DESIGNING LANDSCAPE FRAMES AND PROCESSES – CONTEMPORARY DILEMMAS IN THE AGE OF CLIMATE CHANGE

Rosłon-Szeryńska Edyta, Jacek Materski
Department of Landscape Architecture, Faculty of Civil and Environmental Engineering, Warsaw University of Life Sciences, Nowoursynowska 159, 02 787 Warsaw, Poland

https://doi.org/10.11118/978-80-7701-087-0-0110

Abstract
Human attitudes towards nature and trees have evolved from fear, humility, and respect, through triumph and nonchalance, to concern for the future. Contemporary cities, in the age of climate change, should develop in accordance with the concept of "sustainable development," which is understood, among other things, as actions that reconcile the well-being of nature with human needs, with the well-being of future generations in mind.
Generally speaking, we distinguish three design trends in contemporary landscape architecture: conceptual (artistic), functional, and ecological. Unfortunately, it often happens that nature-based solutions or actions under the banner of biodiversity protection are based on form, placing a strong emphasis on aesthetics in the traditional sense and harmony. In this article, the author presents several important assumptions that should guide the actions of designers pursuing the mission of adapting to and mitigating climate change. The foundation for effective action is understanding the processes occurring in the ecosystem and the role and position of humans in nature.
The aim of the work is to present models of dynamic landscape shaping (DLS) with particular emphasis on vegetation typical of floodplains in the Vistula River valley in the city of Warsaw. The research results allowed us to formulate guidelines for the proper shaping of plant landscapes in river valleys in urban space, which has practical use in urban planning and landscape architecture.

Key words: Dynamic landscape shaping, biodiversity, ecological design, adaptation to climate change, river valley.

Introduction

Conventional landscape design paradigms have become insufficient in the context of contemporary social, economic, and climatic challenges. In response, landscape architecture has shifted from conceptual, form-oriented approaches toward ecological design focused on protecting phytocoenoses, enhancing biodiversity, and strengthening ecosystem services. Current design concepts increasingly adopt a systemic, landscape-based perspective that integrates ecological, social, and economic interdependencies, treating the landscape as a social-ecological system (Parks & Liao 2022).
A key expression of this shift is the concept of Nature-Based Solutions (NbS), defined as actions that use ecosystem processes to address environmental and societal challenges while supporting biodiversity and human well-being (Cohen-Shacham et al. 2016; Sowińska-Świerkosz & García 2024). NbS offer an alternative to “gray” infrastructure by embedding natural processes into spatial planning and design.
Within a functionalist paradigm, shaping natural systems is understood as supporting and regulating ecological processes—such as energy and matter flows—through long-term monitoring, targeted interventions, maintenance, and, where appropriate, deliberate non-intervention (Beatley 2016). In this context, design should not aim at achieving a fixed climax state, but rather at managing dynamic processes. Succession depends on periodic disturbances (e.g., grazing, cutting), which are essential for maintaining biodiversity (Sikorski & Rosłon-Szeryńska 2011). However, in urban environments, uncontrolled processes may lead to undesirable outcomes, such as the dominance of expansive synanthropic species (Rosłon-Szeryńska & Sikorski 2011; Fortuna-Antoszkiewicz et al. 2018).
Understanding succession mechanisms is therefore fundamental to process-based ecological design. Classical ecological theory distinguishes two primary models: the deterministic (Clementsian) model, which assumes a predictable progression toward a stable climax (Clements 1916), and the individualistic (Gleasonian) model, emphasizing species-specific responses and the absence of a fixed endpoint (Gleason 1926). While the former supports restoration-oriented design, it is often criticized for oversimplification (Pickett et al. 1987), whereas the latter underlines the need for flexibility and acceptance of variability.
Contemporary ecology integrates these perspectives through mechanistic models that highlight species interactions and environmental conditions, including facilitation, tolerance, and inhibition (Connell & Slatyer 1977), as well as disturbance-based and mosaic dynamics (Pickett et al. 1987).

The aim of this paper is to present a model for designing dynamic ecological processes in naturally valuable urban areas, using river valleys as a case study. The approach is based on vegetation dynamics and succession theory, interpreting succession as a process leading to relative, dynamic stability of phytocoenoses, shaped by internal and external factors and contributing to ecosystem resilience.

Material and methods.

An ecological approach was adopted, incorporating the theory of vegetation dynamics and succession mechanisms. The study is based on the premise that succession represents a phytocoenosis's pursuit of relative stability—a dynamic and flexible process, shaped by internal and external factors, that enhances ecosystem resilience.

Pilot research was conducted using the Golędzinów Nature Park project, located within the Natura 2000 site of the middle Vistula River Valley in Warsaw (Poland) (fig. 1). The research comprised three stages, based on long-term environmental monitoring, including analyses of vegetation cover transformations and physiographic conditions.

Fig. 1: Golędzinów Park in the Vistula Valley. Aerial view.

Scenarios of predicted vegetation development were elaborated, accounting for both natural and anthropogenic processes. These projections were grounded in an analysis of historical and current succession mechanisms observed in the Golędzinów area over the past century. The proposed design interventions aim to stimulate or initiate desirable ecological processes, support the sustainability of climax communities, and restore degraded systems.

The study applied key criteria for assessing vegetation variability, with particular emphasis on succession processes and human impact, including management practices such as mowing, tree removal, and land-use changes.

Results

Characteristics of the study area, conditions, and natural and landscape transformations

The study area is located within the floodplain of the Vistula River Valley, between the Gdański Bridge and Gen. S. Grota-Roweckiego Bridge, within the Natura 2000 Central Vistula Valley Special Bird Protection Area. Its formation has been shaped by fluvial processes and anthropogenic activity. The Golędzinów floodplain developed on sandy and organic sediments within former meandering oxbow systems.

Over the last century, the area has undergone significant transformations, enabling the identification of future landscape dynamics under climatic and urban pressures. Before World War II, large parts of the area were waterlogged, with extensive sandbanks and active river branches. Subsequent cut-offs formed oxbow lakes, some of which still retain water periodically or permanently. Riparian communities originally dominated the area.

Fig. 1. shows a orthophotomap from 1935 with the marked and current boundaries of the Vistula River shoreline and treeline. Visible zones of sandbanks in the northern and central parts indicate the later development of less fertile meadows and grasslands. The southern areas, wooded and underwater in 1935, are now covered with riparian shrubs, reed beds, and fresh floodplain meadows. Sandy coastal banks remaining from the pre-war period Area underwater in the pre-war period Oxbow lake

connected to the Vistula River in the 1930s and early 1940s. Current boundary of Golędzinów Park between the Puck Coast earthwork and the Vistula shoreline.
Until the 1980s, natural succession led to the expansion of riparian vegetation, later disrupted by the establishment of family allotment gardens (fig. 2). Three clusters of riparian trees are visible, left within the allotment gardens. Riparian trees in a striped arrangement are visible in the Vistula riverbank zone. These sites indicate the historical continuity of phytocoenoses. The remaining area has seen development changes, including modification of the inland shoreline and the formation of islands, the transformation of riparian forests into pastures and meadows, followed by the cultural cultivation of allotment gardens, and ultimately the restoration of meadow phytocoenoses.
In 2014, a high river level was visible in this area. Thanks to deposited sediments, riparian forest stands are regenerating. This is the period of liquidation of allotment gardens. The successional development of riparian communities is closely linked to the physiographic conditions of the area (including terrain, geomorphology, water-soil, and microclimate conditions). The drifting spatial arrangement of emerging clusters of trees and shrubs shapes the shape of the Vistula oxbow lake, and their persistence and further development is conditioned by the flood movements of the Vistula flood wave and the direction of valley ventilation.
Remnants of natural phytocoenoses persisted in oxbow depressions and along the river. Since the early 2000s, following the removal of allotments, renaturalization processes have intensified, including the regeneration of riparian shrubs and the restoration of floodplain meadows (2014–2016).
Fig. 4. Shows contemporary land transformations with secondary succession. The present landscape is typical of urban river valleys, dominated by floodplain meadows (*Molinio-Arrhenatheretea*) with synanthropic and non-native species, and riparian forests (*Salici-Populetum*). However, it has cultural features resulting from the presence of ornamental plants (including trees) from former allotment gardens.

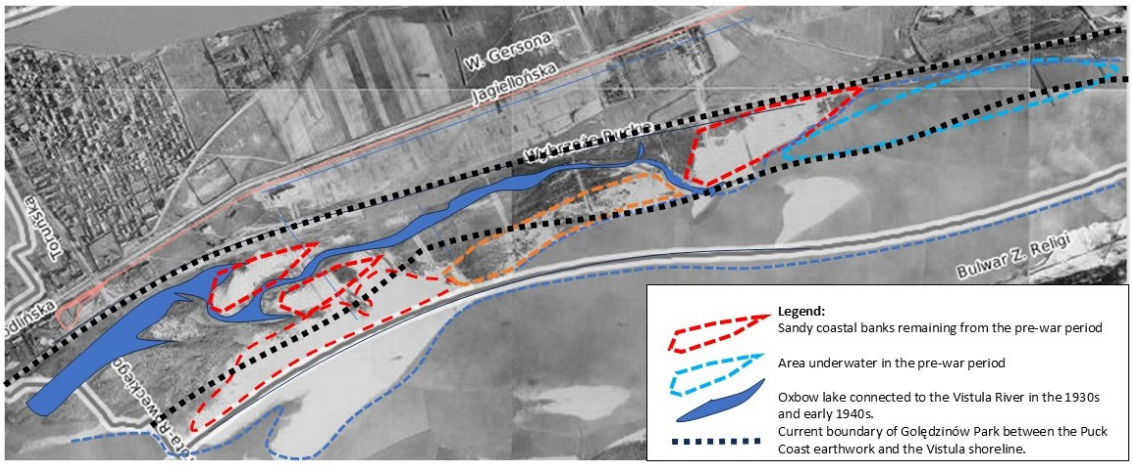

Fig. 2: Orthophotomap of the area from 1935, showing the boundaries of the riverbank and its numerous oxbow lakes. Shallow areas are visible in the northern and central parts.

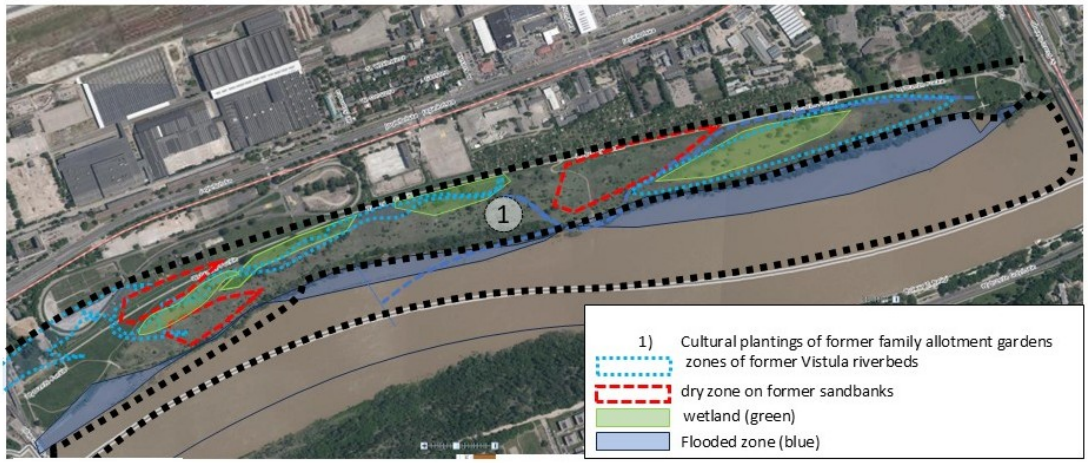

Fig. 3: Orthophotomap of the area developed with allotment gardens from the 1980s and 1990s, with the marked and current boundaries of the Vistula River shoreline and treeline layout.

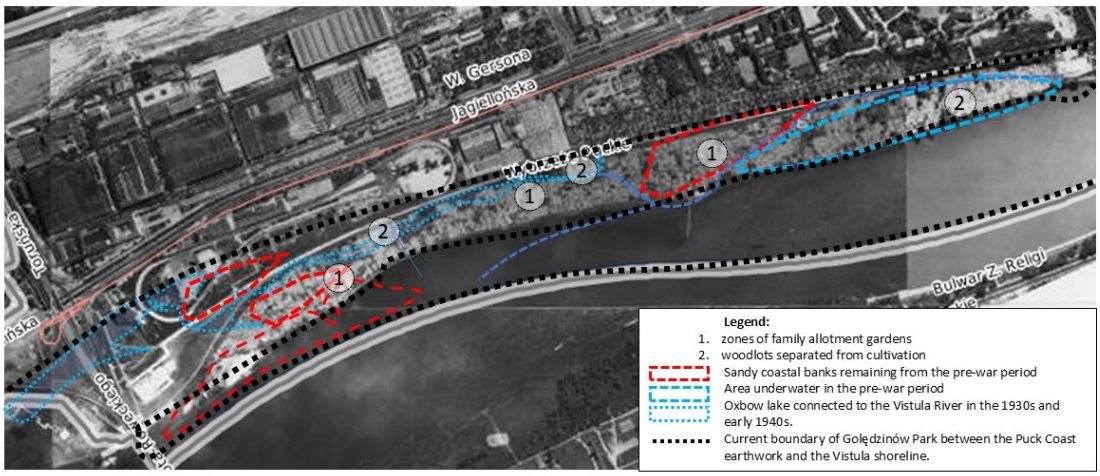

Fig. 4: Orthophotomap of the area during the Vistula River's high water level in 2014. Flooded zone (blue), wetland (herb), and in the oxbow lake basin (red).

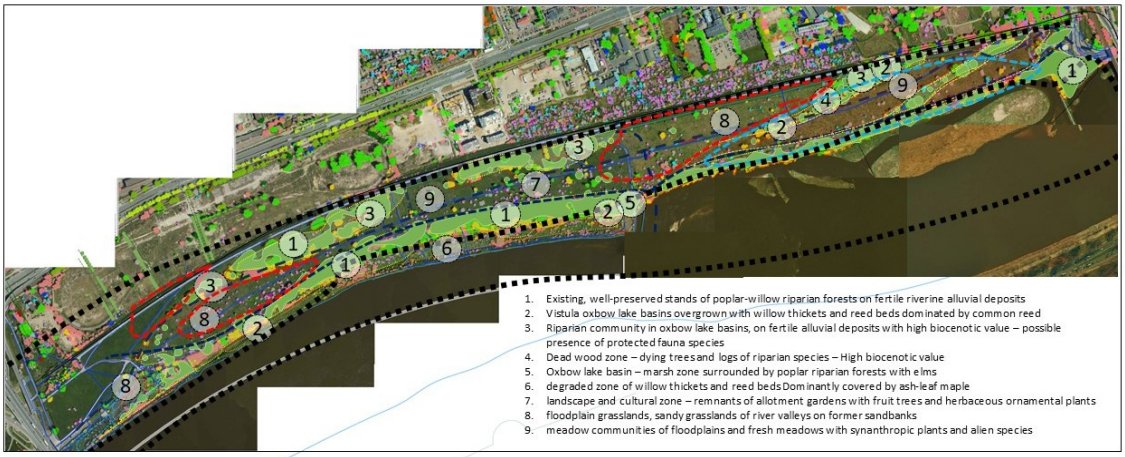

Fig. 5: Contemporary land transformations with secondary succession.

Conclusions from the analyses and design assumptions

The study adopts an ecological approach grounded in vegetation dynamics and succession theory, treating succession as a dynamic process leading to relative ecosystem stability and resilience. The research framework consisted of three stages: (1) long-term monitoring and physiographic analysis, (2) development of scenarios of vegetation transformation under varying levels of human intervention, and (3) evaluation of predicted changes leading to habitat protection concepts.

The spatial structure of vegetation is strongly determined by fluvial processes and human activity. Based on historical and current succession patterns, forecasts of phytocoenotic transformations were developed. Design interventions aim to stimulate desirable ecological processes, support climax communities, and restore degraded systems through targeted actions, maintenance, or controlled non-intervention, supported by monitoring.

Key assumptions include: maintaining strip-like riparian forests along the river; restoring willow shrub communities on riverbanks; enabling secondary succession in former oxbow zones following allotment removal; halting succession of semi-natural meadows through active management; and allowing succession of aquatic communities towards terrestrial forms under eutrophication and climate change pressures.

The developing landscape and spatial structure of the vegetation are closely linked to the river's fluvial processes (linear character, drifting tree clusters, and belt-like tree plantings) and human activity (open meadows, scattered tree and shrub plantings). It is important to consider that animals (including birds and small mammals) and wind will be significant architects of the emerging plant structures and species composition of the "Golędzinów" Natural Park.

Guidelines and Recommendations for Habitat Protection

For well-preserved riparian forests (*Salici-Populetum*), management focuses on monitoring and supporting natural generational and seasonal dynamics. In floodplain meadows, succession towards forest and the spread of invasive species should be controlled through mowing regimes, adapted to

phenological cycles. Early mowing of goldenrod-dominated patches and later mowing of species-rich meadows are recommended, along with biomass removal, seed dispersal support, and optional liming under low flood frequency conditions.
In former oxbow areas, passive management (cessation of mowing) combined with removal of invasive species (e.g., *Acer negundo*, *Solidago canadensis*) is intended to stimulate secondary succession and natural regeneration of native riparian species. Aquatic and semi-aquatic habitats are expected to undergo gradual terrestrialization due to eutrophication and altered hydrological regimes.
In degraded riparian communities, regenerative succession is supported through the gradual removal of invasive species and promotion of native regeneration via natural dispersal mechanisms. Selected specimens of non-native trees may be retained for cultural and landscape value.
Deadwood retention and natural tree senescence are recommended, with safety ensured through spatial planning and selective pruning near paths. Regular inspection of structurally sensitive trees is required. The design of paths and infrastructure aims to minimize human disturbance while enabling controlled observation, thereby supporting biodiversity conservation.

Conclusion

The study demonstrates a design approach focused on shaping dynamic ecological processes rather than static plant compositions. By integrating long-term environmental monitoring, succession theory, and scenario-based forecasting, the proposed model enables adaptive management of urban riverine landscapes.
The results confirm that vegetation structure and landscape form are emergent properties of interacting natural and anthropogenic processes. Design interventions should therefore act as catalysts of desirable ecological dynamics—supporting resilience, enabling regeneration, and guiding succession trajectories—rather than imposing fixed spatial forms.
This process-oriented approach provides a transferable framework for sustainable landscape design, particularly in ecologically sensitive and dynamically changing environments such as urban floodplains.

References

Celletti, S., Poreba, L., Wawer, R., Padoan, E., Comis, S., Bartosiewicz, B., & Schiavon, M. (2025). The potential of nature-based solutions for urban soils. *Frontiers in Environmental Science, 13*.
Clements, F. E. (1916). *Plant succession: An analysis of the development of vegetation*. Carnegie Institution of Washington.
Connell, J. H., & Slatyer, R. O. (1977). Mechanisms of succession in natural communities. *The American Naturalist, 111*(982), 1119–1144.
Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). *Nature-based solutions to address global societal challenges*. IUCN.
European Commission. (2021). *Evaluating the impact of nature-based solutions*. Publications Office of the European Union.
Fortuna-Antoszkiewicz B., Łukaszkiewicz J., Rosłon-Szeryńska E., Wiśniewski P., Wysocki Cz. 2018. *Invasive species and maintaining biodiversity in the natural areas - rural and urban - subject to strong anthropogenic pressure.* Journal of Ecological Engineering, Volume 19, Issue 6, November 2018: 15-24 DOI https://doi.org/10.12911/22998993/92888
Gleason, H. A. (1926). The individualistic concept of the plant association. *Bulletin of the Torrey Botanical Club, 53*(1), 7–26.
Hobbs, R. J., & Higgs, E. (2005). Novel ecosystems: Implications for conservation and restoration. *Trends in Ecology & Evolution, 20*(11), 599–605.
Olivadese, M. (2025). Rethinking nature-based solutions: Unintended consequences, ancient wisdom, and the limits of nature. *Land, 14*(6), 1272. https://doi.org/10.3390/land14061272
Parks, L., & Liao, J. (2022). The changing roles of landscape design in nature-based solutions. *ASLA*.
Pickett, S. T. A., Collins, S. L., & Armesto, J. J. (1987). Models, mechanisms and pathways of succession. *The Botanical Review, 53*(3), 335–371.
Rosłon-Szeryńska E., 2018.
Rosłon-Szeryńska E., Sikorski P. 2011. *Wybrane problemy zarządzania drzewostanem w parkach miejskich cz. 1 Ochrona różnorodności biologicznej zadrzewień a ich pielęgnacja*, 2011, Zeszyty Problemowe Postępów Nauk Rolniczych zesz. Nr 562: 197-205.
Rosłon-Szeryńska E., Sikorski P. 2011. *Wybrane problemy zarządzania drzewostanem w parkach miejskich cz. 2. Bezpieczeństwo a różnorodność biologiczna zadrzewień*, Zeszyty Problemowe Postępów Nauk Rolniczych zesz. Nr 562: 207-220.

Sowińska-Świerkosz, B., & García, J. (2024). Linkages between the concept of nature-based solutions and the notion of landscape. *Ambio, 53*, 227–241. https://doi.org/10.1007/s13280-023-01935-z

Souhrn
Postoj člověka k přírodě a stromům se vyvíjel od strachu, pokory a úcty přes pocit nadvlády a lhostejnost až k obavám o budoucnost. Současná města by se v době klimatických změn měla rozvíjet v souladu s konceptem „udržitelného rozvoje“, který se mimo jiné chápe jako opatření, jež sladí blaho přírody s lidskými potřebami, a to s ohledem na blaho budoucích generací.
Obecně lze v současné krajinářské architektuře rozlišit tři designové trendy: koncepční (umělecký), funkční a ekologický. Bohužel se často stává, že řešení založená na přírodě nebo opatření pod záštitou ochrany biologické rozmanitosti vycházejí z formy a kladou silný důraz na estetiku v tradičním smyslu a harmonii. V tomto článku autor představuje několik důležitých předpokladů, které by měly vést k činům projektantů usilujících o přizpůsobení se klimatickým změnám a jejich zmírnění. Základem účinného jednání je pochopení procesů probíhajících v ekosystému a role a postavení člověka v přírodě.
Cílem práce je představit modely dynamického formování krajiny (DLS) se zvláštním důrazem na vegetaci typickou pro nivy v údolí řeky Visly ve Varšavě. Výsledky výzkumu nám umožnily formulovat pokyny pro správné formování rostlinných krajin v říčních údolích v městském prostoru, což má praktické využití v urbanismu a krajinářské architektuře

Contact:
Edyta Rosłon-Szeryńska
E-mail: edyta_roslon_szerynska@sggw.edu.pl