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Kees Lokman

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Cyborg landscapes: Choreographing resilient interactions between infrastructure, ecology, and society

Kees Lokman The University of British Columbia, Canada

Abstract

Contemporary challenges of climate change, population growth, resource scarcity, and environmental decline prompt designers to envision new relationships between nature and culture. Infrastructure design and adaptation are key to addressing theses issues. This article argues for the formulation of a landscape approach that integrates biotic and abiotic systems to envision more dynamic interactions among infrastructure, ecology, and urbanism. Conceptualized as *cyborg landscapes*, this approach embraces notions of change, adaptation, and feedback to create hybrid infrastructures of human and non-human systems, of living and non-living entities, across a range of spatial and temporal scales. Three examples illustrate that the profession is already (knowingly or unknowingly) working within this framework. Designed as co-dependent socioecological networks, these projects transform and choreograph landscape processes across multiple spatial and temporal scales. They promote an aesthetic that is predicated on relationships between dynamic things and systems. By stressing co-evolutionary processes between human agency and ecological systems, cyborg landscapes aspire to create multifunctional landscapes that do not simply operate in the present, but learn from experiences in order to adapt and grow smarter.

Cyborg landscapes / infrastructure / socioecological systems / climate change adaptation / regional planning

Introduction

In the age of the Anthropocene, we are increasingly confronted with messy and complicated relationships between nature and culture (*Wolff 2015*). The concept of the Anthropocene suggests that the accumulative actions of mankind have impacted land-use patterns and ecosystems to such a degree that even global nutrient cycles and biosphere processes have been altered as a result of this (*Crutzen 2002*). Humankind has now become 'a global geological force in its own right' (*Steffen et al. 2011: 843*).

In this context, Ellis and Ramankutty (2008) reveal that anthropogenic biomes—environments characterized by human-dominated land-uses–now cover a significantly larger area of the Earth's land than so-called 'wild' ecosystems. By the early twentieth century, as a result of large-scale land-clearing operations for the purposes of securing fuel (resource mining) and food production (agriculture), half of the world's land ecosystems had already been converted from mostly natural to anthropogenic (*Steffen et al. 2011*). The Millennium Ecosystem Assessment concluded that approximately 60 per cent (15 out of 24) of the ecosystem services—such as the provisioning of food and fresh water, disease and pest control, nutrient cycling, and climate regulation—were found severely degraded or used unsustainably (*World Health Organization 2005*). This means society can no longer solely rely on natural ecosystem services to provide a sustainable basis for future generations. Taking into consideration that nearly 1.2 billion people already live in extreme poverty, the prospect of providing sufficient access to food, water, and energy for an additional 2 billion people by 2050 further stresses the need to fundamentally change our relationship with the planet (*Olinto et al. 2013*).

Furthermore, the realities of climate change, ongoing urbanization, and loss of biodiversity at an unprecedented rate are clear signals that, from a spatial planning and design perspective, 'business as usual' is no longer responsible. Following the Anthropocene framework, we not only have to develop new ways of conceptualizing the environment as a product of complex interactions between anthropogenic forces and biophysical systems, we also have to envision new spatial relationships. Here, landscape architects have the capacity (and responsibility) to actively manipulate and choreograph diverse social and ecological processes in order to create more resilient landscapes.

Infrastructure design and adaptation is key to addressing these challenges (*Brown 2014*). As the interface between human and natural systems, networked infrastructures are essential for producing, facilitating, mediating, and transporting flows of water, food, energy, waste, goods, and services (*Bélanger 2009*). With global populations increasingly living in, and moving to, urbanized regions, the pressure on these infrastructural systems to perform well is critical. On the one hand, modern societies are facing high costs associated with maintaining infrastructures that have reached their lifespan (*Swilling 2011*). At the same time, emerging and developing nations are rapidly planning and implementing new large-scale infrastructural networks to improve their material standards of living. In both instances it is critical to ensure that future infrastructures are multifunctional, responsive to natural systems, and capable of adapting to a changing climate.

In this article, I argue through literature and project review for the formulation of a landscape approach that integrates biotic and abiotic systems to envision more dynamic interactions among infrastructure, ecology, and urbanism. Conceptualized as cyborg landscapes, this approach embraces notions of change, adaptation, and feedback to create hybrid infrastructures of human and non-human systems, of living and non-living entities, across a range of spatial and temporal scales. Whereas the term cyborg has enjoyed a great deal of attention in the fields of sociology, urban geography, and political ecology in recent decades (*Haraway 1991, Swyngedouw 1996, Gandy 2005, Swyngedouw 2006*), the discipline of landscape architecture has yet to critically explore the usefulness of this concept. This article aims to fill this gap by focusing on the cyborg and its potential to aid the construction of symbiotic relationships between nature and technology, between environment and society. In doing so, it allows students, designers, and educators to imagine new ways of structuring resilient spatial and material relationships in order to address pressing social and environmental issues while enriching the experience of everyday life in the Anthropocene.

Infrastructure and design

Infrastructure is everywhere. Over the past two centuries, large-scale infrastructure developments have enabled the rapid growth of sociotechnical networks, linking the human body to expansive ecological and technological environments (*Swyngedouw 1996, Mitchell 2004, Picon 2005, Gandy 2005*). From utilities, public works, civic improvements, and capital investments to technological systems and networks (physical, social, and cybernetic), infrastructures have constructed a myriad of multidimensional networks that underpin contemporary urbanization. As such, infrastructure can be understood as 'life supports' fully embedded in our environment, channelling 'water, energy, information, people, goods, and wastes to and from the objects supported' (*Neuman 2006: 3*).

At the same time, infrastructures are both transparent and opaque. They are either hidden underground (pipes, cables, tubes, and conduits) or have become so ubiquitous that they remain largely invisible except for when these systems fail (*Bélanger 2009*). Here, the immediate impacts of blackouts, structure collapses, or server failures, for example, remind us of the 'utter reliance of contemporary urban life on networked infrastructures' (*Graham and Marvin 2001: 22–23*). Due to underfunded maintenance budgets, these system failures are a perpetual concern (*Brown 2014*).

Whether by regulating temperatures, providing electricity, diverting water, or enabling the growth and distribution of fresh fruit in the winter, infrastructures also help to control and seemingly eliminate variability and dynamics inherent to natural systems. This has enabled the development of artificial environments that require significant inputs of materials and natural resources. Irrigation infrastructure, for example, has promoted the cultivation of agricultural crops over extensive areas. In addition to requiring substantial quantities of water and energy to operate, this system has also allowed for crop production in places that would otherwise be impossible owing to climate and soil limitations (*Cantrell and Holzman 2016*).

The implementation of infrastructures, such as dams and roads, has also led to landscape changes that range from small-scale land-use transformations to the emergence of wholly new environments at regional scales (*Lokman 2016*). The accumulated effects of these infrastructural interventions continue to change and alter ecosystems and material processes in foreseen and unforeseen ways.

In extension, many existing infrastructures are designed based on outdated modes of thinking. For much of the nineteenth and twentieth centuries, infrastructure design was based on a command-and-control attitude towards natural systems, promoting ideas of stability, efficiency, monofunctionality, and permanence (*Bélanger 2009*). Instead of establishing relationships with other actors, objects, and processes in the landscapes, traditional infrastructural systems are often rigid, inflexible and disconnected from their immediate environments. They work counter to current paradigms in both social and natural sciences, which emphasize that socioecological systems are driven by 'non-linear dynamics, feedback between entities at different hierarchical levels, emergence, and, for regional landscapes, constantly changing external drivers or boundary conditions (e.g. environmental variability, climate change, global economy)' (*Parrott and Meyer 2012: 384*).

Taken together, it is critical to formulate how (contemporary) infrastructural systems can be (re)designed to fit within this framework. This starts by approaching infrastructure not simply as an engineering project, but as a tool to structure new relationships and spatial qualities (*Allen 2010, LeCavalier 2010*).

Beyond merely satisfying the technological and utilitarian requirements of a project, infrastructure has the potential to integrate social needs and biophysical processes to create a greater and longer-lasting impact. A levee, for example, can be more than a flood-control infrastructure to protect adjacent low-lying agricultural land and settlements; by expanding its scope to meet a broader set of goals and constituents (including ecological systems and non-human needs), levees can be redesigned to accommodate a variety of inundation regimes to stimulate sediment deposition supporting the development of wetlands and marshes. These marshes, in turn, can assist with the treatment of wastewater, create critical habitat, and provide spaces for recreation. This way, infrastructure has the agency to cultivate and enhance a series of social and ecological relationships and conditions.

Architects Mason White, Lola Sheppard, and Neeraj Bhatia have used the terms coupling and opportunism to further explore the possibilities of future infrastructures. Here, infrastructure becomes a tool to create new socioecological systems and spatial experiences by choreographing 'opportunistic associations between economy, ecology, politics and information' (*White et al. 2010: 9*). In this expanded framework, infrastructure design concerns not only the physical object, but the way the object performs and organizes relationships within a larger environment (*Easterling 1999*). Along these lines, James Corner (*2006: 31*) argues:

> Urban infrastructure sows the seeds of future possibility, staging the ground for both uncertainty and promise. The preparation of surfaces for future appropriation differs from merely formal interest in single surface construction. It is more strategic, emphasizing means over ends, and operational logic over compositional design.

This provides tremendous opportunities for landscape architecture, a discipline fundamentally engaged in designing productive relationships between users (human and non-human), physical objects, and ecological processes. But how do we create infrastructures that shape dynamic social and ecological processes that are able to adapt to changing conditions over time? How do we interact with these environments? How do we balance human agency with processes of self-organization? I will try to answer these questions by exploring the term cyborg; first as a conceptual framework, and subsequently as a landscape-making practice to spatially articulate notions of integration, synthesis, and hybridity.

The cyborg as a conceptual framework

Technology is often discussed 'as if it were a free-floating set of ideas and applications that are removed from the material, social, and cultural practices through which they were established' (*Allen 2007: 30*). This view strengthens a belief that humans are somehow totally independent from the broader environment, ignoring the hybrid relationships created between technologies, their users, and biophysical systems. Timothy Kaufman-Osborn, a theorist of technology, suggests that instead of approaching technology as a thing or object to be implemented or manipulated, it should be understood as an extension of what it means to be human (*Kaufman-Osborn 1997*). Kaufman-Osborn suggests that just like a spider and her web form a co-evolving relationship as a means to catch food, capture water, and provide protection by continuously adapting to the surrounding environment, humans are also socially, biologically, and technologically embedded. As the interface between humans and the environment, infrastructure is a key agent in shaping these hybrid relationships. In this context, recent literature in the fields of political ecology and urban studies have appropriated the term cyborg as a conceptual tool to describe emerging techno-natures and hybrid environments (*Gandy 2005, Swyngedouw 2006, Wilson 2009*).

Among these, Donna Haraway's theorizing of the cyborg and associated human and non-human relations offers a particularly relevant perspective to inform our discussion. In her essay 'Manifesto for Cyborgs: Science, Technology, and Socialist Feminism' (1985, revised and reprinted in 1991), Haraway uses the concept of the cyborg to discuss the proliferation of organism/machine hybrids and as a framework to interrogate longstanding dualisms such as nature/culture, man/woman, self/other, etc. Both a material manifestation and metaphor, Haraway's notion of the cyborg emphasizes a recombinant and integrated way of thinking where distinctions between nature and culture are completely dissolved. She posits: 'Since the cyborg does not exist as nature or culture, but is rather a hybrid of both and more, it is not limited by traditional binarisms and dualist paradigms. The cyborg exists as a kind of unfettered self' (*Haraway 1991: 151*).

According to Haraway, the cyborg transcends various boundaries: between human and animal, between organism and machine, and between the physical and the non-physical. The material manifestation and functioning of cyborgs varies based on internal relationships between its organic components and its machine attributes. It is through this interdependent and evolving network of connections and communications between organism and machine that the cyborg becomes a hybrid entity. Feedback mechanisms and non-hierarchical connections also make the cyborg dynamic and adaptive, enabling the construction of new identities, relationships, and environments.

In the context of spatial design practices, urban geographer Matthew Gandy proposes that the concept of the cyborg has the power to guide 'an imaginative response to the unknowability of the city' by producing a 'landscape exhibiting different forms of integration between the body, technology and social practices' (*Gandy 2005: 42*). In other words, for designers, beyond a conceptual tool, the promise of the cyborg lies in its ability to inform new landscape-making practices. Concerned with constructing relationships between art and science, the natural and artificial, the real and the imaginary, the cyborg points to a landscape architectural design methodology where humans, non-humans, and technologies (including infrastructures) are fully embedded and always interacting with one another.

To date, only a few works have reflected on the relevancy of the cyborg in the context of contemporary landscape architecture, namely Elizabeth Meyer's *The Expanded Field of Landscape Architecture* (1997), and *Responsive Landscapes* (2016) by Bradley Cantrell and Justine Holzman. The following section will highlight relevant ideas and issues raised in each of these texts.

The cyborg as a landscape-making practice: landscape hybrids and responsive landscapes

Two decades ago, Elizabeth Meyer (*1997*) was the first landscape theorist to discuss how certain designed landscapes can be understood as hybrids, or cyborgs (Meyer uses these terms interchangeably), that seek to eliminate the distinction between human and nonhuman nature. Meyer introduces the term landscape cyborg to describe a category of landscape architectural projects that occupy a 'space between man-made and natural, machine and organism' (*Meyer 1997: 66*). She highlights three specific projects to elucidate this concept.

Firstly, Olmsted's Emerald Necklace in Boston, an innovative system of parks and parkways that integrated ideas of sanitation, recreation, mobility, and flood control to 'shape a hybrid of natural and cultural systems' (*Meyer 1997: 65*). In what can be understood as an early example of green infrastructure, Meyer suggests the project also introduced a new aesthetic, which was 'neither pastoral nor picturesque nor gardenesque' (*Meyer 1997: 66*). Secondly, Bos Park in Amsterdam, where the designers embraced simple engineering techniques, dynamic landscape processes, and progressive management practices to create a landscape that simultaneously takes into account social and ecological systems. Meyer asserts that Bos Park is 'not a static, idealized scene—a universal conception of the pastoral. It is a changing, evolving, and productive site that is dependent upon the care of human nature' (*Meyer 1997: 67–68*). Lastly, OMA's Parc de la Villette, the oft-cited second-prize winning proposal that envisions landscape as a repetitive and non-hierarchical structure of organic and artificial elements that can be generated over time. According to Meyer, the proposal

> . . . does not rely on binary opposites such as architecture and nature, artificial and natural. Instead, nature is conceived as a building material . . . The park is open-ended in its form as it is conceived as a strategy for growth, both human and nonhuman, cultural and natural' (*Meyer 1997, 68*).

Consistent in the interpretation of each of these projects is Meyer's use of the cyborg concept as a means to describe how human and natural systems can be structured in dynamic ways to cultivate spatial typologies that challenge conventional aesthetics. Meyer states: 'Like the Emerald Necklace a century ago, La Villette and Bos Park express a '*systems aesthetic*'—an aesthetic that is concerned with the relationships between things, not the things themselves' (*Meyer 1997: 66*, italics added). And while dynamic conceptions of nature and hybrid appearances are certainly important and relevant, these projects do not fully integrate the multi-layered understanding of the cyborg concept as discussed by Haraway. In particular, the examples fall short in illustrating how designed landscapes can structure co-dependent relationships and feedback mechanisms between both human and non-human, and organic and inorganic systems.

However, since Meyer published her article, the discipline of landscape architecture has significantly expanded both professionally and theoretically. Over the past couple of decades we have seen the emergence of new analytical tools, conceptual frameworks, and design approaches that have aided the development of new modes of practice (*Corner and Hirsch 2014, Reed and Lister 2014*). Among these more recent contributions is *Responsive Landscapes* (*2016*), a book by landscape architects Bradley Cantrell and Justine Holzman that outlines different ways in which designers can integrate responsive technologies to create dynamic interfaces between users and the built environment.

In the book's foreword, Jason Kelly Johnson and Nataly Gattegno describe responsive landscapes as 'an emerging world of robotic ecologies, where matter at all scales is programmable, parametric, networked, and laden with artificial intelligence' (*Johnson and Gattegno 2016: xvii*). Building on *Responsive Environments* (*2006*) by Lucy Bullivant and *Interactive Architecture* (*2009*) by Michael Fox and Miles Kemp, Cantrell and Holzman continue to explore the growing importance and ubiquity of technology and open-source data, which provide designers new opportunities to create synthetic ecologies informed by the co-evolution of biophysical systems, programmable devices, and infrastructural systems.

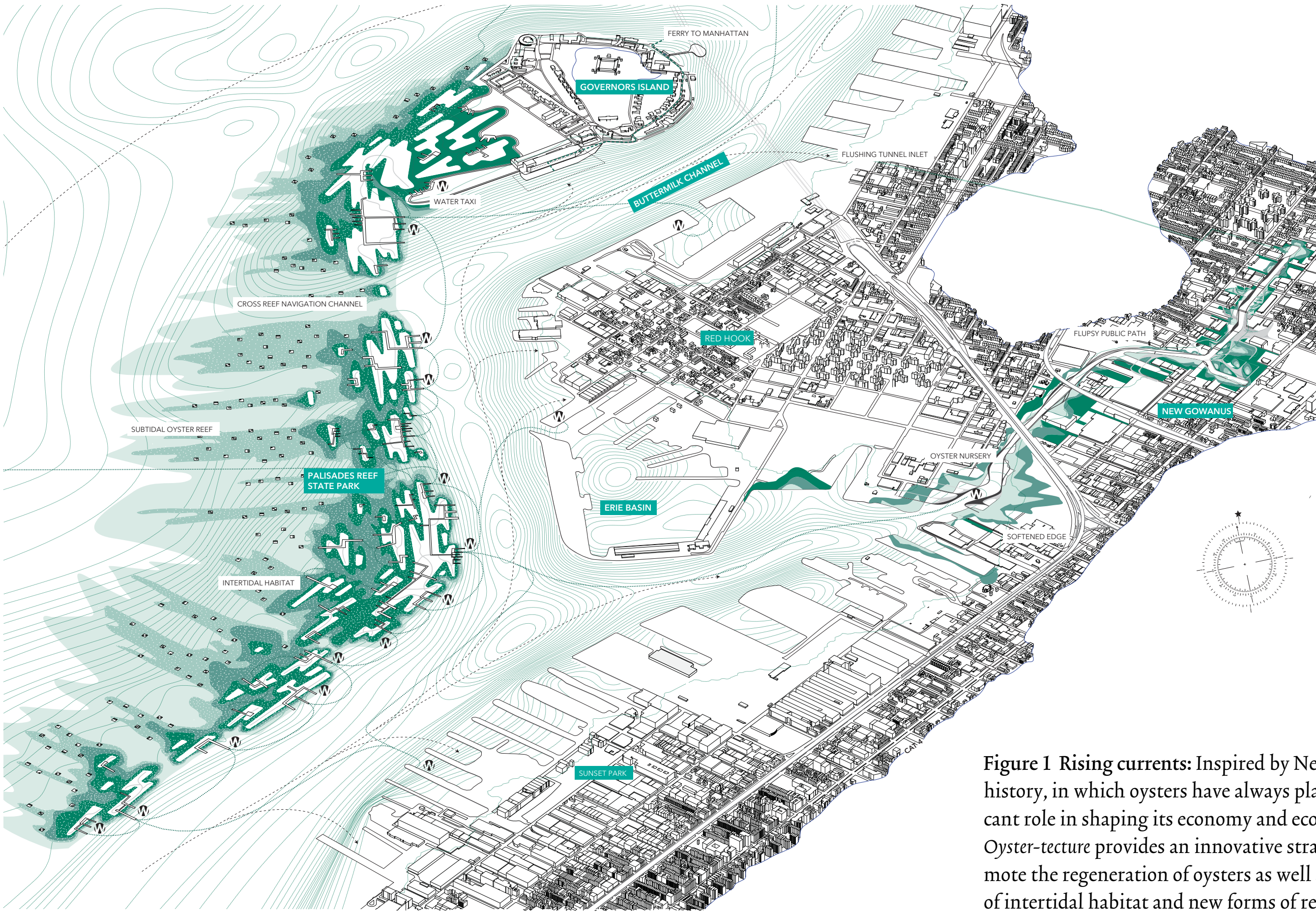
They approach technology as a medium to both augment the existing physical environment, as well as a system that increases our perception and engagement with the surroundings: 'Response or interaction denotes a full cycle where a phenomenon is sensed, the data is processed, and it is then actuated entering into a feedback loop where the product continues to be sensed, processed, and actuated again' (*Cantrell and Holzman 2016: 23*). Designed intelligently, these immersive environments not only change the way users perceive their context, but also enable buildings and landscapes to respond and adapt to changing conditions. Similarly, responsive technologies can help sense, visualize, and augment material-based processes over various temporal and spatial scales in order to inform future landscape transformations. Cantrell and Holzman (*2016: 15*) suggest: 'The landscapes that we can begin to imagine have the capacity to not only embed themselves within their context, but can also evolve with a life of their own, a synthesis between the biological, mechanical, and computational.'

In order to explore these opportunities, the authors introduce six different terms: elucidate, compress, displace, connect, ambient, and modify, each framing different ways for designers to utilize responsive technologies in contemporary practice. But while the essays and case studies are informative, well-thought-out, and help to establish new methods for creating interactive and sensor-laden environments, most of the examples concern relatively small-scale experiments and prototypes that are difficult to characterize as landscapes. As the authors themselves acknowledge: 'While many of the selected projects are not specifically "landscapes", each engages landscape in important ways and develops a pragmatic framework to understand responsive methods in a new context' (*Cantrell and Holzman 2016: 16*).

However, the book includes a couple of projects that do operate at a landscape scale. Among them is *Pod Mod*, which will be discussed in more detail in the following section. This project demonstrates how knowledge gained from robotic devices, modelling software, and data visualization not only enables designers to better understand the dynamics of hybrid socioecological systems, but also becomes a design tool to help guide and inform strategic interventions that can change landscapes physically. According to Cantrell and Holzman (*2016: 47*, emphasis added), 'this is a form of landscape that conceptualizes a *cyborg*—an integrated whole that is formed from integrated processes that are biotic and abiotic.' And while responsive technologies play a key role in shaping these landscapes, the authors state that 'the cyborg speaks to a smartness that goes beyond an environment laden with ubiquitous computing devices' (*Cantrell and Holzman 2016: 47*).

Thus, while the notion of a cyborg landscape can be understood as a responsive landscape, not every responsive landscape is a cyborg. This is because cyborgs are dynamic, affecting change and actively shaping new relationships and feedback mechanisms between biotic and abiotic systems. Responsive landscapes that use robotic devices or computation to merely visualize or simulate climatic phenomena and biophysical processes (without directly affecting or changing these systems) should therefore not be considered as cyborgs.

Moving forward, based on the work of Haraway, Meyer, and Cantrell and Holzman, I would like to make a case for conceptualizing the cyborg as a landscape-making practice that promotes feedback loops and agency, whereby humans, animals, plants, inorganic matter, and biosphere processes create a network of actors and relationships that are mutually dependent and constantly changing. I propose the term cyborg landscapes to characterize landscape architectural projects that address and communicate these ideas. Moreover, cyborg landscapes employ a methodology that is infrastructural, integrative, and productive. Given the implications of climate change, population growth, and issues linked to natural resource management, these landscapes work with biophysical processes to cultivate beneficial spinoffs and by-products such as food, energy, clean water, and so on. Embracing processes and systems of self-organization and non-linearity, cyborg landscapes have the ability to change and respond to changing conditions, thereby building adaptive capacity and increasing a system's resilience. This produces landscapes that are opportunistic and ever-changing, offering opportunities for learning, experimentation, and adaptation.



COURTESY OF KATE ORFF / SCAPE LANDSCAPE ARCHITECTURE

Figure 1 Rising currents: Inspired by New York's history, in which oysters have always played a significant role in shaping its economy and ecosystems, *Oyster-tecture* provides an innovative strategy to promote the regeneration of oysters as well as the creation of intertidal habitat and new forms of recreation.

Cyborg landscapes: three speculative design projects

In order to further illustrate the spatial, temporal, material, and aesthetic aspects of cyborg landscapes, I will now discuss three speculative design projects. Each project reveals different ways in which designers can reimagine intelligent and mutualistic relationships between ecology, infrastructure, technology, and society.

1. Oyster-tecture

Oyster-tecture, developed by SCAPE Landscape Architecture/Kate Orff as part of MoMA's Rising Currents exhibition in 2010 (Fig. 1), connects site-specific infrastructural interventions at various locations along Brooklyn's waterfront to global challenges related to rising sea levels and estuary habitat restoration. Here, water—remediated by oysters and mussels—shapes a fluid geography that connects a network of interdependent infrastructures across a range of scales. The project establishes a physical scaffold for the cultivation and co-evolution of socioecological systems. At the core of this is a belief in a post-human society where people and animals co-exist and 'prosper on mutually beneficial terms' (*Orff 2016: 86*).

As the name suggests, the project employs oysters both metaphorically and operationally to construct new spatial, metabolic, and aesthetic conditions and assemblages. With their tremendous nutrient-filtering capacity, oysters are uniquely adapted to deal with the nitrogen-rich aquatic environment of the post-industrial Gowanus Bay. The designed low-tech FLUPSYs (floating upwelling systems) act as habitat islands for the growth of spats (oysters in their larval stage). Once matured, the spats are transferred to the intertidal zone of the Bay Ridge Flats. Here, the artificially seeded shellfish species are attached to an armature of polyethylene fuzzy rope and old wharf piles, creating a living reef for people, aquatic species, and birds. Over time, through the establishment of dynamic interactions between a diversity of species, the reef becomes a living breakwater that acts as both as a unique ecosystem and wave-attenuating armature to protect the coast from storm surges and rising sea levels (Figs. 2 & 3).

Oyster-tecture not only promotes 'the pragmatic and productive entanglement of industrial and ecological uses' (*Harrison 2013: 361*), it also seamlessly integrates opportunities for new public programmes, education, recreation space, and over time, culinary experiences. The result is a cyborg landscape that is visible and tangible—revealing and spatializing interdependent relationships between humans and non-humans as well as living and non-living things (Fig. 4).

Living Breakwaters, an ongoing project by SCAPE Landscape Architecture, advances many ideas initially developed in *Oyster-tecture*. As the title suggests, the project supports ways of integrating habitat development with flood protection and social resiliency frameworks to foster new shoreline cultures, economies, and ecologies (*Orff 2016*). As one of the six winners of the international Rebuild by Design competition—a public-private partnership initiated to solicit innovative design approaches to revitalize the Hurricane Sandy-affected region—*Living Breakwaters* was adopted by the US Department of Housing and Urban Development in 2014 and is currently in design development. The fact that this type of project is under agency review and moving towards implementation underlines the preparedness of planners, engineers, decision-makers, and coastal communities to experiment with adaptive planning approaches and envision more dynamic relations among humans, nonhumans, and infrastructure.

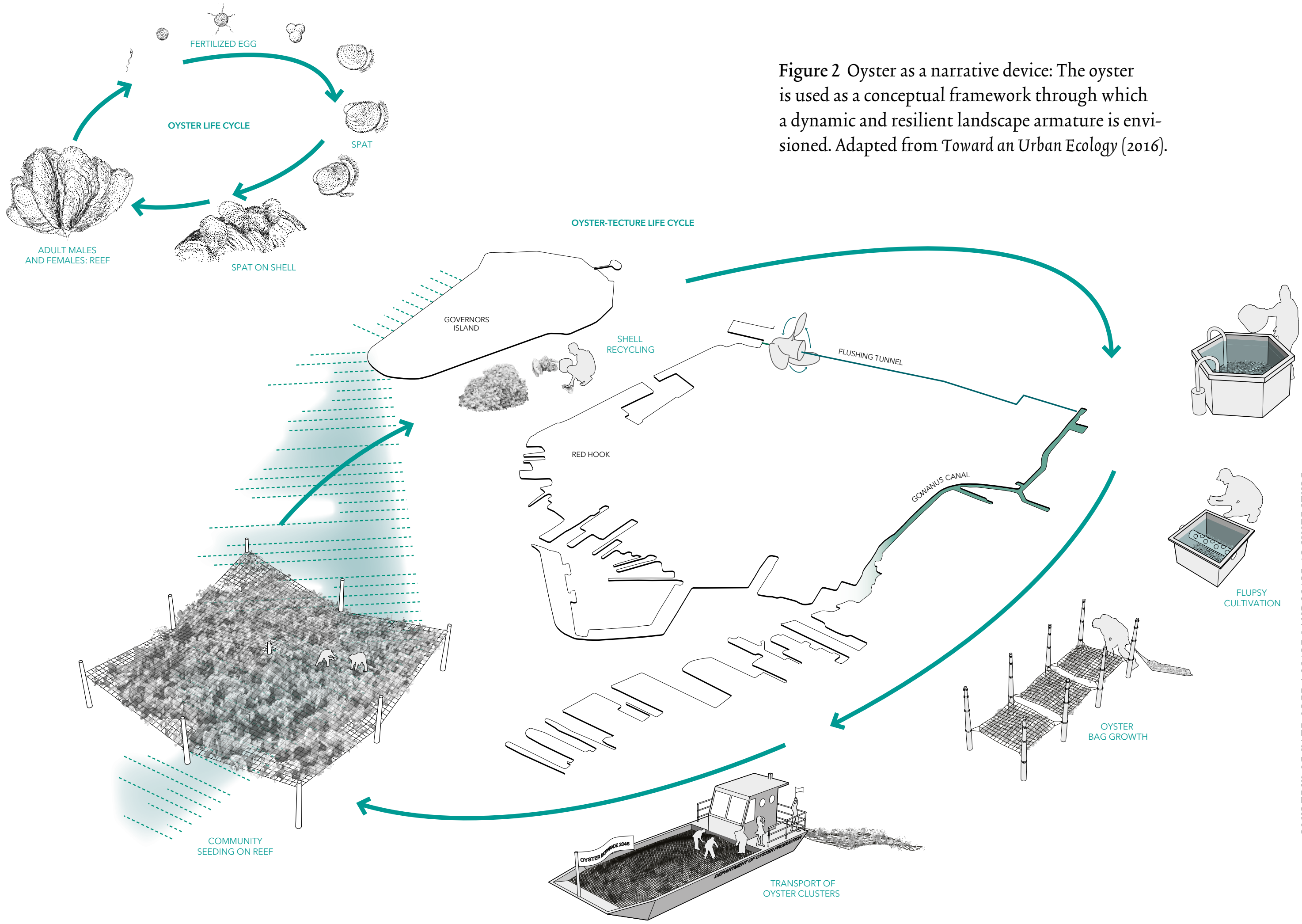
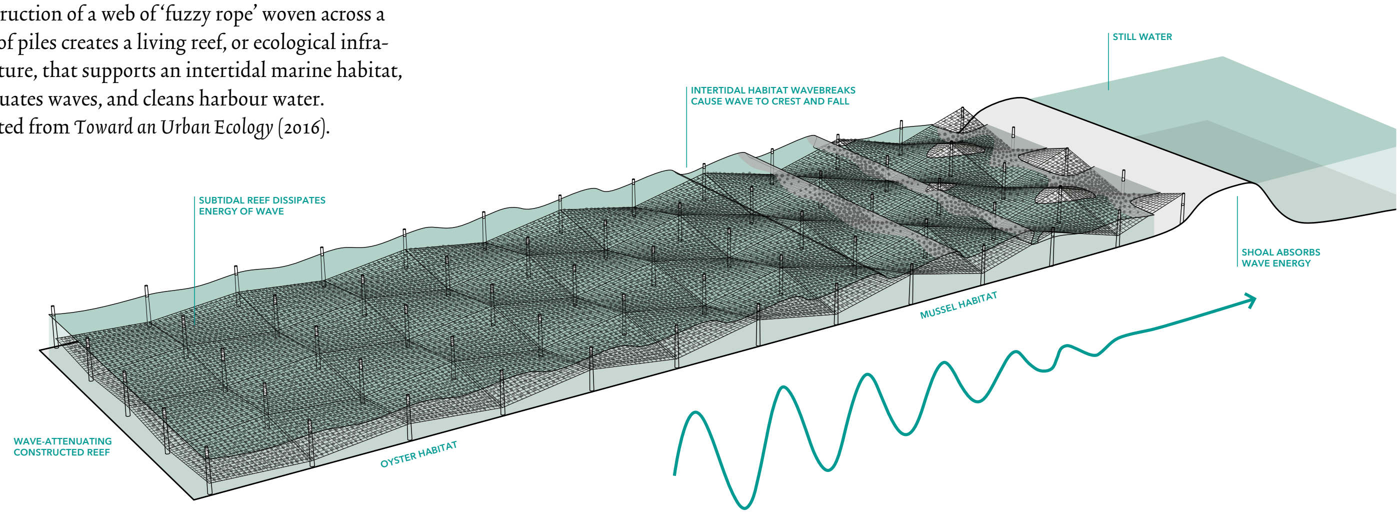


Figure 2 Oyster as a narrative device: The oyster is used as a conceptual framework through which a dynamic and resilient landscape armature is envisioned. Adapted from *Toward an Urban Ecology* (2016).

COURTESY OF KATE ORFF / SCAPE LANDSCAPE ARCHITECTURE

Figure 3 Ecological infrastructure: A simple, low-tech construction of a web of 'fuzzy rope' woven across a field of piles creates a living reef, or ecological infrastructure, that supports an intertidal marine habitat, attenuates waves, and cleans harbour water. Adapted from *Toward an Urban Ecology* (2016).



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COURTESY OF KATE ORFF / SCAPE LANDSCAPE ARCHITECTURE

Figure 4 Ecological infrastructure: As a series of inhabitable archipelagos for both humans and non-humans, the fuzzy rope armatures in the Bay Ridge Flats become a new marine park for the New York region.

COURTESY OF ROB MACHIDA AND MARK WOYTIUK

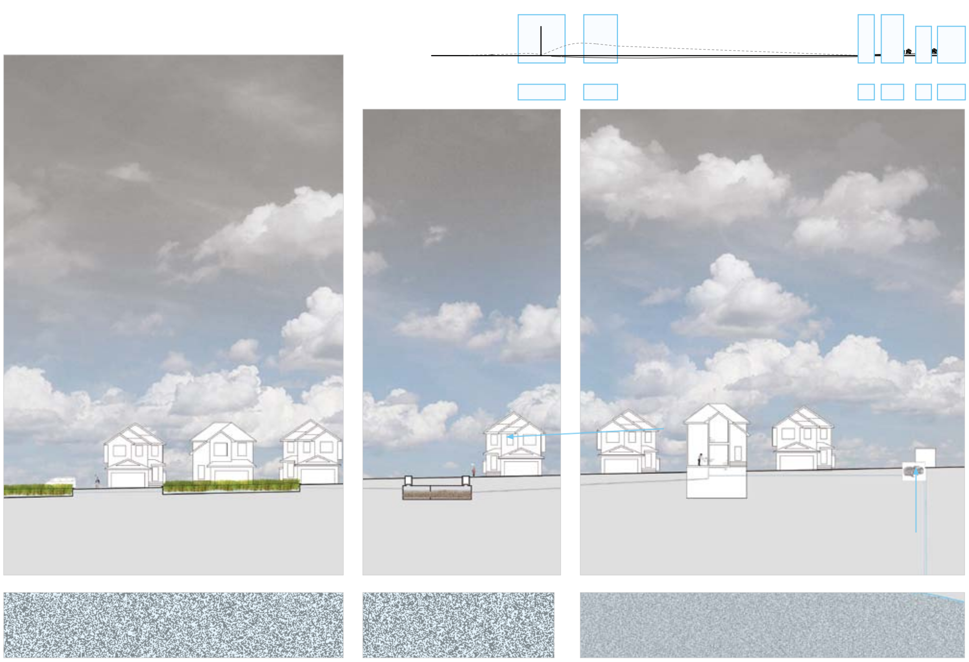
2. Mega Snow Fence

Envisioned by Rob Machida and Mark Woytiuk, the following proposal can be understood as a cyborg landscape that is ‘part natural part social, part technical part cultural, but with no clear boundaries’ (*Swyngedouw 2006: 118*). Situated within the Edmonton-Calgary Corridor, the *Mega Snow Fence* leverages the operative logic and spatial characteristics of existing regional infrastructural archetypes in order to produce a dynamic environment that couples multiple social and ecological programmes.

The proposal directly responds to the Alberta Clipper—a synoptic-scale weather phenomenon in North America that produces a very fast-moving low-pressure system, usually during the months of December and January. Telecommunication towers are used as anchors for the construction of a superstructure in order to create a wind-shallow zone. During heavy winds, snow particles are suspended from the structure, forming large drifts behind the fence. Over time, the weight of the snow compacts the soil and creates a water-filled depression resembling a prairie pothole, a type of shallow wetland which is common in the region. The wetland not only creates a physical framework and amenity for future urban developments, but the water can also be used to recharge regional aquifers that have been depleted due to large-scale withdrawals for farming operations and municipal/industrial use over the past century. Moreover, by adjusting the length and orientation of the structure, the size and position of the wetland can be modified and reconfigured (Figs. 5 & 6).

The high wind speeds at the top of the *Mega Snow Fence* are leveraged for energy production and to supercharge a lake aerator system that reinforces the health of the wetland. This way nearby housing developments with conventional grey infrastructures can be coupled with biophysical treatment methods to treat municipal wastewater. The project also provides unique opportunities for the development of lakeside living and a variety of seasonal recreational opportunities. The 50-m vented sails become ‘a register of both the prevailing weather and the otherwise discrete infrastructure that makes suburban living possible’ (*Machida and Woyiuk 2015: 139*). Its visual, physical, and performative elements help ground the project in a way that is radically different from the ‘geographies of nowhere’ of typical suburban developments (*Kunstler 1993*) (Fig. 7).

By referencing and reconfiguring existing infrastructural archetypes, the *Mega Snow Fence* produces a familiar yet radically new environment. The project integrates ‘socio-physical constructions that are actively and historically produced, both in terms of social content and physical-environmental qualities’ (*Swyngedouw 2006: 118*). The relationship between infrastructures and non-material actants—in this instance atmospheric phenomena and biological processes—become key drivers for setting up new socioenvironmental processes and metabolic relationships. The *Mega Snow Fence* illustrates how hard infrastructures (material/mechanic) and soft infrastructures (biophysical/organic) can be calibrated to produce a co-evolving landscape that is fully intertwined.



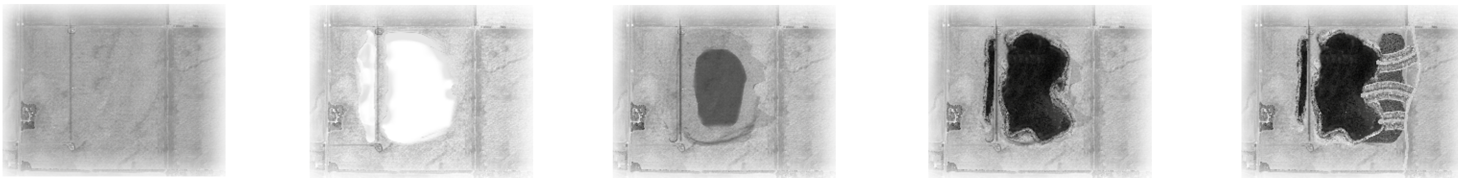
Constructed wetland boxes sit in the the middle of the residential roads, taking pumped surface run from septic tanks acting as secondary microbiotic treatment vessels.

Large communal septic tanks act as primary treatment vessels (settling and anaerobic breakdown).

Water is pumped from the underground aquifer and used by the wind-sheltered community.

Figure 5 Operative logic: The *Mega Snow Fence* directly interacts with complex processes of wind, moisture, soil, and shelter. It defines boundaries, produces synthetic ecologies, generates energy, and lends itself to alternative programmes.

Deployment phases



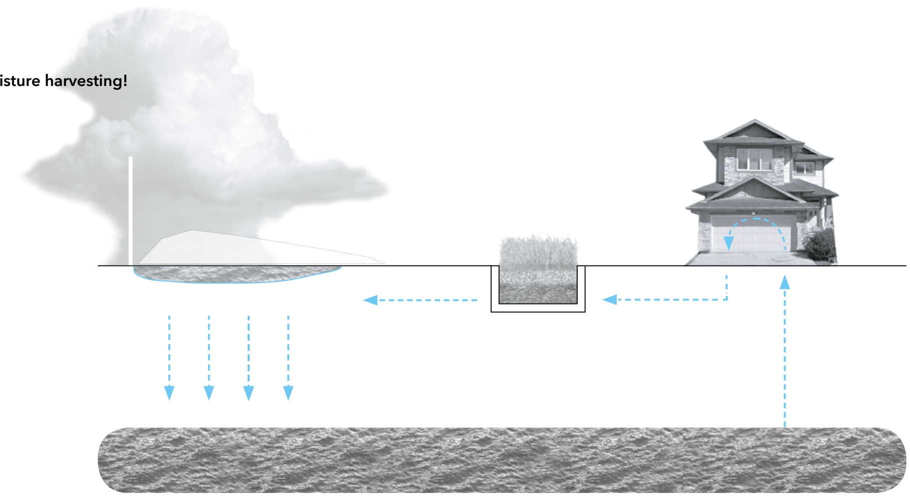
Year 1
Snow fence is put in.

Year 1 (Winter)
Drift creation

Year 1 (Summer)
Depression and soil compaction slows infiltration.

Year 2 (Summer)
Wetland/lake system starts to become established.

Year 4 (Summer)
Natural shelter belt is established.



COURTESY OF ROB MACHIDA AND MARK WOYTIUK

Figure 6 Moisture harvesting: The structure promotes the cultivation of a new water body over time, providing fish and wildlife habitat, a recreational amenity for new developments, and a resource to recharge local aquifers.

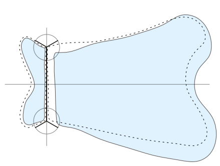
Optimal snow fence configurations

The configuration of the snow fence wetland generator responds to predominant wind conditions. Each configuration results in an approximate wetland shape and orientation that reflects prevailing winter winds of the region.

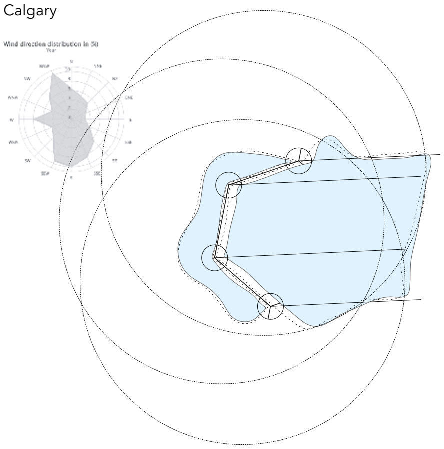
Test configuration

Assuming primarily westerly winds

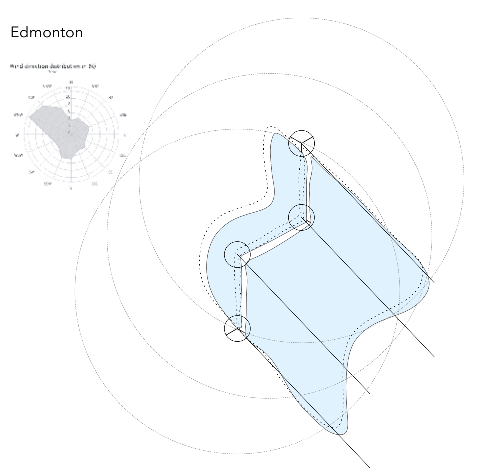
100 m



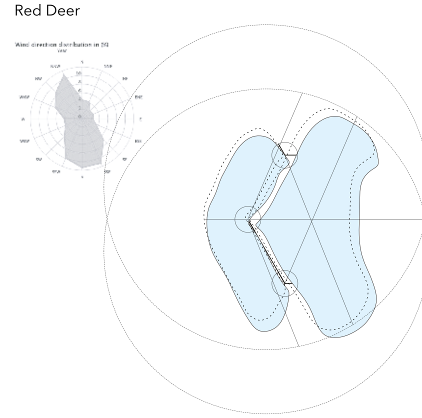
Calgary



Edmonton



Red Deer



COURTESY OF ROB MACHIDA AND MARK WOYTIUK

Figure 7 Configurations: Depending on the direction of prevailing winter winds, the *Mega Snow Fence* can be implemented in multiple configurations to optimize wind shelter and snow deposition patterns.

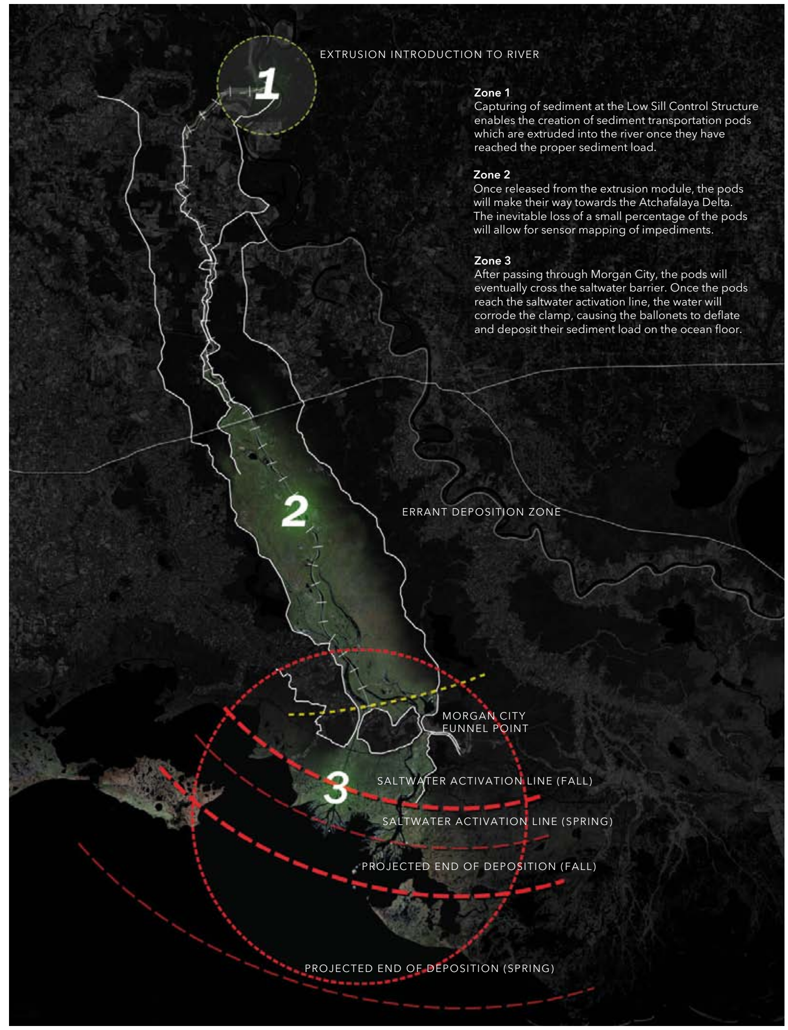


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Figure 8 Sedimentation zones: The *Pod Mod* proposal manipulates the ways in which sediment is being distributed from the Old River Control Structure to the Gulf of Mexico.

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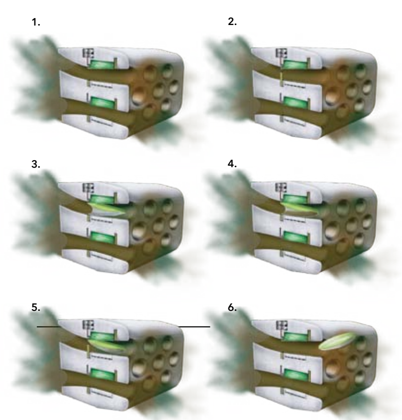
Detailed cutaway of extrusion module showing inner components and scale reference figure

A Wildlife exclusion mesh
B Extrusion port
C Sleeve loading bay mechanism
D Air tanks
E Air lines
F Transportation pod sleeves
G Clamping mechanism
H Pressure sensor
I Extrusion panel



Sequential diagrams of sediment pod extrusion process

1. Sediment-laden water begins flowing through the extrusion module.
2. The sediment transportation pod sleeve is pulled down from the loading bay.
3. The transportation mesh portion of the pod is stretched across the extrusion port.
4. Water filters through the transportation mesh, leaving the gathered sediment behind.
5. Once the pod reaches a desired weight, the transportation mesh and inflatable ballonet portion of the pod are sealed with a corrosive clamp.
6. The pod receives a burst of air inflating the ballonet, expelling the pod from the module.

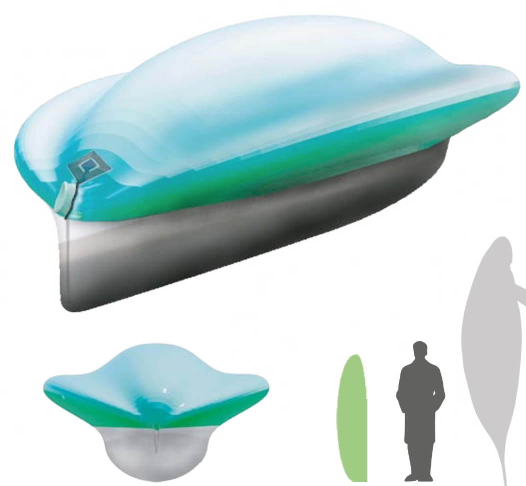
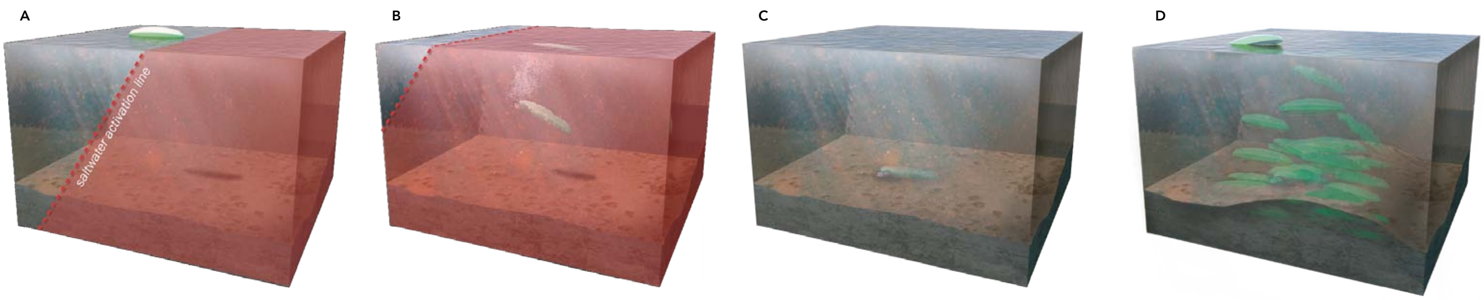


Figure 9 *Pod Mod* attachments: Detailed cutaway of the extrusion module, scale comparison drawings, and sequential diagrams of the sediment pod extrusion process from the Old River Control Structure.



A Once the pods pass through the Morgan City funnel point, they come in contact with the saltwater barrier line which begins the deposition process.

B The salt in the water expedites the galvanic corrosion process in the clamp holding the ballonet closed. Once the clamp has degraded, the ballonet deflates, causing the pod to drop.

C The pod deposits with the RF sensor embedding the ballonet skin.

D As the pods begin to deposit on top of one another, they maintain some of their structural integrity, allowing them to mound. While the transportation pod itself will degrade, the RF sensors will remain, creating a traceable network of deposition.

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Figure 10 Extrusion modules: Sequential diagrams of the deposition process of the sediment transportation pods.

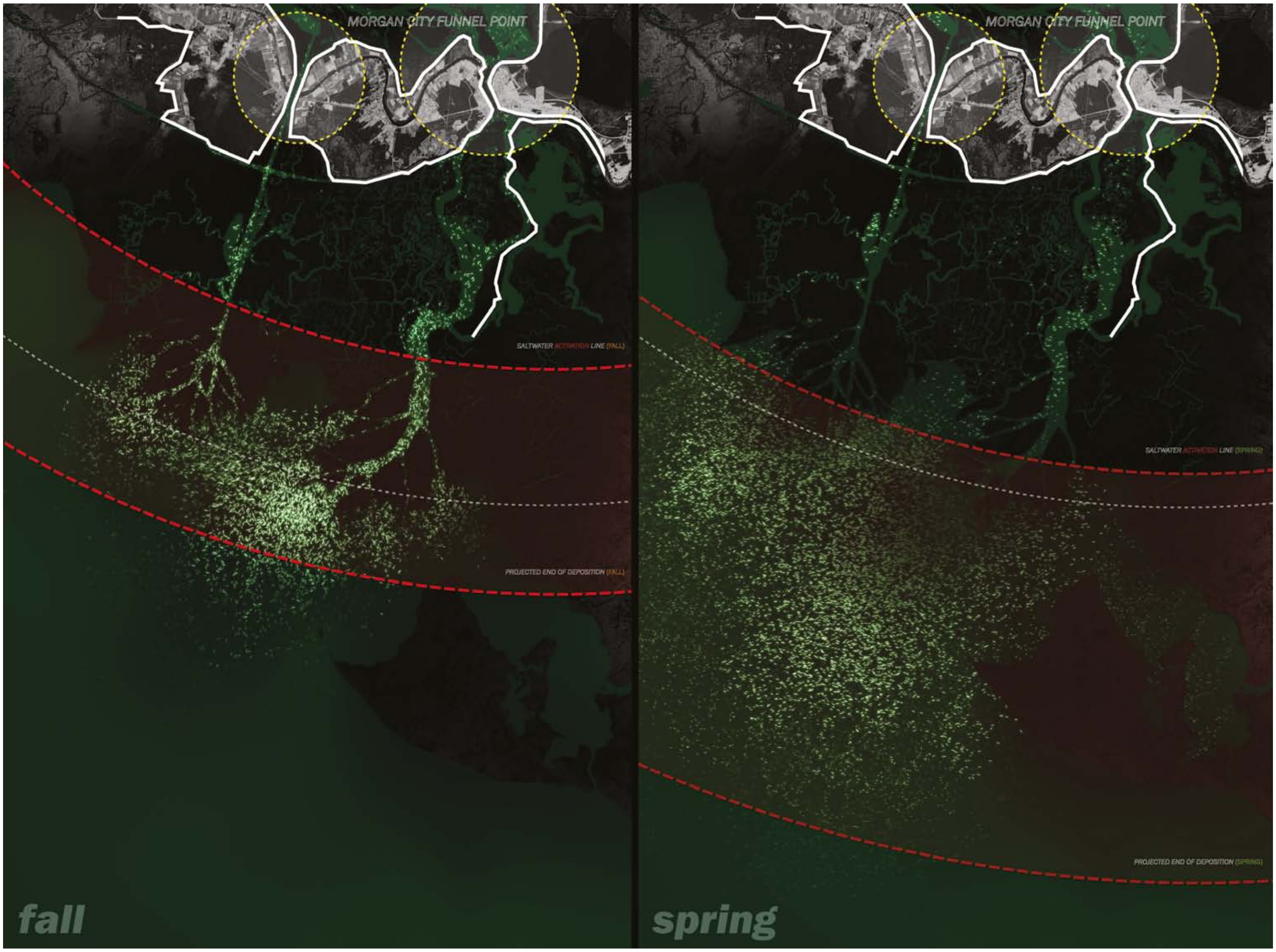
3. Pod Mod

The third example of cyborg landscapes is *Pod Mod* by Charlie Pruitt, Brennan Dedon, and Robert Herkes under the supervision of Bradley Cantrell, a speculative project that envisions a conveyance system of 'sediment pods' to collect existing sediment loads in the Mississippi River in order to transport them downriver for redistribution in the Atchafalaya Delta, thereby aiding and accelerating the construction of mudflats and coastal wetlands.

Today, the Old River Control Structure (completed in 1963) regulates the flow of water leaving the Mississippi River into the Atchafalaya River in order to prevent the Mississippi River from carving a new path to the Gulf of Mexico. Currently, 30 per cent of the water from the Mississippi River is diverted into the Atchafalaya River. However, the diversion also redirects 65 per cent of all sediment from the Mississippi River into the Atchafalaya Delta. The result is a significant sediment deficit in the Lower Mississippi Delta, which in combination with the rapid disappearance of coastal wetlands, makes the coastal system susceptible to flooding and damages as a result of climate change and storm surges. At the same time, much of the sediment deposited in the Atchafalaya Delta is lost to the relatively deep waters of the Gulf of Mexico. As such, the proposal aims to manipulate the ways in which sediment is being distributed within the Lower Mississippi Delta (Fig. 8).

Pod Mod proposes a modular conveyance system comprised of two units: the first is an 'extrusion module' that is integrated into the existing Old River Low Sill Control Structure, the second is a 'sediment pod' released from the extrusion module after a predetermined amount of sediment is captured (*Cantrell et al. 2012*). The sediment-filled modules are equipped with biodegradable ballonets, which allow them to float downriver. Once in the Atchafalaya Delta, the Gulf's saltwater triggers galvanic corrosion of a metal clamp, which in turn deflates the pod, depositing its sediment at the bottom of the ocean (*Cantrell et al. 2012*). Sensors embedded in the ballonets allow the pods to be tracked and linked to real-time visualizing software (Figs. 9 & 10).

The system not only optimizes sedimentation processes, it also reduces the amount of dredging needed, thus minimizing habitat disturbance and optimizing navigation. Understanding seasonal fluctuations of river water volumes and dynamics of the saltwater line, the release of pods can be coordinated to create beneficial environments for fish spawning or shipping, for example. As such, *Pod Mod* provides a simple yet bold and flexible solution that strategically manipulates natural processes in order to shape a resilient living coastal system to absorb storm surges and addresses sea level rise (Fig. 11). Fully embracing the Anthropocene, the project suggests a kind of planetary stewardship in which humans still manage the environment, but in a 'softer' and more responsive way, allowing for the cultivation of richer and more resilient nature-culture relations.



COURTESY OF CHARLIE PRUITT, BRENNAN DEDON, ROBERT HERKES. LSU RRSLA 2011 RESPONSIVE SYSTEMS STUDIO, BRADLEY CANTRELL AND FRANK MELENDEZ.

Figure 11 Deposition patterning: The number of sediment pods to be released from the Old River Control Structure can be adjusted according to seasonal fluctuations in water levels and the saltwater line. The result is a dynamic, two-way interface between human intention and geomorphological processes.

Blending the physical and non-physical, the proposal speculates on the ability of small, inexpensive, and data-driven sensors to be networked in order to reorganize geomorphological processes on a regional scale. The sediment pods not only change the timescale in which ecological processes work, but through real-time visualization, monitoring, and response, intelligence is embedded within the landscapes. The result is the emergence of what Cantrell himself calls 'a cyborg coast' (Cantrell quoted in *Strickland 2015*). Following Schuurman, the project illustrates that responsive landscapes are 'more than metal and flesh; they come to life in the presence of data' (*Schuurman 2004: 1337*). Thus, *Pod Mod* not only imagines productive interfaces between human intention, technology, and biophysical systems, it also reveals exciting possibilities for choreographing and manipulating future landscape processes, and informing adaptive management approaches.

Performance, adaptation, and resilience

In making a case for cyborg landscapes, the three examples discussed embrace the full complexity of socioecological processes and material life cycles across an extended footprint of urbanization. Capitalizing on the metabolic circulation of various material flows, these projects imagine infrastructural landscapes based on co-dependencies and interconnections among available resources and waste streams. They not only actively engage natural processes such as nutrient cycling, sediment flows, and atmospheric phenomena, but also produce food and energy, and initiate water purification, carbon sequestering, and phytoremediation. Yet, unlike the concept of landscape machines (*Roncken et al. 2011*), cyborg landscapes do not solely rely on landscape systems, but purposefully interweave synthetic materials in order to speed up or slow down biophysical processes, and to structure regenerative spatial relationships. In fact, as demonstrated by *Pod Mod*, the integration of technology and synthetic materials opens up opportunities for time-based programming, environmental modelling, and real-time visualization in order to embed intelligence within the built environment. The focus here shifts from designing systems of control to systems of interaction and co-evolution.

Cyborg landscapes also become key drivers for orchestrating, redistributing, or propelling processes of emergence and resilience in socioecological systems. In his seminal publication *Steps to an Ecology of Mind*, Gregory Bateson argued that a healthy 'ecosystem of human civilization' would depend on our ability to create nature-culture relationships that have high flexibility and are 'open-ended for slow change of even basic (hard-programmed) characteristics' (*Bateson 1972: 507*). For Bateson, the goal was to distribute flexibility among the many components of a system in order to make it less vulnerable to unpredictable change. He used the term 'preadaptation' to describe this capacity of a system to adapt and absorb change over time (*Bateson 1972*). This idea of preadaptation can be linked to our contemporary understandings of resilience, which Gunderson et al. (*2002: 6*) have defined as 'the strength of mutual reinforcement between processes, incorporating both the ability of a system to persist despite disruptions and the ability to regenerate and maintain existing organization'.

Within this context, I argue, cyborg landscapes create socioenvironmental and spatial conditions that have an 'uncommitted potentiality for change' (*Bateson 1972: 497*). Built-in feedback mechanisms allow them to respond and adapt to changes that develop as a result of ongoing interactions between living and non-living entities. As such, cyborg landscapes 'do not simply fit their surroundings, but positively affect that environment in various ways by affecting change in it' (*Foster 2000: 15–16*).

Furthermore, the nature of complex systems is such that local, regional, and global processes are completely intertwined and always interacting. Changing conditions at one scalar level can trigger the emergence of processes and relationships at others (*Parrott and Meyer 2012*). These conditions call on designers to integrate systems, devices, and feedback mechanisms that simultaneously take advantage of, and can adapt to, processes occurring at different scale levels. As the examples in this article have illustrated, the promise of cyborg landscapes is to shape resilient interactions between various 'hard' and 'soft' infrastructures in order to positively affect the material, behavioural, and spatial configuration of systems both locally and at larger landscape scales.

Moving forward: embracing hybrid approaches

We are no longer fully contained within our skins but part of an extended network of socioecological and sociotechnical relations (*Mitchell 2004, Picon 2005, Swyngedouw 2006*). The extraordinary scale of ongoing urbanization, combined with pressing challenges of climate change, global loss of biodiversity, and increasing water and food scarcity, poses tremendous challenges on a planetary scale. New ideas are necessary to reformulate relationships between social, environmental, and technological systems. This requires a cognitive shift that aims to overcome longstanding dualisms of nature and culture.

I have argued that in bringing together landscape design, infrastructure, and the concept of the cyborg, a framework emerges that enables landscape designers to shape future landscapes based on the integration and synthesis of human and non-human actors as well as biotic and abiotic processes. The three examples in this article illustrate how the profession is already (knowingly or unknowingly) working within this framework. Purposefully designed as co-dependent socioecological networks, these projects transform and choreograph landscape processes across multiple spatial and temporal scales. This results in new spatial and material conditions, exchanges, and temporalities that enrich the experience of everyday life; promoting an aesthetic that is predicated on relationships between dynamic things and systems, not static, single objects alone (*Meyer 1997*).

Cyborg landscapes also suggest a more open-ended relationship between planning, design, and implementation processes. Moving forward, future research is needed to explore how these projects can be fully implemented and realized. The focus here shifts from planning for fixed landscape forms to adaptive co-management strategies that rely on multistakeholder participation and learning-by-doing in order to respond to ongoing transformations of the built environment (*Parrott and Meyer 2012*). As Cantrell and Holzman (*2016*) have illustrated, this requires designers to test and develop new methods of simulation, prototyping, and monitoring.

Taken together, the design approach outlined in this article offers tremendous opportunities for the discipline of landscape architecture. The cyborg challenges us to reconsider our relationship with the environment and technology, thereby prompting designers to reimagine the physical nature of these metabolic interactions. An overemphasis on control and efficiency gives way to dynamic and open-ended linkages between people's intentions for the landscape and the non-anthropogenic forces at work. By structuring non-hierarchical relationships and co-evolutionary processes, it is possible to create more sustainable and resilient interactions among all elements, actors, and systems that make up complex socioecological systems. In doing so, cyborg landscapes aspire to create multifunctional landscapes that do not simply operate in the present, but learn from experiences in order to adapt and grow smarter over time.

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BIOGRAPHICAL NOTES

Kees Lokman is an assistant professor of Landscape Architecture at the University of British Columbia. He holds degrees in planning, urban design, and landscape architecture. His writing and academic research, which focus on the intersection of landscape, infrastructure, and ecology, has been published in various journals, including *Topos*, the *Journal of Architectural Education*, *LandscapesPaysages*, and *New Geographies*.

Kees is also the founder of Parallax Landscape, a collaborative and interdisciplinary design and research platform that explores design challenges related to water and food shortages, depleting energy resources, climate change, and ongoing urbanization. Parallax Landscape is the recipient of numerous design awards and recognitions.

CONTACT

Kees Lokman
The University of British Columbia
School of Architecture and Landscape Architecture
379 – 2357 Main Mall
Vancouver, BC V6T 1Z4, Canada
Phone: +1 604-827-3143
klokman@sala.ubc.ca
www.parallaxlandscape.com