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Convergence, transition, and variability in a co-produced waterscape

Moreton Bay is not (just) a bay. Framed in Western cartographic and scientific terms as a partially enclosed coastal waterbody, it is often reduced to a bounded geographic feature—a discrete object of management, development, or ecological concern. This paper resists such reductive framings. Instead, it argues that Moreton Bay—known as Quandamooka to Aboriginal people, its traditional custodians—is a dynamic and co-produced waterscape: a relational space shaped by the entanglement of cultural histories, ecological processes, hydrological systems, and colonial infrastructures. As such, the bay must be understood not as a passive backdrop for human action, but as an active and evolving socio-natural formation. This reframing invites a reconsideration of how landscape architects, designers, and researchers engage with watery places, attending not only to their ecological fragility or utility, but also to their ongoing, interdependent, and evolving cultural-hydrologies.

As the sole author of this paper, I write from the position of a non-Indigenous landscape architecture scholar and practitioner working on unceded Quandamooka Country. My engagement with Moreton Bay is informed by my disciplinary training, but equally by an evolving responsibility to attune to Country as a living, sovereign presence. Living aboard a boat on Moreton Bay's waters over several years has shaped an embodied understanding of its shifting spatio-temporalities and materialities—informing how I relate to the bay as a site of entangled knowledge and practice.

The methodology underpinning this research emerges from that relational positioning. It adopts a field-based and critically reflexive approach that weaves together lived experience, pedagogy, and research. Residing on the bay, teaching its ecological processes to undergraduate students, and drawing on scientific literature, design theory, and archival histories, the method cultivates a situated knowledge of Moreton Bay as a dynamic landscape. While I acknowledge the limits of my perspective in comprehending the full cultural and spiritual significance of this place, this work is offered in the spirit of attentive, respectful, and responsive engagement with water, people, and Country.

In the context of landscape architecture, "waterscape" offers a critical lens through which to reimagine coastal and aquatic environments, such as Moreton

Bay. Both "landscape" and "waterscape" share the suffix "-scape," which confers the expression of human activity on the material conditions of the environment.[1] Traditionally privileging terrestrial perspectives, "landscape" often overlooks the agentive and dynamic qualities of water. In contrast, "waterscape" reorients attention to watery environments as fluid systems shaped by entangled human and nonhuman actors, ecological processes, cultural practices, and infrastructural interventions. This conceptual shift invites more situated, responsive design approaches that attend to the dynamism, precarity, and potentiality of hydrological systems. As a waterscape, Moreton Bay functions as a site through which the interconnected logics of hydrological transformation, colonial legacy, capitalist extraction, and infrastructural intensification are rendered visible offering a rich example of just such a co-constituted "-scape."

Conceptualising waterscape

As a concept, waterscape carries varied meanings across disparate disciplines. In landscape architecture, it often refers to designed water features—fountains, reflective pools, water play areas, or constructed wetlands—that shape spatial experience, regulate microclimate, and invite sensory engagement. These waterscapes foreground water not only as infrastructure or ecology, but as a malleable and expressive design medium.

In this paper, however, waterscape is understood through a different lens: as a dynamic socio-natural formation in which water is both materially and symbolically produced through the entanglement of ecological processes, political structures, cultural imaginaries, and infrastructural systems. Rather than treating water as a neutral resource or "natural" element, the waterscape perspective foregrounds its inherently fluid, hybrid character emerging through the ongoing and contested co-constitution of natural and social domains.

This understanding of waterscape draws from contributions by new materialists, political ecologists, and environmental historians, who have foregrounded the need to rethink water beyond narrow disciplinary or functionalist framings.[2] In resisting closure by dominant epistemologies—particularly those rooted in hydrological science—the concept creates space for alternative ways of knowing and relating to water. Research into waterscapes has therefore provided a critical anchor for reshaping debates around water, highlighting its spatial, material, cultural, and political dimensions as interconnected and mutually constitutive.

Erik Swyngedouw's seminal work formulates waterscapes as inherently fluid, positioning them as resisting stable categorisation.[3] He argues that water cannot be fully understood through the deterministic logics of natural science, nor can it be reduced to a purely social construct. Instead, it exists in a constant state of transformation—flowing across physical geographies while simultaneously moving through cultural imaginaries and social systems. Rooted in political ecology, this perspective recognises that nature and society do not exist as separate spheres. Rather, they are intertwined in the production of hybrid socio-natures.[4] Swyngedouw's work in framing the Spanish waterscape exemplifies this through examining the intricate ways in which they are "fused . . . inseparable," producing water as a "restless hybrid."[5]

This conceptualisation of Moreton Bay as a waterscape foregrounds the dynamic co-production of socio-natural systems.[6] Here, "co-production" refers to the entangled processes through which human activities (such as urban development, agriculture, and conservation) and natural forces (like tides, sediment flows, and ecological succession) collectively shape the bay. Crucially, these entanglements are not symmetrical in scale, intensity, or intentionality. Colonial infrastructure and capitalist extraction do not merely entangle with ecological-cultural rhythms; they often overwhelm, displace, or redirect them. Moreton Bay's socio-natural formation emerges through uneven and historically charged interactions between human and nonhuman forces. This contested co-production highlights the asymmetries embedded within these multi-scalar interrelationships, challenging reductive binaries such as resilience versus degradation. For landscape architecture, this perspective demands a rethinking of the -scape suffix—not simply as a sign of human intervention, but as a marker of ongoing, uneven, and contested co-production across multiple scales.

Moreton Bay exemplifies these complex, entangled dynamics across catchment, regional, and local scales. As a waterscape, it has been reshaped by human intervention from Indigenous stewardship to post-colonial damming and dredging—all of which have altered the bay's chemistry, ecological function, and spatial character. At the same time, the bay's hydrodynamic forces—sediment flows, tidal rhythm, and currents—have conditioned patterns of settlement, land use, cultural practice, and environmental governance. These reciprocal processes foreground the co-production of the -scape, where human agency and ecological systems are mutually (though not equally nor benignly) constitutive.

The following analysis focuses on three aquatic zones within the bay, tracing how natural variability and human activity co-produce its distinctive spatial, cultural, and ecological contours. These zones—marginal reefs, intertidal edges, and a river mouth—form a transect through which the waterscape of Moreton Bay can be read. Each reveals how resilience and variability are emergent from ongoing and co-constituted processes.

***Convergence*: The waters of Moreton Bay** draws from landscape architectural, environmental humanities, and marine science perspectives to examine how convergence—of oceanic flows, riverine loads, and anthropogenic inputs—produces a uniquely dynamic waterscape. The bay's converging temperate and tropical waters offers a valuable case for understanding how "natural stressors" and human interventions can unintentionally or deliberately support adaptive processes.

***Transition*: Intertidal edges and creeping limits** positions the shoreline as a socio-ecological threshold—where sediment flows, tidal rhythms, and engineered structures interact to constantly redraw the land-sea boundary. Changing sea levels, infrastructural intervention, and the phenomenon of "mangrove creep" reveal uneven shifts in adaptive responses of this vulnerable ecosystem.

***Variability and control*: River mouth as a manufactured interface** examines the interplay of freshwater and tidal forces at the river mouth and the extent to which it is mediated by human engineering. Damming, dredging, and flood control have rendered this liminal zone a "made" condition, where the variability of subtropical hydrology meets the force of urban design.

An evolving entanglement: Subtropical flux, deep-time adaptation, and cultural reshaping

As a catchment, Moreton Bay, located in the Australian subtropics, occupies one of the most hydrologically volatile regions on the continent.[7] Defined by pronounced climatic variability—manifest in unpredictable rainfall, fluctuating river flows, and shifts in humidity—this heightened dynamism continues to exert a formative influence on coastal morphology, settlement patterns, and hydrological systems. Large-scale climatic oscillations such as the El Niño Southern Oscillation and the Pacific Decadal Oscillation also modulate these environmental conditions,[8] amplifying the inherent unpredictability and dynamism of the subtropical regime.

This dynamism is evident in the ancient history of the bay's catchment formation, which occurred approximately 6,000 years ago when rising sea levels inundated the coastal lowlands,[9] drowning an extensive river valley. Upstream, the original river still flows—its meandering, serpentine course is a signal of its age (and its ongoing propensity to flood). Now called Brisbane River, it flows through a shallow bedrock gorge,[10] that has been shaped and reshaped over deep time. Just beyond the river mouth, the bay's boundaries have also continued to shift and evolve. Historical sea-level rise and changes in the pattern of riverine input over a geological time scale, displaced Indigenous groups who had inhabited the fertile coastal floodplains—now the seafloor of Moreton Bay—for at least 25,000 years, but who subsequently had to move further inland.[11]

These forces collectively generate hydrological rhythms that are neither stable nor linear, shaping natural systems that are broadly attuned to unpredictable-but-recurring environmental pressures. Emerging from the intrinsic volatility of the subtropical climate, these dynamic natural stressors have long influenced the adaptive trajectories of native species and ecosystems.[12] These stressors are understood not as ecological disturbances per se, but as evolutionary forces.[13] Thus, the bay is situated within a long-term condition of natural stress, where ongoing climatic variability forms the ecological baseline.

Alongside this ecological dynamism, the bay has been shaped over millennia by sustained Indigenous management practices, particularly by Quandamooka clan groups. These practices worked in concert with the region's climatic and hydrological variability, forming an enduring socio-natural system. Far from passive occupants of a "primeval wilderness," the Quandamooka actively modified the catchment and waterways through techniques such as: cultural burning to manage vegetation and reduce fuel loads; the construction of stone fish traps and tidal weirs to regulate and harvest aquatic species; and the strategic location of camps and freshwater wells attuned to seasonal availability and tidal flows.[14] These interventions were deeply relational—embedded within cultural protocols, seasonal calendars, and knowledge systems that recognised and respected natural variability as part of life on Country.[15]

This form of landscape modification contrasts starkly with the extractive and industrial transformations that followed non-Indigenous colonisation in the 1820s. Whereas Indigenous practices operated through a logic of reciprocity and responsiveness to ecological rhythms, colonial and later industrial systems imposed fixed infrastructures—ports, levees, and dredged channels—that sought to control or override natural processes. These interventions restructured the bay's hydrology, disrupted sediment transport, and degraded ecological functions, generating cumulative and often irreversible impacts.

Recognising these differing modes of co-production underscores that not all landscape modification is equal in intent or effect. Indigenous shaping of this waterscape was—and continues to be—adaptive, small-scale, and deeply embedded in cultural responsibility; colonial-industrial interventions have been large-scale, extractive, and driven by economic imperatives. For landscape architecture and environmental governance today, this comparison foregrounds the importance of engaging with Indigenous knowledge not as heritage, but as an ongoing and vital mode of environmental stewardship.

Understanding waterscape as an active formation means recognising that these entangled socio-natural forces shaping the bay do not create a fixed or harmonious state, but a shifting condition marked by contestation and change. In Moreton Bay, the entanglement of human and nonhuman processes does not guarantee stability or balance; rather, it generates complex feedback loops, adaptive pressures, and emergent vulnerabilities. Framing these complex reciprocities in this way moves beyond metaphors of mutual shaping to consider how power, history, and intention actively structure these interrelationships.

In this context, Moreton Bay emerges as inherently hybridised: a waterscape simultaneously engineered and ecological, shaped by the interaction of human interventions and nonhuman forces. This hybridity is not simply the overlay of culture upon nature, but rather a system in which built and biophysical processes are mutually constitutive. It is through this entangled and ongoing negotiation that the bay may be understood as a socio-natural waterscape—a term that underscores the inseparability of social and ecological dynamics in shaping form, function, and resilience. These are not merely environmental impacts; they are active, cultural, historical, and spatial processes through which the waterscape continues to be made and remade.

The following sections examine how socio-natural hybridity manifests across three interconnected aquatic zones of Moreton Bay. Through the lenses of convergence, transition, and variability, each zone reveals spatial and ecological configurations shaped by environmental processes and human agency—underscoring the imperative to rethink dominant design paradigms in response to the complex dynamics of this evolving waterscape.

Convergence: The waters of Moreton Bay

Shallow, semi-enclosed and protected by a string of massive sand islands, Moreton Bay spans over 21,000 km^2. Its geographic typology is defined by the partial enclosure of bay water alongside its direct connection to a larger body of water such as an ocean.[16] A bay's underlying hydrology is thereby deeply relational: its character and water quality shaped by oceanic, riverine, groundwater, and other land-based percolation processes occurring across its catchment.

Hydrologically, a characteristic convergence occurs in most bays—where freshwater from river systems meets and mingles with saltwater from the sea. Moreton Bay receives the discharge of multiple rivers including the highly urbanised Brisbane River. The bay's salinity, water clarity, and chemical composition are governed not only by tidal flows and oceanic currents, but also by its semi-enclosed morphology, which renders it a repository for concentrations of urban discharges and terrestrial flows.

The second type of convergence relates to the bay's subtropical location whereby the tropical water from the north flows towards the southern regions of the continent, carried by the East Australian Current. This water is warmer than the surrounding ocean and regular tidal exchange in the bay sees warm tropical waters mix with colder temperate waters to produce a distinctive aquatic convergence zone—a dynamic marine entanglement that emerges from this confluence of climate, currents, and urban systems.

These convergences produce a uniquely hybrid hydrology emerging from this underlying natural variability which is further amplified by human activity and urban systems. An example of this occurs at various points along the foreshore where industrial recycled water management sees treated wastewater discharged into the bay. This water is typically warmer than the surrounding ocean water, contributing to localised temperature increases.[17] Additionally climate change-induced intensification and increased frequency of storm events result in significant volumes of urban stormwater runoff piped and rapidly discharged into the bay.[18] This, in conjunction with the documented post-colonial increases in riverine sediment loads, results in newly hybridised hydrologic confluences.[19] Collectively, these influxes of runoff and treated water contribute to specific convergence conditions where warmer water temperatures and increased nutrient inputs interact in complex and sometimes unpredictable ways.

Across multiple scales, these convergence conditions are evidenced in the complex and novel specificities of the bay's high-latitude reef ecologies and how we understand the relationship between adaptation and resilience. The continuity of marine assemblages from the Holocene to the present suggests that ecological marginality in parts of the bay is not a recent condition, but a long-standing feature of its dynamic history.[20] Yet, rather than operating as a model of episodic adaptation, these marginal assemblages offer a situated example of continuous dynamic change, where reef communities adapt variably to persistent and episodic environmental stressors without reaching long-term equilibrium.[21] This reflects a broader shift in ecological thought: contemporary ecological discourse increasingly emphasises dynamic adaptation and system-level resilience, departing from earlier paradigms that presumed ecosystems tend toward a stable, equilibrium state.[22] While biodiversity fluctuates in these marginal ecosystems, it does so within a relatively constrained range, and resilience in this context appears to derive from functional persistence under marginal conditions, rather than from increasing taxonomic diversity. Additionally, though biodiversity is generally considered a foundation of ecological resilience, in certain conditions of existing low biodiversity, resilience can persist through traits and responses such as functional redundancy, response diversity, or dominance of highly adaptable species.[23] Thus, the normative assumption that increased diversity equates to increased resilience may not apply in naturally variable, marginal systems—where endurance and adaptability under stress are key ecological strategies.[24]

For corals and other sensitive marine organisms, Moreton Bay's variable hydrology—shaped by long-standing subtropical volatility and exacerbated by anthropogenic warming—has selected for stress-tolerant species. Recent studies suggest that coral communities in high-latitude convergence zones like Moreton

Bay may persist under conditions of temperature fluctuation and acidification.[25] However, this persistence reflects tolerance rather than benefit; these reefs remain highly vulnerable. The bay's mixed environment may continue to support certain coral taxa and temperate species, particularly near oceanic inlets, but only if anthropogenic stressors are actively reduced. In such conditions, the normative binary of resilience versus degradation becomes increasingly unstable. The bay's waterscape invites a rethinking of ecological agency that recognises how systems adapt, reorganise, or persist through disturbance, rather than returning to stable states. Understanding this relational dynamism is critical for design approaches which too often rely on fixed baselines and restoration ideals.

The reef system in Moreton Bay also contains different approaches and models of artificial reefs composed of scuttled ships, engineered substrates, and other built structures which now coexist with natural reef systems, providing habitat complexity and refugia for diverse temperate and tropical marine species. The Living Shorelines oyster project in Moreton Bay contributes to this hybrid reef system and exemplifies a different restorative paradigm. In response to the functional extinction of shellfish reefs in most Australian estuarine systems,[26] the Robust Oyster Basket (ROB) was developed. Rather than aiming to return ecosystems to a pre-disturbance state, this design response exemplifies a logic of adaptive resilience. Strategically deployed in Moreton Bay, the ROBs leverage material cycles (recycled oyster shells), species behaviour (the clumping tendency of rock oysters), and biodegradable scaffolding (steel mesh) to facilitate the gradual re-formation of reef habitats. These structures are not imposed restorations but designed catalysts—interventions that recognise and amplify the agency of more-than-human actors in shaping habitat over time.

The ROB exemplifies relational waterscape infrastructure: a modular, degradable form that transforms over time through interaction with tides, sediment, and multispecies occupation. As the mesh corrodes and the oysters grow, the structure transitions from human-made scaffold to ecological substrate. This approach reframes resilience as a temporally open, materially entangled process, in which design seeds ecological possibility rather than enforcing control. In Moreton Bay's shifting aquatic terrain—where sedimentation, thermal stress, and urban runoff shape ecologically uncertain futures—the ROB demonstrates how design logics rooted in co-evolution and ecological symbiosis can support more-than-human flourishing within damaged environments.

In this light, adaptation is not a passive biological response, but an ongoing process that gives rise to hybridised ecological conditions. The waterscape of Moreton Bay does not neatly conform to dominant narratives of either degradation or resilience. Rather, it complicates this binary by revealing how ecological systems can persist, recalibrate, or even reorganise under stress, without necessarily returning to a prior or optimal state.

While some indicators—such as coral persistence in marginal zones—may suggest adaptive capacity, these must be read alongside profound and ongoing ecological disruptions, including sedimentation, warming, and nutrient loading. Resilience, in this context, does not signal recovery or stability, but a form of conditional persistence shaped by constant negotiation with disturbance. The bay is not resilient despite human impact, nor wholly degraded because of it. It is both—and more—a socio-natural formation where multispecies adaptation occurs amid ongoing transformation, uncertainty, and constraint.

For design practice, this recognition matters. Too often, ecological resilience is operationalised through metrics that seek to restore systems to a previous condition or maintain them in a stable state. Yet in places like Moreton Bay, where disturbance is ongoing and embedded, design must engage with resilience as an open-ended, negotiated process, not a destination or idealised equilibrium. This requires moving beyond reductive templates of restoration or control and embracing strategies that work with volatility, acknowledge layered histories, and support multispecies cohabitation.

In this context, waterscape becomes not only a descriptor of spatial dynamics, but a conceptual tool for rethinking landscape intervention. It foregrounds relationality, flux, and co-production as central design logics. Designing for such a waterscape means cultivating responsiveness over mastery, allowing for ecological improvisation, and attending to the overlapping agencies—tidal, climatic, cultural—that shape coastal conditions. Rather than treating resilience and degradation as opposites, this approach sees them as co-present forces that must be held in tension. It is in designing with, rather than against, this tension that more ethical, situated, and enduring practices might emerge.

Transition: Intertidal edges and creeping limits

Moreton Bay's intertidal edge is defined by a long, shallow incline that is cyclically submerged and exposed by the tides. At low tide, the water recedes over 100 metres in places, revealing saltmarshes, rock shelves, and mudflats—alongside stormwater pipes, seawalls, concrete jetties, groynes, and piers. These built interventions contribute to the shaping of the shoreline and mudflats through creating artificial deposition zones. This intertidal zone is not only shaped by tidal rhythms but also by erosion, sedimentation, and wind—processes increasingly entangled with anthropogenic pressures. Urban development and engineered interventions choreograph water flows, often intensifying or interrupting natural cycles.

The bay's designed esplanades and foreshore public spaces, often assumed to sit beyond tidal influence, are occasionally inundated during king tides and onshore winds, leaving behind seagrass debris and saltwater residue. This challenges conventional urban delineations of land and sea and situates the intertidal edge as a hybrid and contested space; a liminal zone where foreshore infrastructures and ecological systems coexist in uneasy proximity.

Alongside their vulnerability, intertidal ecosystems have remarkable adaptive capacities. For example, many keystone plant species tolerate alternating periods of inundation and desiccation, thriving in dynamic, saturated environments. These naturally stressed systems are also under increasing pressure from urbanisation whereby nutrient imbalances, pollution, habitat fragmentation, and sedimentation loads all contribute to the ecological character of the shoreline.

Paradoxically, these changing coastal conditions and the impacts of increased sedimentation are creating opportunities for certain species to thrive, inadvertently privileging some over others.[27] Mangrove forests, for instance—key constituents of the intertidal edge—are expanding inland in response to rising sea levels and altered sediment regimes.[28] This process, dubbed "mangrove creep,"[29] reveals the capacity of some ecosystems to respond to changing conditions with resilience and agency, exemplifying the dual nature of human-environment entanglement: whereby rapid, multi-scalar shifts in climate, sea level, and development disrupt ecological balance, they can also provoke adaptive responses in nonhuman systems.

Mangroves, with their aerial roots and salt tolerance, stabilise shorelines, filter pollutants, and provide critical habitats. Their landward expansion into saltmarshes and upland zones reflects not only environmental stress but also ecological agency—a reoccupation of space facilitated by anthropogenic transformation. The reshaping of Moreton Bay's intertidal edge—marked by muddying seafloors, shifting vegetative boundaries, and hardening shoreline infrastructure—signals a broader shift: one in which natural systems are not merely reacting to human change, but actively adapting, reorganising, and, in some cases, flourishing in unexpected ways.

However, this adaptation comes at a cost. Mangrove and saltmarsh habitats often coexist, and mangrove creep can displace existing saltmarsh habitats[30]—ecosystems that support distinct assemblages of species, including migratory shorebirds, crustaceans, and salt-tolerant vegetation. As saltmarsh areas contract, species reliant on them face habitat loss and potential population decline. Mangrove expansion into new areas may alter the composition of intertidal habitats and reshape the intertidal landscape.[31] Thus, mangrove creep is not simply evidence of ecological thriving but also of ecological reorganisation—where gains for some species coincide with losses for others.

Understanding this dynamic change highlights the complexity of these socio-natural interrelationships. Anthropogenic activity may provoke adaptive ecological shifts, but these shifts are uneven in their impacts. Recognising this allows us to approach intertidal transformations not only as zones of loss or resilience, but as evolving terrains of negotiation between human actions and the differentiated capacities of ecological systems to respond, persist, or transform.

Contemporary design practice plays a critical role in engaging with these complex transitional zones in a manner that goes beyond seeking to control them or create hyper-stable edges but rather creates frameworks that acknowledge the ongoing co-production of this "scape," enabling ecological negotiation, and supporting multi-species habitation over time. The City of Moreton Bay's recent pilot project *Living Coast Plan* exemplifies how contemporary design can engage with socio-natural systems. Rather than imposing fixed boundaries, these interventions work with the continual interplay of tidal flows, sediment movement, and built infrastructure—demonstrating that shoreline resilience emerges not from separation, but from the co-constituted interactions of built and living systems.[32] By integrating mangrove planting, biodegradable materials, and soft engineering techniques, the project reflects a design ethos grounded in reciprocity and an understanding that resilience and adaptation are co-produced through socio-natural relations. These efforts do not seek to halt transition, but to scaffold it—to create space for ecological processes to continue adapting under the pressures of rapid urbanisation and climate change.

In this context, design becomes a means of mediating transition—facilitating negotiation between human and nonhuman agency, between infrastructure and ecological succession. Adaptive strategies such as soft shorelines, amphibious infrastructure, and dynamic zoning offer frameworks for living with uncertainty, rather than seeking to control it. As Moreton Bay's intertidal edges continue to shift, these approaches allow us to reimagine transitional landscapes not as zones of loss or risk alone, but as shared, evolving spaces—sites of encounter and co-constituted futures.

Variability and control: River mouth as a manufactured interface

The mouth of the Brisbane River is a critical interface between the urbanised catchment and the waters of Moreton Bay. It exemplifies the complex, co-produced conditions of this waterscape—where a dynamic subtropical hydrology is continually shaped and reshaped by anthropogenic activities. For millennia, the river's natural flow regime has been governed by highly variable rainfall patterns. Since colonisation, however, this variability has been increasingly managed through dredging, levees, and flood-control infrastructure. These technocratic efforts seek to control the river's inherent unpredictability but remain embedded within the volatile climatic and hydrological forces of the subtropics. As historian Margaret Cook observes, this altered river mouth and its floodplains represent a space where "the competing interests of the river and humans are most exposed."[33]

Brisbane's hydrology—characterised by cycles of heavy rainfall, frequent flooding, and episodic drought—is central to understanding its contemporary socio-natural condition. Extreme events punctuate the river's history: the catastrophic floods of 1841, 1893, 1974, 2011, and 2022 reveal the ongoing tension between human settlement and a climate marked by high variability.[34] Despite successive investments in flood mitigation, including dams and levees, floods persist, and their impacts intensify due to expanding urban development across the river's floodplains.[35]

These hydrological extremes of interspersed floods and droughts produce cascading effects throughout the catchment. Floodwaters deliver heavy sediment loads and nutrient-rich runoff into the river and bay, reducing water clarity and threatening seagrass meadows reliant on high light penetration for photosynthesis.[36] Conversely, prolonged droughts decrease freshwater flows, heighten salinity, and disrupt sediment dynamics. Reduced flow also allows pollutants and nutrients to accumulate, stressing aquatic ecosystems. These oscillating conditions are emblematic of the variability intrinsic to both subtropical climates and rapidly shifting urban conditions, challenging the adaptive capacities of both human infrastructure and ecological systems.

As previously discussed, subtropical ecosystems have evolved to accommodate many of these fluctuations. Species such as the ancient lungfish illustrate this adaptability in a riverine context—able to breathe through both gills and a lung, they survive in stagnant, oxygen-poor water during floods and persist through dry spells without surface water.[37] Such species embody unique ecological resilience in the face of ongoing and extreme climatic fluctuations.

Even within the broader Australian context, the Brisbane River exhibits a particularly volatile hydrological regime.[38] South-east Queensland's hot, humid summers and erratic rainfall patterns have shaped a river system that blends tropical and temperate fluvial characteristics. Subtropical rivers display seasonal extremes: high sediment yields, large flood ranges, and drought-induced ponding.[39] This hybridity—oscillating between contraction and inundation—has historically defined the Brisbane River, whose geomorphology was formed by dramatic fluctuations in annual rainfall long before colonisation. Despite land clearing, urban expansion, and significant floods recorded since European settlement, the river's channel morphology has remained strikingly resilient, likely due to its adaptation to its characteristic high-magnitude flood events on decadal timescales.[40]

Prior to extensive dredging, the river alternated between deep waterholes and shallow crossings, reflecting its dynamic fluvial behaviour.[41] Today, though artificially deepened, the river retains a serpentine form, with surrounding topography bearing the imprint of centuries of flooding and sediment deposition. These processes created nutrient-rich floodplains that were desirable to early European settlers who were drawn to the fertility of the estuarine lowlands. In seeking to manage the river's unpredictability, settlers introduced a range of flood mitigation techniques including levees, dams, channelisation, and especially dredging that have profoundly reshaped the lower reaches and mouth of the river.

At the river's mouth, where freshwater meets saltwater, sediment-laden flows slow and deposit their load onto the estuarine floor. Empirical data suggests that sediment transport has increased dramatically—by up to fourteen times[42]—since colonisation. These interventions have altered water quality and disrupted ecological functions, contributing to seagrass decline and harmful algal blooms.[43]

This engineered environment constitutes the manufactured condition of the river mouth and reveals the paradox of control. While intended to safeguard human settlement, such interventions remain vulnerable to the broader climatic forces that continue to define the region. Infrastructure may buffer some effects, but it cannot eliminate the hydrological volatility that defines the Brisbane River. Thus, the mouth of the Brisbane River is not merely a site of water exchange, but a zone of intense and ongoing negotiation between ecological processes and human attempts at control. As a subtropical waterscape, it is shaped by a deeply variable climate and its socio-natural character lies in this very entanglement: a co-constituted condition where control is always provisional, and variability remains the defining force.

In the face of this extreme variability, design—particularly within landscape architecture, architecture, environmental design, and urban planning—often occupies an ambivalent position, caught between the impulse to impose control and the imperative to adapt. Historically, these disciplines have often operated on assumptions of environmental stability, producing spatial solutions aimed at resisting or containing ecological variability through fixed forms, hard infrastructure, and risk-averse planning. In subtropical waterscapes like the Brisbane River and Moreton Bay, however, where climatic volatility and hydrological extremes are endemic, such approaches are increasingly inadequate. These design and planning disciplines are now being challenged to engage with variability not as a problem to be solved, but as a defining condition of place. This shift calls for adaptive, process-oriented, and temporally aware practices that work with flood, drought, sedimentation, and ecological succession rather than against them. In this context, design becomes a medium of negotiation rather than domination—foregrounding flexibility, resilience, and the co-evolution of human and nonhuman systems—and attuned stewards of this dynamic socio-natural environment.

Convergence, transition, variability, and the design of socio-natural futures

According to marine scientists, "little of the Moreton Bay catchment, apart from isolated areas [. . .] remains unaltered,"[44] highlighting the co-produced nature of the bay, where even remote biophysical processes are shaped by human activity. Framing Moreton Bay as a waterscape—a spatial and temporal assemblage shaped by hydrological, ecological, and sociopolitical forces—foregrounds its deeply altered yet dynamically responsive state in the Anthropocene. Understood as a waterscape, Moreton Bay's significance lies in both its layered histories of Indigenous stewardship and colonial restructuring, alongside its "naturally stressed" ecological baseline that has been shaped by long-term climatic variability. This context highlights both ongoing and continual change within this co-constituted socio-natural environment.

The interrelated conditions of convergence, transition, and variability offer useful vantages for framing the complex particularities of Moreton Bay's shifting character of adaptation and habitat transformation. "Convergence" shifts focus from purely hydrological or spatial aspects to highlight evolving thresholds of ecosystem resilience and fragility, that is continually reshaped by underlying hydrothermal variability, biotic adaptations, and infrastructural discharges. These entangled processes in turn create the socio-natural character of Moreton Bay's waters and are made visible in the adaptive behaviours of coral species and other marine life, which respond to complex stressors in ways that signal both vulnerability and resilience. For designers, working in this context demands a paradigm shift—from reactive mitigation to the deliberate co-production of adaptive waterscapes. In this context anthropogenic inputs may be leveraged as deliberate materials for crafting adaptive, more-than-human assemblages.

The phenomenon of "mangrove creep" shows that anthropogenic disturbance can catalyse transitions, fostering complex re-territorialisations in which some species thrive while others recede. The co-produced intertidal edge represents a liminal zone, where socio-natural agency creates a choreography of both loss and resilience, underscoring the need for design frameworks that support transition rather than halt it. Resilience is reframed as an ongoing practice of design-mediated reciprocity, with human and more-than-human actors continually reshaping the waterscape.

The Brisbane River mouth exemplifies hydrological variability, complicating the view of natural flow versus engineered control. Variability, as an embedded, cyclical force, structures the catchment's hydrodynamics, driving flooding, drought, and sedimentation. As a condition, variability reveals the limits of infrastructural control, prompting a shift from control-based strategies to adaptive, processual approaches that engage flux, sediment, and flood as co-authors of spatial form.

Collectively, this reorientation also opens new imaginaries for human habitation—not as a fixed, autonomous domain, but as flexible assemblages within dynamic socio-natural systems. In this framing, habitation becomes a responsive and participatory act, shaped through convergence, transition, and variability. Whereby convergence reveals the interweaving of urban and ecological systems; transition highlights the mutable character of liminal habitats; and variability calls attention to the temporal fluctuations—tides, floods, sedimentation—as a key consideration to be negotiated rather than controlled in planning and developing for future habitation "zones."

Thus, future approaches to inhabiting this waterscape must embrace permeability, adaptation, and new types of reciprocity as generative design logics. A waterscape is not only a register of past socio-natural entanglements but also an experimental site for developing forms of life and living that are attuned to flux. From amphibious architectures and floating infrastructures to sediment-responsive and seasonally shifting morphologies, the waterscape invites speculative approaches to co-living that foreground reciprocity over resilience and transformation over stasis.

By integrating human habitat into the socio-natural dynamics of Moreton Bay, many new possibilities emerge; and convergence, transition, and variability evolve beyond ecological descriptors to offer critical design provocations for inhabiting the Anthropocene. As a waterscape, Moreton Bay demands design practices that are not only responsive but also speculative—capable of engaging the uncertainties and instabilities that define its socio-natural condition.

NOTES

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