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RESEARCH ARTICLE

Mega-eco projects: a global assessment of large-scale ecological restoration initiatives

Robert Levinthal[1] · **Richard Weller**[2]

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Abstract

One way to address the crises of climate change and biodiversity loss is the rapid deployment of so-called nature-based solutions (NbS). Coined in 2008, NbS have become exceedingly popular, with many calling to upscale these works. However, many large-scale ecological restoration and construction endeavors already exist. To capture these projects, this paper coins and defines a new term, the "mega-eco project" and identifies roughly 250 examples worldwide as material evidence. This paper explains what constitutes a mega-eco project and organizes the examples into four typological categories: connectivity, anti-desertification, watershed, and metropolitan projects. Although our primary concern is with contemporary and emerging mega-eco projects, we also show that mega-eco projects have a history and not all of it is good. It is important to consider mega-eco projects in this light because one of their distinguishing characteristics is that when set against the backdrop of environmental crises, many view these projects as virtuous, benevolent undertakings. While we agree with this sentiment and believe mega-eco projects have the potential for a profound shift in how industrialized humans treat the environment, this introductory analysis is part of a more extensive study aimed at identifying best practices to distinguish them from cases of greenwashing and exploitation.

Keywords Nature-based solutions · Megaprojects · Landscape-scale · Sustainability · Adaptation

1 The need for mega-scaled environmental works

Anthropogenic activities have created two interrelated crises: biodiversity loss and global warming. Addressing these catastrophic trends now and in the coming decades requires landscape-scale interventions. Many of these large-scale environmental restoration endeavors are currently underway, ranging from afforestation to conservation and construction, and many more are in the planning stages. However, no one has considered these projects as an emergent type with shared characteristics, nor has anyone inventoried and evaluated them as a set. This paper argues that these works form a coherent new type of endeavor, which we have named mega-eco projects, that are best understood within the tradition of the megaproject (dams, highways, railroads, etc.) and as an extension of what is now commonly referred to as nature-based solutions (NbS).

1.1 Background information of the problem

Our current environmental crises stem from the Industrial Revolution (1760–1840), when technological advancements allowed the global population to grow from under one billion to eight billion today, with another two billion expected by mid-century. In 1800, only 36 cities had a population over 100,000 (Hoyt 1963, p. 170). There are now 33 megacities with 10 million people or more, and half of the world's inhabitants live in cities—a figure that will grow to two-thirds in the next three decades (UNDESA 2018, p. 10, 58). Where and how this urban growth occurs will significantly affect the biosphere (Banai and DePriest 2014, p. 79; Calthorpe 2011).

✉ Robert Levinthal
Robmlev@upenn.edu

Richard Weller
rjweller@design.upenn.edu

[1] Weitzman School of Design: City and Regional Planning, University of Pennsylvania, Philadelphia, USA

[2] Chair of Landscape Architecture, Martin and Margy Meyerson Chair of Urbanism, Weitzman School of Design, University of Pennsylvania, Philadelphia, USA

Before the present expansion of the human footprint, the predicted number of extinctions was one species per 10,000 every 100 years. The rate is now 1000 times higher than the previous natural base rate and has the capacity to reach 10,000 times higher in the near term should drastic measures not be taken (De Vos et al. 2015, p. 460). A major contributor to species decline is habitat loss and the fragmentation of open space (Sole et al. 2004, p. 65). For example, half of the remaining forest fragments around the world exist within 500 m before being interrupted (Haddad et al. 2015) usually by agriculture, which now covers half of the earth's arable surface (Ellis et al. 2010, p. 593). At the same time species are being forced to migrate to adapt to global warming. For many species, the barriers and distance between their natural habitat types are too challenging to surmount, leading to their reductions and ultimately extinction (Hilty et al. 2019). Presently, 1 in 8 plant and animal species are at risk of being lost (IPBES 2022).

Rising levels of atmospheric carbon are further challenging the future survival of most species, including humans. The current warming trajectory ranges from an anticipated 2.1 °C to a 5 °C rise in the global average temperature by the end of the century (IPCC 2021). Climate change continuing at this pace has the capacity to displace 1.2 billion people (IEP 2020). Many of the displaced will be from economically developing countries in arid and semi-arid regions which make up 41% of the terrestrial planet and 45% of the world's agricultural lands that are susceptible to desertification from overpopulation, poor land use decisions, and anthropogenic climate change (Burrell et al. 2020; D'Odorico et al. 2013).

The effects of the present irreversible 1 °C increase since the pre-industrial era are just beginning to show in a nascent form of sea-level rise, coral bleaching, prolonged droughts and floods, wildfires, increased intensity of storms, hurricanes, and heatwaves (Biermann and Boas 2010). The infrastructure along coastlines and in floodplains and waterways were not built for this new climate regime (Pyper 2011; Nazarnia et al. 2020; Chester 2022). To control the extent of warming, the Intergovernmental Panel on Climate Change (IPCC) Special Report of 2018 identified a 1.5 °C target set in the Paris Agreement as the most attainable level with the least repercussions to people. More recently, the IPCC recognized that despite many nations pledging net-zero emissions by 2050, these efforts will still fall short of the stated goal (IPCC 2021).

Current measures of carbon dioxide removal from industrial technologies, like bioenergy with carbon capture and storage, are incapable of reaching any notable contribution within the next few decades (Wallace-Wells 2019, pp. 43–45). However, afforestation, reforestation, and the restoration of ecosystems can make a sizable impact if started now (Baur et al. 2021). Griscom et al. (2017) predicted that when fully realized, natural climate solutions could sequester 37% of the necessary excess greenhouse gases by 2030. This figure has come under scrutiny for being exaggerated. Despite this, those who disagree recognize the importance of sequestration through nature-based solutions (NbS) and the co-benefits they create (Seddon et al. 2021).

The World Bank coined nature-based solutions in 2008 as a critical tool to combat climate change and mass extinction simultaneously, while also providing benefits to humans (MacKinnon et al. 2008). It was made popular and expanded by the International Union for Conservation of Nature (IUCN) in 2012 (IUCN 2012), and in 2022, the United Nations Environmental Assembly reached a multilaterally agreed upon definition for NbS as: "[a]ctions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, coastal, and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits" (UNEP 2022).

Evidence for the proliferation of NbS is illustrated in the Nationally Determined Contributions (NDCs) that countries propose as their plan to address climate change through the 2015 Paris Agreement. In the first iteration of NDCs, 82% of signatory countries had NbS for a total of 103 projects (Seddon et al. 2020). In the 2021 global stocktake of NDCs, this representation increased to 92% (Bakhtary et al. 2021, p. 4). If these projects are to help with the adaptation to and mitigation of climate change, they will have to be massive and they will have to happen fast because biodiversity loss is immediate, higher temperatures render environmental processes less efficient at sequestration, and these projects will be susceptible to natural disasters (IPCC 2021; Seddon et al. 2020). Consequently, scholars and advocates of NbS often call for their rapid upscaling (Cohen-Schacham et al. 2019; Van Eekelen and Bouw 2020; Salafsky et al. 2021).

NbS is considered an umbrella term encompassing over 15 different concepts (Dhyani et al. 2020; Seddon et al. 2020, pp. 1519–1521). However, nowhere in these related concepts is there a term that exclusively discusses upscaled works as a separate type. Due to their unique history and challenges, we believe they warrant a stand-alone title and as such, refer to them specifically as "mega-eco projects." In this renaming, we stop the frequently misguided use of "nature" and "solutions," which are variously problematic, not least of all that they imply a quick fix. We also include large-scale endeavors that may not follow NbS guidelines or seek this classification, such as the Great Green Wall Initiative, which also builds traditionally extractive interventions, like roads (Gravesen and Funder 2022, pp. 7). Furthermore, we are creating order from recent literature that uses the term "green" megaprojects for a wide range of unrelated large works, from the Brooklyn Bridge Park to tech hubs like Masdar City,

and and even the aforementioned Great Green Wall Initiative (Landis 2022; Rizzo 2016; Gravesen and Funder 2022, pp. 30–32). Though some of these upscaled works could be encompassed by the general umbrella of NbS, our proposed term covers all large-scale projects that intend to create outsized social, climate, and biodiversity benefits. This creates a coherent collection that has defined and shared characteristics, which can then, in turn be methodically analyzed as a set to begin to ascertain what constitutes best practices.

2 Defining the mega-eco project

2.1 From megaprojects to mega-eco projects

Beginning in the 1950s, economically developed nations built a plethora of billion-dollar infrastructure to meet the growing demands of consumer society (Altschuler and Luberoff 2003, pp. 13–21). The term megaprojects first appeared in the literature two decades later to identify these works as a new phenomenon. Investments in dams, airports, factories, tunnels, highways, railroads, and vast tracts of urban development, often costing tens of billions of dollars, have now become commonplace, constituting 8% of the annual global gross domestic product (GDP) (Flyvbjerg 2014, p. 6). The International Monetary Fund (2020) predicts that spending on megaprojects will skyrocket to 24% of global GDP by 2025.

Bent Flyvbjerg provides a well-used definition of megaprojects as "large-scale, complex ventures that typically cost a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people" (2014, p. 3). Through his analysis of hundreds of such works, Flyvbjerg reaches what he refers to as the "iron law of megaprojects" namely that they are "over budget, over time, under benefits, over and over again" (Flyvbjerg 2017, p. 12). It is important to note here that Flyvbjerg's research and much of the literature on megaprojects, only consider "hard" or "grey" infrastructure composed of manufactured materials like concrete and steel. Studies on megaprojects almost never consider green infrastructure, which utilizes mainly organic materials or the landscape itself as a fundamental component of the project. Although materially different, because upscaled NbS projects are like megaprojects in size and ambition, we need to ask how they can avoid Flyvbjerg's iron law as they proliferate in the twenty-first century to combat global warming, rapid species loss, and poverty. Naming them in a way that links them to the negative tradition of the megaproject is a critical first step. Analyzing a set to establish principles of best practice is the second.

2.2 Developing the new term

Using the prefix "mega-" for the proposed term makes a connection to megaprojects and other concepts that arose simultaneously, including Jean Gottman's (1964) "megalopolis" which identified the joining of urban areas into a singular unit from Boston to Washington D.C. and Reyner Banham's (1976) "megastructures," an architectural concept for the future city. In megaprojects, the mega-prefix is a misnomer with a Greek root affiliated with the measurement in millions. The correct giga-prefix measuring billions, in this case signifying dollars, is ignored (Flyvbjerg 2014, p. 4). While some mega-eco projects eclipse the billion-dollar threshold, we retain the use of "mega" to explicitly place landscape-scale green infrastructure projects within the tradition of megaprojects and make a connection to these other concepts for measuring "mega-" as something very large.

Derived from the Greek "oikos," meaning "household" (Steiner 2008, p. 27), the addition of "-eco" serves to distinguish a new type of megaproject that uses primarily living materials. However, the affix "-eco" is never straightforward. It implies the ecosystem, the science of ecology, the economics of ecosystem services, and the vague but important adjective "ecological." For something to be ecological means, it not only performs an ecological function unto itself (producing oxygen or filtering stormwater) but that it enables other aspects of the environment to flourish within a complex network of relations. Therefore, the "ecological project" is understood relationally, whereas the megaproject tends to stand alone both conceptually and physically. Furthermore, when a work is labeled ecological, it is generally considered good.

In addition to using "eco" to register these meanings, we also use it to avoid the use of "nature," a word Raymond Williams (1976) highlighted as the most complex in the English language. We reject the use of nature for its vagueness and because when used concerning the ecosystem, or the landscape, it comes with the semantic baggage of the natural, which is commonly used in opposition to the artificial or "human-made." The mega-eco project is neither natural nor cultural in terms of this old dyad—it is a hybrid of the two. We also choose not to use the word "green" because of its frequent use that does not accurately encapsulate the projects we are trying to bring into conversation with one another, such as small, expensive urban parks, like the Brooklyn Bridge Park, which, as previously mentioned, has recently been referred to as a green megaproject (Landis 2022).

We also take issue with "solution" in the NbS formulation. "Solution" perpetuates the myth that engineering can focus on a specific problem and solve it without causing unforeseeable consequences and externalities (Lutsky and Burkholder 2017). Urban historian Lewis Mumford understood this when standing in sole defiance of the Interstate Highway System in 1956

for the outstanding problems he knew it would create (Seltzer and Carbonell 2011, pp. 248–250). This type of megaproject is now replicated worldwide and is a key contributor to the current environmental crises (Ibisch et al. 2016). Realistically, an ecological conception of an engineering project would confess that our knowledge of ecological relations is always incomplete. A successful mega-eco project is then less a case of a predetermined solution than one of trial and error. Instead of touting simple solutions to complex problems, the mega-eco project is framed more modestly as an experiment that is open to being adjusted over time to achieve varying degrees of resilience.

2.3 Definition and parameters

With these matters in mind, we define mega-eco projects as complex, landscape-scale ecological restoration and construction endeavors that aim to help biodiversity and communities adapt to degraded ecosystems and climate change. A global desktop analysis found hundreds of works that fit this definition. We sorted them into types based on similar characteristics in terms of their location and modus operandi. This resulted in four types: connectivity projects, anti-desertification, watershed, and metropolitan projects.

We created parameters by theme using existing literature and deducing measurements from databases like the Center for Large Landscape Conservation's Globescapes and Mongabay's Reforestation Catalogue to determine what qualified as very large or "mega" in terms of scale. We also created an optional dimension of cost to avoid missing some of the best funded projects that might fall short of these spatial parameters. To satisfy its affiliation with NbS, mega-eco projects must also include biodiversity, climate change mitigation and adaptation, and human benefits. Applying these conditions reduced the list of projects to roughly 250, which we then mapped based on available project boundaries using Geographic Information Systems. Table 1 sets out the parameters that projects need to qualify as mega-eco projects by theme and type. "Appendix" contains the names of identified mega-eco projects and their qualifications. Figures 1, 2, 3, 4 illustrate project boundaries, distribution, and scale by type. Figure 5 maps them all together to show that the mega-eco project is now a global phenomenon.

3 Proposed typology

3.1 Connectivity projects

Connectivity projects aim to restore terrestrial habitats at a landscape scale and are the most abundant category of mega-eco projects. Forms of these works can differ drastically, though overlaps are present throughout. The largest themes within this type, corridors and large landscapes, seek to join extant patches of habitat to enable species movement and reproduction. Some projects focus solely on developing a corridor to conserve land between protected areas while others cross-vast distances allowing species dispersal in response to climate change. Large landscapes work on an assortment of conservation practices for connectivity through an established boundary. Also included are international peace parks, which have similar traits to traditional protected areas, but the added dimension of coordination across country borders. Smaller themes within this type seek to improve degraded landscapes across habitats through the process of rewilding, restoration, and reforestation and are declared "mega" by the size and effort required for their completion.

The history of these projects begins with the formation of the 8,991 km^2 Yellowstone National Park in 1872. Since Yellowstone's creation, the concept of national parks has extended around the globe. However, precedents of large-scale open space protection and management in forestry, hunting, and Indigenous practices were around hundreds of years prior. Scientific evidence shows that even at its massive size, Yellowstone and most of the world's protected areas are not big enough for a viable population of apex predators (Hilty et al. 2019). National parks and other large protected open spaces, commonly referred to as hubs, are connected by a system of links or corridors expanding a species range (Hoctor et al. 2000). Alongside Yellowstone, the 3500 km Appalachian Trail, proposed in 1921 and completed in 1937, is one of the earliest examples of a corridor connecting protected lands with the original intention of saving vast open spaces for recreation (Anderson 2002, pp. 148–153). Ambitious grassroots organizations, non-profits, and non-government organizations lead these efforts, though a coalition of multiple countries or even a single nation may make these endeavors a priority.

One of the best examples of a mega-eco project doing this is the Yellowstone to Yukon Conservation Initiative (Y2Y). Founded in 1993, Y2Y is a non-profit agency that collaborates with local and Indigenous governments, landowners, other non-profits, and corporations to create interconnected landscapes between disparate protected areas. Together they have spent millions of dollars on landscape conservation and restoration within an identified boundary of 470,000 km^2, stretching nearly 3700 km (Hilty et al. 2019). Y2Y has had extraordinary success, where "the rate of protected area growth increased 90%" since its inception, and with the creation of over 100 wildlife road-crossing structures (Hebblewhite et al. 2022, p. 1) Y2Y changed its original mission statement in 2001 to include human well-being and sustainable industry following public outcry and suspicion they were interested in removing property rights (Chester 2003). Despite Y2Y's popularity and lobbying with their many

Table 1 Mega-eco project parameters

TYPE	Theme	Scale	Cost	Vision
CONNECTIVITY PROJECTS				
+	Large Landscape Conservation	25,000 km^2		
+	International Peace Parks	2+ Countries with 10,000 km^2		
+	Corridors	100 km between 2 Protected Areas or 250 km		
+	Restoration	100,000 ha	or $100 Million	Biodiversity Benefits
+	Rewilding	100,000 ha		
+	Afforestation / Reforestation	20,000 ha		
+	Tree Planting (Across a Landscape)	20 Million Trees		
ANTI-DESERTIFICATION PROJECTS				
+	Green Walls / Shelterbelts	10,000 km^2 or 1,000 km		+
+	Desert Greening	100,000 ha		
+	Restoration	100,000 ha	or $100 Million	
+	Afforestation / Reforestation	20,000 ha		
+	Tree Planting (Arid/semi-Arid)	20 Million Trees		Climate Adaptation/ Mitigation
WATERSHED PROJECTS				
+	Infrastructure Removal / Modification	(See Cost)		
+	Connectivity	100 km of River / Streams		
+	Afforestation / Reforestation	20,000 ha	or $250 Million	
+	Restoration	10,000 ha		
+	Lake Replenishment	Restoration of >100 km^2 Lake		+
+	Tree Planting (Riparian Buffer)	1 Million Trees		
METROPOLITAN PROJECTS				
+	Greenbelt	100,000 ha		
+	Megapark	10,000 ha		Human Benefits
+	Natural + Nature-based Features	(See Cost)		
+	Waterways (i.e. Daylighting)	10 km	or $1.5 Billion	
+	Greenway	80 km		
+	Brownfield Restoration	800 ha		
+	Tree Planting (Urban)	1 Million Trees		

partners, they did not have the power to prevent the creation of the large Site C Dam within their project's boundaries (Gilchrist 2014). In examining other mega-eco projects, there are top down endeavors that have a lot of centralized power and move quickly, but may lack citizen participation. For example, the Chinese government established the Giant Panda National Park in 2020. At over 27,000 km^2 and with a price tag of $2 billion, this work will connect 67 existing habitat preserves representing 80% of the wild panda population and generate significant tourist revenue (Huang et al. 2020). However, when completed, this top-down project is projected to forcefully displace over 172,000 people (Shanghai Daily 2017). The context surrounding these mega-eco projects are complex and highlights the different spheres of influence and power involved in the formation of these works.

Most mega-eco connectivity projects do not exclude humans from them. While the creation of Yellowstone National Park violently displaced Native Americans from their land, it is now widely accepted that Indigenous and Local Knowledge (ILK) and expanding Indigenous-led protected areas are critical to conservation (Maxwell 2020). Scientific study shows that Indigenous-held or claimed lands contain 80% of the Earth's biodiversity, despite representing less than 5% of the world's population (Etchart 2017). The Forest Conservation and Sustainability in the Heart of the Colombian Amazon program is a mega-eco project that exemplifies this finding. The project boundaries cover 42,000 km^2 –promoting ILK, increasing protected areas, and promoting co-management within them, and strengthening Indigenous organizations (Moreira 2020, p. 5).

Within this program's boundaries, the Vichada Climate Reforestation is a connectivity project within the smaller theme of reforestation. It has planted 80 million trees on 84,310 hectares and pursues biodiversity protection and ecosystem restoration while serving as sustainable timber production for economic growth (Forliance 2020). We identify restoration and rewilding projects as slightly larger themes at 100,000 hectares. This is because restoration can take numerous forms of small interventions over a large area and rewilding recovers degraded landscapes through a generally more hands-off approach. The European form of rewilding uses minimal interventions including the removal of fences, levees, roads, and related infrastructure and then letting natural processes take over (Corlett 2016, p. 455). It may be accompanied by its traditional pursuit and the difficult process of what is now called trophic rewilding, which reintroduces keystone species that provide valuable environmental services to pursue its goals (Perino et al. 2019). In 2022, Ripple et al. proposed a massive rewilding of the western USA that includes 11 large reserves, restored wolf and beaver populations, the retirement of 285,000 km^2 in public land from grazing, and a compensation plan for ranchers.

3.2 Anti-desertification projects

Anti-desertification projects arise from two main sources: excessive degradation through poor land use decisions and climate change, and the perception of arid and semi-arid environments as wasted land. Considered crucial to a country's future growth, prosperity, and image, revegetating degraded drylands and efforts to green the desert have

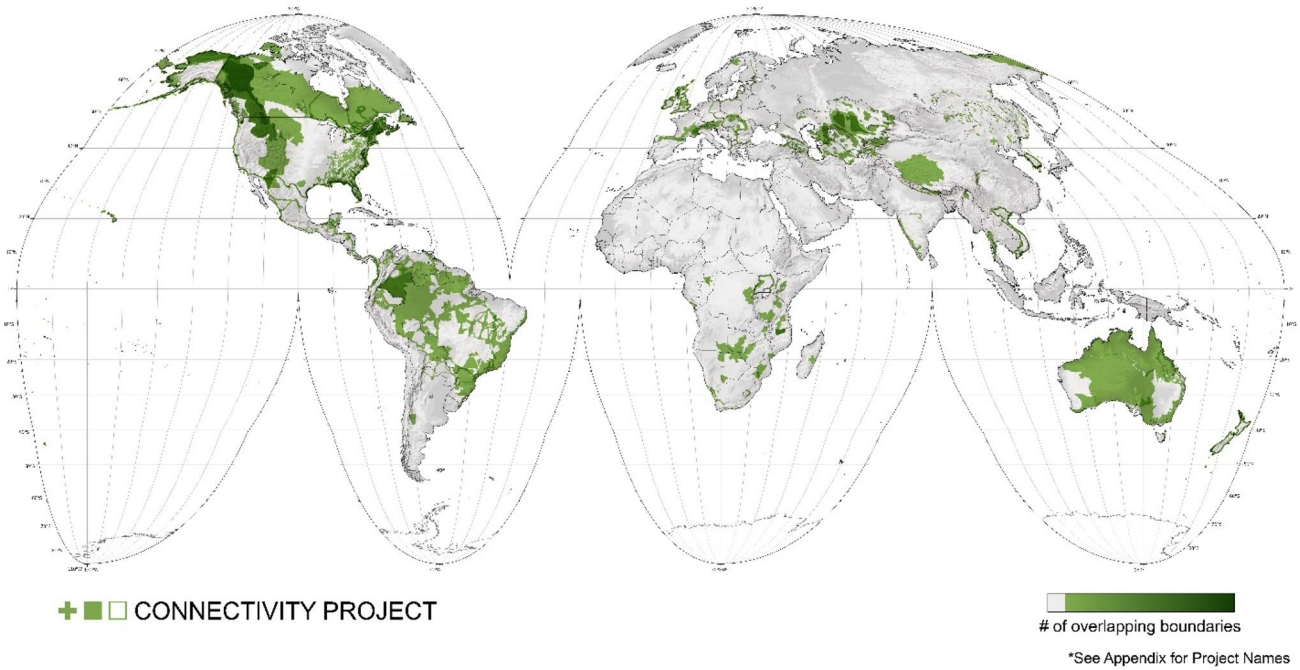

Fig. 1 Locations and boundaries of connectivity projects

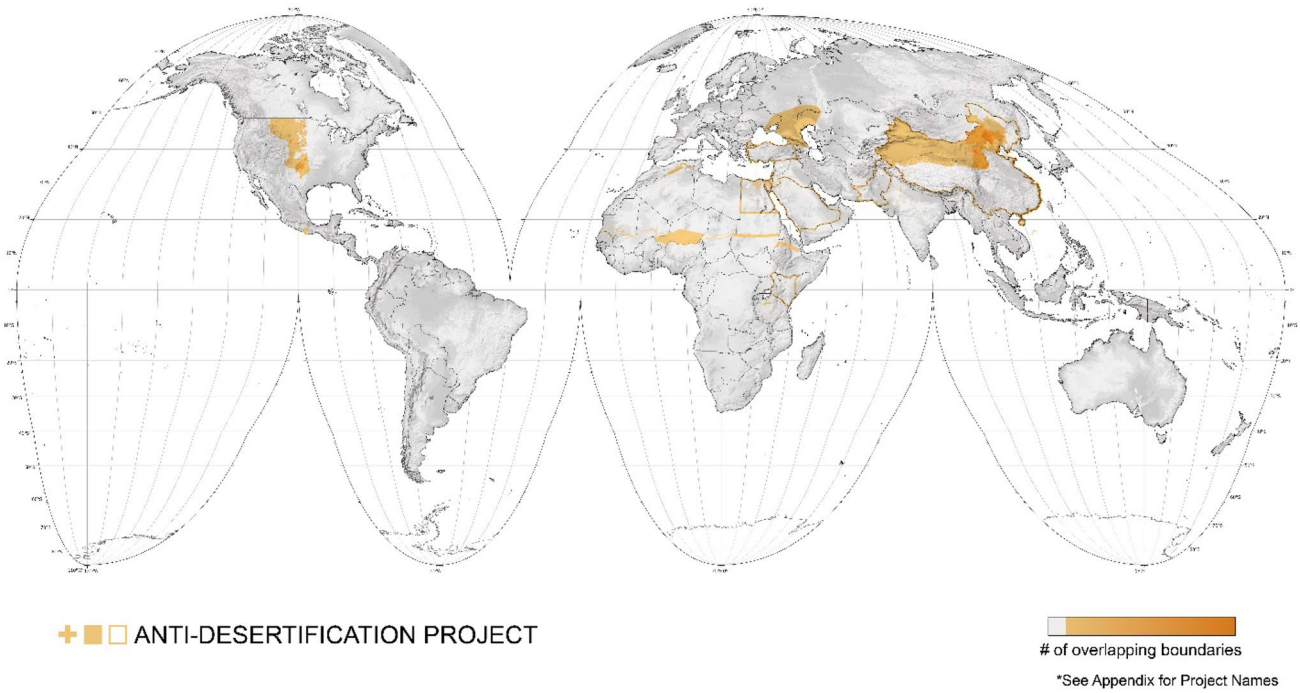

Fig. 2 Locations and boundaries of anti-desertification projects

received significant funding from governments, development banks, non-government organizations, and corporations. As a result, investments in this type of mega-eco project regularly eclipse the billion-dollar threshold of megaprojects. These works often involve geopolitical machinations, colonial impositions, poor understanding of ecosystem processes, and top-down implementation. However, recent private industry, non-profit, and community-led works also inhabit this type.

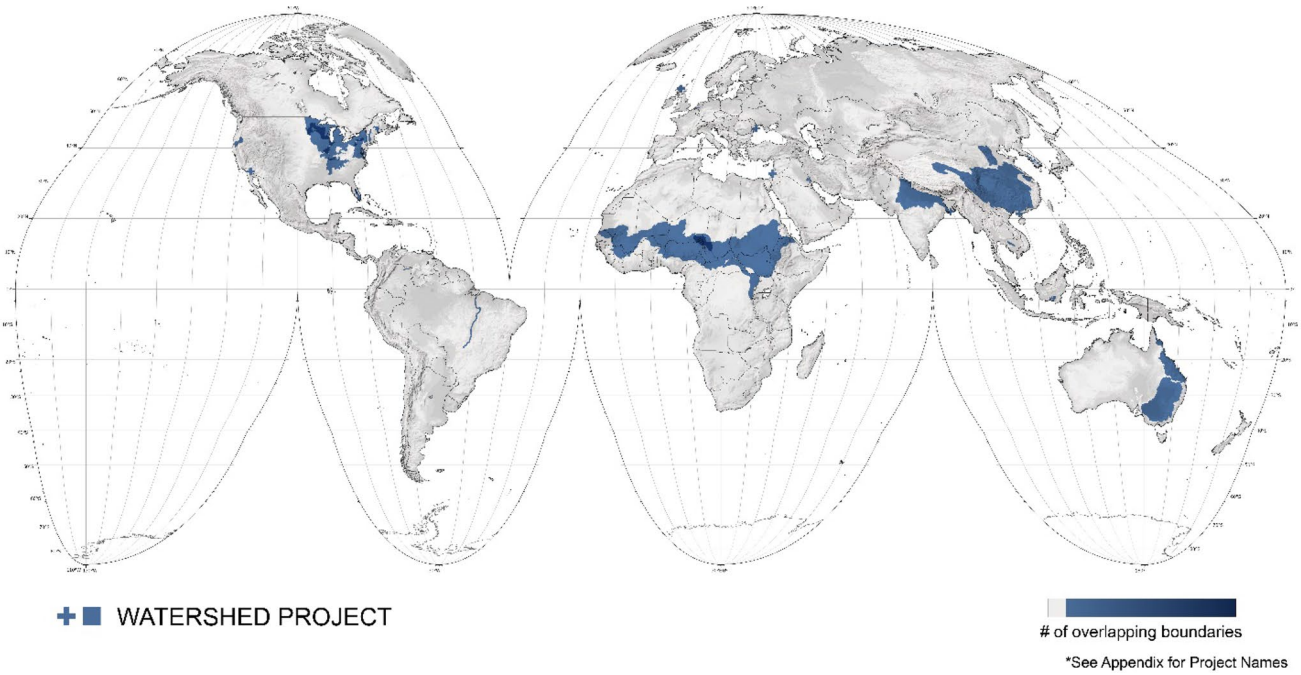

Fig. 3 Locations and boundaries of watershed projects

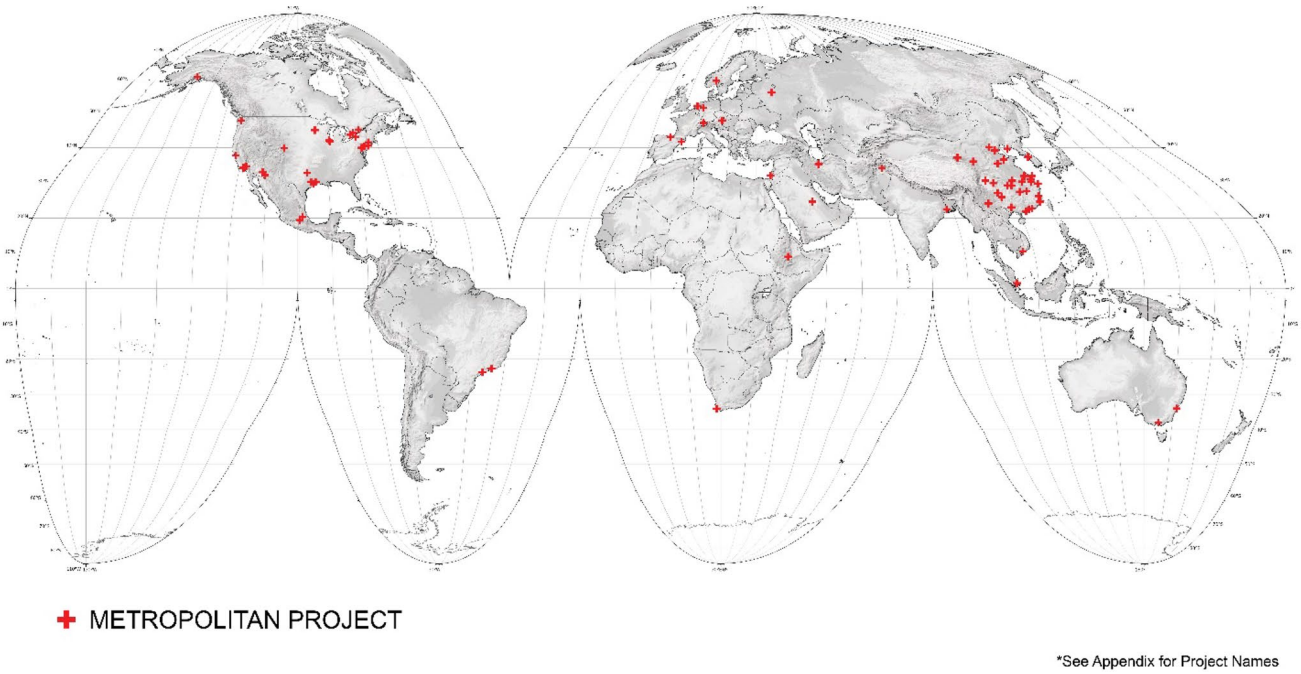

Fig. 4 Locations of metropolitan projects

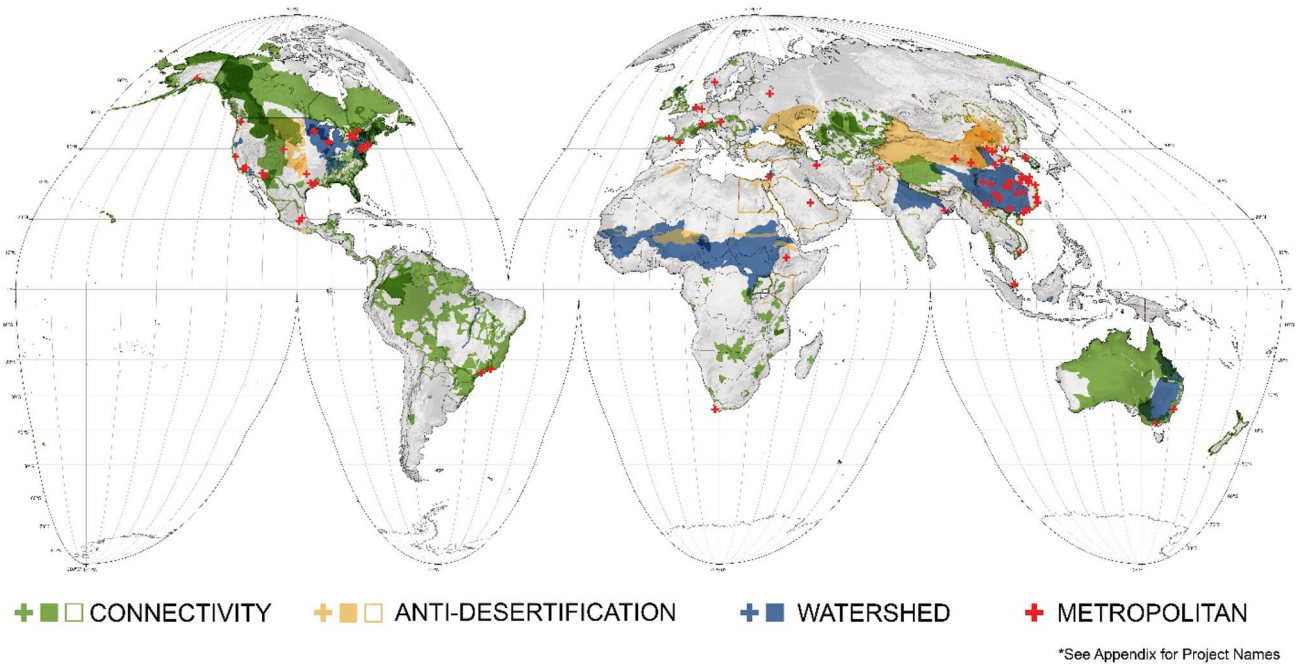

Fig. 5 Locations and boundaries of mega-eco projects by type

The history of the anti-desertification projects begins with the British occupation of India. As part of the 3700 km Inlands Custom Line built in the 1850s, the "Great Hedge of India" was less about holding back the desert than stopping people from collecting tax-free salt. The live fence portion of the Inland Customs Line stretched over 1200 km, composed of thorny species of trees and shrubs, with another 480 km of the driest sections reinforced with 300 tons of dead thorny material per kilometer. At its height, the Inlands Custom Line employed 14,000 people and cost tens of millions of dollars annually for approximately a decade. As a result of this living barrier, over 3000 people were arrested annually, and a concurrent famine was exacerbated (Moxham 2001). This trend of a dominant group benefiting at the expense of the subaltern continues in current anti-desertification projects like Keren Kayemeth LeIsrael—Jewish National Fund's afforestation program, and to a lesser extent the Ten Billion Tree Tsunami, and the Great Green Wall Initiative (Braverman 2009; Ashraf 2022, pp. 38–39; Ahmed 2022).

Anti-desertification projects underwent a significant surge beginning around the 1930s when large governments saw an opportunity to declare their might and grow their industry. In the USA, a mega-eco project arose in response to the Dust Bowl in 1934. Many decades prior, the Homestead Act of 1862 encouraged roughly 1,000,000 km^2 of semi-arid land in the Great Plains to be settled and overexploited through unsustainable land-use practices. Coupled with a prolonged drought, these activities led to severe erosion (Otho 2007). In response, Roosevelt's New Deal planted three billion trees through the Civilian Conservation Corps to combat erosion around the country and created the Great Plains Shelterbelt (GPSB). This project would employ thousands. However, Black and Native Americans had fewer opportunities and segregated work camps, tarnishing the program's reputation despite efforts to halt discrimination (Maher 2009, pp. 106–110). In total, the GPSB created nearly 30,000 km of windbreaks with 220 million trees from North Dakota to the Texas Panhandle and successfully combated the erosion crisis. It also spread invasive species, created a novel environment, and furthered fixed colonial settlement into Indigenous territorial claims (Elkin 2022, pp. 109–110). Presently, with long-lasting drought and the planted windbreaks being torn down in the 1950's and accelerating in the present day, a second dustbowl is possible (Lee and Gill 2014, pp. 24; Wertz 2013), requiring mega-eco projects to consider long-term maintenance and outreach plans.

In the Soviet Union, afforestation occurred throughout the Russian South's sparsely settled arid lands before Stalin's Great Plan for Transforming Nature took these efforts to new heights in the late 1940s. This mega-eco project sought to irrigate and dam waterways and plant 5.6 million hectares of trees in eight enormous shelterbelts. Before Stalin's death and the termination of the project after just five years, afforestation took place on one million hectares. Less than half initially survived (Brain 2010, pp 681–690). Built on faulty science and misguided beliefs, the draining of the Aral Sea would be one of the results of Stalin's vision (Olšáková 2016, p 239). Following Russian precedent, a reclusive

Chinese government in the 1950s took a similar mega-eco approach to its abundant drylands that continue to the present day and have expected completion dates in the 2050s. In one instance, this became the 4000 km shelterbelt that continues through the modern Three North Shelter Forest Program (Stein 2015). Despite having some success restoring degraded land, these works have also experienced significant setbacks. For example, massive monoculture plantings could not withstand the local pests requiring total replacement (Liu et al. 2009) and the excessive plantings have caused severe water shortages (Wang et al. 2020).

The Great Green Wall Initiative (GGW) in sub-Saharan Africa is another example of a modern-day anti-desertification project. Founded in 2007, the GGW received $14.3 billion of further investment in 2021 (UNCCD 2021). First conceived in the 1950s as a continuous shelterbelt of trees around the Sahara Desert (Baker 1954), the GGW originally followed a misunderstanding of desertification and an antiquated idea that a barrier of trees at the edge of the desert can stop its spread. Consequently, the initiative planted millions of trees across 11 countries where they often could not thrive. However, recent efforts have evolved into combatting land degradation through a mosaic of projects that are increasingly incorporating ILK, showing renewed promise (Steiner et al. 2019).

As climate change intensifies and populations swell, anti-desertification projects are proliferating. In 2018, India proposed a 1400 km "green wall" at the edge of the Thar Desert (Mohan 2019). In Pakistan, the Ten Billion Tree Tsunami (2019–2023) reinforces their Billion Tree Tsunami (2014–2018) mega-eco project (UNEP 2021), and Algeria is re-establishing its Green Dam from the 1960s (Saifi et al. 2015). Meanwhile, Saudi Arabia has pledged billions of dollars to the Saudi Green Initiative and the Middle East Green Initiative to plant billions of trees and add millions of hectares of dry lands into protected areas (Independent 2021).

3.3 Watershed projects

Watershed projects are characterized by their mission to restore water quality, flow, function, and the productivity of freshwater and estuarine environments throughout a catchment. They can take numerous forms involving a single intervention, such as the removal of a large dam that impacts an entire riverine system, or multiple interventions that restore riparian buffers, recreate damaged wetlands, and soften hard infrastructure. Projects in this type often replace rigid twentieth-century megaprojects with natural and nature-based features that utilize landscapes with engineering functions to create resiliency to severe flooding and droughts while simultaneously facilitating environmental and social benefits.

The history of mega-eco watershed projects begins in the 1930s with the creation of the Tennessee Valley Authority (TVA) during the US' New Deal. The TVA was originally imagined as a large-scale economic development initiative *and* an environmental restoration program. Therefore, we can consider it a mega-eco project, not just a collection of dams. Regional Planner Benton MacKaye was brought in during the first year of its development to provide a comprehensive plan for the future of the extensive watershed. He proposed – extensive protection of open spaces, highways with limited exits to control sprawling development, highwayless towns, and abundant scenic and active outdoor recreation opportunities over the 100,000 km^2 area. Unfortunately, MacKaye's mega-eco project vision was pushed out by the politicians and engineers who were chiefly concerned with economic growth and engineering solutions (Schaffer 1990, pp. 10–15). In the end, the TVA provided drinking water and energy, but the constructed dams of the TVA considerably altered their ecosystems and caused biodiversity loss. However, it also did some good in reforesting a quarter of the TVA's boundary (Maher 2009, pp. 192–195). Despite few studies ever measuring the veracity of its apparent success of the program, the TVA model shows that when a project is considered successful, it is quickly replicated the world over and can lose some of its restorative qualities (Adams 1992, pp. 115–122). Differences between the TVA's image and substance are instructive for today's mega-eco projects as they position themselves as environmental panaceas.

A similar modern-day example is the Four Major Rivers Restoration Project (FMRRP) in South Korea, completed in 2011 for roughly $18 billion. The project has its fair share of advocates and critics. It was built during the nation's first Green New Deal and its heavy-handed top-down delivery has attracted criticism for failing to follow environmental protocols, reaching promised water quality improvement levels, and was marred by political controversy. Like the TVA, the FMRRP constructed three dams and 16 weirs, but it was implemented under the pretense of being a forward-thinking environmental restoration project that would also create human benefits for adapting to climate change. The achievements of this project include restoring riverbanks, creating recreational and tourist opportunities and offering slightly greater resilience to flooding and drought (Lah et al. 2015; Park et al. 2017). However, scientists and environmental activists are now calling for the removal of these weirs for the expansive negative impacts they have had on these riverine systems (Kim 2013).

In a recent 2021 report, a third of all freshwater fish species are classified as endangered worldwide mainly because of dams and other barriers (Hughes 2021). In the USA alone, over 80,000 dams clog waterways, and nearly every major

river in the world has a large dam or multiple dams blocking sediment, water, and aquatic species. As many dams in the Global North are rapidly approaching their expiration date (Perera et al. 2021), a movement to remove them is occurring throughout industrialized countries like the United States (Daniels 2014; p. 156). The Elwha River Restoration Project is the first mega-eco project to remove two consecutive large dams at roughly $350 million to restore salmonid migration (Mauer 2021). By 2024, this project will be surpassed by the Klamath River Renewal Project when four large dams will be removed and degraded habitat restored at a cost of $434 million (Andrews 2022). Dams are not the only hard infrastructure being retrofitted or removed—dikes, canals, levees, and seawalls are now subject to re-evaluation. The Room for the River Programme in the Netherlands is a mega-eco project developed in response to deadly floods in the 1990s. This program built over 30 projects at the cost of $2.5 billion in the Rhine delta across four Dutch rivers, where hard infrastructure has been removed and modified and floodplains restored and expanded (Steiner et al. 2019).

4 Metropolitan projects

The last type of mega-eco project occurs around and inside major cities. These projects focus on alleviating environmental degradation from urbanization and its related infrastructure. Though they often have the smallest footprint of any mega-eco project, they are some of the most expensive due to land value and construction costs. Mega-eco projects of this type seek to curb sprawl with greenbelts, restore polluted urban waterways, and provide safety from rising sea levels and natural disasters through green infrastructure. While their individual components can be small—for example, vacant lots or streetscapes—these projects become mega-eco when multiplied across large urban areas. Metropolitan projects have the potential to serve millions of people by reducing the urban heat island effect, providing mental respite and physical recreation, improving biodiversity, and adapting to changing environmental conditions.

The history of this type of mega-eco project often begins with 19th-century parks and greenbelts to ameliorate the impacts of industry and population growth (Beatley 2016). However, a precedent of greenbelts dates back to the Muslim Prophet Muhammad's edict in Medina, which outlawed felling trees around the city (Ismael 2021, p. 1786). While successful in providing urban amenities for citizens, modern greenbelts have typically been unsuccessful in negating sprawl (Daniels 2010). That said, many cities have or are attempting to implement plans which mitigate growth to ensure some measure of landscape connectivity and secure watershed protection, along with other ecosystem services at a metropolitan scale. Mega-eco greenbelts include the massive Sao Paulo Greenbelt and Biosphere Reserve,[1] the 810,000-hectare Toronto Greenbelt, and London's 405,000-hectare Metropolitan Greenbelt (Jones 2022; Edwards 2021).

Frederick Law Olmsted's Emerald Necklace in Boston, although just 4.5 km^2, serves as an early form that fits many metropolitan project themes. For this work, Olmsted designed a string of parks to restore the ecological functionality of degraded waterways through artificially created wetlands with multiple co-benefits in what is perhaps the first western green infrastructure project (Eisenman 2013). Following Olmsted, landscape architect Horace Cleveland in Minneapolis proposed an 82 km greenway of connected parks, "the Grand Rounds," in 1891, which in 2022 received funding for completion (Rainville 2022). In Singapore, the popular Park Connector Network plans to connect large green spaces with 300 km of "Nature Ways" and plant 1 million trees across the densely inhabited island by 2030 (Singapore Green Plan 2030, 2021).

In older cities, combined sewers pollute waterways with excrement and surface run-off during storm events. In response, cities like Chicago, Kaula Lumpur, and Tokyo have built big pipe megaprojects to hold water until it is safe for release. In Philadelphia, a mega-eco alternative, Green City Clean Waters, is building small-scale green stormwater infrastructure distributed throughout the city to reduce the pressure on an old sewer system. Landscape architect and environmental planner Anne Whiston Spirn envisioned this project in the 1980s to restore and reimagine a culverted creek and its floodplain (Steiner et al. 2016, pp. 56–58) The project has since expanded to a nearly $2.5 billion, 25-year pursuit across the city (Stutz 2018). Despite the project's obvious merits, its effectiveness is under scrutiny (Kim 2022, pp. 178, 199), which may necessitate a change to its current operations.

Waterway restoration projects in metropolitan regions can take many forms. Oslo is daylighting large stretches of its seven rivers and tributaries to provide residents with flood control and green space (Connolly and Campion 2018). Across China, landscape architect Kongjian Yu's Sponge City Initiative seeks to expand floodplains and store water during drought with blue-green infrastructure in 23 pilot cities. If successful, the project will be the first trillion-dollar mega-eco project upon completion (Chan et al. 2022). Implemented over several decades, Emscher Landscape Park is a network of greenways that transformed the toxic industrial landscape of the Ruhr in Germany into an expansive park system replete with renewed biodiversity, clean water, and a high-quality amenity for citizens (Steiner et al.

[1] Figures of this project range from roughly 1.5 million (Victor et al. 2004, p. 243) to over 600,000 hectares (Ramos-Ribeiro 2012, p. 94).

2019). Finally, in New York City and Tel-Aviv, landfills of 800 + hectares are beginning the slow, expensive process of being capped and transformed into valuable habitat though their original recreational vision has yet to materialize to the extent proposed.

5 Discussion and opportunities for future studies

E.O. Wilson and Tony Hiss postulated that preserving half of the earth would retain an estimated 90% of the world's biodiversity (Hiss 2021, pp. 118–120). Our research shows that the collective boundaries of today's mega-eco projects cover a little over half of earth's terrestrial area, including a wide range of habitats.[2] However, mega-eco projects proposed boundaries can be misleading and are far from the preservation that Wilson's half-earth proposal espoused (Wilson 2016). Despite efforts to conserve 20% of the planet by 2020, and the recent expansion to 30% by 2030, newly created protected lands since 2004 have been some of the most marginal and least contested lands with low levels of threatened biodiversity (Venter et al. 2018), suggesting a need for mega-eco projects to supplement the half-earth vision.

In the present moment of rampant population growth, the incorporation of people's needs living within and adjacent to mega-eco projects must be considered. An identified gap within current NbS literature is stakeholder perceptions of these programs, especially in emerging economies. A recent review by Chausson et al. (2020) found that only 15% of the current literature focuses outside economically developed countries. Large-scale projects often fail to acknowledge cultural and environmental differences (Elkin 2022), but local opinions are critical to the long-term success of these often top-down endeavors. Therefore, determining local buy-in and perceptions of these works is significant for determining best practices.

In our preliminary studies, financing mechanisms for landscape-scale environmental restoration projects appear under-researched and is a pressing need for greater implementation. Similarly, analyzing adaptation to climate change and biodiversity retention and recovery in individual mega-eco projects is necessary to gauge project performance. Currently, neither adaptation nor biodiversity targets have a United Nations consensus on measuring goals. During the Conference of Parties 26, the Adaptation Committee received a mandate to establish goals for the Paris Agreement's three adaptation elements: enhancing adaptive capacity, strengthening resilience, and reducing vulnerabilities. The Convention for Biodiversity is in the same process of setting goals in draft form in *The Open-ended Working Group on the Post-2020 Global Biodiversity Framework* (2020). When complete, future studies will calculate performance according to these globally recognized goals to differentiate successful mega-eco projects from greenwashing.

One clear example of greenwashing or "disinformation disseminated by an organization so as to present an environmentally responsible public image," (Oxford English Dictionary 2018) concerns large-scale tree planting projects. Scientists and scholars are particularly worried that the attention to planting trees replaces the concern for deforestation, which holds significantly more carbon (Berwyn 2020). Placing tree planting projects within all four types of the mega-eco project typology is necessary due to the propensity for these works to use scale and large figures as a selling point. Tree planting initiatives, like the LA Million Trees and Denver's Mile High Million, were abandoned or failed due to a lack of funding, simplicity of approach, and poor follow-through (Fallows 2020; Meyer 2016). Yet, announcements of new, similarly ill-devised initiatives continue to grab international headlines and public praise, following the same trajectory as megaprojects but without the same level of awareness or assessment. Literature and studies on megaprojects are finally changing how expensive infrastructure development occurs. Establishing the proposed mega-eco project term now, will help illuminate trends in greenwashing and wasted resources happening at a large scale, shortening the learning curve of these endeavors. Future research should consider using case studies that push qualitative fine-grain analysis through fieldwork measuring local perceptions, quantitative studies of project performance before and after the program's start, and counterfactual analysis in adjacent land outside the project's boundaries. In this way, successful endeavors can be identified and serve as a basis for replication.

6 Conclusion

Motivated by biodiversity loss, climate change, and their related negative environmental impacts, the mega-eco project is emerging worldwide as a new breed of megaproject and an extension of NbS. In defining the mega-eco project, we have not sought a financial cut-off as the sole case for inclusion in the accepted definition of the megaproject. On the contrary, we offer a set of characteristics that mega-eco projects share and accept a degree of flexibility in our definition. We also make room for programs that might not follow NbS principles in their entirety. As such, we accept considerable diversity among the types of mega-eco projects we have

[2] Oceanic projects like Beringia to Baja and the Reserve Naturelle Nationale des Terres Australes Francaises could classify as a fifth type but are outside the scope of this paper.

identified and make sense of this through the use of four categories: connectivity projects, anti-desertification projects, watershed projects, and metropolitan projects. We believe the value add of this new term will help provide insight into future efforts to upscale NbS and other large-scale environmental works that currently lack categorization.

We propose that the mega-eco project differs from the megaproject in several significant ways. First, whereas the megaproject is typically singular in its function and designed exclusively for humans—a bridge, for example—the mega-eco project is multifunctional and designed for both humans and nonhumans. Second, whereas the megaproject is constructed of inert materials such as concrete and steel, mega-eco projects are composed mainly of organic materials, where the landscape itself is the fundamental component of the mega-eco project. Third, whereas the megaproject is generally proffered as a direct solution to a single issue, the mega-eco project is couched in more experimental terms broaching especially difficult problems that defy single solutions. Finally, whereas the megaproject is delivered within a profit-based financial model, the mega-eco project often also requires alternative and ongoing not-for-profit funding with an open-ended timeline. In short, unlike megaprojects which are extractive, the mega-eco project strives to ultimately be restorative.

Importantly, while the fact that so many mega-eco projects are now taking place around the world is unprecedented and remarkable, we are not claiming the mega-eco project is something entirely new. On the contrary, we have indicated that mega-eco projects have histories where even the very best intentions have unforeseen and often harmful consequences. Better understanding these histories as well as developing a more nuanced understanding of the critical characteristics of the full range of current mega-eco projects is ongoing work. Further, we are not making value judgements as to whether these projects are providing environmental restoration or are a form of greenwashing and disinformation.

In conclusion, this brings us to perhaps the most critical aspect of this research. In a cultural moment where the environmental crisis of climate change seems overwhelming, it is tempting to hail the mega-eco project as environmental salvation. Within the "good" mega-eco project, there are signs that humans can work together for a greater cause, be a constructive and caring part of this planet, and use their intelligence to design environments that work with, not against, natural forces. However, it is necessary to approach these emerging and rapidly proliferating projects with academic circumspection and criticality, to analyze their motives and monitor their impacts dispassionately. Only in this way will we avoid replicating the failings of megaprojects. Only in this way will we be able to champion successful projects fulfilling their virtuous intentions and separate them from those that are just the same old forces of extraction and exploitation only now cloaked in green.

Appendix

TYPE + project name	Theme	Qualification
Connectivity projects		
Yellowstone National Park+	Large landscape	Predecessor (1872)
Ten Deserts	*	2,700,000 km^2
Arctic Beringia	*	945,000 km^2—2 Countries
Northern Great Plains	*	740,000 km^2—2 Countries
Altyn Dala Conservation Initiative	*	700,000 km^2
Patagonia and Andean Steppe	*	699,000 km^2
Kavango Zambezi Transfrontier Conservation Area (TCA)	*	520,000 km^2—5 Countries
Changtang	*	496,000 km^2
Emerald Edge	*	400,000 km^2—2 Countries
2 Countries 1 Forest	*	330,000 km^2
Caucasus Ecoregion	*	~207,000 km^2
Habitat 141 Alliance	*	180,000 km^2
Tsa Tue Biosphere Reserve	*	93,310 km^2
Sky Island Alliance	*	89,000 km^2—2 Countries
Roundtable at the Crown of the Continent	*	72,840 km^2
Dawna Tenasserim Landscape	*	64,300 km^2—2 Countries
Alpine Network of Protected Areas	*	53,000 km^2—6 Countries
Heart of the Amazon Colombia	*	47,000 km^2
Coast to Cascades Grizzly Bear Initiative	*	45,000 km^2
Hill County Alliance		44,510 km^2

TYPE + project name	Theme	Qualification
Great Gila Bioregion	*	40,500 km^2
Niassa National Reserve Co-Management Arrangements	*	42,000 km^2
Maiko-Tayna Kahuzi- Biega Landscape	*	40,460 km^2
Sacred Himalayan Landscape	*	38,450 km^2—3 Countries
Kgalagadi Transfrontier Park	*	38,000 km^2—2 Countries
Carpathian Network of Protected Areas	*	36,000 km^2—7 Countries
Mayombe Transboundary Protected Area	*	36,000 km^2—4 Countries
Great Limpopo TCA	*	35,000 km^2—3 Countries
Malawi- Zambia TCA	*	32,278 km^2 2 Countries
Northern Rangelands Trust	*	> 32,000 km^2
Northern Forest Complex	*	31,000 km^2
Northern Tanzania Rangelands Initiative	*	30,000 km^2
Giant Panda National Park	*	27,000 km^2
Gorongosa-Marromeu Landscape Complex	*	25,840 km^2
Kruger to Canyons	*	25,000 km^2—2 Countries
Kimberley to Cape	*	Proposed: 1,500,000 km^2
Central Asia Econet	*	Proposed: 600,000 km^2—7 Countries
Ustyurt Plateau Conservation Initiative	*	Proposed: 200,000 km^2—2 Countries
Central India Tiger Landscape	*	Proposed: 152,000 km^2
Wildlands, Woodlands, Farmlands and Communities	*	Proposed: 149,000 km^2
Western Ghats	*	Proposed: 140,000 km^2
Amur Green Belt	*	Proposed: 76,000 km^2—3 Countries
Pilbara Corridors	*	Proposed: 45,000 km^2
Eastern Plains Landscape	*	Proposed: 27,460 km^2
Waterton Glacier International Peace Park+	International Peace Park	Predecessor (1932)
Lower Zambezi- Mana Pools TCA		17,440 km^2—2 Countries
Maloti- Drakensberg TCA		14,750 km^2—2 Countries
Greater Virunga Transboundary Area		10,000 km^2—3 Countries
Big Bend Rio Bravo International Peace Park		Proposed: 12,000 km^2—2 Countries
Appalachian Trail	Corridor	Precedent (1921)
Eastern Wildway Network		Continental
Western Wildway Network		Continental
Pacific Wildway Network+		Continental
Boreal Songbird Initiative		Continental
Jaguar Corridor 2030		Continental
European Greenbelt		12,500 km
Yellowstone to Yukon	*	3,700 km
Great Eastern Ranges Kanangra Boyd to Wyangala Link		3,600 km
La Ruta de los Parques (Patagonia)	*	2,800 km + 115,000 km^2
Florida Ecological Greenways Network		2,400 km (non-linear)
Gondwana Link		1,000 km
Zambian Carnivore Programme		~950 km
Terai Arc Landscape		700 km—14 Protected Areas (PAs)
Algonquin to Adirondacks		300 km

TYPE + project name	Theme	Qualification
Reconnecting Northland		300 km
Tasmania East Coast Conservation Corridor		280 km
Kaeng Krachan Forest Complex		> 260 km
Wild Eyre Corridor		255 km
Eden to Addo		250 km—3 PAs
Kariba Wildlife Corridor		> 200 km—3 PAs
Ocala to Osceola		160 km corridor—3 PAs
Murchison-Semliki Landscape		125 km corridor—Multiple PAs
Selous-Niassa Corridor		125 km corridor—2 PAs
Southern Highlands and Ruaha- Katavi Landscape		> 100 km corridor—Multiple PAs
Strong Roots Gorilla Corridor		100 km corridor—2 PAs
Trinational De La Sangha		*100 km long—3 PAs—3 Countries*
The Greater Mountain Corridor	*	Proposed: 1,300 km
Shan-Shui Initiative†+	Restoration*	10,000,000 ha×
America's Longleaf Restoration Initiative	*	1,860,000 ha×
Succulent Karoo Ecosystem Programme		500,000 ha
The Restoration Initiative: China		209,000 ha
The Restoration Initiative: Tanzania		110,000 ha
Rewilding Europe: Swedish Lapland	Rewilding*	3,000,000 ha
Rewilding Europe: Southern Carpathians	*	3,000,000 ha
Rewilding Europe: Affric Highlands		202,000 ha
Rewilding the American West+	*	Proposed: 28,500,000 ha
Five Million Hectare Reforestation Program (Vietnam)	Afforestation / Reforestation	5,000,000 ha
Republic of Korea's National Reforestation Program		2,100,000 ha
Community and Government Planting Project (Uganda)		600,000 ha
The Fandriana Marolambo FLR Project		200,000 ha
Vichada Climate Reforestation		84,300 ha
The National Forest		52,000 ha
SOS Mata Atlantica		23,000 ha
Civilian Conservation Corps	Tree Planting*	3,000,000,000 Trees + NNbF
New Zealand Billion Tree Programme	*	1,000,000,000 Trees×
USA's Plant 1 Billion Trees	*	1,000,000,000 Trees×
Ireland Climate Action Plan	*	440,000,000 Trees×
England Trees Action Plan	*	$587,000,000 + 30,000 ha Trees annually × 5
ROOTS (Uganda)	*	160,000,000 Trees×
Northern Forest†	*	~ $607,000,000 Total + 50,000,000 Trees×
Yucatan Reforestation Project	*	100,000,000 Trees×
Amazon Reforestation Project, Inc	*	80,000,000 Trees
Forest Ontario's 50 Million Tree Program	*	50,000,000 Trees×
Trillion Tree Campaign†+	*Natura 2000+*	*Madagascar Corridors+*
Costa Rica Conservation and Reforestation+	*Bonn Challenge†+*	*Trillion Tree Campaign†+*

TYPE + project name	Theme	Qualification
20× 20 *National Campaigns*+	*30×30 National Campaigns*+	
Anti-desertification projects		
Great Hedge of India	Green Wall/ Shelterbelt	Predecessor (1850s)
Great Green Wall Initiative	*	8,000 km × 15 km
Three North Shelter Forest Program	*	86,000,000 ha×
Coastal Shelterbelt Development Program (SDP)†	*	42,770,000 ha
PRC's (6) Forest Shelterbelts (Green Great Walls)+	*	129,500 km (1950–1957)
Great Plan for the Transformation of Nature	*	5,700,000 ha×
Great Plains Shelterbelt	*	300,000 km
Algerian Green Dam (1970)	*	3,000,000 ha
Algerian Green Dam (2021)+	*	1,200,000 ha
SDP—along the Middle Reaches of the Yellow River†	*	1,050,000 ha (1996–2000)
Integrated SDP in Liaohe River Valley†	*	717,000 ha
Great Green Wall of India	*	Proposed: 1400 km × 5 km
Middle East Green Initiative+	Desert Greening*	200,000,000 ha + 50,000,000,000 Trees×
Saudi Green Initiative	*	40,000,000 ha + 10,000,000,000 Trees×
Regreen the Sinai	*	Proposed: ~ 35,000 km^2
Grain for Green (China)+	Restoration	35,130,000 ha
Kubuqi Ecological Restoration Project		600,000 ha
Shinyanga Soil Conservation Programme		> 350,000 ha
Buffalo Commons†		Proposed: 930,000 km
Plain Afforestation Programme (China)+	Afforestation/reforestation*	26,310,000 ha
The Sandification Control Program (Beijing and Tianjin)	*	4,940,000 ha
The National Afforestation and Erosion Control (Türkiye)	*	2,300,000 ha
National Programme to Combat Desertification (China)	*	1,000,000 ha
Saihanba Afforestation Community	*	76,700 ha
Chocho—Mixtecas Community Alliance		> 20,000 ha
African Landscape Restoration Initiative (Kenya)†	Tree planting*	15,000,000,000 Trees×
Ten Billion Tree Tsunami (Pakistan)	*	10,000,000,000 Trees×
Billion Tree Tsunami	*	~ 1,000,000,000 Trees
KKL-JNF Israeli Forest Program	*	240,000,000 Trees (2009) /120,000 ha
Greenbelt Movement (Kenya)		52,000,000 Trees
Egypt Sustainable Agriculture Initiative		22,000,000 Trees×
100 Million Trees (Egypt)		Proposed: 100,000,000 Trees
Watershed projects		
Tennessee valley authority	Infrastructure removal/ modification	Predecessor: (1933)
Comprehensive Everglades Restoration Project	*	~ $23,200,000,000 (Total)
Four Major Rivers Project	*	$18,000,000,000

TYPE + project name	Theme	Qualification
Great Lakes Restoration Initiative (GLRI)		$3,800,000,000
Room for the River	*	$2,500,000,000
Murray Darling Basin Plan	*	$1,800,000,000
Upper Mississippi River Restoration Program	*	$1,500,000,000 (2021 Total)
Reef 2050	*	$1,390,000,000
Kissimmee River Restoration Project	*	$980,000,000
Border Meuse[+]	*	$534,000,000
Elwha River Restoration		$351,400,000
Klamath River Renewal Project	*	Proposed: 4 dams @ ~ $434,000,000 (2019) + 643 km
Tonle Sap Lake and Inundation Zone Corridor		*Details Emerging*
Lower Danube Green Corridor†	Connectivity/protection	1000 km
Protection of the Free-Flowing Bita River		520 km
Penobscot River Restoration Project		322 km
Salmon SuperHWY		290 km[×]
SDP—Upper and Middle Reaches of the Yangtze River†	Afforestation / reforestation*	6,000,000 ha
Taihang Mountains Afforestation Programme †	*	1,623,000 ha
SDP—Huaihe River and Taihu Lake Basin Area†	*	728,000 ha
SDP—in the Pearl River Valley	*	622,000 ha
Agenda 21—Mangrove Restoration in Southern China	*	20,000 ha
Iraqi Marshlands Restoration Project	Restoration*	2,000,000 ha
Central Kalimantan Peatlands Restoration Project	*	2,000,000 ha
Peatland Restoration (Scotland)		250,000 ha
Humberhead Levels Partnership		202,000 ha
Namami Ganges Programme	*	134,000 ha[×] + ~ $5,000,000,000 (2026)
Mangrove Afforestation Programme of the National Forest Department (Bangladesh)		120,000 ha
Katingan Peatland Restoration and Conservation Project		108,200 ha
Rewilding Europe: Danube Delta		40,000 ha (of 580,000 ha delta)
Blue Lifelines for a Secure Sahel		Proposed: 20,000,000 ha
The National Water Carrier	Lake Replenishment	31 km canal + > 100km^2 lake
Transaqua Project		Proposed: 2,400 km canal + > 100 km^2 lake
Red Sea-Dead Sea Conveyance		Proposed: 193 km canal + > 100 km^2 lake
Rally for Rivers (India)	Tree Planting	2,420,000,000 Trees[×]
Araguaia Biodiversity Corridor†	*	1,700,000,000 Trees[×]
Chesapeake Bay Program		13,000 km Riparian Buffer Trees Planted
River Dee Trust		1,000,000 Trees[×]
Regional Flyway Initiative†[+]	*Nile Basin Initiative[+]*	*Free-Flowing Rivers (World Wildlife Fund) [+]*

TYPE + project name	Theme	Qualification
Resilient Asian Deltas (World Wildlife Fund)+	*Restore America's Estuaries*+	
Metropolitan projects		
Medina Edict	Greenbelt	Predecessor: (seventh Century)
Barcelona Greenbelt		2,400,000 ha
Sao Paulo Greenbelt and Biosphere Reserve		1,600,000–600,000 ha
San Francisco Bay Area Greenbelt/ Greenprint		1,300,000 ha
Ontario Greenbelt		810,000 ha
Melbourne Green Wedges		605,000 ha
Metropolitan Greenbelt (London)		406,000 ha
Green Heart (Netherlands)		180,000 ha
Seoul Metropolitan Greenbelt		143,000 ha
Forterra—The Cascade Agenda		111,000 ha
Stugach State Park	Megapark	200,000 ha
Biosphere Park Wienerwald		105,000 ha
Hunan East Dongting Lake National Nature Reserve		157,000 ha
Addis-Bah Development Forestry Project + Ethiopian Forest Action Program		33,000 ha
Texcoco Lake Ecological Park		> 14,000 ha
Greater Sydney Parklands	*	Proposed: 1,500,000 ha
Chicago Wilderness†	Restoration	202,000 ha
Emscher Landscape Park	*	80,000 ha
Tehran Greenbelt		53,000 ha
Emerald Necklace	NNbF	Predecessor: (1870)
Sponge City Initiative		~ $1.5 Trillion (Total)
LA River Plan		$19—24,000,000,000
Green City Clean Water		$2,600,000,000
Croton and Catskill Reservoir Areas†		$1,500,000,000 (1997) + 485,600 ha
Galveston Bay Park Plan		Proposed: $3–6,000,000,000
East Kolkata Wetlands	Waterways*	12,500 ha
Mangrove Restoration in Can Gio†	*	20,600 ha
Zurich Stream Day-Lighting Program		22 km
Oslo Reopening Waterways		10.8 km×
Rio la Piedad Project		Proposed: 15 km + 45 other urban streams×
Guangzhou Ecological Belt	Greenway	513 km (2020) 2000 km×
Singapore Park Connector Network†		75 km (2021) > 300 km×
Houston Bayou Greenways		240 km
The Grand Rounds National Scenic Byway		82 km
Greenbelt Vitoria Gasteiz	*	80 km
Freshkills Park	Brownfield Restoration	890 ha
Hariya Landfill		809 ha
Green Riyadh	Tree Planting*	7,500,000 Trees×
Houston Climate Action Plan		4,600,000 Trees×
Plant 1 Million Philadelphia		1,000,000 Trees×
Million Trees NYC		1,000,000 Trees
Million Trees LA		1,000,000 Trees×

TYPE + project name	Theme	Qualification
One Million Tree Initiative (Amherst, NY)		1,000,000 Trees×
One Million Trees Mississauga		1,000,000 Trees×
Mile High Million (Denver)		1,000,000 Trees×
The Shanghai Roots and Shoots Million Tree Project		1,000,000 Trees×
Tucson Million Trees		1,000,000 Trees×

Italics—difficult to place within a theme/type

†—fits multiple types

+—not mapped

*—fits multiple themes

×—goal

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Declarations

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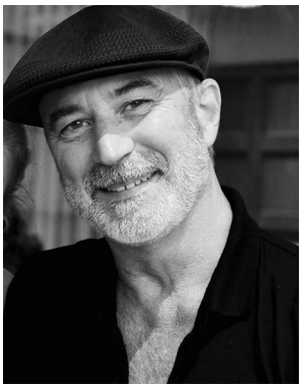
Robert Levinthal is a City and Regional Planning PhD Candidate at the University of Pennsylvania, where he specializes in Environmental Planning and Landscape and Land Use Design. He is a 2022–2023 Landscape Architecture Foundation Fellow and a 2020 LAF National Olmsted Scholar Finalist. He is also a recent graduate of UPenn's Master of Landscape Architecture program. Before commencing his graduate studies, Rob served in the Peace Corps in Senegal as an Agroforestry Extension Agent (2013–2015).



Richard Weller is the Meyerson Chair of Urbanism and Professor and Chair of Landscape Architecture and Executive Director of the McHarg Center at The University of Pennsylvania. He has published 8 books and more than 120 single-authored academic papers, book chapters and articles on the theory and practice of landscape architecture and urban design. He is also the Creative Director of the interdisciplinary journal of landscape architecture LA+ and his design work has been exhibited in major museums world-wide.