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Nature as Agent

Mass-Event, Incremental, and Biotic Perspectives

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ABSTRACT

The concept of the Anthropocene is based on the premise that humans have had a profound and increasing impact on our environments. Yet many environmental conditions (earthquakes, storms, tsunamis, fire, disease, and other dramatic natural phenomena) can easily overpower human capacities and result in significant change. Incremental processes such as soil creep, vegetation growth, oxidation, and material fatigue similarly act against human intentionality by causing deterioration and decay whose denouement is unpredictable in timing and magnitude. The sentient world of animals, in which behavioral patterns have evolved for viability in a diverse world of predators and reproduction strategies, similarly presents challenges when managed under the assumption that humans are the primary determinant of comportment. In this volume, we consider the agentive effects of natural phenomena to which the direct human response is primarily reactive. The objective is twofold: to highlight that even within the "Anthropocene," not all natural phenomena can be anticipated, much less controlled, by humans; and second, to critically evaluate the variety of past human responses to natural and biological entities as seen through the archaeological record.

The archaeological study of human-environmental dynamics has been heavily weighted on the "human" side of the equation. In recent years, that focus has been augmented by an increasingly pointed indictment of the way human activities can

https://doi.org/10.5876/9781646423521.c001

not only alter local environments but can also collectively push the entire planet into new physiological configurations. The development of the "Anthropocene" as a distinct geologic era, added to a century's worth of scholarly discussion about the role of humans in their ecosystems, has further solidified an interpretive view of humans as prime mover. In this volume, we challenge the interpretation of human centrality by focusing on the force and impact of nature relative to human knowledge, action, and volition. We identify the ways natural entities, ranging in size from viruses to mega-storms, have presented our species with dynamic conditions that overwhelm human capacities. Using an archaeological perspective, we illustrate and analyze the many ways in which people do *not* control their environments.

The dynamic world of nature is so large and complex that cause and effect are rarely the result of dyadic interactions but instead encompass synergies among multiple entities and along multiple timescales (e.g., Cordova and Porter 2015; Doughty et al. 2013:4; Wright 2017). An ecosystems perspective is the only way to evaluate physical forces as parameters for human activities in both the past and the present; the goal is not to identify causalities and prime movers as much as to document the generative and mutually implicated relationships among entities that include static factors such as latitude and longitude as well as dynamic factors of climate change, plant and animal species, and biochemical shifts (Wright 2017:2, 4). Mutually generative relationships also include human actions, in which people respond proactively and reactively to their surroundings, thereby contributing to the complexity of ecosystems.

Our species came into existence within a framework of powerful natural forces, evolving in an environment that included the vagaries of sunlight, wind, water, weather, fire, magma, quicksand, tides, gravity, seasonal cycles of temperature, and plate tectonics. Humans could recognize the effects of those natural processes but could rarely control or even predict their onset, amplitude, duration, and frequency. Everyday actions related to food, energy expenditure, living spaces, and mates were conditioned by ecosystems inhabited by hundreds of other species. Early in our evolutionary trajectory, however, humans became more than just another mesopredator. Starting a million or more years ago, our ancestors began to use tools to leverage individual actions in ways that impacted larger and larger portions of the surrounding environment. They not only utilized fire to serve individual and household needs by altering the taste and texture of food but also modified entire local ecosystems by increasing the periodicity of fires beyond natural frequency, intensity, and seasonality. People consumed plants and animals disproportionately to their natural population distributions and, in selectively targeting prime animals instead of weak ones, exercised strategies of culling that were different from any other carnivore. This modification further intensified when humans undertook the genetic manipulation of plant and animal populations through the process of

domestication and through the terraforming of the natural landscape to facilitate agriculture and enhance aesthetics.

In modifying their environments, our species remained subservient to the forces of nature that continue to provide both gentle and terrifying parameters for human actions. The resultant fraught and complex relationship between people and their surrounding landscapes has long been the subject of philosophical commentary. Ancient Greek writers, starting with Homer in the first millennium BCE, poetically articulated widespread cultural recognitions of the power of nature over human intentions. In the *Iliad* and the *Odyssey*, the elements of wind, water, and tide thwarted even the most determined of ships' captains sailing to Troy and the most determined of heroes trying to return home afterward. Hesiod's *Works and Days*, written a few centuries later, provided wisdom to farmers as they faced endlessly cycling seasons of agricultural opportunity and risk punctuated by frost, rain, and scorching sun.

Religious and literary traditions from around the world likewise have noted the power of nature to destroy human creations. The Hebrew Bible, for example, is replete with natural assaults including plagues, locusts, and the Flood; devastating inundations also make their appearance in narratives from Australia, sub-Saharan Africa, the Indian subcontinent, Polynesia, and North America (Witzel 2010). Volcanoes, strung along fault lines globally and concentrated around the Pacific Ring of Fire, are worrying both when they are active and when they are dormant; they are the subject of continual vigilance and appreciation, as in New Zealand where "good and bad outcomes from volcanism are part of long-term cycles of reciprocity and equilibrium that link modern Maori to their ancestors" (Cashman and Cronin 2008:407). Other natural phenomena—storms, plagues, earthquakes—are measured and memorialized by their impact on human volition and human creations.

THE ANTHROPOCENE

Since the mid-1800s, philosophers and scientists have devised new terms to describe human-environmental dynamics in ways that increasingly implicate our species as prime movers in a "human domination of earth's ecosystems" (Vitousek et al. 1997:494). These terms have included the "Anthrocene" (Revkin 1992), the "Anthropozoic" and the "noösphere" (see Erlandson and Braje 2013:2), and the most popular current neologism: the "Anthropocene." Over the brief twenty years since the first published appearance of the term, the definition of the "Anthropocene" has increasingly emphasized human culpability. In their original formulation, Paul J. Crutzen and Eugene F. Stoermer (2000:17) proposed that the Anthropocene defined a time when "the global effects of human activities have become clearly

noticeable." More recent definitions have highlighted the way human activities are "outcompeting natural processes" (Crutzen 2006:13) and "overwhelming the great forces of nature" (Steffen et al. 2007:614). The Anthropocene is now being considered as a formal epoch and as a successor to the Holocene in the International Chronostratigraphic Chart, a move that has generated considerable controversy given the "lithologically thin" geological record and the perceptions of a strong political impetus to the designation of a human-focused geological era (Zalasiewicz et al. 2017).

The chronology as well as the impact of the Anthropocene have been subject to debate. Many ecologists suggest a formal inception that corresponds with significant human technological innovations or intensifications, such as fossil fuels beginning around 1800 CE (Steffen et al. 2007) or atomic detonations starting in the mid-twentieth century (see Barnosky et al. 2014:226; Zalasiewicz et al. 2017:207). Archaeologists have argued for much earlier starting dates, noting that the human impact on the environment can be materially demonstrated long before the fossil-fuel era. Jon M. Erlandson and Todd J. Braje (2013:1) propose that the Anthropocene started 10,000 years ago, concomitant with the domestication of plants and animals, a time that David K. Wright (2017:6) suggests could be termed the "long Anthropocene" and that Lucas Stephens and coauthors (2020) call the "deep Anthropocene." Applied in this way, the Anthropocene would thus overwrite (and eliminate) the Holocene as a geological era. Christopher E. Doughty and colleagues (2013:4) roll the clock back even earlier, to the pre-agricultural demise of the mammoths ca. 14,000 years ago. Stephen F. Foley and coauthors (2013:84) propose the most generous allocation of all, defining a Paleoanthropocene coincident with the emergence of the genus *Homo* around 1.8 million years ago, a term that recognizes humans' distinct effects on the environment while reserving a formally defined Anthropocene for the very recent past.

Regardless of the proposed starting date, the appellation of the Anthropocene or any of its cognate labels implies that as soon as humans appear in a landscape, they instigate change. This emphasis on the (largely destructive) effects of our species endows us with a special focal point that we may not wholly deserve and does so in a manner that dissipates and underemphasizes the forces of nature that still exist even in the modern, fossil-fuel era. Geologists share this discomfiture about pivoting to a cultural rather than physiological threshold for defining geologic eras; in an elegant move that sidesteps the question of the Anthropocene, the International Union of Geological Sciences (IUGS) has divided the Holocene into three parts marked by global-scale and objectively measurable climate anomalies at 8.2 kya and 4.2 kya (Walker et al. 2019). The third of the three divisions in particular hammers home the fact that culture is subservient to nature: naming the 4.2 kya event the

Meghalayan, the IUGS acknowledges that the era of drought toppled many well-known Old World Bronze Age civilizations.

In our view, calls to affix the start of the "Anthropocene" with premodern archaeological cases seem to distract from a much more interesting question: how do humans respond to and plan for the power of nature? As an alternative to the geological cause-and-effect rhetoric of the Anthropocene, we embrace the more holistic, mutualistic notion of the "anthroposcape" as a description of the ways humans have physically altered the physical environment through the selective consumption of plants and animals and the modification of terrestrial slope, gradient, hardscapes, watercourses, and vegetation regimes. The term *anthroposcape* has already been used in the philosophical sense that encompasses the concept of agency and being-in-the-world, with an initial definition offered by Bee Scherer (2014:1) as "the landscape of our embodied experiences." A materialized, archaeological use of the term enables us to counter the visible effects of human actions with and within the powerful counterbalance of the natural world, in which agency and (re)animation is encompassed within both sentient and non-sentient components of the Earth.

The use of an anthroposcape perspective incorporates the recognition of the long history of human interactions with the remainder of the natural world and extends the impact of humans to the first tool-using australopithecines 3.3 million years ago, (cf. Harmand et al. 2015), far earlier than even the most generous-minded proponents of the Anthropocene concept would generally accept. Given the controversies of the Anthropocene as a marker of compelling human control of the environment, the use of anthroposcape is a politically neutral and nonjudgmental term that measures the impact, rather than the morality, of human and natural mutualism. The term also provides a sense of the complex responses humans have developed as recipients of natural actions and how our collective past provides the inescapable background for both the present and the future and helps us identify the range of individual and collective responses of the type that would make archaeological investigations truly relevant to modern life.

The scale and impact of the human-nature dialectic as an anthroposcape can be approached in productive ways using iterative perspectives borrowed from linguistics. One avenue for the assessment of natural and human interactions can be found in frame analysis, as developed by the theoretician Erving Goffman. Frames, also termed frames of reference, constitute "schemata of interpretation" for the input of new information and actions (Goffman 1974:21), resulting in realities that are measurable and physically evident. Frame analysis need not be limited to entities capable of intentional or sentient actions but can be viewed as the constituent quality of inanimate collectives (e.g., Snow et al. 1986, 2014) in which frames are literal or figurative "sedimented histories of particular ways of understanding and engaging with the world" (Jepson

2010:314). Although the majority of his development of frame analysis (as well as others' use of the concept) focuses on the relationships within and among social groups, Goffman (1974:23) emphasized the necessary coexistence of non-sentient natural entities and sentient human capacities in the frame-creation process.

For nature, frames of reference are encoded through repetitive events: successive volcanic eruptions pile lava flows one on another; successive rainstorms fill lakebeds; successive drought seasons transform shallow lakes into desert. Human frames of reference make use of these naturally iterative processes and the cultural processes of new knowledge and innovation, as well as memories of successful past attempts and the physical entities created by human hands. The generative impact of human actions is scalable (from an individual lighting a fire, weeding a field, or cutting down a tree to collective groups engaged in dam construction or cooperative hunting). The process of reassessment and renegotiation at both the individual and the group level results in the ongoing trial and error that characterizes human approaches to a dynamic environment, in which participation in a course of action is "subject to frequent reassessment and renegotiation" (Snow et al. 1986:467). But the concept of frames also permits natural entities to engage in actions that are similarly of the moment yet subject to preexisting conditions: a sudden storm can spread out its waters as a thin wash across a plain or can deeply gouge the landscape's surface through incipient or existing channels, whether those channels are natural or human-made.

In addition to the concept of framing that can be identified through the archaeological and paleontological records, the dynamics of iteration can be evaluated through the concept of "conversation analysis" in which dialogue is understood to be recursive, situational, and cumulative because of the memory of past utterances and actions (Ahearn 2001; Sacks et al. 1974; Schegloff 2006). Conversation analysis takes as a given the existence of interlocutors' prior experiences that are brought with them into any new conversation, in which linguistic expectations about grammar and the meanings of words provide the scaffolding for each new interaction. Although non-sentient natural elements transfer energy through actions rather than through independence of volition and communication, the concept of a "dialogue" as a process that involves back-and-forth iterations provides a way of thinking about the dynamic interlocution of natural and human forces in which each action carries forward into the "conversation." For example, clear-cutting of forests provides both farmland and fuel and may alleviate risks of fire or predator ambush. Such actions also render benefits to humans along a long timescale, including the opening up of habitats that favor grasses and the ruminants that feed on them. At the same time, clear-cutting leaves newly exposed areas vulnerable to erosion and nutrient depletion, reduces habitat for some desired species such as birds, and entails additional costs of resource collection once the felled trees are used up.

Both conversation analysis and frame theory support an anthroposcape concept, in which there is a mutualism of natural and human actions. Archaeologists have discussed the dynamism of human-material engagement as a relationship that is not only recursive but incrementally additive such that each interaction results in a slightly new configuration, in which the return to an "original" state is impossible. Severin Fowles and Jimmy Arterberry (2013:69) have discussed this phenomenon as one in which object "agency" is encompassed within "recursive networks and alliances between people and things that are irreducible to anything else." In other words, the mutualisms of interaction not only are impossible to reverse but cannot be pulled apart at all once they have started down the path of synergy. Mutualisms are materially evident at every scale archaeologists investigate, from the site to the landscape and even to the level of an entire planet. These observations help us recognize that unambiguous archaeological explanations are difficult to achieve because of the many different responses humans can use to counter objectively measurable phenomena such as climate, biodiversity, or tectonics.

Eliciting explanations about human-nature mutualisms requires the support of evidence from both large-scale and microscopic perspectives. The most salient and archaeologically discoverable locus for the articulation of human-natural mutualism is the human settlement. Settlements, constituted of sociably organized human dwellings, provide physical places of investment in architecture, possessions, foodstuffs, and cooking equipment that reflect everyday needs of biological and social subsistence (cf. Smith 2010). The settlement is a scalable concept that includes every size of habitation, from the spare collection of forest foragers' huts to the most densely occupied cities. Any settlement also has a temporal component that crosscuts the concept of scale. Short-term encampments can be small if occupied by forager groups, but they also can be large when encampments are places of pilgrimage or refuge in ways that accelerate human impacts on the surrounding landscape. As a physical locale and the focus of quotidian human investment, the settlement can thus be identified as the prime locus of action and a hinge between natural actions and the actions that materialize as the result of human memory, volition, and response.

Although settlements are conceptualized as parts of "giving" environments because humans gravitate toward places of natural abundance of some desired aesthetic or material condition (Moore and Schmidt 2017, drawing from Ingold 2000), it is clear that settlements of all sizes can also induce, harbor, and accelerate natural effects. Settlements can prove to be particularly resilient to storms through sturdy construction and mutual aid or can be particularly vulnerable to domino effects of flooding and wind brought by inclement weather (e.g., Liao 2019; Rodríguez et al. 2006). Settlements provide conditions for unintended mutualisms between

diurnal people and nocturnal commensals such as rodents. Concentrations of people result in concentrations of invisible viruses and bacteria as well as visible disease vectors, such as feral animals attracted by human waste accumulations. The effects of human activities radiate beyond the boundaries of collective living quarters into the surrounding areas that serve as the spatial locales of interaction and constitute the support networks for water, food, and fuel. In between settlements as intensely manipulated environments and the greater wilderness in which there is successively less impact, there exist catchment zones of opportunistic mutualisms brought about by human action. Agricultural fields provide attractive foliage for browsing animals with the risk to them of garden hunting; impounded water for agricultural irrigation provides environments for populations of species that would not otherwise be found, including captives (fish) and free-ranging (mammalian and avian) species. The advent of arboriculture (and its oscillating opposite, timber harvesting for fuel and construction material) alters the landscape of birds, which, in turn, affects their availability for human food, feathers, and soundscapes.

AGENCY

The study of agency as a foundational component of human social engagement has been a focal point of anthropological and archaeological theory for the past twenty years. Seminal works of this genre included the edited volume *Agency in Archaeology* (Dobres and Robb 2000) and the influential articles "Language and Agency" (Ahearn 2001) and "Agency and Archaeology" (Dornan 2002). These writings considered the meaning and intentionality of human actions in the past, as reflected in artifacts and architecture and encompassed within a tradition of material theory. These works were followed nearly ten years later by a broader perspective on the subject titled *Material Agency: Towards a Non-Anthropocentric Approach* (Knappett and Malafouris 2008), which focused primarily on memory, material objects, and text—all of which are exclusively human domains of initiation and reflexivity in which objects "speak" because they are invested with human intent in their creation. A continuation of this important line of thought about the mediating effects of artifacts in the creation and manifestation of human agency is found in the volume *Relational Identities and Other-than-Human Agency in Archaeology* (Harrison-Buck and Hendon 2018).

In this volume, we eschew the consideration of intentionality and human efforts as prime movers of physical change, focusing instead on the physically measurable effects of action rather than considering animacy, intentionality, or personhood. Instead, we focus on agency as a measurable initiator of cause and effect and adhere to the clearly delineated causality proposed in Stephanie Spengler and colleagues'

(2009:290) definition of agency: "was it me or was it you?" In our chapters, the dialogic back and forth of causality between natural actions that occur without reference to human beings, and the human attempts to survive and thrive within those natural parameters, provides the opportunity to evaluate human-nature dynamics beyond the rubric of an "Anthropocene" in which human actions take center stage. We thus turn to the agency of natural phenomena at multiple spatial and temporal timescales and within the anthroposcape through three categories: mass event, incremental, and biotic phenomena.

Mass-Event Natural Phenomena

Mass-event occurrences include weather phenomena such as storms (hurricanes, typhoons, tornadoes), earthquakes (and their follow-on effects such as tsunamis), and volcanic eruptions. Natural events on this scale provide some of the most dramatic changes to the landscape; to this day, hurricanes, typhoons, volcanic eruptions, and tsunamis can affect continental-size portions of the earth. By comparison, single-event destructive attempts by humans—even the atomic bomb—are puny analogs to the forces of wind and water that can destroy hundreds of thousands of square km of habitable land within a matter of hours or days. Other natural events such as earthquakes can be more localized and their debris fields more limited, perceived by humans through the effects on settlements but holding great potential for change in topography and waterways. Seasonality is a factor in some natural mass-event activities, lending some predictability to the timing of events such as sandstorms, dust storms, and monsoons even though their duration and amplitude are unknown except in retrospect.

Human perceptions and responses to mass events are characterized by distinct stages of reaction: a sudden impact followed by a heroic phase, a disillusionment phase, and a rebuilding and restoration phase.[1] If local inhabitants interpret a mass event as destructive, they may flee the area. But people also may perceive a benefit from a mass event, such as the clearance of land that makes available new locations for settlement and increases the potential for agricultural productivity. When interpreted as an opportunity (e.g., an act of divine retribution that supports the further development of a millennial movement or a rationale for large-scale reorganization that has long been desired but for which there was no proximate impetus), then a mass event becomes a generative turning point in human-environmental dynamics.

In this volume, we term large-scale natural occurrences as "mass events" rather than "catastrophes" because the latter is a value judgment assessed within the frame of reference of the people who experience the event and its aftermath and who move forward from that experience through subsequent actions. When resilience

is built into the process of human landscape use, mass events take on diminished cultural significance. An example comes from the North American Great Plains, where a 1950s drought was climatologically more significant than the one that produced the 1930s Dust Bowl phenomenon; although the 1950s event was potentially more destructive, "catastrophe" was averted through multiple human activities that had been emplaced because of knowledge gained from the Dust Bowl days: some of the responses to the later drought were slow and incremental (conservation practices such as the conversion to grasslands and the construction of erosion dams) and some were circumstantial (the increased use of irrigation from the Ogallala aquifer; Cordova and Porter 2015).

Incremental Natural Phenomena

In contrast to mass events, processes of incremental change are often so subtle that they elude direct notice. Incremental physical changes such as chemical reactions, crystallization, and oxidation are continually active, often on a microscopic scale imperceptible to humans. Some processes are extremely active in nature, such as dry rot that facilitates forest growth and regeneration but also attacks human architectural timbers. Some processes are latent in nature but become aggressive agents disproportionately on human creations, such as salt effluorescence on pottery and in agricultural fields (cf. Redman 1999). Some incremental changes (whether visible in the form of oxidation or invisible in the form of microstructural change) can eventually result in sudden-onset failure (Lehner 2018). This has interesting implications not only for individual-use artifacts ("Grandpa's bronze sword isn't good for battle anymore") but also for large-scale configurations such as infrastructure and other monumental constructions, which can in a single day be transformed from a functioning utilitarian necessity to a disruptive failure.

To what extent would ancient people have seen, worried about, or mitigated the risks of incremental change, whether in the purely natural realm or as applied to wood, cloth, basketry, and other artifacts and architecture made of organic materials? Human settlements increased the canvas on which incremental natural actions could take place because of the propensity of humans to accumulate utilitarian and decorative objects. Humans also provided the opportunity for otherwise latent natural processes to manifest themselves through the creation of anthropogenic materials such as bronze, which immediately upon its invention provided a new substance for oxidation (Lehner 2018). Other metals such as silver and iron did exist in a natural state and were subject to oxidation processes, but the collective surface area available for oxidation increased dramatically once people began to smelt ores for metal production.

One of the most important incremental phenomena is vegetation. The human relationship with plants began within a context of thousands of wild species throughout the world, from which humans selected a subset of plants for use. Among that subset of selected plants, humans further invested time and effort into an even smaller subset that they manipulated to the point where those plants became dependent on humans for propagation (those plants—our grain crops—were bred by humans to hold tight to their seeds until threshed, a factor of utility to humans but maladaptive to free-seeding natural plant propagation). The process of agriculture and domestication was an agentive act renewed each season in the face of accumulated knowledge, capacities, and climatic variation, with agricultural fields of purposive species as a monocrop; as an interspersed group of two or three species such as the corn, beans, and squash triad in North America; or as patches of species within a mosaic (such as vegetables and herbs in a kitchen garden). The human and animal relationship with the many wild species that grow adjacent to farmed fields is not necessarily an antagonistic one, however, as untended species can serve as important sources of fuel, raw materials, medicine, and "famine" foods.

Archaeologists have been particularly good at addressing human-vegetation interactions from the perspective of domestication and human volition, with an emphasis on the hardship and energy expenditure of cultivation (e.g., Hayden 2014; Smith 2001). Will Steffen and colleagues (2007: 616) refer to the "biological inefficiencies" of energy capture through the growth of plants and the tending of animals; experimental plantings of early domesticates in the modern day—seeking to replicate ancient conditions—reflect the challenges of actually getting a crop (e.g., Toll et al. 1985). Because the complexities of the vegetative world involve multiple, shifting inputs that vary from year to year (including weather, rainfall, pests, and nutrient load), the process of growing plants involves numerous adjustments even by experienced gardeners growing the same plants on the same plot of land from year to year. In fact, we might analyze human activities of cultivation not under a rubric of performance suggestive of a definitive and planned-for outcome but under a rubric of "practice" (cf. Goffman 1974:64) subjected to constant changes in the natural frames of reference in which the outcome is achieved within a "syncopated rhythm of the river, rain, and seasons" (Erickson and Walker 2009:249).

Unwanted plants, characterized as "weeds," are an integral part of human cultivation systems in which the number of weed species often greatly outnumbers the domesticates (e.g., Kingwell-Banham 2015). Weeds compete with purposive plantings at all scales and grow without any visible human effort, in contrast to the energy expenditure required to grow domesticates. Cultivated grains are disturbed-earth plants, as are many weeds, such that actions undertaken by people including soil clearance, watering, and provision of fertilizers to provide hospitable conditions

for wanted plants unwittingly provide environments that are equally preferred by weeds. Our understanding of landscapes as denuded by human actions (as in North America) or by our technologies of lidar downplays the realities of the lived landscape of explosive organic growth. Tall vegetation such as trees impedes sunlight on agricultural clearances and thwarts viewsheds and lines of sight—an especially important point given that many of our understandings of ancient landscape dynamics and intra-community interactions assume visibility across the landscape (e.g., Doyle 2012:366). Particularly in tropical environments, robust year-round vegetation growth would have necessitated continual clearance as a form of architectural and environmental maintenance.

Unwanted vegetation growth also bedevils the built environment of cities. Bettina Stoetzer (2018) has discussed the ways urban centers produce conditions for "ruderal ecologies" in which vegetation grows spontaneously in the forgotten or unplanned interstices of pathways, rubble piles, and garbage heaps. Rooted in place, plants become both a vertical and a horizontal reminder of vegetative agency. Windborne and animal-borne seeds lodge in the crevices of architecture where they readily take root. One might even see cities as an overlap of ecotones, from the wholly human-made conditions of architecture to the channeled and manicured banks of urban waterways to the untamed fringes of forests and abandoned buildings that all serve as hosts to commensal species.

Humans thus live with incremental changes of growth while sometimes initiating sudden and dramatic alterations (such as cutting down a tree, damming a river, or setting fire to a forest). But incremental change is also perceptible at moments of naturally induced failure in which the cumulative effects of incremental processes become visible: the soil creep that leads to a sudden blowout of an agricultural terrace, the metal fatigue that results in the collapse of a bridge, the unnoticed infestation of ants or mildew that spoils a full storage bin of grain. As agents of cumulative incremental change, processes such as oxidation work in concert with the organic materials they attack, resulting in ecosystem changes in which the "tipping point does not have to be large scale" (Wright 2017:2).

Biotic Phenomena

The natural world is replete with living entities that grow, reproduce, and die under conditions broadly defined by the processes of natural selection and "survival of the fittest." Utilizing the definitional rubric of "was it me or was it you," we can evaluate biotic agents at all levels of complexity, from bacteria and fungi to birds and mammals. Today, every biotic agent in the world is implicated in the human realm; in a critique of the concept of the Anthropocene, Piers Locke (2016:3) has noted that

"the built environments of human civilizations and the economic activities that support them can no longer be treated in isolation from the ecological processes of a natural world made possible by so many other life forms" (see also Barua 2021). Starting at least 100,000 years ago with the worldwide migration of *Homo sapiens*, humans have created new environmental niches, including agricultural fields, dwellings, storage spaces, and even personal artifacts such as articles of clothing that provide opportunities for some species to expand their range and for new identifiable species to emerge in a process that can actually increase biodiversity (cf. Kittler et al. 2003; Pincetl et al. 2013). Monocropping enabled already extant viruses and bacteria to grow on a scale that would not have been possible without human intervention. Diseases such as cholera, flu, plague, and tuberculosis benefited from the larger and more concentrated pools of biotic vectors present in human settlements.

It is with the interaction with other sentient animals that the complexities of environmental dynamics become particularly subject to the agentive actions of nonhumans. Mammals and birds have complex behavioral characteristics and act with perceptible agency relative to the possibilities available to them through distinct variations of personality such as curiosity, boldness, and timidity that are increasingly recognized by ecologists as factors in individual selective fitness (Biro and Stamps 2008; Locke 2016). Wild animals' interactions with humans depend on individual responses to human enticements of companionship and food, a phenomenon of affect that may have been a contributing factor in the inception of domestication (Reed 1977:563–564). Mutualisms with wild birds involve intensive one-to-one interactions with human caretakers in which individual birds exhibit personalities of compliance and engagement, while humans themselves must also develop skills that are particular to the species and, perhaps most important, to the individual birds with which they interact (e.g., Jepson 2010). Mutualisms also are pronounced in group-to-group behavior, such as the dolphin pods that cooperate with fishermen by driving fish toward boats and giving instructions to humans about the timing of casting and netting (e.g., Daura-Jorge et al. 2012; Smith et al. 2009).

Perhaps the most complex and intense relationship with intelligent, independent-minded creatures is the one humans have with elephants, where interactions are the result of the taming of individuals in which the elephant-human relationship is mediated by the fact that both species typically have long life spans. As with humans, however, elephants' personalities are sometimes superseded by instincts that run deeper than the rationality of the moment or the carefully cultivated mutualisms of physical work (Baker 2016). As extra-large animals in an ongoing competitive dynamic with humans, elephants provide a unique vantage point from which to query the trajectory of human relationships with smaller mammals. Although elephants have been tamed on an individual basis, they have never been fully

domesticated—a configuration that can inform us about the way other animals have been incorporated into human lifeways across a gradient of "wild" to "domesticated," with intermediate characteristics exhibited by both individuals and populations until free-ranging populations were either extinct or vastly outnumbered by domesticates. And while our colloquial understanding of a "commensal" animal is something of rodent size, Charles Santiapillai and S. Wijeyamohan (2016:235) have revealed that in the case of elephants in Sri Lanka, the human modification of the landscape to include hundreds of artificial reservoirs starting more than 2,000 years ago constituted a technological change that facilitated the growth of both elephant and human populations.

As Locke (2016:1) has observed for South Asia, humans have regarded elephants through a variety of lenses: prey, cohabitants, companions, weapons of war, emblems of prestige, symbols of divinity, objects of entertainment, commodities, and sources of labor. One could invest many of the large domestic animals of both the Old World and the New World (cattle, sheep, goats, llamas, horses, camels, reindeer) with the same dynamic range of words. Domestic animals ostensibly under the control of *Homo sapiens* act in ways that are sometimes in compliance with and sometimes defiant of human volition, with individual variations of personality that play into the human selective process as well as subsequent long-term relationships that involve close daily proximity and mutual dependence. Intensive relationships with domesticated animals are then projected back onto the wider world of sentient creatures on the continuum from free-ranging "wild" populations to habituated to tame animals, in which the language of animal husbandry applies to many species beyond those that are domesticated (see Jepson 2010:325).

Cultural shifts in human preferences for ornamentation, food, clothing, and architectural elements can lead to localized pressure on or outright extirpation of plant and animal species, a factor evident in extinctions starting as early as 50,000 years ago and continuing to the present (Braje and Erlandson 2013; Houston 2010). Cultural shifts also can result in the differential preservation of species; Stephen Budiansky (1997) suggests that if domestication had not happened, human hunting pressure would have likely rendered horses extinct. Physical interactions with domesticates not only provided new opportunities for food, traction, and symbolic accoutrements but also introduced new vectors for zoonoses as animals were brought into closer quarters with humans. This interaction, in turn, sparked a new dynamism between humans and invisible biotic agents that further stimulated evolutionary responses when "humans that possessed a genetic predisposition to survive zoonoses contributed more offspring to future generations, demonstrating the evolutionary influence of the animal-human relationship" (Olsen 2010:529).

DISCUSSION

As noted in the chapters in this volume, mass-event, incremental, and biotic agents frequently overlap in their environmental effects. Mass events such as volcanic eruptions and meteors can directly or indirectly kill a multitude of organisms, as well as provide new landscape conditions that favor in-migration and colonization by species previously unknown in a region. Analyses of modern and historical large-scale ecosystem events such as storms, earthquakes, and volcanic eruptions enable us to address the challenging complexities of human-environmental interactions when nature is the precipitating agent of change. Further opportunities are provided by humans who make agricultural terraces that provide new verticalities subject to gravity, craft metal objects that provide an increased number of surfaces for oxidation, and engage in foodways that provide new niches for parasites. As the authors in this volume discuss, many other "natural" events set into motion human reactive responses that can, in turn, be generative of new social configurations, including a social milieu in which inventive and creative responses to environmental circumstances enable people to activate new strategies of architecture, agriculture, and resource extraction.

Humans' responses to natural events occur at a timescale that is often inversely proportional to the chronology of natural actions. Rapid-onset events such as earthquakes may last only a few minutes but can trigger human investments in years of planning foresight and reactionary recovery, often resulting in entirely new forms of architecture and anthroposcapes. Fostering plants requires multiple scales of planning and intent, from the collection of seed grains to the preparation of fields to the growth, harvest, and storage of the agricultural resource; each of these stages is subject to the caprices of nature, which require ongoing adjustments to achieve humans' desired outcomes. The capture of a wild animal may take days of planning and mere minutes of direct action but usher in years of painstaking training and taming to make the animal responsive to human commands. Fire, water, air, and earth all provide the opportunity for intense human-nature interactions because of their tripartite capacity: they exist independent of humans, they can overwhelm humans' intentionality, and they can respond to human intervention to create circumstances and conditions that could not have occurred naturally. Fire is controlled by humans to result in high-temperature transformations that produce metal from smelted ores, water is channeled through conduits to places it would not otherwise reach, air is compressed in bellows to speed fire combustion, and earth can be containerized (to promote and deter organic growth) or heated (to produce an artificial stone-like substance in the form of pottery and bricks).

CHAPTERS IN THIS VOLUME

The authors in this volume assess the ways humans respond to natural changes, foregrounding the independence of natural forces at the mass-event, incremental, and biotic scales. Addressing the largest natural phenomena, Matthew C. Peros, Jago Cooper, and Frank Oliva engage with the way hurricanes have impacted ancient human populations and prompted a variety of proactive and reactive responses. They advocate the pursuit of paleotempestology—the study of past hurricanes—not only to understand ancient human activities but also as the only means by which a long record of extreme weather can be generated given the short time span of modern records. Peros and colleagues note that despite the lack of predictable periodicity, storms conditioned ancient peoples' landscape strategies in ways that allowed for resilience and cultural continuity, as they demonstrate through their case studies of medieval Japan, the Terminal Maya collapse, and the archaeology of the Caribbean.

Kanika Kalra's chapter on rainfall addresses the incremental side of the heaven-borne spectrum of water. Through her research on the Indian monsoon, she assesses the environmental impact of regular seasonal rainfall that serves to define entire landscapes and punctuates the annual cycle of human activities. Her chapter contrasts the Bronze Age Indus culture (which was centered on rivers in the western subcontinent) with the Early Historic and medieval cultures of southern India, whose agricultural and political growth took place in a more arid environment in which water capture was essential. Through the comparison of three areas and cultures including Vijayanagara, Tamil Nadu, and the region known as the Raichur Doab, Kalra evaluates the many different individual-, household-, and community-level practices of water management that included wells, reservoirs, cisterns, embankments, and opportunistic catchments woven into the construction of fortifications—all of which served as infrastructure to capture, retain, and divert seasonal rainwater abundance.

The intensity of mass natural events may not be predictable or stoppable, but humans respond to such events in a variety of ways. In his discussion of the effect of earthquakes on ancient Roman cities, Jordan Pickett reconstructs architectural histories to show that our colloquial phrase "don't waste a good crisis" was well understood by ancient civic leaders. In many Roman cities of the eastern Mediterranean, the destruction of buildings by earthquakes provided the opportunity to rebuild to suit new specifications and social movements, most notably the growing influence of Christianity with its new architecture of churches that became the focal point of post-earthquake donations and urban renewal. His treatment of the three case studies of Antioch, Ephesus, and Hierapolis illustrates the ways resilience and sustainability are always couched in social terms.

Fire is a natural phenomenon whose existence on the planet can be documented for the past half-billion years. As Smith examines in her chapter, fire as an interactive system of fuel and combustion has long shaped biotic communities around the world; humans' engagement with fire starting with our earliest ancestors further accelerated the mutual dependence of fire with its surrounding environments. The adoption of fire technologies required a cognitive understanding of unilinear processes, but fire was infinitely scalable and became both a tool and a weapon of mass destruction. In stark contrast to the human relationship to stone as an inert substance, the human engagement with fire was one of constant management and risk: a single spark can result in long-lasting scars to an entire landscape.

Compared to physical events that violently disrupt settlements and their surroundings, diseases are natural phenomena that are invisible but whose effects often are far more insidious, disruptive, and widespread. In their chapter, Sara L. Juengst and colleagues identify all of the types of medical malaise that beset humans from their contacts with each other and with their environments, including viruses, bacteria, parasites, and fungi. These pathogens, widespread but generally dispersed in the natural environment, become pooled and concentrated in human settlements and thrive in the niches created by human habitation, storage, and land-use practices. The authors propose that these human-altered environments, especially after the advent of plant and animal domestication, have become "microbe-scapes" in which human activities actively enhance disease replication and transmission. The bioarchaeological results from their case study of the transition from foraging to farming in Bolivia illustrate that the challenges of zoonotic-origin diseases, as we well know in our own times, also have a long history in the archaeological record.

Incrementalism in natural phenomena presents a subtle but compelling revelation of the way natural processes overwhelm and thwart human intention. In their insightful chapter on vegetation growth, Harper Dine, Traci Ardren, and Chelsea Fisher use the ancient Maya site of Coba to critically address the category of "weeds" in a human landscape of cultivation. They observe that the categories of domesticated plants and weeds emerge simultaneously, with a linguistic gloss on vegetative growth as either wanted or unwanted. While domesticated plants often require conscious tending and a significant amount of work, weeds take advantage of the same conditions of soil tillage and fertility to compete with domesticates. The category of "weeds" is further complicated by the ways both purposefully planted and opportunistic vegetation figures into the human worldview as occasional famine foods, as pharmaceuticals, and as mute evidence of human habitation that can linger long after the abandonment of a settlement.

Human-environmental interactions often are transformed by multiple agents simultaneously. In their chapter, Seth Quintus, Jennifer Huebert, Jillian A. Swift,

and Kyungsoo Yoo evaluate the complex relationships among humans, mammals, birds, and plants over the past 1,000 years in Polynesia. Dramatic cycles of change are evident even in the most recently settled islands such as Rapa Nui, the Marquesas Islands, Mangaia (Cook Islands), and Mangareva (Gambier Islands). Configurations of mutual dependence were continually changed at points of inflection that included the introduction of new species and new cultigens, in which humans responded to new patterns of animal and plant activities through actions that, in turn, provided both intentional and unintentional ecological niches.

Katelyn J. Bishop's chapter on birds examines the way birds are able to exploit their capacities of flight to challenge humans' attempts at capture and control. Using a detailed accounting of bird bones from archaeological sites at the ancient site of Chaco Canyon, Bishop creates a rubric for assessing the relative difficulty of engaging with particular birds found in the site's cultural deposits, suggesting that there was a range of human avian use, from routine meals to spiritual investments. Some birds were of value precisely because they were hard to capture; the unexpectedly high rates of recovery of both high-flying raptors and ground-dwelling turkeys illustrate the ways birds' patterns of locomotion and relative ease of capture resulted in differential patterns of appearances in human settlements.

Steven Ammerman's chapter on domesticated animals critically addresses what we mean by the levels of engagement that can be characterized as wild, tamed/habituated, domesticated, and feral animals. Very few species among the world's animal population have been domesticated, and the selectivity for domestication relied at least in part on the extent to which animals of particular species found human settlements tolerable or advantageous. He emphasizes that the domestication process involves the capacity of animals to react to or even initiate their commensal relationship with humans, a factor that illustrates that species—regardless of whether they are domesticated—are not composed of identical individuals but present variance that can aid or hamper the trajectory toward both domestication and subsequent instances of ferality.

In her chapter on reindeer, Silvia Tomášková examines the transactional status of wild and domestic members of this unusual species, given that the two populations live side by side and regularly interact. She details the relative helplessness of human keepers who experience runaway reindeer populations, highlighting that the animals' agency of movement is far greater than that of humans. Using archival historical documents, she critiques the way Siberia has often been made to stand in for prehistory through ethnographic and historical accounts and offers an alternative view of complexity and mutualism as exhibited in the long history of human-animal relations. Through the prism of a harsh environmental zone, she suggests that reindeer in their agentive practices provide an alternative model of

domestication compared to the considerably more docile herd animals of the Near East and other temperate global regions.

By way of a concluding chapter, John Robb's thoughts on the future of agency bring the perceptive light of the present day into a reconsideration of the human-environmental dynamic. Using the case of the Black Death in Europe, Robb documents the way scholars have credited a single episode of illness in the fourteenth century with being a critical turning point for political, economic, and social change. Yet as he notes, our current perceptions of the impact of the 1347–1350 CE plague may be greatly overdrawn because those who were in the midst of that pandemic may have perceived it in quite different ways and with far less disruption given the already short life spans of the era, the continuity of religious traditions despite dramatic loss, and the cellular structure of social groups that enabled the rapid regeneration of economic patterns. In sum, crisis and catastrophe are in the eyes of the beholder, and even the most dramatic turns of events are incorporated into prevailing belief systems.

CONCLUSION

Natural phenomena and human cultures interact as systemic interdependencies within complex feedback loops. Humans engage with their environments, both social and physical, within a risk-based rubric of assessment that results in a synthetic physical configuration that can be analyzed as an anthroposcape. Natural forces and human actions occur within physical frames of reference, in which the settlement provides the key archaeologically visible locus of interaction. Many aspects of natural environments (ranging from benign and anticipated conditions of weather and climate to extreme natural events such as earthquakes and storms) are completely beyond human control in initiation, duration, frequency, and magnitude; for all of our sophisticated measuring devices today, we are still unable to predict the weather with complete accuracy, to ascertain the exact forthcoming path of cyclonic storms, or to predict the timing and amplitude of natural events such as earthquakes and volcanic eruptions. The power of nature to shape the environment still overwhelms human capacities and provides the framework within which human responses are proactive or reactive, but never in equal measure.

Acknowledgments. I would like to thank Karl LaFavre and two anonymous reviewers for comments on an earlier version of this chapter. Many thanks go to the participants in the SAA session Things with a Mind of Their Own: Agentive Approaches to Non-Human Agency for their lively interactions and stimulating presentations.

NOTE

1. http://www.ictg.org/blog/learning-phases-of-collective-trauma, August 2017.

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