



DESIGN FOR OTHER SPECIES: AUSTRALIAN EXAMPLES

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ABSTRACT

Recognizing that most design solutions are human-centered, this study focuses on the agency of design to serve the needs of other living things and the broader ecosphere. Promising examples of non-anthropocentric innovations in Australia were collected; 12 were selected and written as mini case studies, and then analyzed using the lens of Metcalfe's principles of Multispecies Design. The research concludes that designing practical innovations that have benefits for other species as well as for humans is possible and shows potential in meeting biodiversity goals.

KEY WORDS

Post-anthropocentric design; Biophilic design; Biocentric design; Multispecies design; More-than-human design.

1. INTRODUCTION

Anthropocentrism – the worldview that humans have supremacy in the Universe – has been argued to be at the root of the ecological crisis (KOPNINA *et al*, 2018; MURDY, 1975; SESSIONS, 1974). Also known as 'human centeredness', this traditionally Western perspective implies 'human supremacy' and 'human exceptionalism', where humans are perceived as unique beings separate from and superior to nature, and that nature exists to be under the dominion of humans and to be exploited for the benefit of humanity.

Throughout history, design has for the most part been anthropocentric. Anything that was designed – that is, 'devised courses of action aimed at changing existing situations into preferred ones' (SIMON, 1969) – exists primarily to meet human goals and purposes and increase human happiness. Human-centered design – or the integration of the human perspective and knowledge of human capabilities and limitations in all steps of a problem-solving process – has improved the user experience in products, services, and systems and made them more usable, useful, and desirable. Certainly, human-focused design was a positive development of the field over the predominantly function-focused and market-focused design paradigms during the early years of the profession.

Anthropocentrism is evident when humans express care for nature, not because they feel nature is valuable for its own sake but because nature contributes to their pleasure and welfare. For instance, people might be concerned about rainforest deforestation because future generations would be deprived of lumber or medicinal sources, not because it

robs wildlife of their habitats; or feel that lakes are rivers need to be kept clean so that people can enjoy water sports, not because marine flora and fauna will suffer from water pollution (GAGNON THOMPSON & BARTON, 1994).

Within design circles, researchers are proposing a non- or post-anthropocentric approach, where design practice would mark a departure from benefitting solely the human members of nature and extend its agency to non-humans as well (GARCÍA-ACOSTA & RIBA-ROMEVA, 2010). This paper is an attempt to garner some examples of design innovations in Australia that are primarily intended to benefit non-human ‘clients’ and categorize and compare them through a ‘multispecies design’ perspective. It is hoped that by highlighting these life-centered solutions, the community of design thinkers and innovators might be inspired to develop designs in balance with nature and realize the value that design can offer to the community of other forms of life: the other 8.7 million species (MORA *et al*, 2011) that we share planet Earth with.

2. THEORETICAL FOUNDATION

Biocentrism focuses on the needs of the natural world, including humankind, rather than solely on the needs of human beings. This theory views all life as possessing intrinsic value and inherent worth. Biocentrism traces its roots to the ‘Reverence for Life’ philosophy of Alsatian polymath Albert Schweitzer, who believed that one who reveres life ‘injures and destroys life only under a necessity he cannot avoid, and never from thoughtlessness’ (SCHWEITZER, 1933). In the book ‘Animal Liberation’, Australian philosopher Peter Singer argued that the interests of animals should be considered because, like humans, they can experience pain, suffering, and misery (SINGER, 1975). ‘Biocentric egalitarianism’ was emphasized when American environmental philosopher Paul W Taylor wrote ‘Respect for Nature’, where he argued that humans are members of the Earth’s community of life in the same sense and on the same terms as other living things; that the natural world is an interdependent system; that every organism has a purpose and a reason for being; and that humans are not inherently superior to other species (TAYLOR, 1986). Biocentrism can be considered as a system of values within ecocentrism or nature-centeredness, which acknowledges not only the organisms in the living systems but also the ‘inanimate’ elements in the non-living systems of the Earth, such as rocks in the geosphere, clouds in the atmosphere, oceans in the hydrosphere, and glaciers in the cryosphere. Aldo Leopold’s ‘Land Ethic’ essay about caring holistically for people and the soils, waters, plants, and animals of ‘the Land’ is considered the foundation of ecocentrism and has influenced the conservation movement (LEOPOLD, 1949).

Biocentric design is ‘design for all of life’. Life-centered design is about designing not just for humans, but for all of life on the entire planet; it is about addressing humans as part of a greater ecosystem, as opposed to being at the center of everything (CURTIS, 2020; MAU, 2020; THACKARA, 2018). The Sentient Collective proposed 10 principles of life-centered design: design with the full picture in mind, design for the future, design for all, design to last, design symbiotically with nature, detailed design, intelligent design, humane design, and design as few things as possible (OWENS, 2019).

2.1. Biophilic design

The American naturalist Edward O Wilson – nicknamed the ‘father of biodiversity’ – published ‘Biophilia’ in 1984, in which he hypothesized that humans have an innate urge to affiliate with nature and other forms of life (WILSON, 1984). This term Biophilia was first used in 1964 by the German psychoanalyst Eric Fromm to mean ‘the passionate love of life and all that is alive’ (FROMM, 1964).

Biophilic design is ‘the deliberate attempt to translate an understanding of the inherent human affinity with natural systems and processes into the design of the built environment’ (KELLERT, 2008). Biophilic urban design elements include green rooftops, water features, green walls, daylit interior spaces, edible landscaping on streets, community gardens, and the like (BEATLEY, 2008). In the realm of industrial design, experimental product applications of biophilic

design were collected by WOLFS (2015), ranging from plant-based air purifiers and oxygen generators to nature-based manufacturing materials, renewable energy appliances, and cyclical ecosystems within the home.

2.2. Multispecies design

Multispecies design is the practice of designing systems and artifacts that address the needs of both human and non-human species; it entails recognizing plants and animals as clients of design, recognizing interactions between humans and nature as designed experiences, and viewing manmade systems as further extensions of ecological systems (METCALFE, 2015a). METCALFE (2015b) proposed four principles of multispecies design, which were described in 20 multispecies design processes (Table 1).

2.3. More-than-human design

David Abram is credited with coining the locution 'more-than-human' when he published 'The spell of the sensuous: perception and language in a more-than-human world'. In this major work on ecological philosophy, Abrams emphasizes that the life-world that humans inhabit is also inhabited by more-than-human beings and that as humankind developed, their ancient reciprocity and balance with the natural world has been shattered (ABRAM, 1996). There is a growing body of work that shows how more-than-human perspectives are being considered in human design endeavors. Several publications include collections of examples on decentering human agency, exploring more-than-human temporalities, incorporation of wisdom about more-than-humans, educating designers with a more-than-human pedagogy, and cohabitation with more-than-humans (CLARKE *et al*, 2019; LOH *et al*, 2020).

Multispecies design principle	Multispecies design process	Multispecies design principle	Multispecies design process
Treating plants and animals as clients of design	(1) Extending responsibility	Designing interactions between humans and other species	(10) Representing flora/fauna in society
	(2) Identifying needs		(11) Focusing on mutually beneficial interaction
	(3) Participatory design by plants/animals		(12) Soft reservation
	(4) Representing flora/fauna in the design process		(13) Addressing existing cultural baggage
Researching other species in a design context	(5) Learning the science		(14) Avoiding domestication
	(6) Multispecies design ethnography		(15) Opening up communication channels
	(7) Proxy interviews		(16) Seeking synergies
	(8) Identifying animal spokespeople	Designing like an ecosystem	(17) Open-ended design
	(9) Somatic design research		(18) Ecology of reference
			(19) Connectivity
			(20) Embrace complexity

Table 1: Multidisciplinary design principles and processes. SOURCE: Extracted from Dr Daniel Metcalfe's Multispecies Design Cards.

3. METHOD

A comprehensive search for existing cases of non-anthropocentric design solutions that are present in Australia was carried out via internet search engines, using combinations of the keywords design and Australia with 'biophilic', 'biocentric', 'wildlife', 'nature', and 'post-anthropocentric'. The results were filtered according to the criteria below:

1. The solution must prioritize the welfare of non-human species over those of humans.
2. The solution must be existing, commercially available, installed, or prototyped and field-tested; it cannot be theoretical, abstract, experimental, or conceptual ideas or plans.
3. The solution must either be designed in Australia or developed elsewhere but in place in Australia.
4. The solution must consider the unique constraints of the Australian environment and native flora and fauna.

After the cases were identified, more related literature was gathered from online sources, and in many of the cases, personal communication was established with project originators or researchers to gain further insights. The collected case studies were analyzed using the Multispecies Design Principles in Table 1 (METCALFE, 2015b).

4. RESULTS

The 12 most innovative cases matching the search filter criteria are described in this section as mini case studies.

4.1. Permaculture

A portmanteau of ‘permanent’ and ‘agriculture’, permaculture was coined by Australian ecological educators Bill Mollison and David Holmgren in 1976 to describe a natural approach to self-sufficient human settlements and agricultural systems. This creative counterculture process is based on whole-systems thinking informed by ethics and 12 design principles (HOLMGREN, 2020). These principles mimic the patterns and relationships found in nature and can be applied to all aspects of human habitation, including organic and edible gardening, passive house design, and appropriate technology. Through the permaculture principles, people are aided in transitioning from being dependent consumers to becoming responsible producers, and in being resilient and being prepared for a climate-changed future with fewer resources. Domesticated animals, such as fish, goats, bees, worms, and poultry are often introduced intentionally into permaculture spaces.

After a chance meeting at the University of Tasmania in the 1970s, Mollison and Holmgren collaborated for several years and this led to the seminal book ‘Permaculture One’ (MOLLISON & HOLMGREN, 1978), which proposed solutions about living responsibly on the land. These ideas led to the creation of Crystal Waters, Australia’s first ecovillage; the publication of ‘Permaculture Magazine’ and ‘Permaculture International Journal’; and the beginning of the global Permaculture network. Mollison started the Permaculture Institute in Tasmania, where thousands of people from around the world came to learn nature-based principles for growing food and for sustainable living. An estimated 1 million people from 140 countries have been certified in permaculture and there are more than 4,000 permaculture projects now running worldwide (NIERENBERG, 2015).

4.2. Land bridges

Wildlife overpasses or land bridges over highways help large or herd-type animals cross between habitats that have been fragmented by roads and traffic and prevent them from running into cars on the road. Roads across habitats are an anthropogenic disturbance, and in Australia, about 5.5% of all road accidents are due to wildlife-vehicle-collisions (WVC), which results yearly in about 12 human casualties, 174 hospitalizations, and about 4 million animal deaths (ENGLEFIELD, 2020; ROWDEN *et al*, 2008). Of the 13,000 animal collision insurance claims received by the National Roads and Motorists Association in 2019, 85% involved kangaroos; about 42% of human fatalities were due to drivers swerving to avoid the animals (NRMA, 22 Jun 2019).

In the 1950s France originated the wildlife-friendly landscaped overpass or ‘green bridge’; by 1991, there were 125 fauna overpasses all over France (BANK *et al*, 2002). Many such animal crossings now exist over highways in Europe and North America. Also referred to as ‘ecoducts’ or ‘forest bridges’, they are typically planted with native vegetation and enhanced with hollow logs, rocks, or even shallow water bodies to mimic the surrounding nature corridor and facilitate a seamless transition of landscapes (QLD-TMR, 2010).

In Australia, at least 10 land-bridge fauna overpasses have been built or are under construction (Table 2). Studies show that these vegetated crossings were used most frequently by kangaroos and wallabies (*Macropodiformes*), bandicoots

(*Peramelemorphia*), and rodents (*Rodentia*); and that road-kills were fewer in highway sections which had fauna crossing structures (BOND & JONES, 2008; HAYES & GOLDINGAY, 2009).

Road crossed	Location	State	Coordinates	Year built
Pacific Motorway M1 (National Highway 1)	Yelgun, Byron Shire	NSW	-28.47511, 153.51024	2002
Pacific Motorway M1 (National Highway 1)	Cudgera Creek, Tweed Shire	NSW	-28.40307, 153.52789	2002
Pacific Highway A1 (National Highway 1)	Bongil-Bongil National Park, Coffs Harbour	NSW	-30.41677, 153.02498	2003
Compton Road (QLD State Route 30)	Karawatha Forest, Kuraby, Brisbane	QLD	-27.61602, 153.08426	2005
Hamilton Road	Milne Hill Reserve, Chermide, Brisbane	QLD	-27.38204, 153.00455	2008
Caloundra Road (QLD State Route 6)	Meridan Plains, Sunshine Coast	QLD	-26.7764, 153.05776	2009
Illaweena Street	Drewvale, Brisbane	QLD	-27.64052, 153.0594	2020
Tonkin Highway (WA State Route 4)	Ellenbrook, Swan, Perth	WA	-31.74316, 115.98176	2020
Mona Vale Road (NSW State Route A3)	Ku-ring-gai National Park, Ingleside, Sydney	NSW	-33.68804, 151.24089	Begun 2019
Bruce Highway A1 (National Highway 1)	El Arish, Cassowary Coast	QLD	-17.84307, 145.99101	Begun 2020

Table 2: Land-bridge fauna overpasses in Australia. SOURCE: Original table by author.

4.3. Rope bridges

Native tree-dwelling marsupials such as ringtail possums (*Pseudocheiridae*), brushtail possums (*Phalangeridae*), and gliders (*Petauridae*) become vulnerable when they travel along the ground, either due to predation by feral cats, foxes, or dingoes or due to getting run over by cars. In their native habitats, these arboreal animals leap between tree branches to forage for food. In 1995 Rupert Russell of the Queensland Environmental Protection Agency designed and installed Australia's first rope tunnel for arboreal wildlife; this was built 7m above the Kauri Creek Road in the Danbulla National Park in Far North Queensland and was found to be used by green ringtail possums (*Pseudochirops archeri*), Herbert River ringtails (*Pseudochirulus herbertensis*), and lemur-like ringtails (*Hemibelideus lemuroides*) (WESTON, 2003).

Also referred to as canopy bridges, rope overpasses enable arboreal fauna to cross the road from one side of the forest to the other without having to descend the trees. These flexible crossings are tensioned and suspended from poles high above the traffic and are linked to adjacent canopy vegetation via ropes. They take several forms, including flat ladder-like bridges, tunnel-shaped bridges, three-sided bridges, and single rope crossings. The predominant material used is marine-grade UV-stabilized polyethylene rope (aka 'silver rope'), which has high strength and is resistant to wear, abrasion, oil, mildew, and weathering. Fibrillated fibers give the rope a 'furry' texture, making it easy to grip and non-slip. When woven into a rectangular tube, the resulting rope tunnel offers protection from predators such as hawks and owls (BAX, 2006). Motion sensor cameras proved that native arboreal mammals used the rope bridges and were quickly habituated, particularly the squirrel gliders (*Petaurus norfolcensis*), feathertail gliders (*Acrobates pygmaeus*), common ringtail possums (*Pseudocheirus peregrinus*), slender ringtail possums (*Pseudochirulus*), and common brushtail possums (*Trichosurus vulpecula*) (GOLDINGAY *et al*, 2013; WESTON *et al*, 2011; YOKOCHI & BENCINI, 2015).

4.4. GLIDER POLES

Australian gliding marsupials (*Petaurus*), aka flying phalangers or wrist-winged gliders, have evolved to glide or parachute between trees. However, some forests are fragmented by roads whose widths exceed the gliding capability of these animals. To help them traverse expansive treeless areas, tall hardwood poles were installed between habitat patches, with horizontal crossbars at the tops provided as launching pads. In 1995, the first glider poles in Australia were installed in Bomaderry Creek, Nowra, New South Wales, upon recommendation of Dr Ross Goldingay of Southern Cross University SCU (GOLDINGAY *et al*, 2011). Glider poles were later installed in other locations and studied for use by target species. Those installed in Brisbane and Mackay in Queensland and in Port Macquarie in New South Wales were found to be readily used by squirrel gliders (*Petaurus norfolcensis*), sugar gliders (*Petaurus breviceps*), yellow-bellied gliders (*Petaurus australis*), and feathertail gliders (*Acrobates frontalis*) (BALL & GOLDINGAY, 2008).

4.5. VIRTUAL FENCES

A series of roadside posts with audible warning sounds and flashing strobe lights have been installed along roadkill-prone roads in Tasmania, Queensland, Victoria, South Australia, and New South Wales. Together, these posts formed a ‘virtual fence’ that alerts wildlife of approaching vehicles and scares them from the road. The virtual fences are active from dusk to dawn, which is when the risk of vehicle collisions with native animals is highest. Electronic sensors detect the headlights of an oncoming vehicle 300 meters away, triggering the acoustic and bi-color optical alerts in the posts and giving the animals enough warning to move away without panicking, as terrified animals can run into the path of a vehicle. The device does not face the road to prevent the blue-and-amber LED lights from dazzling the drivers. The posts are spaced every 25 meters in a zigzag arrangement on both sides of the road, and the sensors are powered by lithium batteries recharged by thin-film solar cells. These collision avoidance systems were developed by iPTE Traffic Solutions Ltd, based in Graz, Austria, and have been installed in locations in Europe and North America since 2001. In Australia, these systems were first installed in 2014 by Wildlife Safety Solutions. They are currently installed in 22 locations in 5 Australian states. Targeted species include kangaroos and wallabies (*Macropodidae*), wombats (*Vombatidae*), koalas (*Phascolarctos cinereus*), quolls (*Dasyurus*), bandicoots (*Peramelemorphia*), deer (*Cervinae*), and Tasmanian devils (*Sarcophilus harrisii*). Preventing contact between vehicles and animals reduces adverse harm to wildlife and at the same time creates safer roads for motorists. Limited trials of virtual fencing in a remote road in Tasmania showed modest efficacy (ENGLEFIELD *et al*, 2019). While displaying potential, further scientific validation is needed, as tests of various animal repellent innovations based on acoustic and photic stimuli – including the Shu-Roo ultrasonic emitters and the Swareflex and Strieter-Lite flashing reflectors on road posts – did not show significant effectiveness in altering animal behavior or in preventing roadkill (D’ANGELO & VAN DER REE, 2015).

4.6. CRAB BRIDGE

During the first rainfall of the wet season in Australia’s Christmas Island, about 50 million red crabs (*Gecarcoidea natalis*) leave their homes in the forest and migrate *en-masse* towards the Indian Ocean to breed. The male crabs march back to the forest after mating, the females return after spawning their eggs into the water, and the baby crabs head home after one month of growing up in the ocean. This phenomenon happens over 2 months from October to November.

During this annual migration, hundreds of thousands of crabs are accidentally crushed by motorists. In the 1990s, rangers at Christmas Island National Park initiated, developed, and implemented a comprehensive mitigation program to minimize wildlife mortality. These included raising awareness in the community, temporary road closures, and detours during peak migration periods, and installing special crab crossing infrastructure in high traffic zones. Metal fencing on the roadside verges direct the crabs towards several open-ended grid-style underpasses and across a 5.5m-high overpass over Murray Road, known colloquially as the ‘crab bridge’. Fabricated from galvanized steel C-channels and heavy-duty mesh, the bridge was a prototype to test if the crabs will cross it as part of their natural migratory path. The decking surface on the bridge has undergone several material experimentations to test which was preferred by the crabs, firstly using marine carpets, then marine plywood with glued-on gravel, and the current fiberglass reinforced plastic grating. Photographs and video footage prove that the crabs do use the overpass and the underpasses; moreover, monitoring surveys showed that road mortality in areas with fences and crossings was reduced by as much as 80% compared to areas with unfenced roads (ORCHARD, 2020).

4.7. Purple Hive

Bees are dying at alarming rates, mainly due to climate change, habitat loss, pollution, pesticides, and parasites (SÁNCHEZ-BAYO & WYCKHUYS, 2019). One of the factors for bee deaths is the parasitic mite (*Varroa destructor*), which has been decimating entire colonies of European honeybees (*Apis mellifera*) around the world. Australia is the only inhabited continent still free of infestation by these pests. *Varroa* mites attach, debilitate, and eventually kill the adult

bees and the developing larvae and pupae in the hive. They also spread pathogens such as the deformed wing virus. The detection and monitoring of varroa mites are highly laborious and tedious.

In 2020 Australian food manufacturer Bega Cheese Ltd engaged Melbourne creative agency Thinkerbell Pty Ltd in creating the Purple Hive Project (<https://purplehiveproject.com.au>), an initiative to protect the Australian bee and honey industry. Melbourne-based engineering firm Vimāna Tech Pty Ltd designed and developed the physical hardware and Internet-of-Things device that connects the Purple Hive to the artificial-intelligence software and algorithms developed by Sydney-based computer-vision specialist Xailient Pty Ltd. The Purple Hive is solar-powered and has computer vision cameras on the transparent landing surface, which visually scans and analyzes each bee as it enters the hive, detecting any parasites piggybacking on the bee's body. Upon detection of a parasite, an alarm signal is sent in real-time to the beekeeper so that the affected hive can be quarantined. The Purple Hive is currently being trialed at the Port of Melbourne, identified as the most likely entry point for bee pests in Victoria.

4.8. Felixer

Introduced to Australia after European settlement in 1788, feral cats (*Felis catus*) now number about 6.3 million across the continent. Feral cats have contributed to the extinction of 25 of the 30 Australian native mammal species lost since Europeans settled so tackling feral cats is a priority of the Australian Government (LEGGE *et al*, 2017). Feral cats often do not take poison baits or enter food-laden traps because they prefer abundant live prey. Another damaging invasive species is the European red fox (*Vulpes vulpes*), introduced for recreational hunting in Australia in 1855 and now have spread across most of the continent and have decimated populations of native rodent and marsupial species.

Cats compulsively lick themselves to keep their coat clean and to regulate their body temperature. Dr John Read of Ecological Horizons Pty Ltd, a South Australian consultancy, exploited this self-grooming behavior of cats and used it as a nature-based strategy for instinctive toxin delivery. Adelaide-based product engineering firm Applidyne Australia Pty Ltd collaborated in bringing the idea to reality in 2016. This resulted in the Felixer 'grooming trap': a novel, humane and automated solution for eradicating feral cats and foxes from nature reserves, thereby allowing native wildlife to flourish (<https://thylation.com>). An array of laser-based infrared rangefinder sensors on the Felixer detects and distinguishes cats and foxes from other animals and humans through their size, shape, and gait, and then squirts a dose of poison gel to the fur of the target, which the animal later ingests whilst grooming itself. Powered by solar-charged batteries, these devices can hold 20 sealed cartridges of toxic gel and can auto-reset after firing. They are less labor-intensive compared to trapping, shooting, and poison-baiting. Felixer photographs all animals detected and has audio lures to entice feral predators. Field trials show that 100% of feral foxes and 82% of feral cats were correctly identified as targets (READ *et al*, 2019). In 2020, as part of the Environment Restoration Fund, the Australian Government committed \$2 million to upscale the production of the Felixer and the Curiosity® bait for feral cats.

4.9. Airseed

The unprecedented chain of bushfires during the Black Summer of 2019-2020 burned 19 million hectares of Australia's forest and woodland estate (FILKOV *et al*, 2020) and destroyed or damaged up to 7 billion trees and 3000 homes (WWF-AUSTRALIA, 2020). In response to the bushfire crisis, Australia's largest conservation charity World Wide Fund for Nature launched 'Regenerate Australia', which included a program for saving and growing 2 billion trees by 2030, through reforestation 10 million hectares of native forests and woodlands on cleared or degraded lands to improve resilience against climate and drought.

WWF-Australia has partnered with the Sydney-based ecosystem restoration startup Airseed Technologies to trial drone seeding for planting trees (<https://airseedtech.com>). The goal was to create nature corridors with diverse endemic species that can help restore primary habitat so that koalas and other wildlife can move freely across the landscape.

The Airseed re-vegetation process starts with ecosystem mapping and modeling to work out the species best suited in specific locations and to plan an optimized seeding pattern. The seeds are compacted into ball-shaped ‘carbon seed pods’, which are designed to protect the seeds from rodents, birds, and insects and are enriched with nutrients, minerals, and probiotics to boost the growth of germinated seedlings. Autonomous flying drones fire the seedpods into the soil at predefined GPS coordinates, using a higher pressure where greater soil penetration is required, thus protecting the seed from wind, rain, and erosion. Once planted, artificial intelligence (AI) on the drones identifies which species have successfully established and helps monitor and report the growth rates. Each drone can plant 100 seed pods per minute or 40,000 per day, which enables lands to be restored 25 times faster and 80% cheaper than traditional manual planting techniques. Drones can also plant in difficult terrain and other inaccessible areas.

4.10. Rangerbot

Apart from climate change, pollution, and overfishing, the other major threat to corals is predation by the crown-of-thorns starfish (*Acanthaster planci*). Also known by its acronym COTS, this venomous coral-eater is the world’s second-largest starfish and can grow up to 75 cm. Each night a single COTS can devour its body size in coral, and during severe COTS outbreaks, entire reef systems can be quickly stripped of living coral. COTS accounted for 42% of coral mortality on the Great Barrier Reef (GBR) (DE’ATH *et al*, 2012).

In 2016, Prof Matthew Dunbabin of Queensland University of Technology (QUT) developed the COTSBot, an autonomous underwater vehicle (AUV) that scans the GBR for COTS and culls the starfish through a lethal single-shot injection of bile salts or vinegar. The machine is equipped with sonar, multiple cameras, GPS navigation, and powerful thrusters to cruise smoothly up and down the reef on a preprogrammed path. COTSbot carries enough toxins to kill over 200 starfish in a day’s mission; each poisoned starfish dies within 24 hours (DUNBABIN *et al*, 2020). QUT artificial-intelligence researcher Dr Feras Dayoub trained the COTSBot with computer vision to identify and distinguish COTS from other aquatic life using an image-analyzing neural net that is 99.4% accurate (DAYOUB *et al*, 2015).

Building on the successful COTSBot prototype, a smaller, more maneuverable, and less costly Rangerbot AUV was developed through a collaboration between QUT Centre for Robotics (<https://research.qut.edu.au/qcr>) and Designworks Group Pty Ltd, commissioned by the Great Barrier Reef Foundation. Like the COTSBot, the Rangerbot sea drone can perform COTS pest control and has the additional functionality of being able to spread coral larvae over damaged reefs and to autonomously monitor and map multiple reef health indicators like coral bleaching, pollution, and water quality. It can stay underwater 3x longer than a human diver and operate 24/7 even in waters with crocodiles and sharks, and through its real-time computer vision, gather more data and map sprawling subaquatic areas at scales not previously possible. Rangerbot won the People’s Choice award in the 2016 Google Impact Challenge Australia and the Good Design Australia 2019 Award for Sustainability.

4.11. Living Seawalls

In 2018 the Sydney Institute of Marine Science (SIMS) collaborated with the Melbourne-based Reef Design Lab (RDL) to create the ‘Living Seawalls Project’. This eco-engineering project resulted in novel microhabitat-enhancing tiles, cast with a marine concrete mix using 3D-printed molds designed by RDL and retrofitted to the sandstone embankments lining the foreshores of Sydney Harbor. The tiles were of varying textures, ridge heights, and crevice separations, and were intended to mimic the complex root structure of native mangrove trees, which used to provide habitat for marine organisms but have now disappeared from most urbanized estuaries after they were replaced by stone or concrete walls to minimize coastal erosion. Many of these mangrove-dwelling organisms absorbed and filtered out water-borne pollutants. Some of the Living Seawalls were ‘seeded’ with juvenile Sydney rock oyster (*Saccostrea glomerata*), and then deployed into the mid-intertidal zone of the embankments where wild populations of oysters naturally occur. After 12 months, 66 species – including oysters, barnacles, and mussels – have been observed on the Living Seawalls, which

showed the potential of the tiles in boosting biodiversity and particle removal rates (VOZZO *et al*, 2021). There are currently 9 Living Seawall installations along Sydney Harbor; there are also installations in Adelaide SA, Townsville QLD, and Narooma NSW, and internationally in Singapore, Gibraltar, and Wales. The tiles will remain in place until 2038, with SIMS regularly monitoring their effectiveness and ecological performance. SIMS is the principal marine research facility in New South Wales and is a cooperative partnership between 4 Australian universities. ‘Living Seawalls’ is a flagship program of SIMS and is led by researchers from Macquarie University and the University of New South Wales.

4.12. Seabin

Ocean debris adversely affects over 800 species worldwide through ingestion, entanglement, smothering, and habitat effects, with the proportion of marine mammal and seabird species that have swallowed marine debris now at 40% and 44% (CBD, 2016). During the 2020 International Coastal Cleanup, the top 10 marine debris were candy and chips wrappers, cigarette butts, plastic beverage bottles, plastic bottle caps, straws and stirrers, plastic cups and plates, plastic grocery bags, plastic takeaway containers, other plastic bags, and plastic lids (OC, 2020)

One solution to marine debris is the Seabin (<https://seabinproject.com>), a trash skimmer for floating rubbish in the waters of marinas, yacht clubs, and ports. Australian boat builders Andrew Turton and Pete Ceglinski co-founded Seabin Project Pty Ltd in 2014 after conceptualizing the device, which was later crowd-funded and now manufactured and distributed by Poralu Marine Inc of France. Constructed from HDPE plastic and held by a stainless-steel bracket, the Seabin collector ascends and descends with the tide. A submersible water pump sucks debris from the water surface, trapping them inside the catch bag for future recycling or waste processing. By capturing the debris near land, less of it will go into the oceans and harm aquatic life. In 2016 Seabin won the Good Design Australia Award for Social Impact and in 2018 TIME Magazine named it amongst the best inventions of the year. As of Jun 2021, 860 Seabin units have been installed around the world, each capturing about 1.5 tons of floating trash per year (www.seabinproject.com).

5. ANALYSIS

The 12 cases of non-anthropocentric innovations in Australia were matched with the Multispecies Design Principles and processes (METCALFE, 2015b), and then tabulated in Table 3.

Multispecies D Principle	Multispecies design process	Perma culture	Land bridges	Rope bridges	Glider poles	Virtual fences	Crab bridge	Purple Hive	Felixer	Ranger bot	Living Seawall	Seabin
Treating nature as clients of design	Responsibility	x	x	x	x	x	x	x	x	x	x	x
	Identifying needs	x	x	x	x	x	x	x	x	x	x	x
	Participatory	x					x				x	
	Nature in design	x	x	x	x		x	x	x	x	x	
Researching other species in a design context	Learning science	x	x	x	x	x	x	x	x	x	x	x
	MD ethnography	x	x	x	x	x	x	x	x	x	x	x
	Proxy interviews	x	x	x	x	x	x	x	x	x	x	x
	Spokespeople	x	x	x	x	x	x	x	x	x	x	x
	Somatic design	x	x	x	x	x	x	x	x	x	x	x
Designing interactions between humans and other species	Nature in society	x	x	x	x	x	x	x	x	x	x	x
	Mutual benefit	x	x	x	x	x	x	x	x	x	x	x
	Soft reservation	x	x	x	x	x	x					
	Cultural baggage	x	x	x	x	x	x		x	x		x
	No domestication		x	x	x	x	x		x	x	x	x
	Communication	x					x					x
	Synergies	x						x	x	x		x
Designing like an ecosystem	Open-ended	x	x	x							x	
	Ecology of reference	x	x	x	x						x	
	Connectivity	x	x	x	x	x	x				x	
	Complexity	x	x	x							x	

Table 3: Matrix of non-anthropocentric innovation versus multispecies design principles. SOURCE: Original table by author.

The matrix shows that overall, the 12 non-anthropocentric examples sufficiently comply with the principles and processes of multispecies design. As for Principle 1 ‘Treating nature as clients’, all examples demonstrated identification of, and respect for, the needs of the animals and their wild nature; it was clear that these designs were assessed from an animal’s perspective during prototyping. The one process where the examples were weak was ‘participatory design’, in which animals modified the designs as they interacted with them. This ‘participatory design’ was positively demonstrated by permaculture – such as when bees create their hives – and in the ‘Living Seawalls’ where marine creatures build their habitats on the tiles. The red crabs ‘participated’ in the design of their under-road crossings; they refused to enter dark culverts for fear that a predator might be lurking, so the rangers re-designed the crossings with open grates to allow natural light to shine through the tunnel. In the case of the Felixer, the ‘client’ was not the feral cats and foxes, but the endangered wildlife whose flourishing depends on the eradication of feral predators. In the case of the Seabin, the salient client was the aquatic life whose welfare is dependent on cleaner oceans.

Principle 2, ‘Researching plants and animals in a design context’, was excellently demonstrated in all examples. Several of them heavily involved university academic staff as inventors or as research investigators: QUT in Rangerbot, SIMS in Living Seawalls, SCU in glider poles. Most projects were field-tested and monitored by wildlife scientists who specialized in studying the target species. In their role as experts in animal behavior, the scientists served as ‘animal spokespeople’ capable of speaking on behalf of affected animals throughout the design process. Conversations between designers and scientists served as ‘proxy interviews’ whereby the scientists talked about the animals and for the animals. ‘Multispecies design ethnography’ was evidenced by the photographic and video recordings of the interaction of the animals with the animal crossings. The images allowed observation of the eco-socio-technical interactions between animals, humans, and manmade objects. Because the images were captured from the viewpoint of the animal, these images characterized a ‘somatic design research’, which is about experiencing the world from the animal’s perspective.

Many of the multispecies design processes of Principle 3 ‘Designing interactions between humans and other species’ were adequately evidenced. Most of the designs helped make the presence of urban wildlife more visible in cities. ‘Mutually beneficial interaction’ was evident in the crab bridge, as the design shows benefits to animals as well as humans – the crabs are protected from being crushed while vehicles can safely travel on the road while enjoying the spectacle of the crab migration – and brings the human and the non-human species closer together in a respectful way. ‘Soft reservation’, or the structured separation between animals and humans to keep them both safe is demonstrated well by the land bridge and rope bridge. ‘Addressing cultural baggage’ – that is, challenging misconceptions and misunderstandings about the animal – was shown by the animal crossings and the Seabin: they change the narrative that roadkill is an inevitable consequence of highway driving or that floating rubbish in waterways are part of the landscape. ‘Avoiding domestication’ is present in all except two examples: the Purple Hive where honeybees are farmed, not wild, and permaculture where domesticated goats, poultry, fish, and bees are part of the permaculture solution. Not all of the designs were strong in ‘opening communication channels’; the ones that do, with the use of video recordings, were able to translate animal language and behavior into cues understandable by humans and vice-versa. ‘Seeking synergies’ is strongly evident in the Purple Hive: by helping the bees stay pest-free, they will be able to pollinate flowers and assist with human food production. The Seabin also shows synergistic satisfaction of both human and animal needs: clean waterways are more enjoyable for recreational water users and safer for marine creatures to dwell in.

Compared to the other principles, Principle 4, ‘Designing like an ecosystem’ was weakly manifested. ‘Open-ended design’ was found in the Living Seawalls, where the design was considered as part of an ever-changing system that humans will not have full control over the outcomes of. ‘Ecology of reference’ – the similarity of designed features to natural features enabling animals and plants to be pre-adapted to the urban environment – is evident in the glider poles and rope bridges, which are morphologically similar to tall trees and woody vines in the rainforest. ‘Connectivity’ is present through the animal crossings that reconnect separated green habitats. The complexity of form and materials to provide diverse options and niches for animals was demonstrated well by the Living Seawalls.

6. CONCLUSION

The study shows that more-than-human design projects can be just as stimulating as human-focused design projects. Designing for other species provides an avenue for innovators to appreciate the entanglements in the web of life. As Aldo Leopold said: ‘When we see Land as a community to which we belong, we may begin to use it with love and respect’ (LEOPOLD, 1949). The Multispecies Design principles by METCALFE (2015a) facilitate the sensitization and empathy of designers towards other life forms with whom we cohabit in the ecosphere. The practice of learning and reflecting about nature and its processes and systems offers an opportunity for the designer to be humble and to appreciate the complexity of ‘life’.

The emerging strategies for life-centered design – and with it the biophilic, biocentric, eco-centric, multispecies, more-than-human, and others that decenter the humans – provide a useful addition to the toolbox of the 21st-century designer and design thinker. Most design-for-sustainability strategies are still largely human-centric; for instance, we design products and packaging that are recyclable or compostable because we abhor the sight of landfills and trash-filled beaches and not because of manmade products endangering other species in their native habitats. Through an improved understanding of the impacts of our designs on the natural environment and other earthlings, our creative solutions might in the future be mutually beneficial and synergistic to all planetary inhabitants. The Canadian designer Bruce Mau quoted British economist Arnold Toynbee as saying in 1957: ‘The 20th century will be chiefly remembered by future generations... as an age in which human society dared to think of the welfare of the whole human race as a practical objective’; he later reflected that in the 21st century, the welfare of all-of-life, not just the human race, should be the practical objective of designers (MAU, 2020).

In the 21st century, design practice and global consumer culture need to be overhauled towards a genuinely holistic and systemic worldview, past the anthropocentrism of recent eras. If we are to achieve the United Nations Sustainable Development Goals by 2030, this radical shift towards life-centered design might just usher in the creative reboot that we all need.

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