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Site prioritization and the reproduction of inequity in the restoration of Biscayne Bay

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Abstract

The restoration of urban estuaries is challenging due to the complexity of prioritizing sites in a context of social and biophysical unevenness. Site prioritization and selection are crucial components of ecological success and equity in restoration. In many cases, site prioritization is conducted according to simple opportunity or political expediency, but this needs to be investigated further in local contexts, with accompanying analysis of the impacts on urban environmental equity. Using a critical physical geography framework, I explore site selection processes in the restoration of Biscayne Bay through case studies of two urban streams. I use multiple data types to present an integrated perspective on urban restoration priority and the social context that produces restoration siting decisions. I find that the logics of restoration site selection in the Biscayne Bay watershed have produced ecologically questionable decisions and inequitable outcomes. Therefore, I argue that restoration decision making needs to include environmental justice criteria.

KEYWORDS

Biscayne Bay, critical physical geography, ecological restoration, Miami, urban estuaries

Résumé

La restauration des estuaires urbains est un défi en raison de la complexité de la priorisation des sites dans un contexte d'inégalités sociales et biophysiques. La sélection des sites est une composante cruciale du succès écologique et du respect du principe d'équité dans le processus de restauration. Dans de nombreux cas, la sélection des sites est effectuée en fonction de simples opportunités pratiques ou de considérations politiques. Cette dynamique doit être étudiée en mettant l'accent sur les questions de justice environnementale. En utilisant un cadre de géographie physique critique, nous explorons ici les processus de sélection des sites dans la restauration de la baie de Biscayne à travers l'étude de deux cours d'eau situés en milieu urbain. Nous utilisons plusieurs types de données afin de présenter une perspective intégrée sur la priorisation des sites dans la restauration et le contexte social qui façonne les décisions. Nous constatons que les logiques de sélection des sites de restauration dans le bassin versant de la baie de Biscayne ont produit des décisions fort discutables du point de vue écologique et en termes d'équité. Par conséquent, nous soutenons que la prise de décision en matière de restauration des cours d'eau et des berges doit inclure des critères de justice environnementale.

MOTS CLÉS
baie de Biscayne, géographie physique critique, restauration écologique, Miami, estuaires urbains

Key messages

- Restoration decisions in the Biscayne Bay watershed are driven by opportunity and institutional fit.
- Restoration decision making without environmental justice criteria exacerbates environmental inequities.
- Critical physical geography provides a needed framework for analyzing urban restoration planning.

SNAPSHOTS OF DEGRADATION AND RESTORATION IN BISCAYNE BAY

On August 10, 2020, residents along the coast of northern Biscayne Bay in Miami, Florida woke to the disturbing sight of thousands of dead fish floating on the water's surface. This mass mortality event—known as a fish kill—was caused by low dissolved oxygen levels in the water, stemming in large part from chronic nutrient pollution (Miami Waterkeeper, n.d.) The same morning, approximately 26 kilometres south, a pump was rerouting canal water into the headwaters of a small coastal stream called Cutler Creek, where, after less than two kilometres, it would drain into Biscayne Bay. This was a component of a restoration project aimed at reintroducing natural freshwater inputs to the bay. Meanwhile, three kilometres inland from the fish kill, very little was happening at two lots on the banks of Wagner Creek, a polluted stream in the bay's watershed. These lots had been proposed as sites for a restoration project that would have re-established riparian vegetation, promising to filter polluted runoff before it entered the creek and, ultimately, Biscayne Bay. Before construction began, however, the project was cancelled.

These vignettes show different faces of the degradation and restoration of the Biscayne Bay estuary and watershed. The fish kill spurred reporting on the dire state of the bay, but worries about its health go back decades, provoking rehabilitation and restoration initiatives. The pumping of water through Cutler Creek and into the bay was a product of one of those restoration initiatives; the absence of restoration activity along Wagner Creek was a consequence of changing priorities in another.

Biscayne Bay's situation is not unique. Environmental degradation in many urban estuaries has prompted large-scale ecological restoration projects. One of the challenging aspects about planning these projects is the need for prioritizing which sites to select. Site prioritization is critical for ecological success, with the persistence of restoration interventions and their ecological benefits dependent on the selection of adequate sites (Bayraktarov et al., 2016; Liu et al., 2021). It is also important socially because urban waterway restoration provides a range of benefits for surrounding communities, including access to urban greenspace, flood reduction (Mant et al., 2020), and increased property values (Jarrad et al., 2018). However, research shows that neither ecology (Palmer, 2009) nor equity (Moran, 2010) is a dominant driver of site selection. There is a clear need to improve this situation, but doing so is challenging because of limited understanding of the processes by which individual sites are selected or rejected in restoration planning. Critical physical geography (CPG) provides a robust framework for addressing such multifaceted problems, through its emphasis on pairing biophysical inquiry with qualitative social science and a critical perspective on environmental science.

Using a CPG framework, I analyze site prioritization and equity in the restoration of Biscayne Bay through case studies of two streams. Cutler Creek is a coastal stream that traverses a protected area in a wealthy neighbourhood. As mentioned above, it was featured in a restoration project implemented by the South Florida Water Management District (SFWMD). Wagner Creek, an inland stream that flows through an industrial zone and impoverished neighbourhoods, was proposed but later abandoned as a restoration site by The Nature Conservancy (TNC). On account of their differing restoration trajectories and socio-economic contexts, these streams provide useful windows into the logics of urban environmental interventions and their equity and ecological outcomes in uneven cities.

SITE SELECTION AS A KEY FOR RESTORATION SUCCESS AND EQUITY

Estuaries are partially enclosed bodies of water that receive saltwater and freshwater inputs (Wolanski, 2007). They feature high biological productivity and provision of ecosystem services but are under severe threat from numerous factors, including upstream nutrient pollution and altered freshwater inputs (Barbier et al., 2011; Kennish, 2002; Lockwood & Maslo, 2014; United Nations Environment Programme [UNEP], 2006). Addressing threats to large, degraded estuaries is a daunting problem (Simenstad et al., 2005), but restoration efforts targeted at the watershed scale have been successful in some cases (Greening et al., 2014; Lefcheck et al., 2018). The connectivity of estuaries to marine and terrestrial habitats means that estuary watershed restoration can involve numerous practices, including stormwater management, riparian vegetation establishment, removal of coastal barriers, replanting seagrass beds, and the restoration of wetlands and streams. However, estuary connectivity also means that restoration often requires collaboration among multiple entities to be successful (Sayles, 2018). Limited availability of resources, such as land and money, further complicates restoration efforts (Simenstad et al., 2005).

Given constraints posed by limited resources, appropriate site selection is critical for the success of restoration projects (Bayraktarov et al., 2016). The case of water quality interventions to benefit Coho salmon in the Puget Sound illustrates this importance. Coho are most threatened by poor water quality in small, freshwater streams, which affects them during their spawning and rearing phases (Levin et al., 2020). To effectively address threats to the salmon, restoration must prioritize sites on small streams rather than focusing on larger streams that contribute more to total coastal pollution. Studies of restoration in practice have found that the locations of projects do not reflect such ecological priorities. Instead, sites are often selected based on the availability of land under public ownership or the match between site characteristics and predetermined institutional restoration approaches (Bernhardt et al., 2007; Lave & Doyle, 2020; Simenstad et al., 2005). The precedence of these selection criteria, which I hereafter refer to as "land opportunities" and "institutional fit," suggests that the likelihood of success in restoration projects may depend on factors unrelated to ecological conditions, such as the presence of waterfront public land in a watershed or stipulations attached to restoration funding sources. However, conflicting results in regional studies (Stanford et al., 2018) point to a need for research in contexts that have not yet been studied, like the Biscayne Bay watershed (Castillo et al., 2016).

In addition to effects on ecological outcomes, site selection in estuary restoration may have unequal social impacts. Site prioritization has been identified as a key element for assessing equity or justice outcomes of restoration (Hillman, 2004). Studies have found distributional inequities in project locations, with disproportionately low percentages in urban areas (Moran, 2010) and high percentages in affluent, white, and educated communities (Dernoga et al., 2015; Stanford et al., 2018). Additional equity dimensions relevant to restoration are the contextual background of racism or colonialism at restoration sites and the inclusion of local community perspectives in restoration planning procedures (Baptiste & Moran, 2018; Wells et al., 2021). The procedural aspects of equity are beyond the scope of this paper. Instead, I focus on the distributional and contextual equity of restoration site selection as a means of describing the social and ecological legacies of urban development logics.

Equity dimensions and ecological priorities in restoration are not independent of each other, but addressing both in research is challenging due to the transdisciplinary nature of questions that arise. Such research requires interpretation of environmental processes behind ecological priorities, analysis of social decision-making processes, and understanding of the spatial and historical contexts of environmental justice. CPG offers a framework for meeting these research needs by integrating biophysical analysis of problems like estuary degradation with qualitative social science methods (Lave, 2015) and an explicit commitment to environmental justice (Lave et al., 2018). Fundamentals of CPG include recognition that social processes and inequities have shaped landscapes and waterways, that science and scientists are shaped by those same social processes, and that scientific research may likewise play a role in shaping social and physical landscapes (Lave et al., 2018). Through these fundamentals, CPG offers a critical, integrated perspective for studying biophysical change and environmental interventions, including ecological restoration.

CPG as a framework is uniquely well-suited for analysis of urban estuary restoration. Restoration couples *explicit* ecological goals with *implicit* sociopolitical commitments (Light & Higgs, 1996). This means that analyzing restoration siting decisions, especially those made in socially uneven cities, requires integration of social and biophysical data in a theoretical framework sensitive to impacts on equity and justice. Such integration of data sources is a strength of CPG scholarship, allowing researchers to interpret biophysical processes that degrade or contaminate environments and their relationship to social processes and ideologies (e.g., McClintock, 2015). Another strength of CPG is critical analysis of scientific theory, elucidating sociopolitical interests or perspectives that it may represent (King & Tadaki, 2018) and human impacts of the application of such theory (Law, 2018). A critical perspective on scientific theory is common across critical geography subfields, but CPG differs from approaches like political ecology through greater emphasis on biophysical processes and explanations (Lave, 2015) and a commitment to critique within, rather than critique of, environmental science (Tadaki et al., 2015). This distinction points to CPG's emphasis on reflexivity and "changing intellectual practice through interdisciplinary research" (Lave, 2015, p. 572), both of which have been identified as priorities in restoration (Boyce et al., 2022; Edrisi & Abhilash, 2021).

Previous CPG work relevant to estuary restoration includes research on politics in stream restoration practice (Lave, 2012), conservation outcomes of stream mitigation banking (Lave & Doyle, 2020), and construction of a sociogeomorphology framework for understanding urban river transformations (Ashmore, 2015). To continue these advances, there is a need for CPG engagement with the management or restoration of urban coastal environments. Along similar lines, Hatvany et al. (2015) explored changes in scientific paradigms on coastal marshes, and Spears (2021) analyzed how race and income interact with sea level rise to mediate vulnerability in the southeastern United States (US). These studies address scientific theory and the human impacts of environmental change, but leave a gap around management interventions meant to address environmental change in urban coastal zones.

In this paper, I contribute to filling these gaps in the CPG literature while simultaneously addressing the need for in-depth study of how priority is assigned to restoration sites and the implications this process has for environmental equity. Using case studies from the Biscayne Bay watershed of South Florida, I explore two questions: 1. What factors lead to the selection or rejection of restoration sites in Biscayne Bay's urban watershed? 2. What are the equity effects of these restoration siting decisions, given the watershed's history of degradation and its socio-economic context?

ASSESSMENT OF ECOLOGICAL PRIORITY AND DETERMINANTS OF SITE SELECTION

I selected Biscayne Bay as a study area based on the presence of upstream restoration initiatives and the existence of historical documentation of environmental change. The region's relatively recent urbanization and well-documented stream and bay modifications made it possible to describe historical changes in detail. Within the Biscayne Bay watershed, I selected Cutler Creek and Wagner Creek for case studies because of their diverging restoration trajectories and contrasting socio-economic contexts, which provided the opportunity to explore both sides of restoration—siting selection and rejection—and their effects on equity.

My approach included a preliminary biophysical assessment of restoration priority, qualitative analysis of site selection rationales, and consideration of the broader socio-economic and historical context. I assessed restoration priority based on the planned project's likelihood of improving water quality downstream in Biscayne Bay. This likelihood was estimated according to a summary of historical degradation in each creek's watershed and an evaluation of each project's ability to reverse changes based on key informant interviews and my judgement. This was paired with analysis of nutrient pollution in the creeks and adjacent sections of the bay, with the idea that there is greater potential benefit from restoration in areas of greater upstream and downstream water quality impairment.

The data and analysis methods used to describe historical degradation and the potential to reverse degradation included key informant interviews and a review of published documents. Document types I reviewed included newspaper articles, government reports, and scientific articles. I found historical newspaper articles through keyword searches in newspaper databases. To properly bound my description of change in the creeks, I defined watershed boundaries. For Cutler Creek, this involved more than simply using watershed boundary datasets, on account of the small size of the catchment and complexities posed by drainage and restoration. Instead, using US Geological Survey (USGS) and Environmental Protection Agency (EPA) data (USGS & EPA, 2022), I joined the Cutler Creek catchment, from the NHDPlus dataset, with an adjacent canal catchment, from the WBD HUC12 dataset, to account for water pumped into the creek via the restoration project. Meanwhile, in the case of Wagner Creek, I used the Florida Department of Environmental Protection's Waterbody ID shapefiles (FDEP, 2005).

Next, I assessed the degree of water quality impairment in Cutler Creek and Wagner Creek and adjacent sections of Biscayne Bay in order to determine the potential benefits of restoration at each site. To do so, I conducted a preliminary analysis of publicly available nutrient pollution data and paired it with a review of published documents, including scientific articles, published reports, and the meeting minutes of government agencies. In one case, to describe an unpublished study, I conducted a key informant interview with one of the study's investigators. Water quality data for Cutler Creek came from SFWMD's sampling at the S-700 pump, which is at the creek's source (South Florida Water Management District [SFWMD], 2019, 2020, 2021). Water quality data for Wagner Creek came from the Florida Department of Environmental Protection's Watershed Information Network (FDEP, 2021). In both cases, annual geometric means for total nitrogen and total phosphorus were calculated for the period 2017–2020. In the case of Wagner Creek, values represent the average from three monitoring stations. Total nitrogen for Wagner Creek was calculated by adding the values for total Kjeldahl nitrogen and NO_x, which is the combined concentration of nitrate a nd nitrite (EPA, 2020). I chose 2017 as the beginning date because this was the earliest year for which monthly samples were available for Wagner Creek.

For the evaluation of restoration siting decisions, I conducted semi-structured interviews with 12 key informants, each of whom had professional experience with restoration or management at the sites. I audio- recorded seven of the interviews and took extensive field notes during five. Then, I reviewed transcripts and field notes for information relevant to restoration decision making or site histories. For the Cutler Creek case, key informants included: three university professors involved in research at the site or restoration planning; three current or former employees of management agencies at the site, two of whom have roles in project implementation; one staff member at a non-profit organization responsible for project monitoring; and one staff member of the SFWMD involved in project implementation. Meanwhile, for the Wagner Creek case, key informants included three current or former employees of TNC, two of whom were involved in project planning at Wagner Creek, and one staff member of a watershed management agency with jurisdiction over part of the Wagner Creek watershed.

DIVERGING RESTORATION TRAJECTORIES IN AN UNEVEN WATERSHED

Biscayne Bay is a clear-water tidal estuary on the southeastern coast of Florida fed by overflow from the Florida Everglades (Lodge, 2017). It is bounded on the east side by a line of barrier islands, which partially divides it from the Atlantic Ocean, and on the west side by the southeastern tip of the Florida mainland. Before the area's hydrology was extensively modified for drainage and flood control, freshwater flowed to Biscayne Bay across the Miami Rock Ridge, a high elevation band of limestone that served as a porous rim along the Eastern Everglades (Lodge, 2017). Flow from groundwater discharge and many small streams, including Cutler Creek and Wagner Creek (Figure 1), provided sufficient freshwater to maintain estuarine conditions in Biscayne Bay and support a diverse assemblage of fish species (Browder et al., 2005).

The combination of aquatic and upland resources offered by Biscayne Bay and the Miami Rock Ridge supported Indigenous societies for several millennia prior to European arrival. These groups, which have been collectively referred to as Tequesta by archaeologists (Carr, 2012) and Ancestors by the Seminole Tribe of Florida (Seminole Tribe of Florida, n.d.), built communities on the high ground near the mouths of Biscayne Bay's streams. Streams offered them canoe access to the Everglades and Biscayne Bay, while the uplands of the Miami Rock Ridge provided important plant foods (Carr, 2012). European conquest resulted in the disappearance of the coastal Indigenous population by the late 18th century (Frank, 2017). In the early 19th century, US territorial expansion pushed Seminole and Miccosukee groups from northern Florida into the Everglades, where they followed the footsteps of earlier inhabitants, using streams for transportation and uplands as hunting and foraging grounds (Frank, 2017). Between the 1830s and the 1850s, the US waged two wars against the Seminole and Miccosukee people with the goal of completely removing them from Florida. The US military set up bases on the Biscayne Bay coast and attempted to destroy food gardens and foraging grounds in the uplands (Frank, 2017). Ultimately, the effort to expel the Seminole and Miccosukee people failed, but it decimated their population and forced them further into the interior, setting the stage for the US settlement and development of the Biscayne Bay coast.

Moving to the present, as a result of drainage, pollution, flood control, urban development, and sea level rise, the ecosystems of Biscayne Bay are under threat. These environmental changes and water quality threats are not uniform, however. They vary across regions of the bay (Figure 2). The North Bay, into which Wagner Creek ultimately drains, has the most impaired water quality, leading to a reduction of estuarine

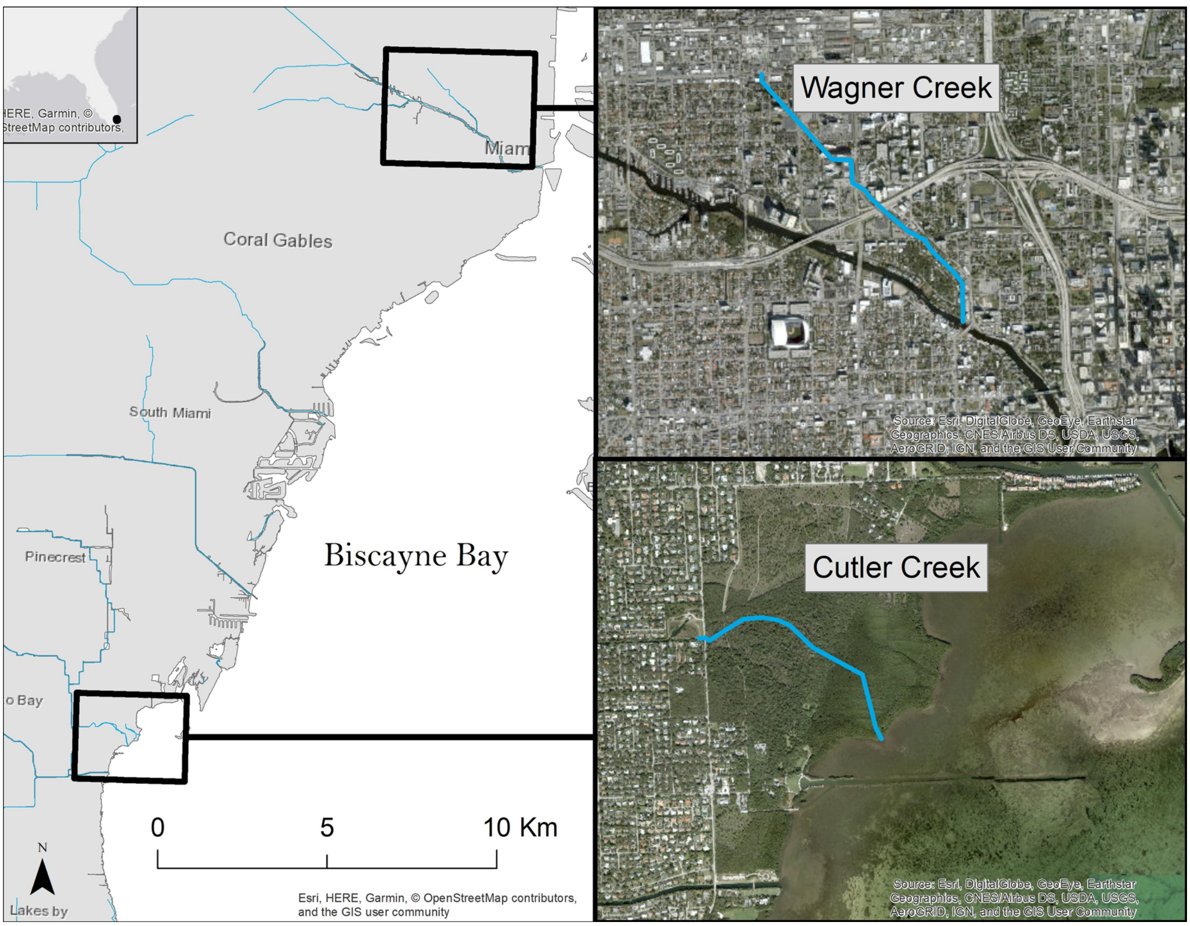

FIGURE 1 Study site locations in the Miami, Florida metropolitan area. Streams are shown in blue against satellite imagery of surrounding landscapes.

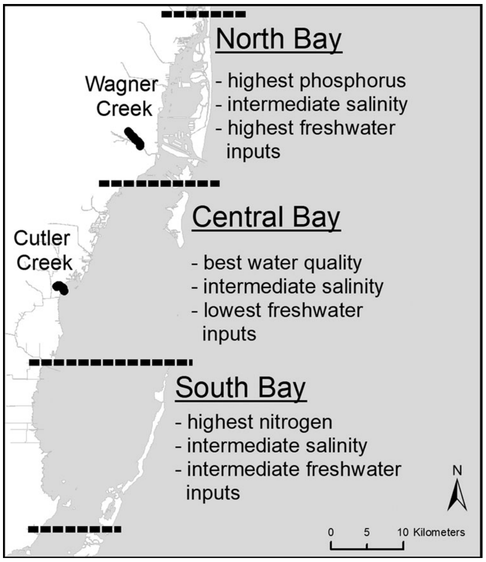

FIGURE 2 Characteristics of Biscayne Bay's three primary regions (Caccia & Boyer, 2005; SFWMD, 1988).

seagrass habitats (Caccia & Boyer, 2005). The primary environmental problems of the Central Bay, into which Cutler Creek drains, are decreased and altered freshwater inputs, leading to increased salinity and a loss of estuarine habitats. High salinity and seagrass loss have already caused Biscayne Bay to lose many of its estuarine fish species (Browder et al., 2005). Meanwhile, largely due to nutrient pollution in the North Bay, there are worries that the bay system is nearing an ecological regime shift, which would entail a change from a clear-water system with abundant seagrass to a eutrophic, algae-dominated system (Millette et al., 2019).

Biscayne Bay's degradation and the potential for disastrous economic effects raised concern among a variety of groups (Brasileiro, 2019) and prompted two sets of restoration initiatives: Biscayne Bay-focused projects within the Comprehensive Everglades Restoration Plan and a developing set of projects given formal recognition through the recommendations of the Biscayne Bay Task Force (BBTF). Within the Comprehensive Everglades Restoration Plan, the Biscayne Bay Coastal Wetlands (BBCW) project was aimed at increasing freshwater inputs to coastal wetlands in the South and Central Biscayne Bay (US Army Corps of Engineers [USACE], 2014). Responsibility for BBCW planning and implementation was shared by the US Army Corps of Engineers and the SFWMD. It did not include any projects aimed at the North Bay.

The other program, the BBTF, was the name given to a Miami-Dade County committee tasked with providing recommendations on restoration priorities in the bay (Biscayne Bay Task Force [BBTF], 2020). These recommendations—aimed primarily at improving water quality in the North Bay by decreasing nutrient inputs—were formalized and published in a June 2020 report, at which point the committee was disbanded (BBTF, 2020). The BBTF report included a set of recommendations on watershed habitat restoration, including coastal strategies aimed at re-establishing mangrove forests along shorelines and inland initiatives aimed at establishing green infrastructure to minimize pollutant runoff.

Both of my case studies were the sites of planned projects that fit within one of the restoration initiatives. The Cutler Creek project—called the Deering Estate component by the SFWMD—was a part of BBCW for which construction was completed in 2012. Operation of the project is still ongoing and involves pumping freshwater from the nearby C-100 canal into the head of Cutler Creek (USACE, 2014). SFWMD's primary goal at Cutler Creek was to reduce salinity levels in the adjacent nearshore environment of the bay by reintroducing more natural, dispersed freshwater inputs, with a secondary goal of re-establishing freshwater marsh vegetation at the head of the creek in an area that had been invaded by upland trees. The project also included the construction of an educational wetland at the point where canal water was pumped into Cutler Creek's headwaters. Wagner Creek, meanwhile, would have been the site of a restoration project planned by TNC had it not been cancelled. TNC's plans, which would have fit neatly within the BBTF's recommendations on watershed habitat restoration, were to establish native riparian vegetation along Wagner Creek. The goals of the project were to increase greenspace while slowing and filtering stormwater runoff (The Nature Conservancy [TNC], 2017). This project progressed through several years of planning before being cancelled in 2020.

In addition to differences in their restoration trajectories, Cutler Creek and Wagner Creek differ in terms of physical and socio-economic watershed characteristics. Cutler Creek's watershed is 350 hectares in area, but because of the connection to the C-100 canal established by the restoration project, it drains 10,578 hectares when the pumps are running. The creek's channel lies entirely within the Deering Estate, a Miami-Dade County park that features protected archaeological sites, historic buildings, and one of the largest tracts of protected upland vegetation in the Miami area (Diamond & Heinen, 2016). Beyond the Deering Estate, Cutler Creek is surrounded by census tracts that are wealthy and characterized by a high percentage of white households. The collective median household income of these tracts is $73,656 (US Census Bureau, 2020), and the population is 73% white Hispanic or white and 22% Black or non-white Hispanic (US Census Bureau, 2022).

The watershed of Wagner Creek, meanwhile, comprises impoverished neighbourhoods and a notable lack of urban greenspace. The creek's watershed covers 468 hectares and includes an industrial district and parts of two of the most impoverished neighbourhoods in Miami—Allapattah and Overtown. Median household income of census tracts in the watershed is $27,237 (US Census Bureau, 2020), and the population is 54% white Hispanic or white and 44% Black or non-white Hispanic (US Census Bureau, 2022). Due to their different socio-economic contexts and restoration trajectories, Cutler Creek and Wagner Creek provide useful case studies for assessing the processes and outcomes of site prioritization in estuary restoration. In the following sections, I assess restoration priority at the sites and evaluate the factors—social or ecological—that help explain their restoration trajectories.

AVAILABLE LAND AND WATER FOR RESTORATION AT CUTLER CREEK

Records of biophysical change in Cutler Creek begin around the turn of the 20th century. Prior to this time, Cutler Creek was likely a short tidal creek constrained to coastal wetlands (Florea et al., 2015), and land at the head of the creek was the site of Indigenous inhabitation between 750 and 1750 CE (Carr, 2012). Indigenous inhabitants widened and deepened many South Florida waterways for canoe travel (Frank, 2017), but it is unknown if Cutler Creek or its catchment was modified in such a way. The first records of change show that the creek was extended westward in 1897 via a channel blasted through the Miami Rock Ridge, in order to drain wet prairies for a growing winter tomato production industry (Kleinberg, 1988; Weber, 1939). Around the same time—and perhaps as part of the same efforts—the coastal portion of Cutler Creek's channel was likely deepened and straightened through what is now a mangrove forest. Later, in 1962, severe flooding in the watershed caused by Hurricane Donna led to Congressional appropriation of drainage funds to construct the C-100 canal (US Congress, 1962), which severed Cutler Creek's connection to wet prairies in the upper part of its watershed. Drainage provided by the C-100 and other canals lowered groundwater levels in the region and disrupted freshwater inputs into Biscayne Bay, leading to degradation of the bay's nearshore environments.

Terrestrial landscapes in Cutler Creek's watershed also experienced change when, around 1900, the town of Cutler was established near the creek. Growth of the town resulted in development in the surrounding forest and prairie until 1913, when Charles Deering, Chairman of the Board of the agricultural implement company International Harvester, began to buy up properties (Matthews, 1992). Deering was keenly interested in environmental conservation and preservation, and he enlisted the assistance of botanist John Kunkel Small in establishing much of his property as a preserve. Together—and with the help of a sizable landscaping crew—they replanted vegetation along the stream's banks and destroyed all buildings in the surrounding forest (Matthews, 1992). By the time of the earliest aerial photos, in 1928, visible evidence of the town of Cutler had disappeared, and Cutler Creek's modified channel traveled through an unbroken block of upland and mangrove forest before emptying into Biscayne Bay. All told, the history of Cutler Creek presents a mixed view of ecosystem degradation. Hydrological modifications altered freshwater inputs from the creek's watershed into the bay, but, in terms of the terrestrial landscape, the entire lower watershed of the creek had, in a sense, already been restored and protected through the actions of Charles Deering.

Regarding the restoration project's likelihood of reversing past watershed modifications, information given by key informants suggests that the chance of success was low due to constraints on the design of the project. This is explained well by the statements of one key informant who worked on an early BBCW planning study commissioned by the SFWMD. The study assigned the lowest priority to Cutler Creek, as explained by the key informant: "That's what upset us about the [Cutler Creek] restoration. Because it was least important on the list, it didn't even make our final management list." The reasons for this low priority were explained by the same key informant, as follows: "We felt that the canal through the mangroves, in order to be properly restored, would have to be backfilled. And that's when they came up with the idea that they can't backfill because it's a historic canal …That was one of the major reasons that [Cutler Creek] slipped to the bottom of the list." Here, the term "canal" is used by the key informant to refer to Cutler Creek's modified channel. Taken together, the data on historical degradation and restoration design suggest that the project's potential for undoing hydrological modifications was limited.

Although Cutler Creek experienced significant changes to its watershed and channel, water quality data suggest that it was less polluted and had fewer disruptions to freshwater inputs than other streams in the Biscayne Bay watershed. As shown in Table 1, nitrogen and phosphorus concentrations in Cutler Creek exceeded water quality standards for the corresponding region of Biscayne Bay for 2017–2020, but by a much

TABLE 1 Total nitrogen (N) and phosphorus (P) concentrations in streams calculated as geometric means.

		May 2017–Apr 2018	May 2018–Apr 2019	May 2019–Apr 2020	Regional Biscayne Bay standards
Total N (mg/l)	Cutler Creek	0.49	0.52	0.46	0.31
	Wagner Creek	0.56	0.61	0.76	0.29
Total P (mg/l)	Cutler Creek	0.013	0.011	0.013	0.007
	Wagner Creek	0.048	0.040	0.051	0.010

Source: Cutler Creek data from SFWMD (2019, 2020, 2021). Biscayne Bay standards from the Florida Department of State (FDS, 2016).

lesser degree than in Wagner Creek. The coastal environment near Cutler Creek features the lowest degree of saltwater intrusion along the entire Biscayne Bay coast (Renken et al., 2005) and among the lowest nearshore salinity levels and water quality impairment (Caccia & Boyer, 2005; Millette et al., 2019). This combination of relatively low nutrient concentrations in the creek and adjacent coastal waters suggests that the restoration project would have had limited effects on pollutants in the bay. In terms of nearshore salinity, potential benefits were diminished by the unwillingness of site managers to undo channel modifications, though, according to key informants, the project has had a limited beneficial effect. Taken all together, these data suggest low potential water quality gains.

Having briefly evaluated the benefits of restoration at Cutler Creek, I will proceed to describe how and why it was selected. Restoration at Cutler Creek was part of the Comprehensive Everglades Restoration Plan, meaning that decision making followed US Army Corps of Engineers and SFWMD protocol, including the evaluation of project alternatives according to ecological and economic costs and benefits, but with stipulations that disallow any threats to flood control or water supplies (US Army Corps of Engineers & South Florida Water Management District [USACE & SFWMD], 2011). The BBCW suite of projects, including Cutler Creek, was first evaluated and recommended in a 1999 US Army Corps report on Everglades Restoration (USACE & SFWMD, 1999). A later document, known as the Project Implementation Report, featured an evaluation of the cost effectiveness of various BBCW plan formulations and selection of a final restoration plan (USACE & SFWMD, 2011). However, neither of these documents considered versions of the BBCW plan without Cutler Creek, and there is an absence of published information on how the creek was selected as one of the BBCW restoration sites.

Early planning documents do not give much information about why Cutler Creek was selected for inclusion in BBCW, but key informant statements suggest that the reasons can be described by land opportunity and institutional fit. Land opportunities for restoration at Cutler Creek were created by Charles Deering's consolidation of property in the watershed and the public acquisition of the property in 1985 (Frank, 1985). These two processes combined to produce a single property that encompassed Cutler Creek's entire channel and put that property in public ownership. An SFWMD staff member explained that “availability of land was a key factor” in the selection of Cutler Creek. This available land meant lower project costs, as explained by a university professor who had a role in early planning: “It didn't cost that much to do it. It was really cheap. All they had to do was scrape a hole. The biggest expense was the pump, right?”

In addition to having land available for restoration, key informants mentioned that Cutler Creek provided a good institutional fit for SFWMD's approach to restoration. One factor in this fit was the proximity of Cutler Creek to canals in the regional water control system. As explained by a staff member of SFWMD, “availability of water was a key factor” in the selection of Cutler Creek, given its location 200 metres from an offshoot of the C-100 canal. Another component of institutional fit was that BBCW restoration plans called for rerouted water to go through coastal wetlands, and the volume of water rerouted was a metric used in reporting project progress. Cutler Creek was a good match for these plans because it passes through coastal wetlands without crossing any populated zones. Therefore, large volumes of water could be rerouted without affecting nearby residences, which was important because, as a staff member of SFWMD noted, “risk of flooding was a constraint.” In this way, the geography of Cutler Creek was a good fit for the features and constraints of SFWMD's restoration approach, even if its ecological benefits were limited.

HIGH PROJECT COSTS AND CHANGING PRIORITIES AT WAGNER CREEK

Although Wagner Creek was ultimately rejected as the site of a restoration project, its early history of modifications is like that of Cutler Creek. The creek is directly adjacent to land that was an important foraging ground for Indigenous groups for over a thousand years before Europeans arrived (Frank, 2017). As with Cutler Creek, however, it is not known if Indigenous inhabitants modified the creek for transport or any other purposes. A two-kilometre canal extension of Wagner Creek was dug in 1909 as a means of draining wetlands for agricultural production (Gaby, 1993). The nearby dredging of the Miami Canal in 1909—a centrepiece of early efforts to drain the Everglades—likely also affected the creek by lowering the water table. These drainage efforts would have had similar negative effects on the hydrology of Biscayne Bay, as did drainage and flood control at Cutler Creek. However, unlike at Cutler Creek, open space in the Wagner Creek watershed was gradually closed through urbanization, and the area was left with few parks and little urban greenspace.

Another consequence of urbanization at Wagner Creek that would prove to be important in Biscayne Bay's water quality issues was contamination through dumping. Wagner Creek became a dumping ground early in Miami's history. In one early example, animal carcasses and other food wastes were dumped in the vicinity of the creek in 1905 by the operators of Miami's first luxury hotel (*The Miami Evening Record*, 1905). Toxic contamination of Wagner Creek likely began in 1921 with the construction of a city incinerator in the northeastern part of the watershed (*The Miami News*, 1921). In 1955, the first incinerator was replaced with a new model that piped contaminated effluent directly to the creek (Pennekamp, 1955). It was later discovered that operation of the incinerators left Wagner Creek and surrounding soils contaminated with dioxins—toxic chemicals produced from combustion of plastics and bleached paper products (Florida Department of Health [FDH], 2004). This discovery prompted a 2018 dredging project aimed at removing contaminated sediments from the channel. Meanwhile, illegal dumping and illegal wastewater connections were also longstanding problems in the creek (Metropolitan Dade County Planning Department [MDCPD], 1986). This history of drainage, dumping, toxic contamination, and poor wastewater management all suggest that there was extensive degradation that restoration initiatives could have addressed.

Wagner Creek's history of degradation and initial cleanup efforts spurred TNC's plans for a restoration project. They planned to build upon the 2018 dredging project by restoring habitat along the creek through the installation of stormwater-absorbing bioswales and other riparian vegetation (TNC, 2017). As a TNC staff member said, “We [wanted] to take the dredging to the next level. They dredged it, they got a couple feet [of contaminated sediments], let's go from here and make sure that we don't have to continue to do this every decade.” Their plan was for restoration to proceed in two phases. The construction of bioswales and greenspace was to serve as a pilot project, followed by a larger-scale effort at daylighting upstream portions of Wagner Creek that had been buried, making it possible to address hidden pollution sources. These plans were received enthusiastically by other environmental management agencies in Miami. As one agency staff member said, “We were so excited when [TNC] reached out … [the project was] consistent with our goals and intentions for management of the Miami River basin.” The project was kicked off with an outreach event for local elementary students in November 2019, but within a few months of that event, project plans had been cancelled.

Given its cancellation, it is challenging to determine the project's likelihood of success in addressing degradation at Wagner Creek. At a minimum, TNC's pilot project would have resulted in the addition of native vegetation and greenspace to the watershed. Replanting riparian vegetation has been shown to reduce nutrient pollution in urban streams (McMillan et al., 2014), but this effect may have been minimal if the pilot project did not lead to more restoration work. Similarly, the pilot project alone would have had little effect on hydrologic modifications of the creek, given that it was planned to restore vegetation on less than 10% of the creek's length, but if it led to upstream daylighting, the impact could have been much greater.

In terms of ability to improve downstream water quality in Biscayne Bay, recent water quality data suggest that Wagner Creek is an important site for interventions. The Miami River system, including Wagner Creek, is among the biggest problem areas for pollution entering the Bay (BBTF, 2019). Within the Miami River system, Wagner Creek has been the site of many of the worst water quality violations in recent years (Miami River Commission [MRC], 2017, 2018, 2019). Furthermore, as shown in Table 1, nitrogen and phosphorus concentrations in Wagner Creek exceeded corresponding Biscayne Bay standards by a much greater degree than in Cutler Creek for 2017–2020. Looking at it from a broader perspective, northern Biscayne Bay, which Wagner Creek ultimately drains into via the Miami River, suffers from poor water quality conditions that are continuing to deteriorate (Millette et al., 2019). As summarized in Table 2, these data suggest that well-designed interventions at Wagner Creek could have improved water quality in the bay. However, as mentioned above, benefits would have been minimal if efforts stopped with TNC's pilot project.

The above analysis shows that restoring Wagner Creek could have been beneficial, given the creek's degraded watershed and its potential contribution to Biscayne Bay water quality problems. In this section, I analyze the process by which the Wagner Creek project was proposed, as well as the factors that led to its rejection by TNC. To understand this process, it is first necessary to consider the administrative context of TNC in Miami. The Wagner Creek project fell under the administrative authority of TNC's Florida Chapter. Within the Florida Chapter, there are various program areas, including Cities and Coastal Resilience & Climate Adaptation, but all come under the decision-making authority of the chapter's Board of Trustees, which is made up of members from throughout Florida.

The first impetus for restoration at Wagner Creek came from a watershed plan that TNC staff developed for the Miami River. As explained by one key informant, “[The watershed plan] was the bigger picture view that led us to start with Wagner Creek … that kind of made Wagner Creek pop up.” From there, they considered ways to clean up the creek, initially planning for a trash cleanup event before realizing they could address pollution at broader scales through a restoration project. As one key informant stated, “And so this idea came about … how do we dive a little deeper into what this creek could do to help not just with that area, but around the river and essentially into the Bay? So this idea came to us, why don't we look at these upstream pollution issues?” Taken together, these quotations suggest that the Wagner Creek project was attractive to local TNC staff because it would have had benefits for the creek and Biscayne Bay.

However, the benefits of a Wagner Creek restoration project were never realized for reasons that can be described, once again, in terms of land opportunities and institutional fit. Key informants described the high cost of constructing greenspace on previously developed land and the challenges of working with multiple land lessees as two of the issues that doomed TNC's restoration plans. Unlike at Cutler Creek, there are not large blocks of undeveloped public land along Wagner Creek. While there are small parcels of public land, they are disjunct and partially paved.

TABLE 2 Summary of characteristics guiding restoration priority.

Site characteristics	Cutler Creek	Wagner Creek
In-stream water quality problems	N	Y
Nutrient pollution nearby in bay	N	Y
Altered freshwater flows into bay	Y	Y
Lack of natural habitat in watershed	N	Y
Environmental inequities in surrounding communities	N	Y

This lack of extensive greenspace meant that project construction would necessarily take place in multiple developed parcels, requiring buy-in from landowners and those leasing the land. In the case of one pilot project site, a TNC staff member explained, “Part of the challenge was, we had a landowner, as well as a tenant that has the management authority over it … so that always adds some complications to things.” Key informants pointed out that such a situation would not normally derail a TNC project, given the organization's experience managing complex land ownership situations. However, in this case, because the land had already been developed, the cost of demolition was going to be high. Another TNC staff member explained how these demolition costs made the project less attractive to Board members: “[There were] parking lots or fences that we had to break up and think about how to demolish those areas. Those costs compared to what could go towards just purchasing land elsewhere in the state … it is costly, even if it's public land … that same amount of money could be used to just buy and protect land in the north.”

The second reason identified by key informants for the cancellation of TNC's project was a narrowing of institutional focus onto coastal resilience. The Florida Chapter of TNC decided to concentrate efforts in South Florida on adaptation to sea level rise along the Biscayne Bay coast, meaning that Wagner Creek, an inland waterway, was a poor fit. A key informant explained how this change in institutional focus prompted TNC decision makers to reject the project despite their high regard for it: “Wagner Creek is not a coastal project. It's an upstream project, you're trying to basically think about capturing stormwater and cleaning it before it filters to the coast … And so, they liked the project, but the interest became about how do we protect our coast … versus going two to three miles inland on the river, on the creeks.”

The change in institutional focus was partly driven by external funding opportunities. TNC did not have external funding for inland projects like Wagner Creek, but they had secured corporate donations for coastal resilience work. As explained by a TNC staff member: “We had funding dedicated from [several private corporations] that were funding us to do this work, because it's in areas that they're extremely interested in … comparatively, there was less interest inland.” This indicates that a project at Wagner Creek was not aligned with the interests of external funders, and therefore not a good match for TNC's programs. Thus, poor institutional fit and a lack of low-cost land opportunities convinced TNC to cancel the project, despite Wagner Creek's degraded state and the potential for benefit to Biscayne Bay.

THE PRODUCTION OF UNEQUAL LANDSCAPES OF RESTORATION

In the Cutler Creek and Wagner Creek case studies presented above, I found that prioritization decisions at the two sites supported Palmer's (2009) assertion that land opportunity and social considerations, such as institutional fit, play a dominant role in site selection. In this section, I consider the implications of these decisions in the context of uneven cities. Specifically, I begin with an exploration of inherent equity issues with opportunity-based prioritization, given unequal distributions of greenspace in urban areas. Next, I analyze institutional fit by describing the political implications of the approaches espoused by restoration actors in my study sites.

Given that land availability is a primary driver of restoration siting decisions, including those in my case studies, urban processes that produce publicly owned land are of tantamount importance in determining where restoration projects take place. In the case of Cutler Creek, consolidation of land by a wealthy industrialist, Charles Deering, was the first step in creating land opportunities for restoration today. This effect was not limited to the Cutler Creek watershed, as Deering was just one of several wealthy landowners whose property purchases at the time have had effects that persist in the present. Others included James Deering—Charles' brother and partner in International Harvester—and W. J. Matheson, an early leader in the manufacture of synthetic dyes. Each of these men set aside significant parts of their properties as nature preserves (Blank, 1996; Rybczynski & Olin, 2007) and, in large part, these preserves have been maintained into the present—now as public parks—forming a green ring around central Biscayne Bay.

While development processes initiated by financial elites created protected natural areas along the coast of Biscayne Bay, a different set of processes turned the inland Wagner Creek watershed into a dumping ground. Although outside the city limits at the time of the construction of the incinerator, the upper Wagner Creek area was incorporated shortly afterward, as part of the Allapattah neighbourhood. In the 1950s–1960s, Allapattah suffered from disinvestment and decline, becoming one of Miami's “second ghettos” (*sensu* Hirsch, 1983), which were refuges for Black residents displaced by urban renewal and recent immigrants with few resources (Mohl, 1995). It is not clear what role polluting facilities like the incinerator, or the pollution of Wagner Creek, played in disinvestment in Allapattah, but, as environmental justice studies have shown, pollution, racism, and disinvestment tend to be tightly linked (Pulido, 2000).

One of the likely consequences of disinvestment around Wagner Creek, and in similar disadvantaged neighbourhoods across the world, is a lack of public greenspace. Research has shown that marginalized communities have less access to urban park acreage (Rigolon, 2016). Given the importance of land opportunities in restoration siting decisions, such differences in greenspace are likely to influence decisions about where to host restoration projects. As shown above, the presence of public urban greenspace helped attract a restoration project at Cutler Creek. Meanwhile, in Wagner Creek, disinvestment processes and marginalization may have contributed to a lack of public greenspace, a lack which was later implicated in the cancellation of the creek's restoration project. In this way, wealthy neighbourhoods may be selected for restoration initiatives that create environmental amenities simply by virtue of already possessing other environmental amenities, like public greenspace.

Thus, urban restoration siting decisions based on land opportunities are likely to be produced by, and to reproduce, unequal landscapes of restoration.

In addition to land availability, institutional fit was another driver of restoration decisions in my case studies. The geography of Cutler Creek, in terms of its proximity to the regional network of canals and coastal wetlands, made it an excellent fit for the BBCW restoration plans. Meanwhile, when TNC shifted their focus to South Florida's coastal environments, the inland location of Wagner Creek was no longer a good match for their priorities. These institutional approaches have political and ecological implications. BBCW's emphasis on routing water through coastal wetlands limits its scope to the coasts of Central and Southern Biscayne Bay, which are the only coastlines still bounded by mangrove wetlands, even though the North Bay is more polluted. Furthermore, the general coastal focus of BBCW—and TNC—concentrates restoration work in wealthy neighbourhoods and municipalities, which in Miami are more likely to be located on the water. This means that coastal residents who are already likely to benefit from improved conditions in the bay—given proximity and waterfront access—will also enjoy better access to the more localized amenities of restoration projects, like urban greenspace. In this way, restoration decisions based on institutional fit, like those based on land opportunities, may reproduce environmental inequities when institutions do not prioritize justice.

However, as a final discussion point, it should be mentioned that restoration projects are not always a benefit to local communities. Instances of green gentrification have been documented following restoration projects (Gould & Lewis, 2012), including efforts to clean up degraded waterways (Baptiste, 2018). This complicates the evaluation of equity, especially in a case like Wagner Creek. The same legacies of disinvestment that created a need for restoration in such watersheds may make their residents more vulnerable to displacement. This risk brings up an issue I have not explored in this paper, the importance of seeking procedural equity by centring local community perspectives in restoration design and goal setting (Newman, 2011). My findings show, however, that this focus on procedural equity must be accompanied by changes in the way sites are selected for restoration.

A CALL FOR ENVIRONMENTAL JUSTICE-BASED CRITERIA IN SITE SELECTION

In this paper, I use two case studies in the Biscayne Bay watershed to explore restoration siting decisions and assess potential inequities that siting priorities entail. Arguably more important than any claims I make about restoration priorities, however, is the idea that restoration decision making regarding Biscayne Bay does not happen in a vacuum devoid of social context or consequences. Given that power and inequality in Miami have spatial contexts, as they do in all cities, restoration decision making cannot avoid political entanglements or the risk of reproducing inequities. Considering these realities, I echo others who have called for explicit attention to justice and equity in restoration planning (Osborne et al., 2021). I further argue that these same entanglements and risks make urban estuary restoration an important area of study for the field of CPG.

To reduce the risk of reproducing unequal landscapes of restoration, it is imperative that public agencies and their non-profit collaborators consider environmental justice in their decision making. Without environmental justice-based selection criteria, the odds are stacked against poor and otherwise marginalized neighbourhoods getting restoration projects. This is despite the likelihood that these neighbourhoods contain water bodies and landscapes that export contamination to regional ecosystems, like Biscayne Bay.

The problems of urban estuaries—their dynamic combination of environmental change, restoration efforts, and social unevenness—are an excellent fit for CPG approaches. Despite this fit, there are few CPG analyses of coastal areas or of urban restoration. There is a need for interdisciplinary analyses capable of interpreting biophysical change in estuaries, assessing social impacts with an eye toward environmental justice, and taking a critical view of scientific theory behind environmental interventions. These needs align well with Tadaki's (2017) call for CPG to embrace an integrated mode of critique, in which rigorous biophysical science is paired with nuanced exploration of the ways that scientific theory and practice may reproduce systems of domination or inequity. These modes of critique are separately well-established in other disciplines, such as ecology (Palmer, 2009) and political ecology (Gould & Lewis, 2012; Moran, 2007), but the promise of CPG is to integrate them (Tadaki, 2017). As I show in this paper, the integration of these modes of critique is necessary to untangle the historical legacies of uneven urban development and address urgent threats of environmental change in urban estuaries.

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