Chapter 4
'Detritus of a Coming World': The Colonization of Islands as Microcosms for Human Impacts on an Interplanetary Scale

Scott M. Fitzpatrick

Abstract The ability of humans to colonize islands in the ancient past required centuries of innovation in boat construction and the development of increasingly sophisticated seafaring technologies and wayfinding strategies. Nowhere is this more evident than in the vast expanse of the Pacific, where around 3000 years ago, Micronesian and Polynesian voyagers colonized what were arguably the most remote and difficult places to reach on Earth. Because the biota on these islands evolved for thousands, or even millions of years, high rates of endemism in these environments also made them ecologically fragile. The first arrival of *Homo sapiens*—the ultimate adaptive omnivore—caused a wide variety of impacts that were amplified by an order of magnitude with Euro-American incursion. In this sense, as aquatically bounded places, islands serve as model systems and microcosms for how humans have affected the earth's biosphere in the modern age. In this chapter, I document how the first island colonizers caused certain levels of ecological destruction, using Hawaiian and New Zealand birds as primary case studies. However, I take this concept further, suggesting that the processes involved in the prehistoric colonization and settlement of islands is also a corollary for how we can view the earth and future efforts to colonize other planets. Humanity is at a global tipping point, with unsustainably high human population impacts, habitat destruction, climate change, and recent pandemics. As the possibility of extraplanetary migration becomes an increasing reality—perhaps a necessity to ensure our survival—what lessons can be learned from the anthropological and archaeological study of islands as we seek new lives beyond *terra firma*? What are the possible consequences for our lineage and extraterrestrial life on this planet and beyond?

The title derives from a quote in the movie *Tenant* (2020) in which one of the characters describes remnants of complex objects from the future as "detritus of a coming war."

S. M. Fitzpatrick (✉)
Department of Anthropology, University of Oregon, Eugene, OR 97403, USA
e-mail: smfitzpa@uoregon.edu

Museum of Natural and Cultural History, Eugene, OR 97401, USA

B. Swartz and B. D. Mishler (eds.), *Speciesism in Biology and Culture*,
https://doi.org/10.1007/978-3-030-99031-2_4

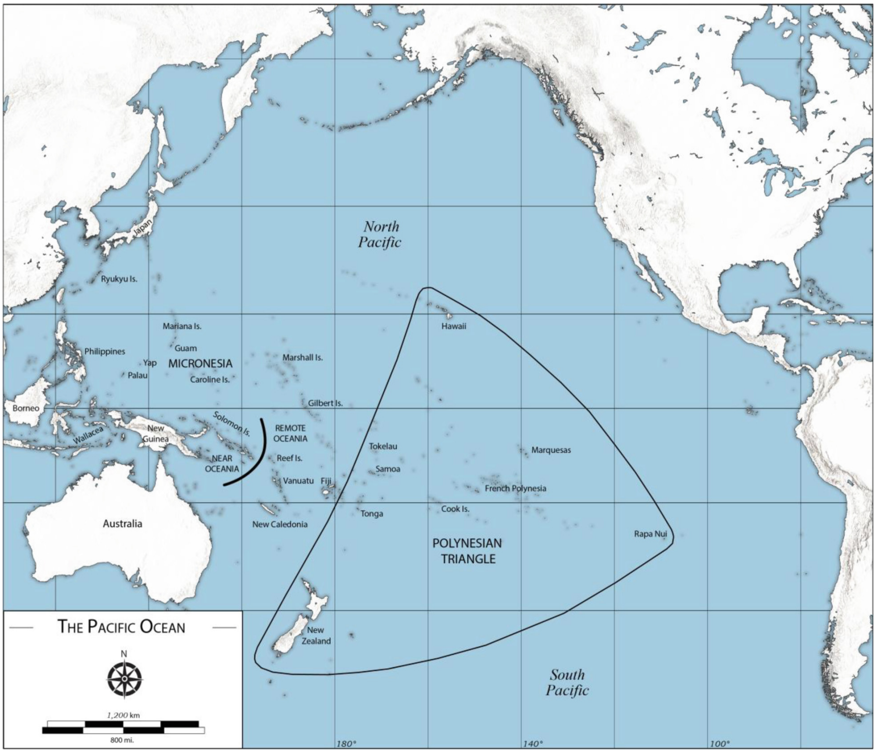

Fig. 4.1 Map of the Pacific showing separation of near and remote Oceania, the Polynesian triangle, and major islands and archipelagos

4.1 Introduction

During the late Holocene, between 3300 and 800 years ago, humans underwent the most rapid and extensive migrations in history. They colonized Micronesia and Polynesia, which comprise much of the Pacific and what is known today as Remote Oceania[1] (Fig. 4.1). After honing their skills for millennia around the hundreds of islands comprising Wallacea, the Philippines, and those surrounding New Guinea, these voyagers began colonizing the Pacific in a series of migratory movements that took them to what were arguably the most remote places on the planet. Reaching them required planning, provisions, and the ability to navigate across a seemingly boundless ocean for weeks or months using the stars and various wayfinding techniques. They took with them roots and tree crops, domesticated animals, tools made from stone and other materials, and centuries of inbuilt cultural knowledge. Combining these extraordinary efforts and carefully honed skills led Pacific Islanders to become

[1] This is a term given to those islands in the Pacific that are not intervisible, including Micronesia, Polynesia, and parts of island Melanesia.

the first colonists to step foot on these aquatically bounded landscapes. Yet as archaeological research shows, these islands would forever be altered by the presence of *Homo sapiens*.

What were the effects of humans on pristine island environments and how can these be tracked archaeologically? How has humanity altered the composition of island biotas? Has it always been destructive? These are fundamental questions for archaeologists who work on islands and are often situated within a framework that aims to identify long-term processes that occurred before and after the arrival of humans. By integrating paleoecology, archaeology, anthropology, and more recent history, scholars have tried to identify the ecological distribution of biodiversity and how human contact may have affected these newly discovered places (Braje et al. 2017; Braje and Erlandson 2013; Erlandson and Rick 2005; Fitzpatrick and Keegan 2007; Rick et al. 2013). Knowing the timing and extent of anthropogenic effects is important for understanding how humans dealt with new environments and how we modified them to ensure long-term survival. We must also consider the impact of people (mis)managing their social affairs and resources (Kirch 2007; Leppard 2019).

In this chapter, I examine how islands can serve as model systems for examining human impacts using the Pacific as a case study. This region documents how *Homo sapiens* has overcome significant technological challenges in long-distance transport (e.g., watercraft) that enabled them to endure travel across the open-ocean and establish colonies that over time became disconnected from their homeland. However, I expand on these cases and use them as corollaries for how nations, particularly the Soviet Union/Russia, United States, and China, have put humans into space, while many others, including the European Union, Japan, and United Arab Emirates, have made continued efforts to move beyond Earth and explore the universe for signs of the universe's origins, extraterrestrial life, and extraterrestrial habitats.[2] As colonizing Mars and other planets becomes more of a reality—perhaps even an ecological necessity—what lessons can we learn from archaeology and the ancient settlement of islands to help us better understand the future?

4.2 The Pacific Diaspora

Just prior to 3000 kya (kya: thousands of years ago), seafarers in the southwest tropical Pacific began to venture from their island homes and settle others that were 100s–1000s of kilometers away. This was not the first time that humans ventured to other islands of course. Examples range from the early case of *Homo erectus* reaching the Indonesian island of Flores around 800 kya; more frequent seafaring between 60 and 10 kya when Australia, the Bismarck Archipelago, and Solomon Islands were settled (Kealy et al. 2016, 2017; Roberts et al. 2020; Shipton et al. 2020); the island of

[2] While the number of nations with established space programs is relatively few, and those that have put humans into space is even fewer, this belies the fact that to date, astronauts/cosmonauts from 41 countries have now been to space.

Kozu off the coast of Tokyo at 20 kya and Ryukyu archipelago ca. 35 kya (Erlandson 2001); Crete, Sicily, Sardinia, Corsica, Cyprus, and Melos in the Mediterranean ca. 10 kya and 13 kya, respectively (Broodbank 2006; Dawson 2014:136–137; 173); and the Channel Islands of California ca. 13 kya (Rick et al. 2005) (see also Erlandson 2001; Fitzpatrick and Erlandson 2018). What these population movements clearly show is that humans around the world were independently inventing seaworthy craft and developing the skills to travel longer distances (between 20 and 180 km from the mainland), likely taking advantage of abundant coastal resources to settle regions such as the Americas (Erlandson et al. 2007, 2008, 2015). Interestingly, in some cases these ventures seem largely exploratory with a desire to only acquire resources such as obsidian and not to necessarily establish colonies (e.g., Kozushima, Melos). Incidentally, they also do not coincide with large scale faunal extinctions (Louys et al. 2021).

Not long after, many of the Caribbean islands were settled between 6 and 1 kya, as were those in the Mediterranean, North Atlantic, and Pacific (Anderson 2008; Cherry and Leppard 2015; Fitzpatrick 2013, 2015; see also papers in Boyle and Anderson 2010). The rapid development of sailing and navigational (wayfinding) technologies is astounding, and ultimately led to revolutions in transport and far-reaching effects on how we use the earth's natural systems.

While this global phenomenon was taking hold, one of the most pivotal seafaring movements was beginning in the crook of seas surrounding the Moluccas between the Philippines and New Guinea. Here, Austronesian-speaking groups that had traveled through the Philippines, perhaps originating in Taiwan, were intruding into occupied territories around 4.5 kya and moved farther eastward, eventually settling the Bismarck Archipelago and Solomon Islands in a region known as Near Oceania (Fig. 4.1). By 3.3–3.0 kya, however, pulses of voyaging activity are seen when islands in western Micronesia like the Marianas (Carson 2008; Hung et al. 2011; Rieth et al. 2019) and Palau (Clark 2005; Fitzpatrick and Jew 2018) were settled temporally alongside the dispersal of Lapita peoples eastward from the Bismarcks to remote archipelagoes such as the Reef Islands, New Caledonia, Vanuatu, Fiji, Tonga, and Samoa (Bedford and Spriggs 2019; Bedford et al. 2006; Kirch 1997a). These forays into Remote Oceania represent the first time in the Pacific where humans sailed to other islands that were not intervisible, indicating the ability to track the rising and falling of stars as a sidereal compass coupled with various techniques such as identifying wave patterns, cloud formations, seabird congregations (signaling land), and known migratory routes of whales. Enhanced knowledge of oceanographic processes—for instance, winds that shifted episodically during El Niño/Southern Oscillation events and favored eastward travel—also likely played a role (Anderson et al. 2006; Finney 2003; Gladwin 1970; Goodwin et al. 2014; Irwin 1994; Lewis 1994; Montenegro et al. 2014, 2016). Archaeological evidence shows that these were not always one-way trips but were repeated to obtain important resources, including obsidian, basalt, and pottery, engage in trade and exchange, find marriage partners, and maintain connections with relatives (e.g., Chiu et al. 2020; Sheppard 1993; Torrence and Swadling 2008; White and Harris 1997).

Key dispersals aside, what had transpired with Lapita and its descendent communities for two millennia also laid the foundation for another major episode in Pacific prehistory—the colonization of East Polynesia beginning 1200–800 years ago (Hunt and Lipo 2008; Kirch 1997b; Sear et al. 2020; Wilmshurst et al. 2011). After a 'long pause' of nearly two millennia, the descendants of Lapita groups in Samoa and/or Tonga spread rapidly across the Eastern Pacific, settling the Cook Islands, the Society Islands, the Marquesas, the Tuamotus, Aotearoa (New Zealand), Rapa Nui (Easter Island), Hawai'i, and many islands in between. It is unclear what exactly spurred these movements, but it seems they probably involved a combination of pushing and pulling factors: exceeding carrying capacity, climate change that caused extended periods of rain or drought affecting agricultural production (Sear et al. 2020), displeasure with local leaders, or simply the desire to explore. There is also a case to be made for religious exile having been the impetus for maritime migration in Polynesia and elsewhere historically (Anderson 2006). These migrations would not have been possible, however, without a combination of new technological developments, primarily double hulled canoes that could carry dozens of people and their provisions along with enhanced knowledge of celestial navigation.

While the motivations that drove Micronesians and Polynesians to search for new islands may never be known entirely, it is clear that they were exceptionally prepared colonizers because they brought with them many of the things needed to survive. These included domesticated animals like pigs, dogs, and chickens; cultigens such as taro, yams, coconut, and breadfruit; resources for manufacturing tools; and ecological knowledge of how to exploit each region's abundant marine resources (e.g., Allen 2002, 2007; Fitzpatrick et al. 2011; Harris and Weisler 2018; Horrocks et al. 2015; Kirch 2017; Lambrides and Weisler 2016; Leach and Davidson 2001; Matisoo-Smith and Robins 2004; Sheppard et al. 2010; Storey et al. 2013; Reepmeyer et al. 2012; Szabó and Amesbury 2011; Weisler and Woodhead 1995). This combination of introduced biota, material culture, and ecological expertise is often described as a "transported landscape" (Anderson 1952) in which Pacific Islanders modified their new island homes based on how and where they lived previously (e.g., see Gosden 1992; Kirch 1983, 2007; Storey et al. 2013). Not only that, but they were able to sail to places like Hawai'i, which was colonized from Central-East Polynesia more than 2200 nautical miles away (as the crow flies). However, this would have been much farther when having to use standard tacking maneuvers in a zig-zag fashion (a.k.a. *beating*) while also harnessing the wind to move in the desired direction. These colonizing events are even more extraordinary knowing that Polynesia comprises 10 million square miles (16 million km^2) of ocean with only around 1000 islands which are extremely remote and mostly low-lying atolls and uplifted limestone.

Considering these oceanographic effects, their remoteness, the technological requirements for sailing, and thousands of years of cultural evolution, it is no surprise then that these islands were settled relatively late. This also means that the islands of Micronesia and Polynesia were devoid of humans for thousands or even millions of years after their emergence, and led to endemic environments that were untouched by humans and extremely sensitive to introduced organisms. For example, as of 2014, 26,608 different terrestrial and marine lineages (vertebrates, invertebrates, plants, amphibians, insects, arthropods, etc.) were recorded in the Hawaiian Islands, including 10,000–10,500 endemics and 5000 non-natives (Evenuis and Miller 2015). This means that Hawai'i, like many other Pacific islands that are distant, ecologically fragile, and settled relatively late by humans, were destined to have their habitats impacted to some degree.

How do we measure these potential impacts (if they occurred), and what can we learn from archaeology to postulate how these findings might affect what humans are doing now and in the future? To do this, we can look to the concept of model systems as a convenient and useful approach.

4.3 Islands as Model Systems

Model systems have been widely used in the fields of molecular biology and ecology. Vitousek (2002:573) notes that these are "a system—which could be a gene and its regulators, an organism, or an ecosystem—that displays a general process or property of interest, in a way that makes it understandable (Vitousek 2002:574)." Given this definition, oceanic islands can serve as useful model systems for understanding human-land interactions (Vitousek 2002:574–575; 2004).

Building on this framework, archaeologists have argued that these types of environments have succumbed to the presence of humans and the purposeful (or accidental) introduction of non-native organisms (DiNapoli and Leppard 2018; Kirch 2007; Fitzpatrick and Erlandson 2018). This follows a human ecodynamics approach which states that humans are an integral part of any environment, that we can look to the past for lessons in sustainability and resilience, and understanding these processes can benefit society at large (Fitzhugh et al. 2019). This is essentially the recognition that *Homo sapiens* cannot be decoupled from their environment and will always be an integral part of their surroundings physically and culturally. Doing so allows us to better explore the effects that our species has had on islands and other landscapes by taking advantage of data deriving from different fields of study that cover the *long durée* of human history—from millennial (archaeology, palaeoecology) to centennial (human cultural history) and decadal or annual scales (e.g., marine biology). These can then all be joined to provide temporal perspectives on environmental influence and change (e.g., see Braje et al. 2017; Erlandson and Rick 2008, 2010; Kirch and Hunt 1997a, b; Fitzpatrick and Keegan 2007; Rick et al. 2013).

Examining how humans have affected islands can be accomplished in different ways archaeologically, but includes identifying the animal and plant species that were present before human arrival (an often difficult task considering the notoriously poor preservation of organic remains in some environments) and determining how humans modified landscapes after colonization. The latter evidence might be things like clearing forests for settlement and agriculture using slash and burn (leading to erosion), the extraction of resources (e.g., timber, stone), diversion of water vis-à-vis canals and irrigation networks, stone construction (e.g., walls, fortifications, fish traps or ponds), and modifying landscapes as populations grow. It is critical that these data also be anchored with good chronologies to ensure that the timing of human occupation is known (e.g., see Wilmshurst et al. 2011; Napolitano et al. 2019).

An excellent example of an oceanic island model system is Hawai'i, which Kirch (2007) notes has:

> (1) relatively late colonization of a previously uninhabited landscape by people with an advanced "Neolithic" form of economy; (2) a short, well-controlled time scale (ca. 1,000 years, C.E. [A.D.] 800-1800 for cultural evolution; (3) near-total isolation of the cultural group after an initial period of colonization and two-way voyaging; (4) a demographic transition from small, low-density populations to large, high density populations; and finally, (5) a major transformation in the scale of sociopolitical complexity, as expressed in social hierarchy, economic control systems, material symbols of rank, monumentality, and similar indices.

While not all Pacific Islands provide the same useful evidence for answering questions regarding human-environmental interactions, Hawai'i, and also New Zealand, provide important case studies for examining these issues. Below I briefly discuss what is observed archaeologically for both archipelagoes in terms of human impacts on birds, which are among the most ecologically sensitive and easily impacted island animals. It is also well documented that humans have had profound effects on these environments, leading to significant impacts on birds globally (Blackburn et al. 2004; Burney 1997; Duncan and Boyer 2002, 2013; Steadman 1995, 2006; Steadman et al. 2002; Weisler and Gargett 1993). These two archipelagos then provide a snapshot of human-induced changes to the islands showing that birds are literally and figuratively 'canaries in a coal mine' and serve as a litmus test for detecting and estimating ecological impacts (see Steadman 2006).

4.4 Islands as Microcosms of Human Destruction

Hawai'i was the most remote group of islands ever colonized by humans in the ancient past. Typical of oceanic archipelagos, the farther they are from mainland areas the more ecologically impoverished they become. This trend is seen in the Pacific where there is a decline in diversity from west to east, known as faunal attenuation (Keast 1996). As noted earlier, these pristine island environments, having been colonized over time by encounters with floating debris carrying seeds, pollen, insects, and animal castaways that do not disperse well over water (e.g., ants, lizards, small mammals), along with flying organisms (primarily birds and occasionally bats), evolved for millions of years with few new migrants. The result was the evolution of biota in near isolation that led to numerous endemics. As Steadman (2006:40) notes, "[t]errestrial biotas in Oceania are influenced by the island's isolation from source areas (usually other islands), size, age, climate, and geological and edaphic environment. Of these attributes, perhaps none is more important than isolation."

Among these biological changes were a tendency for birds to become flightless and ground-dwelling, including rails (Steadman 2006:296–319) and ratites (e.g., the large flightless moa that evolved in New Zealand over millions of years). Flightlessness has evolved in ratites more than in any other group of birds, a trend observed in birds more broadly (Steadman 2006:296). This kind of evolutionary change is not uncommon given the absence of apex predators or terrestrial omnivores that are typically highly mobile and adaptive. For the Pacific Islands, humans were the primary predator and rats were the other, though the introduction of domestic dogs and pigs also played a significant role (Anderson 2009). Dogs, in particular, have served as hunting companions for humans worldwide and are predators themselves (Doherty et al. 2017). In one modern case, a single stray dog roaming the Waitangi State Forest in New Zealand was deemed responsible for killing an estimated 500 North Island Brown Kiwi (*Apteryx australis mantelli*) in a period of weeks or months, which represented more than half the known population of this endangered bird. This kiwi was easy prey since it is known to be a noisy animal with a strong and distinctive smell. Further, given its low reproduction rate, it was estimated that it could take 8–10 years for the population to rebound to its original size of around 900 individuals (Taborsky 1988).

Many mechanisms explain the decline in bird (or other) diversity on islands, but none were as quick or profound as the arrival of humans. It is important to remember that long periods of isolation and evolution led to naïveté toward people—there was no initial fear of predation by these new human colonists or their domestic companions and it would have taken little effort to capture birds or collect their eggs. While the need for food and resources like feathers would have enacted a terrible toll on local avifauna, it was likely the widespread clearance of forests for villages and arable land through burning that accelerated the decimation of island bird diversity.

An excellent case in point was arrival of the Maori to New Zealand around AD 1200 that led to the rapid extinction of nine species of the aforementioned moa, which were overhunted within ~150–200 years (Anderson 1989, 2003). Steadman (2006:405–417) reports that since human arrival in the Pacific, there have been between 820 and 1960 species of passerines (small, perching birds), non-passerine landbirds, and seabirds that have gone extinct, with the number of extirpated populations potentially 10 times higher. In addition, the decline or eradication of certain food resources also caused ecological cascades—the presumed extinction of the Haast's eagle (*Hieraaetus mooreiin*) in New Zealand, the largest eagle ever known (~15 kg) due to its adaptations for hunting moa, went extinct around AD 1400 as its primary food source was removed. Given that these are remote, insular environments, there was little chance for populations to rebound through breeding or immigration like what would have more easily occurred on larger landforms. It should be noted that it is difficult to provide more precise estimates without robust fossil assemblages that pre-date human contact and which are also difficult to find given generally poor preservation and a lack of survey on many islands.

When and how birds and other animals went extinct in the Pacific Islands is variable. However, we must consider issues such as population density and growth, whether occupation was temporary or permanent, if settlements were inland or coastal, subsistence strategies (e.g., hunting-gathering-fishing, horticulture, large scale agriculture), and the types of introduced plants and animals (e.g., degrees of husbandry, roaming and/or feral species) (see Steadman 2006:414). While we may never truly know the amount of Pacific biodiversity prior to human arrival—and thus extirpation or extinction rates—data here and in other island regions such as Madagascar and the Caribbean (e.g., Burney and Flannery 2005; Fitzpatrick and Keegan 2007; Hawkins et al. 2019; Martin and Steadman 1999; Steadman 2006; Steadman et al. 2002) clearly point to varying degrees of ecological destruction, particularly for birds but also many other organisms.

There are numerous explanations for how human impacts on native ecologies played out in the Pacific. These range from perceptions of overly sustainable practices and harmonious relationships (i.e., Polynesian versions of "the noble savage") that had limited to no effects on island biota, to "overkill" or "blitzkrieg" models often used as explanations for megafaunal extinctions during the Pleistocene (e.g., see Barnosky et al. 2004; Brook and Bowman 2004; Grayson and Meltzer 2003; Louys et al. 2007; Rule et al. 2012). In overkill scenarios, species are progressively hunted at a rate where they cannot be replaced (more typical of k-selected species), which may take place over centuries or millennia. By contrast, blitzkrieg models account for humans moving at an extremely rapid pace as they carve a path through the landscape and leave no viable remnants of a given species which would allow it to maintain a sufficient breeding population. In some cases, the reasons behind this are unrelated to subsistence and may involve the desire for other resources like pelts, fur, or feathers; sometimes it is simply done for sport. History is replete with examples of both. These include well-known cases such as (1) the dodo (*Raphus cucullatus*) from the island of Mauritius that was first observed by Dutch sailors in 1598 and last seen only 64 years later after overhunting, habitat destruction, and the introduction of invasives; (2) the American plains bison (*Bison bison bison*) that numbered more than 25–30 million in the sixteenth century, but where overhunting nearly drove it to extinction in the late nineteenth century when only about 100 animals remained; and (3) the passenger pigeon (*Ectopistes migratorius*), which had an estimated population of three billion, but became an important food resource for settlers who migrated westward across the American continent, and subsequently became extinct in the early 1900s due to both overhunting and deforestation.

While these are extreme examples in recent history with no real archaeological corollaries, they do serve as stark reminders of what Garrett Hardin (1968) famously called the "Tragedy of the Commons" in which multiple users of a resource, unrestricted from extracting that resource, will eventually deplete it until nothing is left. With all of the evidence available, can we use the past colonization and settlement of islands as analogues for what we might expect in the future as humans move beyond our 'Earth Island' to other celestial bodies?

4.5 The Colonization of Other Worlds

On December 17, 1903, the Wright brothers took the first controlled flight near Kitty Hawk, North Carolina in an aircraft they built that instigated a technological revolution. It is astonishing that only 24 years later, Charles Lindbergh made his landmark solo non-stop crossing of the Atlantic in the *Spirit of St. Louis* (1927), and eight years after that in 1935, Amelia Earhart flew 2,408 miles from Honolulu to Oakland, CA (Fig. 4.2a). In 1986, Dick Rutan and Jeana Yager completed the first non-stop flight around the world without refueling in the custom-made Rutan Model 76 *Voyager* (Fig. 4.2b).

While advances in aviation quickly altered the fabric of human society, it did not take long for a human-made object to be propelled into space. In 1949, the Germans

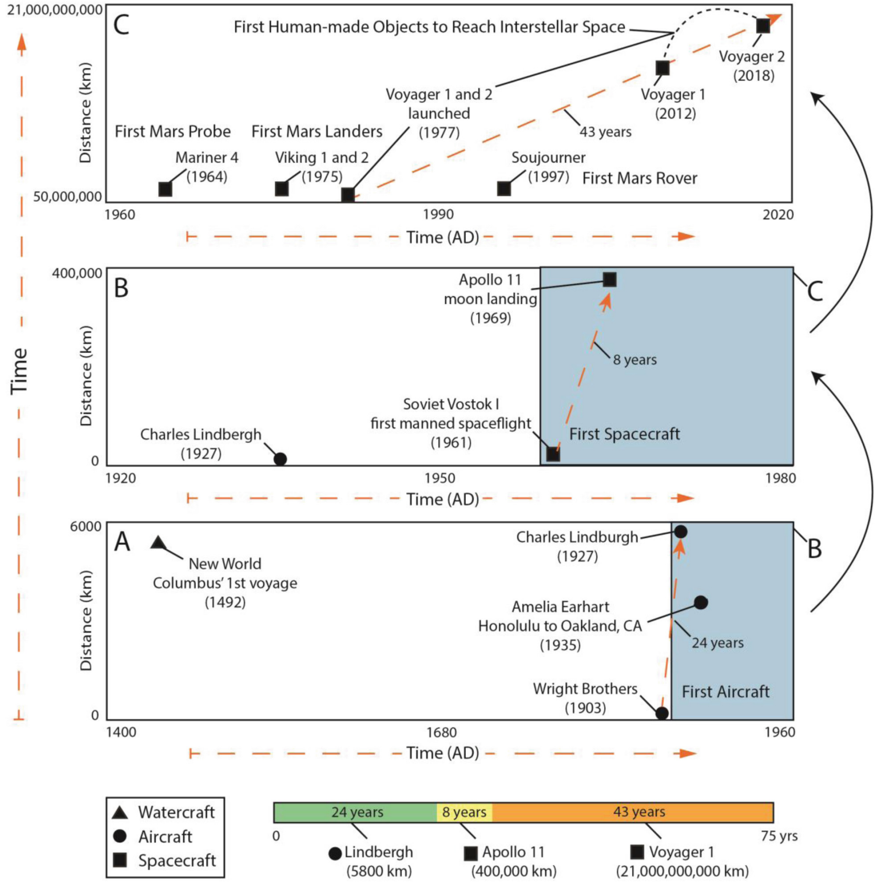

Fig. 4.2 Time slice chart of different transport technologies developed by humans over the last 500 years to colonize or reach different environments and some of the associated significant achievements. Note how distances increase (y axis) over shorter time spans commensurate with the development of more advanced technologies (adapted and revised from Fitzpatrick and Erlandson 2018: Fig. 1). The timeline at the bottom summarizes three of these accomplishments, showing how just 24 years after the Wright Brothers' success, Charles Lindbergh flew 5800 km across the Atlantic; it only took eight years for Apollo 11 to reach the moon after Yuri Gagarin became the first human to orbit Earth in the Soviet *Vostok 1*; and it took only 43 years for *Voyager* 1 to travel 21 billion miles from Earth after it was launched in 1977

launched their "Bumper-WAC" missile atop a V-2 rocket that reached an altitude of 244 miles. Eight years later, and only 54 years after Orville and Wilbur Wright first harnessed the wind in their heavier-than-air contraption, the Soviet Union launched Sputnik 1 on October 4, 1957; a short time later in 1961, Yuri Gagarin became the first human to orbit Earth aboard the Vostok I. Seven years after that in 1968, Apollo 8 became the first manned crew to leave low-Earth orbit and travel around the moon, with astronaut William Anders taking the first 'Earthrise' photo. A short time later, the United States accomplished the extraordinary feat of traveling 385,000 km and landing on the Moon where Neil Armstrong became the first human to step foot on the lunar surface as part of the American Apollo 11 space mission on July 20, 1969 (Fig. 4.2b). Subsequent attempts by NASA eventually led to six more Apollo moon missions between 1969 and 1972 where a total of 12 astronauts eventually walked on its surface, with another (Apollo 13) having to abandon their attempt due to a series of mechanical failures. And how could we forget the *Voyager* 1 and 2 missions, launched in 1977 with the primary goal of exploring Jupiter and Saturn but continuing on to reach interstellar space on August 2012 and November 2018, respectively? They are now between 11 and 14 billion miles from Earth and still sending back important data on the history and composition of our solar system (Fig. 4.2c). What these events demonstrate is that humans have developed increasingly more sophisticated transport technologies over shorter periods of time, allowing us and our machines to go farther and faster in the last 100 years than in the millions before that.

There is no question that these were all extraordinary feats of human ingenuity, perseverance, and engineering prowess. They also continued to whet the appetite of those who would dare to venture beyond the more stable platforms of *terra firma*—not only to the oceans, mountains, and other inhospitable places on Earth—but those moons and planets in our own solar system, namely Mars. The Red Planet has captured the imagination of humans for millennia due to its size and relative proximity to the earth, leading many ancient civilizations to recognize its presence and hue, like the Greeks and Romans who attributed Mars to their gods of war. As a testament to the Red Planet's interest to those of us on Earth, NASA has sent a series of orbiters, landers, and rovers there since 1964, with the Pathfinder mission landing the first rover named *Sojourner* which touched down on July 4, 1997 (Fig. 4.2c). Four other rovers from the United States have successfully landed there and explored the planet's surface, including *Spirit* and *Opportunity* in 2003, *Curiosity* in 2011, and *Perseverance* in 2021 that carried with it the first rotorcraft named Ingenuity. Notably, China landed its first rover on Mars named *Zhurong* in May 2021. Europe's space agency in conjunction with Russia, plans to send another in 2022 named *Rosalind Franklin.*

The fascination with Mars is not only scientific, but pragmatic. As Earth's nearest accessible corollary, researchers are interested in how the planet formed, whether water was present (now confirmed to pre-date life on Earth ca. 3.5 billion years ago; see Deng et al. 2020; Heydari et al. 2020), if there is evidence for past or current lifeforms (still unknown), and a host of other questions. But the Red Planet is also the focus of scholars who believe that it may be the next logical step in a series of major human diasporas as technological innovations improve to the point where interplanetary travel to Mars, and the establishment of colonies, is feasible. Like all such ventures, there are associated costs and underlying reasons that drive the decision by humans to move beyond firm ground and explore environments that may be familiar, but can also be extremely hostile.

The well-known theoretical physicist Stephen Hawking (2010) once stated:

> If we can avoid disaster for the next two centuries, our species should be safe as we spread into space. If we are the only intelligent beings in the galaxy we should make sure we survive and continue…. Our only chance of long-term survival is not to remain inward looking on planet Earth but to spread out into space. We have made remarkable progress in the last hundred years. But if we want to continue beyond the next hundred years, our future is in space.

The "disaster" that Hawking was referring to is not a single, impending cataclysmic event, but a slow train of tragedy involving a myriad of problems that largely began when humans became sedentary agriculturalists between 12 and 3 kya, grew in population, and expanded into nearly every corner of the world. Over the course of the next few millennia, civilizations have risen, technologies improved that have allowed humans to surpass our own physical limitations, and exponential growth, doubling from 3.9 billion to 7.8 billion in less than 50 years. These processes have led to a nearly complete human domination of Earth's terrestrial ecosystems and significant impacts on our hydrosphere and atmosphere.

These events have increased by an order of magnitude to the point where over the last 200 years—largely due to the Industrial Revolution—we have overharvested (and in some cases, exhausted) resources, driven numerous plants and animals to extinction (with many others threatened), extracted materials through subterranean and strip mining to manufacture products we want or need, and caused widespread pollution of land and sea. Testaments to just how far our impacts have reached include microplastics found in the most remote places on Earth, including the tallest mountain, Mt. Everest (Napper et al. 2020) and the world's deepest ocean trenches (Jamieson et al. 2019; Peng et al. 2016). The burning of fossil fuels used in a wide range of industries—and relied upon by much of Earth's population—has led to carbon dioxide emissions that are warming our planet, melting glaciers and polar ice caps, and causing rising sea levels that will continually threaten those who live on islands and low-lying coastal zones, now estimated to be about 10% of our planet's population (760 million people). That some governments, notably the United States, have continued to deemphasize the effects of, or entirely reject, the impending climate change catastrophe—highlighted even more clearly during the Trump administration—is not only irresponsible, but will cause irreparable damage to the places we live and hundreds of millions of other people on our planet who have little to no control over these decisions—they will ultimately be left to the whims of politicians and large corporations who would rather serve their self-interests. Exxon Mobil's well-known history of funding climate change denial organizations and politicians, lobbying against legislation to reduce fossil fuel use, and generally using their political clout to thwart clean energy, is one case in point.

Major disconnects also exist between observable trends in climate change and human dispersal behaviors, evident in the US where population centers in Sunbelt areas like Phoenix are seeing an influx of migrants even as annual average temperatures increase. Historically, humans have occupied habitable niches that average around 55.4 °F (13 °C) (Xu et al. 2020). As the climate crisis continues to grow, many nations will see drastic transformations in temperature and humidity, where certain kinds of food can be grown, and areas of wildfire risk that will stress resources and influence human migration to more northerly and southerly latitudes (see: projects.propublica.org/climate-migration). Even if global population remains static, this will lead to many areas where human habitation is no longer feasible socially or economically. The result will be an amplification of what we are already seeing with climate migration, where millions of people are forced to leave their homes. In 2017 it was estimated that almost 69 million people around the world were displaced forcibly, with about one-third of those due to "sudden onset" weather events, including intensified storms, flooding, and forest fires that occurred after prolonged droughts (The Nansen Imitative 2015). A few years ago, the World Bank (Rigaud et al. 2018) estimated that there will be 143 million more climate migrants by 2050 from just three regions—Southeast Asia, Latin America, and sub-Saharan Africa. Where does that leave us?

If we look at the history of human civilization and the underlying reasons behind why major population dispersals occur, there are some obvious parallels to what is observed archaeologically in the ancient Pacific and what we see happening today. People often leave their homes and seek to establish colonies elsewhere because their societies have exceeded environmental carrying capacity, are overpopulated, oppressed, engaged in conflict, or have overexploited local resources, though it is usually a combination of many (or all) of these factors. But we also cannot discount the inherent curiosity that humans have about what lies beyond. Keegan and Diamond (1984, 1987:67) discussed the concept of 'autocatalysis' which proposes that once people began discovering islands, there was an expectation that there would be more, thereby fueling the drive to continually voyage further. This kind of motivation could have been highly influential in promoting migration in the Pacific and other island regions despite the inherent risks involved. Jennings (1979), for example, proposed that as many as 500,000 Polynesians died in attempts to colonize the region. This is purely speculative as we will never know how many people actually perished on these voyages, a phenomenon I have referred to as the "seafaring paradox" (i.e., in a watery realm where evidence is easily lost, only successful landfalls can be traced archaeologically) (Fitzpatrick 2018). It is reasonable to suggest, however, that there were many failed voyages because of storms, getting lost, illness, exposure, and loss of provisions.

Regardless of what may have motivated Polynesian or other seafarers to colonize islands, the fact remains that we know most voyages were purposeful and not accidental because as noted previously, they brought with them the things they needed to survive for which there is good archaeological evidence. And it is also clear that many of these non-native plants and animals had adverse effects on pristine island ecologies that was only amplified after the arrival of Euro-Americans, new efforts at (re)colonizing, and commercialization ventures. With what we have seen historically in the Pacific, are these reminiscent of what humans will do in the future after leaving Earth? What issues must we consider as we encounter new habitats?

4.6 Transported Landscapes on an Interstellar Scale

As the feasibility for traveling and living beyond Earth becomes more of a reality, what are, or should be, the concerns that we as a species have for impacting other worlds? Are there lessons we have learned here on Earth that we can apply to the process of colonizing planetary bodies in interstellar space? What corollaries can we use to theoretically conceptualize how this might occur?

In a paper that I published with Jon Erlandson (2018) we discussed, albeit briefly, how the prehistoric colonization of islands can serve as useful analogues to the human colonization of environments beyond Earth. This was partly inspired by the work of anthropologist Ben Finney (1985) who, along with the Hawaiian artist and cultural icon Herb Kāne and Tommy Holmes, co-founded the Polynesian Voyaging Society that constructed the famous Hōkūle'a double-hulled sailing canoe replica and wrote a series of papers on the subject of Pacific voyaging and remote island colonization (see Finney and Jones 1985a, b). Finney's (1985) argument was that these ventures were a testament to how human curiosity, ingenuity, and desire to populate distant landmasses were essentially no different than modern efforts to go into space. Other chapters in the volume by Finney and Jones (1985a, b), written by such illustrious anthropologists and historians as Joseph Birdsell and Alfred Crosby, along with notable scientists like Carl Sagan (1961), also described what the next stages of the human experience might be for humans beyond *terra firma* (see also Broodbank 2018:191).

We took this concept a step further, however, and suggested that the archaeological study of islands under a model systems approach also had implications for understanding and managing the future colonization of planetary bodies (Fitzpatrick and Erlandson 2018; see also Webb 2021). It is becoming increasingly likely that humans at some point in the relatively near future—perhaps this century—will establish a colony on Mars (or at least, that seems a medium or even short-term goal of different private companies and space agencies). As Elon Musk (2020)—the famed CEO of Tesla and SpaceX and strong proponent of Mars colonization remarked recently at a virtual conference on the subject, "[i]f there's something terrible that happens on Earth, either made by humans or natural, we want to have…insurance for life as a whole. Then, there's the kind of excitement and adventure." The development of these hypothetical scenarios are not meaningless exercises. If the predictions by Stephen Hawking and others come true—that humans are causing irreparable harm to Earth's ecosystems—so much so that even current efforts to reduce carbon emissions, curb resource extraction, and implement sustainable practices—then reaching beyond our planet may be the only way for our species to survive. But is this a one-sided, human-centric affair, or should there be other things we consider as we move forward with plans for extra- or multi-planetary settlement?

In a move to highlight the potential pitfalls of planetary colonization, the Equity, Diversity and Inclusion Working Group (EDIWG) for NASA recently presented a white paper titled "Ethical Exploration and the Role of Planetary Protection in Disrupting Colonial Practices" to the Planetary Science and Astrobiology Decadal Survey committee. In this manifesto, published by Tavares et al. (2020:1) and signed by 109 scholars, they state that:

> Ethical considerations must be prioritized in the formation of planetary protection policy. The choices we make in the next decade of space exploration will dictate the future of humanity's presence on other worlds, with the potential to impact the environments we interact with on timescales longer than the human species has existed. We should make these choices consciously and carefully, as many will be irreversible, especially those pertaining to how we interact with potential extraterrestrial life.

They go on to say that:

> … Violent colonial practices and structures—genocide, land appropriation, resource extraction, environmental devastation, and more—have governed exploration on Earth, and if not actively dismantled, will define the methodologies and mindsets we carry forward into space exploration... It is critical that ethics and anticolonial practices are a central consideration of planetary protection. We must actively work to prevent capitalist extraction on other worlds, respect and preserve their environmental systems, and acknowledge the sovereignty and interconnectivity of all life. The urgency of finding a second home on Mars in the shadow of looming environmental catastrophe on Earth is not only a questionable endeavor but scientifically impossible with present technology, and is often used as a justification for human exploration and to suggest that these ethical questions may be antiquated in the face of that reality. Here we argue the opposite: that the future of our own species and our ability to explore space depends on pursuing anticolonial practices on Earth and beyond. An anticolonial perspective can push us towards an ethic that acknowledges our interconnected and entangled lives. Rather than an escape, or a continuation of manifest destiny, the Moon and Mars may provide the key to practicing other ways of exploring and of being (Tavares 2020:1).

Here, Tavares et al. (2020) point to some obvious concerns rooted in the history of speciesism and Western expansionism that still resides in the collective consciousness of those whose relatives (human and non-human) were subjected to enslavement, forced relocation, indiscriminate killing, subjugation, land grabbing, and erosion of cultural lifeways—that we must be considerate of the toll these events have taken on human society and biodiversity, and ways in which we might pause or ameliorate their effects (e.g., see Gamble et al. 2020). While Tavares et al. (2020) argue for a cessation of space exploration and a focus on saving our own planet from our current dilemmas, their fears belie the natural evolution of human behavior—that at some point, we will likely (or must) leave Earth to survive as a species.

Though these philosophical dilemmas will persist, a natural outcome in this scenario—at least in the beginning—will be the transport of things we use on Earth to other places as a matter of necessity. Like Polynesians a millennium ago, there was stark recognition that ultimate survival depended on bringing with them plants to cultivate, animals to raise, and tools that could be used to ensure a successful colony. These were supplemented with centuries of traditional ecological knowledge that allowed these transported landscapes to be implemented and expanded through ‘landscape learning’ of novel environments (Rockman and Steele 2003). The movement of humans to Mars or other moons and planets will involve many of these same processes—but at what cost?

4.7 Lessons for the Future?

In this chapter I have not concerned myself with identifying when various impacts on Earth will become so severe that our survival requires migration beyond our planet, or what can be done to mitigate the effects of human impacts on Earth. The challenges we face—from pollution to climate change, rising sea levels, habitat destruction, overexploitation of resources, and unhindered population growth—are becoming more well documented every year by those who have skill sets beyond my level of expertise. I do, however, want to reiterate what should be some fundamental concerns for future generations involved in the exploration and eventual colonization of planetary bodies beyond our planet.

1. What lessons can we learn from archaeology and the prehistoric settlement of islands to help us better understand the future?

The well-known British naturalist, Sir David Attenborough, recently said in reference to a newly released World Wildlife Fund (WWF) on threats to Earth’s biodiversity that the Anthropocene—a proposed geological epoch created by human dominance of Earth (for archaeologically related discourse, see Braje and Erlandson 2013; Braje et al. 2014; Fitzpatrick and Erlandson 2018; Leppard 2019; Rick et al. 2013)—may be the wake-up call that humans need in effort to reinstate a balance with “the natural world and become stewards of our planet.” But doing so “will require systemic shifts in how we produce food, create energy, manage our oceans and use materials,” Attenborough said, and “above all it will require a change in perspective. A change from viewing nature as something that’s optional or ‘nice to have’ to the single greatest ally we have in restoring balance to our world” (Briggs 2020).

Is this achievable? The same WWF report shows that 20,000 different populations of birds, amphibians, reptiles, fishes, and mammals have declined an average of 68% since 1970 and “a separate intergovernmental panel of scientists concluded that one million species (500,000 animals and plants, and 500,000 insects) are threatened with extinction, some within decades” (Briggs 2020). A report recently released by the National Oceanic and Atmospheric Administration (NOAA) and the University of Maryland that examined the health of coral reefs under U.S. jurisdiction between 2012 and 2018, including those in the Pacific (Guam, Hawai‘i, American Samoa) and Atlantic/Caribbean (Florida, U.S. Virgin Islands, Puerto Rico), show that while many of the more remote islands were “good,” those in South Florida and the Florida Keys were critical. The introduction of sewage, fertilizers, and various other chemicals and pollutants have taken their toll on Gulf Coast coral reefs with only about 2% remaining (NOAA 2020). What these numbers show is that despite some major conservation efforts over the last 50 years across a wide range of habitats on all seven continents—and the bodies of water that separate them—we are reaching a tipping point that will not be easily reconciled, largely due to the rapid and exponential growth of Earth's population that has led to the continued and unsustainable extraction of resources and the overall destruction and pollution of our planet's ecosystems.

What the archaeology of islands has told us is that humans have not often considered the implications of what it means to settle new lands for the first time. There are cases, however, of societies in the Pacific that seem to have recognized patterns of behavior that are detrimental to the health and vitality of the environments in which they live and made corrective decisions to diminish their impact. The island of Tikopia (Bódi and Takács-Sánta 2020; Kirch 1983) is a well-known example, with a strong case being increasingly made for Rapa Nui (Easter Island) (DiNapoli et al. 2021; Mischen and Lipo 2021). There are ones in other island regions like the Mediterranean (Plekhov et al. 2021), Florida Keys (LeFebvre et al. 2022), and Caribbean (Giovas et al. 2013; Poteate et al. 2015) with the latter indicating intensified consumption of marine foods through time but with no apparent impacts on their populations. While there have certainly been some bright moments, history shows that our species will be hard pressed to save ourselves from ourselves. While on vastly different scales, islands and planets, conceptualized as model systems, may be no different in the ways in which they are affected by humans.

2. What can the historical study of islands teach us about colonizing space?

The search for habitable exoplanets is continuing at an ever-increasing pace with scientists around the world using more advanced telescopes, observational satellites, and statistical data-crunching to try and discover planets that may reside in the "Goldilocks Zone" where temperatures and pressures are stable enough (not too high or too cold) for water to remain in its liquid state. It is incredible to think that within our own galaxy, the Milky Way, there could be an estimated 400 billion stars; Earth revolves around just one of those. Bryson et al. (2020), using data from the Kepler space telescope, suggest that within our galaxy there may be close to 300 million Earth-like rocky planets that could potentially be habitable, though our ability to see them up close, let alone visit them, is something not yet attainable and will not be for centuries or millennia to come.

Astronaut William Anders noted after his famous Apollo 8 mission around the moon, "When you're in a spacecraft, you think in terms of oceans of islands" (Earthrise 2018: 0:05:30). On a hypothetical scale, if the history behind human colonization of the Pacific Islands has anything to say, it is that where there is a will, there is a way. Like ancient Pacific Islanders who began to settle Remote Oceania three thousand years ago, they needed to perfect transport (boat construction), determine where they were spatially in the fluid realm of a vast ocean using navigational and wayfinding skills, and carry with them the provisions, tools, and knowledge they needed to increase their chances of establishing a successful and viable colony—the "transported landscape" package mentioned earlier. Irwin (1994, 2008) proposed that to accomplish these feats, different parts of the Pacific had in effect served as "voyaging nurseries" where people could practice their skills, refine their techniques, and slowly but surely expand their search beyond sight of land. There is no question that these were exceptional seafarers, and archaeological evidence attests to their accomplishments, though there were many who surely perished in the attempt or became relatively or completely isolated (Fitzpatrick and Anderson 2008). Planetary migration, using the Moon and Mars as fertile experimental grounds for testing and practicing new forms of transport, may in effect proceed in much the same way.

3. Can islands serve as corollaries for planetary migration?

What we have seen with island colonization in the ancient past that it is a corollary for how humans have approached space exploration. Beginning a little more than a century ago with the Wright Brothers, our skies have served as voyaging nurseries for planes and other mechanical flying machines. These quickly evolved to the propulsion of rockets and satellites through the stratosphere, leading to landings on the moon 50 years ago and now rovers that have explored the surface of Mars that is more than 55 million km away. These extraordinary achievements of human dispersal into unknown and often unpredictable environments are the result of millennia of technological and cultural evolution and hark back to what Keegan and Diamond (1987) termed "autocatalysis"—the notion that if there is one habitable place out there in the distance, there must be more. It is this concept that I believe will continue to spur human exploration of space. But similar to that which likely occurred with Polynesians in the Pacific, there will be both social and economic considerations that factor into the costs and benefits of moving beyond *terra firma.*

While there are a multitude of reasons why our species has sought to explore new worlds, we should be cognizant of the fact that other celestial bodies in our solar system and beyond are macrocosms of islands found on Earth—pristine environments untouched by humans, but that on a geological scale, quickly succumbed to the whims of what Baleé (1998) has called *Homo devestans*—the most destructive and adaptive species on the planet. It must be remembered that the places we eventually colonize beyond Earth are essentially islands floating off in the distance and may have (or had) a long history of biological evolution that could easily be destroyed by our mere presence and that may be equally detrimental to humanity.

4. How will humans approach reaching, living, and interacting with extraterrestrial environments?

In terms of our solar system, researchers are investigating tantalizing clues that there may be life—or the building blocks of life—in a number of places we did not expect. These include the possible presence of phosphine (PH_3, also known as hydrogen phosphide) around Venus (Greaves et al. 2020), which Carl Sagan (1961) had suggested decades ago might be a fruitful place to look for such things. Given that phosphine on Earth is only known to be associated with human and biological sources, closer examination has led scientists to search for explanations as to why this chemical could be found on Venus. One group concluded that "[t]he presence of PH_3…must be the result of a process not previously considered plausible for Venusian conditions. The process could be unknown geochemistry, photochemistry, or even aerial microbial life" (Bains et al. 2020). This is certainly a provocative study, though subsequent analysis of the data suggests phosphine levels are not as high as previously thought. Additionally, a newly discovered ring-shaped molecule called cyclopropenylidene was just found on Titan, one of Saturn's moons (Nixon et al. 2020). While not directly indicative of life, it is a compound that is highly reactive with other molecules, types which tend to be biological building blocks for DNA and importantly, has not been seen before in any other planet or moon's atmosphere. A new spacecraft, *Dragonfly*, is on schedule to be launched in 2027 to take a closer look at Titan's surface and perhaps answer some of these lingering questions about possible extraterrestrial life.

This all leads us back to the Red Planet, which is still the most reasonable candidate for having evidence of life in our solar system given the presence of water that is—at least on Earth—what we think is a required building block. If that is the case, and evidence for life is eventually found, how should that affect our goals and strategies for colonization? Because Mars is inhospitable to humans due to high levels of radiation, a thin atmosphere, and air that is about 95% carbon dioxide, this will require both personal (spacesuits) and large-scale (livable structures) protection from the elements that is relatively low-cost and durable. Interestingly, Shiwei et al. (2020) propose the use of chitinous materials, which is a primary constituent of insect and crustacean exoskeletons and fish scales. They write that the application of: "principles of bioinspired chitinous materials and manufacturing, initially developed for production within circular regional economies on Earth…[could be used to] develop a composite with low manufacturing requirements, ecological integration, and versatile utility in a Martian environment… [and that demonstrate] the development of a closed-loop, zero-waste solutions to tackle unsustainable development on Earth [which] may also be the key to our development as an interplanetary species" (Shiwei et al. 2020:6–7). This is both a novel and feasible pathway for helping to ensure a successful colonizing endeavor and not unlike the intentional transport of materials that Pacific Islanders brought with them such as stone, plants, and animals.

In addition, there are also suggestions of finding ways to potentially terraform Mars and other interplanetary bodies to create habitats for humans that would be less expensive and more conducive to long-term survivability. Elon Musk (2020) has touted the idea that nuclear bombs could be used to vaporize the Red Planet's ice caps to release large amounts of carbon dioxide water vapor that would have the effect of warming the planet's atmosphere which averages a cool -80° Fahrenheit. This and other terraforming ideas, however, pose some philosophical dilemmas—first and foremost, whether it is ethical for us to ever pursue efforts at manipulating a planet's lithosphere, hydrosphere, etc. given that we may not know for sure the impact this could have on known, or unknown, organisms. Do humans have an inalienable right to modify Mars or other planets and moons for the purpose of exploration, colonization, resource extraction, and habitation even if there is no evidence of extraterrestrial life?

In the past, peoples often reached islands with the sole purpose of colonizing them as is seen by the intentional movement of plants and animals. These landscapes were also transformed through burning, earth-moving, agriculture, and construction that allowed humans to survive in what were sometimes very marginal environments such as atolls or extremely remote islands. These activities are visible archaeologically across a broad spectrum of island types and often impacted native flora and fauna (the aforementioned birds being just one example). Though early island colonists were causing upheaval to varying degrees, they were not widespread destructors of these pristine habitats. But if our own more recent history has anything to say about it, it is that religious doctrine and other sociopolitical mechanisms have led our species to believe that we do have certain inalienable rights and dominion not only over all of other species, but even those who may look or act differently. These belief systems have rationalized behaviors which have proven detrimental to the environments we live in, other human societies, and our overall survival.

There is now greater discussion about who will, or whether people/companies /nations should, own the rights to different planets and the resources they may contain. One of Elon Musk's goals is for his company SpaceX to build a Martian colony that eventually supports a million people (see Musk 2017; Salter 2020). In a not-so-hypothetical scenario then, a private company builds the infrastructure, offers transport to Mars, establishes communication networks, provides basic services such as sanitation and food distribution, and charges individuals through different means (e.g., hard currency, indentured servitude) for the ability to live and work there. Though on the surface this seems nefarious, it is not unlike the scenario that many immigrants to the United States faced in the 19th and early twentieth centuries. It also would not violate agreed upon stipulations outlined in the 1967 Outer Space Treaty, often referred to as the "Magna Carta of Space."

For the most part, neither Mars nor other celestial bodies provide any real economic incentive to establish a colony. The mineral resources found on the Red Planet are substantial, but currently not economically viable for mining and shipment back to Earth, which would require transporting huge amounts of equipment and personnel. The most likely rationale for human colonization of the Red Planet would be to determine ways in which our species could survive the physically and psychologically grueling trip through space for 5–9 months using current technologies—a testing ground if you will—for eventual settlement and residence that lasts years or even decades. Similar to what probably occurred in the Pacific during Polynesian expansion, it is equally plausible that some Mars colonists would face the precarious reality of never coming home even if they initially arrived safely.

However, given that space tourism is becoming more of a reality, with companies like Virgin Galactic trying to meld suborbital visits with scientific research, it may be that the super wealthy like Richard Branson and Jeff Bezos, eager to go where no human has gone before, will help to bankroll the first visits to Mars. There is also much discussion on how to build bigger and better rockets that could carry enormous payloads—hundreds of metric tons versus what is currently possible (the Saturn V moon rocket built by NASA holds the record at 135 metric tons) and could cut the trip to three months using thermal nuclear engines now in development.[3] This also raises the question of who could eventually lay claim to different parts of Mars—would this be similar to America's "manifest destiny" that justified expansion across the country regardless of who or what was there?

[3] It is possible that thermal nuclear engines that are twice as efficient as standard chemical propulsion engines could reduce the length of a trip to Mars to three months (Delbert 2020).

5. Are there lessons we have learned here on Earth that we can apply to the process of colonizing planetary bodies in interstellar space?

The archaeological record for Hawaii, New Zealand, and many other islands clearly demonstrates how humans have not only impacted these pristine environments, but how new human groups who came afterward—for the specific purpose of colonizing—unintentionally (at least initially) annihilated Indigenous peoples through the transfer of communicable diseases like measles, smallpox, and other pathogens (Gamble et al. 2020). But, these occurred on our own planet which has an evolutionary history that connects the earth's biodiversity. One can imagine how different and even more dramatic the effects of biological contact would be on a planet with no previous connection to Earth's biosystems. This was something that NASA scientists were concerned about from the beginning and developed procedures to sterilize spacecraft to avoid potentially contaminating the moon or other planets and vice versa (see Webb 2021).

While not mutually exclusive, we should also be cognizant of how humans might affect physical (abiotic) environments. Though my primary concern in this chapter has been to highlight the ways in which humans have impacted Earth's biosystems and projecting what might occur to extraterrestrial (biotic) life, we should be equally concerned as to how we might affect the various landforms on moons or planets that give insight into their formation over time. Though still in its infancy, our efforts at interplanetary exploration has already revealed important information on the geological, climatological, and other processes that have shaped these worlds. One might imagine a known or perceived lack of biota providing an excuse for extracting resources through mining or other destructive activities that wreaks havoc on the landscapes of celestial bodies. Afterall, what has prevented this from happening on Earth even when the presence of biological diversity is known?

There are many other lessons to be learned from the impact of humans first reaching remote islands that had evolved for millions of years without our interference, European arrival on Indigenous populations in the Americas, and the exploitation or eradication of species both accidentally and purposefully (Jackson et al. 2001). The wholesale transfer of biota (plants, animals, insects, microbiomes, and pathogens) between the Old World and the Americas as part of the Columbian Exchange (Crosby 2003) began almost immediately after the arrival of Europeans to the Caribbean islands in AD 1492. This was one of the most pivotal points in human history, leading to biotic transfers that permanently transformed landscapes and human societies, including the introduction of many diseases for which Indigenous peoples had no natural immunity.

What these events demonstrate is that archaeology and history are crucial facets for understanding the ways in which humans have settled and transformed island environments. The end results have not always been ideal—in fact, examples abound for how new colonizing groups caused irreparable damage and transformed landscapes. For traditional societies, this seems to have been the exception rather than the rule for much of the Pacific, at least until Europeans arrived and commercial ventures began taking place (whaling, fishing, mining, etc.) that have largely devastated many island ecologies.

So, should there be things we consider as our species moves toward plans for extra- or multi-planetary settlement (e.g., biotic exchange) based on what archaeology has found? Musk (2020:46) notes that to find a path forward, "[t]he values that we take with us into space exploration should be front and center." As an archaeologist who works on islands, I could not agree more, for islands serve as a stark reminder of what can happen to those who are interested in this pursuit. But what are these values? Are they those that prioritize humans over other lifeforms, as we have on Earth for much of our existence? Or will they reflect the lessons we've learned from the havoc we have wrought on our own planet and simply imprint these onto other worlds? There is no clear-cut answer, but I would argue that we must continue to look to the past, lest we fail to understand the implications of our actions and Earth simply becomes the detritus of a coming world.

Acknowledgements I would like to thank Brian Swartz for the kind invitation to contribute to the volume. Brian, Brent Mishler, Christina M. Giovas, Thomas Leppard, Damion Sailors, and Brian Lane all provided useful feedback and discussion on earlier drafts of this paper.

References

Allen MS (2007) Three millennia of human and sea turtle interactions in remote Oceania. Coral Reefs 26(4):959–970

Allen MS (2002) Resolving long-term change in Polynesian marine fisheries. Asian Perspect 41(2):195–212

Anderson A (2009) The rat and the octopus: Initial human colonization and the prehistoric introduction of domestic animals to Remote Oceania. Biol Invasions 11(7):1503–1519

Anderson A (2008) Traditionalism, interaction, and long-distance seafaring in Polynesia. J Island Coastal Archaeol 3(2):240–250

Anderson A (2006) Islands of exile: ideological motivation in maritime migration. J Island Coastal Archaeol 1(1):33–47

Anderson A (2003) Prodigious birds: Moas and Moa-hunting in New Zealand. Cambridge University Press, Cambridge

Anderson A (1989) Mechanics of overkill in the extinction of New Zealand moas. J Archaeol Sci 16(2):137–151

Anderson A, Chappell J, Gagan M, Grove R (2006) Prehistoric maritime migration in the Pacific islands: an hypothesis of ENSO forcing. Holocene 16(1):1–6

Anderson E (1952) Plants, man, and life. University of California Press, Berkeley

Bains W, Petkowski JJ, Seager S, Ranjan S, Sousa-Silva C, Rimmer PB, Zhan Z, Greaves JS, Richards A (2020) Phosphine on venus cannot be explained by conventional processes. http://arxiv.org/abs/2009.06499

Baleé W (ed) (1998) Advances in historical ecology. Columbia University Press, New York

Barnosky AD, Koch PL, Feranec RS, Wing SL, Shabel AB (2004) Assessing the causes of late Pleistocene extinctions on the continents. Science 306(5693):70–75

Bedford S, Spriggs M (eds) (2019) Debating Lapita: distribution, chronology, society and subsistence, vol 52. Australian National University Press, Canberra

Bedford S, Spriggs M, Regenvanu R (2006) The Teouma Lapita site and the early human settlement of the Pacific Islands. Antiquity 80(310):812–828
Blackburn TM, Cassey P, Duncan RP, Evans KL, Gaston KJ (2004) Avian extinction and mammalian introductions on oceanic islands. Science 305(5692):1955–1958
Bódi B, Takács-Sánta A (2020) Hardin's mistake: Tikopia, the society that avoided the tragedy of the commons. World Futures 1–17
Boyle KV, Anderson A (eds) (2010) The global origins and development of seafaring. The McDonald Institute for Archaeological Research, Cambridge
Braje TJ, Erlandson JM (2013) Human acceleration of animal and plant extinctions: a late pleistocene, holocene, and anthropocene continuum. Anthropocene 4:14–23
Braje TJ, Leppard TP, Fitzpatrick SM, Erlandson JM (2017) Archaeology, historical ecology and anthropogenic island ecosystems. Environ Conserv 44(3):286–297
Braje TJ, Erlandson JM, Aikens CM, Beach T, Fitzpatrick SM, Gonzalez S, Kennett DJ, Kirch PV, Lee G-A, Lightfoot KG, McClure SB, Panich LM, Rick TC, Roosevelt AC, Schneider TD, Smith B, Zeder MA (2014) An anthropocene without archaeology—should we care? SAA Archaeol Record 26–29
Briggs H (2020) Wildlife in 'catastrophic decline' due to human destruction, scientists warn. www.bbc.com/news/science-environment-54091048. Accessed on 9 Nov 2020
Broodbank C (2018) Does island archaeology matter? In: Knodell A, Leppard T (eds) Regional approaches to society and complexity: studies in honor of John F. Cherry, pp 188–206. Equinox, Sheffield
Broodbank C (2006) The origins and early development of Mediterranean maritime activity. J Mediterr Archaeol 19(2):199–230
Brook BW, Bowman DM (2004) The uncertain blitzkrieg of Pleistocene megafauna. J Biogeogr 31(4):517–523
Bryson S, Kunimoto M, Kopparapu RK, Coughlin JL, Borucki WJ, Koch D, Aguirre VS, Allen C, Barentsen G, Batalha N, Berger T et al (2020) The occurrence of rocky habitable zone planets around solar-like stars from Kepler data. arXiv:2010.14812
Burney DA (1997) Tropical islands as paleoecological laboratories: gauging the consequences of human arrival. Hum Ecol 25(3):437–457
Burney DA, Flannery TF (2005) Fifty millennia of catastrophic extinctions after human contact. Trends Ecol Evol 20(7):395–401
Carson MT (2008) Refining earliest settlement in Remote Oceania: renewed archaeological investigation at Unai Bapot, Saipan. J Island Coast Archaeol 3(1):115–139
Cherry JF, Leppard TP (2015) Experimental archaeology and the earliest seagoing: the limitations of inference. World Archaeol 47(5):740–755
Chiu S, Killick D, Sand C, Su Y (2020) Long-distance Lapita pottery transfers and ancient social relationships: a case study from the St. Maurice-Vatcha (KVO003) Lapita site on Île des Pins, New Caledonia (Southern Melanesia). J Archaeol Sci Rep 34:102641
Clark GR (2005) A 3000-year culture sequence from Palau, western Micronesia. Asian Perspect 44(2):349–380
Crosby AW (2003) The Columbian exchange: biological and cultural consequences of 1492, vol 2. Greenwood Publishing Group, Westport, CT
Dawson H (2014) Mediterranean voyages: the archaeology of island colonisation and abandonment, vol 62. Left Coast Press, Walnut Creek, CA
Delbert C (2020) The Thermal nuclear engine that could get us to mars in just 3 months. Popular Mech. https://www.popularmechanics.com/science/energy/a34622021/thermal-nuclear-engine-mars/. Accessed on 10 Nov 2020
Deng Z, Moynier F, Villeneuve J, Jensen NK, Liu D, Cartigny P, Mikouchi T, Siebert J, Agranier A, Chaussidon M, Bizzarro M (2020) Early oxidation of the Martian crust triggered by impacts. Sci Adv 6(44):p.eabc4941
DiNapoli RJ, Leppard TP (2018) Islands as model environments. J Island Coast Archaeol 13(2):157–160

DiNapoli RJ, Lipo CP, Hunt TL (2021) Triumph of the commons: Sustainable community practices on Rapa Nui (Easter Island). Sustainability 13(21):12118
Doherty TS, Dickman CR, Glen AS, Newsome TM, Nimmo DG, Ritchie EG, Vanak AT, Wirsing AJ (2017) The global impacts of domestic dogs on threatened vertebrates. Biol Cons 210:56–59
Duncan RP, Boyer AG, Blackburn TM (2013) Magnitude and variation of prehistoric bird extinctions in the Pacific. Proc Natl Acad Sci 110(16):6436–6441
Duncan RP, Blackburn TM, Worthy TH (2002) Prehistoric bird extinctions and human hunting. Proc Royal Soc London Ser B Biol Sci 269(1490):517–521
Earthrise (2018) Directed by E. Vaughan-Lee. New York: The New York Times Op-Docs
Erlandson JM (2001) The archaeology of aquatic adaptations: paradigms for a new millennium. J Archaeol Res 9(4):287–350
Erlandson JM, Rick TC (2010) Archaeology meets marine ecology: the antiquity of maritime cultures and human impacts on marine fisheries and ecosystems. Ann Rev Mar Sci 2:231–251
Erlandson JM, Rick TC (2008) Human impacts on ancient marine ecosystems: a global perspective. University of California Press, Berkeley
Erlandson JM, Braje TJ, Gill KM, Graham MH (2015) Ecology of the kelp highway: did marine resources facilitate human dispersal from Northeast Asia to the Americas? J Island Coast Archaeol 10(3):392–411
Erlandson JM, Moss ML, Des Lauriers M (2008) Life on the edge: early maritime cultures of the Pacific Coast of North America. Quatern Sci Rev 27(23–24):2232–2245
Erlandson JM, Graham MH, Bourque BJ, Corbett D, Estes JA, Steneck RS (2007) The kelp highway hypothesis: marine ecology, the coastal migration theory, and the peopling of the Americas. J Island Coast Archaeol 2(2):161–174
Evenuis NL, Miller SE (eds) (2015) Hawaii biological survey for 2014, part II: index. Bishop museum occasional papers, No. 117. Bishop Museum Press, Honolulu
Finney BR (1985) Voyagers into space. In: Finney BR, Jones EM (eds) Interstellar migration and the human experience, pp 164–179. University of California Press, Berkeley
Finney BR (2003) Sailing in the wake of the ancestors: reviving polynesian voyaging. Bishop Museum Press, Honolulu
Finney BR, Jones EM (eds) (1985a) Interstellar migration and the human experience. University of California Press, Berkeley
Finney BR, Jones EM (1985b) The exploring animal. In: Finney BR, Jones EM (eds) Interstellar migration and the human experience, pp 15–25. University of California Press, Berkeley
Fitzhugh B, Butler VL, Bovy KM, Etnier MA (2019) Human ecodynamics: a perspective for the study of long-term change in socioecological systems. J Archaeol Sci Rep 23:1077–1094
Fitzpatrick SM (2018) Islands in the comparative stream: the importance of inter-island analogies to archaeological discourse. In: Regional approaches to society and complexity: studies in honor of John F. Cherry (A. Knodell and T. Leppard, Eds):207–224. Sheffield: Equinox.
Fitzpatrick SM (2013) Seafaring capabilities in the pre-Columbian Caribbean. J Marit Archaeol 8(1):101–138
Fitzpatrick SM, Anderson A (2008) Islands of isolation: archaeology and the power of aquatic perimeters. J Island Coast Archaeol 3(1):4–16
Fitzpatrick SM, Erlandson JM (2018) Island archaeology, model systems, the Anthropocene, and how the past informs the future. J Island Coast Archaeol 13(2):283–299
Fitzpatrick SM, Keegan WF (2007) Human impacts and adaptations in the Caribbean Islands: an historical ecology approach. Earth Environ Sci Trans R Soc Edinb 98(1):29–45
Fitzpatrick SM, Jew NP (2018) Radiocarbon dating and Bayesian modelling of one of Remote Oceania's oldest cemeteries at Chelechol ra Orrak, Palau. Antiquity 92(361):149–164
Fitzpatrick SM, Giovas CM, Kataoka O (2011) Temporal trends in prehistoric fishing in Palau, Micronesia over the last 1500 years. Archaeol Ocean 46(1):6–16
Gamble LH, Claassen C, Eerkens JW, Kennett DJ, Lambert PM, Liebmann MJ, Lyons N, Mills BJ, Rodning CB, Schneider TD, Silliman SW Finding archaeological relevance during a pandemic and what comes after. Am Antiquity 1–21

Giovas CM, Clark M, Fitzpatrick SM, Stone J (2013) Intensifying collection and size increase of the tessellated nerite snail (*Nerita tessellata*) at the Coconut Walk site, Nevis, northern Lesser Antilles, AD 890–1440. J Archaeol Sci 40(11):4024–4038

Gladwin T (1970) East is a big bird: navigation and logic on Puluwat Atoll. Harvard University Press, Cambridge, MA

Goodwin ID, Browning SA, Anderson AJ (2014) Climate windows for Polynesian voyaging to New Zealand and Easter Island. Proc Natl Acad Sci 111(41):14716–14721

Gosden C (1992) Production systems and the colonization of the Western Pacific. World Archaeol 24(1):55–69

Grayson DK, Meltzer DJ (2003) A requiem for North American overkill. J Archaeol Sci 30(5):585–593

Greaves JS, Richards AM, Bains W, Rimmer PB, Sagawa H, Clements DL, Seager S, Petkowski JJ, Sousa-Silva C, Ranjan S, Drabek-Maunder E (2020) Phosphine gas in the cloud decks of Venus. Nature Astron 1–10

Hardin G (1968) The tragedy of the commons. Science 162(3859):1243–1248

Harris M, Weisler M (2018) Two millennia of mollusc foraging on Ebon Atoll, Marshall Islands: sustained marine resource use on a Pacific atoll. Archaeol Ocean 53(1):41–57

Hawking S (2010) Interview with Andrew Dermont on the website 'Big Think' (August 6, 2010)

Hawkins S, Worthy TH (2019) Lapita colonisation and avian extinctions in Oceania. In: Bedford S, Spriggs M (eds) Debating Lapita: distribution, chronology, society and subsistence, pp 439–467. Terra Australis No. 52, Canberra

Heydari E, Schroeder JF, Calef FJ, Van Beek J, Rowland SK, Parker TJ, Fairén AG (2020) Deposits from giant floods in Gale crater and their implications for the climate of early Mars. Sci Rep 10(1):1–16

Horrocks M, Peterson J, Carson MT (2015) Pollen, starch, and biosilicate analysis of archaeological deposits on Guam and Saipan, Mariana Islands, Northwest Pacific: evidence for Chamorro subsistence crops and marine resources. J Island Coast Archaeol 10(1):97–110

Hung HC, Carson MT, Bellwood P, Campos FZ, Piper PJ, Dizon E, Bolunia MJLA, Oxenham M, Chi Z (2011) The first settlement of Remote Oceania: the Philippines to the Marianas. Antiquity 85(329):909–926

Hunt TL, Lipo CP (2008) Evidence for a shorter chronology on Rapa Nui (Easter Island). J Island Coast Archaeol 3(1):140–148

Irwin G (2008) Pacific seascapes, canoe performance, and a review of Lapita voyaging with regard to theories of migration. Asian Perspect 47(1):12–27

Irwin G (1994) The prehistoric exploration and colonisation of the Pacific. Cambridge University Press, Cambridge

Jackson JB, Kirby MX, Berger WH, Bjorndal KA, Botsford LW, Bourque BJ, Bradbury RH, Cooke R, Erlandson J, Estes JA, Hughes TP (2001) Historical overfishing and the recent collapse of coastal ecosystems. Science 293(5530):629–637

Jamieson AJ, Brooks LSR, Reid WD, Piertney SB, Narayanaswamy BE, Linley TD (2019) Microplastics and synthetic particles ingested by deep-sea amphipods in six of the deepest marine ecosystems on Earth. Royal Soc Open Sci 6(2):180667

Kealy S, Louys J, O'Connor S (2017) Reconstructing palaeogeography and inter-island visibility in the Wallacean Archipelago during the likely period of Sahul colonization, 65–45 000 years ago. Archaeol Prospect 24(3):259–272

Kealy S, Louys J, O'Connor S (2016) Islands under the sea: a review of early modern human dispersal routes and migration hypotheses through Wallacea. J Island Coast Archaeol 11(3):364–384

Keast A (1996) Avian biogeography: new Guinea to the eastern Pacific. In: Keast A, Miller SE (eds) The origin and evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: patterns and processes, pp 373–398. Amsterdam: SPB Academic Publishing

Keegan WF, Diamond JM (1987) Colonization of islands by humans: a biogeographical perspective. In: Schiffer M (ed) Advances in archaeological method and theory, pp 49–92. Academic Press, Cambridge, MA

Keegan WF, Diamond JM (1984) Supertramps at sea. Nature 311:704–705
Kirch PV (2017) On the road of the winds: an archaeological history of the Pacific islands before European contact. University of California Press, Berkeley
Kirch PV (2007) Hawaii as a model system for human ecodynamics. Am Anthropol 109(1):8–26
Kirch PV (1997a) The lapita peoples: ancestors of the oceanic world. Blackwell, Cambridge
Kirch PV (1997b) Feathered gods and fishhooks: an introduction to Hawaiian archaeology and prehistory. University of Hawaii Press
Kirch PV (1983) Man's role in modifying tropical and subtropical Polynesian ecosystems. Archaeol Ocean 18(1):26–31
Lambrides AB, Weisler MI (2016) Pacific islands ichthyoarchaeology: Implications for the development of prehistoric fishing studies and global sustainability. J Archaeol Res 24(3):275–324
Leach F, Davidson J (2001) The use of size–frequency diagrams to characterize prehistoric fish catches and to assess human impact on inshore fisheries. Int J Osteoarchaeol 11(1–2):150–162
LeFebvre MJ, Ardren T, Thompson VD, Fitzpatrick SM, Ayers-Rigsby S (2022). In support of sustainability: The historical ecology of vertebrate biodiversity and native american harvest practices in the florida keys, USA. Sustainability 14(11):6552. https://doi.org/10.3390/su14116552
Leppard TP (2019) Anthropocene dynamics in the prehistoric Pacific: modeling emergent socioecological outcomes of environmental change. Nature and Culture 14(2):119–146
Lewis D (1994) We, the navigators: the ancient art of landfinding in the Pacific. University of Hawaii Press, Honolulu
Louys J, Braje TJ, Chang C-H, Cosgrove R, Fitzpatrick SM, Fujita M, Hawkins S, Ingicco T, Kawamura A, MacPhee RDE, McDowell M, Meijer HJM, Piper P, Roberts P, Simmons AH, van den Bergh G, van der Geer A, Kealy S, O'Connor S (2021) No evidence for widespread island extinctions after Pleistocene hominin arrival. Proc Natl Acad Sci 118(20):e2023005118
Louys J, Curnoe D, Tong H (2007) Characteristics of Pleistocene megafauna extinctions in Southeast Asia. Palaeogeogr Palaeoclimatol Palaeoecol 243(1–2):152–173
Martin PS, Steadman DW (1999) Prehistoric extinctions on islands and continents. In: MacPhee RDE (eds) Extinctions in near time. Advances in vertebrate paleobiology, vol 2. Springer, Boston, MA
Matisoo-Smith E, Robins JH (2004) Origins and dispersals of Pacific peoples: evidence from mtDNA phylogenies of the Pacific rat. Proc Natl Acad Sci 101(24):9167–9172
Mischen PA, Lipo CP (2021) The role of culture in sustainable communities: the case of Rapa Nui (Easter Island, Chile). SN Soc Sci 1(5):1–21
Montenegro Á, Callaghan RT, Fitzpatrick SM (2016) Using seafaring simulations and shortest-hop trajectories to model the prehistoric colonization of Remote Oceania. Proc Natl Acad Sci 113(45):12685–12690
Montenegro A, Callaghan RT, Fitzpatrick SM (2014) From west to east: environmental influences on the rate and pathways of Polynesian colonization. Holocene 24(2):242–256
Musk E (2020) Quote taken from the virtual humans to mars summit (August 31–September 3, 2020) Sponsored by the Explore Mars Project (https://www.exploremars.org/). https://www.cnn.com/2020/09/08/tech/spacex-mars-profit-scn/index.html
Musk E (2017) Making humans a multi-planetary species. New Space 5(2):46–61
Napolitano MF, DiNapoli RJ, Stone JH, Levin MJ, Jew NP, Lane BG, O'Connor JT, Fitzpatrick SM (2019) Reevaluating human colonization of the Caribbean using chronometric hygiene and Bayesian modeling. Sci Adv 5(12):p.eaar7806
Napper IE, Davies BF, Clifford H, Elvin S, Koldewey HJ, Mayewski PA, Miner KR, Potocki M, Elmore AC, Gajurel AP, Thompson RC (2020) Reaching new heights in plastic pollution—preliminary findings of microplastics on Mount Everest. One Earth 3(5):621–630
Nixon CA, Thelen AE, Cordiner MA, Kisiel Z, Charnley SB, Molter EM, Serigano J, Irwin PG, Teanby NA, Kuan YJ (2020) Detection of cyclopropenylidene on Titan with ALMA. Astron J 160(5):205
NOAA (2020) Coral reef condition: a status report for U.S. coral reefs. NOAA Coral

Peng X, Chen M, Chen S, Dasgupta S, Xu H, Ta K, Du M, Li J, Guo Z, Bai S (2018) Microplastics contaminate the deepest part of the world's ocean. Geochemical Perspectives Letters 9:1–5

Plekhov D, Leppard TP, Cherry JF (2021) Island colonization and environmental sustainability in the postglacial Mediterranean. Sustainability 13(6):3383

Poteate AS, Fitzpatrick SM, Clark M, Stone JH (2015) Intensified mollusk exploitation on Nevis (West Indies) reveals~six centuries of sustainable exploitation. Archaeol Anthropol Sci 7(3):361–374

Reepmeyer C, Clark G, Sheppard P (2012) Obsidian source use in Tongan prehistory: new results and implications. J Island Coast Archaeol 7(2):255–271

Reef Conservation Program (CRCP) and the University of Maryland Center for Environmental Science

Rick TC, Erlandson JM, Vellanoweth RL, Braje TJ (2005) From Pleistocene mariners to complex hunter-gatherers: the archaeology of the California channel islands. J World Prehist 19(3):169–228

Rick TC, Kirch PV, Erlandson JM, Fitzpatrick SM (2013) Archeology, deep history, and the human transformation of island ecosystems. Anthropocene 4:33–45

Rieth TM, Athens JS (2019) Late holocene human expansion into near and remote Oceania: a Bayesian model of the chronologies of the Mariana Islands and Bismarck Archipelago. J Island Coast Archaeol 14(1):5–16

Rigaud K, de Sherbinin A, Jones B, Bergmann J, Clement V, Ober K, Schewe J, Adamo S, McCusker B, Heuser S, Midgley A (2018) Groundswell: preparing for internal climate migration. The World Bank, p 2. https://openknowledge.worldbank.org/handle/10986/29461

Rockman M, Steele J (eds) (2003) Colonization of unfamiliar landscapes: the archaeology of adaptation. Routledge, New York

Roberts P, Louys J, Zech J, Shipton C, Kealy S, Carro SS, Hawkins S, Boulanger C, Marzo S, Fiedler B, Boivin N (2020) Isotopic evidence for initial coastal colonization and subsequent diversification in the human occupation of Wallacea. Nat Commun 11(1):1–11

Rule S, Brook BW, Haberle SG, Turney CS, Kershaw AP, Johnson CN (2012) The aftermath of megafaunal extinction: ecosystem transformation in Pleistocene Australia. Science 335(6075):1483–1486

Sagan C (1961) The planet venus. Science 133(3456):849–858

Salter AW (2020) Elon Musk's Martian way (Empire not Included). Published online November 12, 2020 for the National Review (https://www.nationalreview.com/2020/11/elon-musks-martian-way-empire-not-included/#slide-1). Accessed on 12 Nov 2020

Sear DA, Allen MS, Hassall JD, Maloney AE, Langdon PG, Morrison AE, Henderson AC, Mackay H, Croudace IW, Clarke C, Sachs JP (2020) Human settlement of East Polynesia earlier, incremental, and coincident with prolonged South Pacific drought. Proc Natl Acad Sci 117(16):8813–8819

Sheppard PJ (1993). Lapita lithics: trade/exchange and technology. A view from the Reefs/Santa Cruz. Archaeol Ocean 28(3):121–137

Sheppard P, Trichereau B, Milicich C (2010) Pacific obsidian sourcing by portable XRF. Archaeol Ocean 45(1):21–30

Shipton C, O'Connor S, Reepmeyer C, Kealy S, Jankowski N (2020) Shell adzes, exotic obsidian, and inter-island voyaging in the early and Middle Holocene of Wallacea. J Island Coast Archaeol 1–22

Shiwei N, Dritsas S, Fernandez JG (2020) Martian biolith: a bioinspired regolith composite for closed-loop extraterrestrial manufacturing. PLoS ONE 15(9):e0238606. https://doi.org/10.1371/journal.pone.0238606

Steadman DW (2006) Extinction and biogeography of tropical Pacific birds. University of Chicago Press, Chicago

Steadman DW (1995) Prehistoric extinctions of Pacific island birds: biodiversity meets zooarchaeology. Science 267(5201):1123–1131

Steadman DW, Pregill GK, Burley DV (2002) Rapid prehistoric extinction of iguanas and birds in Polynesia. Proc Natl Acad Sci 99(6):3673–3677

Storey AA, Clarke AC, Ladefoged T, Robins J, Matisoo-Smith E (2013) DNA and Pacific commensal models: applications, construction, limitations, and future prospects. J Island Coast Archaeol 8(1):37–65

Szabó K, Amesbury JR (2011) Molluscs in a world of islands: the use of shellfish as a food resource in the tropical island Asia-Pacific region. Quatern Int 239(1–2):8–18

Taborsky M (1988) Kiwis and dog predation: observations in Waitangi State Forest. Notornis 35(3):197–202

Tavares F (2020) Ethical exploration and the role of planetary protection in disrupting colonial practices: a submission to the planetary science and astrobiology decadal survey 2023–2032. In: Equity, diversity, and inclusion working group, national aeronautics and space administration

The Nansen Initiative (2015) Disaster-induced cross-border displacement, p 6. https://nanseninitiative.org/wp-content/uploads/2015/02/PROTECTION-AGENDA-VOLUME-1.pdf

Torrence R, Swadling P (2008) Social networks and the spread of Lapita. Antiquity 82(317):600–616

Vitousek PM (2004) Nutrient cycling and limitation: Hawai'i as a model system. Princeton University Press, Princeton

Vitousek PM (2002) Oceanic islands as model systems for ecological studies. J Biogeogr 29(5–6):573–582

Webb CI (2021) Gaze-scaling: planets as islands in exobiologists' imaginaries. Sci Cult. https://doi.org/10.1080/09505431.2021.1895737

Weisler MI, Gargett RH (1993) Pacific island avian extinctions: the taphonomy of human predation. Archaeol Ocean 28(2):85–93

Weisler MI, Woodhead JD (1995) Basalt Pb isotope analysis and the prehistoric settlement of Polynesia. Proc Natl Acad Sci 92(6):1881–1885

White JP, Harris MN (1997) Changing sources: early Lapita period obsidian in the Bismarck Archipelago. Archaeol Ocean 32(1):97–107

Wilmshurst JM, Hunt TL, Lipo CP, Anderson AJ (2011) High-precision radiocarbon dating shows recent and rapid initial human colonization of East Polynesia. Proc Natl Acad Sci 108(5):1815–1820

Xu C, Kohler TA, Lenton TM, Svenning JC, Scheffer M (2020) Future of the human climate niche. Proc Natl Acad Sci 117(21):11350–11355

Scott M. Fitzpatrick is a Professor in the Department of Anthropology and Associate Director for Research and Collections at the Museum of Natural and Cultural History, University of Oregon. He is an archaeologist who specializes in the settlement and historical ecology of island and coastal regions, particularly the Pacific and Caribbean. Much of his research has focused on ancient colonization events, seafaring strategies, adaptations to smaller islands, exchange systems, human impacts on ancient environments, and how islands can serve as analogues for human settlement beyond Earth. He has published several books and more than 140 journal articles and book chapters, much of it based on field projects he has conducted in western Micronesia, the Caribbean, and Florida Keys. Fitzpatrick is the founding Co-Editor of *The Journal of Island and Coastal Archaeology* (Routledge/Taylor & Francis), an Associate Editor for *Archaeology in Oceania*, and serves on the editorial boards for the *Caribbean Journal of Science* and *Journal of Archaeological Science: Reports.*