical Transactions of the Royal Society B: Biological Sciences* 363:3309–3317.

A review of the geological history and phylogenetic studies of New Caledonia. Demonstrates the complex history of this island’s rich biota. They argue that New Caledonia was once completely submerged and that the biota of this Gondwanan relict formed through a series of re-colonization and local diversification events.

Marshall, Andrew J., and Bruce M. Beehler. 2007. *The ecology of Papua, Part One and Part Two*. Singapore: Periplus.

A comprehensive two-volume guide to the ecology and natural history of Papua New Guinea, covering the physical environment, flora, fauna, natural ecosystems, human interactions with nature, and the conservation of natural resources.

Ryan, Paddy. 2000. *Fiji’s natural heritage*. Auckland, New Zealand: Exilse.

Written for a general audience, this book provides an introduction to the flora, fauna, and ecology of the Fiji Islands. This is the revised and expanded version of a book first published in 1988.

Polynesia

Considered here under this name (*poly* for multiple and *nesos* for islands) is a set of archipelagos (including both high islands and atolls) located in the middle of the Pacific Ocean in both hemispheres, within a triangle connecting New Zealand, Hawaii, and Rapa Nui. Polynesian archipelagos include New Zealand, Tuvalu, Kiribati, Tonga, and Samoa, all of them independent countries. Also considered are New Zealand's associated islands (Cook Islands and Niue), the French territories of Wallis and Futuna and French Polynesia (a meta-archipelago including the Society, Austral [see Meyer and Claridge 2014], Gambier, Tuamotu, and Marquesas archipelagos), the British territory of Pitcairn, the Chilean islands of Rapa Nui and Salas y Gómez, and finally, the US State of Hawaii (Carlquist 1980, Ziegler 2002), including the leeward chain extending from Kauai to the Kure atoll (Rauzon 2001), plus other dependencies (Johnston, Palmyra, Kingsman Reef, etc.). All these archipelagos share a volcanic origin (with the outstanding exception of Aotearoa/New Zealand and Chatham, which formed part of Zealandia, a sunken Gondwanaland fragment, dealt with in Gibbs 2006) and a common ethnic group, the Polynesians. Despite its modest area (with the exception of New Zealand), the contribution of Polynesia to the earth's biodiversity is outstanding, with a high level of endemicity on the high islands. For short overviews see also entries on "Cook Islands," "Easter Island," "French Polynesia," "Hawaiian Islands," "Honeycreepers," "Midway," "Pitcairn," "Samoa," "Silverswords," and "Tonga" in Gillespie and Clague 2009 (cited under General Overviews).

Carlquist, S. 1980. *Hawaii: A natural history*. 2d ed. Lawai, HI: Pacific Tropical Botanical Garden.

Though somewhat dated, this classic book remains an insightful introduction to the geology, geography, climate, and especially the flora and fauna of Hawaii for lay readers or undergraduates.

Gibbs, G. 2006. *Ghosts of Gondwana: A history of life in New Zealand*. Nelson, New Zealand: Craig Potton.

Summarizes the historical biogeography of New Zealand for scientists and educated laypersons. Gibbs uses techniques ranging from palaeontology to molecular biology to examine the origin and evolution of New Zealand's unique biota. Significant attention is given to birds, reptiles, amphibians, many invertebrates, and plants.

Meyer, Jean-Yves, and Elin M. Claridge, eds. 2014. *Terrestrial biodiversity of the Austral Islands (French Polynesia)*. Chicago: Univ. of Chicago Press.

As part of a research program aiming to inventory and evaluate the terrestrial biodiversity of French Polynesia, a series of scientific expeditions were conducted to the five inhabited Austral Islands—Raivavae, Rapa, Rimatara, Rurutu, and Tubuai—at the southernmost tip of French Polynesia. This edited book contains the findings of those expeditions.

Rauzon, M. 2001. *Isles of refuge: Wildlife and history of the Northwest Hawaiian Islands*. Honolulu: Univ. of Hawaii Press.

Introduces the general public to the islands, designated in 2006 as the Papahānaumokuākea Marine National Monument. The book combines personal narrative, excellent photos, and the geological, human, and, especially, the natural history of low-lying northwest Hawaiian Islands.

Ziegler, A. C. 2002. *Hawaiian natural history, ecology, and evolution*. Honolulu: Univ. of Hawaii Press.

A step-by-step overview, including geology, climatology, ecosystems, biota, and ecological and evolutionary processes. Though oversimplified in some respects, this is a thorough, well-illustrated introduction to Hawaii for undergraduates or educated laypersons.

East Pacific

In this region we include volcanic islands located in the eastern part of the Pacific Ocean relatively close to the North, Central, or South American coasts. From north to south the following island groups can be found: Californian Farallón and Channel Islands (with a complex tectonic-volcanic origin, see Schoenherr, et al. 2003); Mexican islands of Guadalupe, Marías, and Revillagigedo; islands of the Sea of Cortés (see Case, Cody and Ezcurra 2002), Clipperton atoll (see Charpy 2009); Malpelo Island (Colombia); Coco Island (Costa Rica); the Galápagos (see Walsh and Mena 2013 and Nicholls 2014); and the Chilean islands of Las Desventuradas and the Juan Fernández archipelago. All of them are characterized by their valuable biodiversity despite (with the

Desventuradas and the Juan Fernández archipelago. All of them are characterized by their valuable biodiversity despite (with the exception of Galápagos) their small area, and were not inhabited until the arrival of the Europeans (except for the Californian Channel Islands). For short overviews see also entries on Baja California, Channel Islands (California), Farallón Islands, Galápagos Finches, Galápagos Islands, and Juan Fernández Islands in Gillespie and Clague 2009 (cited under General Overviews).

Bernardello, G., G. J. Anderson, T. F. Stuessy, and D. J. Crawford. 2006. The angiosperm flora of the Archipelago Juan Fernández (Chile): Origin and dispersal. *Canadian Journal of Botany* 84:1266–1281.

Reviews the origin and evolution of the reproductive characteristics of the flora of Juan Fernández, a tiny volcanic archipelago in the Pacific Ocean belonging to Chile. Pays special attention to the evolution of dispersal.

Case, Ted, Martin Cody, and Exequiel Ezcurra, eds. 2002. *Island biogeography in the Sea of Cortés*. Oxford: Oxford Univ. Press.

Twenty years after the original publication of a book with the same name, Case and coeditors have published a new version of the biogeography of islands of the Sea of Cortés (also known as the Gulf of California). The book introduces the physical, biological, and human aspects of these islands.

Charpy, Loïc, ed. 2009. *Clipperton: Environnement et biodiversité d'un microcosme océanique*. Paris: Publications Scientifiques du Museum NHN.

Comprehensive edited volume with thirty contributions on the terrestrial and marine biodiversity as well as the environmental characteristics of this large French atoll, located halfway between French Polynesia and Mexico. The book is the result of a scientific expedition that took place in 2005. Written in French.

Nicholls, Henry. 2014. *The Galápagos: A natural history*. New York: Basic Books.

There are countless books about the Galápagos Islands. This is written by the editor of *Galápagos Matters*, a biannual magazine for the Galápagos Conservation Trust. The book builds on narratives and anecdotes and has only a few pictures; however, it is rich in information and covers diverse topics from volcanism to conservation.

Schoenherr, A. A., C. R. Feldmeth, and M. J. Emerson. 2003. *Natural history of the islands of California*. Berkeley: Univ. of California Press.

This comprehensive book discusses both the human and the natural history of the islands of California, including all eight Channel Islands, Año Nuevo, the Farallons, and the islands of San Francisco Bay.

Walsh, Stephen J., and Carlos F. Mena, eds. 2013. *Science and conservation in the Galápagos Islands*: *Social and ecological interactions*. Berlin: Springer.

This is the first volume of the Springer series. The first chapter gives a good overview of past and present research and conservation in this hotspot of island biology research. The other chapters focus mostly on social aspects and conservation challenges with a growing population in this World Heritage Site.

Southeast Asia

This region embraces a series of large land-bridge islands straddling the Indian and west Pacific oceans that constitute the most biodiverse region in the world. Corlett 2014 is a good starting point for learning about the region, and Gower, et al. 2012 introduces regional research. Wallace 1872 is a classic text about the island biology of Southeast Asia. The huge Indonesian archipelago includes more than eighteen thousand islands, with several of the largest islands in the world, among them Sumatra, Java, Sulawesi, Borneo (shared among Indonesia, Malaysia, and Brunei) (see Göltenboth, et al. 2006). Finally, the volcanic Philippines archipelago encompasses some seven thousand islands (Heaney and Regalado 1998). Many islands in both archipelagos were connected to the Asian continent when sea level was lower during the last glacial maximum, and this is reflected in their biogeography. For short overviews, see also entries on "Borneo," "Indonesia," "Komodo Dragons," "Philippines," and "Wallace's Line" in Gillespie and Clague 2009 (cited under General Overviews).

Corlett, R. T. 2014. *The ecology of tropical east Asia*. 2d ed. Cambridge, UK: Cambridge Univ. Press.

Updated second edition of a textbook that introduces the geography, biogeography, and plant, animal, and ecosystem ecology of subtropical and tropical East Asia from southern China to western Indonesia.

Göltenboth, Friedhelm, Kris H. Timotius, Paciencia Po Milan, and Josef Margraf, eds. 2006. *Ecology of Insular Southeast Asia: The Indonesian Archipelago*. Philadelphia, PA: Elsevier.

An introduction to the different habitats of the Indonesian archipelago, covering marine, freshwater, terrestrial, and agricultural ecosystems. Introductory chapters treat the geography and climate of the archipelago, while concluding chapters focus on social factors.

Gower, D., K. Johnson, J. Richardson, B. Rosen, L. Rüber, and S. Williams, eds. 2012. *Biotic evolution and environmental change in Southeast Asia*. Cambridge, UK: Cambridge Univ. Press.

This edited volume provides an overview of 21st-century research on the paleogeography, biogeography, and conservation biology of Southeast Asia.

Heaney, L. R., and J. C. Regalado Jr. 1998. *Vanishing treasures of the Philippine rain forest*. Chicago: Field Museum.

Introduces the flora and fauna of the Philippines' rainforests to a general audience.

Wallace, Alfred Russel. 1872. *The Malay Archipelago*. London: Macmillan.

A detailed account of the physical and human geography and biology of Southeast Asia based on Wallace's extensive travels in the region. The book is a foundational work of biogeography, modern evolutionary theory, and island biology. Available online in English and German together with Wallace's other writings.

Indian Ocean

The Indian Ocean is a diverse region stretching from the east coast of Africa to Australia and from India to Subantarctic islands such as Crozet or Kerguelen. The region is characterized by a tightly linked regional biogeography that involves the mini-continent Madagascar and its low lying satellites, continental fragment islands of the Seychelles, different coralline island groups (including Aldabra atoll, which is dominated by giant tortoises), the oceanic Comoros (Grand Comoro, Moheli, Anjouan and Mayotte [a French dependence]) and the Mascarenes (La Réunion, a French overseas department, Mauritius, Rodrigues), the dry islands of Socotra with its satellites, Sri Lanka and Andaman and Nicobar south of India, and a number of islands west of Australia (e.g., Christmas Island). For a recent overview of the biogeography of the region see Warren, et al. 2010, cited under Island Paleobiogeography. Madagascar is covered by Goodman and Benstead 2004, Socotra by Brown and Mies 2012, Seychelles by Stoddart 1984, and the Mascarenes by Checke and Hume 2008. For short overviews see also the entries "Indian Region," "Comoros," "Dodo," "Madagascar," "Maldives," "Mascarene Islands," "Seychelles," "Socotra Archipelago," "Sri Lanka," and "Zanzibar" in Gillespie and Clague 2009 (cited under General Overviews).

Brown, Gary, and Bruno A. Mies. 2012. *Vegetation ecology of Socotra*. Berlin: Springer.

Most comprehensive treatment available to date on the geography, geology, ecology, vegetation, and flora of the Socotra archipelago. Socotra is a group of dry climate islands near the Horn of Africa, and nowadays it is also a World Heritage Site.

Checke, and Hume. 2008. *Lost land of the Dodo: An ecological history of Mauritius, Réunion and Rodrigues*. New Haven: Yale Univ. Press.

Comprehensive treatment of the palaeocology, human history, and ecology of the Mascarenes Islands (La Réunion, Mauritius, and Rodrigues). The most complete overview available to date for these islands, famous for their flightless giant pigeons (dodo, solitaire). More generally, this is an informative review of different phases of human impacts on island ecosystems, from early settlements and opportunistic exploitation to colonial plantation systems.

Goodman, S. M., and J. P. Benstead. 2004. *The natural history of Madagascar*. Chicago: Univ. of Chicago Press.

Comprehensive encyclopedia on the natural history of Madagascar.

Stoddart, D. R., eds. 1984. *Biogeography and ecology of the Seychelles Islands*. Monographiae Biologicae. The Hague and Boston: W. Junk.

Although dated, this is still the most comprehensive reference book for the ecology and biogeography of the Seychelles. It treats both the Coralline Islands (in particular Aldabra atoll, now a World Heritage Site) and the granitic and main inhabited islands, which are old continental islands of Gondwanan origin.

Arctic Islands

The Arctic Islands (reviewed in Dowdeswell and Hambrey 2002) consist of land-bridge islands (Canadian Arctic Archipelago, Greenland, Svalbard, Franz Josef Islands, Novaya Zemlya, Novosibirskiye Islands, Severnaya Zemlya, and Wrangel Islands), together with some oceanic ones, such as Iceland, Faroe, and Jan Mayen, plus two volcanic arcs, Aleutian and Kuril (see Collins, et al. 1945 and Pietsch, et al. 2003, respectively). All of them, independently of their geological origin, share a species-poor biota and environments dominated by ice and very low temperatures. Due to the geographic configuration of the Arctic, these islands also share a number of widely distributed species (Alsos, et al. 2015). For short overviews see also the entries “Arctic Islands,” “Arctic Region,” “Atlantic Region,” “Baffin,” “Faroe Islands,” “Kurile Islands,” “Newfoundland,” “Spitsbergen,” “Surtsey,” and “Warming Island” in Gillespie and Clague 2009 (cited under General Overviews).

Alsos, Inger Greve, Dorothee Ehrich, and Pernille Bronken Eidesen, et al. 2015. Long-distance plant dispersal to North Atlantic islands: Colonization routes and founder effect. *AoB PLANTS* 7:plv036.

Interesting account of the different ways a selected group of northern-latitude angiosperm plants have colonized the arctic islands, arriving from temperate sources or even arctic refugia since the last glaciation.

Collins, H. B., Jr., A. H. Clark, and E. H. Walker. 1945. *The Aleutian Islands: Their people and natural history (with keys for the identification of birds and plants)*. Washington, DC: Smithsonian Institute.

Classic book about this far-north volcanic arc. It covers the geography, plant and animal life (including taxonomic keys), and human life on the archipelago, together with interesting white and black plates.

Dowdeswell, Julian, and Michael Hambrey. 2002. *Islands of the Arctic*. Cambridge, UK: Cambridge Univ. Press.

Indispensable text for anyone interested in the Arctic Islands. Mainly focused on physical geography, the book includes ten chapters dedicated to their geography, evolution, climate, glaciers, icebergs, frost, coasts, rivers and lakes, biota, indigenous people and their future, as well as many maps and color photos.

Pietsch, Theodore W., Victor V. Bogatov, and Kunio Amaoka, et al. 2003. Biodiversity and biogeography of the islands of the Kuril Archipelago. *Journal of Biogeography* 30:1297–1310.

Interesting overview of the natural history of this lesser known volcanic arc produced by a group of Russian, Japanese, and American researchers. It includes an introduction to its palaeogeography and a biogeographical analysis based in the distribution patterns of the native vascular plants and invertebrates and their Kamchatkan vs. Japanese affinities.

Subantarctic Islands

Subantarctic islands are a heterogeneous set of islands and island groups with different geological origins located in the south of the Atlantic, Indian, and Pacific oceans. These islands are characterized by a species-poor terrestrial biota but have an outstanding marine biota, including seals, seabirds, and penguins that profit from a nutrient-rich sea environment. From west to east, the region includes Falkland (land-bridge islands), South Georgia (microcontinent), and South Sandwich (archipelagic arc), all of which are British Overseas Territories; Prince Edward Island and Marion (volcanic islands), belong to South Africa; Bouvet Island is a volcano covered by ice (Norway); Crozet is a volcanic archipelago, and Kerguelen is a microcontinent (French Overseas Territories); Heard, MacDonald (volcanic), and Macquarie (continental) are administrated by Australia, and the New Zealand subantarctic islands (Snares, Campbell, Auckland, Bounty, and Antipodes) are all based on continental crust (see Peat 2003). Also included in this zone are Gough, and the small archipelago of Tristan da Cunha, composed of Tristan itself and the islets of Inaccessible and Nightingale (Ryan 2007) that are a bit farther to the north in the Atlantic. With the exception of Falkland and Tristan da Cunha, the islands are either totally uninhabited, or have only research or military stations on them. For general references see Riffenburgh 2007, and for more information on the biology and conservation challenges of these islands consult Bergstrom, et al. 2006. Short overviews are also provided by the entries on “Antarctic Islands,” “Atlantic Region,” and “Tristan da Cunha and Gough Island” in Gillespie and Clague 2009 (cited under General Overviews).

Bergstrom, D. M., P. Convey, and A. H. L. Huiskes, eds. 2006. *Trends in Antarctic Terrestrial and Limnetic Ecosystems*. Berlin: Springer.

An introduction to the geography and biota of Antarctic habitats, and especially of future global change threats such as climate change or invasive species.

Peat, Neville. 2003. *Subantarctic New Zealand: A rare heritage*. Wellington, New Zealand: Department of Conservation.

Beautiful introduction to the natural history of New Zealand’s Subantarctic archipelagos (Snares, Campbell, Auckland, Bounty, and Antipodes), all of them protected natural areas. Includes several maps and many color pictures.

Riffenburgh, Beau, ed. 2007. *Encyclopedia of the Antarctic*. 2 vols. New York: Routledge.

A comprehensive reference for Antarctica including its islands.

Ryan, Peter G., ed. 2007. *Field Guide to the Animals and Plants of Tristan da Cunha and Gough Island*. Newbury, UK: Pisces.

Useful guide to the biota of southern Atlantic islands, containing good descriptions and color photos of flowering and non-flowering

Useful guide to the biota of southern Atlantic islands, containing good descriptions and color photos of flowering and non-flowering plants, fungi, birds, marine and terrestrial mammals, terrestrial invertebrates, and marine life, plus a general description of the environment and conservation problems.

Island Biogeography

Islands have been models for developing a theoretical understanding of the distribution of species among isolated land fragments, whether these are islands in an ocean, a lake, or are habitat islands. Of pivotal importance was the development of the Equilibrium Theory of Island Biogeography (ETIB) by MacArthur and Wilson in the 1960s (see Historical Accounts and Foundational Works). The research triggered by the ETIB is extensively treated in the *Oxford Bibliographies* entry Island Biogeography Theory. Here we focus on work that tested the ETIB on islands or expanded in ways that attempted to better capture the real-world complexities of islands and their biotas, as well as the underlying geographical, historical, ecological, and evolutionary causes. A classical experimental test of ETIB involving islands is Simberloff and Wilson 1970. Cody 2006 summarizes long-term work on real islands in a tiny archipelago off Vancouver Island. Lomolino and Brown 2009 reviews the history of island biogeographical research. For a review of recent developments in island biogeography see Fernández-Palacios, et al. 2015. Lowry 2004 and Leigh, et al. 2007 are two general overviews of the distribution of biodiversity on islands and its causes. There are two subsections here that present some early-21st-century attempts to make island biogeography more realistic and discuss the key question of long-distance dispersal, respectively. A comprehensive introduction to island biogeography is given in Whittaker and Fernández-Palacios 2007 (cited under General Overviews). See also entry on Island Biogeography Theory in *Oxford Bibliographies* and entry on “Island Biogeography” in Gillespie and Clague 2009 (cited under General Overviews).

Cody, Martin. 2006. *Plants on islands. Diversity and dynamics of a continental archipelago*. Berkeley: Univ. of California Press.

Summarizes a thirty-year analysis of species turnover on different islets in a tiny archipelago off Vancouver Island. Due to its continental origin and proximity, frequent immigration and extinction processes produced high species turnover as expected by the Equilibrium Theory of Island Biogeography (ETIB).

Fernández-Palacios, José María, Christoph Kueffer, and Donald R. Drake. 2015. A new golden era in island biogeography. *Frontiers of Biogeography* 7.1: 14–20.

Review of recent developments in island biogeography. The authors argue that, in particular, three developments may lead to new dynamism and breakthroughs in the field. First, new information from the geosciences, phylogenetics, and paleoecology provides an increasingly more realistic understanding of the geological and biological development of island biotas. Second, available data cover increasingly more taxonomic groups and islands. Third, new theoretical and methodological advances enable increasingly integrative and comprehensive analyses.

Leigh, Egbert Giles, Jr., Annette Hladik, Claude Marcel Hladik, and Alison Jolly. 2007. The biogeography of large islands, or how does the size of the ecological theatre affect the evolutionary play? *Revue d’Ecologie: La Terre et la Vie* 62:105–168.

Provides an interesting comparison of the biotas of old islands (focusing on three microcontinents of Gondwanan origin: Madagascar, New Zealand, and New Caledonia) with isolated but younger volcanic islands (especially the Hawaiian Islands).

Lomolino, Mark V., and James H. Brown. 2009. The reticulating phylogeny of island biogeography theory. *Quarterly Review of Biology* 84:357–390.

A historical and conceptual account of how island biogeography has advanced in the second half of the last century from four independent discoveries and formulations to their final integration in the 1960s into the paradigm that ruled the field thereafter for four decades.

Lowry, Porter P. II. 2004. Patterns of species richness, endemism, and diversification in oceanic island floras. In *Oceans and aquatic ecosystems*. Edited by Eric Wolanski, 1–15. Encyclopedia of Life Support Systems (EOLSS). Oxford: UNESCO.

Excellent introduction to the origin, endemicity patterns, and features of oceanic island floras, including relevant examples from island groups worldwide. Appropriate text for introducing island biogeography, ecology, and evolution of island plants to students.

Simberloff, Daniel, and Edward O. Wilson. 1970. Experimental zoogeography of islands. A two-year record. *Ecology* 51:934–937.

This article reports results of the first attempt to experimentally test the Equilibrium Theory of Island Biogeography (ETIB) with mangrove islets differing in size and isolation in the Florida Keys, which were first sterilized and then monitored for colonization and community assembly for two years.

Toward a Modern Theory of Island Biogeography

Calls for a new paradigm in island biogeography are well represented by Whittaker, et al. 2000 and Heaney 2007. Whittaker, et al. 2008 was an attempt to include geological changes in a mathematical form of island biogeography theory. For more conceptual and database analyses of the role of island history for island biotas see Geography. Rosindell and Phillimore 2011 presents a model that incorporated in situ speciation, and Bellemain and Ricklefs 2008 reviews the evidence of (re-)colonizations of continents from islands. Borregaard, et al. 2015 and Fernández-Palacios, et al. 2015 attempt to provide a unified framework for island biogeography, integrating geological, ecological, and evolutionary processes. A broad overview of these and other new developments in island biogeography is available through Losos and Ricklefs 2010.

Bellemain, Eva, and Robert E. Ricklefs. 2008. Are islands the end of the colonization road? *Trends in Ecology and Evolution* 23:461–468.

Challenges the idea that islands are evolutionary dead ends for species based on a growing phylogeographic literature. According to recent studies, islands might have regularly served as climatic refugia from which back colonization of continents happened.

Borregaard, M. K., T. J. Matthews, and R. J. Whittaker. 2015. The general dynamic model: Towards a unified theory of island biogeography? *Global Ecology and Biogeography*.

A worthy contribution that highlights the potentials of the General Dynamic Model for providing a unified framework for island biogeography, integrating geological, ecological, and evolutionary processes.

Fernández-Palacios, José María, and Kenneth F. Rijsdijk, et al. 2015. Towards a glacial-sensitive model of island biogeography. *Global Ecology and Biogeography*.

Introduces a first step toward the development of a model of island biogeography that accounts for glacial cycles and associated sea-level changes.

Heaney, L. R. 2007. Is a new paradigm emerging for oceanic island biogeography? *Journal of Biogeography* 34.5: 753–757.

Argues that the new data (especially phylogenies) question several core assumption of classical island biogeography that need changing. Heaney proposes six hypotheses related to dispersal, in situ speciation, species persistence and turnover, and colonization of continents from islands as a starting point for a new paradigm.

Losos, and Ricklefs, eds. 2010. *The theory of island biogeography revisited*. Princeton, NJ: Princeton Univ. Press.

A book that resulted from a conference at Harvard celebrating the fortieth anniversary of the Equilibrium Theory of Island Biogeography. Sixteen contributions of leading island biogeographers introduce the range of new ideas in island biogeography.

Rosindell, J., and A. B. Phillimore. 2011. A unified model of island biogeography sheds light on the zone of radiation. *Ecology Letters* 14:552–560.

In an attempt to integrate speciation into formal island biogeography theory, the authors introduce a model where the immigration on small and nearby islands gives way to speciation as island area and isolation increase. Examining the avifauna of thirty-five archipelagos, they find that the radiation zone comprises two different regions: endemic species diverge from mainland sister-species at intermediate isolation and from insular sister-species at high isolation. The model also makes predictions about species ages and abundances.

Whittaker, Robert J., Mark V. Lomolino, and F. Ian Woodward, eds. 2000. *Special issue: Island biogeography*. *Global Ecology and Biogeography* 9:1–99.

Includes seven papers by leading island biogeographers of the time, challenging underlying assumptions of the Equilibrium Theory of Island Biogeography (ETIB): in particular, these papers argued that the number of species on an island is in equilibrium, in situ evolution is largely neglected, and the particularities of the island systems and species are not considered. The introduction by Lomolino concisely summarizes the new ideas.

Whittaker, Robert J., Kostas A. Triantis, and Richard J. Ladle. 2008. A general dynamic theory of oceanic island biogeography. *Journal of Biogeography* 35:977–994.

Attempts to incorporate island age, controlling the ontogenetic stages that a hotspot oceanic island will experience during its existence from its origin until its disappearance beneath the sea—all in a mathematical formulation of island biogeography. The model predicts that islands will achieve maximum speciation rate when attaining maximum size and area but achieve its maximum species number during its maximum topographic complexity.

Long-Distance Dispersal

A key question in island biogeography is how frequently long-distance dispersal of colonizing species to remote islands occurs and whether species traits affect dispersal probability: or, in other words, how important isolation is for determining immigration rates and the composition of the immigrating biota of islands. Thereby it should be kept in mind that characterizing isolation can be challenging given changing arrangements of islands over geological times and the possibility of dispersal via stepping-stone islands (see Geography). For this question the classical work by Sherwin Carlquist is still foundational (see Carlquist 1974, cited under General Overviews, as well as Carlquist 1966 and Carlquist 1967). Meanwhile, the relative contribution of different source regions to the biotas of particular islands is rather well understood (for the Arctic Islands consult works such as Alsos, et al. 2015, cited under Arctic Islands). Gillespie, et al. 2012 reviews recent insights on long-distance dispersal, and Le Roux, et al. 2014 is just one particularly striking example that shows how long-distance dispersal is probably a relatively frequent event.

Carlquist, Sherwin. 1966. The biota of long distance dispersal. I. Principles of dispersal and evolution. *Quarterly Review of Biology* 41:247–270.

Foundational text where the author proposes twenty-four principles governing colonization and evolutionary processes on islands.

Carlquist, Sherwin. 1967. The biota of long distance dispersal. V. Plant dispersal to Pacific islands. *Bulletin of the Torrey Botanical Club* 94:129–162.

In this classic contribution, Carlquist analyzes and comments extensively on the dispersal means of the Hawaiian flora and their ecological and evolutionary implications.

Gillespie, R. G., B. G. Baldwin, J. M. Waters, C. I. Fraser, R. Nikula, and G. K. Roderick. 2012. Long-distance dispersal: A framework for hypothesis testing. *Trends in Ecology and Evolution* 27:47–56.

Examines data for terrestrial organisms in the Pacific showing that knowledge of dispersal means can be used to generate biogeographic predictions. They examine their predictions in the context of the origin, frequency of arrival and establishment, as well as patterns of endemism and diversification on remote islands. They demonstrate that the predicted patterns are increasingly supported by phylogenetic data.

Le Roux, J. J., D. Strasberg, M. Rouget, C. W. Morden, M. Koordom, and D. M. Richardson. 2014. Relatedness defies biogeography: The tale of two island endemics (*Acacia heterophylla* and *A. koa*). *New Phytologist* 204:230–242.

Using molecular data, this article demonstrates that two *Acacia* species (*A. koa* from Hawaii and *A. heterophylla* from La Réunion), growing 18,000 kilometers apart, belong to the same species derived from an Australian ancestor (*A. melanoxylon*). This fact implies the occurrence of two long-distance dispersal (LDD) events, first to Hawaii and then from there to La Reunion, highlighting the role of LDD in shaping present insular biotas.

Island Colonization

One of the fascinating issues in island biology is the possibility of monitoring in real time a colonization process of a *de novo* island from the beginning. This may happen with the emergence above sea level of a volcanic island, the sterilization of an old one, or the deglaciation of an ice-covered high-latitude island. A comprehensive treatise of island formation is Thornton and New 2007. Opportunities to study *de novo* islands are rare, but luckily there are some exceptions, such as the Krakatau sterilization in 1883 and the subsequent emergence of Anak Krakatau in 1927 (Whittaker, et al. 1989; Thornton 1996), the formation of Surtsey in 1963 (Fridriksson 2006) or the emergence of Motmot lacustrine islet in the Wisdom Lake, Long Island, off Papua New Guinea (Thornton, et al. 2001). For short overviews see also entries on Krakatau and Surtsey in Gillespie and Clague 2009 (cited under General Overviews).

Fridriksson, S. 2006. *Surtsey: Ecosystems formed*. Reykjavik: Univ. of Iceland Press.

Colorfully illustrated booklet for a general audience about the *de novo* island, Surtsey, near Iceland. Different chapters discuss the geology and volcanism of the new island and the early assembly of the marine and terrestrial ecosystems. See also Surtsey (cited under Island Conservation Biology).

Thornton, Ian W. B. 1996. *Krakatau: The destruction and reassembly of an island ecosystem*. Cambridge, MA: Harvard Univ. Press.

Summarizes nearly everything known about the geology and natural history of Krakatau, both before and after the 1883 cataclysm. The book is easy to read and therefore highly recommended for students and scholars.

Thornton, Ian W. B. 2001. Colonization of an island volcano, Long Island, Papua New Guinea: A nested pair of colonization

sequences. *Journal of Biogeography* 28 (11–12): 1299–1408.

Deals with the colonization processes of the tiny island of Motmot in the Long Island caldera lake. Articles discuss the origin of the island, their vascular flora, and the colonization processes of figs, arthropods, birds, and non-avian vertebrates.

Thornton, Ian A. W., and Tim New. 2007. *Island colonization: The origin and development of island communities*. Cambridge, UK: Cambridge Univ. Press.

Posthumous work of Ian Thornton, a world-famous specialist in island colonization, that synthesizes the existing literature about island colonization and assembly processes including the identity and origin of the colonizing diasporas, the order of arrival and establishment, establishment failures, and community assembly processes. Cases examined include Santorini, Surtsey, Anak Krakatau, Motmot in Long Island, and Tuluman.

Whittaker, Robert J., M. B. Bush, and K. Richards. 1989. Plant recolonization and vegetation succession on the Krakatau Islands, Indonesia. *Ecological Monographs* 59:59–123.

Analysis of the colonization and posterior development of successional stages of the coastal and inland ecosystems of the islands of Rakata, R. Kecil, and Sertsung, after the 1883 sterilization event, as well as of the newly emerged (1927) islet Anak Krakatau.

Evolution on Islands

Whereas most general works about evolution will contain many examples of evolution on islands, the following references highlight islands as showcases for the study of evolution and evolutionary diversity. Losos and Ricklefs 2009 provides a clear and concise summary of how evolutionary diversification follows colonization of new islands. Grant 1998 contains reviews by many leading experts, each of whom examines specific aspects of evolution on both true islands and habitat islands. Funk and Wagner 1995 is unique in examining evolution of a wide range of taxa within the context of a single archipelago, thereby facilitating the quest for generalized, universal patterns of evolutionary diversification and phylogeography. The special journal issues edited by Trewick and Cowie 2008 (cited under Pacific) and Schilthuizen, et al. 2010, as well as Pérez-Mellado and Ramón 2010, take advantage of the 2009 Charles Darwin celebrations to showcase a wide range of contemporary and ongoing evolutionary research, much of it based on the latest molecular techniques on a diverse array of islands and taxa—in many cases placing it explicitly in the context of Darwin's legacy. Warren, et al. 2015 highlights the opportunities that ongoing advances in molecular biology and other disciplines are providing for the study of evolutionary and ecological processes involved in species interaction networks, community assembly, and ecosystem functioning. In two subsections we review some more specific literature about microevolution and macroevolution. Evolution on islands is also covered in many of the other references included in this bibliography, and especially in those included in General Overviews and Island Biodiversity.

Funk, Vicki A., and Warren L. Wagner, eds. 1995. *Biogeography of the Hawaiian Islands*. Washington, DC: Smithsonian Institute.

A well-organized volume, in which contributors take advantage of Hawaii's well-known geological history to examine the evolutionary histories and within-archipelago relationships of numerous lineages, especially arthropods and plants. Most suitable for graduate students and researchers.

Grant, Peter, ed. 1998. *Evolution on islands*. Oxford: Oxford Univ. Press.

Originating from the contributions presented to a discussion meeting organized by the Royal Society of London, this classic reference encompasses eighteen chapters dealing with evolutionary patterns, speciation mechanisms, and their ecological and biogeographic implications in different settings (real islands, lakes, and habitat islands). Useful for students and scholars.

Losos, Jonathan B., and Robert E. Ricklefs. 2009. Adaptation and diversification on islands. *Nature* 457:830–836.

A concise review, suitable for advanced undergraduates and professionals, discussing how island research has demonstrated the evolutionary roles of geographical isolation in speciation, species interactions in adaptive radiation, and both chance and determinism. Molecular phylogenies are shown to offer a way to examine evolutionary patterns across multiple spatial scales.

Pérez-Mellado, Valentín, and Concepción Ramón, eds. 2010. *Islands and evolution*. Maó, Spain: Institut Menorquí d'Estudis.

Compiles the contributions presented at a symposium entitled, "Islands and Evolution: 150 Years after Darwin's Legacy," organized in 2009 in Menorca, Balearic Islands. It includes eighteen chapters covering topics ranging from island biogeography to conservation.

Schilthuizen, Menno, Niels Raes, Peter Linder, Konstantinos Triantis, José María Fernández-Palacios, and Robert J. Whittaker, eds. 2010. *Special issue: Evolutionary islands: 150 years after Darwin*. *Journal of Biogeography* 37:983–1174.

Product of the symposium with the same name held in Leiden, the Netherlands, in 2009. This special issue compiles ten of the contributions presented there, dealing with different topics such as molecular clocks, radiations, extinctions, or the Flores dwarf man.

Warren, Ben H., Daniel Simberloff, and Robert E. Ricklefs, et al. 2015. Islands as model systems in ecology and evolution: Prospects fifty years after MacArthur-Wilson. *Ecology Letters* 18:200–217.

This review highlights how island systems have provided new insights and developments in evolutionary and ecological theory. The authors identify prospects for research on islands to improve our understanding of the ecology and evolution of communities in general, with implications reaching far beyond islands to other ecosystems.

Microevolution: Evolution in Action

Evolution is often regarded as something that is discernible only over geological timespans, but many examples of microevolution—evolutionary change that occurs at rates detectable over ecological timescales—are now known, and some of the best come from islands. Grant and Grant 2014, on the Galápagos finches, summarizes what is arguably the best-studied and most documented example of the process of microevolution in nature. The long-term, comprehensive (from molecular genetics to field ecology) nature of the work makes familiarity with this system essential for students of evolution. Losos 2009 is an excellent and accessible complement to the Grants' book, focusing on evolutionary research with island lizards. Cody and Overton 1996 demonstrates how rapid evolution in seed dispersal traits can be inferred by combining data on plant morphology and a site's geological history. Givnish 2010 reviews the role of ecology in plant speciation, and Savolainen, et al. 2006 empirically documents an example of a sympatric speciation on an island.

Cody, Martin L., and Jacob McC. Overton. 1996. Short-term evolution of reduced dispersal in island plant populations. *Journal of Ecology* 84:53–61.

An elegant study demonstrating the evolutionary reduction in capacity for wind dispersal occurring in plants that have colonized small islands, where dispersal by wind could lead to propagules being blown out to sea. A classic study demonstrating rapid effects of natural selection in nature, suitable for advanced undergraduates and researchers.

Givnish, T. J. 2010. Ecology of plant speciation. *Taxon* 59:1326–1366.

Givnish, T. J. 2010. Ecology of plant speciation. *Taxon* 59:1326–1366.

Reviews the role of ecology in speciation, focusing on Hawaiian and Macaronesian angiosperms. It focuses on five main topics: (1) the role of spatial scale, (2) the contribution of adaptive radiation to island floras, (3) ecological speciation, (4) the contribution of hybridization, and (5) the ecological determinants of diversification rates for individual lineages.

Grant, Peter R., and Rosemary B. Grant. 2014. *40 years of evolution: Darwin's finches on Daphne Major Island*. Princeton, NJ: Princeton Univ. Press.

A testament to what can be learned by thorough, detailed, and imaginative field research during the course of a career. Written by dedicated scientists who employ a broad array of scientific techniques. This exemplary study of evolution in ecological time is aimed at advanced undergraduates and beyond.

Losos, Jonathan. 2009. *Lizards in an evolutionary tree.* Berkeley: Univ. of California Press.

An excellent textbook that synthesizes long-term research on the adaptive radiation and convergent evolution in Caribbean anoles. The website provides additional virtual material for students, including films.

Savolainen, Vincent, Marie-Charlotte Anstett, and Christian Lexer, et al. 2006. Sympatric speciation in palms on an oceanic island. *Nature* 441:210–213.

An exemplary study using genetic and ecological evidence to provide support for disruptive/divergent selection leading to sympatric speciation in two species of *Howea*, a genus endemic to Lord Howe Island.

Macroevolution: Phylogenetics and Adaptive Radiations

Islands provide excellent examples of a variety of macroevolutionary processes and the patterns of diversity that they produce. Emerson 2002 introduces the use of molecular techniques for detecting these evolutionary processes and patterns in island lineages. Schluter 2000 presents a detailed discussion of adaptive radiation, which is a rapid burst of cladogenic speciation resulting in diverse taxa adapting to new environments and niches (see also entry on "Adaptive Radiation" in Gillespie and Clague 2009, cited under General Overviews). The most thoroughly studied example of adaptive radiation, the Hawaiian silversword alliance, is described in great evolutionary and ecological detail in Carlquist, et al. 2003. Pratt 2005 (cited under Island Faunas) covers the adaptive radiation of Hawaiian honeycreepers. Rundell and Price 2009 compares adaptive and nonadaptive radiation, the latter being an alternative pathway that can produce patterns outwardly similar to those produced by adaptive radiation. Stuessy, et al. 2006 calls attention to the underappreciated importance of anagenesis—whereby a single island endemic diverges from a colonizer without splitting in multiple species—in the evolution of island endemic species. Silvertown 2004 explains how adaptive radiation within a lineage results in niche preemption, potentially limiting later colonization by related taxa. Kisel and Barraclough 2010 further explores how spatial scale affects speciation. Wilson 1961 is an exemplary work demonstrating the intellectual development of the field. This classic paper on the taxon cycle in Melanesian ants is a must-read for all students of island biogeography and evolution. More information on Founder Effect Speciation and Speciation can be found in separate entries in *Oxford Bibliographies* in Evolutionary Biology.

Carlquist, Sherwin, Bruce G. Baldwin, and Gerald D. Carr, eds. 2003. *Tarweeds & silverswords: Evolution of the Madiinae (Asteraceae)*. St. Louis: Missouri Botanical Garden.

A thorough treatment of the Hawaiian silverwords and their continental relatives—the best-studied example of adaptive radiation in plants. This book covers taxonomy and phylogeny, as well as ecophysiology, anatomy, chromosome evolution, hybridization, and secondary metabolites. Suitable for graduate students and professionals.

Emerson, Brent C. 2002. Evolution on oceanic islands: Molecular phylogenetic approaches to understanding pattern and process. *Molecular Ecology* 11:951–966.

This review explains the value and methodology of applying molecular techniques to the study of evolutionary patterns on islands, such as convergent evolution and dating lineages. Examples are drawn from paradigmatic cases of the biota of Galápagos, Hawaii, and Macaronesia. Limitations of the methods are also discussed. Good background for graduate students.

Kisel, Y., and T. G. Barraclough. 2010. Speciation has a spatial scale that depends on levels of gene flow. *American Naturalist* 175:316–334.

Analyzes the correlation between island size and speciation patterns for a broad range of taxa (including bats, carnivorous mammals, birds, flowering plants, lizards, butterflies, and snails) and relates it to the level of gene flow.

Rundell, Rebecca J., and Trevor D. Price. 2009. Adaptive radiation, nonadaptive radiation, ecological speciation and nonecological speciation. *Trends in Ecology and Evolution* 24:394–399.

This essay describes how radiations of ecologically differentiated sympatric species could be produced either by (1) ecological divergence between populations followed by reproductive isolation or by (2) geographical isolation, ecological differentiation, and later sympatry. Most of the cases studies involve island radiations.

Schluter, Dolph. 2000. *The ecology of adaptive radiation*. Oxford: Oxford Univ. Press.

An advanced text, suitable for graduate students and researchers, which provides an in-depth account of the ecological causes of adaptive radiation that arise through environmental heterogeneity and interspecific interactions. Although this is a general treatment, many of the classic examples involving radiations of island taxa are examined in detail.

Silvertown, Jonathan. 2004. The ghost of competition past in the phylogeny of island endemic plants. *Journal of Ecology* 92:168–173.

An essay directed at researchers, proposing that plant taxa that have undergone extensive speciation and adaptive radiation on islands are likely to be monophyletic. Phylogenies of Canary Islands plants are used to support the argument that niche preemption by descendants of early-arriving taxa prevents subsequent colonization by related taxa.

Stuessy, T. F., G. Jakubowsky, and R. S. Gómez, et al. 2006. Anagenetic evolution in island plants. *Journal of Biogeography* 33:1259–1265.

A valuable review for researchers that discusses anagenesis, a process in which a single endemic species diverges from its progenitor through founder effects, genetic drift, and selection. This underappreciated process is shown to be responsible for 25 percent of the endemic species on thirteen archipelagoes around the world.

Wilson, Edward O. 1961. The nature of the taxon cycle in the Melanesian ant fauna. *American Naturalist* 95:169–193.

This dated-but-classic research paper used biogeography of Melanesian ant species to develop the concept of the taxon cycle. It provides a mechanism to explain how species colonize and adapt to islands and how they become increasingly specialized while their populations eventually become fragmented and go extinct as additional species colonize.

Island Biodiversity

Islands of a given size (area) tend to support fewer species than comparable continental areas do. However, by virtue of their isolation, islands have generated high levels of endemism. As a result, the world’s islands make a disproportionately large contribution to the world’s total biodiversity. These patterns are highlighted by Myers, et al. 2000 and Kier, et al. 2009, both of which support the case that islands comprise vital components of the world’s biodiversity but are facing extreme threats, which merits increased attention to conservation. In subsections we provide more specific information on island floras, faunas, and traits of island species (island syndromes and reproductive biology). More information on island biodiversity can be found in most documents covered in this article.

Kier, Gerold, Holger Kreft, and Tien Ming Lee, et al. 2009. A global assessment of endemism and species richness across island and mainland regions. *Proceedings of the National Academy of Sciences USA* 106:9322–9327.

Islands and continents are assessed with respect to species richness, endemism, and conservation threats. When these factors are combined, the biodiversity and conservation importance of islands relative to continents is significantly increased. This analysis will be of value to advanced undergraduates, practicing scientists, and policymakers.

Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A. B. da Fonseca, and Jennifer Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853–858.

A highly influential and controversial paper that is essential reading. The world’s key conservation areas are identified and prioritized on the basis of species endemism and conservation risk. Of particular significance is that nine of the twenty-five identified biodiversity hotspots consist entirely or chiefly of islands. For more information see Biodiversity Hotspots (cited under Island Conservation Biology).

Island Floras

Bramwell and Caujapé-Castells 2011 comprehensively introduce the biology of island floras. Kreft, et al. 2008 and Weigelt, et al. 2015 analyze differences in plant species richness and phylogenetic structure respectively, based on a comprehensive data set. And García-Verdugo and Fay 2014 is an overview of recent plant-related island research.

Bramwell, David, and Juli Caujapé-Castells, eds. 2011. *The biology of island floras*. Cambridge, UK: Cambridge Univ. Press.

Update of Bramwell’s 1979 textbook, *Plants and Islands*, this textbook includes twenty-one chapters, some of them with a general perspective (reproductive biology, impacts of climate change, and conservation biology). Other chapters are focused on specific outstanding floras such as those of Macaronesia, Madagascar, Galapagos, Hawaii, Socotra, New Caledonia, or New Zealand.

García-Verdugo, Carlos, and Michael F. Fay, eds. 2014. *Special issue: Ecology and evolution on oceanic islands: Broadening the botanical perspective. Botanical Journal of the Linnean Society* 174:271–501.

Dedicated to the ecology, evolution, and biogeography of oceanic islands floras. Through the use of case studies, these sixteen contributions highlight 21st-century developments in the field related to island biogeography, plant colonization, life history traits, phylogeny, genetic variation, or pollination.

Kreft, H., W. Jetz, J. Mutke, G. Kier, and W. Barthlott. 2008. Global diversity of island floras from a macroecological perspective. *Ecology Letters* 11:116–127.

A global analysis of 488 island and 970 mainland floras that looks at the relationships between island characteristics (area, isolation, topography, climate, and geology) and species richness and endemism. Area appears to be the strongest determinant of island richness, whereas elevation and island geology show relatively weak yet significant effects.

island richness, whereas elevation and island geology show relatively weak yet significant effects.

Weigelt, P., W. D. Kissling, and Y. Kisel, et al. 2015. Global patterns and drivers of phylogenetic structure in island floras. *Scientific Reports* 5.

This contribution links phylogenetic assemblage structure to island characteristics across four hundred islands worldwide and more than 37,000 vascular plant species, showing that signatures of dispersal limitation, environmental filtering, and in situ speciation differ markedly among taxonomic groups on islands.

Island Faunas

As a group, mammals have been relatively poor at colonizing remote islands; bats, by virtue of their power of flight, are an exception. Fleming and Racey 2009 provides a thorough introductory overview, covering many aspects of the biology of island bats. Coming from a paleontological perspective, Van der Geer, et al. 2010 covers other island mammals, especially unusual or extinct dwarf forms from land bridge islands. Holland 2009 is a brief but excellent introduction to land snails—a group of animals that has been exceptionally successful at colonizing and radiating on islands but that has also suffered high rates of extinction attributable to invasive alien animals. Pratt 2005 is noteworthy as a thorough and complete description of the evolution and ecology of all the extant and extinct species of an entire family of more than sixty birds that radiated from a single ancestral species.

Fleming, Theodore H., and Paul A. Racey, eds. 2009. *Island bats: Evolution, ecology, and conservation*. Chicago: Univ. of Chicago Press.

The sixteen chapters here include several general overviews and many case studies of evolution, ecology, or conservation of bats from specific island groups. Content is suitable for advanced undergraduates and researchers.

van der Geer, Alexandra, George Lyras, John de Vos, and Michael Dermitzakis. 2010. *Evolution of island mammals: Adaptation and extinction of placental mammals on islands*. Oxford: Wiley-Blackwell.

Fossil island mammals from sixteen island groups are covered at a level appropriate for graduate students. The treatment first discusses faunas island by island and then examines each major taxonomic group across islands. Throughout, interpretations are based on Oligocene-to-Holocene fossil and subfossil remains.

Holland, Brenden. 2009. Land Snails. In *Encyclopedia of islands*. Edited by Rosemarie Gillespie and David A. Clague, 537–542. Berkeley: Univ. of California Press.

A brief, well-illustrated summary of the basic biology, patterns of biodiversity, and conservation concerns of land snails on the world’s oceanic islands.

Pratt, H. Douglas. 2005. *Hawaiian honeycreepers*. New York: Oxford Univ. Press.

A thorough, comprehensive summary of the Hawaiian honeycreepers, a spectacular example of adaptive radiation in birds. The first half covers the origin, evolution, biology, and conservation of honeycreepers in general. The second half provides detailed accounts of all known extinct and extant species. Aimed at everyone from the educated layperson to the professional biologist.

Island Syndromes

Islands are renowned for species with special traits. It has been argued that island species from different taxonomic groups are characterized by similar traits resulting from the same selective pressures. Such recurrent traits have been called “island syndromes” or “island rules” (summarized in Carlquist 1974, cited under General Overviews and Grant 1998). Among them, several

features have been highlighted, such as (1) the size shift in animals either toward gigantism or dwarfism (see the synthetic work Lomolino 2005), (2) insular plant woodiness (Lens, et al. 2013), (3) loss of dispersability in island plants (see Cody and Overton 1996, cited under Microevolution: Evolution in Action), (4) flightlessness in birds and insects, (5) diminution of clutch size in vertebrates, (6) diminution of defensive behavior (Stamps and Buechner 1985), and (7) development of sexual dimorphism in plants (Crawford, et al. 2011), among others. For traits related to the reproductive biology of island plants see also Reproductive Biology, Population Biology and Genetics of Island Species.

Crawford, Daniel J., Gregory J. Anderson, and Gabriel Bernardello. 2011. The reproductive biology of island plants. In *The biology of island floras*. Edited by David Bramwell and Juli Caujapé-Castells, 11–36. Cambridge, UK: Cambridge Univ. Press.

Updated review of the most important features of island plants, illustrated with examples from around the world, including the breeding system of the colonizers, a general syndrome of island flowers and their pollinators, sex of flowers and separation of sexes, and a final conservation epigraph about the impact of invasive plants and pollinators on the reproductive biology of island plants.

Grant, Peter R. 1998. Patterns on islands and microevolution. In *Evolution on islands*. Edited by Peter R. Grant, 1–17. Oxford: Oxford Univ. Press.

Brief, introductory chapter about the different island syndromes written by one of the world’s leaders in island evolution, including syndromes such as the loss of dispersal ability, size changes, floral colors and pollinator shifts, diminution of clutch sizes, or animal tameness, among others.

Lens, Frederic, Nicolas Davin, Erik Smets, and Marcelino del Arco. 2013. Insular woodiness on the Canary Islands: A remarkable case of convergent evolution. *International Journal of Plant Sciences* 174:992–1013.

Interesting analysis focused on the conspicuous case of island woodiness in the Canaries. Updated here are hypotheses regarding the herbaceous ancestry of woody Canarian lineages in a molecular phylogenetic context, finding at least thirty-eight independent shifts toward insular woodiness, representing 220 species, the majority of which typically grow in the markedly dry lowland regions. This suggests a possible link between secondary woodiness and increased drought resistance.

Lomolino, Mark V. 2005. Body size evolution in insular vertebrates: Generality of the island rule. *Journal of Biogeography* 32:1683–1699.

Assesses the generality of the trend of gigantism in small and dwarfism in large insular vertebrates species, using the body sizes of island species and comparing them with their closest mainland relatives. The author states that the island rule is a general phenomenon resulting from a combination of selective forces that vary in a predictable manner along a gradient from small to large species. As a result, body size of insular species tends to converge on an optimal, intermediate size.

Stamps, J. A., and M. Buechner. 1985. The territorial defence hypothesis and the ecology of insular vertebrates. *Quarterly Review of Biology* 60:155–181.

This interesting contribution focuses on the behavior of insular vertebrates. Stamps and Buechner attributed the reduced aggression toward conspecifics that they exhibit to two non-exclusive hypotheses: the resource hypothesis, which suggests that territorial behavior is primarily adjusted to resource densities (with resources being more abundant on islands than on the mainland due to a lack of competing species) and the defense hypothesis, which suggests that the costs of defense against territorial intruders are higher on islands.

Reproductive Biology, Population Biology, and Genetics of Island Species

Island populations are often naturally small, and the numbers and sizes of the populations of many island species have been further dramatically reduced through human impacts. Therefore, both out of a scientific interest in the adaptations of species to isolated and small land fragments, and for conservation purposes, there exists a long interest in the reproductive biology, population biology, and genetics of island species. Introductions to classical thinking about the subject can be found in Williamson 1981; Barrett, et al. 1996; Barrett 1998; and Frankham 1998. A review of recent empirical data is found in Crawford, et al. 2011 (cited under Island Syndromes). The availability of detailed molecular data is rapidly growing, allowing researchers to test and adapt classical ideas as exemplified by Caujapé-Castells 2011 and Stuessy, et al. 2014.

Barrett, Spencer C. H. 1998. The reproductive biology and genetics of island plants. In *Evolution on islands*. Edited by Peter Grant, 18–34. Oxford: Oxford Univ. Press.

A nice introduction to the special features of reproductive biology and genetics of island plants, including a review of pollination on islands, evolution of mating systems, and the genetics of island populations. This text is especially suited for students and scholars who would like to introduce themselves to this fascinating issue.

Barrett, S. C. H., B. Emerson, and J. Mallet. 1996. The reproductive biology and genetics of island plants. *Philosophical Transactions of the Royal Society of London B* 351:725–733.

Formulates some of the classic hypotheses about the reproductive biology and genetics of island plants and especially those on isolated and small islands: increased selfing, sexual dimorphism, importance of stochasticity for genetic variation, and low genetic diversity.

Caujapé-Castells, Juli. 2011. Jesters, red queens, boomerangs and surfers: A molecular outlook on the diversity of the Canarian endemic flora. In *The biology of island floras*. Edited by David Bramwell and Juli Caujapé-Castells, 284–324. Cambridge, UK: Cambridge Univ. Press.

A comprehensive synthesis of molecular genetics information for the Canarian flora, probably the most thoroughly studied island archipelago in this regard.

Frankham, Richard. 1998. Inbreeding and extinction: Island populations. *Conservation Biology* 12.3: 665–675.

A classic text of conservation biology that asks whether inbreeding depression in small island populations is a driving factor of species extinctions on islands.

Stuessy, Tod F., Koji Takayama, Patricio López-Sepúlveda, and Daniel J. Crawford. 2014. Interpretation of patterns of genetic variation in endemic plant species of oceanic islands. *Botanical Journal of the Linnean Society* 174.3: 276–288.

Reviews the growing population genetics data available and proposes explanations other than founder effects that might explain low genetic diversity in island plants. Looks at the role of disturbances such as volcanic activities affecting population sizes and numbers, speciation through cladogenesis, breeding systems, hybridization, and human disturbances.

Williamson, M. 1981. *Island populations*. Oxford: Oxford Univ. Press.

Now somewhat dated, this book is still important for having summarized the first generation of research inspired by the hypotheses posed by MacArthur and Wilson 1967 (cited under Historical Accounts and Foundational Works) and Carlquist 1974 (cited under General Overviews). Suitable for advanced undergraduates.

Vegetation Zonation

Islands are often characterized by high habitat diversity compressed into a small area. High elevation islands are characterized by elevational vegetation zones similar to those on continental mountains and often also by pronounced differences in rainfall patterns between the windward and leeward sides of the island. Low-lying islands are often drier than higher ones. The rugged topography of islands can contribute further important microhabitats such as cliff, rock, ridge, or inselberg habitats. Edaphic factors further contribute to habitat differentiation—depending on island type, for instance—through the age of lava flows, the age of the islands along island chains (that can lead to a shift from nitrogen to phosphorus-limited soils) or special soil types such as ultramafic substrates in New Caledonia. In addition coastal habitats such as beach crest vegetation or mangroves are important vegetation types on islands. For more information on vegetation zones in different oceanic regions and on particular islands, see the section on oceanic regions of the world. A comprehensive overview of vegetation types in the tropical Pacific is Mueller-Dombois and Fosberg 1998, and an equally detailed treatise for New Zealand is Wardle 1991. Juvik, et al. 2014 reviews the ecology and conservation of subalpine and alpine habitats on islands.

Juvik, J., C. Kueffer, and S. Juvik, eds. 2014. Losing the high ground: Rapid transformation of tropical island alpine and subalpine environments. *Arctic, Antarctic and Alpine Research* 46.4: 705–904.

Focuses on the physical characteristics, ecology, and conservation challenges of subalpine and alpine habitats on tropical islands worldwide.

Mueller-Dombois, D., and F. Raymond Fosberg. 1998. *Vegetation of the tropical Pacific islands*. New York: Springer-Verlag.

A thorough review of the physical environment and vegetation of Melanesia, Micronesia, and Polynesia (excluding New Guinea and New Zealand), plus eastern Pacific islands. Plant communities and vegetation zones are described in detail.

Wardle, Peter. 1991. *Vegetation of New Zealand*. Cambridge, UK: Cambridge Univ. Press.

A thorough and detailed review of the physical environment, vegetation, and vegetation dynamics of New Zealand, including its outlying islands. Chapters also examine various aspects of plant autecology.

Community Assembly

Recent years have seen a surge of new interest in community ecology and the coexistence of species, especially as a result of the increasing availability of data sets on fine-scale species distributions, phylogenies, and species traits. Many classical ideas in community ecology have been developed or tested based on island systems. One critical question is whether—and to what extent—competition shapes the co-occurrence of species. Diamond 1975 proposes that the co-occurrence of bird species on New Guinean islands is predictable based on a set of assembly rules. Simberloff 1970 is a classical paper emphasizing the importance of null models for studying such species co-occurrence patterns. MacArthur, et al. 1972 assesses the role of density compensation on islands (i.e., the idea that due to a lack of species, those species that are present are more abundant than would be expected on continents). Silvertown 2004 (see Evolution on Islands: Macroevolution: Phylogenetics and Adaptive Radiations) proposed that the effect of competitive exclusion is visible in the high frequency of monophyletic adaptive radiations (i.e., resulting from a single colonizing species): adaptive radiations might take up ecological niche space and exclude closely related later-arriving species through competitive exclusion. Grant and Grant 2006 demonstrates that character displacement happened in Darwin's finches (i.e., evolutionary divergence of two co-occurring species arose through competitive interactions). The integration of ecology and evolution for understanding community assembly has become a major research avenue in island biology (see Warren, et al. 2015, cited under Evolution on Islands) and will likely expanded substantially in the future (see Kueffer, et al. 2014, cited under General cited under Evolution on Islands) and will likely expanded substantially in the future (see Kueffer, et al. 2014, cited under General Overviews). Besides their simplicity, island systems provide the opportunity to study eco-evolutionary assembly processes along chains of islands of differing age. A classical study using the chronological arrangement of the Hawaiian Islands for such a purpose is Gillespie 2004. Emerson and Gillespie 2008 reviews the current state of such research and points out future research opportunities on islands.

Diamond, Jared M. 1975. Assembly of species communities. In *Ecology and evolution of communities*. Edited by Martin L. Cody and Jared M. Diamond, 342–444. Cambridge, MA: Belknap.

A classic paper on community assembly. Based on data from land-bird communities on islands near New Guinea, the paper proposes that species co-occurrence on an island can be predicted based on its isolation and area, which influences dispersal and competitive exclusion, respectively. The paper has triggered ongoing theoretical debate.

Emerson, Brent C., and Rosemary G. Gillespie. 2008. Phylogenetic analysis of community assembly and structure over space and time. *Trends in Ecology and Evolution* 23:619–630.

This technical review demonstrates how data on phylogeny, geographic distribution, and ecology can be combined to investigate community assembly on islands by allowing, for example, the relative roles of immigration and speciation/adaptation to be assessed.

Gillespie, R. 2004. Community assembly through adaptive radiation in Hawaiian spiders. *Science* 303:356–359.

Based on data about spider communities on islands of different age in the Hawaiian archipelago, the author shows that community patterns are non-random. Within any community, similar sets of ecomorphs arise through both dispersal and evolution; and species assembly is dynamic, with maximum species numbers in communities of intermediate age.

Grant, Peter R., and Rosemary Grant. 2006. Evolution of character displacement in Darwin's finches. *Science* 313.5784: 224–226.

An empirical demonstration of character displacement—the evolutionary divergence in resource-exploiting traits through competition between co-occurring species—in two species of Darwin's finches in the Galapagos.

MacArthur, Robert H., Jared M. Diamond, and James R. Karr. 1972. Density compensation in islands faunas. *Ecology* 53:330–342.

Classical work on the concept of density compensation on islands. Studying the avifauna of the Pearl archipelago, off the Panama Pacific coast, the authors analyze the factors determining the existence of (or lack of) density compensation on islands.

Simberloff, D. S. 1970. Taxonomic diversity of island biotas. *Evolution* 24:23–47.

An important conceptual article emphasizing the importance of null models for interpreting species co-occurrence patterns. Data on species-to-genus ratios in island floras and avifaunas is used for illustration and to test whether island biotas are more or less phylogenetically clustered than continental ones.

Mutualistic Networks

Mutualistic interactions between flowering plants and the animals that pollinate their flowers and disperse their seeds have long been a focus of ecological and evolutionary research on continents. In the 21st century, islands have increasingly offered unique insights and opportunities regarding these relationships. Abe 2006 is a groundbreaking attempt to relate the diverse flora and pollinator fauna of an entire archipelago. Traveset, et al. 2013 quantifies pollination networks at a fairly large scale, and Heleno, et al. 2012 applies a similar approach to frugivory networks. Hansen and Traveset 2012 demonstrates that the most important seed dispersers on islands are often different from dispersers on continents. Schleuning, et al. 2014 likewise notes that at the community level, island frugivory networks differ from those on continents, in part because of reduced bird diversity. Olesen and Valido 2003 points out the surprisingly important role played by lizards on islands (in both frugivory and pollination), speculating that it may in part be attributable to the relative lack of other frugivores, such as birds and mammals. All of these studies emphasize the conservation consequences of taxonomically or functionally poor or unbalanced mutualistic networks on islands and, in particular, how alien species might change these. Conservation implications are the specific focus of Kelly, et al. 2010 and Kaiser-Bunbury, et al. 2010. Kelly, et al. 2010 is a well-organized and thorough examination of the ecological changes that have taken place in New Zealand as its plant-vertebrate interactions (including herbivory) have shifted from bird dominated to mammal dominated following the introduction of alien mammals and the loss of many native birds, including the extinct moas. Finally, Kaiser-Bunbury, et al. 2010 points out the ecological importance of plant-animal interactions for the maintenance of biodiversity on islands and explores the possibility of intentional introductions of alien animals to restore function in island ecosystems that have lost native species.

Abe, Tetsuo. 2006. Threatened pollination systems in native flora of the Ogasawara (Bonin) Islands. *Annals of Botany* 98:317–334.

This thorough, detailed review assesses plant breeding systems and flower traits for the archipelago's entire flora and relates them to pollination syndromes and actual observations of flower visitation by various pollinators. Pollination networks are shown to be the most altered on disturbed islands where honeybees replace native insects.

Hansen, D. M., and A. Traveset, eds. 2012. *Special issue: Seed dispersal on islands*. *Journal of Biogeography* 39:1933–2030.

Presents nine research papers from the 2010 Frugivory and Seed Dispersal Conference. Case studies cover a nice range of examples, including birds, bats, lizards, and tortoises as dispersers on islands in the Mediterranean, Caribbean, Indian Ocean, and Pacific.

Heleno, Ruben H., Jens M. Olesen, Manuel Nogales, Pablo Vargas, and Anna Traveset. 2012. Seed dispersal networks in the Galápagos and the consequences of alien plant invasions. *Proceedings of the Royal Society B* 280.

Seed dispersal networks involving native birds and reptiles and both native and alien plants are described quantitatively. The role of alien plants, and their increasing integration into networks, is examined as a pathway for successful invasions over time.

Kaiser-Bunbury, C. N., A. Traveset, and D. M. Hansen. 2010. Conservation and restoration of plant-animal mutualisms on oceanic islands. *Perspectives in Plant Ecology Evolution and Systematics* 12:131–143.

A review paper arguing that islands' disharmonic biotas result in relatively generalized pollination and seed dispersal mutualisms relative to those on continents. Patterns and effects of (animal) mutualist extinctions and introductions are described. Challenges and opportunities for conservation of mutualisms and species are also discussed, including opportunities for re-wilding.

Kelly, D., J. J. Sullivan, and J. J. Ladley, eds. 2010. Feathers to fur: The ecological transformation of Aotearoa. *New Zealand Journal of Ecology* 34:1–217.

A well-focused series of papers from a 2007 conference reviewing ecological impacts resulting from the loss of native animals (mainly reptiles and birds) and their replacement by functionally different non-native species (mainly mammals) in New Zealand. Emphasizes consequences of functional changes in species interactions.

Olesen, J. M., and A. Valido 2003. Lizards as pollinators and seed dispersers: An island phenomenon. *Trends in Ecology and Evolution* 18:177–181.

A brief essay asserting that lizards are disproportionately important as pollinators and seed dispersers on islands relative to continents. The essay hypothesizes that this may result from the relatively high population densities and low predation risks that lizards experience on islands and then suggests avenues for research.

Schleuning, Matthias, Katrin Böhning-Gaese, D. Matthias Dehling, and Kevin C. Burns. 2014. At a loss for birds: Insularity increases asymmetry in seed-dispersal networks. *Global Ecology and Biogeography* 23:385–394.

A review and comparative analysis of seed-dispersal networks from islands and continents. The key findings are that measures of network diversity differ little between islands and continents but that island networks are significantly more asymmetrical, owing to a paucity of vertebrate frugivores, especially birds.

Traveset, Anna, Ruben Heleno, and Susana Chamorro, et al. 2013. Invaders of pollination networks in the Galápagos Islands: Emergence of novel communities. *Proceedings of the Royal Society B* 280.

Pollination networks involving both native and alien animals and plants are described quantitatively. Alien species—especially insects—are shown to be strongly integrated into the networks and contribute substantially to the establishment of novel communities—but with potential negative consequences for native biodiversity.

Ecosystem Processes

The International Biological Program (IBP) of the 1970s in Hawaii set the stage for comprehensive research on the ecosystem ecology of islands (Mueller-Dombois, et al. 1981). The program emphasized in particular two influential ideas: the importance of gradient studies (island or substrate age, elevational or anthropogenic disturbance), and the idea that island ecosystems are characterized by single (or a few) keystone canopy trees that are abundant and determine forest and ecosystem dynamics. Gradient studies have been further developed in particular through the work of Vitousek and his colleagues (summarized in Vitousek 2004) that focused on the role of substrate age and climate for ecosystem processes and, in particular, nutrient limitation of these. Dieter Mueller-Dombois and colleagues further investigated the forest dynamics of single-species-dominated forest ecosystems based on *Metrosideros*-dominated forests (Mueller-Dombois 2008; Mueller-Dombois, et al. 2013). Vitousek, et al. 1995 summarizes the knowledge of island research on ecosystem processes of the 1970s to 1990s. Since then no major new synthesis on the ecosystem ecology of islands has been published; although the section on ecological processes in insular systems in Towns, et al. 2002 provides some more recent perspectives.

Mueller-Dombois, D. 2008. Pacific island forests: Successionally impoverished and now threatened to be overgrown by aliens? *Pacific Science* 62.3: 303–308.

Discusses that forests of remote islands are often dominated by one canopy tree species while early-successional species are missing, resulting in a succession pattern that the article refers to as “autosuccession” or “direct succession,” (i.e., the late-successional species is also the species that forms early-successional vegetation after major disturbance). According to the author the lack of early-successional species is a reason for the high vulnerability of island ecosystem to alien plant invasions.

Mueller-Dombois, Dieter, Kent W. Bridges, and Hampton L. Carson, eds. 1981. *Island ecosystems. Biological organization in selected Hawaiian communities*. US/IBP Synthesis series, 15. Stroudsburg, PA: Hutchinson Ross.

Classic book resulting from the research done in Hawaii between 1971 and 1976 within the frame of the International Biological Program (IBP). An important historic milestone that initiated much of the comprehensive ecosystem-level research that has since been published from the Hawaiian archipelago.

Mueller-Dombois, D., J. D. Jacobi, H. J. Boehmer, and J. P. Price. 2013. *Ohia Lehua Rainforest. The story of a dynamic ecosystem with relevance to forests worldwide*. Charleston, SC: n.p.

Discusses forest dynamics and succession in island ecosystems dominated by single canopy species based on long-term research on Metrosideros-dominated forest in the Hawaiian archipelago. Richly illustrated.

Towns, D. R., C. H. Daugherty, D. R. Drake, and C. P. H. Mulder, eds. 2002. The biology of insularity. *Journal of Biogeography* 29:563–834.

Twenty case studies and syntheses from a 2001 conference on the ecology of insular biotas. Papers address a wide range of different topics from evolution to ecology for both true islands and habitat islands and for a wide range of taxa (vertebrates, invertebrates, plants). The introductory article, concluding article, and the section on ecological processes in insular systems provide new perspectives for ecology on islands.

Vitousek, P. 2004. *Nutrient cycling and limitation: Hawaii as a model system*. Princeton, NJ: Princeton Univ. Press.

A milestone of ecosystem ecology, Vitousek introduces islands and their elevational and substrate age gradients as model systems for ecosystem ecology. Based on comprehensive and long-term studies in the Hawaiian archipelago, this study explores the implications of increased availability of nitrogen and parallel decreased availability of phosphorus with substrate age.

Vitousek, Peter M., Lloyd L. Loope, and Henning Adsersen, eds. 1995. *Islands: Biological diversity and ecosystem function*. Ecological Studies series. New York: Springer.

Somewhat dated but still the most comprehensive edited book on the different aspects of ecosystem ecology on islands, including effects of global change drivers such as invasive species or climate change. A rich source of older research and inspiring ideas that remain relevant.

Island Paleobiogeography

The aim of island paleobiogeography is to understand how changes in the climate (including wind and sea current systems) and other geographical features (such as emergence, submergence, size, isolation, altitude, archipelago configuration, etc.) through time (both deep and recent time) help to explain the biotic composition of islands. In recent years, new data, such as bathymetric maps based on multibeam technology, helped to provide a better understanding of the role of island age and within-archipelago connectivity between islands (Price and Clague 2002; Ali and Aitchison 2014), and changing regional island configurations (Warren, et al. 2010), including past stepping stones (Fernández-Palacios, et al. 2011), for the assembly of island biotas.

Ali, Jason R., and Jonathan C. Aitchison. 2014. Exploring the combined role of eustasy and oceanic island thermal subsidence in shaping biodiversity on the Galapagos. *Journal of Biogeography* 41:1227–1241.

Provides a reconstruction of Paleo-Galápagos during the last million years, taking into account the Pleistocene sea-level shifts as well as the thermal subsidence affecting this archipelago. The authors discuss how this has left a signal in the present biotic assemblage of the Galápagos.

Fernández-Palacios, José María, Lea de Nascimento, and Rudiger Otto, et al. 2011. A reconstruction of PalaeoMacaronesia, with particular reference to the long-term biogeography of the Atlantic island laurel forests. *Journal of Biogeography* 38:226–246.

Reevaluates the biogeographical history and relationships of Macaronesia in the light of geological evidence, which suggests that large and high islands may have been continuously available in the region for much longer than is indicated by the maximum surface area of the oldest current island (27 million years)—possibly for as long as 60 million years. The article discusses the role of these past islands as stepping stones, refugia of species, and islands of past speciations.

Price, Jonathan P., and David A. Clague. 2002. How old is the Hawaiian biota? Geology and phylogeny suggest recent divergence. *Proceedings of the Royal Society of London, Series B Biological Sciences* 269:2429–2435.

The authors reconcile geological data on the old age (more than 50 million years) of the now low-lying or drowned leeward islands and seamounts of the Hawaiian chain with phylogenetic data on the recent origin of the Hawaiian biota. They argue that colonization of young islands from islands older than about 5 million years (Kauai's age) did not contribute importantly to the Hawaiian biota, as these islands and current high islands never coexisted as elevated islands in the same time.

Warren, B. H., D. Strasberg, J. H. Bruggemann, R. P. Prys-Jones, and C. Thébaud. 2010. Why does the biota of the Madagascar region have such a strong Asiatic flavour? *Cladistics* 26:526–538.

Highlights the fascinating biogeography of the Western Indian Ocean based on new phylogenetic and geological data that indicate major changes of island arrangements and sizes over geological time periods.

Island Paleoecology

The study of past insular environments, and their biotic composition and ecology, is the aim of island paleoecology. Paleoecology enabled important insights into the role of past climate change (McGlone 1985) and human impacts such as species extinctions (Wood, et al. 2012; Froyd, et al. 2014; Flannery 1994) and habitat change (including through changes of the fire regime and through prehistoric impacts of indigenous communities, e.g., de Nascimento, et al. 2009). Analyses of soil properties have recently been used to understand the ecology and impacts of traditional agriculture on the leeward dry versus windward wet sides of islands such as Hawaii or Rapa Nui (Easter Island) (Vitousek, et al. 2014).

de Nascimento, Lea, Katherine J. Willis, José María Fernández-Palacios, Constantino Criado, and Robert J. Whittaker. 2009. The long-term ecology of the lost forests of La Laguna, Tenerife (Canary Islands). *Journal of Biogeography* 36:499–514.

Demonstrates that vegetation composition of different forests in the Canary Islands changed dramatically in the last millennia—and probably in relation with indigenous land use.

Flannery, T. 1994. *The future eaters*. Kew, Australia: Reed.

A provocative book, accessible to lay readers. It presents ecological histories of Australia, New Guinea, New Zealand, and New Caledonia from their geological origins through prehuman, aboriginal, and European eras. Thereby reviews the major changes that happened to ecosystems due to human impacts in different phases.

Froyd, Cynthia A., Emily E. D. Coffey, Willem O. van der Knaap, Jacqueline F. N. van Leeuwen, Alan Tye, and Katherine J. Willis. 2014. The ecological consequences of megafaunal loss: Giant tortoises and wetland biodiversity. *Ecology Letters* 17:144–154.

The demise of the Galápagos tortoises due to human impacts and its consequences for freshwater wetlands is highlighted in this work. The article makes evident how the disappearance of keystone species can widely affect whole ecosystems and their constitutive species.

McGlone, M. S. 1985. Plant biogeography and the late Cenozoic history of New Zealand. *New Zealand Journal of Botany* 23:723–749.

Classic work that reviews the patterns of regional endemism, vicariance, and disjunction in New Zealand higher plants. The article concludes that the active tectonism since the Oligocene, especially the rapid rising of the Southern Alps (and not the disruptive effects of ice and severe climates during the last glaciation) are responsible for the present distribution patterns.

Vitousek, Peter M., Oliver A. Chadwick, Sara C. Hotchkiss, Thegn N. Ladefoged, and Christopher M. Stevenson. 2014. Farming the rock: A biogeochemical perspective on intensive agriculture in Polynesia. *Journal of Pacific Archaeology* 5.2: 51–61.

Synthesis of an interdisciplinary research program that integrated biogeochemical analyses of Pacific island ecosystems with studies of the pre-European-contact human societies. This was done in order to understand the ecology and impacts of traditional agriculture on Pacific islands.

Wood, Jamie R., Janet M. Wilmshurst, Trevor H. Worthy, Avi S. Holzapfel, and Alan Cooper. 2012. A lost link between a flightless parrot and a parasitic plant and the potential role of coprolites in conservation paleobiology. *Conservation Biology* 26:1091–1099.

Based on the analysis of coprolites (fossil faeces) the authors reconstruct a past ecological interaction between two now-rare species with distributions that no longer overlap: a large, nocturnal, flightless parrot (kakapo, *Strigops habroptilus*), and a cryptic root-parasite (*Dactylanthus taylorii*).

Species Extinctions

Islands are hotspots of species extinctions. Quammen 1996 is a journalistic account of species extinctions on islands. Sakai, et al. 2002 reports on the dramatic situation for Hawaiian plants, Steadman 2006 is a classic treatise of bird extinctions in the Pacific, and Goodman and Jungers 2014 reviews animal species extinctions in Madagascar. An important implication of species extinctions is the loss of mutualistic interactions between plants and animals. Meehan, et al. 2002 and Hansen and Galetti 2009, for instance, demonstrate the dramatic loss of large frugivores (see also Island Paleoecology). Massive further extinctions of island species are expected in the near future. Caujapé-Castells, et al. 2010 comprehensively reviews the different threats affecting island floras. More extinctions are expected due to time lag effects alone (i.e., many island species do not have the necessary living conditions anymore and will go extinct without support). Triantis, et al. 2010 estimates that magnitude of such an extinction debt that results from habitat loss and fragmentation alone. An overview of the magnitude of the conservation challenge is given in the appendix of Kueffer and Kaiser-Bunbury 2014 (cited under Biological Conservation). Walker and Bellingham 2011 provides a broad introduction based on selected case examples of the numerous conservation challenges on islands. In other subsections there are reviews on patterns of biodiversity loss and the impacts of invasive species and climate change.

Caujapé-Castells, J., A. Tye, and D. J. Crawford, et al. 2010. Conservation of oceanic island floras: Present and future global challenges. *Perspectives in Plant Ecology Evolution and Systematics* 12:107–130.

A comprehensive review of the conservation status of island floras, their main threats, and capacity and needs for conservation action.

Goodman, Steven M., and William L. Jungers. 2014. *Extinct Madagascar: Picturing the island's past*. Chicago: Univ. of Chicago Press.

In this nicely illustrated book the authors depict the loss of land animal species, unique to Madagascar, that have vanished since the arrival of humans some 2,500 years ago. The authors seek to recapture these extinct mammals in their environments, reconstructing their biology and relationships to animals that are still alive.

Hansen, D. M., and M. Galetti. 2009. The forgotten megafauna. *Science* 324:42–43.

Highlights the loss of megafauna by comparing the sizes of the largest extinct, still extant but rare, and still present and common frugivorous animal species on continents and islands. They document a downsizing of the mass of the largest frugivore by several orders of magnitude and discuss the implications for seed dispersal and the risk of secondary loss of plant species.

Meehan, H. J., K. R. McConkey, and D. R. Drake. 2002. Potential disruptions to seed dispersal mutualisms in Tonga, Western Polynesia. *Journal of Biogeography* 29:695–712.

Examines the seed dispersal capacity of Tonga's pre-human and current (reduced through extinction) bird and bat fauna, and compares it to fruit sizes in the flora. The study concludes that many large-seeded plant species that might formerly have been dispersed by multiple bird and bat species are now reliant on a single remaining bat species.

Quammen, D. 1996. *The song of the dodo*. New York: Touchstone.

A well-written overview for laypeople, covering the history of island biogeography from Darwin and Wallace to the 1990s, with a focus on evolution, ecology, and particularly conservation of island vertebrates. Quammen visits many islands and accompanies scientist in the field, engaging readers with the dramatic decline of island biotas.

Sakai, Ann K., Warren L. Wagner, and Loyal A. Mehrhoff. 2002. Patterns of endangerment in the Hawaiian flora. *Systematic Biology* 51.2: 276–302.

Illustrates the dramatic situation for island floras based on data from the Hawaiian archipelago: more than 50 percent of the species are endangered and many of them are known from only a few remaining populations.

Steadman, D. W. 2006. *Extinction and biogeography of tropical Pacific birds*. Chicago: Univ. of Chicago Press.

A detailed and comprehensive description of the extinct and extant avifaunas of most of Melanesia (except New Guinea), Polynesia (except Hawaii, and New Zealand), and Micronesia.

Triantis, K. A., P. A. V. Borges, R. J. Ladle, et al. 2010. Extinction debt on oceanic islands. *Ecography* 33:285–294.

Based on theoretical species-area relationships and data on forest arthropods in the Azores, the authors estimate that more than half of all extant species might die out after a time lag due to past habitat loss and fragmentation (extinction debt).

Walker, L. R., and P. Bellingham. 2011. *Island environments in a changing world*. Cambridge, UK: Cambridge Univ. Press.

A selected number of islands (Iceland, Britain, Japan, Canary Islands, Jamaica, Puerto Rico, Hawaii, Tonga, and New Zealand) are compared with respect to the following: physical environment, natural disturbance, biota, and human impacts. The final chapter predicts the future of increasingly disturbed island ecosystems. A broad overview suitable for lay readers.

Invasive Species

Biological invasions are particularly widespread on oceanic islands and are considered one of the most important threats affecting island biotas. Not surprisingly, examples from islands were already prominent in the foundational text of invasion biology by Elton 1958. Different hypotheses explaining the high incidence of invasions on islands are reviewed by Simberloff 1995, Denslow 2003, and Helmus, et al. 2014. Kueffer, et al. 2010 compiled a comprehensive data set on plant invasions on islands and review current knowledge, and Reaser, et al. 2007 review impacts of invaders on islands. Of particular concern for nature conservation are invasive mammals and their control, as exemplified by Courchamp, et al. 2003 and Drake and Hunt 2009. For more recent updates see Database of Island Invasive Species Eradications (cited under Island Conservation Biology). Short introductions to introduced species and biological invasions on islands can be found in the entries “Ants,” “Biological Control,” “Introduced Species,” “Invasion Biology,” “Pigs and Goats,” and “Rodents” in Gillespie and Clague 2009 (cited under General Overviews).

Courchamp, F., J. -L. Chapuis, and M. Pascal. 2003. Mammal invaders on islands: Impact, control, and control impact. *Biological Reviews* 78:347–383.

A detailed review of the impacts of invasive cats, rats, goats, rabbits, and pigs, followed by consideration of methods for control or eradication. Outcomes are described in which eradication (1) restores ecosystems, (2) must be followed by reintroduction of native species, and (3) may result in unexpected further environmental degradation.

Denslow, J. S. 2003. Weeds in paradise: Thoughts on the invasibility of tropical islands. *Annals of the Missouri Botanical Garden* 90.1: 119–127.

Different hypotheses explaining the high degree of plant invasions on islands are reviewed.

Drake, D. R., and T. L. Hunt, eds. 2009. Invasive rodents on islands. *Biological Invasions* 11:1483–1754.

Eighteen papers from a 2008 conference examining effects of invasive rodents on islands, especially rat species in the Pacific. Papers focus on effects of rats as functionally novel predators and herbivores and the ecological effects of rat removal from islands.

Elton, C. S. 1958. *The ecology of invasions by animals and plants*. London: Methuen.

Foundational text of the research field of invasion biology that builds heavily on examples from islands including in a chapter entitled “the fate of remote islands.”

Helmus, Matthew R., D. Luke Mahler, and Jonathan B. Losos. 2014. Island biogeography in the Anthropocene. *Nature* 513:543–546.

The article uses data on the distribution of exotic anole lizards among Caribbean islands to conclude that, unlike the island biogeography of the past that was determined by geographic area and isolation, in the Anthropocene biogeographic patterns are mainly determined by economic isolation.

Kueffer, C., C. C. Daehler, C. W. Torres-Santana, C. Lavergne, J. -Y. Meyer, R. Otto, and L. Silva. 2010. A global comparison of plant invasions on oceanic islands. *Perspectives in Plant Ecology, Evolution and Systematics* 12:145–161.

A comprehensive global review of plant invasion patterns on islands around the world. The article concludes that different species become invasive on different islands and reviews possible explanations.

Reaser, J. K., L. A. Meyerson, and Q. Cronk, et al. 2007. Ecological and socioeconomic impacts of invasive alien species in island ecosystems. *Environmental Conservation* 34.2: 98–111.

A review of both ecological and socioeconomic impacts of invasive species on oceanic islands.

Simberloff, D. 1995. Why do introduced species appear to devastate islands more than mainland areas? *Pacific Science* 49:87–97.

Questions the idea that islands are inherently more vulnerable to invasions than continental areas. The author emphasizes that more data on introduction rates of species and failed invasions would be needed to make sound comparisons of invasibility between islands and continents. Concludes that higher invasion rates on islands are mainly a result of islands' lack of particular functional groups of species, especially terrestrial mammals.

Climate Change

Oceanic islands are increasingly faced with the threat of climate change. Due to their small area, topographic heterogeneity, and associated steep climatic gradients they have many distinct climate zones that are often restricted in size and characterized by extreme climates (e.g., dry, wet, cold). Islands might thus frequently experience the loss of whole climate zones and associated biotas. Another major threat is sea-level rise, which will threaten biodiversity both directly through the loss of habitat (Bellard, et al. 2013) and indirectly through the inland movement of humans that are displaced by sea-level rise (Wetzel, et al. 2012). Surprisingly, climate change impacts on island biodiversity have only recently received major scientific attention (see Petit and Prudent 2008 and Harter, et al. 2015).

Bellard, C., C. Leclerc, and F. Courchamp. 2013. Impact of sea level rise on the 10 insular biodiversity hotspots. *Global Ecology and Biogeography* 23:203–212.

Models project how sea-level rises of one to six meters would affect biodiversity losses to the 4,447 islands located within biodiversity hotspots, by estimating the number of entire islands and species of plants and vertebrates that would be lost.

Harter, David E. V., Severin D. H. Irl, and Bumsuk Seoc, et al. 2015. Impacts of global climate change on the floras of oceanic islands: Projections, implications and current knowledge. *Perspectives in Plant Ecology, Evolution and Systematics* 17.2: 160–183.

The most comprehensive review of climate change impacts on island biodiversity available today, focusing on plants.

Petit, Jérôme, and Guillaume Prudent. 2008. *Climate change and biodiversity in the European Union overseas entities*. Gland, Switzerland: IUCN.

This is the first comparative analysis of the twenty-eight overseas entities of the European Union. It starts with a thematic analysis presenting the transversal threats on overseas entities in the face of climate change, with subsequent sections, specific for each of the twenty-eight entities, which provide some contextual data and an overview of their remarkable biodiversity.

Wetzel, F. T., W. D. Kissling, H. Beissmann, and D. J. Penn. 2012. Future climate change driven sea-level rise: Secondary consequences from human displacement for island biodiversity. *Global Change Biology* 18:2707–2719.

The article points out that climate change might also lead to major indirect impacts on island biodiversity through the movement of humans displaced from coastal areas through sea-level rise and into inland biodiversity areas.

Biological Conservation

Given the magnitude of the conservation challenge on islands, biological conservation on islands has a long tradition. Conservation

Given the magnitude of the conservation challenge on islands, biological conservation on islands has a long tradition. Conservation issues and projects are discussed in most articles reviewed in this document, either in relation to particular islands, species groups, or ecological processes. In particular, many conservation projects deal with invasive species, which are discussed in a previous section. Baret, et al. 2012 is an example of a comprehensive conservation strategy for plants in La Réunion. Kueffer and Kaiser-Bunbury 2014 points out that islands are model systems for new conservation approaches such as the adoption of novel ecosystems, inter situ conservation, or "re-wilding," and the article also reviews conservation innovations on islands. One successful strategy in many island groups is to restore small offshore islands; this is a strategy pioneered in New Zealand (Towns, et al. 1990). Burney and Burney 2007 and Florens and Baider 2013 demonstrate that intensive habitat restoration and subsequent management can also be effective on densely populated main islands. Ewel, et al. 2013 reviews the characteristics of novel ecosystems on islands and their potential value for conservation, of which Meyer, et al. 2015 provides a concrete example. Hansen 2010 gives an overview of ongoing re-wilding projects on the world's islands.

Baret, Stéphane, Christophe Lavergne, and Christian Fontaine, et al. 2012. Une Méthodologie concertée pour la sauvegarde des plantes menacées de l'île de La Réunion. *Révue d'Ecologie (Terre et Vie)* 67:85–100.

Presents the comprehensive plant conservation strategy of La Réunion (Mascarenes) in the Western Indian Ocean.

Burney, D. A., and L. P. Burney. 2007. Paleoecology and "inter-situ" restoration on Kauai, Hawaii. *Frontiers in Ecology and the Environment* 5:483–490.

The authors propose inter-situ conservation—the conservation of species outside of their past distribution but with the aim of maintaining essential ecological interactions—as a third strategy besides in situ and ex situ conservation. They illustrate their concept with a conservation project on Kauai Island in the Hawaiian archipelago.

Ewel, J. J., J. Mascaro, C. Kueffer, A. E. Lugo, L. Lach, and M. R. Gardener. 2013. Islands: Where novelty is the norm. In *Novel ecosystems: Intervening in the new ecological world order*. Edited by R. J. Hobbs, E. S. Higgs, and C. M. Hall, 29–44. Oxford: Wiley-Blackwell.

The chapter of the reference book on novel ecosystems, focusing on islands.

Florens, F. B. V., and C. Baider. 2013. Ecological restoration in a developing island nation: How useful is the science? *Restoration Ecology* 21:1–5.

Demonstrates that a combination of fencing, removal of all invasive species, and subsequent maintenance management can, in the space of a few years, have a dramatic positive effect on native species recovery, even on highly populated islands. The authors also emphasize the importance of science in supporting such conservation projects.

Hansen, D. M. 2010. On the use of taxon substitutes in rewilding projects on islands. In *Islands and evolution*. Edited by V. Pérez-Mellado and C. Ramón, 111–146. Menorca, Spain: Institut Menorquí d'Estudis.

Re-wilding is the process of restoring ecosystem functioning and the functional composition of biotas through the introduction of non-native species that are functionally (i.e., in their ecology) similar to extinct species that previously were responsible for a particular function (such as seed dispersal, pollination) in an ecosystem. This contribution summarizes the arguments in favor of re-wilding on islands and presents ongoing projects from around the world involving birds, reptiles (especially tortoises) and plants, among others.

Kueffer, C., and C. Kaiser-Bunbury. 2014. Reconciling conflicting perspectives for biodiversity conservation in the Anthropocene. *Frontiers in Ecology and Environment* 12:131–137.

A conceptual review of biodiversity conservation on oceanic islands, emphasizing that different conservation strategies must be

A conceptual review of biodiversity conservation on oceanic islands, emphasizing that different conservation strategies must be integrated (protected areas, restoration, novel ecosystems, reconciliation of land use with biodiversity, and creation of artificial biodiversity areas).

Meyer, J. -Y., R. Pouteau, E. Spotswood, R. Taputuarai, and M. Fourdrigniez. 2015. The importance of novel and hybrid habitats for plant conservation on islands: A case study from Moorea (South Pacific). ***Biodiversity and Conservation*** **24:83–101.**

Maps the distributions of native plants in three major types of vegetation: native-dominated, alien-dominated (novel), and hybrid (mixed). Although rare and threatened native plants are most heavily concentrated in the tiny remnant patches of native vegetation, significant numbers occur in hybrid and even novel vegetation, which highlights the potential conservation value of invaded habitats.

Towns, D. R., H. Daugherty, and I. A. E. Atkinson, eds. 1990. ***Ecological restoration of New Zealand islands*****. Wellington, New Zealand: Department of Conservation.**

Documents the use of small offshore islands for biodiversity conservation, a strategy pioneered in New Zealand and used on many islands around the world. On small islands it is possible to eradicate or control all invasive species, restore the vegetation, and translocate threatened species to the restored habitats—possibly supporting their survival through assistance such as supplementary feeding.

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