Cite as: Roudavski, Stanislav. "Interspecies Design." In *Cambridge Companion to Literature and the Anthropocene*, edited by John Parham, 147–62. Cambridge: Cambridge University Press, 2021.

Chapter 8

Interspecies Design

Stanislav Roudavski

Design is a distinct form of practice with a typical focus on human aspirations for products, buildings, infrastructure, urban spaces, services and land use. As such, design affects all planetary environments, societies and the capabilities of individual humans. This chapter begins by establishing design as both a force responsible for the current situation and a primary concern of the future. Next, the chapter uses cities as a characteristic example of significantly modified habitats that are simultaneously biological and cultural. The cultures within such habitats combine the behaviours and traditions of many lifeforms. Consequently, the chapter argues that design approaches to the management of future habitats – conceptualised as 'interspecies design' – must engage with non-human as well as human cultures. This has implications for theoretical and practical engagements with the Anthropocene, pointing to the significance of design and the need for a transformation of design practices.

Design in the Future

By now, the concept of the Anthropocene is familiar in many disciplines. Conceptualisations of a pervasive human impact emerged at least in the early nineteenth century and developed in the work of Carl Ritter (1810s), George Perkins Marsh (1860s), Jacques Élisée Reclus (1870s), Vladimir Vernadsky (noosphere, 1920s) and Nikolai Vereshchagin (technocene, 1970s), among others. However, the proposal to formalise the Anthropocene as a geological epoch at the turn of the twenty-first century resulted in much more attention. The desire to highlight the detrimental impact of human activities and motivate remedial action underpinned this proposal. As one of the authors wrote in 2002: '[M]ankind will remain a major environmental force for many millennia. A daunting task lies ahead for scientists and engineers to guide society towards environmentally sustainable management.'[1] This chapter understands the term Anthropocene as a label for the situation where human activities substantially affect the Earth system. Two characteristics of the Anthropocene are especially relevant. Firstly, the Anthropocene is important as the prevailing condition of the future: future cultures (human and non-human) will have to live within its effects. Secondly, many of the

Anthropocene's effects are undesirable. A reasonable response is to change current human practices.[2]

The focus on the future and the responsibility for managing change are – also – the key characteristics of design. This point requires elaboration because public opinion associates design with styles and forms of objects. Business practices cultivate this focus as a marketing instrument. For them, human users are factors that determine the look and comfort of 'pleasurable products'.[3] The end goal of such design is financial gain.

Theories of design advance beyond such popular definitions. A common goal is to encompass all possible design practices, as is evident in an early and popular definition by Herbert A. Simon: 'Everyone designs who devises courses of action aimed at changing existing situations into preferred ones.'[4] Simon believed that all professions design. He included engineering, architecture, business, law and medicine as examples. His list stopped there. For him, scientists were not designers: 'Design … is the principal mark that distinguishes the professions from the sciences.'[5]

This focus on paid occupations makes Simon's influential definition inadequate because it makes presumptions that do not match the observable effects of the Anthropocene. For example, Simon's definition assumes that a preferred future state can exist. This is not always the case. Situations where a preferred state is attainable are increasingly rare. As a rule, destroyed ecosystems, like extinct species, cannot return to life. Ecosystem dynamics and biological evolution are irreversible. Novel ecologies such as those that exist in urban parks might be more attractive than treeless cityscapes or monoculture farming. However, such environments almost never constitute preferred states. They are compromises that are substantially less desirable than pristine ecosystems. People might prefer such ecosystems, but no design can make them attainable.

Furthermore, Simon's definition presumes the existence of professionals who can distinguish existing situations from preferred states. However, this is always difficult and often impossible. Modification of ecosystems leads to complex, often surprising results. In most cases, the only way to understand the consequences is to obtain new evidence through experimentation. The job of producing such evidence rests with the scientists and other experts that he excludes.

Crucially, Simon's definition of design presumes the possibility of an agreement between designers and those they design for. However, such agreements are rare. Biologically and culturally, forms of life can and do have incompatible interests. In most cases, relationships between interests, life histories, abiotic events and other factors prevent stakeholders from agreeing on a preferred future state. In a large city, these

stakeholders might include coffee-loving bankers, elderly homeless, rats and birds. For example, peregrine falcons struggled in 1930s New York. During the 1940s, their wintering population in the city increased because the war effort removed pigeon fanciers, falconers and other interfering humans. In this period, female falcons seemed at home in the city and developed territorial attractions to certain skyscrapers. However, with the 'golden age' of the 1950s, peregrine numbers dropped and by 1961 the entire population was extirpated.[6] Tom Cade and others bred and reintroduced falcons in the 1970s and 1980s. In this post-DDT era, New York provided artificial shelters and bright lights that illuminated prey. The new generation of falcons took to the city and their return continues to attract media attention and public support.[7] The measure of this success at the time of writing is sixteen couples.[8] By contrast, up to 230,000 birds per year die in New York through collisions with buildings. In the United States as a whole, the annual figure can be as high as one billion.[9] Such deadly interactions between the drive for human occupation density and the migratory routes of avian life indicate that it is too early to celebrate urban interspecies harmony. These examples show that designerly agreements between birds and humans are not impossible, but neither are they easy. In many cases, human and non-human stakeholders struggle to cohabit. Even where co-presence is obvious, communication about possible futures or necessary actions will remain challenging. As a result, all relevant (human and non-human) stakeholders are unlikely to be present when professionals assess states or devise plans.

The term 'preferred future state' suggests a goal within a configuration of some situation, a state of affairs. A city without overcrowding, or sprawl, or slums would be an example. Design Studies inherits the notion of states from Future Studies. Neither field defines this notion clearly. In practice, states are local, limited and pragmatic. A developer's brief for a high-rise building might ask for the maximum possible area of office space within a predefined footprint and fixed budget. This confines designing to a search for configurations that can satisfy given conditions.

The focus on 'states' in the 'preferred future state' conception is also problematic. States are subjective. Designers or clients can attempt to specify future states to represent problems and ideas. However, resulting specifications are invariably partial and discontinuous. Design theories that build on Simon's definition operate with cultural constructs that remain coherent only within narrow boundaries. Such boundaries confine design projects in time, space and complexity. Professional designers begin by excluding most of the world and proceed to define states and devise courses of actions within these artificial confines. Professional projects often inherit such exclusions from

powerful stakeholders in the form of briefs, laws, regulations, disciplinary training and budgets. Because Simon's definition depends on exclusions, it cannot be compatible with the demands of the Anthropocene and its global, continuous, inescapable impacts.

Other design theorists have sought to expand the notion of design to include 'everyday design'. Harold Nelson and Erik Stolterman propose that '[d]esign is a natural and ancient human ability – the first tradition among many traditions of human inquiry and action. Everyone is designing most of the time – whether they are conscious of it, or not.'[10] Klaus Krippendorff calls this approach to design 'the realization of everyday life'.[11] Design theory that follows these trends seeks to apply 'design approaches' to a broader spectrum of activities, including management and governance. However, much of this focuses on professional services and capitalist business practices. As a result of recent expansion, more paid consultants claim that they use 'design thinking'. Textbooks advocate 'design-focused problem solving' for organisational management,[12] and practitioners within the lucrative field of business leadership argue that design thinking is the best tool for creating empathetic and responsive organisational cultures.[13] Reframing such practices as types of 'designing' validates the limitations of existing approaches, not least their anthropocentrism, disregard for non-proximal implications and compliance with the injustices of the political status quo.

An enduring focus on narrowly understood benefits is an example. The contribution of Krippendorff's approach is to see design as a meaning-making activity: design as a discursive practice that discusses designed artefacts within its discourse communities. These communities develop traditions and institutions. The discourse therefore occurs within permeable but distinguishable boundaries. It seeks to justify and promote its methods and achievements. Krippendorff's goal is to expand the positive impact of design. His approach to such expansion is through 'human-centred design'. The objective of human-centred design is to derive solutions from and for stakeholders' lives. He prefers this approach to 'technology-centred design' where experts impose solutions on 'users'. According to Krippendorff, the desired result of human-centred design is an artificial world filled with designed artefacts that play various social roles. The transparently anthropocentric aim of this insular world is to make sense to humans, be useful and give them 'a feeling of home'.[14] Unfortunately, environmental history demonstrates that humans can value or love highly damaging, even suicidal practices. Easter Islanders dedicated a large proportion of their resources to the construction of giant statues. It is likely that they had a most powerful 'feeling of home' among them. However, the commitment to this much-admired example of human-centred design did

nothing to prevent the severe exploitation of the island's ecosystem, a dramatic thirty-fold reduction in the number of human inhabitants and the disappearance of the statue-making societies in the ensuing starvation.[15] The debate on the complete composition of causes – from ecocide to genocide – is still ongoing.[16] However, the human contribution to a rapid near-total deforestation and the resulting cascade of societal and environmental degradations seem undeniable.

So far, this chapter has outlined the significance of design and introduced existing understandings of design as well as their limitations. The next section advances this narrative of design as a cause of destruction.

Design as the Problem

Many understandings of design seek to explain existing practices and give them logic and credence. This approach is limiting because the combined outcome of all past design in all its diversity is the current condition of acute environmental crisis. Innovative design is responsible for introducing all major contributors to the crisis including technologies for hunting and fishing, agriculture, urban settlements, transportation or fossil-fuelled devices. Power to re-engineer the world comes at a cost. Professional designers or any humans that engage in design should be wary of promoting inherited approaches. The anthropocentric bias of most current practices prevents the consideration of all possible futures and limits opportunities for reassessing human-induced impacts.

Human designing has a long history of interference with planetary systems. Many commentators link the Anthropocene with effects of industrialisation initiated by the patenting of Watt's steam engine in 1764 and magnified by the 'great acceleration' after World War II. However, impacts of intentional human activities resulted in significant environmental degradations long before that. Examples include the global destruction of megafauna by various Homo species,[17] desertification and pivotal societal transformations in the fertile crescent under the influence of agricultural innovations from about ten thousand years ago[18] and some six thousand years of European deforestation.[19] With industrialisation, the consequences are more serious, though not entirely novel. Consequently, it is important to rethink the pervasive influence of design on the future of life in the Anthropocene. Conditions of the future will offer novel, difficult (but interesting) challenges that will necessitate the refashioning of design.

For example: design, along with many other creative practices – from literature to engineering – prizes ingenuity, innovation and impact. However, creativity is a force of

destruction as well as making. In a world where resources such as materials or energy are finite, making something new requires a destruction of the old. On Earth, life had enough time to spread into every place that can work as a habitat. Scientists find organisms deep in the Earth's crust, in the stratosphere, in hot springs and at the bottom of ocean trenches. When newly evolved *Homo sapiens* began to colonise the planet, other creatures already occupied most available spaces to their maximal carrying capacity. The introduction of a new species, especially one as successful as humans, can occur only at the cost of diminishing the opportunities of others. Today, this is approaching catastrophic proportions. Consequently, an urgent need for design is to develop approaches that prioritise balance over efficiency and a small footprint over large impact.

Another difficult challenge is the need to plan for substantially different futures. Many ongoing trends have crossed or will soon cross qualitative thresholds that can lead to substantially altered habitats. Examples include technological advances, biodiversity loss, global warming and urbanisation. For example, insect populations are in sharp decline, globally. Estimates claim that more than 40 per cent are threatened with extinction.[20] Designed land use that transfers habitats to intensive agriculture or urban uses is the main driver. Industrial deployment of poisons is another cause. Beyond agricultural industries, most families have and apply poisons at home. The retail trade in designed insecticides and the related designed narratives of hygiene, safety and efficiency are worth billions of dollars each year. The result is a decline in ecosystem productivity and health. Among other consequences, loss of insects leads to a precipitous increase in bird deaths and equally large decreases in pollination, shifting whole regions towards ecosystem collapse.

Life, human and non-human, seeks to adapt in response to numerous pressures. The result is novel environments and novel relationships among their inhabitants. Societal values, education and business practices – including procurement, development and implementation of designs – struggle to match this novelty.

Appropriate responses to novelty are especially difficult because of multiple uncertainties. Ignorance is one factor. Human impact outpaces the accrual of human knowledge in many domains. For example, most biological species remain unknown and undescribed. Current estimates say that there are 8.7 million species on Earth with more than 86 per cent still undiscovered.[21] About fifteen thousand to twenty thousand new species are described each year. It will take hundreds of years to find the rest. At the same time, some 50 per cent of species will be unviable by mid-century.[22] Humans are still largely ignorant about their environment and in many cases lose the

opportunity to learn more. The intrinsic unpredictability of complex systems is another factor that limits planning and modelling. These challenges become even more difficult in the presence of differing cognitive abilities and the resulting perceptions of relevant stakeholders. Any efforts towards more holistic design will have to develop methods that can alleviate such constraints on shared knowledge.

Cultural Habitats

Cities provide a characteristic example. Urbanisation is accelerating globally, and this trend will persist into the foreseeable future. Even if human societies arrest the spread of cities, existing artificial environments will remain. Urban effects include waste, pollution, destruction of old ecosystems and depletion of resources well beyond the confines of cities. These effects inhibit the population of many organisms through heightened mortality, ill health and poor quality of life. At the same time, cities and adjacent areas act as significant habitats for many organisms.[23] Some individuals and species prefer cities. Others, such as urban pigeons, mice and most domesticated animals, can no longer survive without cohabiting with humans. Many more non-human organisms could live in cities but are excluded by prevailing human cultures, design and management practices.[24] Often, design choices exclude unintentionally.[25] Examples include the sealing of road surfaces, removal of old trees, introduction of non-native vegetation and light pollution. Careful management of urban ecosystems can be necessary, for example, for safety or disease control. However, the form and regulation of cities emerged to enable an expansive growth of human civilisations. Resulting environments neglect habitat requirements and negatively affect all lifeforms, including humans themselves.

The proposal of this chapter is that the participation of all lifeforms in design is a prerequisite to the viability of future habitats. Three propositions underpin this hypothesis: firstly, that habitats are necessarily cultural; secondly, that cultures involve human and non-human lifeforms, even if unknowingly and; thirdly, that design can learn from and support such interspecies cultures.

Developing approaches in urban ecology seek to study cities as ecosystems.[26] However, this field predominantly focuses on the observation and understanding of existing cities. Parallel, and more recent, areas such as political urban ecology seek to understand the management of urban environments in the context of societal interactions.[27] Here, green design methods seek to minimise urbanisation's damage.[28] Yet, these approaches continue to prioritise the needs of humans, interpreting them as distinct from the needs of the other lifeforms and considering them over relatively short timescales.

For example, most 'green building standards' attempt to minimise energy consumption but do not seek to provide habitat opportunities for non-human life. Most 'nature-based solutions' seek to purify water and air, reduce heat island effects and provide recreational opportunities for humans. Such approaches use other lifeforms as tools, dispensing with them as human needs change. The scope of a typical urban masterplan is thirty years. A typical lifespan of a commercial building is about fifty years. By contrast, most trees become valuable as habitats after 150 years and can live much longer. Their communities, with all the associated wildlife, can be many magnitudes older.

A body of work on animals, plants and other non-humans considered in relation to human cultures has grown in a variety of disciplines including geography, philosophy, political science, law and environmental history.[29] However, these recent advances are yet to penetrate the field of design or inform other, related professional practices and public opinion. In 1990, distinguished ecologist Daniel B. Botkin wrote that 'our beliefs about nature have fallen well behind our knowledge'.[30] These beliefs are important because they guide design. Unfortunately, since the 1990s, the gap has only widened despite recent efforts to address the needs of non-human stakeholders such as animals.[31] For example, a recent systematic review of 200 studies on urban biodiversity revealed 'critical knowledge gaps about the people-biodiversity interface in cities'[32] while a group of prominent researchers argued that future urban-design research ought to encompass non-human inhabitants.[33] Reciprocally, researchers in biological conservation argue that the discipline needs to develop an integration with urban planning.[34] The literature, therefore, indicates substantial gaps in the knowledge about the interaction of human culture, including design, with biology and ecology.

Cultural barriers often prevent beneficial actions. For example, as diurnal animals, humans prefer brightly lit environments. They associate darkness with danger and crime. Yet, outdoor lighting is hugely harmful to many forms of life, including humans.[35] Information on harmful effects is not penetrating design disciplines. With further research, design could support the required cultural shift in the homes, business spaces and public areas of cities. This shift must involve multiple cultural interactions, including education, communication, regulation and technologies. Parts of this shift can occur only if non-human lifeforms adjust their cultures. For example, the introduction of artificially constructed nest sites in urban areas invite birds that do not typically dwell in cities to recognise new opportunities for habitation.[36] To accept this invitation, birds need to learn to recognise and accept artificial nesting sites, be tolerant of noise and the presence of humans and their devices, modify their hunting strategies, adjust their diets

and modify how they socialise. The next section sketches a conception of design that can benefit from integrating more-than-human cultures.

Interspecies Design

The extent of environmental degradation poses risks to numerous forms of life, including many or most humans, especially those less privileged.[37] A century ago, only 15 per cent of Earth's surface was used to grow crops and raise livestock. Today, more than 77 per cent of land (excluding Antarctica) and 87 per cent of the ocean have been modified by the direct effects of human activities.[38] Humans have destroyed a tenth of Earth's wilderness in twenty-five years.[39] New forms of interspecies responsibility should, therefore, guide all future practices.[40] Yet, human societies struggle to modify their behaviours, as illustrated by failures in setting and meeting environmental-protection goals. The inability to imagine an attractive future that diverges from business-as-usual is an important constraint.[41] Current policies acknowledge culture and design as major organisational forces in the cities. However, the notion of culture used in these policies emphasises human production and consumption.[42] This understanding sees humans and other forms of life as fundamentally different: only humans have cultures and their needs trump those of others.

However, many (maybe even all) lifeforms have cultures. Consequently, it is possible to promote shared cultures that can better reflect ecosystem interactions among forms of life. The abstract nature of environmental ethics is one of the barriers preventing consideration of morality within environmental politics.[43] Yet, cultures that encompass human and non-human lives can foster critically important support for environmentally responsible behaviours and policies. As Paul Downton has written:

> Because cities are the drivers of environmental degradation the challenge is to turn them into agents of ecological restoration, supporting massive human populations and simultaneously repairing the damage to the world that humans have already done. The survival of our species' civilisation depends on how we make our cities work.[44]

The absence of a framework theorising interspecies cultures in the context of design makes a meaningful choice between alternative approaches towards environmental management difficult, or impossible. This impasse results in coexistence of dramatically incompatible attitudes, ranging from the extreme modifications of geoengineering[45] to the arrant protectionism of 'affluent environmentalism'.[46]

The emerging understanding of cities as living ecosystems is an important advancement. Nonetheless, leading literature in urban ecology inherits the

anthropocentric bias of previous scholarship. It sees the urban environment as 'a dynamic interaction between the natural environment and human culture'.[47] In such interpretations, human culture gets a privileged position. The anthropocentric bias situates other forms of life as separate from humans, undifferentiated as individuals, inferior and mechanical: co-mixed as the 'environment'. For example, undetected, undescribed and many 'lower' species – insects, worms or fish – remain unprotected by laws. New construction can remove or kill them if the viability of known non-human inhabitants is not affected. In similar situations, humans would receive compensation or even acquire protective status as refugees. Illustrating relevant recent thinking, proposals for animal property rights constitute one attempt to address this gap.[48]

Positioning that sees humans as valuable individuals but other lifeforms as environmental forces devoid of individuality or culture is often unintentional. Yet, this is detrimental to the environmental-protection goals of urban ecology. Theory and practice need, therefore, to advance beyond such separations. The study, management and design of urban ecologies need to see them as cultural as well as physical, chemical or biological phenomena. Necessary to developing practices that can address the future challenges of such environments is the study of interspecies cultures.

Humanist traditions define culture as something unique to humans. Ellwood insists that 'there is a qualitative difference between the social behavior of men and the social behavior of animals'.[49] Yet, recent scientific work disproves this.[50] It argues that many forms of life have rich cultures that are definable in terms of outcomes such as survival and well-being. For Allen et al., culture is 'shared behavior propagated by social learning'.[51] Laland and Janik understand 'culture (or tradition) as all group-typical behaviour patterns, shared by members of animal communities, that are to some degree reliant on socially learned and transmitted information'.[52] This chapter follows a similar definition proposed by Ramsey: '[C]ulture is information transmitted between individuals or groups, where this information flows through and brings about the reproduction of, and a lasting change in, the behavioral trait.'[53] This definition typifies a large and rapidly growing body of work in multiple disciplines.

Human and non-human cultures are always shared. They evolve in constant interaction within ecosystems and implicate multiple forms of life. Thus, cultures are always interspecies. Such cultures constitute a crucial mechanism of evolution and will have a pervasive impact on the health and well-being of humans and all other lifeforms.[54] This understanding of culture also has important implications for established bodies of knowledge in ethics, aesthetics, governance and other areas important for design.

The notion of interspecies cultures will require practical trials of a new ethics that builds upon existing work. This work includes forms of 'land ethic' that expand the socio-environmental community to include soils, waters, plants and animals.[55] Such an ethic has precedents but will necessitate innovation in rapidly changing environments.[56] Such innovation will have to deal with novel ecologies and social relationships. Andrew Dobson suggests that socio-environmental ethics should constitute a way of being rather than a code of conduct.[57] Future work must trial novel but plausible patterns of lived multispecies interactions.[58]

Consequently, interspecies design can be understood as a subset of interspecies culture, one that rejects speciesism. It is a form of design that seeks to involve and benefit both human and non-human lifeforms; to design *for* and *with* all life. Interspecies design can have human or non-human clients, consider human and non-human stakeholders and seek participatory contributions from human and non-human parties. It is committed to further research and conceptual innovation in areas of more-than-human co-habitation, interspecies culture, aesthetics and communication. To illustrate, modifications of existing seawalls into welcoming habitats for marine life respond to the needs and preferences of both human and non-human inhabitants.[59] Recent installations in Sydney illustrate how biodiversity-sensitive designs can improve the habitat capabilities of protected architectural heritage while enhancing humans' aesthetic appreciation of the shoreline. In Melbourne, digitally fabricated owls' nests combine ecologists' understandings of habitat needs with advances in design technologies.[60]

The definition of culture that frames this chapter emphasises, then, the transmission of information content. The practical implementation of interspecies design is likely to depend, therefore, on technologies of data gathering, representation, analysis, modelling, communication and generation. Capabilities provided by computation are a qualitative leap that could restructure socio-environmental relationships. The resulting changes can be detrimental as well as beneficial. The continuing impact of increasingly automated technology seems unavoidable, however, and this chapter proposes its judicious integration into constructive approaches that can support design with scientific evidence and measurable performance criteria. The bulk of the work in this area focuses on physical functions such as structural stability or energy efficiency. In extension, computation can have substantial positive effects on cultural interactions. Such effects are clear in the case of human cultures. It is likely that the impact of digital technologies on interspecies cultures will be as important.

Conclusion

An unfolding era of environmental collapse calls for new forms of interspecies responsibility, including new types of science, new scientific data and reconfigured relationships between science and politics.[61] Within this interdisciplinary endeavour, design plays a particularly significant role. Broadly understood, design encompasses all planning. Past designs affected all planetary environments, societies and the capabilities of individual humans. The conditions of the Anthropocene make it clear that human-centred design will continue to result in increasingly diminished living worlds. Thus, human impact in the Anthropocene makes the role of design in the future even more important. This chapter proposes an interspecies design that will engage with all life and encourage a productive rethinking of concepts such as culture, traditions, intelligence, sentience and language. Design relies on agile try-and-adjust methods supported by technical creativity. Reoriented to include more-than-human stakeholders, such methods can usefully extend the purviews of sciences and humanities. For example, design can serve as a testing ground that can combine scientific evidence on the ethology of a species with radical proposals for its legal status and evocative narratives of possible neighbourly friendship with humans. Expressed as inspirational demonstrators, reproducible recipes, guidelines, regulations or curricula as well as functional practical projects, the resulting scenarios can help to mobilise research and imagination in the exploration of preferable – and plausible – futures.

Notes

1. Paul J. Crutzen, 'Geology of Mankind', *Nature* **415**(6867) (2002), 23.

2. Libby Robin, Sverker Sörlin and Paul Warde (eds.), *The Future of Nature: Documents of Global Change* (New Haven, CT: Yale University Press, 2013).

3. Patrick W. Jordan, *Designing Pleasurable Products: An Introduction to the New Human Factors* (London: Taylor & Francis, 2000).

4. Herbert A. Simon, *The Sciences of the Artificial* [3rd ed.] (Cambridge, MA: MIT Press, 1996 [1969]), p.111.

5. Ibid.

6. Richard A. Herbert and Kathleen Green Skelton Herbert, 'Behavior of Peregrine Falcons in the New York City Region', *The Auk* **82**(1) (1965), 62–94.

7. Joel E. Pagel et al., 'Peregrine Falcons: The Neighbors Upstairs' in Clint W. Boal and Cheryl R. Dykstra (eds.), *Urban Raptors: Ecology and Conservation of Birds of Prey in Cities* (Washington: Island Press, 2018), pp.180–95.

8. New York City Department of Environmental Protection, 'Peregrine Falcons in New York City' (2019), www1.nyc.gov.

9. Scott R. Loss et al., 'Bird-Building Collisions in the United States: Estimates of Annual Mortality and Species Vulnerability', *The Condor* **116**(1) (2014), 8–23.

10. Harold G. Nelson and Erik Stolterman, *The Design Way: Intentional Change in an Unpredictable World* [2nd ed.] (Cambridge, MA: MIT Press, 2012 [2002]), p.1.

11. Klaus Krippendorff, *The Semantic Turn: A New Foundation for Design* (Boca Raton: CRC, 2006), p.32.

12. Joan Ernst van Aken, Hans Berends and Hans van der Bij, *Problem-Solving in Organizations: A Methodological Handbook for Business Students* (Cambridge: Cambridge University Press, 2007).

13. Jon Kolko, 'Design Thinking Comes of Age', *Harvard Business Review* (1 September 2015).

14. Krippendorff, *The Semantic Turn*, p.39.

15. Jared M. Diamond, *Collapse: How Societies Choose to Fail or Survive* (London: Allen Lane, 2005).

16. Valentí Rull, 'Natural and Anthropogenic Drivers of Cultural Change on Easter Island: Review and New Insights', *Quaternary Science Reviews* **150** (15 October 2016), 31–41.

17. Nicole L. Boivin et al., 'Ecological Consequences of Human Niche Construction: Examining Long-Term Anthropogenic Shaping of Global Species Distributions', *Proceedings of the National Academy of Sciences* **113**(23) (2016), 6388–96.

18. Simone Riehl et al., 'Mid-to-Late Holocene Agricultural System Transformations in the Northern Fertile Crescent: A Review of the Archaeobotanical, Geoarchaeological, and Philological Evidence' in Liviu Giosan et al. (eds.), *Climates, Landscapes, and Civilizations* (Washington: American Geophysical Union, 2013), pp.115–36.

19. Yuval N. Harari, *Sapiens: A Brief History of Humankind* (Toronto: Signal, 2014); Diamond, *Collapse*.

20. Francisco Sánchez-Bayo and Kris A. G. Wyckhuys, 'Worldwide Decline of the Entomofauna: A Review of Its Drivers', *Biological Conservation* **232** (2019), 8–27.

21. Camilo Mora et al., 'How Many Species Are There on Earth and in the Ocean?', *PLOS Biology* **9**(8) (2011).

22. Chris D. Thomas et al., 'Extinction Risk from Climate Change', *Nature* **427** (6970) (2004), 145–8.

23. Jenni Garden et al., 'Review of the Ecology of Australian Urban Fauna: A Focus on Spatially Explicit Processes', *Austral Ecology* **31**(2) (2006), 126–48.

24. Alexandra Botzat, Leonie K. Fischer and Ingo Kowarik, 'Unexploited Opportunities in Understanding Liveable and Biodiverse Cities: A Review on Urban Biodiversity Perception and Valuation', *Global Environmental Change* **39** (2016), 220–33.

25. Thomas Elmqvist et al. (eds.), *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities* (Dordrecht: Springer, 2013).

26. See, for example, Ian Douglas and David Goode (eds.), *The Routledge Handbook of Urban Ecology* (London: Routledge, 2011).

27. Nik Heynen, Maria Kaika and Erik Swyngedouw (eds.), *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism* (London: Routledge, 2006).

28. See, for example, Timothy Beatley, *Green Urbanism: Learning from European Cities* (Washington: Island Press, 2000).

29. See, respectively, Chris Philo and Chris Wilbert, *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations* (London: Routledge, 2000); Matthew Hall, *Plants as Persons: A Philosophical Botany* (Albany: State University of New York Press, 2011); Robert Garner and Shiobhan O'Sullivan (eds.), *The Political Turn in Animal Ethics* (Lanham, MD: Rowman & Littlefield, 2016); Christopher D. Stone, *Should Trees Have Standing? Law, Morality, and the Environment* [3rd ed.] (New York: Oxford University Press, 2010 [1974]); Sue Donaldson and Will Kymlicka, *Zoopolis: A Political Theory of Animal Rights* (New York: Oxford University Press, 2011); Clay McShane and Joel A. Tarr, *The Horse in the City: Living Machines in the Nineteenth Century* (Baltimore: Johns Hopkins University Press, 2007).

30. Daniel B. Botkin, *Discordant Harmonies: A New Ecology for the Twenty-First Century* (New York: Oxford University Press, 1990).

31. Jennifer R. Wolch, 'Zoöpolis', *Capitalism Nature Socialism* **7**(2) (1996), 21–47; Jennifer R. Wolch, 'Green Urban Worlds', *Annals of the Association of American Geographers* **97**(2) (2007), 373–84.

32. Botzat, Fischer and Kowarik, 'Unexploited Opportunities', p.220.

33. Kirsten M. Parris et al., 'The Seven Lamps of Planning for Biodiversity in the City', *Cities* **83** (2018), 44–53.

34. Briony A. Norton, Karl L. Evans and Philip H. Warren, 'Urban Biodiversity and Landscape Ecology: Patterns, Processes and Planning', *Current Landscape Ecology Reports* **1**(4) (2016), 178–92.

35. Davide M. Dominoni, Jeremy C. Borniger and Randy J. Nelson, 'Light at Night, Clocks and Health: From Humans to Wild Organisms', *Biology Letters* **12**(2) (2016), 1–4.

36. Ed McNabb and Jim Greenwood, 'A Powerful Owl Disperses into Town and Uses an Artificial Nest-Box', *Australian Field Ornithology* **28**(2) (2011), 65–75.

37. J. Baird Callicott, *Thinking Like a Planet: The Land Ethic and the Earth Ethic* (New York: Oxford University Press, 2013).

38. James E. M. Watson et al., 'Protect the Last of the Wild', *Nature* **563**(7729) (November 2018), 27.

39. James E. M. Watson et al., 'Catastrophic Declines in Wilderness Areas Undermine Global Environment Targets', *Current Biology* **26**(21) (2016), 2929–34.

40. Jamie Lorimer, *Wildlife in the Anthropocene: Conservation after Nature* (Minneapolis: University of Minnesota Press, 2015).

41. Stephen M. Gardiner, *A Perfect Moral Storm: The Ethical Tragedy of Climate Change* (New York: Oxford University Press, 2011).

42. Tüzin Baycan and Luigi Fusco Girard, 'Case Study Window: Culture in International Sustainability Practices and Perspectives: The Experience of "Slow City Movement – Cittaslow"' in Greg Young and Deborah Stevenson (eds.), *The Ashgate Research Companion to Planning and Culture* (Farnham: Ashgate, 2013), pp.273–92.

43. Donald A. Brown, 'The Importance of Creating an Applied Environmental Ethics: Lessons Learned from Climate Change' in Ben A. Minteer (ed.), *Nature in Common? Environmental Ethics and the Contested Foundations of Environmental Policy* (Philadelphia: Temple University Press, 2009), pp.215–27.

44. Paul Downton, *Ecopolis: Architecture and Cities for a Changing Climate* (Collingwood, Australia: CSIRO, 2009), p.21.

45. Clive Hamilton, *Earthmasters: The Dawn of the Age of Climate Engineering* (New Haven, CT: Yale University Press, 2013); Jack Stilgoe, *Experiment Earth: Responsible Innovation in Geoengineering* (London: Routledge, 2015).

46. Peter Dauvergne, *Environmentalism of the Rich* (Cambridge, MA: MIT Press, 2016); Hannah Holleman, *Dust Bowls of Empire: Imperialism, Environmental Politics, and the Injustice of Green Capitalism* (New Haven, CT: Yale University Press, 2018).

47. Ian Douglas and Philip James, *Urban Ecology: An Introduction* (London: Routledge, 2015), p.9.

48. Karen Bradshaw, 'Animal Property Rights', *University of Colorado Law Review* **89**(3) (2018), 809–62.

49. Charles A. Ellwood, 'Culture and Human Society', *Social Forces* **23**(1) (1944), 6–15.

50. Charles T. Snowdon, 'Introduction to Animal Culture: Is Culture Uniquely Human?' in Jose M. Causadias (ed.), *The Handbook of Culture and Biology* (Hoboken, NJ: John Wiley & Sons, 2018), pp.81–104.

51. Jenny Allen et al., 'Network-Based Diffusion Analysis Reveals Cultural Transmission of Lobtail Feeding in Humpback Whales', *Science* **340**(6131) (2013), 485–8.

52. Kevin N. Laland and Vincent M. Janik, 'The Animal Cultures Debate', *Trends in Ecology & Evolution* **21**(10) (2006), 542–7.

53. Grant Ramsey, 'Culture in Humans and Other Animals', *Biology & Philosophy* **28**(3) (2013), 457–79 (p.464).

54. Eva Jablonka, Marion J. Lamb and Anna Zeligowski, *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life* (Cambridge, MA: MIT Press, 2014).

55. Aldo Leopold, *A Sand County Almanac and Sketches Here and There* (New York: Oxford University Press, 1949).

56. See Philippe Descola, *Beyond Nature and Culture* (Chicago: University of Chicago Press, 2013); Tim Ingold, *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill* (London: Routledge, 2000).

57. Andrew Dobson, *Green Political Thought* [4th ed.] (London: Routledge, 2007 [1990]).

58. Alasdair Cochrane, *Sentientist Politics: A Theory of Global Inter-species Justice* (Oxford: Oxford University Press, 2018); Donaldson and Kymlicka, *Zoopolis*; Nicole Rogers and Michelle M. Maloney (eds.), *Law as if Earth Really Mattered: The Wild Law Judgement Project* (Abingdon: Routledge, 2017).

59. Elisabeth M. A. Strain et al., 'Eco-engineering Urban Infrastructure for Marine and Coastal Biodiversity: Which Interventions Have the Greatest Ecological Benefit?', *Journal of Applied Ecology* **55**(1) (2018), 426–41.

60. Roudavski, Stanislav, and Dan Parker. "Modelling Workflows for More-than-Human Design: Prosthetic Habitats for the Powerful Owl (Ninox Strenua)." In Impact - Design with All Senses: Proceedings of the Design Modelling Symposium, Berlin 2019, edited by Gengnagel, Christoph, Baverel, Olivier, Burry, Jane, Thomsen, Mette Ramsgaard, and Weinzierl, Stefan, 554–64. Cham: Springer, 2020. https://doi.org/10/dbkp.

61. Lorimer, *Wildlife in the Anthropocene*.