MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY, ENGINEERING AND TECHNOLOGIES
DEPARTMENT OF ENVIRONMENTAL SCIENCE

APPROVED TO DEFENCE
Head of the Graduate Department
_____ Tamara DUDAR
«_____» _____ 2024

BACHELOR THESIS
(EXPLANATORY NOTE)

Theme: «Development of the eco-network at urban areas: the city of Kyiv case study»

Done by: seeker of EK-402 group, Valerii V. Huz
(student, group, surname, name, patronymic)

Supervisor: PhD. in Eng. Sc., Associate Professor of the Department of Environmental Sciences, Marharyta M. Radomska
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KYIV 2024

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
_____ Тамара ДУДАР
«_____» _____ 2024 р.

КВАЛІФІКАЦІЙНА РОБОТА
(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ «БАКАЛАВР»

Тема: «Розвиток екомережі урбанізованих територій на прикладі міста Києва**»**

Виконавець: здобувач(ка) групи ЕК-402а Гузь Валерій Володимирович

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Нормоконтролер: _____ Андріан ЯВНЮК

КИЇВ 2024

NATIONAL AVIATION UNIVERSITY
Faculty of Environmental Safety, Engineering and Technologies
Department of Environmental Science
Specialty, Educational and Professional Program: specialty 101 “Ecology”,
Educational and Professional Program: “Ecology and Environment Protection
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APPROVED
Head of the Department
_____ Tamara DUDAR
«____» _____ 2024

BACHELOR THESIS ASSIGNMENT
Valerii V. Huz

1. Theme: «Development of the eco-network at urban areas: the city of Kyiv case study» approved by the Rector on September 3, 2024 № 504/ст.

2. Duration of work: from 20.05.2024 to 16.06.2024.

3. Output data of work: maps and satellite images of Kyiv, regulations and reference data about ecological corridors, characteristics of protected areas of the city of Kyiv.

4. Content of explanatory note: eco-network of cities, formation of ecological networks, project for the formation of an ecological network in Kyiv.

5. The list of mandatory graphic (illustrated) materials: tables, figures.

6. Schedule of thesis performance

№ з/п	Task	Term	Advisor's signature
1	Collection and analysis of data	20.05.2024 – 22.05.2024	
2	Review of literary sources	23.05.2024	
3	Writing chapters I of the thesis	23.05.2024 – 25.05.2024	
4	Writing chapters II of the thesis	25.05.2024 – 27.05.2024	
5	Writing chapters III of the thesis	27.05.2024 – 29.05.2024	
6	Preliminary defense of diploma theses	03.06.2024	
7	Registration of diplomas and work with the normative control	20.05.2024 - 04.06.2024	
8	Delivery of finished works to the department	07.06.2024	
9	Defense of the diploma thesis	12.06.2024	
10			
11			

7. Date of task issue: «20» May 2024

Thesis supervisor: _____ Radomska M.M.

(advisor's signature) (name,surname)

Task is taken to perform: _____ Huz V.V.

(graduate's signature) (name, surname)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Факультет екологічної безпеки, інженерії та технологій
Кафедра екології
Спеціальність, освітньо-професійна програма: спеціальність 101 «Екологія», ОПП «Екологія та охорона навколишнього середовища»
(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
_____Тамара ДУДАР
«____» _____ 2024 р.

ЗАВДАННЯ
на виконання кваліфікаційної роботи
Гузь Валерій Володимирович

1. Тема кваліфікаційної роботи «Розвиток екомережі урбанізованих територій на прикладі міста Києва» затверджена наказом ректора від Вересень 3, 2024 № 504/ст.

2. Термін виконання роботи: з 20.05.2024 по 16.06.2024.

3. Вихідні дані роботи: карти і супутникові зображення міста Києва, вимоги до та зразки екокоридорів, опис природоохоронних об’єктів міста Києва.

4. Зміст пояснювальної записки: екомережа міст, формування екомережі, проект формування екомережі м. Києва.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Збір та аналіз матеріалів	20.05.2024 – 22.05.2024	
2	Огляд літературних джерел	23.05.2024	
3	Написання І розділу дипломної роботи	23.05.2024 – 25.05.2024	
4	Написання ІІ розділу дипломної роботи	25.05.2024 – 27.05.2024	
5	Написання ІІІ розділу дипломної роботи	27.05.2024 – 29.05.2024	
6	Попередній захист дипломної роботи	03.06.2024	
7	Оформлення дипломів та робота з нормоконтролером	20.05.2024 - 04.06.2024	
8	Здача готових дипломних робіт на кафедру	07.06.2024	
9	Захист дипломної роботи	12.06.2024	
10			
11			

7. Дата видачі завдання: «20» Травня 2024 р.

Керівник кваліфікаційної роботи: _____ Радомська М.М.

(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання: _____ Гузь В. В.

(підпис випускника) (П.І.Б.)

ABSTRACT

Explanatory note to thesis «Development of the eco-network at urban areas: the city of Kyiv case study»: 74 pages, 23 figures, 3 tables, 15 references.

Object of research – living activity of urban biota.

Subject of research – connectivity of habitats within urban areas.

Aim of work – design and implement a network of eco-corridors in Kyiv to connect existing green spaces, enhance urban biodiversity, improve environmental quality, and create a more sustainable and livable urban environment.

Mehods of research - extensive literature review, land cover assessment, wildlife assessment, node analysis, connectivity analysis, species habitat assessment, network generation, overall assessment.

The project promises to improve air quality, conserve biodiversity, enhance urban microclimates, and provide significant social and economic benefits, contributing to a more sustainable, healthy, and livable urban environment in Kyiv.

ECO-CORRIDORS, ECO-NETWORK, GREEN SPACES, URBAN MICROCLIMATE, SUSTAINABLE DEVELOPMENT, FUNCTIONAL ZONES.

CONTENT

INTRODUCTION

Relevance of the work. Nowadays, urbanization and industrialization continue to exert significant pressure on natural ecosystems, leading to habitat fragmentation and loss of biodiversity. In response, the establishment of eco-corridors has emerged as a crucial strategy to mitigate these effects and promote ecological connectivity within urban landscapes.

Aim and tasks of the diploma work

Aim of the work – assess the effectiveness and potential impact of implementing eco-corridors in urban environments, with a focus on the city of Kyiv, Ukraine.

Objectives of the work:

1. Assess the current status of urban green infrastructure and biodiversity distribution in Kyiv.
2. Consider the possible approaches to the development of connectivity between the elements of green infrastructure in Kyiv and find the gaps, which need to be removed in order to provide efficient mobility and living activity of urban biota.
3. Develop a system of eco-corridors for the territory of Kyiv, which will efficiently amend the connectivity of green spaces and habitats within them.
4. Investigate the potential environmental and ecological benefits of implementing new eco-corridors.

Object of research – living activity of urban biota.

Subject of research – connectivity of habitats within urban areas.

Methods of research – extensive literature review, land cover assessment, wildlife assessment, node analysis, connectivity analysis, species habitat assessment, network generation, overall assessment.

The project promises to improve air quality, conserve biodiversity, enhance urban microclimates, and provide significant social and economic benefits, contributing to a more sustainable, healthy, and livable urban environment in Kyiv.

Personal contribution of the graduate: Conducting a comprehensive literature review, collecting and analyzing data on urban green spaces and biodiversity in Kyiv, field visits and environmental assessments to collect primary data, engaging stakeholders through surveys, and using maps to develop recommendations for planning and managing eco-corridors.

Approbation of results:

1. Radomska M., Huz V., Yarokhmedova I. ECOSYSTEM SERVICES OF GREEN AND BLUE INFRASTRUCTURE AT URBAN AREAS: тези доп. IV міжнародного наукового симпозіуму «Сталий розвиток – стан та перспективи», 13–16 лютого 2024, Україна, Львів – Славське. С. 232-234.

2. Huz V., Radomska M. Development of the eco-network of urbanized territories on the example of the city of Kyiv: тези доп. V Всеукр. наук.-прак. конф. „Євроінтеграція екологічної політики України”, (25-26 жовтня 2023 р.). – Одеса: Одеський державний екологічний університет. - С. 354-356.

3. Huz V. V., Radomska M. M. The preservation of urban biotic and landscape diversity via development of eco-corridors: case study of the City of Kyiv: тези доп. Міжнар. наук. конференції за участю молодих науковців «Регіональні проблеми охорони довкілля та збалансованого природокористування», 11 – 12 квітня 2024 р., Одеса, ОДЕКУ.

4. Huz V.V., Yarokhmedova I.V., Yaroshenko D.R., Radomska M.M. Features of the formation of environmental quality in the main functional zones of large and small cities : зб. матер. IX Міжнар. молодіж. конгресу «Сталий розвиток: захист навколишнього середовища. Енергоощадність. Збалансоване природокористування», 28-29 березня 2024, Україна, Львів. Київ : Ярочéнко Я. В., 2024. С. 216.

Publications:

1. Radomska, Marharyta & Ratushnyuk, Lesya & Yaroshenko, Dmytro & Yarokhmedova, Ivanna & Guz, Valeriy & Melnychenko, Vitaly. (2023). Comparative analysis of strategies for adaptation of urban areas to climate changes. Construction Engineering. 50-58.

CHAPTER 1
ECO-NETWORK OF CITIES

1.1. The concept of an ecological network

An ecological network encompasses interconnected natural elements that form a cohesive system, engaging in mutual interactions and supporting vital ecological processes. Biodiversity preservation is central to the functioning of ecosystems within this network, ensuring the continuity of successive processes essential for ecosystem health. Spanning various habitats such as forests, lakes, swamps, and meadows, the eco-network orchestrates the placement of specific natural elements within distinct locations. This strategic arrangement fosters a balanced metabolism, facilitating the sustainable development of entire ecosystems. Through its regulation, the eco-network maintains harmony among diverse components, thus promoting resilience and ecological stability across landscapes.

In the 1990s, the term "ecological network" became widely recognized in Europe and has since been adopted by influential organizations such as the International Union for Conservation of Nature (IUCN) and the Convention on Biological Diversity (CBD) in the Conferences of the Parties. However, the concept of Ecological Networks (ENs) has evolved over the past 40 years with the broad goal of preserving the integrity of ecological processes in landscapes, rooted in the ecological understanding that emerged during the 20th century.

Ecological networks embody a multifaceted approach to conservation, characterized by several key features. Firstly, habitat connectivity lies at the core of these networks, emphasizing the necessity of maintaining linkages between habitats to facilitate species movement. Whether through corridors, or larger habitat patches, connectivity enables species to disperse, migrate, and colonize new areas, thereby promoting biodiversity.

Ecological networks are intricately tied to metapopulation dynamics, a concept derived from metapopulation theory. By recognizing the interconnectedness of subpopulations within habitats, ecological networks aim to mitigate the risk of local extinctions and bolster overall population viability through migration and colonization pathways.

Functional connectivity is crucial in sustaining ecological processes across landscapes. This aspect considers the landscape's capacity to support vital functions such as nutrient cycling, pollination, and seed dispersal, ensuring ecosystem resilience despite environmental fluctuations.

Operating across various spatial scales, from local to continental levels, ecological networks embrace a multi-scale approach. This holistic perspective integrates diverse ecological processes while considering landscape heterogeneity and connectivity, fostering a comprehensive understanding of ecosystem dynamics.

Crucially, ecological networks acknowledge the intertwined relationship between humans and nature. By incorporating the human dimension into conservation strategies, these networks seek to balance conservation objectives with human land use needs. Promoting sustainable practices that support biodiversity and human well-being, ecological networks exemplify a harmonious coexistence between people and the environment.

1.2. The importance of ecological networks for the city ecosystem

Urbanization and land use changes over past centuries have led to the reduction and fragmentation of natural habitats worldwide. Habitat fragmentation, resulting in decreased connectivity between habitat patches, poses a long-term threat to biodiversity. Conservation efforts prioritize preserving biodiversity and maintaining ecologically stable landscapes to counteract these effects. Habitat connectivity plays a crucial role in supporting biodiversity in fragmented landscapes by facilitating gene flow and individual movement between populations. However,

human-induced alterations, such as artificial barriers, can impede species dispersal and complex propagation processes, jeopardizing population survival.

Since the 1980s, ecological research has focused on ecological networks. Identifying, designating, and protecting ecological networks help maintain biodiversity and reduce isolation in fragmented landscapes. GIS applications are valuable tools for exploring ecological networks and estimating connectivity between habitat patches. Ecological networks, characterized as functionally connected habitat patches, facilitate species dispersal and support biodiversity conservation. Ensuring the coherence of ecological networks and addressing threatening barriers are crucial for supporting the survival of species typical to natural and semi-natural habitats.

The concept of greenway and green space planning has historical roots dating back over a century. Early examples, such as the Adirondack Park Region Concept in the United States, laid the foundation for modern greenway planning. Throughout the 20th century, cities in Europe, including Berlin, Budapest, and Prague, developed plans and catalogues of plant species suitable for urban greening and those, which need protection and conservation.

Eventually came the understanding that cities are part of animal habitats for which safe movement is an integral part of existence and survival. Therefore, it is expedient to combine greening of cities and provision of migration routes and habitat for animals. This, in turn, helps maintain the stability and functionality of the urban ecosystem as a whole.

However, increasing urban sprawl and land use changes have formed barriers in natural environments, with cities, industrial areas, transport infrastructure, and intensively cultivated agricultural lands encroaching on semi-natural habitats. Conscious planning in urban environments is essential for maintaining biodiversity in landscapes fragmented by human impacts.

1.2.1. Functional zones of the eco-network

An eco-network includes core zone, buffer zone and corridors. They are essential elements and econetwork can function properly only if they are present and and interact properly.

Core areas within ecological networks serve as designated regions where habitat connectivity is paramount. These core areas, whether legally protected (such as Protected Areas or Marine Protected Areas) or managed with conservation-oriented approaches, act as hubs for biodiversity conservation efforts. They provide crucial habitats and resources for various species, serving as anchors for maintaining ecological processes.

Buffer zones, surrounding these core areas, further reinforce habitat connectivity by providing transitional areas characterized by compatible land uses. These zones serve as buffers against potential harm to core areas, with certain land use restrictions in place to protect biodiversity. By allowing for a gradual transition between human activities and natural habitats, buffer zones facilitate the coexistence of conservation and economic activities.

Similarly, ecological corridors serve as vital conduits for maintaining connectivity between core areas. These corridors enable the exchange of individuals and genetic material essential for species persistence and ecosystem resilience. They must be sufficiently large and diverse to accommodate species movement, considering behavioral aspects as well.

However, formation of some or even all elements of econetwork in cities can be significantly compromised/ therefore it is necessary to look for or develop special approaches to accommodate the needs of ecological connectivity within citites.

1.2.2. Advantages of eco-networks

The main advantages of eco-networks for the urban ecosystem are:

– Urban ecological networks serve as vital providers of ecosystem services, offering a multitude of benefits that enhance the well-being of city residents.

– Green spaces integrated within ecological networks play a pivotal role in mitigating the urban heat island effect. They provide valuable shade, facilitate evaporative cooling, and reduce surface temperatures through the process of transpiration. By cooling the urban environment, ecological networks help alleviate the adverse impacts of heat stress and enhance urban climate resilience, thereby mitigating the effects of climate change.

– Urban ecological networks significantly contribute to the improvement of air and water quality, essential for the health and well-being of urban residents. Vegetation in parks and green spaces act as natural filters, absorbing air pollutants such as particulate matter and harmful gases.

– Green plants, in particular trees, are able to reduce carbon footprint of cities by capturing carbon dioxide

– Well developed plant communities regulate surface run-off and reduce the risk of flooding and water pollution.

So, ecological networks are essential for creating sustainable and resilient city ecosystems that support biodiversity, provide ecosystem services, and enhance the quality of life for urban residents. By integrating green spaces and natural habitats into urban planning and development, cities can promote environmental sustainability, mitigate climate change impacts, and create healthier and more livable urban environments for present and future generations.

1.3. Ecological networks in cities

The creation of ecological networks, or eco-networks, within cities worldwide represents a paradigm shift in urban planning and environmental management.

The creation of eco-networks in cities involves collaborative efforts between government agencies, community organizations, environmental groups, and residents. By integrating ecological principles into urban planning some cities have developed and started implementing comprehensive plans of ecolo0gical network development.

1.3.1. Fuzhou City, China

In urban landscapes characterized by dense development, the creation and optimization of ecological networks pose significant challenges and opportunities. Fuzhou City in China serves as a prime example of the complexities involved in balancing urbanization with environmental sustainability.

The rapid expansion of urban infrastructure has resulted in the depletion of green areas, underscoring the pressing need to improve landscape connectivity. Previous studies, including research conducted in Beijing and Wuhan, have demonstrated the efficacy of strategies such as green roofs and forest conversion in enhancing urban connectivity.

The idea of transformation was focused on transforming barren land into parkland to bolster connectivity within Fuzhou City's ecological network. Additionally, key barriers within the network were identified, and opportunities for ecological restoration were explored, finding that developing bare land as ecological sources yielded better results than converting non-ecological land into woodland.

Addressing the inherent tensions between ecological preservation and urban development, the project proposes innovative approaches to constructing and optimizing urban ecological networks.

Key insights from the Fuzhou City case study include:

– An integrated approach, considering both landscape structure and ecological function, proves effective in identifying urban ecological source areas.

– Fuzhou City's ecological network comprises 44 source sites and 92 corridors, providing a robust framework for biodiversity conservation in the urban landscape.

– Transforming the top 30% of barren land patches into green spaces or parks emerges as the most impactful strategy for enhancing connectivity within Fuzhou City's ecological network.

1.3.2. Tabriz, Iran

A comprehensive framework was devised, relying on a thorough examination of trends over the past three decades using classified multi-temporal satellite images and landscape metrics. This approach aimed to evaluate the current ecological connectivity of the study area and propose optimal corridors through the implementation of minimum-cost designed corridors. The framework, incorporating well-established and accessible methods and models, is aligned with similar research endeavors.

Initially, a detailed analysis of land use changes spanning from 1984 to 2020 was conducted, utilizing land use maps derived from multi-temporal satellite images and landscape metrics. The findings underscored a notable expansion of built-up areas attributed to urbanization, coupled with a decline in ecological land uses such as farmlands, gardens, and green spaces, alongside other land categories like unoccupied areas. These trends signified a marked fragmentation and loss of cohesion within the Tabriz landscape over the past three decades.

Furthermore, the evaluation of ecological connectivity in the Tabriz landscape, employing Cohesion and IIC indices, revealed an increasing uniformity of built-up lands and the fragmentation of ecological spaces. This gradual

transformation has seen built-up lands progressively dominating the Tabriz landscape, while green and ecological areas have dwindled and become increasingly disjointed.

The analysis also identified and prioritized significant ecological patches, particularly within central regions characterized by high population and residential density. These patches play a pivotal role in the future ecological development of Tabriz, given the impracticality of accommodating large habitats in densely populated areas. Least-cost corridors were then computed using graph theory and the least-cost approach to connect these key patches, considering ecological spaces such as farmlands, green spaces, and water bodies, as well as unoccupied lands within the city.

However, it is essential to acknowledge that this project primarily focused on the historical and current state of the city, which may entail limitations and uncertainties warranting further investigation. The habitat destruction and convergence observed in Tabriz are the repercussions of years of ineffective land management planning. To prevent exacerbating the complexity of the situation, it is imperative to utilize the findings of research in future city planning endeavors. The multistage framework proposed in this study offers valuable insights for identifying least-cost corridors in urban areas, facilitating informed decision-making for sustainable urban development in Tabriz and beyond.

1.3.3. Suwon, South Korea

Analyzing ecological networks based on land cover and urban habitat maps in Suwon, priority areas for protection were identified, and an ecological network was established by integrating results from both maps. Discrepancies were observed between the two maps, particularly concerning water bodies, agricultural lands, bare areas, and forests. While the urban habitat map highlighted high connectivity for

water bodies and agriculture, the land cover map showed elevated connectivity for forests, bare lands, and wetlands.

Highlighting the substantial contribution of small urban green patches to overall ecological connectivity in cities through quantitative measurements, it was noted that different types of green patches varied in their level of contribution. Mountainous and fragmented forest areas exhibited high conservation priority but often lacked connectivity with other patches. Conversely, streams and linear patches significantly enhanced connectivity due to their branching structure. Additionally, agricultural areas acted as stepping stones, bolstering connectivity.

In Suwon City, an ecological network was devised to enhance biodiversity. This map serves as a reference for the introduction of green infrastructure and the development of plans. The method employed in this study may serve as a foundation for future analyses of ecological networks by local governments constructing urban habitat maps. Various indicators should be weighted according to their permeability using appropriate methods.

1.3.4. Harbin, China

In the study area, a total of 198 ecological patches cover 64,999.71 hm2. However, the older districts like Daowai, Xiangfang, and Nangang exhibit small, fragmented patches with high internal porosity, necessitating urgent measures to establish an ecological network for integration. Conversely, newer districts like Songbei, Hulan, and Acheng show a stronger ecological foundation. Yet, as these districts are focal points for urban expansion in Harbin, sustainable development amidst increasing building land warrants attention.

The зкщоусеув ecological network in the study area comprises 119 ecological sources and 142 ecological corridors. While watershed and greenfield sources are relatively well-connected, woodland sources are fewer and some remain uncrossed by corridors. Ecological corridors, especially in Hulan, Xiangfang, and Nangang,

face challenges due to urban construction, resulting in poor overall connectivity. However, Songbei and Acheng districts demonstrate better circularity in their ecological networks despite structural issues.

Optimization of the ecological network employed the edge-adding strategy from complex network theory. Implementing the LDF strategy involved adding 43 ecological corridors, resulting in a more resilient and interference-resistant network. This optimized network is poised to facilitate efficient ecological flow transmission across the study area.

1.3.5. Bogota, Colombia

Bogotá has conceptualized and embraced the Environmental Enhancement Plan (EEP) as a network of green and blue infrastructures aimed at safeguarding and restoring the essential ecological processes supporting the city's territory. This initiative seeks to enhance the well-being of Bogotá's population by protecting various types of natural and semi-natural spaces, including protected areas, metropolitan parks, and ecological corridors. The EEP serves multiple purposes, including recreation, urban enhancement, risk prevention, and runoff control.

To fulfill its objectives, the EEP in Bogotá has engaged in promoting the protection, restoration, and sustainable use of ecological networks through participatory approaches involving academic, governmental, and civil society stakeholders. These efforts involve tools to understand and communicate the benefits of green and blue spaces for citizens' well-being. Notably, the hills surrounding the eastern part of the city, known as the "Cerros Orientales de Bogotá" (COB), play a crucial role in maintaining the EEP. These hills are part of the protected area known as the "Reserva Forestal Protectora del Bosque Oriental de Bogotá," serving as an ecological corridor and provider of ecosystem services.

Despite the legal protection status of the COB area, urban growth has encroached upon it both formally and informally. In response, a court order issued

by the state of Colombia mandated the establishment of an adequacy strip, prompting various institutions and authorities to implement a management plan. This has led to projects such as the consolidation of a socio-ecological corridor, aimed at fostering citizen engagement with the hills. Additionally, an ecological restoration initiative led by the Instituto Alexander von Humboldt has facilitated knowledge exchange among citizens and highlighted the ecosystem services offered by the COB to the city.

The processes developed within the EEP, such as the COB case, present a replicable approach for other urban areas worldwide, particularly in Latin America where there is a growing emphasis on using Nature-Based Solutions (NBS) to mitigate the impacts of urban growth and enhance access to nature for people.

Since its inception in 2000, the EEP has had significant impacts on Bogotá, particularly in the management of green spaces and urban biodiversity conservation. Conservation efforts in the COB area exemplify this impact. Other outcomes include improved climate resilience, risk reduction, urban regeneration, and social cohesion through citizen initiatives focused on EEP spaces protection.

The key benefits of EEP implementation include maintaining biodiversity, enhancing green and blue infrastructures, improving connectivity and functionality, promoting ecological connectivity across urban regenerated sites, carbon sequestration, water and air quality improvement, flood risk reduction, and increasing green open spaces for residents. Additionally, the EEP fosters community ownership, social interaction, and contributes to climate change adaptation and mitigation efforts.

1.4. Threats to the functioning of ecological networks in cities

Urban ecosystems are partly man-made structures that often function in violation of natural principles and patterns. The concentration of sources of negative environmental impacts creates a wide range of risks not only for human health and

well-being, but also for the existence and functioning of green infrastructure and ecological networks built on its basis.

When implementing a program to create and maintain a city's ecological network, it is necessary to assess and take into account the environmental risks associated with the functioning and development of cities. Under the constant pressure of urbanization, the inclusion of environmental risk assessment in ecological network development projects is becoming increasingly necessary to promote sustainable and resilient urban ecosystems. By identifying and addressing potential environmental risks, it is possible to simultaneously protect biodiversity, preserve ecological functions, and improve the overall environmental quality of urban areas.

1.4.1. Environmental Pollution

Environmental Pollution poses a significant threat to the functionality and health of eco-networks within urban areas. Pollution stems from various sources, including industrial emissions, vehicle exhaust, and improper waste disposal practices, and can have detrimental effects on air, soil, and water quality within these ecosystems.

Air pollution, primarily caused by vehicle emissions, industrial activities, and urban development, introduces harmful pollutants such as particulate matter, nitrogen oxides, and volatile organic compounds into the atmosphere. These pollutants can adversely affect the respiratory systems of plants and animals, leading to reduced growth and reproductive success. Additionally, air pollution can contribute to the formation of smog and ozone, further compromising air quality and posing health risks to both humans and wildlife.

Soil pollution occurs when contaminants from industrial activities, chemical spills, or improper waste disposal practices leach into the soil. These contaminants can include heavy metals, pesticides, and industrial chemicals, which can

accumulate in the soil and negatively impact soil health and fertility. Soil pollution can disrupt soil microbial communities, impair nutrient cycling processes, and inhibit plant growth and development.

Water pollution is another critical issue affecting eco-networks in urban areas, primarily due to runoff from urban surfaces carrying pollutants into water bodies. This runoff can contain various contaminants, including heavy metals, nutrients, pathogens, and synthetic chemicals. Water pollution can degrade water quality, impair aquatic ecosystems, and harm aquatic organisms. Additionally, pollutants in water bodies can bioaccumulate in aquatic organisms, posing risks to both aquatic and terrestrial species that rely on these ecosystems for survival.

1.4.2. Habitat Fragmentation

Habitat Fragmentation, a consequence of urbanization, presents a significant challenge to the integrity and resilience of eco-networks within urban environments. As urban areas expand, natural habitats become fragmented into isolated patches of green spaces, disrupting the continuity and connectivity of ecosystems.

The fragmentation of habitats creates barriers that impede the movement of species between patches of suitable habitat. This restriction on species movement can disrupt critical ecological processes such as dispersal, migration, and gene flow. As a result, populations become isolated and more susceptible to the adverse effects of genetic drift, inbreeding, and demographic stochasticity.

Habitat fragmentation increases the vulnerability of species to extinction by reducing the effective size of populations and limiting their ability to adapt to changing environmental conditions.

1.4.3. Invasive Species

The introduction of invasive species poses a significant threat to the stability and functioning of eco-networks within urban environments. Invasive plants and animals have the ability to outcompete native species, disrupt ecological processes, and alter ecosystem dynamics, ultimately leading to negative impacts on biodiversity and ecosystem health.

Invasive species often have competitive advantages over native species, such as rapid reproduction rates, lack of natural predators, and tolerance to a wide range of environmental conditions. As a result, they can quickly establish and spread within eco-networks, outcompeting native species for resources such as food, water, and habitat.

The dominance of invasive species can lead to the degradation of habitat quality within eco-networks. They may form monocultures, where a single species dominates the landscape, leading to a loss of biodiversity and ecological complexity. Additionally, invasive species can alter soil chemistry, nutrient cycling, and hydrological processes, further disrupting ecosystem functions and reducing overall ecosystem resilience.

Invasive species can have cascading effects on native species and ecosystems. They may directly prey on native species, compete with them for resources, or alter habitat structure in ways that are detrimental to native species' survival. This can result in declines in native species populations, changes in species composition, and overall ecosystem instability.

1.4.4. Climate change

Climate change represents a formidable challenge to the resilience and functionality of eco-networks within urban environments. Alterations in temperature

and precipitation patterns, driven by anthropogenic greenhouse gas emissions, have profound impacts on ecosystem dynamics and biodiversity within cities.

One of the primary consequences of climate change is habitat loss and alteration. Rising temperatures and changing precipitation patterns can lead to the degradation and fragmentation of habitats within urban eco-networks. Increased frequency and intensity of extreme weather events, such as heatwaves, droughts, and storms, can exacerbate habitat destruction and result in the loss of critical habitat for many species.

The impacts of climate change also extend to the vulnerability of species, particularly those already facing habitat loss and fragmentation. Species with narrow habitat requirements or limited dispersal abilities may struggle to adapt to rapidly changing environmental conditions, increasing their risk of extinction. Additionally, invasive species may exploit new habitats made accessible by climate change, further threatening native biodiversity.

1.4.5. Overexploitation and unsustainable use of natural resources

Overexploitation and unsustainable use of natural resources represent significant threats to the integrity and resilience of ecological networks. Activities such as logging, farming, and fishing, when conducted without proper management and regulation, can lead to the depletion of key species and disruption of eco-network dynamics.

When too many species are extracted from an ecosystem, or when certain keystone species are removed, the delicate balance of the ecological network can be disrupted, leading to cascading effects throughout the entire ecosystem. This can result in the collapse of food webs, loss of biodiversity, and degradation of ecosystem services.

1.5. Conclusion to Chapter 1

The chapter discusses the concept of ecological networks, their importance for biodiversity conservation and maintaining ecological sustainability of landscapes. The key features of ecological networks, such as habitat connectivity, metapopulation dynamics, functional connectivity, and a multi-scale approach, are analyzed. The relationship between humans and nature in the context of ecological networks is also emphasized.

Particular attention is paid to the importance of ecological networks for urban ecosystems, where urbanization and land use changes have led to the fragmentation of natural habitats. It is established that the city's green infrastructure, in particular green areas, corridors and buffer zones, contribute to the conservation of biodiversity, improve air and water quality, reduce the urban heat island and regulate surface runoff.

Based on the data analysis presented in this section, the overall objective of this paper is to develop strategies for integrating ecological networks into urban planning to increase the resilience and environmental sustainability of urban landscapes. This includes identifying the best approaches to creating and maintaining green corridors, buffer zones, and other elements of ecological networks in urban settings, as well as developing recommendations for balancing the needs of biodiversity and urbanization.

CHAPTER 2
FORMATION OF ECOLOGICAL NETWORKS

2.1. Structure and requirements for an ecological network

Formation of ecological networks involves the creation and management of interconnected natural or semi-natural areas that facilitate the movement of species, maintain biodiversity, and provide ecosystem services. These networks are vital for conserving biodiversity, promoting ecological resilience, and mitigating the impacts of habitat fragmentation and climate change.

One key aspect of forming ecological networks is the identification of core areas. Core areas are regions with high ecological value, such as protected areas, nature reserves, and areas with significant biodiversity. Identifying these core areas is essential as they form the backbone of the ecological network, providing critical habitat for numerous species and serving as sources for colonization and genetic diversity.

Establishing corridors is another crucial element of ecological network formation. Corridors are linear patches of habitat that connect core areas, allowing for the movement of species, gene flow, and colonization of new habitats. Creating corridors can involve habitat restoration, establishing wildlife-friendly agricultural landscapes, or implementing green infrastructure in urban areas to enhance connectivity.

In addition to core areas and corridors, buffer zones and transition areas play a significant role in ecological network planning. Buffer zones around core areas and corridors help reduce edge effects, protect against human disturbances, and provide additional habitat for species. Transition areas between different habitat types can also be managed to enhance biodiversity and ecosystem functions.

An effective approach to ecological network formation involves a multi-scale perspective, considering both local and landscape-level connectivity. Planning and implementing networks at multiple spatial scales ensure resilience to environmental changes and provide connectivity across diverse habitats, thereby supporting a wide range of species and ecological processes.

A crucial facet of ecological networks is habitat heterogeneity, encompassing a diverse array of habitat types and structural complexities. This diversity fosters a rich tapestry of species assemblages and sustains vital ecological functions. Variation in habitat structure, spanning vegetation composition, topography, and hydrology, nurtures niche specialization and fosters robust species interactions.

Connectivity and permeability within the network are paramount, ensuring unimpeded movement of species and the unhindered flow of ecological processes. Prioritizing enhanced connectivity through corridors, stepping stones, and permeable landscapes bolsters population viability, fosters genetic exchange, and facilitates species dispersal.

Regular monitoring and evaluation of ecological network structure and function are indispensable for gauging progress toward conservation objectives. Biodiversity surveys, habitat assessments, and socio-economic indicators furnish critical insights into the ecological, social, and economic benefits of the network, guiding informed decision-making and adaptive management initiatives.

Stakeholder engagement is crucial for the success of ecological network formation. Involving local communities, landowners, NGOs, and governmental agencies in collaborative planning and management efforts helps address conflicts, ensure effective land use practices, and garner support for conservation initiatives.

Integration with land use planning is also critical to ensure that ecological network planning aligns with broader development objectives. Integrating conservation goals into land use planning processes helps minimize habitat fragmentation, prioritize areas for protection, and promote sustainable land

management practices, ultimately contributing to the long-term success of ecological networks in conserving biodiversity and supporting ecosystem health.

2.2. Methods of forming eco-networks

The creation of an ecological network raises a number of issues and problems that need to be addressed effectively. The main task is to choose the most effective strategy for integrating green spaces into the urban environment and connecting them into a continuous network.

This work usually begins with a thorough analysis of the urban landscape, a close examination of existing green spaces and the identification of potential locations for new ones. Gathering detailed data on ecosystem health, target species, and the needs of residents is imperative, as is identifying opportunities for preserving and developing natural features.

An important aspect of this process is collecting information and taking into account the requirements of all stakeholders. It is important for the successful development of an ecological network to establish several alternative routes, which ensures that the optimal path is chosen through comparison.

The structure of the ecological network in a city is a key element for creating sustainable and ecologically balanced urban environments. Taking into account the diversity of urban landscapes and the needs of residents, the ecological network should have a flexible and adaptive structure.

Several approaches help to define eco-corridors, which are listed in Table 2.1.

Table 2.1

Methods of forming eco-networks

Approach	Description
1. Land cover assessment	This approach involves evaluating the types and distribution of land cover within the study area. It helps identify areas suitable for eco-corridor development.
2. Wildlife assessment	Analyzing the presence, distribution, and movement patterns of various wildlife species within the study area. This helps identify important habitats and routes.
3. Species habitat assessment	Considering factors such as food availability, shelter, water sources, and nesting sites for different species. This informs corridor design to meet species' needs.
4. Node analysis	Identifying crucial sites for preservation and obstacles, including areas of high biodiversity or human-made structures. Nodes serve as key points for corridor connectivity.
5. Connectivity analysis	Assessing landscape features or barriers to wildlife movement between nodes, such as roads, urban areas, or natural barriers. This ensures effective connectivity between habitats.
6. Network generation	Developing a network of wildlife corridors that maximize connectivity between key habitats and nodes. This integrates findings from other approaches into a cohesive corridor plan.
7. Overall assessment	Analyzing performance through modeling future scenarios and monitoring wildlife populations. This ensures adaptive management and continuous improvement of corridor design.

The Land Cover Assessment method (1) is particularly suitable for areas with diverse land cover types, such as regions with a mix of urban, agricultural, and natural landscapes. It provides valuable insights into the distribution of land cover, guiding corridor planning in heterogeneous environments. Wildlife Assessment (2) is essential in areas rich in biodiversity or those with known wildlife corridors, helping to identify key habitat areas and potential connectivity routes. It is especially

relevant in regions undergoing urbanization or habitat fragmentation. Species Habitat Assessment (3) is most appropriate in areas where specific species of conservation concern are present or where habitat restoration efforts are planned. It ensures that corridors meet the specific needs of target species, enhancing their effectiveness. Node Analysis (4) is valuable in areas with notable ecological features or where habitat preservation is a priority. It helps identify critical sites for corridor placement and conservation efforts. Connectivity Analysis (5) is crucial in landscapes intersected by barriers such as roads or urban areas, ensuring effective connectivity between habitat patches. It is particularly relevant in urban or fragmented landscapes. Network Generation (6) is beneficial in complex landscapes with multiple habitat patches, facilitating the optimization of corridor connectivity. It is essential in regions where habitat loss and fragmentation are significant concerns. Overall Assessment (7) is relevant in all localities, providing ongoing monitoring and evaluation to inform adaptive management and improve corridor effectiveness over time. While each method has its specific applicability, their combined use ensures a comprehensive approach to eco-corridor planning tailored to the characteristics of the local landscape.

2.3. Problems and prospects of creating eco-networks in cities

The creation of ecological networks within urban environments presents both challenges and opportunities, reflecting the complex interplay between urbanization and biodiversity conservation. Addressing these issues is crucial for realizing the potential benefits of urban eco-networks while mitigating potential drawbacks.

Thus, eco-networks in cities are faced at solving the follwong problems:

– Habitat Fragmentation: Urbanization often results in habitat fragmentation, dividing natural landscapes into isolated patches. Fragmentation disrupts ecological connectivity, hinders species movement, and diminishes biodiversity within urban areas.

– Loss of Green Spaces: Rapid urban development can lead to the loss of green spaces and natural habitats, further exacerbating habitat fragmentation and diminishing opportunities for biodiversity conservation within cities.

– Human-Wildlife Conflict: As urban areas encroach upon natural habitats, conflicts between humans and wildlife may arise. Issues such as wildlife-vehicle collisions, predation on pets, and nuisance wildlife behavior can pose challenges to coexistence and biodiversity conservation efforts.

– Pollution and Habitat Degradation: Urbanization often results in increased pollution, habitat degradation, and loss of ecological integrity. Pollution from sources such as industrial activities, vehicle emissions, and improper waste disposal can degrade habitat quality and negatively impact urban biodiversity.

– Limited Space and Competition for Resources: Urban environments typically have limited space for biodiversity conservation, leading to competition for resources between conservation priorities and urban development needs. Balancing these competing demands requires careful planning and management strategies.

– Prospects opened by econetworks cover not only direct users, which is wildlife, but also residents of a city:

– Green Infrastructure Development: Urban eco-networks offer opportunities for the development of green infrastructure, including parks, greenways, and urban forests. Green infrastructure enhances biodiversity, improves urban air and water quality, and provides valuable ecosystem services to city residents.

– Habitat Restoration and Enhancement: Efforts to restore and enhance natural habitats within urban areas can help mitigate habitat fragmentation and support urban biodiversity. Restoration projects may include reforestation, wetland restoration, and creation of wildlife corridors to promote connectivity.

– Community Education: Educational programs, citizen science projects, and community-based conservation efforts can mobilize residents to participate in eco-network creation and management.

– Policy and Planning Integration: Integrating biodiversity conservation goals into urban planning and policy frameworks is essential for mainstreaming eco-networks in cities. Incorporating green space requirements, biodiversity corridors, and habitat protection measures into urban planning ordinances can help preserve and enhance urban biodiversity.

– Multifunctional Land Use Practices: Implementing multifunctional land use practices, such as urban agriculture, green roofs, and permeable pavement, can contribute to biodiversity conservation while addressing urbanization challenges. These practices enhance habitat availability, promote ecosystem services, and contribute to urban sustainability.

– Technological Innovations: Advancements in technology, such as remote sensing, Geographic Information Systems (GIS), and ecological modeling, provide valuable tools for urban eco-network planning and management. These tools enable spatial analysis, habitat mapping, and monitoring of urban biodiversity, supporting evidence-based decision-making and adaptive management strategies.

By addressing these challenges and capitalizing on opportunities, cities can create eco-networks that enhance urban biodiversity, improve ecological resilience, and foster sustainable urban development for present and future generations. Collaboration among stakeholders, integration of biodiversity considerations into urban planning processes, and innovative conservation approaches are essential for realizing the full potential of eco-networks in cities.

2.4. Principles of creating eco-networks of the city

When creating ecological networks in cities, it is important to be guided by several key principles that take into account the specifics of the urban environment. My approach to creating an ecological network in a city is based on the following principles:

– Integrated approach: The creation of an ecological network should be comprehensive, taking into account various aspects such as green spaces, water systems, recreational and sports spaces, as well as networks for pedestrians and cyclists. An integrated approach makes it possible to maximize the use of the city's area to form an ecological network and provide a variety of ecosystem services.

– Landscape analysis: When creating ecological networks in a city, it is important to consider landscape analysis, which allows you to identify the diversity of natural environments, their ecological value, and potential routes for creating ecosystem corridors. Integrating this data into ecological network planning helps to optimize the location of green areas, contributing to biodiversity conservation and creating a harmonious combination of the urban environment with the natural surroundings.

– Creation of eco-corridors: The formation of biological corridors that connect green areas and natural sites facilitates the movement and migration of species, which is important for the conservation of biodiversity in the urban environment.

– Analysis of existing infrastructure: It is important to utilize existing infrastructure such as roads, bridges, tunnels, and buildings to create an ecological network. Integrating green spaces on rooftops, along streets, and on other infrastructure helps to maximize the use of available space.

– Biodiversity analysis: This involves assessing the diversity of plant and animal species, as well as their location and distribution in the city.

– Safety and comfort: Ecological network planning should take into account the safety and comfort of city residents. Creating safe pedestrian and bicycle routes, arranging recreation and sports areas near transport routes, and providing convenient access to public transport contributes to the active life and health of residents.

To provide efficient functioning of ecological network it is necessary to meet certain requirements, set by available experience and derived from projects already developed or implemented:

– The network should ensure the continuity of the city's natural areas for the efficient movement and dispersal of species, but should not create restrictions on its use as recreational facilities. Green areas, including parks, squares, forest parks, and blue infrastructure facilities, should remain accessible to the public and improve the quality of life in the city as a whole.

– Corridors for access to nature are an important element in the ecological network of the natural region in which the city is located. And the planning of the urban part of the network should be guided by the overall regional scheme

– Biodiversity conservation is the main objective in creating an ecological network, and therefore its development and implementation should also include additional measures to protect and care for the city's flora and fauna within the ecological corridors. This includes measures to protect against invasive species, support for birds, protection against pollution and its spread from adjacent areas, protection against collisions with vehicles, etc.

– The most valuable elements of the network should be granted protected status, and the corridors should be identified on the ground and appropriately labeled.

2.5. Conclusion to Chapter 2

This section discusses methods for the formation of ecological networks, which includes the creation and management of interconnected natural or semi-natural areas. Important aspects include the identification of core areas, the creation of corridors, buffer zones and transition zones, as well as a multi-scale approach and consideration of habitat diversity. The importance of habitat heterogeneity and

ensuring network connectivity and permeability to support species movement and ecological processes is emphasized.

Regular monitoring and evaluation of the structure and functioning of the ecological network are essential for assessing progress in achieving conservation goals. Stakeholder involvement and integration with land use planning is also important, allowing for the alignment of conservation objectives with broader development goals.

This paper uses a combination of the above methods to provide a comprehensive approach to eco-corridor planning that is adapted to the characteristics of the local landscape. In particular, focus on Land Cover Assessment, Wildlife Assessment, Species Habitat Assessment, Connectivity Analysis and Network Generation to ensure that the ecological network is robustly connected and functional in urban settings.

CHAPTER 3
PROJECT FOR THE FORMATION OF AN ECOLOGICAL NETWORK IN KYIV

3.1. Threats to biodiversity at the territory of Kyiv city

Kyiv, as one of the largest cities in Ukraine, faces numerous environmental challenges resulting from intensive urbanization and industrialization. The main environmental threats that affect the functioning of ecological networks in Kyiv include environmental pollution, habitat fragmentation, invasive species, climate change, and overuse of natural resources.

3.1.1. Air pollution in Kyiv

Kyiv often faces high levels of air pollution due to emissions from road transport and industrial enterprises. The main pollutants are particulate matter (PM), nitrogen oxides (NOx), and volatile organic compounds (VOCs). These pollutants can affect the health of plants and animals, reducing their reproductive capacity and growth, and pose risks to human health. A significant role in this is played by outdated equipment at industrial enterprises that is not equipped with modern filtration and purification systems.

3.1.2. Water pollution in Kyiv

Kyiv's water bodies, in particular the Dnipro River, are also significantly negatively impacted by the city's activities. Runoff from urban areas containing heavy metals, nutrients, and pathogens flows into water bodies, degrading water quality and harming aquatic ecosystems. The Dnipro River is a central waterway

that is exposed to pollution from a variety of sources, including industrial plants, domestic wastewater, and agricultural waste.

The bioaccumulation of these pollutants in aquatic organisms can affect food webs and endanger both aquatic and terrestrial species. Outdated water treatment equipment does not provide adequate filtration, leading to the spread of pollutants. This not only degrades water quality, but also poses a threat to the health of the population that uses water for drinking and domestic purposes.

One of the most well-known manifestations of water pollution is water blooms, which become particularly problematic during hot periods of the year. Water blooms are caused by the overgrowth of algae, in particular cyanobacteria, which multiply rapidly when there is an excessive accumulation of nutrients in water bodies, such as nitrogen and phosphorus. These blooms can have a toxic effect on aquatic ecosystems and pose a health risk to humans and animals that consume contaminated water.

Pollution of water bodies contributes to the decline of biodiversity in river ecosystems. Many species of fish and other aquatic organisms cannot survive in conditions of high levels of pollution, leading to declining populations and disruption of ecological balance. The negative impacts of water pollution also extend to terrestrial ecosystems that depend on rivers for water and nutrients.

3.1.3. Soil pollution in Kyiv

Industrial activities and inadequate waste management lead to the accumulation of heavy metals, pesticides, and other chemicals in Kyiv's soils. This can reduce soil fertility, affect microbial communities, and impede plant growth. Many industrial enterprises use outdated filters on pipes, which leads to the release of hazardous substances into soil and water resources.

3.1.4. Waste management in Kyiv

Improper waste management is one of the main environmental problems in Kyiv. There is a large amount of garbage in the city that is poorly sorted, which leads to pollution of streets and public places. Plastic bottles, bags, and other types of garbage can often be seen on the streets, in parks, and near water bodies, which not only worsens the aesthetic appearance but also poses a threat to the environment.

The existence of landfills that are not functioning properly only worsens the situation. Due to insufficient implementation of modern waste treatment and disposal technologies, a large amount of hazardous substances accumulate in landfills. The lack of proper measures to isolate and treat waste leads to the penetration of toxic substances into soil and water resources, which negatively affects human health and ecosystems.

Waste sorting has not yet become a widespread practice in Kyiv, which contributes to the increase in the amount of waste that ends up in landfills. The lack of adequate infrastructure for waste collection and recycling, as well as insufficient public awareness campaigns for environmental education, exacerbate the situation. As a result, the city faces the problem of waste accumulation, which not only pollutes the environment but also creates favorable conditions for the reproduction of harmful microorganisms and rodents.

3.1.5. Lack of green technologies in Kyiv

The lack of implementation of green technologies in Kyiv's industry and municipal services significantly worsens the environmental situation. Modern technologies such as renewable energy sources, emission reduction systems and efficient resource use can significantly reduce the negative impact on the environment. However, many companies continue to use outdated equipment that does not meet modern environmental standards.

3.1.6. Fragmentation of habitats in Kyiv

Urbanization in Kyiv is leading to the fragmentation of natural habitats, creating isolated green areas. This fragmentation prevents species from moving between different parts of the city, disrupting important ecological processes such as dispersal and migration. Fragmentation reduces the effective size of populations, increasing their vulnerability to genetic drift and inbreeding. Interruption of ecological corridors limits the ability of species to adapt to changing environmental conditions, increasing the risk of extinction. Examples of fragmentation are shown in Table 3.1.

Table 3.1

Sources of Fragmentation

Source of Fragmentation	**Description**
1. Residential Areas and Infrastructure	The continuous development of the city leads to the construction of new residential areas and infrastructure, which divides natural environments into isolated parts.
2. Transport Arteries and Road Networks	The construction of transport arteries and road networks in the city creates barriers to the movement of species and limits access to natural habitats.
3. Infrastructure Construction	The expansion of the city and the construction of new infrastructure objects such as industrial complexes, airports, and shopping centers fragment natural environments into pieces.
4. Urbanization of Riverbanks	Urban development on riverbanks and adjacent areas for residential and commercial purposes interrupts natural corridors and disrupts animal migrations.

These examples demonstrate how urbanization and urban development in Kyiv lead to the fragmentation of natural environments, which has a negative impact on the ecological sustainability of urban ecosystems and threatens biodiversity.

3.1.7. Invasive species in Kyiv

Invasive species can significantly alter urban ecosystems by displacing native species and altering ecological processes. Invasive species often have advantages, such as rapid reproduction rates and the absence of natural predators, that allow them to dominate new environments. The dominance of invasive species can lead to the formation of monocultures, reducing biodiversity and ecosystem resilience.

Invasive organisms cover a wide range of taxa, including plants, animals, fungi and microorganisms. These organisms can have a variety of impacts on the environment and can pose a significant threat to local biodiversity and ecosystem functioning. Here are some common types of invasive organisms:

– Many invasive plant species are intentionally introduced for ornamental, agricultural, or landscape purposes, but they can quickly spread beyond the cultivation area and displace native vegetation.

– Invasive animal species often disrupt natural ecosystems through predation, competition for resources, or habitat alteration.

– Invasive insects can have a profound impact on both natural and agricultural ecosystems. They can damage plants, spread disease, or displace native insect species.

– Invasive fish species often disrupt aquatic ecosystems by competing with native fish species for food and habitat, altering food chains, and causing populations of native fish species to decline.

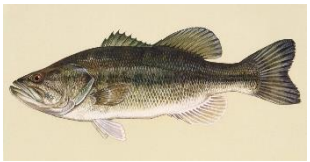
– Invasive microorganisms, including bacteria, viruses, and fungi, can cause disease in native plants, animals, and humans, leading to declines in populations and biodiversity.

Invasive species typical for Kyiv (Table 3.2) possess potential for the transformation of local ecosystems, making some areas less suitable for econetworking and therefore need consistent control and management.

Table 3.2

Invasive species in ecosystems of Kyiv

Group of organisms	Species	Common view	Threats
1. Invasive seed plant species	Japanese clover (*Reynoutria japonica*)		Rapid growth and ability to create dense thickets, outcompeting native plant species contributes to formation of monocultural plant communities, which have ability to support limited number of other species and thus possessing reduced efficiency as an element of eco-network.
	Marsh acacia (*Impatiens glandulifera*)		
	Ragweed (*Ambrosia artemisiifolia*)		
	Mantegazzi hogweed (*Heracleum mantegazzianum*)		
2. Invasive species of mammals	Gray mole (*Talpa europaea*)		Although this species of mole has little impact on the urban environment, it can become a problem if it reproduces intensively and destroys infrastructure.

3. Invasive species of birds	Gray crow (*Corvus cornix*)		These crows are competitors for native bird species, such as eiders and common crows, and can lead to declines in these species due to competition for resources and territory. Gray crows can prey on the eggs and chicks of native species, which threatens their populations.
4. Invasive species of insects	Brown marble bug (*Halyomorpha halys*)		This species of bug originates from East Asia and is spreading rapidly around the world. In Kyiv, it is a pest for many crops, including apples, pears, and vegetables. In addition, the brown marble bug can become an unpleasant neighbor, penetrating houses and creating an unpleasant odor.
	Red fire ant (*Solenopsis invicta*)		This aggressive ant, native to South America, can cause serious problems for humans and animals with its painful bites. Red fire ants are also a threat to native ant species as they compete for resources and territories.
5. Invasive species of fish	Black bass (*Micropterus salmoides*)		This species, native to North America, has become invasive in many regions, including Kyiv. Black bass is a predator and can significantly affect native fish populations by killing their young and competing for food.

	Silver carp (*Hypophthalmic hthys molitrix*)		This fish from China was introduced to control algae, but has become invasive in some regions. Silver carp reproduce rapidly and consume large amounts of phytoplankton.

3.1.8. Climate change in Kyiv

Climate change is exacerbating the environmental threats affecting Kyiv by changing temperature and precipitation patterns. One can observe more frequent incidence of floods and droughts, both of which have destructive effect on local plant communities and waterbodies, thus reducing their habitation quality. The reduction of food bases also affects migratory species of animals, which undergo additional threats on their way added to artificial barriers, created by man made structures.

Climate changes also give way to new species, mentioned above, creating conditions for new invasions.

3.1.9. Overexploitation and unsustainable use of natural resources in Kyiv

Overexploitation of natural resources, such as deforestation, overuse of land for agriculture and industry, contributes to the degradation of ecosystems. Overexploitation of resources can lead to the depletion of key species and disruption of ecological networks. Loss of biodiversity and the destruction of ecosystem services are critical consequences of overexploitation.

In Kyiv, the overexploitation of natural resources manifests itself in several key ways. Deforestation for development and urban sprawl leads to the loss of important green areas that serve as air purification, biodiversity conservation, and climate regulation. Excessive use of land for industry, especially in suburbs, depletes soils, reduces their fertility and contributes to erosion. These activities disrupt

ecological networks, which in turn reduces the ability of ecosystems to recover and maintain their functions.

3.2. Environmental situation in Kyiv districts

The environmental situation in Kyiv varies considerably between different districts of the city, depending on their development, industrial development, green areas and other factors. The main districts of Kyiv where the environmental situation may differ include Podilskyi, Pecherskyi, Darnytskyi, Desnyanskyi, Dniprovskyi, Solomianskyi, Obolonskyi, Shevchenkivsky, Holosiivskyi districts, Sviatoshynskyi district.

Podilskyi district: Podil district is known for its historical buildings and industrial zones. The presence of old industrial enterprises, which often use outdated equipment, contributes to significant air and soil pollution. The density of buildings and high traffic intensity increase the level of air pollution.

Pecherskyi district: Pecherskyi district is located in the central part of Kyiv, and has a rich history and is one of the oldest districts in the city. Pecherskyi district combines residential, administrative, shopping and business centers. The environmental situation in the Pechersk district may be affected by heavy traffic, construction projects, and industrial facilities. The presence of parks and green areas helps to improve the quality of the environment.

Darnytskyi district: Darnytskyi district is one of the largest industrial districts in Kyiv. The high level of industrial activity leads to significant air, water, and soil pollution. Outdated filters on factory pipes and the lack of proper green technologies exacerbate this problem. The water in the area's rivers and lakes is often polluted by industrial wastewater and inadequate sewage treatment facilities.

Desnianskyi district: Desnianskyi district is characterized by its location in a mostly open urban area. It has significant green spaces and parks. However, industry in this district is not as active as in some other parts of the city, which contributes to

a better environmental situation. Nevertheless, there are still some problems, including very dense housing, air pollution from car traffic, and limited accessibility to green spaces in some parts of the district.

Dniprovskyi district: Dniprovskyi district, located along the banks of the Dnipro River, has unique natural resources and potential for environmental initiatives. However, the presence of industrial facilities and transportation arteries can lead to environmental pollution. In particular, wastewater and waste from industrial enterprises can negatively affect the quality of the river's water resources.

Sviatoshynskyi district: Sviatoshynskyi district is one of the most developed industrial areas of Kyiv. A large number of industrial facilities, plants and factories result in extensive air, soil and water pollution. Old industrial infrastructure and inadequate water treatment systems contribute to the accumulation of pollutants in the environment. However, the area also has green areas and parks that provide residents with opportunities to relax and enjoy nature within the city.

Solomenskyi district: The Solomenskyi district is a mixed neighborhood that combines residential, commercial, and industrial areas. Pollution in this area is often associated with high traffic intensity and industrial facilities. The presence of old industrial areas without proper renovation and modernization contributes to high levels of air and soil pollution.

Obolon district: Obolon district is located near the Dnipro River and has significant water resources. Despite this, the district also faces water pollution problems due to runoff from urban areas and industrial enterprises. Old water treatment equipment does not always cope effectively with the load, which leads to the accumulation of pollutants in water bodies.

Shevchenkivskyi district: The Shevchenkivskyi district is characterized by high building density and a large number of historical and commercial buildings. Air pollution in this district is often the result of heavy traffic and construction work. There are fewer industrial facilities here, but the problem of old infrastructure remains relevant, especially with regard to the waste treatment system.

Holosiivskyi district: The Holosiivskyi district is known for its large green areas, such as Holosiivskyi Park, which contributes to a better environmental situation compared to other districts. However, even here, there are problems with air and water pollution, especially near industrial zones and highways. The presence of old industrial plants with outdated filters and inefficient water treatment systems also contributes to the overall environmental situation.

3.3. Description of existing eco-network elements in the city

The ecological network in Kyiv consists of various elements that contribute to the conservation of biodiversity, improve environmental quality, and provide places for recreation and leisure for residents. One of the key elements is parks and green spaces, which include such large natural complexes as Holosiivskyi Park, Partisan Glory Park, M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine, Kyoto Park, Syretskyi Hai Park, and others. These green areas not only provide fresh air to the urban environment and improve environmental quality, but also create a natural environment for flora and fauna.

3.3.1. Holosiivskyi Park

The territory of the Holosiivskyi National Nature Park is located in the central and southern parts of the Holosiivskyi district of Kyiv, as well as in the southern part of the city (Figure 3.1). This park was created to preserve, restore and rationally use the natural complexes and objects of the Forest-Steppe and Kyiv Polissya.

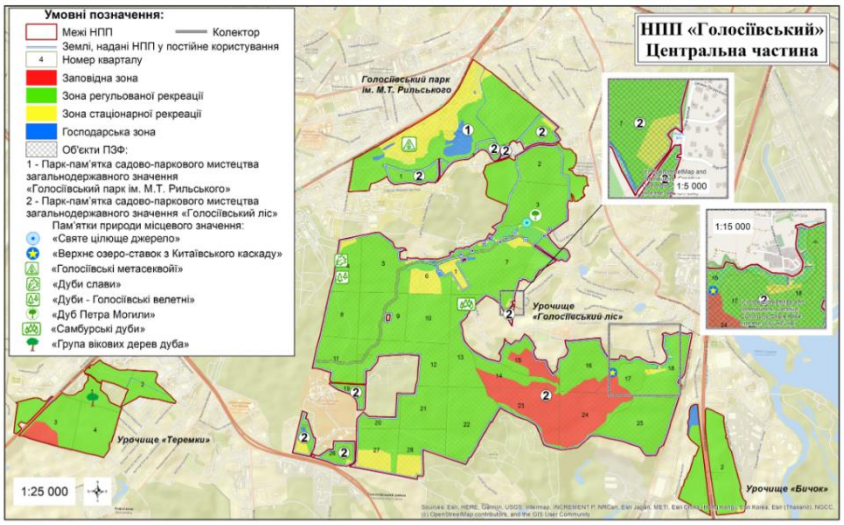


Fig. 3.1 - Map of the functional zoning of Holosiivsky Park

Holosiivskyi Nature Park is located on the territory consisting of several geographically separated forest areas belonging to the Polissia zone. Most of the park is covered by forests, including broadleaf and pine forests, as well as swamps and reservoirs. This unique environment creates ideal conditions for a rich flora and fauna, which consists of rare and protected species.

More than 650 species of higher vascular plants, 118 species of bryophytes, and more than 60 species of aphyllophore fungi have been found in the park. Some of them are included in the Red Data Book of Ukraine and the IUCN. There are also many species of insects, amphibians, birds and mammals, including rare and protected ones.

One of the most important functions of Holosiivskyi Park is to preserve biodiversity. It provides shelter and conditions for the growth and reproduction of numerous rare and protected species of plants and animals, which are an important element of Kyiv's ecosystem. This diversity contributes to the stability of ecosystems and the preservation of their functions in the city.

Overall, Holosiivskyi National Nature Park plays a significant role in conserving nature, ensuring environmental sustainability and improving the quality of life for Kyiv residents. Its uniqueness lies in the fact that it preserves natural

ecosystems right inside the metropolis, reminding people of the importance of nature conservation and creating opportunities for communication with nature in the heart of the city.

3.3.2. Partisan Glory Park

Partisan Glory Park is located in the Darnytskyi district of Kyiv and is a regional landscape park (Figure 3.2). It was created taking into account the natural features of the pine forest. The total area of the park is 111.97 hectares, of which more than 100 hectares are covered with plantations, 3.4 hectares are occupied by water bodies, and buildings are located on an area of 0.3 hectares.

Fig. 3.2 - Map of the functional zoning of Partisan Glory Park

Five types of landscape gardening can be found in the park: forest, park, meadow, garden and regular. The forest and park types make up the majority of the park's territory (approximately 46 hectares each), while the meadow landscape covers the areas around the three lakes (6.0 hectares). Smaller areas are designated

for garden (1.1 hectares) and regular (0.6 hectares) landscapes. An important part of the park (32% of the territory) is occupied by scots pines, among which cultivated plantations and ornamental plantations have been created.

There are 36 species of woody plants in the park, the most common of which are scots pine, sugar maple, pseudoacacia, mountain ash, hanging birch, red oak, common oak, and heart-shaped linden. The park also has lawns that cover about 9 hectares. Additional landscaping was carried out in the renovated area of the park, which included the planting of maples, birch, magnolia, sakura, bush cherry and plums.

3.3.3. M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine

The Botanical Garden in Pechersk district is located on an area of about 129.86 hectares (Figure 3.3). It is an important object of the nature reserve fund of Ukraine and a park-monument of landscape art of national importance.

It contains a variety of plant species and varieties from around the world. The Botanical Garden plays not only the role of a place for preserving plant diversity, but also a research center where research is conducted on nature protection and conservation of the plant gene pool.

An important function is educational activities aimed at popularizing knowledge on environmental issues and the use of plants. Visitors have the opportunity to explore the flora and its properties.

The garden has eight scientific departments that study various aspects of the plant world. The unique collection includes more than 11 thousand taxa belonging to 220 families and 1347 genera, making it one of the largest in Europe.

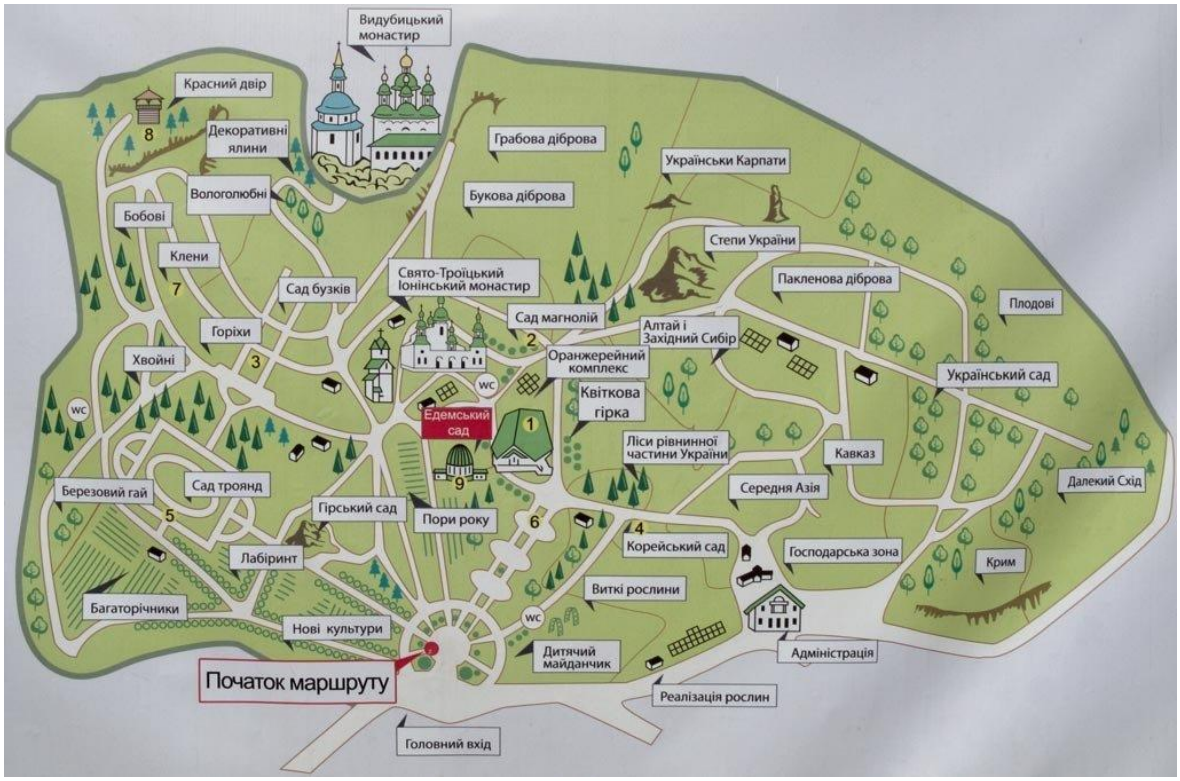


Fig. 3.3 - Map of the functional zoning of M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine

3.3.4. Kyoto Park

It is located in the Desnianskyi district of Kyiv and covers an area of 9.87 hectares (Figure 3.4*)*. The plants here include centuries-old pines and Japanese maple. The central element of the park is a sakura alley, which is accompanied by bonsai, magnolia and rhododendrons.

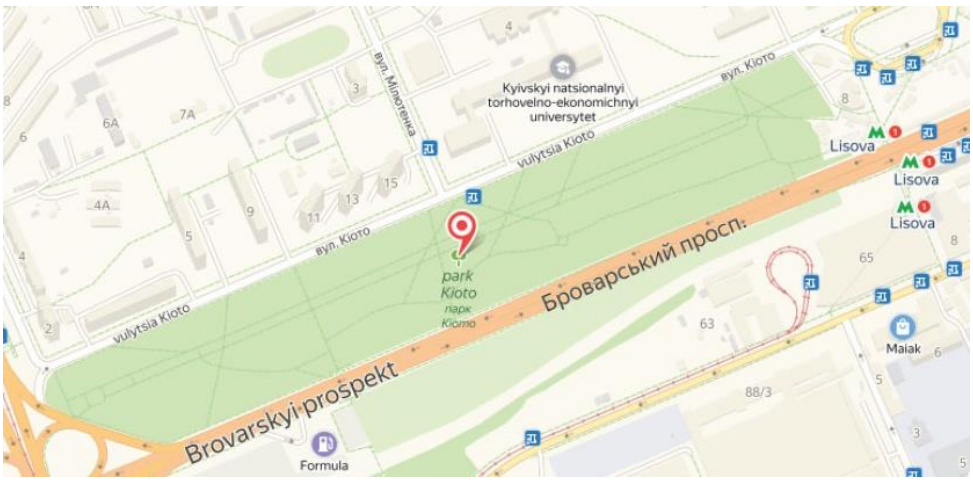


Fig. 3.4 - Map of Kyoto Park

3.3.5. Syretskyi Hai Park

The park, known as a monument of landscape art of national importance, is located in the Shevchenkivskyi and Podilskyi districts of Kyiv (Figure 3.5). Its total area is 175.6 hectares, including 82.9 hectares in Shevchenkivskyi district and 92.7 hectares in Podilskyi district.

The park is divided by ravines, the Syrets River and lakes. The main plant species here are centuries-old oaks, as well as pines and lindens, which predominate in the northwestern part. In recent decades, new plant species have been added to the park, including common spruce, birch, maple, hornbeam, walnut, alder, willow, poplar, and juniper.

Fig. 3.5 - Map of the functional zoning of Syretskyi Hai Park

3.3.6. Dnipro ecological corridor

The Dnipro Ecological Corridor, which runs through the city of Kyiv (Figure 3.6), is an important part of Ukraine's ecological network and is of national and European importance. This corridor plays a key role in conserving biodiversity, maintaining ecological balance, and providing ecosystem services necessary for the region's sustainable development.

Fig. 3.6 - Natural eco-corridors of Ukraine

The Dnipro Ecological Corridor stretches along the Dnipro River, which is one of the largest rivers in Europe. Within Kyiv, this corridor includes coastal zones, water bodies, forests, marshes, and other natural areas. The main natural sites within the corridor include Holosiivskyi National Nature Park, Kyiv Botanical Garden, Trukhaniv Island, Muromets Island, and other environmentally significant areas.

The Dnipro Ecological Corridor is important for species migration, gene pool conservation, and environmental sustainability. It allows wildlife to move between different natural habitats, which is critical for maintaining genetic diversity. The corridor also acts as a natural filter, improving water quality in the Dnipro River by filtering pollution through riparian ecosystems.

The Dnipro Ecological Corridor in Kyiv is home to a large number of flora and fauna species, many of which are rare and endangered. For example, there are Red Data Book species of plants and animals such as river otter, badger, common copperhead, and many others. The vegetation cover includes a variety of forest, meadow and aquatic plant communities, including centuries-old oaks, pines, maples and many others.

3.4. Description of the sites proposed for inclusion in the ecological network

The process of creating an effective and sustainable ecological network involves careful selection and assessment of areas that can significantly contribute to biodiversity conservation, improve ecological conditions and increase the ecological sustainability of the Mitts. This section provides a detailed description of the eco-corridors proposed for inclusion in the ecological network. Each of these eco-corridors was selected based on an ecological analysis, taking into account such factors as the presence of valuable natural complexes, the level of anthropogenic impact, connectivity with existing natural areas, and the potential for restoring natural ecosystems.

The inclusion of these eco-corridors in the ecological network will facilitate the migration and dispersal of species, ensure the stability of ecosystem services, and preserve unique natural landscapes. The described eco-corridors are also seen as key elements for the implementation of environmental initiatives aimed at mitigating the effects of climate change, improving the quality of water and air resources, and maintaining the recreational and aesthetic values of the territories.

3.4.1. Eco-corridor 1

The proposed eco-corridor presents an exciting opportunity to enhance the urban landscape by integrating green spaces and connecting the coastal zone of the Dnipro with forests in the Darnytskyi district, as shown in Figure 3.7.

The most important existing sites (nodes of the econetwork) for the corridor include: Pozniaky Park; Lake Lebedyne; Lake Vyrlytsia; Lake Pozniaky; Lake Sribnyi Kil.

The presence of a large number of lakes was the main reason for the creation of this eco-corridor, which helps to improve the quality of the environment and ensures the diversity of ecosystems.

A key characteristic of this corridor is its proximity to numerous lakes, providing a conducive environment for greening initiatives. However, the presence of a highway and sporadic residential complexes poses challenges that could hinder greening efforts. Despite the presence of small stands of trees along the corridor's route, significant gaps are evident, necessitating immediate action through additional greening initiatives.

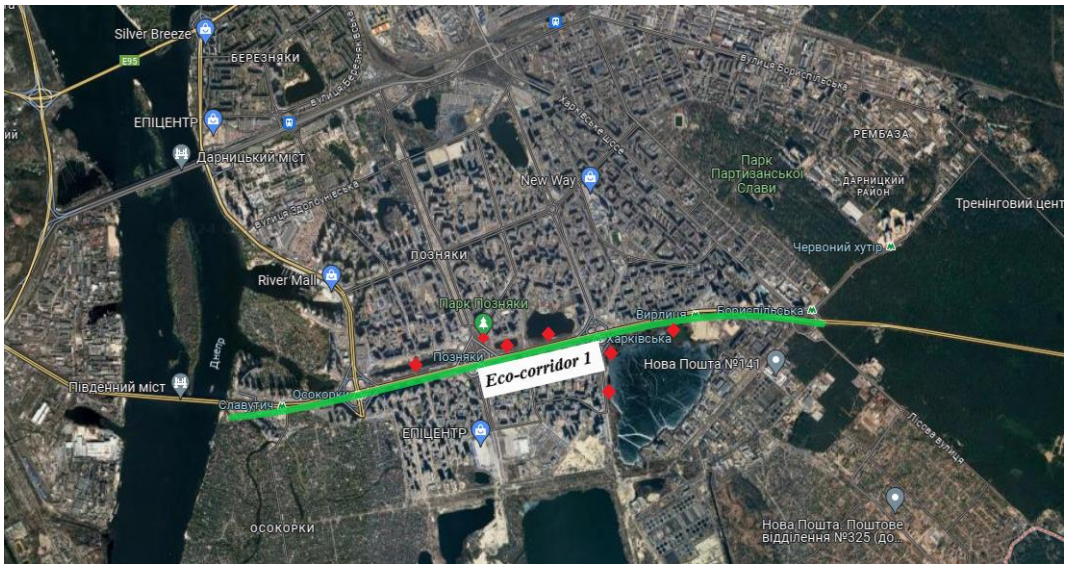


Fig. 3.7 - Eco-corridor 1

If the eco-corridor is established along the path of Revutskoho Street, Petra Hryhorenko Avenue, Mykola Bazhan Avenue, and the Kharkivske and Boryspilske Highways, its potential for environmental enhancement becomes substantial. This route traverses diverse urban landscapes, offering opportunities for strategic greening interventions. However, careful planning is required to navigate the challenges posed by infrastructure such as highways and residential complexes.

To address the gaps along the corridor and maximize its environmental benefits, comprehensive greening initiatives should be implemented, as shown in

Figure 3.8. This could involve planting native vegetation, creating green buffers along the highway, and establishing green spaces in residential areas. Additionally, integrating green infrastructure elements like bioswales and rain gardens can enhance stormwater management and improve ecological resilience. In particular, we offer the following elements to be implemented:

1. Complex planting with a 3-tier structure (grass cover, bushes, trees of the lower tier) 20 m wide, along entire Bazhana Avenue.

2. Creating squares/small parks near Lebedyne, Vyrlytsia, Pozniaky, and Sribnyi Kil lakes.

3. Creation of green walls, roofs, and a large number of flower beds near the intersections of highways and dense buildings on Mykola Bazhana Avenue and Revutskoho Street.

Fig. 3.8 - Mykola Bazhan Avenue and lake Lebedine

The eco-corridor has the potential to serve as a wildlife habitat and migration corridor, contributing to the conservation of biodiversity in the urban environment. By strategically planting vegetation and creating habitat features such as nesting sites and water sources, the corridor can support a diverse range of flora and fauna.

3.4.2. Eco-corridor 2

The proposed eco-corridor is meticulously developed through the integration of various methodologies, with a primary emphasis on node analysis and connectivity analysis. Node analysis assists in identifying potential locations for eco-corridors, while connectivity analysis validates the chosen route, ensuring effective connection of green spaces within the urban landscape.

This eco-corridor presents an opportunity for landscaping and, where feasible, watering initiatives. It serves as a vital link between the forests of the Svyatoshinsky and Goloseevsky districts, passing through the Solomyansky district. The corridor traverses along several streets including Sadova, Soborna, Nova, Yabluneva, Zhmerynska, Zodchykh, and Lvivska, encompassing diverse habitats and landmarks such as Zhulyany airport, large commercial buildings, and Sviatoshynsky forests. The most important natural sites for the corridor include: Volodymyr Poleutychyi Square; Lake Vira and the park of five benches; Sviatoshynske cemetery; Green spaces near the Capital Market; The alley of the Teremky tract, as shown in Figure 3.9.

Large, untouched areas that can be greened play a key role in creating this ecological corridor. Such areas can be used to restore natural habitats, create new green spaces, and integrate them into existing urban green infrastructure.

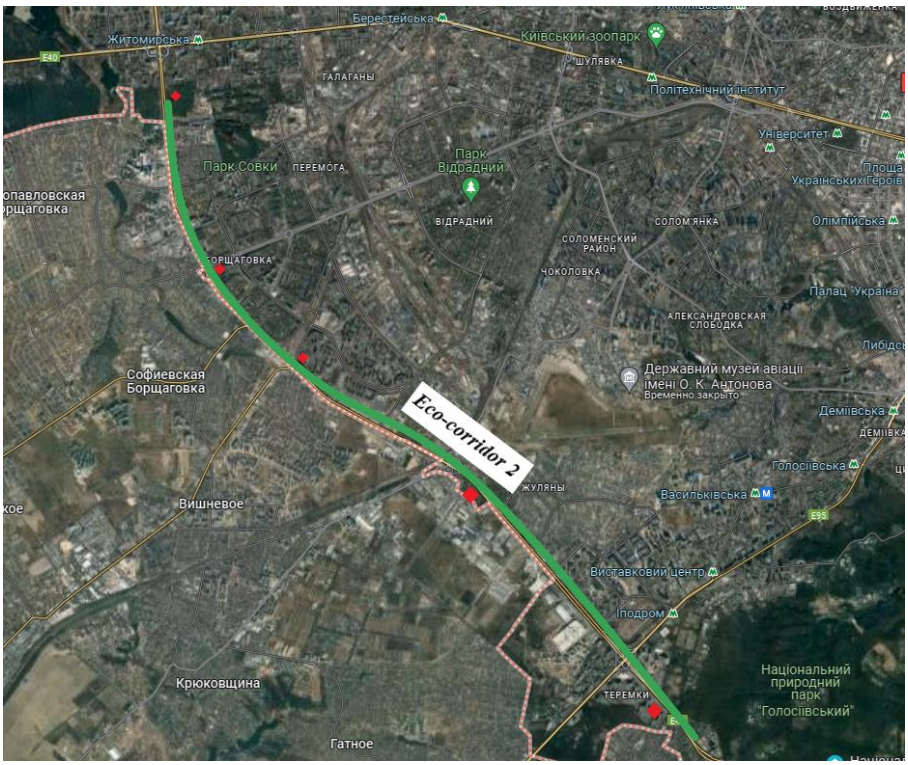


Fig. 3.9 - Eco-corridor 2

An exceptional characteristic of this corridor is its uninterrupted alignment, facilitating extensive greening efforts along its entire length. This uninterrupted pathway presents an opportunity to alleviate the adverse environmental impacts often associated with urbanization. Moreover, its alignment along less densely built areas enables easier connectivity of forests, potentially forming a "Green Ring" in Kyiv.

Despite its advantages, the corridor encounters challenges such as railroad tracks, industrial zones, and numerous garages, necessitating careful planning and environmental protection measures. Areas lacking vegetation due to technogenic characteristics require enhancement through well-designed greening initiatives to improve corridor efficiency and environmental sustainability. Thus, we offer to create the following elements for the provision of the corridor integrity:

1. Uninterrupted planting along the entire Kiltseva Road, predominantly trees and shrubs.

2. Green alleys in the middle of the Kiltseva Road, in free areas from the road, 10-20 meters wide, should be arranged.

3. A large number of fountains should be installed near the Stolychnyi market, along with public gardens.

4. Additional green buffer zones should be created on the streets of the Velyka Kiltseva Road near the enterprises.

Expanding green infrastructure along the corridor will not only diversify ecological niches but also provide vital resting places for wildlife, contributing to biodiversity conservation and overall environmental quality. The selection of plant species should align with local conditions and environmental requirements, emphasizing resilience to local climatic conditions and support for biodiversity.

3.4.3. Eco-corridor 3

The planned eco-corridor is designed to establish a vital connection between the Park Nyvky neighborhoods and the verdant surroundings of Vozdvyzhenka. By following the routes of Hlybochytska and Degtyarivska streets predominantly, this corridor aims to achieve a harmonious balance between urban development and the preservation of natural habitats. The most important natural sites for the corridor include: Munich Square; Petro Bolbochan Park; Heydar Aliyev Square; Alley of Luck Park, illustrated in Figure 3.10.

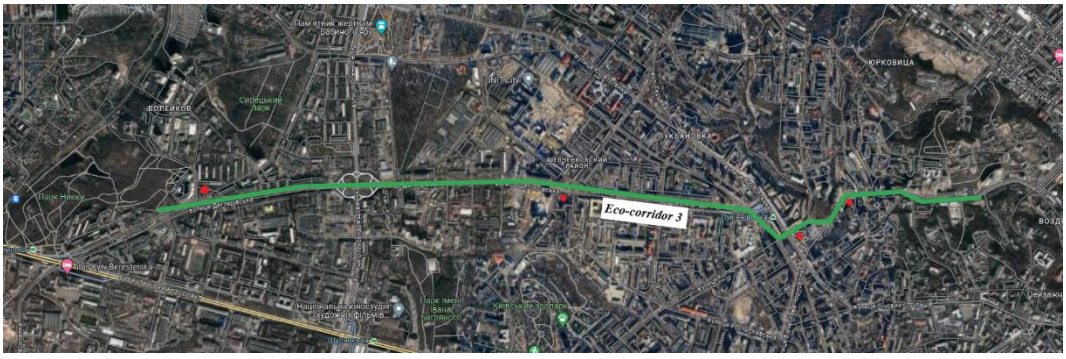


Fig. 3.10 - Eco-corridor 3

An outstanding feature of this eco-corridor is its potential to accommodate a rich diversity of animals and ornamental tree species, providing habitats for dogs, squirrels, various birds, hedgehogs, cats, and more across its entirety. However, several challenges, including urban development density, narrow streets, and the prevalence of garages, must be addressed for successful establishment.

To optimize the functionality of the eco-corridor, proposals include creating numerous small squares, promoting green roofs and walls on buildings, and cultivating flower beds. Moreover, the gently undulating terrain and varied landscape offer favorable conditions for corridor development. In particular, we offer the following elements to be implemented:

1. Additional tree planting along Degtyarivska Street.
2. Additional flowerbeds and green walls/roofs on the Degtyarivska overpass.
3. On Lukyanivska Square, create small squares and green roofs on houses, a shopping center, and a market.
4. Along Hlybochytska Street, massive creation of green walls/roofs on buildings. Mass creation of flower beds.

In essence, the envisioned eco-corridor aims to seamlessly integrate urban landscapes with natural ecosystems, promoting biodiversity and enriching the overall environmental quality of the region. Through meticulous planning and execution of greening initiatives, this corridor holds promise as a vibrant green pathway amidst urban expansion, benefiting both residents and wildlife alike.

3.4.4. Eco-corridor 4

The proposed eco-corridor aims to enhance urban biodiversity, connect green spaces, and improve environmental quality by creating a continuous green pathway from the Dnipro waterfront to the green areas in Voskresenka. This corridor will traverse major thoroughfares, including Roman Shukhevych Avenue and

Bratislavska Street, integrating green spaces and facilitating wildlife movement through urban landscapes.

The eco-corridor will begin at the Dnipro waterfront, leveraging the natural riparian habitats, and move through residential and commercial areas, following Roman Shukhevych Avenue and Bratislavska Street. It will end at the green areas in Voskresenka, connecting various squares and green spaces along the way. The most important natural sites for the corridor include: Monica's Birthday Park; General Vatutin Park; Berizka Recreation Park; Square, as illustrated in Figure 3.11.

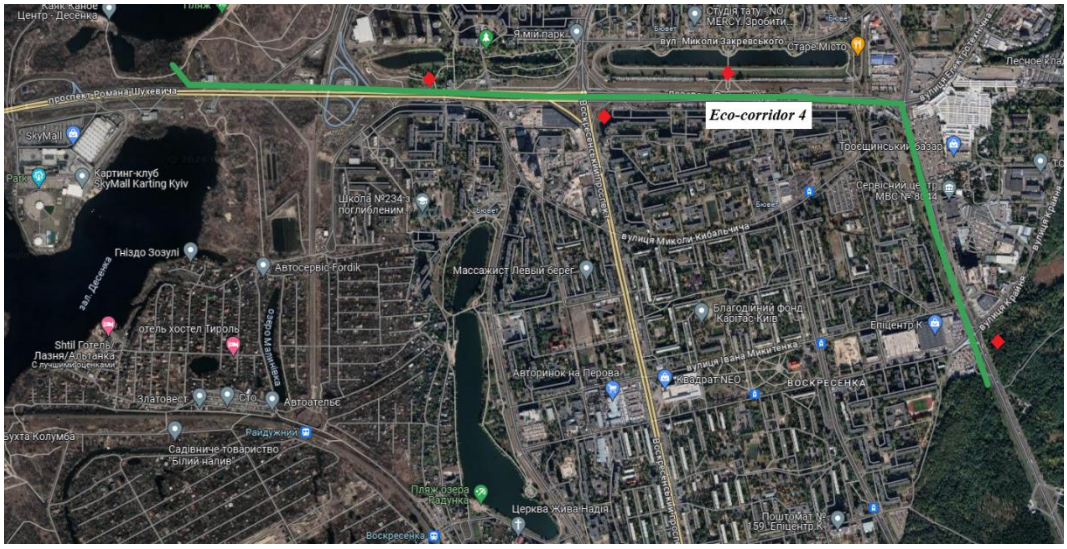


Fig. 3.11 - Eco-corridor 4

The node analysis involves identifying critical green nodes along the eco-corridor route. These nodes, including existing squares, and vacant lots, hold the potential to be transformed into green spaces. Once identified, these key sites will serve as focal points for enhancement. Strategies may include the introduction of native vegetation, water features, and habitat structures to support local wildlife populations and create vibrant green oases within the urban landscape.

Prioritizing the planting of native trees, shrubs, and plants is essential for enhancing the ecological value of the corridor. Native vegetation provides essential habitat and food sources for local wildlife while promoting biodiversity and

ecological resilience. In particular, we offer the following elements to be implemented:

1. Along Roman Shukhevych Avenue, a complex planting with a 3-tier structure (grass cover, bushes, trees of the lower tier).

2. Create a small square near the Troyeschynsky market and green roofs/walls on buildings.

3. Creating a green alley 10-20 meters wide along 52 Bratislavska Street.

4. Creating a large number of flower beds and planting trees near the Epicenter shopping center.

The proposed eco-corridor from the Dnipro waterfront to the green areas in Voskresenka will create a green pathway that enhances urban biodiversity, improves environmental quality, and provides ecological benefits to the community. Through strategic planning and implementation of green infrastructure, this eco-corridor will serve as a vital ecological network in this part of the city, benefiting both residents and wildlife.

3.4.5. Design of new green areas in Obolonskyi and Desnyanskyi districts

The creation of new green spaces and eco-corridors in Obolon and Desnianskyi districts requires detailed design and careful selection of locations. Since these areas are already heavily built up, it is necessary to find optimal locations for creating green areas that will be used to create eco-corridors, as illustrated in Figure 3.12.

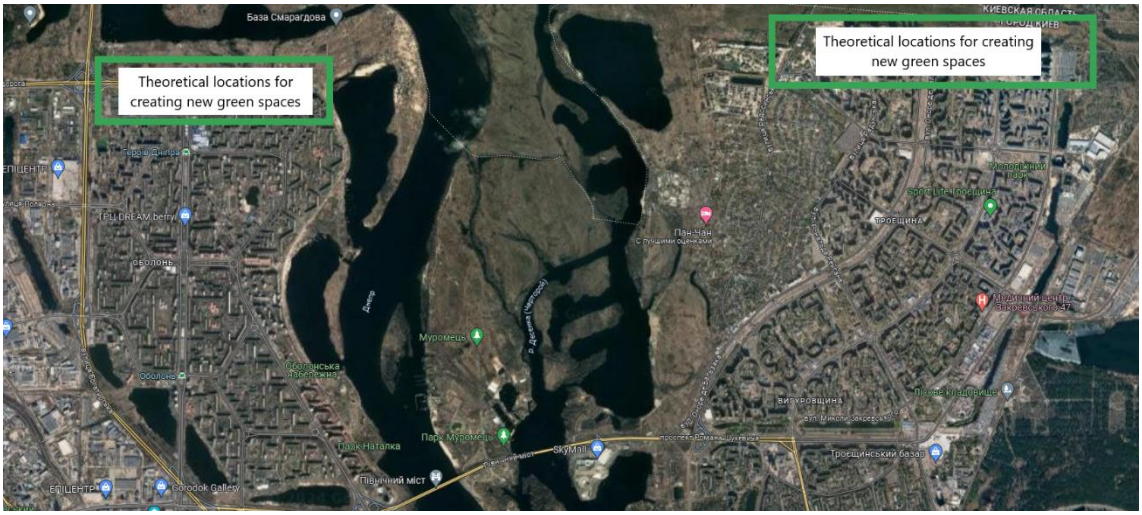


Fig. 3.12 - Theoretical locations for creating new green spaces

The goal is to create a unified ecological network that connects new green areas with eco-corridors in Obolon and Desnianskyi districts. This will improve the quality of the environment, provide places for recreation and leisure for residents, and contribute to the conservation of biodiversity.

On the outskirts of areas where there are no significant buildings and there are opportunities to create new green areas. Such places can include small parks, forest parks or open areas that are not occupied by construction or other activities.

Consider creating new green spaces where garages are located. Many garage cooperatives have large unused spaces that can be used to create green spaces. This will not only increase the ecological value of these areas, but also create new places for recreation and relaxation for residents.

3.5. Description of the network project for the city of Kyiv

The Kyiv Eco-corridors Network project aims to create an ecological system that will unite existing and new green areas. Within the framework of this project, it is planned to develop four main eco-corridors in different parts of the city, covering

the previously described urban areas, as well as to create new green areas in Obolon and Desnianskyi districts, as illustrated in Figure 3.13.

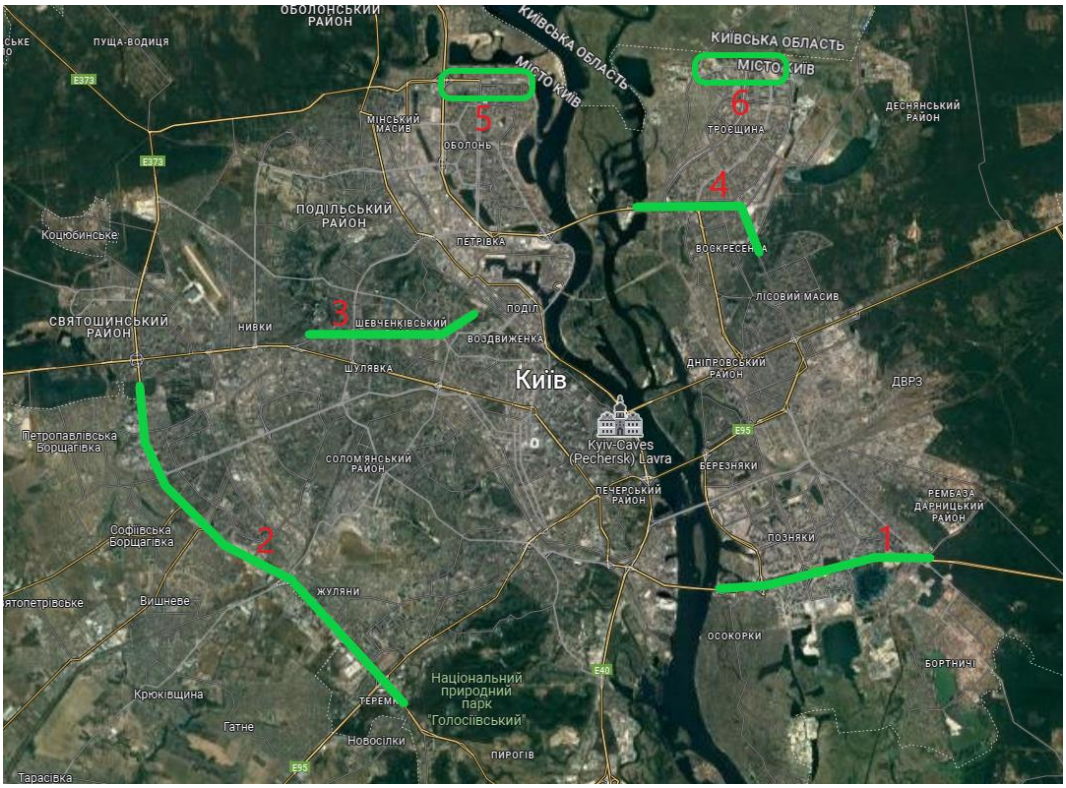


Fig. 3.13 – Eco-network project for the city of Kyiv

The planned eco-corridors and green zones are listed below:

– Eco-corridor 1: connecting the coastal zone of the Dnipro with forests in the Darnytskyi district. Located on floodplain landscapes with a combination of plains. Eco-corridor is established along the path of Revutskoho Street, Petra Hryhorenko Avenue, Mykola Bazhan Avenue, and the Kharkivske and Boryspilske Highways.

– Eco-corridor 2: connecting the forests of the Svyatoshinsky and Goloseevsky districts, passing through the Solomyansky district Meadows and forest-steppe zones can be found on the territory through which the eco-corridor passes. The corridor traverses along several streets including Sadova, Soborna, Nova, Yabluneva, Zhmerynska, Zodchykh, and Lvivska, encompassing diverse

habitats and landmarks such as Zhulyany airport, large commercial buildings, and Sviatoshynsky forests.

– Eco-corridor 3: planned eco-corridor is intended to establish a connection between the Nyvky Park neighborhoods and the green outskirts of Vozdvyzhenka. The eco-corridor will run through hilly terrain.

– Eco-corridor 4: creating a continuous green pathway from the Dnipro waterfront to the green areas in Voskresenka. The eco-corridor will include the natural area of the Dnipro embankment, which includes floodplain meadows and flat terrain. This corridor will traverse major thoroughfares, including Roman Shukhevych Avenue and Bratislavska Street.

– Design of new green areas in Obolonskyi and Desnyanskyi districts: creation of new green spaces and eco-corridors in Obolon and Desnianskyi districts. The planned location of Obolon and Desniansky green areas will be on floodplain meadows.

Overall, the proposed eco-corridors present a significant opportunity to enhance the urban environment and improve ecological connectivity. With careful planning and implementation of greening initiatives, it has the potential to become a valuable asset for both the local community and the surrounding ecosystem.

Kyiv is a green city in itself, famous for its many parks, squares, and even the Dnipro National Ecological Corridor that runs through it. The city is home to the Holosiivskyi National Nature Park, which is a unique feature that only a few cities in the world can boast. However, despite the large number of green areas, anthropogenic impact still exists and negatively affects the ecological state of the city.

The project to create new eco-corridors and expand green spaces in Kyiv will help to strengthen and improve the environmental situation even further. The implementation of such measures will help reduce air pollution, preserve biodiversity, improve the urban microclimate, increase the aesthetic and recreational value of urban areas, effectively manage water resources, and provide significant

social and economic benefits. Thus, the project will contribute to a more sustainable, healthy, and livable urban environment while preserving Kyiv's unique natural features.

3.6. Recommendations for the conservation and restoration of natural complexes included in the project

To ensure the successful conservation and restoration of the natural complexes included in the project, it is necessary to implement a comprehensive approach that includes inventory, protection, restoration, education, infrastructure development, and fundraising. These measures aim not only to preserve existing natural ecosystems, but also to restore degraded areas, promote biodiversity, and raise environmental awareness. Below are the main recommendations that will help achieve these goals and ensure the sustainable development of Kyiv's ecological network.

– Inventory and monitoring: conduct a detailed inventory of all existing natural complexes included in the project to get a complete picture of their condition, structure, and biodiversity. Implement an ongoing monitoring system to track changes in ecosystems, including flora, fauna, air and water quality.

– Protection of natural complexes: establish restricted access zones in key natural areas to reduce the impact of human activity. Ensure control over the implementation of these restrictions. Develop and implement regulations that will promote the preservation of natural complexes and establish severe penalties for violations of environmental standards.

– Restore natural complexes: implement ecological restoration measures, such as planting native plant species, restoring wetlands, and reclaiming degraded land. Ensure the restoration of the natural hydrological regime of water bodies, including rivers and lakes, to maintain biodiversity and ecosystem functions.

– Public education and community engagement: organize educational programs for the public on the importance of preserving natural complexes, including lectures, seminars, and interactive events. Create programs for local communities to participate in activities to protect and restore natural complexes. Support initiatives of public environmental supervision.

– Infrastructure and management development: develop infrastructure projects that will contribute to the conservation of natural complexes, including the construction of ecological trails, information stands and observation platforms. Introduce effective models for managing natural complexes, including coordination between different agencies and organizations, as well as the involvement of environmental specialists.

– Funding and support: find opportunities to attract additional funding from international environmental funds, grants and technical assistance programs to implement measures to restore and preserve natural complexes. Support scientific research and innovative projects aimed at preserving and restoring natural complexes, and introduce the latest technologies in this area.

3.7. Conclusion to Chapter 3

The project aims to address the environmental challenges faced by Kyiv, a city undergoing rapid urbanization and industrialization. By creating eco-corridors and expanding green spaces, the project seeks to mitigate pollution, preserve biodiversity, improve the urban microclimate, and enhance the overall quality of life for residents.

Through careful selection and assessment of areas, the project of eco-corridors was created to facilitate species migration, ensure ecosystem stability, and preserve natural landscapes. These eco-corridors also possess potential for mitigation of climate change pressures on urban ecosystem, improving water and air quality, and providing recreational opportunities for citizens.

CONCLUSIONS

1. The project of ecological network development for Kyiv is of utmost importance for improving the environmental situation and the quality of life of its residents. Known for its rich green infrastructure, numerous parks, squares and national nature parks such as Holosiivskyi, Kyiv is an impressive example of a city where nature coexists harmoniously with the urbanized environment. However, anthropogenic impacts, such as intensive development and traffic, threaten the preservation of natural complexes and require decisive measures to strengthen the city's ecological network.

2. Four key eco-corridors were developed to connect green areas with each other and increase the number of local bird and small mammal species, reduce summer temperatures by 2-3°C within the project areas, and reduce the concentration of fine particulate matter PM2.5 and PM10. Optimal sites for the creation of new green areas have been identified in Obolon and Desnianskyi districts, which are intensively built up and require the integration of new green areas to form an ecological network.

3. The project includes a number of small-scale activities, such as insatlling fountains, green roofs and walls, creating flower beds, as well as more complicated structure, such as 3-tier plant association (grass cover, bushes, trees of the lower tier), and infrastructure elements to avoid flooding (bioswells and bioplato). An important aspect is organizing the continuous monitoring and adaptive management of the ecological network, which is expected to enable quick response to challenges and ensure resilience of ecosystems.

4. Successful implementation of these project will contribute to the preservation and restoration of Kyiv's natural complexes, strengthening the city's environmental sustainability, improving air and water quality, and creation of more comfortable living conditions for residents.

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