From Ridge to Reef

Why Land Governance Determines Marine Outcomes in Samaná Bay

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Executive Reflection

Samaná Bay is internationally recognised for its marine significance. The humpback whale breeding aggregation is the defining public identity of the bay — the reason international attention arrives, the reason conservation investment flows, the reason whale-watching tourism generates the revenue it does. This recognition is deserved. The bay's whale population is globally significant, the seasonal aggregation is among the largest and most accessible in the North Atlantic, and the cultural and economic identity of coastal Samaná communities is deeply interwoven with the whale's annual return. The concentration of conservation effort and governance attention on what happens on the water is therefore understandable.

It is also, taken on its own, structurally insufficient for the long-term protection of any of the ecological values it is trying to conserve.

What I have observed in Samaná, across seasons and across the full geographic range of the bay's contributing landscape, is that marine conservation governance is persistently designed for a fraction of the system it is trying to protect. The boats, the regulations, the enforcement operations, the whale-watching permit structures — these address a set of pressures that are real and important and that sit atop a much larger and largely ungoverned set of terrestrial pressures that are quietly determining the ecological baseline within which any marine management intervention must operate. Governing the sea without governing the land that feeds it is like managing symptoms while the underlying condition continues to progress. The results are consistent with that analogy: real effort producing less change than the effort deserves, and a governance system that is working harder than the ecological trajectory would suggest.

This paper makes a single, consequential argument with implications for every governance, finance, and institutional design choice in the Samaná Bay Ridge-to-Reef Stewardship Initiative. There is no credible long-term pathway to whale protection, fisheries sustainability, reef health, mangrove integrity, or marine tourism resilience in Samaná Bay that treats terrestrial governance as adjacent to the core challenge. Land governance is the core challenge. Marine governance operates within limits that land-use decisions set. Understanding where those limits come from, how they are set, and what it would take to govern them deliberately is the subject of this paper.

The System That Governance Pretends Does Not Exist

Samaná Bay is not a marine system with a land border. It is a single continuous socio-ecological system — forested ridges, agricultural slopes, road networks, settlements, rivers, estuaries, wetlands, mangroves, seagrass beds, reefs, the bay itself, and the whale habitat within it — connected by gravity, water, nutrients, sediment, and the decisions of the people who live and work across its full extent. The ecological state of the bay at any moment is the cumulative downstream expression of decisions made across this entire system, mostly by people who have never thought of themselves as marine managers and who are not governed, monitored, or engaged by the institutions nominally responsible for marine outcomes (Holling, 2001; Levin et al., 2013; Berkes, Colding & Folke, 2003).

This is not a complex observation. The physics of watershed hydrology is well understood. Rainfall on deforested slopes generates faster and more erosive runoff than rainfall on forested ones. Roads — particularly unpaved rural roads on steep terrain — act as drainage channels, concentrating flow and directing it into waterways with far greater erosive energy than natural drainage would produce. Construction sites, agricultural clearings, and settlement expansions on hillsides above the bay's river catchments deliver sediment loads into the river system continuously, not as episodic events. The rivers carry this material to the coast, where it enters the estuarine and coastal environment and begins its propagation through the ecological systems downstream (Fabricius, 2005; Rogers, 1990).

The governance system that has developed around Samaná Bay over decades does not reflect this physical reality. Marine governance, terrestrial governance, watershed governance, agricultural governance, infrastructure governance, and municipal land-use governance operate as parallel institutional tracks with separate mandates, separate legal frameworks, separate accountability chains, and separate monitoring systems. Ecological reality operates as a single connected system. Governance operates as a collection of sector-specific silos. The gap between these two realities is where degradation accumulates, slowly and largely invisibly, until the consequences become visible in the marine environment that the governance system claims to be protecting.

What I have come to understand through engagement with the full ridge-to-reef geography of Samaná Bay is that this gap is the primary governance design failure. Every upstream drainage decision that increases runoff and sediment delivery is a marine governance decision, regardless of whether the institution making it has any awareness of the marine consequences. Every forest clearing on a watershed slope above the Rio Yuna tributaries or the smaller coastal drainages feeding the bay is a fisheries governance decision, regardless of whether a fisheries authority is consulted. Every road construction project that disrupts natural drainage patterns in the bay's contributing watershed is a whale habitat decision, regardless of whether the

infrastructure ministry has any knowledge of or accountability for that connection. The sectoral design of governance institutions creates a systematic blindness to cross-scale causal relationships that the ecosystem does not share.

How Gravity Sets the Ecological Baseline for Marine Governance

The concept of an ecological baseline matters enormously for marine governance design, and it is routinely misunderstood. Marine managers tend to define the baseline in terms of what they can observe within their jurisdictional domain: fish population estimates, coral cover measurements, water quality samples at monitoring stations, whale abundance indices. These measurements are real and valuable. They measure the current state of a system whose baseline condition is substantially determined by processes operating outside the marine manager's field of vision, at timescales that episodic marine monitoring rarely captures.

Rainfall falling on the Samaná Peninsula's uplands, on the agricultural zones of the Limon watershed, on the forest remnants and cleared slopes feeding the coastal drainages above the bay does not simply disappear. It flows downslope according to the hydraulic geometry of the landscape, carrying with it whatever the land surface has made available: soil particles from cleared slopes, sediment from road cuts, nutrients from agricultural fertiliser applications, organic matter from decomposing vegetation, and the chemical signatures of whatever human activities the landscape supports. The rate of this material transport is not constant. It accelerates during rainfall events, particularly the short, intense events that climate change is making more frequent in tropical regions (IPCC, 2019). It peaks during storm events and subsides between them, but the cumulative loading it delivers to the coastal system across a year, a decade, or a generation is continuous and consequential.

By the time a marine manager samples water clarity in Samaná Bay, or estimates coral cover on a nearshore reef, or assesses seagrass density in an estuarine meadow, they are measuring the downstream consequence of land-use decisions made months or years earlier across an area that may be many times larger than the marine governance zone they are responsible for. The ecological baseline they observe is not a natural condition that marine management can choose to maintain or improve in isolation. It is the product of terrestrial governance — or the absence of it — operating upstream. Marine management can slow some of the degradation that reaches its jurisdiction. It cannot reverse the terrestrial processes that set the baseline within which it operates. Governing only within jurisdictional marine boundaries while terrestrial pressures accumulate upstream is governing a moving floor without the authority to stabilise it.

Sediment as the Invisible Policy Variable

Among all the connections between terrestrial land use and marine ecological condition in Samaná Bay, sediment is the most consequential and the least visible in governance terms. It enters the system continuously, its effects accumulate slowly and non-linearly, it is difficult to attribute to specific land-use decisions, and its governance implications span multiple institutional mandates in ways that make clear responsibility assignment nearly impossible within sectoral governance frameworks. These characteristics make it exactly the kind of driver that fragmented governance systematically fails to address until the consequences are severe enough to demand emergency response.

The ecological mechanism is well documented. Forests stabilise soils through root systems that bind surface material, canopy interception that reduces the erosive energy of rainfall, and organic matter accumulation that increases soil permeability and reduces surface runoff. When forests are cleared — for agriculture, for settlement expansion, for road construction, or for the kind of coastal development that Samaná is currently experiencing at pace — these stabilising functions are lost. Rainfall that would previously have infiltrated is now converted to surface flow. Surface flow that would previously have moved slowly through vegetated ground now moves rapidly through bare or compacted surfaces. The hydraulic energy available to detach and transport soil particles increases substantially, and the material mobilised travels downslope into waterways rather than remaining in the terrestrial system (Fabricius, 2005; Rogers, 1990).

Roads compound this dynamic. A road cut on a hillside above a river tributary removes the vegetated slope that was capturing and filtering runoff, replaces it with a bare, compacted surface that generates concentrated flow, and — in the absence of adequate drainage infrastructure — connects that concentrated flow directly to the waterway network. In the Samaná peninsula's topography, where steep slopes descend relatively quickly to coastal drainages, the path length between a construction site and the marine environment can be short. The sediment delivery that results is not buffered by the extended transport distances that flatter watersheds provide. It arrives in the coastal system with greater load and greater speed than the ecological literature on lowland river systems would predict (Fabricius, 2005; UNEP, 2019).

Once elevated sediment loads enter coastal waters, their effects propagate through the system in ways that are ecologically significant and economically costly. Increased turbidity reduces light penetration, constraining the photosynthetic productivity of seagrass meadows and the zooxanthellae communities on which coral health depends. Fine sediment particles that remain in suspension after the initial pulse settle gradually onto benthic surfaces, smothering invertebrate communities, disrupting recruitment of coral and seagrass, and reducing the habitat complexity that fish diversity depends on. Nutrient enrichment associated with agricultural runoff stimulates algal growth that competes with coral and seagrass for space

and light (Fabricius, 2005; Barbier et al., 2011). Taken together, these effects do not produce immediate and dramatic ecological collapse. They produce gradual, cumulative degradation that reduces ecological resilience and pushes the system progressively closer to the thresholds beyond which rapid deterioration becomes likely (Scheffer et al., 2001; Scheffer et al., 2009).

Sediment is therefore a policy variable of first-order importance in Samaná Bay, regardless of whether any existing institution governs it as such. Governance decisions about forest clearance rates, road construction standards, agricultural practice requirements, construction site management obligations, and riparian buffer zone protections upstream of the bay's coastal drainages are marine management decisions in their ecological consequences, whether or not the institutions making them have any awareness of or accountability for those consequences.

Mangroves: Critical Regulators, Not Infinite Buffers

In conservation communications, mangroves tend to be described as buffers — ecological filters positioned between the terrestrial and marine environments that absorb and neutralise the disturbances that land-use practices generate upstream. This characterisation is partially accurate and substantially misleading. Mangroves do regulate the transition zone between land and sea. They trap sediment, absorb nutrients, dampen wave energy, stabilise shorelines, provide nursery habitat for the fish species that support Samaná Bay's artisanal fisheries, and sequester carbon at rates that make them globally significant contributors to climate mitigation (Alongi, 2008; Barbier et al., 2011). These functions are real and ecologically important. They are also finite.

Mangroves have evolved to manage the natural range of sediment and nutrient inputs that healthy watershed systems deliver. They are adapted to the flood and drought cycles, the seasonal variation in freshwater and sediment delivery, and the salinity gradients that characterise naturally functioning estuarine systems. What they are not adapted to is the sustained elevation in sediment and nutrient loading that intensive deforestation, agricultural conversion, and construction activity generate. When inputs exceed the range within which mangrove systems have evolved to function, the buffering capacity that makes them ecologically valuable begins to degrade. Root systems are smothered. Sediment accumulation alters the hydrological conditions that mangrove species require. Nutrient enrichment stimulates competitive species and alters community composition. The mangrove system shifts from a regulator of land-sea inputs to a degraded transitional zone through which elevated inputs pass with diminishing attenuation (Alongi, 2008; IPCC, 2019).

The ecological consequences of this transition extend far beyond the mangrove system itself. Mangrove nursery function supports artisanal fish populations whose productivity the coastal communities of Samaná depend on for protein and income. Mangrove shoreline stabilisation protects coastal infrastructure and real estate from the erosion and storm vulnerability that exposed shorelines face. Mangrove carbon storage underpins the blue carbon finance potential that the SBRI's financing architecture is designed to access. When mangrove integrity declines, each of these functions declines with it — not as a sudden collapse but as a progressive diminishment that reduces the economic and ecological value of the coastal system while the governance institutions responsible for marine outcomes remain focused on the water rather than on the land-sea transition zone that is quietly failing (Barbier et al., 2011; Dasgupta, 2021).

In Samaná Bay specifically, mangrove systems are subject to pressures from multiple directions simultaneously. Upstream, increasing sediment and nutrient loads from agricultural expansion and construction activity are elevating inputs beyond the range that robust mangrove function can absorb. Laterally, coastal development is clearing mangrove margins for tourism infrastructure, residential construction, and port-related development that the Samaná Bayport project is intensifying. Hydrologically, drainage modifications associated with road construction and land clearing are altering the freshwater delivery patterns that mangrove communities are calibrated to. Each of these pressures is managed, if at all, by a different institution with a different mandate, a different monitoring system, and no formal mechanism for assessing the cumulative effect of their combined impact on mangrove ecological function.

Why Terrestrial Pressures Are a Whale Conservation Issue

The connection between terrestrial land-use governance and humpback whale conservation in Samaná Bay is less direct than the sediment-reef or sediment-mangrove relationships, but it is no less fundamental for being less immediate. Understanding it requires thinking about whale conservation at the system level rather than at the individual interaction level that whale-watching regulations address.

Humpback whales do not use Samaná Bay primarily as a feeding ground. Their breeding and calving aggregation in the bay during the January-to-March season is the expression of a long evolutionary history of using specific tropical coastal habitats for reproductive functions that require calm, warm, acoustically stable conditions. The suitability of the bay as breeding habitat depends on ecological conditions that whale management as currently designed addresses only partially. Vessel density, proximity, speed, and acoustic disturbance are governed through whale-watching regulations. The broader ecological quality of the bay — water clarity, ecosystem productivity, acoustic environment, cumulative stress levels — is shaped by the full set of pressures operating across the ridge-to-reef system, including the terrestrial pressures

that whale-watching regulations have no mandate to address (Hoyt, 2012; International Whaling Commission, 2016).

Whales are long-lived, site-faithful, and ecologically sensitive in ways that make them particularly vulnerable to the kind of gradual, cumulative habitat degradation that terrestrial pressures produce. A bay whose ecological condition is deteriorating gradually — whose water clarity is declining, whose acoustic environment is becoming more disturbed, whose food web structure is shifting in response to changes in primary productivity and benthic community composition — may continue to attract breeding aggregations for years or decades after the degradation begins. The whales are not making annual decisions about habitat quality with a full information set. They are returning to sites that their evolutionary history has established as appropriate, across timescales that may be longer than the timescale of the habitat change (IPBES, 2019; Hoyt, 2012). By the time behavioural changes are detectable — reductions in habitat use, shifts in distribution within the bay, changes in calf survival rates — the underlying habitat degradation may already be substantial and its reversal may require governance interventions far more demanding than those that would have prevented it.

In this sense, whales function as sentinel indicators of the broader ridge-to-reef system's health rather than as an isolated conservation target. Changes in whale behaviour, distribution, calf production, and stress physiology — measurable through the monitoring programme that CEBSE maintains — carry information about the ecological condition of the bay system as a whole, including the terrestrial pressures that set the baseline within which whale habitat quality is determined. A whale monitoring programme that generates this kind of system-level diagnostic information, and feeds it into a governance architecture with the cross-sectoral authority to respond to terrestrial pressures as well as marine ones, is a fundamentally different conservation instrument from a programme that generates abundance indices and informs boat regulations. The SBCA's integrated governance mandate makes the first kind of programme possible in ways that sectoral marine management cannot.

Governance Failure by Design: The Cost of Sectoral Thinking

The scientific literature on land-sea linkages in coastal socio-ecological systems is unambiguous and has been for decades (Berkes, Colding & Folke, 2003; UNEP, 2019; OECD, 2016). The political economy of governance design has not kept pace. Governance systems governing coastal environments remain organised around administrative convenience — the historical allocation of sectoral mandates to different ministries — rather than around ecological logic. Forestry, agriculture, infrastructure, environment, fisheries, tourism, and municipal planning are institutionally separated in ways that have no relationship to how the systems they govern actually function. Each institutional domain performs adequately within

its own mandate. The collective outcome of their simultaneous, uncoordinated operation is worse than any of them, individually, would choose to produce.

The specific failure mode that sectoral thinking generates in ridge-to-reef systems is systematic blindness to cross-scale causal relationships. A forestry department managing timber concessions does not have a mandate to assess the downstream effects on fisheries productivity of the changes in sediment delivery that concession-related logging produces. An agriculture ministry promoting fertiliser use does not have a mandate to track the nutrient enrichment effects on coastal seagrass meadows that agricultural runoff delivers. A public works department building rural roads does not have a mandate to design drainage infrastructure with the coastal sediment delivery consequences of road construction in mind. Each of these institutions is behaving entirely rationally within its mandate. Together, they are systematically degrading the ecological conditions that a separate set of institutions — marine environment, fisheries, tourism — is trying to protect, and doing so without any institutional mechanism that would make the conflict visible or create accountability for addressing it.

In Samaná, I have observed this governance design failure operating at every scale from the municipal to the national. Development approvals for coastal projects proceed through environmental impact assessment processes that do not require comprehensive assessment of cumulative ridge-to-reef impacts. Agricultural extension programmes operate without coordination with watershed management initiatives. Road construction decisions are made without reference to the drainage consequences for coastal drainages. And marine governance operations — enforcement patrols, whale-watching permit administration, marine park management — proceed on the implicit assumption that the terrestrial pressures affecting the system they are governing are someone else's problem. The fragmentation is not accidental. It is the predictable outcome of designing governance institutions around administrative categories rather than around ecological systems, and it produces degradation by design even when every institution within the system is operating conscientiously within its mandate.

The Finance Implications of Land-Sea Integration

The implications of the ridge-to-reef governance argument extend directly into conservation finance in ways that the SBRI's financing architecture must account for. Every significant conservation finance mechanism with potential relevance to Samaná Bay — blue carbon credits, biodiversity finance, ecosystem service payments, climate adaptation finance, high-value tourism levies — carries permanence and additionality requirements that can only be credibly met through integrated land-sea governance. Understanding why requires tracing the specific ecological dependencies involved.

Blue carbon mechanisms monetise the carbon sequestration capacity of mangrove, seagrass, and saltmarsh ecosystems. A credible blue carbon claim requires demonstrating that the carbon stored in these ecosystems will remain stored for the duration of the crediting period, typically measured in decades. In Samaná, that permanence depends on the mangrove and seagrass systems remaining functionally intact across the crediting horizon. Mangrove and seagrass functional integrity depends, in ways that are scientifically well established, on the watershed processes that deliver sediment and nutrients to the coastal system, the coastal development pressures that fragment and clear mangrove coverage, and the hydrological modifications that alter the estuarine conditions within which these systems function. A blue carbon claim for Samaná Bay that does not include the governance of the terrestrial processes determining mangrove and seagrass ecological condition is not a credible claim under any rigorous permanence standard. The finance instrument requires the governance integration that the SBCA is being designed to provide (Wunder et al., 2018; Dasgupta, 2021).

From a tourism finance perspective, the ridge-to-reef connection is equally direct. The qualities that give Samaná Bay its position as a high-value marine tourism destination — water clarity, healthy marine ecosystems, scenic landscape integrity, functional fisheries supporting local food culture, and the whale aggregation itself — are all downstream expressions of the ridge-to-reef system's ecological condition. Governance of the tourism experience within the bay, without governance of the terrestrial processes that determine the ecological quality of what tourists are experiencing, is managing the surface presentation of a product whose underlying value is being determined elsewhere. Destinations that follow this trajectory typically respond to ecological degradation by increasing visitor volume rather than maintaining value, initiating the self-reinforcing cycle that converts high-value destination status into volume-dependent fragility (Dasgupta, 2021; OECD, 2020). The governance architecture required to prevent this trajectory in Samaná is an integrated ridge-to-reef platform — not a marine park with improving visitor management protocols.

What Land-Sea Integration Actually Requires in Governance Terms

Acknowledging the ridge-to-reef connection in scientific terms is straightforward and has been done in Samaná in various documents and project proposals across many years. Translating that acknowledgement into governance architecture that actually integrates land and sea management is a fundamentally different and considerably more demanding challenge. It requires institutional arrangements that do not currently exist in Samaná, cannot be created by any single sectoral institution operating within its existing mandate, and cannot be produced by better coordination between existing institutions without a platform that has the authority, legitimacy, and cross-sectoral reach to create genuine accountability for cross-scale impacts.

The specific governance functions that integrated management requires are identifiable and demanding. First, cross-sectoral environmental impact assessment: development decisions — forestry concessions, road construction, agricultural conversion, coastal development — must be assessed for their downstream effects on coastal ecological condition before approvals are granted, by an institutional authority with the mandate and technical capacity to evaluate ridge-to-reef causal chains rather than only the immediate footprint of the proposed activity. Second, riparian and coastal buffer zone governance: the land areas most directly influencing sediment and nutrient delivery to coastal systems — the riparian corridors of rivers and streams feeding the bay, the coastal margins where terrestrial and marine systems meet — require governance that applies consistently across the multiple land-tenure categories and administrative jurisdictions these areas span. Third, cumulative impact monitoring: the monitoring systems that generate information about marine ecological condition must be connected to monitoring systems that track terrestrial land-use change in the contributing watershed, so that the causal relationships between upstream decisions and downstream outcomes are traceable and governable rather than only retrospectively observable.

The SBCA, as a polycentric coordination platform rather than a replacement for existing sectoral institutions, is designed to provide the cross-sectoral alignment that each of these functions requires. Its Working Groups are structured to span the ridge-to-reef system rather than to replicate sectoral governance within a new institutional home. Its monitoring architecture, developed through Pillar Three of the SBRI, is designed to generate information across the full watershed-to-reef system and to connect terrestrial and marine monitoring datasets in ways that make cross-scale causal relationships visible to the governance actors responsible for managing them. And its legitimacy, built through Phase Zero engagement with the full range of actors operating across the ridge-to-reef system — including the upland farming communities and agricultural cooperatives whose land management decisions upstream are among the most consequential marine management decisions in the system — is designed to span the terrestrial-marine governance divide rather than reinforcing it.

Closing Reflection

There is a version of Samaná Bay's governance future in which marine management continues to improve while terrestrial pressures continue to accumulate. Whale-watching regulations become more sophisticated. Marine enforcement patrols become more consistent. Marine monitoring generates higher-quality data. And the ecological baseline within which all of this work operates continues to shift slowly in the wrong direction, driven by land-use decisions made by institutions that have no awareness of their marine consequences and no accountability for them. This version of the future is not hypothetical. It is the trajectory that sectoral governance produces reliably, in coastal systems worldwide, when the ridge-to-reef connection is acknowledged in policy documents but not embodied in governance architecture.

The alternative is an integrated governance architecture that acknowledges gravity as a governing principle — that recognises the physical reality of how terrestrial systems shape marine outcomes, and builds institutional arrangements capable of managing that relationship deliberately rather than allowing it to produce degradation by default. This is what the SBCA is designed to create. It is more complex, institutionally more demanding, and politically more ambitious than sectoral marine governance. It is also the only governance architecture with a credible relationship to the long-term conservation objectives that Samaná Bay's ecological significance justifies.

Gravity does not negotiate with administrative boundaries. Governance that pretends otherwise will continue to produce the outcomes that pretence reliably generates. In Samaná Bay, the ridge and the reef are a single system. They must be governed as one.

References

Alongi, D. M. (2008). Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. Estuarine, Coastal and Shelf Science, 76, 1–13.

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. Ecological Monographs, 81(2), 169–193.

Berkes, F., Colding, J., & Folke, C. (2003). Navigating Social–Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press.

Dasgupta, P. (2021). The Economics of Biodiversity: The Dasgupta Review. HM Treasury.

Fabricius, K. E. (2005). Effects of terrestrial runoff on the ecology of corals and coral reefs. Marine Pollution Bulletin, 50, 125–146.

Folke, C., et al. (2010). Resilience thinking: Integrating resilience, adaptability and transformability. Ecology and Society, 15(4).

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. Ecosystems, 4, 390–405.

Hoyt, E. (2012). Marine Protected Areas for Whales, Dolphins and Porpoises. Earthscan / IUCN.

International Whaling Commission (2016). Whale Watching Handbook. IWC Secretariat, Cambridge.

IPBES (2019). Global Assessment Report on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

IPCC (2019). Special Report on the Ocean and Cryosphere in a Changing Climate. Intergovernmental Panel on Climate Change.

Levin, S. A., et al. (2013). Social–ecological systems as complex adaptive systems. Ecology and Society, 18(2).

Meadows, D. H. (2008). Thinking in Systems: A Primer. Chelsea Green Publishing.

OECD (2016). Coastal Zone Management and Governance. Organisation for Economic Co-operation and Development.

OECD (2020). Blended Finance for the Sustainable Development Goals. OECD Publishing.

Ostrom, E. (2009). A general framework for analysing the sustainability of social–ecological systems. Science, 325(5939), 419–422.

Rogers, C. S. (1990). Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series, 62, 185–202.

Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. Nature, 413, 591–596.

Scheffer, M., et al. (2009). Early-warning signals for critical transitions. Nature, 461, 53–59.

UNEP (2019). Ridge-to-Reef: Integrated Ecosystem Management. United Nations Environment Programme.

UNESCO (1995a). Statutory Framework of the World Network of Biosphere Reserves. Man and the Biosphere Programme, Paris.

UNESCO (1995b). The Seville Strategy for Biosphere Reserves. UNESCO, Paris.

Walker, B., & Salt, D. (2006). Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press.

Wunder, S., et al. (2018). From principles to practice in payments for ecosystem services. Ecological Economics, 156, 1–12.