ISSN: 2710-0170

Urban Ecological Restoration via Rewilding: Theoretical Reconstruction, Technical Pathways, and Multi-Scale Empirical Evidence

Yongyan Zhang *

School of Landscape Architecture, Zhejiang Agricultural and Forestry University, Hangzhou, China

Abstract

In the face of escalating global ecosystem degradation and biodiversity loss, "rewilding" has emerged as a strategic approach for ecological restoration, gradually shifting its focus from wilderness conservation to urban renewal. This paper aims to construct a comprehensive theoretical framework and technical system for "Urban Rewilding"—an emerging strategy tailored to complex built environments. First, by situating the discourse within the "Novel Ecosystem" theory, the study distinguishes urban rewilding from traditional restoration, advocating for "controlled abandonment" to reconstruct ecological resilience. Second, it dissects the underpinning ecological mechanisms, including plant community assembly based on CSR strategies, the restoration of the soil food web, and the reconstruction of trophic cascades. Empirically, a cross-scale comparative analysis of four paradigmatic cases—including New York's High Line Park and London's SUGi Pocket Forests—reveals the necessity of "process-oriented" design, transitioning the designer's role from a creator of form to a choreographer of ecological processes. Finally, the paper proposes implementation pathways spanning technical, aesthetic, and social dimensions, emphasizing native germplasm banks, "Cues to Care," and adaptive management. The study concludes that urban rewilding offers Nature-based Solutions (NbS) for reshaping the human-nature symbiosis in the Anthropocene.

Keywords

Rewilding; Urban Ecological Restoration; Naturalistic Planting; Biodiversity; Adaptive Management.

1. Introduction

1.1. Research Context: The Vulnerability of the "Green Desert"

Since the Industrial Revolution, human activity has become the dominant force shaping geological and ecological processes, marking the entry into the "Anthropocene" [1]. In urban environments, intensive land development has led to habitat fragmentation, the severance of hydrological cycles, and the imbalance of biogeochemical cycles.

While conventional urban landscaping provides significant aesthetic and recreational value, its operational model faces increasing scrutiny. Traditional practices rely heavily on high-intensity anthropogenic interventions—such as frequent irrigation, fertilization, and pruning—to maintain a static, idealized image of nature. Furthermore, the widespread use of identical lawns, ubiquitous street trees, and globally traded horticultural cultivars has accelerated "Biotic Homogenization"[2]. Consequently, many urban green spaces have devolved into "green deserts"—areas that are visually green but biologically impoverished and lacking in ecological resilience. These simplified ecosystems are often incapable of self-regulation, rendering cities critically vulnerable to extreme weather events such as heatwaves and torrential rains.

ISSN: 2710-0170

Therefore, shifting from "cosmetic greening" to functional ecological restoration has become an urgent priority for contemporary landscape architecture and urban ecology[3].

1.2. The Rise of Rewilding and Paradigm Shift

As a radical strategy to counter biodiversity loss, "Rewilding" was first proposed by Soulé and Noss (1998), focusing on the "3 Cs": Cores, Corridors, and Carnivores[4]. However, transplanting this concept into high-density human settlements requires adaptive modification. Urban rewilding does not seek a return to a pre-industrial pristine state; rather, it emphasizes the restoration of ecological processes and trophic interactions. It involves reducing human interference to allow natural forces to regain agency over ecosystem succession [5].

This shift represents a fundamental departure in landscape architecture from "controlling nature" to "partnering with nature" [6]. It challenges the Modernist obsession with certainty and order, embracing instead uncertainty, stochasticity, and dynamic change.

1.3. Research Objectives

Current research on urban rewilding is often limited to conceptual discussions or singular case descriptions, lacking systematic theoretical support and actionable technical guidelines. This paper aims to bridge this gap by:

Theoretical Reconstruction: Defining the boundaries and goals of urban rewilding through the lens of Novel Ecosystem theory.

Mechanism Analysis: Revealing the plant and soil ecology mechanisms supporting urban rewilding.

Technical Pathways: Constructing a lifecycle technical system ranging from substrate restoration to community assembly and adaptive management.

Empirical Analysis: Distilling rewilding strategies across different scales and cultural contexts through comparative case studies.

2. Theoretical Framework: From Naturalism to Urban Rewilding

2.1. Conceptual Evolution: Naturalism, Restoration, and Rewilding

"Naturalism" has a long lineage in landscape history, from the English Landscape Movement to McHarg's "Design with Nature." Its core has traditionally been the aesthetic imitation of natural forms.

Ecological Restoration: Traditionally defines success as returning a damaged ecosystem to a historical baseline prior to disturbance. However, in highly modified cities—altered by changed soil chemistry, heat island effects, and exotic species—returning to the past is often economically unfeasible and ecologically impossible.

Rewilding: Unlike restoration, rewilding is future-oriented. It does not presuppose a terminal state but aims to restore the autonomy and wildness of the system. Jepson (2016) posits that rewilding is about restoring food webs and natural disturbance regimes so that ecosystems can sustain themselves without continuous human management [7].

2.2. Key Theoretical Pillars in the Urban Context

2.2.1 Novel Ecosystems Theory

Hobbs et al. (2006) argue that human activity has created "Novel Ecosystems"—combinations of biotic and abiotic conditions that have never existed before in nature (e.g., brownfields, railway verges). For these irreversible systems, insisting on pristine restoration is futile. Urban rewilding acknowledges the value of these novel systems, utilizing existing conditions (including naturalized non-native species) to guide succession toward high ecological functionality rather than pure nativity [8].

ISSN: 2710-0170

2.2.2 Social-Ecological Systems (SES)

Cities are complex Social-Ecological Systems. Urban rewilding cannot be isolated from human perception, cultural acceptance, and social equity. It requires a "participatory" approach that seeks a dynamic equilibrium between ecological wildness and social well-being, fostering "coexistence" rather than segregation [9].

2.2.3 The Biophilia Hypothesis

E.O. Wilson's Biophilia Hypothesis suggests an innate human tendency to seek connections with nature. Urban rewilding, by providing access to authentic, messy nature (as opposed to manicured horticultural nature), can effectively mitigate "Nature Deficit Disorder," improving the psychological health and cognitive functioning of urban residents [10].

3. Ecological Mechanisms of Urban Rewilding

3.1. Plant Community Assembly: CSR Strategies and Functional Diversity

In rewilding, plant selection must prioritize life-history strategies over aesthetics. Grime's CSR Theory (Competitors, Stress-tolerators, Ruderals) provides a scientific basis for urban planting [11].

Stress-tolerators : Essential for extreme urban niches (e.g., green roofs, roadside verges), such as Sedum spp.

Ruderals : Species with rapid reproduction rates, crucial for initial ground cover to prevent erosion and stabilize soil.

Competitors : Used to establish stable climax communities over time. Successful rewilding often employs a functional group mixing strategy, introducing species with different strategies simultaneously to increase functional redundancy and resilience against disturbances.

3.2. Soil Food Web Restoration: From Below Ground to Above

Soil is the cornerstone of terrestrial ecosystems. Traditional landscaping often degrades soil biodiversity through leaf litter removal and chemical inputs. Rewilding focuses on rebuilding a fungal and bacterial-dominated Soil Food Web.

Mycorrhizal Symbiosis: Reintroducing Arbuscular Mycorrhizal Fungi (AMF) significantly enhances plant uptake of phosphorus and nitrogen in poor urban soils and improves drought resistance.

Organic Matter Cycling: Retaining the litter layer is critical for sustaining soil fauna (e.g., earthworms, collembola), which decompose organic matter into plant-accessible nutrients, closing the nutrient loop [12].

3.3. Trophic Cascades and Biological Interactions

Urban ecosystems typically lack apex predators, leading to simplified trophic structures. Urban rewilding employs "Trophic Rewilding" at a micro-scale:

Bottom-up Control: Increasing the biomass of insects and primary consumers by planting native nectar and food-source plants (e.g., berry-producing shrubs), which in turn attract secondary consumers like birds.

Pollinator Networks: Focusing on the habitat needs of wild bees and butterflies to reconstruct fragmented pollination chains.

The High Line Park was originally an abandoned elevated freight rail line in Manhattan's West Side. Facing demolition, the non-profit organization "Friends of the High Line" promoted a proposal to transform it into a public space. The project eschewed traditional manicured

ISSN: 2710-0170

gardening in favor of an "Agri-tecture" concept, preserving the coexistence of rail relics and spontaneous vegetation.

4. Multi-Scale Empirical Case Studies

To understand the practical logic of rewilding, this section analyzes four cases across different scales and contexts.

4.1. Simulated Secondary Succession on Brownfield: High Line Park (New York)

Context: Originally a freight rail line built in 1934 and abandoned in 1980, the High Line developed a unique "industrial wilderness" via natural succession over 20 years.

Rewilding Strategy:

Phytosociological Translation: Piet Oudolf and ecologists surveyed the 210 species that spontaneously colonized the ruins. The design did not simply keep the weeds but extracted their "wild texture" and "resilience," selecting native and adaptive species like Little Bluestem (Schizachyrium scoparium) and Purple Coneflower (Echinacea purpurea). This "Enhanced Wildness" retains the wild aesthetic while extending the season of interest [13].

Agri-tecture Substrate System: A custom tapered planking system was developed to mimic plants growing in bedrock fissures. This allows stormwater to permeate directly into the substrate, achieving on-site management.

Dynamic Succession Management: Maintenance avoids traditional "deadheading." Dried perennials are left standing in winter, creating a unique structural landscape and providing overwintering habitats for insects. This aesthetic of "embracing decay" is a hallmark of rewilding.

4.2. Urban Wilderness: Südgelände Nature Park (Berlin)

Context: A former railyard abandoned for 50 years after WWII, Südgelände evolved into a complex mosaic of dry grasslands, pioneer woodlands, and climax forests. It is the "grandparent" of urban rewilding.

Rewilding Strategy:

Controlled Abandonment: The core strategy is "minimal intervention." Large areas are designated as strict nature reserves, accessible only to researchers, allowing nature to drive succession.

Spatial Zoning: The site is divided into "Pure Nature Areas," "Nature Experience Areas" (guided by elevated walkways), and "Industrial Relic Areas." This protects sensitive habitats while allowing public recreation.

Industrial Nature: Steam locomotives and water towers are preserved in situ, slowly rusting amidst the encroaching vegetation. This concept of "Industrial Nature" validates the cultural synthesis of anthropogenic and natural history [14].

4.3. High-Density Micro-Greening: SUGi Pocket Forest (London)

Context: Addressing the lack of large green spaces in dense urban areas, the SUGi project in Chelsea applies the "Miyawaki Method" to create micro-forest ecosystems.Key Techniques:

Potential Natural Vegetation (PNV): Strict selection of climax species native to the specific locale (e.g., English Oak, Beech).

Competition-Driven Growth: Planting at an ultra-high density of 3-4 saplings per square meter. This crowding mimics the intense competition of natural forest regeneration, forcing vertical growth rates 10 times faster than conventional afforestation [15].

ISSN: 2710-0170

Microbial Inoculation: The use of "compost tea" and native mycorrhizal fungi activates the soil biological activity, allowing the forest to become self-sustaining (no irrigation) within 2-3 years.

4.4. Ecological Functionalism: Houtan Park (Shanghai)

Context: Located on a former steelworks and landfill along the Huangpu River, Houtan aims to create a regenerative ecosystem for flood control and water purification.

Rewilding Strategy:

Productive Landscape: The introduction of crops (sunflowers, rice) and wetland plants restores the land's productive function, blending agricultural heritage with ecology.

Ecosystem Service Orientation: A terraced wetland system uses plant roots and microbial degradation to purify polluted river water. This "Green Sponge" demonstrates the utilitarian value of rewilding [16].

Table 1: Comparative Analysis of Multi-Scale Urban Rewilding Case Studies

Case Study	Core Rewilding Strategy	Key Technical Interventions	Primary Ecosystem Services
High Line Park(New York,USA)	Simulated Secondary Succession	Phytosociological translation of pioneer species;"Agri-tecture" substrate system	Biodiversity support (pollinators); Stormwater management;Cultural heritage preservation
Südgelände Nature Park(Berlin, Germany)	Controlled Abandonment	Spatial zoning (strict reserves vs. accessible paths);Minimal intervention	Climax habitat provision; Microclimate regulation (cooling effect)
SUGi Pocket Forest (London, UK)	High-Density Micro-Greening	Miyawaki Method (PNVselection);Ultra-high density planting; Soil microbial inoculation	Rapid carbon sequestration;Noise reduction;Air qualit improvement
Houtan Park(Shanghai, China)	Ecological Functionalism	Terraced wetland construction;Extensive use of native "weeds" (e.g., Phragmites)	Water purification (Green Sponge); Flood control; Agricultural production

The Aesthetic of the Wild: The extensive use of native "weeds" like Phragmites (reeds) and Imperata cylindrica challenges traditional Chinese horticultural preferences for exotic flowers, advocating for a "Big Foot Revolution" in aesthetics.

5. Technical Pathways and Implementation System

Based on the theory and cases, we propose a lifecycle technical system for urban rewilding.

5.1. Phase I: Abiotic Restoration & Substrate Engineering

Before introducing biology, physical conditions must be primed.

ISSN: 2710-0170

Habitat Potential Assessment: Evaluate seed bank potential and identify existing spontaneous vegetation. Distinguish between invasive species to remove and native pioneers to retain.

Soil Rewilding & Technosols:

De-compaction: Deep ripping of compacted urban soils.

Substrate Modification: Creating "Technosols" by mixing construction waste (crushed brick/concrete) with compost. This creates a low-fertility, high-drainage substrate that mimics stress-prone wild habitats, suppressing vigorous weeds while favoring stress-tolerant natives [17].

Hydrological Connectivity: Depaving impervious surfaces to restore natural infiltration and creating seasonal vernal pools.

5.2. Phase II: Biotic Assembly

Germplasm Provenance: Prioritize wild-collected seeds from within a 50km radius to ensure genetic adaptability.

Matrix Planting Strategy:

Matrix Layer (>50%): High-coverage grasses (e.g., Carex, Festuca) to cover the ground and suppress weeds.

Structural Layer: Architectural shrubs or tall perennials for visual focus.

Scatter Layer: Randomly dispersed annuals or short-lived perennials to mimic natural stochasticity.

Seed Bombs: For large areas, use hydroseeding or clay-encased seed balls containing native seeds and compost to introduce pioneer communities at low cost.

5.3. Phase III: Adaptive Management

Rewilding is not "no maintenance," but "low intervention management."

Simulated Disturbance Regimes: Mimic natural disturbances. For example, an annual late-winter mow simulates grazing or fire, with the clippings mulched back into the soil to close nutrient cycles [18].

Invasive Species Monitoring: While some naturalized species are tolerated, aggressive invaders (e.g., Solidago canadensis) require targeted removal.

Deadwood Retention: Where safe, retain snags and log piles (hibernacula) to support saproxylic beetles and fungi.

6. Social Dimensions and Aesthetic Challenges

6.1. Ecological Aesthetics and "Cues to Care"

A major barrier to urban rewilding is public perception; unkempt landscapes are often misread as "neglected" or "unsafe." Nassauer's "Cues to Care" theory offers a solution [19].

Orderly Frames: Surrounding wild vegetation with mown edges, crisp hardscape boundaries, or boardwalks. This contrast signals that the wildness is intentional and under stewardship.

Explicit Design Language: Embedding wild nature within clear geometric structures or rows of trees to satisfy the human desire for order while delivering ecological function [20].

6.2. The Risk of Eco-Gentrification

High Line Park warns us that successful greening can drive up property values and displace low-income residents, a phenomenon known as "Green Gentrification" [21]. Urban rewilding must address Environmental Justice. Strategies include: early community engagement, protecting affordable housing, and prioritizing community-led rewilding (e.g., allotment gardens) over high-end spectacular projects.

ISSN: 2710-0170

6.3 Ecosystem Disservices

Rewilding can bring negatives: allergenic pollen, pests, or wildlife conflicts. Species selection must filter out high-allergen plants, and buffer zones must be designed to separate human activity from sensitive wildlife habitats [22].

7. Discussion and Conclusion

7.1. Discussion: From Control to Coexistence

Urban rewilding is not just a technical exercise but an ethical revolution. It demands that humans relinquish the arrogance of "planetary masters" and acknowledge the agency of nature. In the novel ecosystem of the city, rewilding seeks a dynamic equilibrium between "artificial control" and "natural autonomy."

7.2. Policy Recommendations

Ordinance Revision: Amend weed ordinances to allow for taller native vegetation and spontaneous growth.

Incentives: Provide tax breaks or density bonuses for developments that incorporate rewilding features.

Education: Utilize rewilding sites as outdoor classrooms to enhance public"Ecological Literacy."

7.3. Future Outlook

Future research should focus on Quantification and Health Mechanisms. Using sensor networks to measure the specific carbon sequestration and cooling benefits of rewilded versus manicured landscapes. Investigating the impact of the rewilded microbiome on human immune systems. Interdisciplinary Collaboration: Bridging ecology, sociology, and public health.

References

[1] Crutzen, P. J. (2002). Geology of mankind. Nature, 415(6867), 23.

[2] McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. Biological Conservation, 127(3), 247-260.

[3] Xu, Z., Liao, F., Yue, P., et al. (2023). Analysis on the Value of Urban Wild Landscape and Its Promotion Strategy. Journal of Green Science and Technology, 25(11), 57-63.

[4] Soulé, M., & Noss, R. (1998). Rewilding and biodiversity: complementary goals for continental conservation. Wild Earth, 8(3), 18-28.

[5] Wang, K., Zuo, S., Ma, B., et al. (2023). Application of Rewilding in Planning and Design. Forestry Science and Technology Information, 55(04), 138-141.

[6] Lister, N. M. (2007). Sustainable large parks: Ecological design or designer ecology? In Large Parks (pp. 35-57). Princeton Architectural Press.

[7] Jepson, P. (2016). A rewilding agenda for Europe: creating a network of experimental reserves. Ecography, 39(2), 115-124.

[8] Hobbs, R. J., et al. (2006). Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography, 15(1), 1-7.

[9] Tao, J., Jiang, Z., Fang, M., et al. (2023). Analysis and Implications of UK Rewilding Practice from the Perspective of Multiple Ecological Values. In Proceedings of the 2023 Annual National Planning Conference (08 Urban Ecological Planning) (p. 9). Guangzhou: Urban Planning Society of China.

[10] Wilson, E. O. (1984). Biophilia. Harvard University Press.

[11] Grime, J. P. (1977). Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. The American Naturalist, 111(982), 1169-1194.

ISSN: 2710-0170

[12] Zhang, Q. (2022). Discussion on Rewilding of Urban Ecological Space and Its Implementation Pathway. Journal of Chinese Urban Forestry, 20(06), 10-14+40.

[13] Yuan, J., Ou, H., Jin, X., et al. (2023). Overview of Urban Wilderness Ecology Research. Acta Ecologica Sinica, 43(04), 1703-1713.

[14] Fan, J., Liu, Y., & Zhu, X. (2019). Development and Enlightenment of European Wilderness Landscape Rewilding. Chinese Landscape Architecture, 35(12), 106-110.

[15] Miyawaki, A. (1999). Creative ecology: Restoration of native forests by native trees. Plant Biotechnology, 16(1), 15-25.

[16] Zhang, X., Fan, J., & Cai, Y. (2023). Development of Wilderness Landscape Rewilding and Its Implications for National Park Construction in China. National Parks, 1(03), 201-212.

[17] Dunnett, N., & Kingsbury, N. (2008). Planting Green Roofs and Living Walls. Timber Press.

[18] Luo, M., Cao, Y., & Yang, R. (2019). Wilderness Protection and Rewilding: Status Quo and Implications. China Land, (08), 4-8.

[19] Nassauer, J. I. (1995). Messy ecosystems, orderly frames. Landscape Journal, 14(2), 161-170.

[20] Wei, F., Chen, L., Zan, P., et al. (2022). Between Machine and Nature: Public Perception of Post-Industrial Landscape Rewilding. Chinese Landscape Architecture, 38(08), 36-41.

[21] Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. Landscape and Urban Planning, 125, 234-244.

[22] Shao, Y., Xu, X., & Yuan, J. (2021). Urban Wilderness Landscape: Connotation and Value Scrutiny. Landscape Architecture Frontiers, 9(01), 14-25.