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Anthropogenic Landscapes, Human Action and the Process of Co-Construction with other Species: Making Anthromes in the Anthropocene

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Academic Editors: Erle C. Ellis, Kees Klein Goldewijk, Navin Ramankutty and Laura Martin
Received: 15 December 2016; Accepted: 21 February 2017; Published: 24 February 2017

Abstract: We are in the Anthropocene. For millennia, human actions have been shaping the world to the degree that they are inscribed in the geological and ecological record. Recently, this has been occurring with increasing speed and influence. This means we need to be asking integrative and effective questions about the world and how we relate to and in it. Human niche construction has broad and deep effects not just on landscapes and environments, but on the myriad of other beings sharing space with us. Humans are self-appointed ecosystem managers and lead actors in seeking sustainability for planetary and local ecosystems. In order to accomplish this, we need to better understand how anthromes are shaped, inhabited and altered. To this end, we present two different examples of anthropogenic landscapes; one in Ethiopia and one in Bali, Indonesia. These are landscapes that are co-constructed by multiple species through complex webs of ecologies, economies and histories and represent the way that humans are drawn into relationships with non-humans; relationships which in turn alter landscapes.

Keywords: Anthropocene; ecology; Bali; Ethiopia; khat; hyena; rice; macaque; niche construction

1. Introduction

We are in the Anthropocene. For millennia, human actions have been shaping the world to the degree that they are inscribed in the geological and ecological record. Recently, this has been occurring with increasing speed and influence. As Steffen and colleagues tell us "the human imprint on the global environment has now become so large and active that it rivals the great forces of nature in its impact on the functioning of the system of the earth [1]." Hamilton and Grinevald inform us that we are really now in a "kind of a hybrid earth, of a nature injected with human will, however responsibly or irresponsibly that will may have been exercised [2]." Erle Ellis tells us that "It is no longer possible to understand, predict, or successfully manage ecological pattern, process, or change without understanding why and how humans reshape these over the long term [3]."

This means that we are in a time and a place where we need to be asking integrative and effective questions about the world and our relation to and in it. At this point in time, humans are truly shaping the world, as it shapes us, in more massive and rapid ways than ever before. The specifics of how this happens at tens of thousands of locales across the planet becomes central in our quest to understand the incredible diversity of relationships between humans and ecosystems. It is this diversity of anthromes (anthropogenic biomes) that both enriches and challenges our quests to develop and maintain manageable, and sustainable, ecosystems in the Anthropocene.

At every level, humans are entangled with other species. We become ourselves via biological amalgamations; we are the result of melding bodies and genetic legacies. However, even at this

level, humans are never alone; our biological selves are multispecies communities. As Fuentes and Porter note:

> "human biological reproduction does not simply produce other humans, it reproduces whole communities of nonhumans. Human bodies are seething sites of multispecies kinship networks. *Demodex* mites, *Candida* fungi, and a horde of bacteria move from one human body to the next as soon as that next body emerges from the first [4]."

Whole ecologies of flora and fauna are biologically passed from parent to offspring; the microbiome is a critical component of the human being. Even in that most iconic of intra-specific actions, nursing a child, the mother passes not just sugars and fats to her infant, but a plethora of microbes, bacteria and other microbiota. Ancient bacteria and viruses have even written themselves into human genomes. This is how we co-create the multispecies kinship community that we call human. Additionally, this process goes on at a level above and beyond the individual, the group and the community. Humans, and other species of fauna and flora, co-create landscapes, but our inputs are often not of an equal scale. Both intentionally and unintentionally, humans have become ecosystem engineers at the global level, but this massive manipulation of the planet is not as uniformly "bad" or as destructive as we often think, nor is it uniformly "good" either. The way we become ourselves, across our history, co-opts many other species in a myriad of ways; it is just much more pervasive and broadly distributed in the Anthropocene relative to earlier epochs.

By looking at specifics of multispecies communities in the context of a broader niche construction approach, we are better able to understand mutual co-construction of landscapes in both spatial and temporal terms; how mutually-constituted ecologies that transcend human societies contribute to the processes that shape landscapes By taking this approach, our aim is to open up the concept of 'anthrome' to factor in the ways in which these ecological communities are not of human design. Rather, they are human-dominated landscapes, which emerge out of culturally-mediated interdependencies of humans and other species.

2. Anthrome as a Product of Niche Construction

Niche construction, the process by which organisms simultaneously shape and are shaped by their ecologies, plays a key role in evolutionary processes and is particular salient in thinking about anthromes given the impacts that human actions have upon their environments. Niche construction results in the building and destroying of niches and the mutually mutable and synergistic interactions between organisms and their environments. It is the relationships, and agential influences, by multiple species in the processes of niche construction that are often overlooked when thinking about human influences on ecologies. Niche construction creates feedback within the evolutionary dynamic, with organisms modifying the evolutionary pressures acting on them, on their descendants and on other populations (species) sharing the same landscape [5]. Niche construction reflects a synthesis of ecological, biological and social processes rather than treating them as discreet spheres. Such a perspective is critical in approaches to human ecologies that seek to synthesize social and ecological processes and acknowledge the key roles, and agency, of other species.

Human cultural patterns, behavior and perception influence biological and ecological processes (including natural selection), which in turn affect human approaches to engaging with landscapes. In human evolution, biological, cultural and ecological systems are entangled and not separate processes; thus, perception and ideas, and the actions emerging from them, can be evolutionarily relevant for us and for other species sharing the landscape. As Jeremy Kendal and colleagues note, niche construction is:

> "... an endogenous causal process in evolution, reciprocal to the causal process of natural selection. It works by adding ecological inheritance, comprising the inheritance of natural selection pressures previously modified by niche construction, to genetic inheritance in

> evolution. Human niche construction modifies selection pressures in environments in ways that affect both human evolution, and the evolution of other species [6]."

Human niche construction has broad and deep effects not just upon the soil, water and air, but on the myriad of other beings sharing space with us; and in the Anthropocene, this extends to the entire planet. We need to be aware of these impacts and patterns and recognize that nothing we do is only about us, either as a species or as individuals. Humans are ecosystem managers and must be the lead actors in seeking sustainability for planetary and local ecosystems. Responsible management must include an understanding of the roles that various species play in co-construction of ecological systems. In order to accomplish that, we need to better understand the multiple directions from, and processes by, which anthromes are shaped, inhabited and altered. To this end, we present two different examples of anthropogenic landscapes; one in Ethiopia and one in Indonesia. Our respective field-sites are geographically, culturally and ecologically distinct and so too are our methodological approaches. However, what is remarkable is the way that these sites converge with regard to the theoretical approach that we are advocating here. These are landscapes that are co-constructed by multiple species through complex webs of ecologies, economies, histories and individuals. They are neither unique nor typical; they are simply examples that highlight the need to study particulars with a wide-angle lens. What they represent is the way that humans are drawn into specific and complex relationships with non-humans; relationships that transcend human design in the constitution of anthromes.

3. Of Khat, Hyenas and Humans

In eastern Ethiopia, there is a close relationship between humans, spotted hyenas and an unremarkable little shrub with glossy green leaves, *Catha edulis*, known more commonly as khat. This plant is indigenous to East Africa and the Middle-East. The leaves are chewed for their stimulant effects, and despite the negative health effects of khat, the plant is widely consumed and traded. Much of its trade is centered on Ethiopia's Hararge region of which the city of Harar is capital. The use of khat dates back to at least the 15th century where it was reported to compete with coffee as a preferred drink by "lawyers, students, artisans, and those who travelled by night [7]." The English traveler, Richard Burton, mentions it in an account of a journey to Harar in 1855 where he comments on the difference between Yemeni and Ethiopian khat and the psycho-physiological effects that he experienced when he chewed the leaves [8]. When chewed, khat leaves have a mild stimulant effect, creating a sense of focused attention and 'dreamy' well-being [9]; while not highly addictive, these inconspicuous little plants hold people in Harar, and much of the Horn of Africa, under a spell. Khat plants compel farmers to feed, weed and water them before their fresh leaves are sent across the landscape in trucks to markets. These plants compel people to spend large parts of their income to buy the leaves and large amounts of time sitting in smoky rooms, chewing them into mushy green balls, which they roll around in their cheeks. Through its appeal to people's minds, manners and livelihoods, khat has deftly maneuvered itself into a position as a keystone species in the socio-ecologies of the Horn of Africa. Not only is it important in terms of trade and export income, it glues together much of the social fabric. It is chewed daily by people in Harar, many of whom close their businesses at lunchtime in order that they can spend the afternoon with friends, chewing the leaves. Khat is a customary gift at weddings and in visits to shrines, and it is also central to political and business transactions [10]. A prominent politician commented that he did not particularly like chewing the leaves, but that it was unavoidable in his position because getting together and chewing khat is the customary means by which deals are done. With an attention to land use and species compositions through the lens of khat production, we might learn much not only about how social processes construct the landscapes to which their livelihoods are beholden, but about how these landscapes are the result of co-shaping by humans and other forms of life.

Around Harar and in much of the Hararge region in eastern Ethiopia, khat plants are ubiquitous. In some places, the emerald green bushes form a carpet over the landscape punctuated only

here and there by mango, coffee and eucalyptus trees. Khat is a valuable cash crop in Ethiopia. Production involves millions of farmers, and it earns export income from other regions in the Horn of Africa, the Arabian Peninsula, Europe, Asia and America [11]. It is important that the leaves are fresh, as the active constituent, cathinone, rapidly degrades. Prompt transport is crucial. Stockpiling is limited, and fresh leaves are often transported by air, although dried leaves can be surface-transported for a lower-cost, less effective alternative. Where khat is grown, the plants are generally laid out in raised rows, in between which maize is grown during the wet season. In fact, the khat-maize intercropping system has been found to be 2.7-times more profitable per hectare than maize cropping alone [12]. Khat is also less vulnerable to drought than coffee; the plants have few pests and require little maintenance, although some farmers use synthetic pesticides. Hararis buying khat are careful to inspect the leaves for evidence of pesticide residue, known locally as 'diditee', and the more conscientious khat consumers wash the leaves carefully before chewing.

A key feature of the production of khat in the Hararge region is its complementarity with spotted hyenas. The Ethiopian government affords protection to wildlife so hyenas are able to persist relatively unmolested. However, this is not set in stone, as problem animals are allowed to be killed provided a person has the right permit. Government protection also extends to the animals that can cause much destruction to khat plants. These are usually dik diks, small antelopes known locally as 'kruppo'. Goats are also destructive as they savor khat leaves, but they are easier to control than wild animals. Killing goats on one's property is permitted, and the meat tastes better in animals that eat khat. Lastly, humans constitute a significant pest. The desirability and monetary value of khat makes it a target for thieves who use the cover of darkness to steal from farms. It is in all of these respects that hyenas contribute to khat production. In the first place, the hyenas hunt, or at least deter dik diks, goats and thieves. This is a particularly valuable service during the night, when hyenas are active and farmers are asleep. The alternative to having hyenas in the landscape would be sleepless vigils for the farmers or else the expense of paying someone to guard the crops. Moreover, the chalky white hyena feces that lie scattered around farms can be used. Farmers collect the dried feces and make them into a powder which is diluted and sprayed onto khat leaves; they believe that the smell deters ungulates from eating the leaves [13,14]. This also resonates at the khat markets. If a khat seller is challenged by a customer about some powdery white residue on the leaves, the seller can always claim that it is hyena feces rather than pesticide.

Therefore, hyenas are complementary with khat production in ways that differ markedly from other forms of land use. For example, in parts of Kenya where pastoralism predominates, there is nothing like the complementarity of the Hararge region [15]. In a study of human carnivore conflict in the Lakipia District of northern Kenya, Ogada et al. report that livestock husbandry practices have a clear effect on depredations, which in turn has an effect on the numbers of carnivores killed [16]. In this way, the humans and large carnivores co-produce a landscape in which carnivore numbers are in decline. There are clear correlations between the numbers of sheep, goats and cattle killed by predators and the numbers of those predators killed by humans. There are even correlations between the amount of cleared land and type of enclosure used and the number of sheep and goats lost to hyenas. However, there are also culturally-mediated influences at work in these other kinds of human-hyena landscapes. On the one hand, hyenas are highly denigrated in Kenya. While lions, leopards and cheetahs might be valued for their attractiveness to tourists, hyenas are ascribed no such value and are often killed incommensurately with the actual economic cost of having them in the landscape [17]. Moreover, in Kenya, there is a strong association between hyenas, sorcery and shape-shifting, which in turn affects negative attitudes, which in turn influences killings [18].

This highlights the importance of the ways in which people conceptualize landscapes because belief systems and traditions also contribute to the co-production of anthromes. We mentioned above that khat is important as a gift when paying visits to shrines. These visits are known as 'ziara' where people go into the countryside and visit shrine complexes dedicated to particular 'saints'. There, they offer khat or incense to the caretakers of the shrines and make Quran recitations and supplications.

These visits can extend long into the night as crowds of people sing religious songs to the beat of skin drums [19]. Both khat and hyenas are important to these traditions. Khat is important not just in its status as a gift, but in its chewing during the celebrations, which enables pilgrims to stay awake throughout the night. Hyenas are also important, albeit not in as salient a way as khat. They are known locally as derma sheikh, which translates as young man of religion. It is a term that draws a parallel with the young boys who study the Quran under a sheikh and run errands for their teacher. This is because the hyenas are considered to act for the benefit of the caretakers of the shrines. They are believed to protect the caretakers from thieves and people who might harm them and to protect pilgrims who travel at night on their way to or from the shrines. They are even said to deliver khat to the caretakers. In return, the caretakers offer hyenas the skins, bones and entrails from animals that are slaughtered during the celebrations, and this in turn makes religious celebrations shared events, where hyenas stand in attendance not far from the shrines. This valuing of hyenas is most pronounced during Ashura on the tenth day of Muharram. It is on this occasion that porridge is prepared at shrines around the Harar region and put out for hyenas. This is said to reinforce a truce between the people and hyenas and ensure prosperity for the coming year [20].

However, it is not just the presences of particular species that foster these kinds of complementarity. Exclusions also foster co-construction of anthromes, and this is particularly the case with the exclusion of lions from human-hyena landscapes. The distinctive dark-maned lions of Ethiopia have declined massively in recent decades, and they are no longer present in the region around Harar [21,22]. This is due to a combination of factors ranging from human-lion conflict over livestock, to hunting for the distinctive manes and skins. Moreover, forest clearance contributed in its own way by excluding refugia for lions and the prey animals on which lions would depend. Khat production, through its demand for more land and its socio-economic impact, denudes landscapes of the kinds of features that foster complex relationships between lions, prey animals and vegetation. Furthermore, the lack of mechanization in Ethiopia engenders cropping systems that traverse all but the steepest of slopes. Because land is worked by hand, crops can be planted up mountainsides, leaving little space for plants and animals other than khat and hyenas. This is good news for hyenas. In national parks and reserves, lions exert a significant effect on the successful habitation of landscapes by hyenas [23]. This is because lions and hyenas compete directly over the same resources. Where humans are not as prevalent, lions constitute the greatest cause of mortality in spotted hyenas, as they deliberately kill hyenas where the opportunity presents itself [24–26]. Indeed, the ratio of lions to hyenas has been shown to directly affect resource availability for the latter [23,27]. Therefore, in the Hararge region, the production of khat indirectly contributes to the exclusion of lions, which contributes to the flourishing of hyenas, which as we have shown is complementary to khat production.

Another, much underplayed aspect of landscape is temporality. This is a salient feature of the human/hyena landscape in the Hararge region, as it contributes to the complementarity that allows humans and hyenas to coexist. Hyenas are probably more adaptable than humans in terms of their activity times. In places where human impact is low, hyenas can be active at any time of day [28]. However, in the Hararge region, it is extremely uncommon for hyenas to be away from their dens during daylight hours. In this way, their capacity to adopt nocturnal activity times complements the human predilection for daytime activity. Like the quintessential shift workers, they transition with minimal overlap. On the one hand, this reduces conflict with humans and facilitates better animal husbandry practices. The absence of hyenas during daylight hours means that livestock can be grazed during the day without interference. Then, as night falls, livestock animals are brought indoors and kept safe from hyenas. In fact, the livestock animals need little coaxing in this respect; they are normally lined up at the house waiting to be let in as the Sun is setting. Additionally, the farmers appreciate what they consider another service that hyenas provide. Livestock diseases are considered much more of a problem than hyena predation [29], in which case an animal dead of disease becomes a threat to the rest of the herd. Fortunately, hyenas can consume animals rife with pathogens up to and including anthrax with no deleterious effects to themselves [24]. Therefore, hyenas play an important role in

landscape formation during the night when they 'clean up' animal carcasses and by extension the pathogens that the carcasses harbor.

This profoundly altered landscape is not necessarily shaped to the betterment of humans. Khat is deleterious to health and economically costly. Its value in terms of export dollars is always under scrutiny due to its deleterious effects on health and productivity [11]. However, through processes of niche construction, whether people will it or not, they are subject to the landscapes of khat that they sustain. Through valorizing khat and incorporating it into economic prosperity, as well as social cohesion, Harari people's capacity to flourish becomes intertwined with the khat plants and by extension the hyenas that they incorporate into their landscapes. Moreover, human reproduction in Harar is affected in both positive and negative measures by these landscapes. Where Khat causes kidney disease, mental illness and impotence, this is a direct effect on reproductive viability. Yet, in a society where Khat is a necessary gift to the parents of a prospective bride, it is also crucial to reproduction. If a person does not subscribe to the importance of khat in gift giving, politics and business, they will end up on the periphery of society. Therefore, they persist in khat production and consumption under which there can be powerful adverse selective effects. The same applies with respect to encouraging hyenas. In rural areas where hyenas are appreciated for their protective services, they also attack and kill people [13,30]. Therefore, people producing khat and encouraging hyenas in the landscape are vulnerable to predation and by extension subject to the ecological conditions that they co-create. This highlights the complex feedback mechanisms in these niches into which humans and other species mutually construct the landscape and its different, often deleterious selective agents and effects. Khat, hyenas and humans are intertwined in complex webs of co-construction in the Harare region, revealing the interconnectedness of anthromes and the limits to which humans are able to manage these.

4. Of Monkeys, Temples, Tourists and Tradition

Human and non-human primates share a number of interconnections, overlaps and interfaces in what can be termed "zones of sympatry" where humans and other primates have coexisted since the Pleistocene. These areas include much of the continent of Africa, parts of the Middle-East, most of South and Southeast Asia, portions of East Asia and South and Central America (at least since humans moved in during the terminal Pleistocene). This long-term sympatry, the overlap of primate space and human place, especially when it involves mutual usage of the same habitats, can produce a kind of co-ecology, one where a particularly active niche constructing primate (humans) has an extensive hand in shaping the landscape and, thus, the contexts in which they and the other primates live.

The interfaces between humans and other primates are particularly interesting when thinking of anthromes as core contemporary ecological systems. Ecological pressures impact mammals in particular ways, so mammals that share so many morphological and physiological facets in common, such as the anthropoid primates (monkeys, apes and humans), might be experiencing particularly robust similarities in their relationships to local ecologies; especially if they have substantive hands in shaping those ecologies via physical and social activities. In contemporary landscapes of overlap, monkeys and humans might be co-shaping one another. Although, it is most likely that the human hand weighs in with more influence than that of other primates.

There is abundant evidence that long-term overlap and similarity in behavior, locomotion and general morphology (even if slight) between humans and other primates can shape human conceptualizations of "nature" and humans relationships to it [31]. Such similarities act to facilitate distinct patterns of integration/engagement between the humans and other primates that result in particularly complex interweaving of cultural and ecological relationships. Humans incorporate other primates into their mythos, their daily lives and often their diets with regularity [32]. With increasingly rapid habitat alteration, economic shifts and urbanization at the start of the 21st century, the need to better understand these processes and patterns take on a strong sense of urgency, but the variation in these overlaps, in shared human-other primate ecologies is substantial [33]. Here, as a partner to the

khat, hyena, human story, we peruse one of the better studied examples: the macaque-human, and rice, interface in Bali, Indonesia. This anthrome provides a good example for thinking about human-other primate relationships via a particularly distinctive set of emerging ecologies in the 21st century.

The island of Bali is about 5632 km^2 with a deep history of volcanic activity creating highly fertile soils. There are approximately 247 rivers that run down-slope from the central volcanic range creating substantial opportunities for a rich rice agricultural system. Moisture accumulates above the volcanoes in the center of the islands year-round supplying substantial water for the rivers that run rapidly down towards the sea and which have shaped the landscape into one of deep ravines and ready access to water for all of the animals and plants in the south central portion of the island. In 2016, the vast majority of Bali's landscape can be described as an extensively human-modified environment, with more than a millennia of rice agriculture and a complex set of blended social, religious and agricultural practices that have facilitated some of the highest human population densities in the world for a primarily rural population (avg. 482 km^{-2}, range 259 to 1104 km^{-2}) [34,35].

Work by the anthropologist Stephen Lansing and colleagues has demonstrated that the Balinese have developed a particular structured and complex agricultural project, which can be seen as a mosaic of anthromes covering a significant portion of the island [36,37]. Rice is the central staple across much of the world and has a more than 9000 year history of interactions with humans in Asia [38,39]. These interactions reshaped the rice (*Oryza*) genome and morphology and human social and ecological lifeways [38,40]. It was this relationship that enabled large-scale colonization of Bali by Hindu peoples from Java more than 1000 years ago.

On Bali, there is an intensive need for water to maintain high production wet rice agriculture supporting a high density human population for nearly a millennia. Given Bali's steep volcanic topography, 'the spatial distribution of Balinese irrigation canals, which by their nature cross community boundaries, made it impossible for irrigation to be handled at a purely community level' [41], a problem was solved by the Balinese development of a social institution called "subak" [36]. Dating from at least the 11th century, subaks are associations of farmers and villages who manage irrigation water from a common source (stream, spring, river, canal, etc.). This multi-community cooperative enables the sharing, timing and effectiveness of rice agriculture to maximally exploit water sources and water movement in concert with the positions of the villages/fields and the topography of the landscape. However, given the larger context and ecological parameters of the landscapes in Central and Southern Bali, it is not enough that subaks work on their own; they need to be coordinated across large swaths of land. A solution emerged out of a combining of Balinese Hinduism, the physical landscape, rice and village structure. In Bali temple locations, properties and associated functions are integral to the water management system and also mark their surroundings as sacred spaces, changing the meanings of the landscape they occupy. The system of water management, centered around the spatial placement of temples and the pace and social connectivity of the rice agricultural cycles, results in a series of landscapes, structures, focal centers of anthromes, that provide structurally- and ecologically-significant spaces for the one other widespread primate on the island: long-tailed macaques (*Macaca fascicularis*) [42].

Today in Bali, macaque monkeys are also an integral part of the culture, economy and everyday life for humans across the island. The distinctive Balinese ecosystem of temples, villages, religious, social and agricultural practices has structured the waterways, landscapes, human, rice and monkey genetics and ecology, as well as the lives of many other species for centuries. This system reflects a massive niche construction process that stretches across much of the island and centers on the construction and management of complex temple systems [36]. In and around many of the temples and villages emerging from the centuries of Balinese shaping of their ecologies live populations of macaques. The temples, and the land they cover, act as sanctuaries for the macaques that live there. These temple populations consist of between 30 to over 700 individuals, with the larger populations being the result of a very recent (last two decades) expansion in both tourism and management practices by the local Balinese at certain sites. At a time when many primates are facing dramatic

reductions in numbers globally populations of macaques in Bali, at least those in intensively human modified and managed landscapes, are expanding. Researchers have documented at least 63 sites where macaques reside on the island [34]. Each of these sites has one to three groups of macaques that range either fully within the site or the site is a part of their total home range. The multi-faceted and intimate nature of the human-macaque relationship on Bali has required researchers to take an interdisciplinary approach and consider religion, culture and biology simultaneously in describing the macaques' ecology [32,43,44].

This scenario is not totally unique to Bali. The ability of long-tailed macaques to coexist with humans is well documented, and this has enabled a number of macaque populations to thrive in areas where other primate species have become extinct [45]. However, the scenario in Bali, where human-induced alteration of the landscape focused on rice and religion produces anthromic mosaics of riparian forest, small forest patches, agricultural lands, village and urban areas across much of the island, presents a clear context wherein the macaques are exploiting the human-modified landscape effectively. At the temple sites, due to protection and resource availability, macaques are able to exist in amazingly high densities alongside high human population densities [34,46]. It is even likely that these macaques, when dispersing, are exploiting the human-altered landscape, acting as both units of gene flow, as well as potential mechanisms of pathogen transmission between populations across the island [47].

While some have argued that this relationship between the humans and macaques and the benefits for the macaques derives from a kind of cultural "sacredness" of macaques, recent research demonstrates that this sacredness is context-dependent; part of the temple-tourism-landscape anthrome that macaques inhabit [32,34,43]. Outside of these specific contexts, Balinese people view macaques as crop-raiding pests, potential pets and even an occasional source of food. Throughout the island, macaques are chased away from rice fields, shot at and kept as pets by people of all socio-economic levels. However, all of these factors are nullified when the macaques live in and around temples; there they allowed to thrive. However, it is not just a benefit for the monkeys, as their presence at temples has become more than just a part of the Balinese religious landscape. The macaque's habituation and presence at temples is a great promoter for the substantial tourism sector in Bali, and more than a few villages are able to exploit such benefits for their local economy [34,47].

How is this relationship possible? What are the critical aspects of the anthrome that facilitate such a relationship? A particularly critical component of Balinese Hinduism is the regular placement of offerings at shrines and temples across the landscape, from family homes to main temples to small roadside and rice field-side shrines. These offerings consist of flowers, rice, woven bamboo and other assorted organic elements, usually consisting of at least 30% edible items. Surveys and focal data collection projects reveal that that a large percentage of the macaque groups on Bali receive some substantial or integral component of their nutritional requirements from humans or human activity [34,47,48]. In fact, even those macaques who live in the large national park forests preferentially spend their time near the forest edges, where there are human villages and temples [49]. Many macaque groups living in and around temples are also directly provisioned beyond the consumption of temple offerings. These daily provisioning events are generally an array of fruits and vegetables provided by temple staff. In fact, at the larger temples sites across Bali, thousands of macaques receive provisioned foods that can make up over half of their diet [34,47]. Tied directly to this food availability, most temple site macaque populations are larger groups than non-temple site populations and appear to have distinctive social structures, epidemiological profiles, reproductive rates and behavioral patterns.

For example, at the famous monkey-temple site of Ubud/Padangtegal, the population has grown from just over 100 individuals in three groups in the mid-late 1990s to nearly 700 individuals in six groups by 2016. This is despite two major bacterial infection outbreaks that wiped out at least 20% of this population in the years that they hit [47]. At the site, young males buck their species-typical trend and seek to stay in their natal groups or at least within the local population, and novel behaviors, such as stone play and tool use, are much more common relative to other long-tailed macaque sites on

Bali. At the same time, the number of international and national tourists visiting the site can be in excess of a few thousand a day, which with an entrance fee of approximately $1.50USD, produces massive economic benefits for the local village, the temples staff and the local and regional governments. This economic windfall has resulted in expansion and renovation of the temple structures at the site. New buildings have gone up; neighboring fields have been purchased and replanted with trees, expanding the temple forest; and a whole range of infrastructure from water, sewers and electricity lines, to parking lots, to the movement of roadways, has emerged across the village of Padangtegal (the "owner" of the temples and partners to, and managers of, the macaques). In the process of rebuilding and expanding the temples, images of macaques have come to dominate the new artistic representations and carvings at the site (central aspects of Balinese temple architecture) creating an even more monkey-focused representation of Balinese Hindu iconography. This relationship is altering what Balinese Hinduism "looks" like. The funds generated by the monkey-human endeavor have also resulted in significant infrastructure projects beyond the local village and the implementation of a veterinary program and augmented feeding and care-taking regimes for the macaques. This site is at the extreme end of financial and structural changes for such sites on Bali, but it does illustrate the web of entangled social, economic, ecological and behavioral processes at play in this distinctive interface between humans and macaque monkeys. While macaques are dependent on the temples as sanctuaries and resource bases, the temples that are integral to the rice production system derive prestige and resources from the presence of macaques.

Stepping back to take a broader view, we can see that in Bali a history of particular land use patterns and wet-rice agriculture combined with the socially and ecologically complex temple and irrigation systems to result in the construction of a mosaic of riparian forest corridors and small forest islands throughout much of Bali [35,36,41,50] and an anthrome beneficial to both macaques and humans [34]. This landscape not only serves the needs, agriculturally and socially, of the Balinese, but also fits remarkably well with the macaques' patterns of using riparian habitats and small forest clusters for residence, foraging and dispersal. This landscape has been formed over the last millennia, and the pattern of distribution of macaque populations across the island suggests that humans and macaques are exploiting it mutually and potentially co-shaping aspects of one another's lives in the process [32,34].

Here, the concept of niche construction demonstrates how the creation of Balinese place resulted in a particularly distinctive anthrome mosaic of humans, macaques, water, rice, economics and history, creating an ecosystem beneficial to the macaques via protection (when on temple grounds), nutrition (via provisioned foodstuffs) and ecology (connectivity across forested sites via riparian corridors) [34,48,51]. Simultaneously, the humans acquired cultural and economic benefits from the presence of the macaques in and around their temple sites. The economic benefits include temple site entrance fees from tourists who come to see and interact with the monkeys and the additional funds that they spend in the local area on food, lodging and the purchasing of goods. The cultural benefits may include a sense of "merit" or a sense of connectivity with specific Hindu socio-religious narratives elicited via the daily interactions and/or provisioning of the macaques [32,34,49]. The Bali anthrome mosaic, like that produced by the interactions of khat, hyena and humans, reflects intertwined webs of co-construction revealing the interconnectedness of anthromes. They highlight how the conceptions of humans shape and are shaped by cohabitants in the landscape and how these conceptions feedback into the ways that the landscape is altered. Both demonstrate the ways in which belief systems contribute to the nature of anthromes and both demonstrate how plant and animal ecologies co-shape these contributions. However, unlike the situation in Harar, the Bali system is explicitly produced by the specific management (ritual and ecological) practices of the humans, who benefit increasingly from the contributions of the macaques [51].

5. Conclusions

Through a niche construction lens, we can see that anthromes involve multifaceted relationships and co-dependencies that confound top-down approaches, which only consider the effects of humans on landscapes with scant regard to how landscapes influence human actions. The lens utilized in this brief review allows us to see how human-dominated landscapes foster entanglements of species, whereby presences and exclusions create site-specific habitats, which, through dramatic alteration by human hands, promote the flourishing of species of particular plants and animals (and at times, the demise of others). At the same time, these anthromes prove to be shaped not only by human hands, but by human minds as the socio-cultural, socio-cognitive specifics, historical and contemporary, of sites are major contributors to their multispecies make-ups, ecological processes and managerial actions. These in turn create feedback mechanisms through which human populations themselves are altered and affected not only by cultural processes, but by the entanglement and fusion with the other species and habitats with which they co-exist. In addressing the challenges of the Anthropocene, we must acknowledge the aspects of anthromes, whereby social networks of humans and other species, plant and animal, create interdependencies and complex webs of interaction that cannot be easily untangled. These webs call for ever more comprehensive analyses and require multi-disciplinary approaches, but at the same time, they offer hope. Hyenas in Ethiopia and macaques in Bali live at high densities in relative harmony with dense populations of humans and the dominance of single plant species. These examples reflect a kind of mutuality that, in the face of the Anthropocene, is not only possible, but necessary to their flourishing.

Acknowledgments: This work was partly supported by the John Templeton Foundation under Grant Number 57496. The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the John Templeton Foundation.

Author Contributions: Both authors contributed equally to the writing of the paper. M.B.R. is responsible for the content in the Ethiopia research section and on and A.F. for content in the Bali, Indonesia, section.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Steffen, W.; Grinevald, J.; Crutzen, P.; McNeil, J. The Anthropocene: Conceptual and historical perspectives. *Philos. Trans. R. Soc. A* **2011**, *369*, 842–867. [CrossRef] [PubMed]
2. Hamilton, C.; Grinevald, J. Was the Anthropocene anticipated? *Anthropocene Rev.* **2015**, *2*, 59–72. [CrossRef]
3. Ellis, E.C. Ecology in an Anthropogenic Biosphere. *Ecol. Monogr.* **2015**, *85*, 287–331. [CrossRef]
4. Fuentes, A.; Porter, N. Kinship. In *Critical Terms in Animal Studies*; Gruen, L., Ed.; University of Chicago Press: Chicago, IL, USA, 2017; in press.
5. Odling-Smee, F.J.; Laland, K.; Feldman, M. *Niche Construction: The Neglected Process in Evolution*; Monographs in Population Biology 37; Princeton University Press: Princeton, NJ, USA, 2003.
6. Kendal, J.; Tehrani, J.J.; Odling-Smee, J. Human niche construction in interdisciplinary focus. *Philos. Trans. R. Soc. B* **2011**, *366*, 785–792. [CrossRef] [PubMed]
7. Greenway, P.J. Khat. *East Afr. Agric. J.* **1947**, *13*, 98–102. [CrossRef]
8. Burton, R.F. *First Footsteps in East Africa*; Longman, Brown, Green & Longmans: London, UK, 1856.
9. Kalix, P.; Braenden, O. Pharmacological Aspects of the Chewing of Khat Leaves. *Pharmacol. Rev.* **1985**, *37*, 149–164. [PubMed]
10. Gebissa, E. *Leaf of Allah: Khat & Agricultural Transformation in Harerge, Ethiopia 1875-1991*; James Curry: Oxford, UK, 2004; p. 11.
11. Gebissa, E. Scourge of life or an economic lifeline? Public discourses on khat (*Catha edulis*) in Ethiopia. *Subst. Use Misuse* **2008**, *43*, 784–802. [CrossRef] [PubMed]
12. Gyau, A.; Muthuri, C. The socio-economic potential of under-utilized species to small holder farmers: The case of khat (*Catha Edulis*) in Ethiopia. *Afr. J. Bus. Manag.* **2016**, *10*, 279–287. [CrossRef]
13. Baynes-Rock, M. Local tolerance of hyena attacks in East Hararge Region, Ethiopia. *Anthrozoös* **2013**, *26*, 421–433. [CrossRef]

14. Lemessa, D. *Khat (Catha edulis): Botany, Distribution, Cultivation, Usage and Economics in Ethiopia*; UN-Emergencies Unit for Ethiopia: Addis Ababa, Ethiopia, 2001; p. 9.
15. Blair, A. Human-wildlife Conflict in Laikipia North, Kenya: Comparing Official Reports with the Experiences of Maasai Pastoralists. Ph.D. Thesis, McGill University, Montreal, QC, Canada, 2008.
16. Ogada, M.O.; Woodroffe, R.; Oguge, N.O.; Frank, L.G. Limiting depredation by African Carnivores: The role of livestock husbandry. *Conserv. Biol.* **2003**, *17*, 1521–1530. [CrossRef]
17. Frank, L.G.; Woodroffe, R.; Ogada, M.O. People and Predators in Laikipia District, Kenya. In *People and Wildlife: Conflict or Coexistence*; Woodroffe, R., Thirgood, S., Rabinowitz, A., Eds.; Cambridge University Press: Cambridge, UK, 2005; pp. 286–304.
18. Schwartz, N. Spotted Hyenas. In *The Encyclopedia of Religion and Nature*; Taylor, B., Ed.; Thoemmes Continuum: London, UK, 2005; Volume 2, pp. 813–816.
19. Gibb, C.C. Baraka without Borders: Integrating Communities in the City of Saints. *J. Relig. Afr.* **1999**, *29*, 88–108. [CrossRef]
20. Baynes-Rock, M. *Among the Bone Eaters: Encounters with Hyenas in Harar*; Penn State Press: State College, PA, USA, 2015.
21. Bruche, S.; Gusset, M.; Lippold, S.; Barnett, R.; Eulenberger, K.; Junhold, J.; Driscoll, C.A.; Hofreiter, M. A genetically distinct lion (*Panthera Leo*) population from Ethiopia. *Eur. J. Wildl. Res.* **2013**, *59*, 215–225. [CrossRef]
22. Bauer, H.; Van Der Merwe, S. Inventory of free-ranging lions *Panthera leo* in Africa. *Oryx* **2004**, *38*, 26–31. [CrossRef]
23. Watts, H.E.; Blankenship, L.M.; Dawes, S.E.; Holekamp, K.E. Responses of spotted hyenas to lions reflect individual differences in behavior. *Ethology* **2010**, *116*, 1199–1209. [CrossRef]
24. Kruuk, H. *The Spotted Hyena: A Study of Predation and Social Behaviour*; University of Chicago Press: Chicago, IL, USA, 1972.
25. Pangle, W.M.; Holekamp, K.E. Lethal and Nonlethal Anthropogenic Effects on Spotted Hyenas in the Masai Mara National Reserve. *J. Mammal.* **2010**, *91*, 154–164. [CrossRef]
26. Van Lawick-Goodall, H.; van Lawick-Goodall, J. *Innocent Killers*; Collins: London, UK, 1970.
27. Watts, H.E.; Holekamp, K.E. Interspecific competition influences reproduction in spotted hyenas. *J. Zool.* **2008**, *276*, 402–410. [CrossRef]
28. Rainy, M.; Rainy, J. High noon on the Maasai Mara. *New Scientist*, 9 December 1989; pp. 36–40.
29. Baynes-Rock, M. Unpublished data.
30. Dejene, S.W.; Dechassa, N.; Reddy, R.U. Coexistence of human and hyena and associated impacts in Haramaya District of Eastern Ethiopia. *Int. J. Biodivers. Conserv.* **2016**, *8*, 1–7. [CrossRef]
31. Fuentes, A. Ethnoprimatology and the anthropology of the human-primate interface. *Annu. Rev. Anthropol.* **2012**, *41*, 101–117. [CrossRef]
32. Fuentes, A.; Cortez, A.; Peterson, J. Ethnoprimatology and Conservation: Applying Insights and Developing Practice. In *Ethnoprimatology: Primate Conservation in the 21st Century*; Waller, M., Ed.; Developments in Primatology: Progress and Prospects Series; Springer: New York, NY, USA, 2016; pp. 1–19.
33. Dore, K.M.; Riley, E.P.; Fuentes, A. *Ethnoprimatology: A Practical Guide to Research at the Human-Nonhuman Interface*; Cambridge University Press: Cambridge, UK, 2017.
34. Fuentes, A.; Southern, M.; Suaryana, K.G. Monkey forests and human landscapes: Is extensive sympatry sustainable for Homo Sapiens and Macaca Fascicularis in Bali? In *Commensalism and Conflict: The Primate-Human Interface*; Patterson, J., Wallis, J., Eds.; American Society of Primatology Publications: Norman, OK, USA, 2005; pp. 168–195.
35. Lansing, J.S. *The Balinese. Case Studies in Cultural Anthropology*; Wadsworth Publishing: Belmont, CA, USA, 1991.
36. Lansing, J.S.; Fox, K.M. Niche Construction on Bali: The Gods of the Countryside. *Philos. Trans. R. Soc. B* **2011**, *366*, 927–934. [CrossRef] [PubMed]
37. Callaway, E. The Birth of Rice. *Nature* **2014**, *514*, S58–S59. [CrossRef] [PubMed]
38. Fuller, D.Q.; Qin, L.; Zheng, Y.; Zhao, Z.; Chen, X.; Hosoya, L.A.; Sun, G. The domestication process and domestication rate in rice: Spikelet Bases from the Lower Yangtze. *Science* **2009**, *323*, 1607–1610. [CrossRef] [PubMed]

39. Li, C.; Zhou, A.; Sang, T. Rice domestication by reducing shattering. *Science* **2006**, *311*, 1936–1939. [CrossRef] [PubMed]
40. Wisseman Christie, J. Water from the Ancestors: Irrigation in Early Java and Bali. In *The Gift of Water: Water Management, Cosmology and The State in Early Southeast Asia*; Rigg, J., Ed.; School of Oriental and African Studies, University of London: London, UK, 1992; pp. 7–25.
41. Lansing, J.S. *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*; Princeton University Press: Princeton, NJ, USA, 2007.
42. Lane, K.K.; Lute, M.; Rompis, A.; Wandia, I.N.; Arta Putra, I.G.A.; Hollocher, H.; Fuentes, A. Pests, Pestilence, and People: The Long-Tailed Macaque and Its Role in the Cultural Complexities of Bali. In *Indonesian Primates*; Developments in Primatology: Progress and Prospects; Gursky-Doyen, S., Supriatna, J., Eds.; Springer Science: New York, NY, USA, 2010; pp. 235–248.
43. Loudon, J.; Howell, M.; Fuentes, A. The importance of integrative anthropology: A preliminary investigation employing primatological and cultural anthropological data collection methods in assessing human-monkey co-existence in Bali, Indonesia. *Ecol. Environ. Anthropol.* **2006**, *2*, 2–13.
44. Gumert, M.D.; Fuentes, A.; Jones-Engel, L. *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans*; Cambridge University Press: Cambridge, UK, 2011.
45. Brotcorne, F.; Wandia, I.N.; Rompis, A.L.T.; Soma, I.G.; Suatha, I.K.; Huynen, M.C. Recent Demographic and Behavioral Data of Macaca Fascicularis at Padangtegal, Bali, Indonesia. In *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans*; Gumert, M.D., Fuentes, A., Jones-Engel, L., Eds.; Cambridge University Press: Cambridge, UK, 2011; pp. 180–182.
46. Lane-deGraaf, K.E.; Arta Putra, I.G.A.; Wandia, I.N.; Rompis, A.L.T.; Hollocher, H.; Fuentes, A. Human behavior and opportunities for parasite transmission in communities surrounding long-tailed macaque populations in Bali, Indonesia. *Am. J. Primatol.* **2014**, *76*, 159–167. [CrossRef] [PubMed]
47. Fuentes, A.; Rompis, A.L.T.; Arta Putra, I.G.A.; Watiniasih, N.L.; Suartha, I.N.; Soma, I.G.; Wandia, I.N.; Harya Putra, I.D.K.; Stephenson, R.; Selamet, W. Macaque Behavior at the Human-Monkey Interface: The Activity and Demography of Semi-Free Ranging *Macaca fascicularis* at Padangtegal, Bali, Indonesia. In *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans*; Gumert, M.D., Fuentes, A., Jones-Engel, L., Eds.; Cambridge University Press: Cambridge, UK, 2011; pp. 159–179.
48. Wheatley, B.P. *The Sacred Monkeys of Bali*; Waveland: Prospect Heights, NY, USA, 1999.
49. Brotcorne, F.; Maslarov, C.; Wandia, I.N.; Fuentes, A.; Beudels-Jamar, R.C.; Huynen, M. The role of anthropic, ecological, and social factors in sleeping site choice by long-tailed macaques (*Macaca fascicularis*). *Am. J. Primatol.* **2014**, *6*, 1140–1150. [CrossRef] [PubMed]
50. Lansing, J.S. *Perfect Order: Recognizing Complexity in Bali*; Princeton University Press: Princeton, NJ, USA, 2006.
51. Fuentes, A. Naturecultural encounters in Bali: Monkeys, temples, tourists, and ethnoprimatology. *Cult. Anthropol.* **2010**, *25*, 600–624. [CrossRef]