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URBAN, ENERGY AND ENVIRONMENTAL PLANNING

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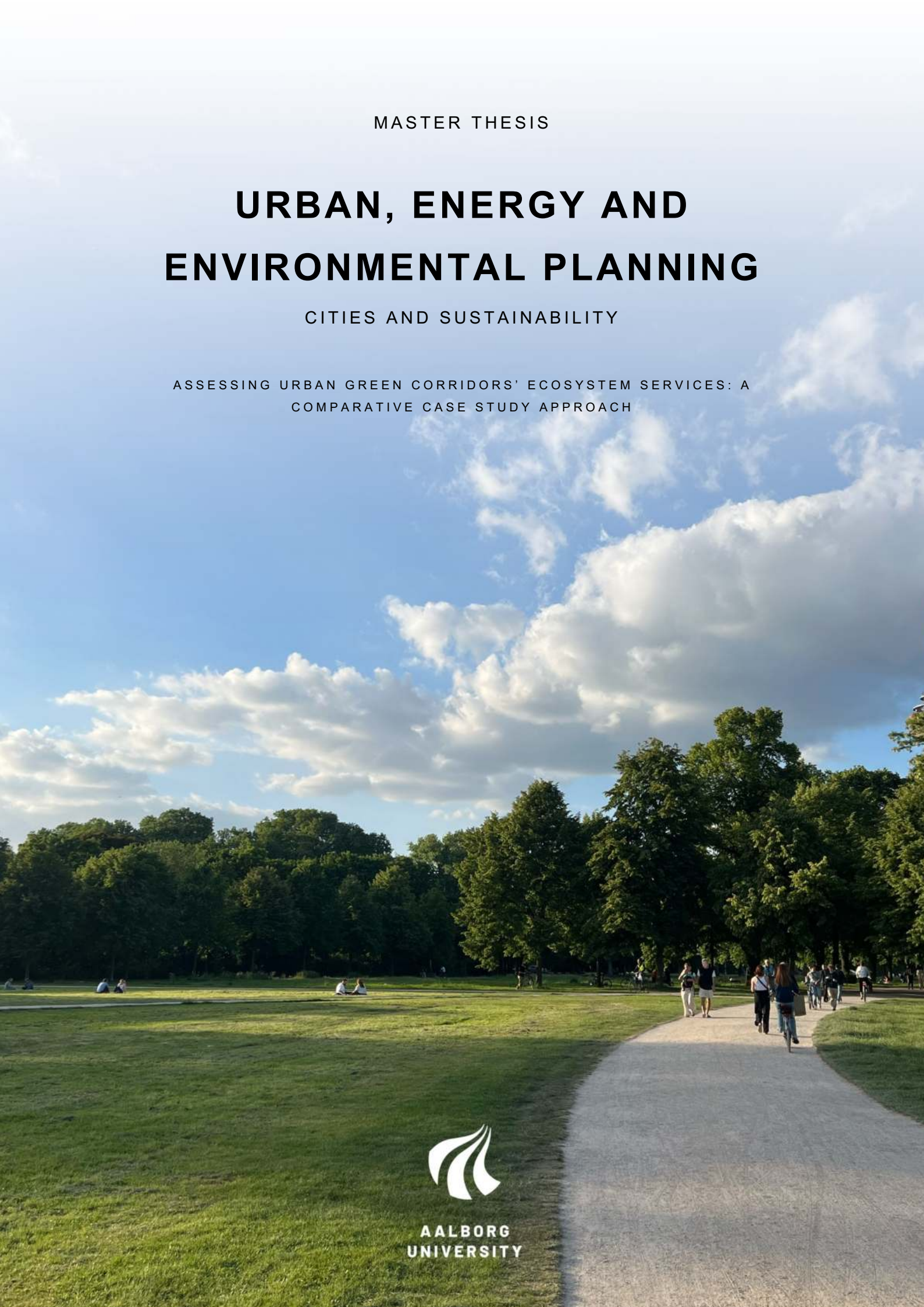
ASSESSING URBAN GREEN CORRIDORS' ECOSYSTEM SERVICES: A COMPARATIVE CASE STUDY APPROACH



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Declaration of originality

I hereby affirm that the content of this thesis is the result of my own independent research and writing, and that I have not received any external assistance in its development. I have not used any resources other than those listed, and I have indicated where I have used material from other sources.

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Abstract

Cities face critical challenges related to climate change and urbanization, including the urban heat island effect, increased flood risk, air pollution, and biodiversity loss, all impacting residents and the environment. Growing urban populations intensify the need to balance multiple societal demands, including recreational, environmental, and infrastructural demands, all within finite spaces. Ensuring the provision of ecosystem services, as benefits derived from ecosystems, is therefore crucial to environmental health and human well-being. Urban green corridors (UGCs) aim to accommodate multiple societal demands simultaneously. This thesis analyzes the potential of UGCs to accommodate diverse interests, highlighting emerging conflicts and trade-offs. The main research question examines the contribution of UGCs to sustainable urban environments through the provision of ecosystem services. A mixed methodology including qualitative and quantitative methods are applied. Five UGCs are analyzed as case studies through an ecosystem service assessment. With urban residents directly impacted by UGCs and their ecosystem services, the role of the local community is analyzed. The key findings indicate that the UGCs vary in their potential supply of ecosystem services due to their unique characteristics. Tree cover has a great potential to supply ecosystem services such as local climate regulation, air quality regulation, flood protection, pollination and the provision of recreational values that promote the use of UGCs such as for active mobility. The supply of ecosystem services depends on land cover type and site condition, emphasizing the need for site-specific research. Some of the UGCs provide educational opportunities and include urban gardens that encourage environmental stewardship and social interaction. Local communities play a crucial role, as some of the UGCs were initiated by grassroot efforts and are partially managed by community members. However, long-term management faces challenges, such as limited financial resources, expertise, and stakeholder collaboration. Although balancing infrastructure and ecology is essential, infrastructure is being prioritized, resulting in critical ecological impacts. Achieving a balance between ecological and societal needs remains challenging due to conflicting interests. Additionally, excessive use of UGCs and the public's critical perception of nature result in disruptions to biodiversity. Large-scale green infrastructure projects such as UGCs catalyze economic development, which can lead to displacement of residents due to rising property values. To ensure the long-term success and enhance ecosystem service supply of UGCs, community participation and transdisciplinary collaboration are essential. UGCs can serve as multifunctional spaces that address societal needs by providing ecosystem services and other benefits, such as connectivity and supporting social interaction and active mobility. However, further site-specific research is needed to enhance the supply of urban ecosystem services and ensure their provision in the face of growing urban pressures.

Preface

This master's thesis concludes the fourth semester of the master's program Urban, Energy, and Environmental Planning with the specialization Cities and Sustainability at Aalborg University in Aalborg. The project period was from February 1st to May 28th, 2025. The present thesis assesses the ecosystem services of urban green corridors using a comparative case study approach. It explores the multifunctionality of urban green corridors and examines the role of the local community.

I want to take this opportunity to acknowledge and thank my supervisors, Lars Bodum and Thomas Elliot, for their support in helping me find a research topic for this thesis and for reviewing it. Their helpful suggestions, encouragement and constructive criticism during the preparation of this thesis were invaluable to the completion of this thesis.

Also, I would like to extend gratitude to the experts and practitioners who gave me the opportunity to conduct interviews, providing valuable insights into urban green corridors, their ecosystem services, and the five completed UGC projects in the USA, Canada, Great Britain, and Australia that were selected as case studies for this thesis. In this regard, special thanks go to the interview partners.

Lastly, I would like to thank my family for making my studies possible through their support and for backing me in all my decisions.

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1 Research background

Nowadays cities are confronted with several intensifying and interconnected challenges related to urbanization, climate change, and biodiversity loss, all of which have significant impacts on the urban environment and livability (Ascione et al., 2024, pp. 1–2; Copernicus, 2025; Damiani et al., 2023, pp. 1–2). The ongoing need to accommodate urban population growth is resulting in loss and fragmentation of urban green spaces. Simultaneously, climate change is intensifying environmental challenges such as the urban heat island effect and flooding. These climate-related challenges are further exacerbated by the decline of urban green spaces (Ascione et al., 2024, p. 2; Joshi et al., 2024, p. 10). For enhancing the quality of life and ensuring sustainability integrating and conserving urban green infrastructure is essential (Pauleit et al., 2017, pp. 34–35). This chapter outlines the research background for this thesis elaborating on urban challenges and highlighting the importance of urban green infrastructure.

1.1 Urban challenges

Today, around 3% of world's land surface is occupied by cities, accommodating around four billion people, which is about 55% of the world's population (Ritchie et al., 2024; United Nations, 2018, 2020). Urban areas are the primary nodes for infrastructure, goods, and people. Anthropogenic activities significantly impact the urban environment including land use and land cover changes as well as changing climate resulting in more frequent and intense extreme weather events (Shilky et al., 2024, p. 339; United Nations Human Settlements Programme, 2025).

Urban areas are the primary drivers of climate change, responsible for approximately 70% of global carbon emissions, while cities are also susceptible to the adverse effects of climate hazards (Lwasa et al., 2023, p. 877; United Nations, 2020). Climate change is globally affecting weather and climate extremes, causing significant impacts for human and nature, which is projected to further intensify (IPCC, 2023, pp. 5–7). The impacts of climate change are already visible such as extreme heat waves, heavy rainfall resulting in severe flooding, droughts, and extreme wildfires (Kumareswaran & Jayasinghe, 2023, p. 47; NASA, 2024). Also, urban ecosystems are significantly impacted by climate change (Sarabi et al., 2019, p. 1). 2024, was the warmest year on record globally, as confirmed by the Copernicus Climate Change Service, with the global temperature exceeding pre-industrial levels by 1.5 degrees (Copernicus, 2025). Global warming is accelerated through impervious surfaces causing increasing solar insolation, increasing greenhouse gas emissions, and climate change (Shilky et al., 2024, p. 341). This phenomenon is exacerbating extreme weather events by warming

the hydrological cycle, shifting weather patterns, melting ice, and further intensifying heat islands within urban areas (Kumareswaran & Jayasinghe, 2023, p. 47; NASA, 2024).

In recent years, urban areas have experienced rapid population growth due to mass migration (Ritchie et al., 2024). The United Nations predict the world to become increasingly urbanized with around 68% of the world's population living in urban areas by 2050 (United Nations, 2018). Urbanization contributes to climate change due to the increase in greenhouse gas emissions, particularly from energy consumption, transport and industrial activities. Besides this, urbanization has social implications such as increasing social disparities and inequality (Ali et al., 2024, p. 2). Also, the vulnerability of cities to climate change is increasing due to their greater density and continued population growth. Urbanization is posing great pressure on urban areas resulting in the fragmentation of green spaces, sealing of surfaces, loss of biodiversity, increasing property values, and degradation of urban ecosystems. Accordingly hydrological and ecological functions in urban areas are significantly impacted in terms of decreased water infiltration causing flooding, alterations to the water cycle, decreasing groundwater recharge, and intensifying urban heat island effect (Eigenbrod et al., 2011, p. 3201; Pamukcu-Albers et al., 2023, p. 53; Sarabi et al., 2019, p. 1; Shilky et al., 2024, p. 341). Urbanized areas are prone to be characterized by absence of urban green space which has impacts on the urban environmental quality (Haaland & van den Bosch, 2015, pp. 760–761).

Urban areas need to be able to withstand shocks and stresses while building resilience to long-term pressures such as climate change and urbanization, which can have a significant impact on the quality of life in cities, while sustainable urban development is becoming increasingly important (Haaland & van den Bosch, 2015, p. 760; Kumareswaran & Jayasinghe, 2023, p. 47). To address these global challenges, the United Nations adopted the 2030 Agenda for Sustainable Development in 2015, which includes 17 Sustainable Development Goals (SDGs) that aim to achieve sustainable development with respect to climate change, economic growth, poverty reduction, and urban development (Maes et al., 2019, p. 182). Particularly, the Sustainable Development Goal 11 highlights the necessity to create safe, resilient, and sustainable cities and urban areas (Vavassori et al., 2024, p. 1). The development of sustainable urban environments requires a multidisciplinary approach involving different stakeholders, such as ecologists and urban planners, to achieve multifunctional green spaces providing biodiversity as well as cultural and social benefits (Ahern, 1995, p. 131 and p. 152).

1.2 Significance of green infrastructure in urban areas

Increasing human development is putting pressure on landscapes through land cover change, fragmentation and land use intensification, resulting in impacts on habitats, species and

biodiversity in these landscapes. Therefore, the protection and conservation of natural areas in urbanized areas is essential to ensure their multiple benefits (European Commission, 2010, pp. 3–4; Zhang, Z. et al., 2019, p. 305).

Sustainable urban environments are crucial for addressing the critical impacts of the challenges on urban areas, while mitigating and adapting to climate change (Choi et al., 2021, p. 1). Various ecosystem-based approaches, such as nature-based solutions (NbS), have been applied to bring nature back to urban areas while increasing the resilience of urban areas. Although the incorporation of NbS has primarily been driven by the need to build resilience to climate change, these measures address socio-economic and environmental challenges (Sarabi et al., 2019, p. 1), highlighting its importance for improving the quality of life and the reduction of the ecological footprint (Pauleit et al., 2017, p. 30). This can ensure urban sustainability through the provision of multiple benefits for meeting societal needs (Haaland & van den Bosch, 2015, pp. 760–761; Shilky et al., 2024, pp. 340–342). These measures are considered innovative and cost-effective solutions based on nature, while providing environmental, social, as well as economic benefits addressing multiple urban sustainability challenges (Dorst et al., 2022, p. 2).

Several concepts have been established for the enhancement and support of urban green spaces, including the concept of urban green infrastructure (UGI) (Hansen, Rieke & Pauleit, 2014, p. 516; Pauleit et al., 2017, pp. 30–31). UGI was introduced by Sandström in 2002 to highlight multifunctional green spaces and to ensure urban sustainability (Zhang, S. & Muñoz Ramírez, 2019, pp. 59–60). Green infrastructure is rooted in landscape architecture and landscape ecology while being strongly connected to spatial planning. This concept has been applied in urban planning practice around the world due to its wide range of environmental characteristics and its applicability at national, regional and local scale. Also, the main principles on which this concept is based are multifunctionality and connectivity (Pauleit et al., 2017, pp. 34–37). Green infrastructure is defined as “a strategically planned network of natural and semi-natural areas and other environmental features designed and managed to deliver a wide range of ecosystem services” (European Commission, 2013, p. 3). UGI aims to provide multiple benefits such as biodiversity and recreational values that are referred to as ecosystem services that are presented in Chapter 2.2 (Shilky et al., 2024, p. 344). These interconnected green spaces contribute to human well-being and quality of life while preserving natural ecological processes, protecting air and water resources, and fostering native species. It has been developed in response to uncontrolled urban sprawl to influence spatial planning by identifying ecologically valuable land and protecting open space (Pauleit et al., 2017, pp. 34–35). Also, has multiple benefits including the reduction of urban heat islands, increasing carbon sequestration, and improving of water and air quality, and provision of sustainable transport

opportunities, while it promotes a harmonious balance between people and nature. Besides this, UGI contributes to climate adaptation and mitigation (Choi et al., 2021, pp. 1–3; ESPON, 2020, p. 3; Vilanova et al., 2024, p. 14). Also, recreational and social cohesion opportunities are provided by UGI (Shilky et al., 2024, pp. 342–343). Parks, street trees, blue-green corridors, and recreational areas are elements of green infrastructure (Vujičić et al., 2024, p. 2). Urban sustainability can be ensured through the integration of UGI into urban developments, prioritizing environmental sustainability (Addo-Bankas et al., 2024, p. 3). Overall, UGI contributes essentially to the SDGs, primarily SDG 11 Sustainable Cities and Communities, due to its various benefits (Herath & Bai, 2024, p. 1055), and it contributes to reducing environmental impacts such as through the promotion of sustainable urban mobility (Hapriyanto & Azmi, 2025, pp. 1–2).

The combination of UGI and infrastructure for active mobility provides significant benefits. The integration of active mobility infrastructure into urban areas facilitates the connectivity of green spaces that support urban biodiversity and the provision of multiple benefits. The combination of these two infrastructure types can impact the active mobility behavior and support physical and mental human health, while contributing to quality of life. In addition, it has the potential to strengthen the connection between human and nature (Liu et al., 2024, pp. 1–2), while it contributes to enhance multifunctional spaces, limit the loss of green spaces and address development pressures (Liu et al., 2024, p. 2). Worldwide cities such as Copenhagen and Amsterdam have implemented such environmentally friendly transport systems (Hapriyanto & Azmi, 2025, p. 2).

However, challenges such as limited financial resources and limited urban space pose barriers to the implementation of UGI. Also, the cooperation of different stakeholders with different interests and priorities is a challenge for development. There is limited understanding of the long-term benefits of UGI among stakeholders highlighting the need for comprehensive education on UGI and collaboration among different stakeholders to promote the development of UGI and ensure sustainable urban environments (Hapriyanto & Azmi, 2025, p. 8).

The local community is generally a stakeholder group that is directly experiencing the impact and the lack of UGI. It is essential to investigate the role of local community in the development, implementation, and management of UGI. Furthermore, the sharing of knowledge and experience on UGI among the local community can result in increasing acceptance and participatory interest in pro-environmental behaviors such as the support of UGI due to experienced consequences of natural hazards. In the literature the participation of the public in UGI projects contribute to informed decision-making, increasing acceptance of decisions, enhanced education on nature, and increasing the level of trust (Barclay & Klotz,

2019, pp. 1–2). The involvement of the local community enhances the long-term success of UGI projects. Also, for enhancing the democracy of the development and management of UGI the collaboration with the local community is essential. However, UGI projects are often based on a top-down and expert-driven approach with limited community engagement resulting in mismatches of multifunctional and inclusive spaces, potentially resulting in failing to address the local community's needs (Campbell-Arvai & Lindquist, 2021, pp. 1–2). Overall, the involvement of the local community into green infrastructure projects is facilitating inclusive and equitable decision-making addressing the local community's needs (Jagadisan & Sen, 2024, p. 211).

1.3 Problem statement

Urban green spaces provide essential benefits to society and habitat for flora and fauna (Haaland & van den Bosch, 2015, pp. 760–761). However, these spaces are under increasing pressure due to climate change, which leads to shifts in ecosystem processes and loss of biodiversity. Changes in land use and land cover exacerbate degradation of ecosystems (Elleaume et al., 2025, pp. 1–2). As a result, their function and their capacities to deliver critical services is compromised (Kreuter et al., 2001, p. 334; Zhang, S. & Muñoz Ramírez, 2019, p. 1). Particularly the increasing land use conflicts due to the overlapping of ecological, recreational, and infrastructural interests, highlight the need for urban green spaces that can address these interests simultaneously (Pauleit et al., 2017, pp. 34–36). Urban green corridors (UGCs) as a type of UGI have the potential to address these interests (Zhang, M. et al., 2022, pp. 1–2). Therefore, this thesis aims to advance the state-of-the-art research by examining the potential UGCs to provide ecosystem services and their role in addressing urban challenges related to climate change and urbanization. Accordingly, Chapter 2 provides a comprehensive review of relevant literature on UGCs and urban ecosystem services.

2 Literature review

In this chapter the state-of-the-art of UGCs and urban ecosystem services is outlined. Besides this, the existing research gap with regards to UGCs and ecosystem services is highlighted.

2.1 Urban green corridors

The fragmentation of urban green spaces, the degradation of the ecological environment and the fragility of urban ecosystems are increasing, especially due to urbanization (Horte & Eisenman, 2020, pp. 1–2; Yan, 2024, p. 2). Based on the goal to ensure sustainable urban environments that meet current needs without compromising future needs, the design of landscapes with patches and corridors for connecting isolated green spaces while preventing the effects of fragmentation has been proposed since the 1980s (Ahern, 1995, pp. 131–133; Al Masri et al., 2019, p. 418). Therefore, the significance of green corridors in urban areas, some of the existing typologies as well as implemented UGCs are highlighted.

2.1.1 Significance of green corridors in urban areas

The concept of green corridors, also referred to as greenway concept, is facilitating the planning of open spaces as part of a wider system linking open spaces through pedestrian and bicycle paths (Groome, 1990, pp. 383–384). In the 1980s this concept has been introduced aiming to protect nature through the connectivity of habitats (Al Masri et al., 2019, p. 418). The development of UGCs is rooted in different disciplines such as ecology, landscape design, architectural design and human behavior due to its multifunctional character (Qian et al., 2018, p. 45). Therefore, involving various stakeholders such as local communities, policy makers, as well as environmental organizations into the planning and implementation process of green corridors for balancing the ecological and social needs, while addressing diverse priorities is necessary (Tigen & Özcan, 2025, p. 286).

UGCs connect urban living space with ecological space, and their continuous structure and function counteract land fragmentation. The integration of this type of green infrastructure into urban areas facilitates the fulfillment of both human and species needs for ecological space (Zhang, M. et al., 2022, pp. 1–2), while allowing for movement and recreational opportunities (Groome, 1990, pp. 383–384). Therefore, UGCs as interlinked networks of linear elements within cities are critical for urban sustainability. The Parkway concept of Olmsted in America and the Garden City concept in England initiated the first roots for planning green corridors with the aim of preserving and providing connected urban open spaces (Golestani Eraghi, 2015, pp. 36–37; Yan, 2024, pp. 7–8). UGCs are essential for enhancing urban sustainable development due to their multiple benefits that are compatible with the concept of sustainable cities. Whereby the concept of sustainable cities encompasses crucial characteristics of sustainability such as quality of life within urban areas that can be addressed through UGCs.

This type of green infrastructure refers to multifunctional linear green spaces facilitating active mobility such as walking and cycling, social interaction of communities and enhancing the health of the environment as well as human well-being (Shahani, 2012, pp. 1514–1516). Studies on UGCs highlight their contribution to climate regulation and improvement of air quality (Xu et al., 2019, pp. 1–2). Also, green corridors contribute to maintain biodiversity through ecological pathways in fragmented environments (Tigen & Özcan, 2025, pp. 276–277). This type of UGI provides recreational and commuting opportunities to society (Shafer et al., 2000). However, Vilanova et al. (2024, p. 2) point out that the interaction of recreational and ecological functions is a remaining challenge within green corridors.

Green corridors vary widely in terms of their physical context, being formed from natural or urban features, and at different scales, from suburban features to trails those cross regions or countries (Ashfield Council & Eco Logical Australia Pty Ltd, 2011, p. 9). There is also a variation in primary purpose and serving multiple functions while being designed primarily for human use. The objectives of UGCs vary according to cultural background, demographics and urban structure, although the overarching goal is to ensure a sustainable environment (Douglas, 2020, pp. 313–314; Peng et al., 2017, p. 25). Some green corridors have been developed by transforming abandoned railroads and canals to connect urban and rural area. UGCs also shape the urban design that limits urban development, and they provide natural ventilation to urban areas (Golestani Eraghi, 2015, pp. 36–37; Groome, 1990, pp. 383–384).

2.1.2 Typologies of urban green corridors

In the literature there is no universal definition for UGCs and there are several terminologies used for UGCs such as greenways, green belts, ecological corridors, ecological network, habitat network as well as ecological infrastructure.

The concept of greenways has been introduced in terms of the Boston Park System aiming to enhance the interaction of nature and residents. Ahern's definition is the primarily used one which defines greenways as linear landscapes that aim to provide multiple functions including ecological, cultural, recreational, aesthetic and others consistent with sustainable urban environments. The main purpose is connectivity as well as the protection and preservation of species habitat. Particularly in the United States and Canada, the concept of greenways developed in the 1990s as part of grassroots land use initiatives at the local or regional level (Ahern, 1995, pp. 131–133; Choi et al., 2021, p. 134; Peng et al., 2017, p. 24). For the sustainable development of cities greenways have evolved over time consisting of multiple objectives that go beyond recreation and beautification including objectives such as the conservation of urban biodiversity, restoration of ecology, opportunities for education, management of growth and active mobility (Palardy et al., 2018, p. 251). In the literature the

term greenway is primarily used for open space corridors (Lynch, 2019, pp. 133–134). The green belt concept has been firstly introduced by William Petty, defining it as a green space aiming to divide urban and rural areas, provisioning of recreational opportunities and shaping the urban development on a spatial scale. The concepts of ecological and green corridors are not clearly distinguished in the currently available literature. Both are defined as linear green spaces with multiple functions (Peng et al., 2017, p. 24). Some literature define UGCs as linear green spaces for active mobility, while others include motorized vehicles such as the Champs Elysées in Paris (Douglas, 2020, pp. 313–314).

These various terminologies and differing understandings reflect the unique implementation with differing main purposes (Ahern, 1995, pp. 131–133). Green corridors in urban areas differ from corridors in rural areas due to limited space, pressure from urbanization, and high demand for use (Horte & Eisenman, 2020, p. 2). In this thesis, the term UGC is used to refer to linear green spaces that serve multiple functions including ecological functions and to provide opportunities for active mobility within urban areas.

2.1.3 Examples of urban green corridors

Worldwide several UGCs have been implemented in the recent years based on the local conditions and needs such as green belts in London, Seoul, and Tokyo (Tuyen, 2021, pp. 1–2). In the United States, several UGCs aim to protect the natural landscape and provide recreational space for urban residents, while in Europe, the primary goal is to preserve biodiversity due to urbanization pressures (Peng et al., 2017, p. 25). The transformation of abandoned transportation infrastructure such as railway tracks, highways, and overpasses as well as waterways, that have been subjected to degradation, into green infrastructure has significantly increased in the recent years due to urbanization (Lynch, 2019, p. 137; Mu & Li, 2024, p. 2; Sim, 2024) such as the High Line in New York City, the 606 in Chicago, Cheonggyecheon in Seoul, and the Turia Fluvial Park in Valencia (Sim et al., 2020, pp. 1–4; Viñals et al., 2012, pp. 5–6). Australia is also implementing UGCs, such as the Cooks to Cove GreenWay in Sydney, that aims to provide movement for residents and wildlife (Rauscher & Momtaz, 2017a, pp. 65–66). The River Torrens Linear Park in Adelaide, the largest stormwater project in Australia, is another green corridor that was implemented due to the flood risk along the river (Ibrahim et al., 2020). The inner green belt in Cologne, Germany, has been developed on the former fortification ring to provide natural ventilation to the urban center while providing recreational opportunities including active mobility (Becker, 2016; RegioGrün). These projects demonstrate the diversity of UGCs worldwide, while each project is designed to address a specific local situation. Figure 1 shows examples of UGCs in Cologne, Germany.

Figure 1: Examples of urban green corridors in Cologne, Germany (Own photographs, 2025)

However, it is important to note, that the integration of such large-scale UGI can have critical consequences that impact social and ecological balance. Greening initiatives can cause shifts in property values and can disproportionately affect marginalized communities. The process of enhancing urban green spaces can lead to economic impacts such as loss of affordable housing due to increased property values and the potential displacement of low-income residents, referred to as green gentrification, which is a critical urban planning and social equity issue. This phenomenon has been observed in the High Line project in New York transforming an abandoned railway into an elevated park resulting in a significant increase in property values in the surrounding neighborhoods. Also, the Chenggycheon stream restoration in Seoul, South Korea and transformation into a vibrant public space with improved environmental quality has resulted in significant increases of property values impacting urban residents and businesses. The development of the network of public green spaces Atlanta Beltline, USA, also led to increased property values. Particularly the integration of large-scale UGI projects is complex and requires considerations for ensuring equitable developments without amplifying social inequalities. The involvement of local communities into urban developments as well as the management of NbS facilitate social cohesion through the inclusion of diverse community groups. Therefore, the different interests of local community members need to be taken into consideration to prevent green gentrification (Bressane et al., 2024, pp. 1–2). The topic of green gentrification is not going to be discussed in more detail in this thesis since it is out of the scope of this study and research direction. However, in relation to some of the selected UGCs it is mentioned.

2.2 Urban ecosystem services

The need of taking the relationship between human well-being and nature into consideration has significantly increased also with regards to conservation planning and environmental management (Blouin et al., 2025, p. 1). Through the provision of benefits derived from

ecosystems, nature has a significant impact on humans (Pauleit et al., 2017, p. 37). Ahern et al. (2014, p. 255) highlight that ecosystem services provided by UGI can be seen as emerging research theme due to their contribution to sustainable urban environments. In this section the state-of-the-art of urban ecosystem services is outlined. Therefore, the terminology and categories of ecosystem services as well as the significance in particularly in urban areas are highlighted.

2.2.1 Definition and categories of ecosystem services

The terminology ecosystem service has been introduced in 1981 (Grunewald et al., 2023, p. 27). The benefits provided by ecosystems to humans, either directly or indirectly, are referred to as ecosystem services. It is important to note that ecosystems can provide multiple services simultaneously (Costanza et al., 1997, p. 253; European Commission, 2025). The concept of ecosystem services has gained increasing attention by scientists from different disciplines after the publications of Ehrlich and Ehrlich (1981), Daily (1997), Constanza (1997) and the Millennium Ecosystem Assessment (2005) (Beichler et al., 2017, p. 2). This concept was developed as a mean of raising public awareness of the need for biodiversity conservation. For addressing ethical issues and the incorporation of this concept into policy making the literature on ecosystem services has expanded since then (Pauleit et al., 2017, p. 37). Overall, the concept of ecosystem services facilitates the assessment of benefits delivery by nature (Pauleit et al., 2017, p. 44), while it can facilitate the conceptualization and management of human-environment interactions for ensuring sustainability (Luederitz et al., 2015, pp. 99–100). Until today this concept has been subject to integrated interdisciplinary and transdisciplinary research. It also has the potential to increase public awareness of nature, while supporting the implementation of science-based sustainable development strategies (Dushkova et al., 2025, pp. 577–578).

There are four main categories of ecosystem services: provisioning, regulating, cultural, and supporting services. Products that are obtained from ecosystems such as food, timber, and fresh water are referred to as provisioning services. Regulating services are defined as the benefits through the regulation by ecosystem processes such as climate regulation, stormwater management, air pollution control, and noise abatement (Dvornikov et al., 2025, p. 1; Shilky et al., 2024, pp. 342–343). Non-material benefits that directly affect people's lives are referred to as cultural services such as recreational opportunities and aesthetics (Dvornikov et al., 2025, p. 1; Romanazzi et al., 2023, pp. 1–2; Shilky et al., 2024, pp. 342–343). All those services that are essential to produce these ecosystem services are referred to as supporting services such as forming soil and cycling nutrients (Gómez-Baggethun et al., 2013, p. 178; Shilky et al., 2024, pp. 342–343). The ecosystem services that are focused on in this thesis are listed in Appendix A.

In recent years, the development of methods for quantifying ecosystem services, particularly in terms of provision and value, has gained significant attention, as it facilitates the planning and decision-making process. A comprehensive understanding of ecosystem services and the impact of changes in ecosystems is therefore essential (Romanazzi et al., 2023, p. 2). Different assessment methods have been developed in the recent years such as the Millenium Ecosystem Assessment (MEA) as the first global assessment for ecosystem services. In the late 1990s, the MEA was applied to the urban context, leading to a significant increase in research on urban ecosystem services due to their essential role in enhancing resilience and quality of life in urban areas. The MEA provides a systematic assessment of the demand and supply of ecosystem services (Pauleit et al., 2017, p. 37–38).

2.2.2 Significance of ecosystem services in urban areas

The MEA report points out that there is an existing degradation of ecosystem services with a rate of around 60% primarily caused due to anthropogenic activities (Millennium Ecosystem Assessment, 2005, pp. 1–2). The simultaneous supply of ecosystem services is particularly important in urban areas with limited space for ensuring multifunctionality of green spaces and addressing urban challenges (Belaire et al., 2023, pp. 1–2; Derkzen et al., 2015, pp. 1020–1021; Haque & Sharifi, 2025, pp. 1–2). However, Pandey & Ghosh (2023, p. 26) highlight that urban ecosystem services are challenged by global challenges such as climate change requiring proactive measures for the enhancement of urban ecosystem resilience and ensuring their ecosystem service provision.

Urban ecosystem services can make a significant contribution to environmental health and human well-being for promoting the quality of life (Veibiakkim et al., 2025, p. 1). It is important to mention, that green spaces provide various functions that go beyond ecosystem services such as the support of active mobility. In urban areas particularly recreational and other cultural functions and services are prioritized (Hansen, R. et al., 2017, p. 32). Urban ecosystem services such as air quality regulation and temperature regulation in terms of the urban heat island effect are particularly important within urban areas. Also, public knowledge on ecology and the awareness of sustainability challenges are important urban ecosystem services (Haase et al., 2014, p. 414).

Decision-making in urban planning significantly influences the provision of urban ecosystem services (Lourdes et al., 2021, p. 15), since it fosters healthy ecosystems, while ensuring long-term sustainable urban environments (Haque & Sharifi, 2025, p. 2; Mu & Li, 2024, p. 1). Ecosystem services can be utilized as decision-making tools as well as conceptual framework for analyzing the social-ecological system with regards to the complex relationship between social and biophysical components (Lu et al., 2021, pp. 77–78). Blouin et al. (2025, pp. 1–2)

point out that the integration of the ecosystem services into urban planning remains low. The complexity of local and regional situations impacts the integration of this concept into the planning process and the understanding of this terminology is limited along different stakeholders (Kabisch, 2015, p. 558). The planning and policies for sustainable urban ecosystem services require the collaboration of various stakeholders such as government agencies, community organizations, and private entities. Integrating this collaborative approach into urban planning practices facilitates the different perspectives that should be considered and integrated into the decision-making process. However, there is a remaining lack of coordination and collaboration among various stakeholders and sectors that are crucial for the urban ecosystem management (Pandey & Ghosh, 2023, p. 25).

In recent years, research has also focused on identifying trade-offs and synergies among ecosystem services (Wang et al., 2024, p. 2). Particularly, the consideration of trade-offs between ecosystem services is essential to prevent compromising long-term sustainability and functionality of urban ecosystems (Pandey & Ghosh, 2023, p. 26). There are various definitions of trade-offs in the literature, which collectively refer to the interaction of ecosystem services that results in an increase in one ecosystem service provided at the expense of other services. However, some of the ecosystem services may intentionally be prioritized and modified based on the priorities of involved stakeholders in the decision-making process resulting in impacts on other ecosystem services. A comprehensive understanding of trade-offs between ecosystem services and its potential consequences of unbalanced management is therefore critical (Deng et al., 2016, p. 955). The assessment of trade-offs between ecosystem services is complex due to biophysical aspects and management decisions that affect trade-offs (Deng et al., 2016, p. 964). In comparison, synergies can be referred to the simultaneously increase of two or more ecosystem services. Overall, the balance of trade-offs and synergies between ecosystem services is essential for the effective management of ecosystems (Wang et al., 2024, p. 2).

2.3 Research gap

The natural degradation due to urbanization that is putting pressure on limited resources and ecological services making ecosystem-based knowledge including ecosystem services and urban resilience a critical field of study (Ramyar et al., 2021, pp. 1–2). Dushkova et al. (2025, p. 577 and p. 597) point out that future research should focus on the role of urban ecosystem services. Existing urban green spaces such as UGCs need to be well managed for the provision of ecosystem services and to balance current and future human needs. However, the interplay of social, cultural, and economic factors involving multiple stakeholders, governance, and societal constraints makes the management and conservation of urban green spaces complex (Aronson et al., 2017, pp. 189–190). For sustainable urban

environments it is crucial to investigate how urban ecosystem services affect the quality and multifunctionality of UGI (Korkou et al., 2025, pp. 1–2).

In the recent years, research that indicates the support of biodiversity and provision of multiple ecosystem services by urban green spaces has significantly increased. However, there is still a limited amount of research that examines how urban planning and management decisions affect environmental benefits, trade-offs and synergies related to multiple ecosystem services. It is stated that these spaces are primarily designed and developed for a specific purpose, with less attention paid to the trade-offs that may occur (Belaire et al., 2023, pp. 1–2). Research on the interconnection between ecosystem services is limited, however an understanding of this is crucial for sustainable urban planning and to reducing potential shortfalls (Russo & Cirella, 2021, p. 1, 2024, p. 6).

Also, there are some studies arguing that the main purposes of UGC development have shifted in the recent years from natural conservation to the provision of recreational opportunities and active mobility opportunities. This shift is critical due to the impacts it may have such as urban habitat connectivity due to an increase in paved areas and a decrease in green spaces. Accordingly, research is needed on how to balance recreational opportunities with ecological aspects (Lynch, 2019, p. 131 and p. 150).

3 Research questions and design

In this chapter, the research questions are formulated in accordance with the previously outlined problem statement and research gap, and the objectives of this thesis are emphasized. Additionally, the research design is outlined, thereby providing a visual overview of the research methodology.

3.1 Objectives, target groups, and research questions

This thesis seeks to investigate the provision of urban ecosystem services by UGCs to address urban challenges related to urbanization and climate change, while improving quality of life. The objective is to provide insights from real-life practices that can guide UGCs to enhance their multifunctional benefits ensuring sustainable urban environments, while minimizing emerging trade-offs. This thesis investigates the role of UGCs with regards to multifunctionality and contributes to advance the current state-of-the-art research on UGCs and its ecosystem services. In addition, this thesis provides researchers, municipalities, and other key stakeholders involved in the planning and management of UGCs with information to inform their decision-making processes. Furthermore, this research can raise awareness of urban ecosystem services and their importance for urban areas. Based on this, the main research question is therefore:

How do urban green corridors contribute to sustainable urban environments through the provision of urban ecosystem services?

This thesis aims to synthesize knowledge on the ecosystem services provided by UGCs from different case studies worldwide, incorporating a value-rational perspective to enhance decision-making. Therefore, a comparative case study approach is applied to this thesis based on three sub-questions aiming to answer the main research question. For building a framework for this research and addressing the main research question the following three sub-questions have been formulated that are posed for each case study. The first sub-question is as follows:

What are the primary objectives of urban green corridors and who are the involved key stakeholders, as observed in case studies?

This question aims to provide an understanding of the primary objective and intended purpose of implemented UGCs. Therefore, the UGCs as case studies are analyzed with regards to the needs and challenges that led to the development, the primary objective and the key stakeholders that are involved in this development. Also, the role of the local community is analyzed. A combination of literature review, document analysis, case study, mapping and

semi-structured interviews is applied to answer this question. The second sub-question for quantifying the urban ecosystem services that can be provided by the selected UGCs is as follows:

Which urban ecosystem services can be provided by urban green corridors, as observed in case studies?

The aim of asking this question is to identify the urban ecosystem services that can be provided by the selected UGCs highlighting the importance for the urban area. Therefore, an ecosystem service assessment based on the mapping of the UGCs is conducted that is combined with further information on the ecosystem services gained through semi-structured interviews, literature review, and document analysis. The third sub-question that is posed is as follows:

How do the quantified urban ecosystem services align with the primary objective of the urban green corridor, and what are emerging conflicts and trade-offs?

The third sub-question is posed to assess how the selected UGCs and their ecosystem services align with the primary objective. Additionally, it aims to highlight potential conflicts and trade-offs that can inform urban planning practices. The answer to this question provides a basis for answering the main research question and drawing conclusions about the fulfillment of the primary objective of UGCs by providing urban ecosystem services. Also, this question aims to provide an understanding of the multifunctionality of UGCs through the provision of ecosystem services and other benefits. For answering this sub-question, the methods that have been applied to the first two sub-questions are applied.

3.2 Research design and structure of the report

This report consists of eight chapters. As introduction the research background including the urban challenges and the importance of UGI for urban areas is outlined. The following literature review defines UGCs and urban ecosystem services, their importance for urban areas, and identifies the existing research gap within the context of UGCs and urban ecosystem services this thesis addresses. The present chapter presents the research questions, objectives and target groups as well as the research approach including transdisciplinary research and phronetic planning research that are inspiring this project. The research design of the present thesis is visualized in Figure 2.

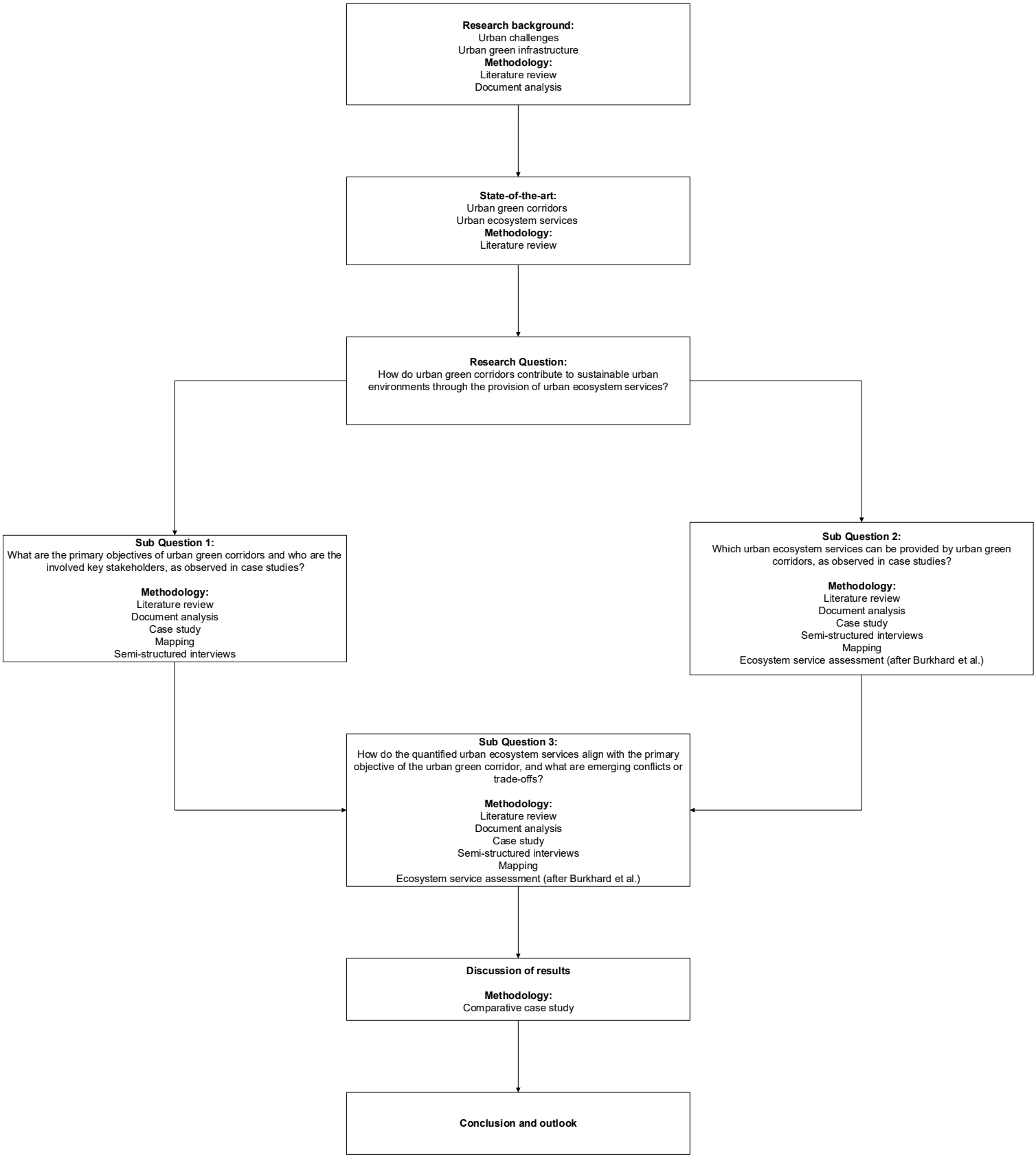


Figure 2: Visualization of research design

In the fourth chapter the conceptual framework focusing on the concept of multifunctionality in the context of UGCs and ecosystem services is outlined, setting a base for this project. A mixed methodology including qualitative and quantitative methods is applied to answer the research questions, which is presented in the fifth chapter including literature review, document analysis, comparative case study, semi-structured interviews, mapping, and ecosystem service assessment. For answering the sub-questions, the sixth chapter presents the collected data and information, starting with the selection of the case studies. Then the development of the case studies, the key stakeholders involved in the projects, and the role of the local community to gain an understanding of the community involvement are presented. The ecosystem services that can be provided by the selected UGCs are outlined for answering the second sub-question. Followed by that the third sub-question is addressed through the analysis of the results of the first two sub-questions with regards to multifunctionality of the selected UGCs. A comparative case study analysis follows, discussing the results of the ecosystem services provided by the UGCs and the role of the local community for answering the main research question. Also, limitations of this thesis are highlighted. The eighth chapter concludes with the key findings of this thesis and future research directions.

3.3 Research approach

In this section, the applied research approach is outlined, integrating components of transdisciplinary and phronetic planning research. Both research approaches are closely linked to the subject of study and serve as inspiration for this thesis. The applied conceptual framework and methodology, which are built on this, are further detailed in Chapter 4 and 5.

3.3.1 Transdisciplinary research

The planning of UGI includes various disciplines such as landscape ecology, urban planning, and landscape architecture, while it is developed in collaboration with local authorities and stakeholders (Hansen, Rieke & Pauleit, 2014, p. 517). To address the previously mentioned complex urban challenges putting pressure on urban environments the input from various disciplines is necessary. Going beyond interdisciplinary research including actors that are working with the challenge in practice is therefore necessary (Binder et al., 2015, p. 545). Childers et al. (2014, p. 321) argue that bridging from interdisciplinary to transdisciplinary approaches to sustainability is essential to engage with practitioners for putting “knowledge into action”. Angelstam et al. (2013, p. 255) point out that the limited collaboration of various stakeholder barriers functional green infrastructure resulting in poor quality of habitat networks. Adaptive governance and management are thus required for developing functional green infrastructure including collaboration among experts and non-experts for facilitating the knowledge and experience sharing. The collaboration between different stakeholders and the sharing of knowledge are two major components of transdisciplinary research (Angelstam et

al., 2013, p. 255). Transdisciplinary research presents an approach for addressing these complex challenges including various actors from different disciplines, dealing with socially relevant complex or so-called wicked problems, and aiming to share knowledge across different actors facilitating to create knowledge in a solution-oriented way relevant for practice and science (Binder et al., 2015, pp. 545–546). The integration of transdisciplinary approaches into research can facilitate the generation of evidence-based, scientific defensible knowledge that can be integrated into urban planning and design practices (Ahern et al., 2014, p. 255). Transdisciplinary research gained even further importance through the adoption of the United Nations' Sustainable Development Goals that highlight its necessity for addressing complex global challenges that humanity is facing (Tejada et al., 2019, p. 3).

Communities have a significant role in the process of joint urban development. Particularly modern urban planning practices are characterized by large-scale top-down excluding the collaboration with local communities. The inclusion of the local community and the collaboration between various stakeholders such as governments, urban planners, and experts is critical for the consideration of various perspectives. Therefore, transdisciplinary practices in combination with co-management present an essential approach for ensuring urban sustainability addressing complexity while supporting the local community (Hes & Hernandez-Santin, 2019, pp. 135–137). This can further facilitate the addressing of human needs, while it can enhance social justice, adaptive capacity and sustainable urban environments. The Cheonggyecheon canal as urban renewal project in Seoul, South Korea, is an example of transdisciplinary management of an UGC (Hes & Hernandez-Santin, 2019, p. 137).

In this thesis the knowledge of science and practice from academic and non-academic actors is incorporated in line with the main principles of transdisciplinary research (Chapa et al., 2023, pp. 15–16). Chapa et al. (2023, pp. 15–16) emphasize that research-practice interface can facilitate the production of common knowledge and enhance communication and collaboration. The integration of transdisciplinary research principles into this thesis enables the combination of scientific and practice-based knowledge from various actors. Expert interviews have been conducted with researchers working on urban ecosystem services, further enhancing an understanding of the theoretical background and highlighting the relevance of the UGCs for urban areas. For the selected case studies interviews have been conducted with non-academic actors, such as key stakeholders actively involved in the UGCs. By combining the knowledge of academic and non-academic actors this research is inspired by transdisciplinary research approach. This facilitates a better understanding of tensions and gaps between science and practice. For investigating the contribution of UGCs to sustainable

urban environments through the provision of urban ecosystem services, both interdisciplinary insights and knowledge from practitioners are necessary.

3.3.2 Phronetic planning research

Also, this thesis is inspired by principles of phronetic approach introduced by Flyvbjerg (2001) utilizing practical wisdom gained from real-life practices for understanding the potential of change contributing to informed decision-making for addressing critical issues (Henderson, 2016, p. 34; Schram, 2012, p. 16 and p. 20). Through the emphasizing of contexts and understanding of power relations, this approach facilitates an understanding of social phenomena (Simmons, 2012, p. 246), while it focuses on real world problems, the engagement with values, and the effective communication of the research results (Farthing, 2016, p. 185). Flyvbjerg (2004) argues that “practical examples are typically more effective vehicles of communication than are discussions of theory and methodology” (Flyvbjerg, 2004, p. 283). Besides this, Flyvbjerg (2004, p. 288) highlights that both scientific and technological knowledge have been incorporated into contemporary planning research to a greater extent than practical knowledge, highlighting the need of setting the focus on it. Accordingly, phronetic planning research prioritizes experience over theoretical knowledge and operates with “practical rationality based on judgment and experience” (Flyvbjerg, 2004, p. 288). Power is seen as one of key element of the analysis with regards to how it is exercised instead of just focusing on who has the power and why (Flyvbjerg, 2004, pp. 292–293). Flyvbjerg (2004, p. 293) highlights that phronetic planning research also focuses on power and the outcomes as well as on power relations between the involved stakeholders and what potential opportunities could change the existing power relations. Therefore, values should be engaged and for determination of the impact of planning practices the following questions should be asked: “Where are we going with planning? Who gains and loses, and by which mechanisms of power? Is this development desirable? What, if anything, should we do about it?” (Flyvbjerg, 2004, p. 293).

Phronetic planning research aims to address challenges that local, national, and global communities face. This type of research is oriented towards action and context-dependent, while reflecting values and interests in planning (Flyvbjerg, 2004, pp. 284–287). It aims to enhance the capacity of society for decision-making processes and facilitate the delivery of sustainability (Briassoulis, 2023, pp. 59–60; Flyvbjerg, 2001, p. 167), while it is problem-driven instead of method-driven and the decision regarding methods is dependent on the specific research problem (Flyvbjerg, 2004, pp. 290–291). Flyvbjerg (2004, pp. 290–291) is not directly specifying a method, however, it is pointed out that the application of mixed methods can be promising for drawing conclusions. In the context of phronetic planning research Flyvbjerg (2004, pp. 294–297) advocates case study research that facilitates an in-depth understanding

of the case, and it informs planning practice based on the practical rationality and judgement. It aims to gain insights from people who are affected by or interested in the research subject (Flyvbjerg, 2004, pp. 300–301). Based on this, decisions can be made regarding how things can be done in a different way (Flyvbjerg, 2004, p. 302). Overall, through a detailed narrative of a real-life case study, this research approach aims to provide a comprehensive understanding of the consequences and implications of the planning process (Boussauw & Vanin, 2018, p. 182).

To ensure the various interests, considerations must be made to ensure that the planning outcomes are in the public interest (Pojani & and Stead, 2016, p. 353). In the context of this thesis, this research approach supports the objective of prioritizing the quality of life in urban areas and human health through the provision of urban ecosystem services by UGCs. In addition, this research approach encourages a focus on the actual use and function of the UGC. Therefore, the combination of qualitative and quantitative methods for the analysis of selected UGCs is applied for gaining in-depth knowledge of the UGCs and to generate knowledge that can inform decision-making. However, it is important that this thesis is not conducting a comprehensive phronetic analysis, although it acknowledges the importance of power dynamics in the development of UGCs. Therefore, the key stakeholders involved in the selected UGCs are identified, aiming to engage with the question posed by Flyvbjerg (2004, p. 293): “Who gains, who loses, and by which mechanisms?” This examination involves the analysis of prioritized interests and potential conflicts, while also exploring the role of the local community to understand their participation in the development and management of UGCs.

4 Conceptual framework

Cities are becoming more complex and urban densities increase, resulting in limited available urban space, putting pressure on open spaces. Therefore, various functions and practices need to be accommodated in limited urban space to provide multiple functions in the same area through clustering natural, social, and economic processes addressing demands (Hes & Hernandez-Santin, 2019, p. 137). Multifunctionality of urban spaces has gained increasing attention due to the accelerated demand for urban ecosystem services (Charoenkit & Piyathamrongchai, 2019, p. 1). The simultaneous provision of multiple ecosystem functions or services is defined as multifunctionality. UGI including UGC has the potential to be multifunctional and enable multifunctional land use (Cook et al., 2024, p. 1; Hes & Hernandez-Santin, 2019, p. 137). In this chapter the concept of multifunctionality is explained in the context of UGCs and their ecosystem services to identify the multiple functions (Ahern et al., 2014, p. 255).

Hansen et al. (2017, p. 31) emphasize that planning for multifunctionality aims to create synergies and reduce trade-offs. Effective use of limited space requires multifunctionality as one of the key principles of UGI. Interconnected networks of green spaces enhance multifunctionality and provide multiple benefits (Hansen, Rieke & Pauleit, 2014, p. 518; Li, L. & Carter, 2025, pp. 60–61). Multifunctional UGI is crucial for providing high-quality green areas to residents contributing to sustainable urban environments (Korkou et al., 2023, p. 7), while it can facilitate adaptation and mitigation of climate change (Charoenkit & Piyathamrongchai, 2019, p. 1). Conflicting land use interests such as climate-relevant functions and recreational needs can be addressed through multifunctionality, enabling the provision of urban ecosystem services despite limited urban space (Beichler et al., 2017, p. 14; Hölting et al., 2019, pp. 226–227). It can further foster synergies between benefits and therefore play a critical role in high density cities. This further underpins the relation between multifunctionality and ecosystem services that are fundamental for ensuring multifunctional urban spaces contributing to human well-being (Charoenkit & Piyathamrongchai, 2019, p. 1). Hölting et al. (2019, pp. 226–227) point out that ecosystem functions are referred to the properties and processes of an ecosystem providing goods and services. In comparison, ecosystem services are the benefits that derived from ecosystems to society including provisioning, regulating, cultural, and supporting services. Social, economic, ecological, and cultural needs can be addressed through multifunctional characteristics of landscapes (Hölting et al., 2019, pp. 226–227). Pauleit et al. (2017, pp. 34–37) highlight that multifunctionality should be based on participatory planning processes involving communities, while the planning of green infrastructure is transdisciplinary based on knowledge and experience from various disciplines (Pauleit et al., 2017, pp. 34–37). Inter- and transdisciplinary collaboration is essential for

ensuring multifunctionality of UGI through the integration of expertise from various disciplines (Cook et al., 2024, p. 2; Hansen, R. et al., 2017, p. 35).

The initial aim of this concept has been the development of sustainable land use strategies addressing multiple land-use targets. However, the term multifunctionality has been utilized in various contexts without any specific spatial scale or land use type (Hölting et al., 2019, pp. 226–227). Various studies highlight multifunctionality as critical due to the provision of multiple uses through land sharing, while indicating multiple functions that can provide benefits to people and ecosystems (Hansen, R. et al., 2017, p. 31; Korkou et al., 2023, p. 2). Cook et al. (2024, p. 2) point out that the consideration of the potential for multifunctionality of UGI is limited resulting in missed synergies. Also, the concept of multifunctionality and its examination has been limited due to methodological shortcomings including the lack of an operational definition of multifunctionality resulting in differing assessment methods and indicators as well as missing consideration of trade-offs and synergies (Charoenkit & Piyathamrongchai, 2019, pp. 2–3). Filyushkina et al. (2022, p. 583) point out the lack of definition of specific ecosystem services that must be provided by green space to be considered multifunctional. Charoenkit & Piyathamrongchai (2019, p. 16) argue the assessment of multifunctionality is lacking a standardized approach leading to complex comparison across cities, limiting the opportunity of applying data gained in different contexts. Therefore, there is a need for a better conceptualization of multifunctionality for measuring and assessing it (Manning et al., 2018, p. 428). Overall, multifunctionality of UGI has received less attention due to uncertainties in terms of the planning of multifunctional UGI, despite increasing pressures due to climate change and urbanization that necessitates a more proactive approach to multifunctionality (Hansen, R. et al., 2017, p. 32). Nevertheless, the assessment of the multiple functions and services of UGI is essential for informing decision-makers. Based on the supply and demand for functions and services areas can be identified that need enhanced multifunctionality (Hansen, R. et al., 2017, p. 34). Therefore, the assessment of ecosystem services can support the identification of the multifunctionality of urban green spaces such as UGC, and trade-offs and synergies (Hansen, R. et al., 2017, p. 35).

This thesis uses the concept of multifunctionality in the context of UGCs and their ecosystem services to investigate their contribution to sustainable urban environments. Therefore, an ecosystem service assessment is integrated into this project to gain information on the ecosystem services that can be provided by UGCs. Also, the use and function of the selected UGCs is explored.

5 Methodology

Farthing (2016, p. 179) argues that research needs to be framed and that it is essential to narrow research down to improve matters. The application of mixed research methods can provide greater and more in-depth research outcomes than the application of one research method, while it facilitates the data collection from various sources. However, it is important to acknowledge that this approach can have weaknesses such as that its time consuming and that it may generate a large volume of information or data (Akotia et al., 2023, pp. 2–3). The present thesis employs a mixed-method approach, combining qualitative and quantitative methods for primary and secondary data collection (Li, Y. & Zhang, 2022, p. 35).

In this chapter an overview of the methodology is provided that is applied to address the research topic of this thesis. This includes the methods literature review, document analysis, comparative case study, mapping, semi-structured interviews with experts and practitioners, and ecosystem service assessment to quantify the ecosystem services provided by selected UGCs. The strengths and weaknesses of each method are presented to provide an awareness of the limitations of each method. This mixed methodology serves as the basis for addressing the research question.

5.1 Literature review

Literature review as a research method is crucial for various types of research to provide a basis for the development of knowledge, to contribute to the guidance of policy and practice, and to provide a basis for future research (Morandi et al., 2021, p. 19; Snyder, 2019, p. 339). Moreover, a literature review has the potential to facilitate the interpretation of findings derived from a variety of studies (Morandi et al., 2021, p. 19). This method is applied to this research for mapping and evaluating previous research, while building a research background and problem that justify the research question. This research method can also be used to identify a research gap or to discuss a particular issue. It also facilitates to provide an overview of the research problem by evaluating the state of knowledge on a specific topic (Snyder, 2019, p. 334), such as the urban ecosystem services of UGCs. However, this research method has limitations including its time-consuming character due to the large amount of literature that is relevant for the research subject. Besides this, the results of this research method are often not presented in a clear way resulting in incomplete conclusions (Snyder, 2019, pp. 338–339). In the present thesis, the application of this research method facilitates the understanding of the research background, state-of-the-art and the research gap. In addition, the application of this research method provides further insights into the selected case studies. For this research method literature has been collected through Google Scholar, Scopus, ScienceDirect as well as the online library of Aalborg University.

5.2 Document analysis

The method document analysis, as systematic review or evaluation of documents is applied to this thesis (Ernst, 2019, p. 7). It is applied in combination with other qualitative research methods such as literature review and interviews for a comprehensive study of the same phenomenon. Documents include agendas, manuals, background papers, books and brochures, newspapers, organizational or institutional reports, survey data, as well as several public records (Bowen, 2009, pp. 27–28). This method is applied to this research for providing a comprehensive overview of the selected UGCs as case studies. In addition, it facilitates the development of understanding and the discovery of insights relevant to the research problem of this study. By analyzing the documents of the different case studies, the historical background, the main purpose as well as the development and management of the selected UGCs are presented (Bowen, 2009, p. 29). The document analysis method has significant advantages, including time- and cost-effectiveness, as well as free availability of documents (Ernst, 2019, p. 7). However, this method is characterized through limitations in terms of insufficient detail due to the documents that are produced for some purpose other than research as well as the accessibility is limited also due to the biased selectivity (Bowen, 2009, pp. 31–32). For this reason, it is recommended that this research method be used alongside other methods to enhance its reliability. Additionally, the purpose and intended audience of the selected documents must be considered to understand its implications (Ernst, 2019, p. 7). For this method sources such as municipal reports have been collected for synthesizing the knowledge on the different case studies that have been selected for this thesis. Documents have been primarily collected through municipal webpages.

5.3 Comparative case study

To answer the main research question, insights into real-life practices are essential. Therefore, the aim of incorporating case studies into this thesis is to analyze different UGCs that provide insights into the provision of urban ecosystem services. Case studies provide in-depth and detailed information of a contemporary phenomenon for the exploration of complex challenges in real-world context. The application of this method aims to explore the complexity of a case and has been applied in many different research fields (Ebneyamini & Sadeghi Moghadam, 2018, pp. 1–2). Luederitz et al. (2015, p. 109) emphasize that case study research has also been applied to various disciplines in the field of urban ecosystem services. Case studies are analyzed with regards to its historical background, physical setting, as well as other contextual factors (Ebneyamini & Sadeghi Moghadam, 2018, pp. 1–2). Flyvbjerg (2006, pp. 219–220) argues that case study research is necessary for gaining an understanding of complex issues and that it can be applied for generating a hypothesis. Case study research can be seen as context-dependent knowledge (Flyvbjerg, 2006, p. 222; Knight, 2001, p. 7040). Flyvbjerg

(2006, pp. 224–226) argues that a single case can be used as a scientific method for drawing conclusions depending on the case and how it has been selected. Overall, the application of case study research depends on the research problem. Random sampling of case studies may not provide the greatest amount of information about a particular problem or phenomenon. Therefore, case studies should be selected for their validity (Flyvbjerg, 2006, pp. 226–229).

The method comparative case study is applied to this research for the examination of the selected UGCs with regards to the provision of urban ecosystem services (Krehl & Weck, 2020, p. 1860). This method entails the analysis of different cases using the same methodology, facilitating the understanding of phenomena (Bryman, 2012, pp. 71–72). Analysis of case studies applied in socio-ecological systems research for delivering case-specific insights can facilitate an understanding of social-ecological systems. The comparison of case studies in a structured way can deliver lessons from selected cases (Pahl-Wostl et al., 2022, pp. 282–283), and it can serve for revealing causal patterns of explanation (Krehl & Weck, 2020, p. 1860). This method facilitates to analyze and synthesize similarities, differences as well patterns across several case studies sharing the same focus or objective. Therefore, the selected case studies are analyzed for building a foundation on which the analysis of this research is based (Goodrick, 2014, p. 1). For the collection of data and information to the case studies different qualitative and quantitative methods are applied including literature review and document analysis, semi-structured interviews, mapping and ecosystem service assessment. However, it should be noted that this method has limitations including its high intensity of resources such as data and information (Goodrick, 2014, p. 8).

This research focuses on the quantification of urban ecosystem services that can be provided by selected UGCs. Since there are various UGCs that differ significantly from each other, the case studies for this thesis were selected based on different criteria. The selection of case studies was based on UGCs developed through the transformation of abandoned or underutilized infrastructure corridors worldwide, while the focus is on UGCs that have been developed in urban areas. The length of the UGC was also a selection criterion, with a minimum length of 3 km and a maximum length of 16 km. The provision of opportunities for active mobility by the UGC was another criterion to further highlight the multifunctionality of UGC. For the quantification of the ecosystem services provided, the availability of data and information on the UGC and its ecosystem services was a selection criterion. The method comparative case study aims to examine similarities and differences across several UGCs with regards to their provision of urban ecosystem services and factors that influence it. Therefore, a comprehensive table visualizes the potential supply values of the identified ecosystem services for the selected case studies. The design and outline of the table have

been inspired by Babí Almenar et al. (2021, pp. 7–10). Also, the role of the local community in the development and management of the selected UGCs is analyzed. However, it is important to note that the selected case studies may not be representative for other UGCs. Nevertheless, the analysis of different UGCs can serve as foundation for understanding on provided urban ecosystem services in practice as well as the role of the local community, and this can further inform the decision-making process regarding urban planning practices, policy and management of UGCs. The comparison of the selected case studies is based on criteria such as the multifunctionality of UGCs with regards to the simultaneously provided urban ecosystem services and the use of green corridors. Based on that similarities and differences between the different UGCs are outlined. Also, trade-offs and conflicts that emerge have been highlighted. Besides this, the role of the local community in the different case studies is outlined.

5.4 Semi-structured interviews

Incorporating the research method interview can provide insights into a specific topic based on the knowledge and experience of the interviewee through the questions asked. Semi-structured interviews facilitate an understanding of the participant's perspective as opposed to a more generic understanding of a phenomenon (Adeoye-Olatunde & Olenik, 2021, pp. 1358–1359), while this type of interview is characterized by flexibility with regards to asking of questions as well as answering these questions (Edwards & Holland, 2023, p. 3). This qualitative research method facilitates data collection through predefined but open questions, moving from unstructured to structured interviews as the investigator and informant collaborate. A significant advantage of this research method is the opportunity for open responses (Oana-Ramona & Doroftei, 2017, pp. 37–38). Besides this, semi-structured interviews provide the opportunity to ask follow-up questions for diving more into specific details (Moser & Korstjens, 2018, p. 14).

For gaining a general understanding of the significance of ecosystem services and the role of UGCs in urban areas semi-structured interviews have been conducted. Therefore, interviews have been conducted with experts working with the topic of ecosystem services to get insights into this research topic. Semi-structured interviews have been conducted with experts listed in Table 1.

Table 1: Semi-structured interviews with experts

Interview partner	Description
Expert A (TH Köln - University of Applied Science, Cologne, Germany)	Professor in ecosystem management. Ecosystem services, ranging from climate adaptation to natural hazard mitigation and biodiversity protection, are an important part of Expert A's professorship.
Expert B (University of New South Wales, Sydney, Australia)	Professor and researcher on green infrastructure, nature-based solutions, and ecosystem services.
Expert C (University of Cologne, Cologne, Germany)	Professor and researcher at the Institute of Geography at the University of Cologne in the field of climate geography and hydology. Expert C's work focuses on climate adaptation in urban areas.
Expert D (Region Cologne/Bonn, Cologne, Germany)	Executive member of the board of the association "Region Köln/Bonn". This association pursues a spatial strategy in the region in the context of landscape, open space and water with concrete projects.

With regards to the research topic conducting of semi-structured interviews with stakeholders that are actively involved in the development and management of the selected case studies provides in-depth knowledge of the UGCs, that may not be publicly available. This facilitates a comprehensive understanding of the UGCs such as in terms of its provided ecosystem services as well as actual use and function. Also, the significance of engaging with stakeholders in research to enhance the quantification of urban ecosystem services has been underscored by Luederitz et al. (2015, p. 108). To gain insights into the selected UGCs, semi-structured interviews were conducted with the stakeholders listed in Table 2.

Table 2: Semi-structured interviews with stakeholders involved in the case studies

Interview partner	Description
Expert E (Midtown Greenway , Minneapolis, USA)	Excecutive Director of the Midtown Greenway Coalition for 14 years. As non-profit organization the Midtown Greenway Coalition advocates for the Midtown Greenway.
Expert F (Inner West GreenWay, Sydney, Australia)	Urban Ecology Team Leader for the Inner West Council. Expert F's work involves the management of bush care groups and maintenance contractors for bush care sites and natural areas.
Expert G (The Meadoway, Toronto, Canada)	Senior project manager in the ecosystem management team of Toronto and Region Conservation Authority. The focus is on the Meadoway project as well as on other terrestrial resotration projects such as meadow restorations.
Expert H (Eastside Trail of Atlanta Beltline, Atlanta, USA)	Director of Design for Atlanta Beltline since 2019 coordinating and overseeing development process of Atlanta Beltline.
Expert I (Eastside Trail of Atlanta Beltline, Atlanta, USA)	Beltline Arboretum Manager at Trees Atlanta responsible for the long-term management and maintenance of the Atlanta Beltline.
Expert J and Expert K (Parkland Walk, London, Great Britain)	Members of the Friends of Parkland Walk, a voluntary community group that has no legal responsibilites, aiming to protect the Parkland Walk from development.

The interview guides for the semi-structured interviews are presented in Appendix B. However, it is important to note that the method semi-structured interview can have limitations such as biased perspectives of the interviewees and limited knowledge on certain topics. Besides this, this research method has a time-consuming character and limited sharing of non-public information when a particular perspective must be maintained presents a limitation. The open-ended questions may lead in a direction not relevant to the research problem being investigated. Nevertheless, this research method can provide insights from stakeholders involved in research on ecosystem services and UGCs, as well as from stakeholders involved

in the selected UGCs and their provision of urban ecosystem services, by sharing knowledge and expertise on the topic. Also, it is important to acknowledge that the interviewee may have subjective perspectives on the UGC development and its ecosystem services.

5.5 Mapping

The research method mapping has been applied to this research for visualizing the location of the selected UGCs as case studies. Also, the land cover types of the UGCs are identified and visualized through this method.

The Geographic Information System (GIS) technology can be used for the creation, management, analysis, and mapping of different types of data. Furthermore, it has the capacity to facilitate the comprehension of patterns, relationships, and geographic context. The implementation of GIS has been demonstrated to address complex challenges such as climate change, sustainability, and social inequity, while informing decision making for action (Esri Deutschland GmbH). GIS mapping has been incorporated into this research due to its valuable information on land cover that are used for the quantification of urban ecosystem services provided by UGCs. The selected UGCs were mapped through GIS mapping for visualizing the location and the different land cover types. Therefore, the open-source program QGIS has been used.

Open Street Map, Google Earth, and municipal documents were used to identify the location of the selected UGCs and map them in QGIS. City boundary data for the various locations of the UGCs was also collected from municipal open data websites. Open Street Map has been used as the base map for all maps presented in this thesis. The data for mapping the land cover types of the UGCs has been collected from ESA WorldCover (2021) that can be downloaded from the European Space Agency's (ESA) webpage (https://esa-worldcover.org/en). This dataset has been chosen for the quantification of ecosystem services of the UGCs and allowing for comparison. ESA WorldCover (2021) is a 10 m resolution global land cover product based on Sentinel-1 and Sentinel-2 data from 2021 (Zanaga et al., 2022). It consists of 11 land cover classes and has an overall global land cover accuracy of about 76.7% (VITO Remote Sensing, 2025). This dataset was part of a demonstration project to produce a WorldCover map for 2020. Due to the success of the 2020 map, a second map for 2021 was developed. However, ESA funding covered only those two years, resulting in the conclusion of this project. In 2025, new global land cover products will be rolled out, presenting maps from 2020 to 2026, as an evolution of the WorldCover product (VITO Remote Sensing, 2023). However, it is important to note that this mapping tool has limitations such as the constrained resolution of the land cover data, and limitation to 11 land cover classes.

Additionally, this dataset is from 2021, so it does not represent changes in land cover in recent years.

Table 3: Visualization of the data model for mapping of the selected UGC

Attribute	Data type	Description
fid	Decimal (double)	Unique ID for each object
DN	Integer (64 bit)	Map code of the land cover classes of WorldCover 2021 (ESA)
Area m2	Decimal (double)	Area that is covered by this object in square meters
Land cover	Text (string)	Land cover classes of WorldCover 2021 (ESA)

The data model that has been used for this thesis to map the land cover types of the selected UGCs is visualized in Table 3. It includes land cover classes of the ESA WorldCover 2021 dataset and the area that is covered by the objects. This data model provides the basis for the assessment of ecosystem services that is conducted in this thesis. Overall, the mapping of should be considered as approximation due to the simplifications associated with it and the resulting degree of uncertainty.

In the recent years, various studies on the mapping of ecosystem services have been conducted to facilitate informed decision-making (Pereira et al., 2025, p. 2). However, it is important to note that an in-depth mapping and assessment of ecosystem services requires additional attributes. Conducted mappings and assessments include the type and condition of ecosystems in combination with site-specific factors as well as the demand of ecosystem services (Vári et al., 2024, p. 2). Furthermore, ecosystem service mapping can draw inspiration from existing projects, such as the Nature2000 project, which includes information on habitats and species (European Environment Agency, 2025). Pereira et al. (2025, p. 3) highlight that mapping of ecosystem services should include validation that involves expertise from different sciences. Therefore, multidisciplinary collaboration is necessary for enhancing mapping of ecosystem services. Also, independent data for the studied area should be utilized for the enhanced accuracy of the results (Pereira et al., 2025, p. 3).

5.6 Ecosystem service assessment

The assessment of urban ecosystem services is important for ensuring the management of urban green spaces, while addressing the current needs and the quality of life in urban areas (Johnson et al., 2019, p. 1). Therefore, the assessment is crucial for the guidance of urban planning and management (Ma & Yang, 2025, p. 11). In the recent years various methods have been developed for the quantification of ecosystem services (Burkhard et al., 2023, p. 139). However, Korkou et al. (2025, p. 2) highlight the implementation of various frameworks

for the assessment of urban ecosystem services is facing barriers such as the political willingness, capacity of resources and humans, and data limitations. Therefore, the available methods for the quantification are just rarely operationalized, assessed and evaluated (Korkou et al., 2025, p. 2).

The approach that is used in this thesis is based on an ecosystem service assessment matrix after Burkhard et al. (2009) that has been developed for the valuation of ecosystem services of different land cover types (Burkhard et al., 2023, pp. 142–143). In the matrix, the different ecosystem services including regulating, provisioning, and cultural ecosystem services are plotted on the x-axis, while the different land cover types are plotted on the y-axis. This facilitates the assessment of ecosystem structures and processes of each land cover type, as well as their capacities for ecosystem services (Burkhard et al., 2012, p. 21, 2023, pp. 142–143). The assessment method includes the supply of ecosystem services due to the influence by its provision, while it is facilitating sustainability assessment of environments (Burkhard et al., 2012, p. 18). Burkhard et al. (2012) extended this ecosystem service assessment method to include the evaluation of the demand for ecosystem services based on human needs. However, it is important to mention that this thesis only focuses on the supply of ecosystem services due to the limited focus on UGCs.

This matrix-based approach combines GIS with spreadsheet analysis of land use and land cover data. It facilitates the development of maps of ecosystem supply. The advantages of matrix-based approaches are the application with limited technical expertise required. However, it is important to note that the values are based on expert knowledge instead of on the quantification of primary data (Burkhard & Maes, 2017, pp. 128–129). Different case studies in European regions have been used for the development of the matrix values (Burkhard et al., 2012, p. 20). In this method the supply of ecosystem services is ranked using a scale from 0 to 5 (no relevant capacity to very high relevant capacity). This facilitates the comparison of various ecosystem services and the assessment of ecosystem services for study areas with low or high data availability (Burkhard & Maes, 2017, p. 225). Therefore, this matrix is used for the quantification of the ecosystem services of selected UGCs focusing on the potential regulating, provisioning, and cultural services.

The assessment method after Burkhard et al. (2009) is acknowledged for its advantages over other methods such as that it is a rapid assessment method. This method primarily requires land cover type data and experts' expertise making it applicable to different regions with a low requirement of initial data (Zhang, S. & Muñoz Ramírez, 2019, p. 59). High flexibility and applicability of this research method for different levels of complexity are significant advantages for the quantification of ecosystem services. It can contribute to awareness-raising

and provide insights into initial ecosystem service mapping studies (Burkhard & Maes, 2017, p. 229). However, it is important to note that this ecosystem services matrix as quantitative research method has limitations with regards to its simplification and using of values based on expert knowledge instead of primary data. Also, the land cover categories may not be sufficient for an ecosystem service assessment on small scales. Accordingly, other research methods are necessary for collecting data on ecosystem services (Burkhard & Maes, 2017, pp. 234–235). Therefore, in this thesis this method is combined with methods such as semi-structured interviews, document analysis and literature review.

This matrix-approach can be applied using spatial land use land cover data as proxies (Burkhard & Maes, 2017, p. 226). For collecting land cover information for this research method CORINE land cover data from the European Union is usually used (Burkhard et al., 2012, pp. 19–20). However, since different UGCs worldwide have been selected for this project and CORINE land cover data is providing land cover data that is limited to Europe, the land cover information from the dataset WorldCover 2021 have been collected, as outlined in Chapter 5.5. The land cover classes of WorldCover 2021 do not directly correspond to the CORINE land cover classes that are included in the matrix according to Burkhard et al. (2009). Therefore, the land cover classes are converted to the CORINE land cover classes in Table 4 based on the definitions of the different classes.

Table 4: Conversion of land cover classes (European Environment Agency, 2019; Van De Kerchove et al., 2022)

WorldCover land cover classes		CORINE land cover classes	
Land cover class	**Definition**	**Land cover class**	**Definition**
Tree cover	Classifies land covered by 10% or more with trees.	**Mixed forest**	Classifies land covered by trees including shrubs and bush understorey.
Grassland	Classifies land covered by 10% or more with natural herbaceous plants .	**Green urban areas**	Classifies land covered with vegetation within or partly mebraced by urban fabrick such as urban greenery accessible for public.
		Natural grassland	Classifies land covered with grassland with no or moderate anthropogenic activity including meadows
Cropland	Classifies land covered with annual cropland that is sowed/planted and harvestable at least once per year after sowing/planting date.	**Annual and permanent crops**	Classifies land as cultivated land parcels with non-permanent crops associated with permanent crops.
Built-up	Classifies land covered by buildings, roads, and other man-made structures excluding urban green.	**Continous urban fabric**	Classifies land covered by urban structures and transport networks with 80% or more non-permeable surfaces.
Bare/sparse vegetation	Classifies land with less than 10% vegetation cover and exposed soil, sand or rocks.	**Bare rock**	Classifies land naturally sparsely vegetated or non-vegetated areas with less than 10% vegetation cover.
Permanent water bodies	Classifies area that is covered by water bodies such as lakes, reservois, and rivers (either fresh or salt-water).	**Water bodies**	Classifies natural or artificial water bodies with mainly standing water surface.
		Water courses	Classifies natural or artificail water courses with flowing water such as natural water streams and rivers that are canalised.
Herbaceous wetland	Classifies land covered by 10% or more with natural herbaceous vegetation and permanently or regularly flooded (by fresh, brackish or salt water).	**Coastal salt marshes**	Classifies low-lying vegetated coastal land (above high-tide line) prone to flooding by seawater.

For some of the WorldCover land cover classes, two different CORINE land cover classes are highlighted. This is due to the local context of the selected case studies. The land cover class "grassland" is translated into "green urban areas" as well as into "natural grassland". This is due to the different characteristics of the case studies such as one that is characterized by a native meadow, which is not accessible to the public and has a low anthropogenic activity. The case study that is characterized by "natural grassland" is explicitly mentioned in the chapter. For the other case studies, "grassland" is translated into "green urban areas". Similarly, the land cover class "permanent water bodies" is translated into "water bodies" and “water courses” based on the local context of the different case studies. This is also explicitly mentioned in the respective chapter. In addition, the conversion of "herbaceous wetland" to "coastal salt marshes" is based on the case study that includes this land cover class that is located by the sea. The matrix after Burkhard et al. (2009) is visualized in the Appendix A,

which includes the relevant land cover classes for this thesis that were identified through mapping the selected UGCs.

For the assessment of ecosystem services summarized ecosystem service supply values have been calculated. Therefore, the identification of land cover types for the UGCs has been conducted through the mapping by utilizing the WorldCover 2021 dataset in QGIS. The area covered by the different land cover classes of the UGCs has been calculated with QGIS. The percentage area for each land cover type has been multiplied with the corresponding supply value from the ecosystem service assessment matrix after Burkhard et al. (2009). For each ecosystem service, the calculated supply values for the different land cover classes have been totaled to obtain one final value. This resulted in summarized ecosystem service supply values for the UGCs. This calculation is visualized in the following:

$$ESSC_i = \sum_{j=0}^{n} (LC_j \cdot ES_{ij})$$

With

$ESSC_i$	Ecosystem service supply capacity for ecosystem service *i* (e.g. local climate regulation)
LC_j	Proportion of land cover class *j* in percentage in the UGC
ES_{ij}	Supply capacity for the provision of ecosystem service *i* through land cover class *j* after Burkhard et al. (2009)
n	Number of land cover classes that comprise the UGC

Since the calculated values are decimals, the ecosystem service supply capacities have been categorized as shown in Table 5. This legend is used to analyze the quantified ecosystem services of the case studies through an ecosystem service assessment according to Burkhard et al. (2009) in Chapter 6. The calculated supply capacities are presented in an attached Excel spreadsheet.

Table 5: Legend to the ecosystem service supply capacities according to Burkhard et al. (2009)

Legend	
0	no relevant capacity
(0,1]	low relevant capacity
(1,2]	relevant capacity
(2,3]	medium relevant capacity
(3,4]	high relevant capacity
(4,5]	very high relevant capacity

6 Results and analysis

In this chapter the results of the applied mixed methods are presented and analyzed aiming to answer the posed sub-questions for addressing the main research question. Expert interviews have been conducted in the early stages of this research to gain a greater understanding of UGCs and their ecosystem services. According to the interview experts, UGCs provide several benefits to society including heat mitigation, natural ventilation, air quality and biodiversity (Expert C, 2025, personal communication (p.c.), pp. 3–4; Expert A, p.c., 2025, pp. 3–4). Also, Expert B (p.c., 2025, pp. 5–6) highlighted that UGCs play an important role in linking green spaces within urban areas and facilitating the movement of fauna and flora. The interviewed expert Expert D (p.c., 2025, pp. 4–6) emphasized that UGCs have a subordinated value in urban planning and are often not perceived in an active manner as suppliers of critical services (Expert D, p.c., 2025, pp. 5–6). Besides this, conflicts between maintaining of biodiversity, supporting active mobility and ensuring climate adaptation within the same corridor has been highlighted (Expert A, p.c., 2025, pp. 5–6; Expert B, p.c., 2025, pp. 5–6).

According to Expert B (p.c., 2025, p. 6), there is a need to understand how UGCs can be more diverse and multifunctional. Additionally, there is a need for comparisons between different urban contexts due to their unique characteristics (Expert C, p.c., 2025, p. 13). Furthermore, during an interview with Expert B (p.c., 2025, pp. 13–14) it has been highlighted that climate change will have significant impacts on urban green spaces and the supply of ecosystem services. Ensuring the multifunctionality of UGCs through preservation or repurposing is of significant importances particularly due to increasing urban densities and climate change (Expert A, p.c., 2025, pp. 5–6). Therefore, UGCs must be developed to tolerate the projected climate conditions. Overall, the growing importance of UGCs, the conflicts of interests as well as the need for a better understanding of their potential and limitations in supplying ecosystem services have been highlighted during the expert interviews.

In this thesis project five UGCs have been selected as case studies based on the selection criteria outlined in Chapter 5.6. The case studies are analyzed in the following based on the results of the applied methods including literature review, document analysis, semi-structured interviews, mapping and ecosystem service assessment. A comprehensive overview of the selected UGCs is provided including the primary objectives, the involved key stakeholders and role of the local community, and the quantified ecosystem services. Also, the multifunctionality of the different UGCs is explored in the context of the quantified ecosystem services as well as the use and function of it. Therefore, the selected UGCs are presented in the following, including the Midtown Greenway in Minneapolis, the Cooks to Cove GreenWay in Sydney,

The Meadoway in Toronto, the Eastside Trail of the Atlanta Beltline in Atlanta, and the Parkland Walk in London. The location of the selected UGCs is visualized in Figure 3.

Figure 3: Overview of selected UGCs

6.1 Midtown Greenway, Minneapolis, United States of America

Minneapolis, located in Minnesota in the United States of America, is impacted by climate change in terms of more intense precipitation resulting in flooding and rising temperature resulting in a local warming trend as well as intensifying heatwaves. Also, days with low air quality are increasing and impacting Minneapolis resulting in significant public health impacts, while it is characterized by limited access to urban green spaces (Minneapolis City Coordinator, 2013, pp. 1–6). Since 2000, Minneapolis is experiencing population growth and is projected to further urbanize in the future causing critical impacts (City of Minneapolis, 2020, pp. 14–16; Minnesota Department of Transportation, 2020b, pp. 9–11). Urban ecosystems are significantly impacted by the built environment resulting in land fragmentation, loss of habitat, and degradation that is putting pressure on biodiversity (Minnesota Department of Transportation, 2025). Minnesota is facing a decline in biodiversity and pollination, such as honeybees, which play a critical role in the health of Minnesota's environment (Minnesota Department of Transportation, 2020a, pp. 3–6). Therefore, the incorporation of green infrastructure is promoted to addressing the urban challenges that Minneapolis is facing (Minneapolis City Coordinator, 2013, pp. 23–27). Also, the enhancement of active mobility within urban environments is a local and national priority (Hirsch et al., 2017, p. 1). According to Expert E (p.c., 2025b, p. 5), active mobility corridors in midwestern cities are less common than in Europe. In the United States with its various cycling routes such as bicycle boulevards, trails, and paths on and off-road Minneapolis is one of the cities with highest ranking as bicycle friendly city. This further contributes to reduce vehicle congestion and pollution in urban areas

of Minneapolis, while it facilitates the quality of life. Therefore, the Midtown Greenway presents a popular bicycle area within Minneapolis. This green corridor has been rated as one of the best urban trails in the USA running from the east and west connecting Mississippi River with the West Minneapolis suburbs (Ubbelohde, 2014, p. 1-7).

6.1.1 Development of Midtown Greenway

In 1992 grassroot efforts initiated the development of transforming the disused Milwaukee Railroad main line into an active mobility corridor serving for cycling and walking (Sant, 2022, p. 34). During an interview with Expert E (p.c., 2025b, pp. 1–2), it has been highlighted that the Midtown Greenway Coalition, as non-profit organization, has been advocating for this development next to the railway line running through the middle of the city of Minneapolis. Due to industries moving out of the city, the disused railway line got removed from most of the trail (Expert E, p.c., 2025b, p. 2). The Midtown Greenway has been developed with the objective of providing multiple benefits such as serving as fast, clean, and green trail that is protected and safe as mentioned by Expert E (p.c., 2025b, pp. 5–6). This green corridor aims to facilitate active mobility, protect the environment and reduce the overall carbon emissions (Expert E, p.c., 2025b, pp. 17–18). The location of the Midtown Greenway in Minneapolis is visualized in Figure 4.

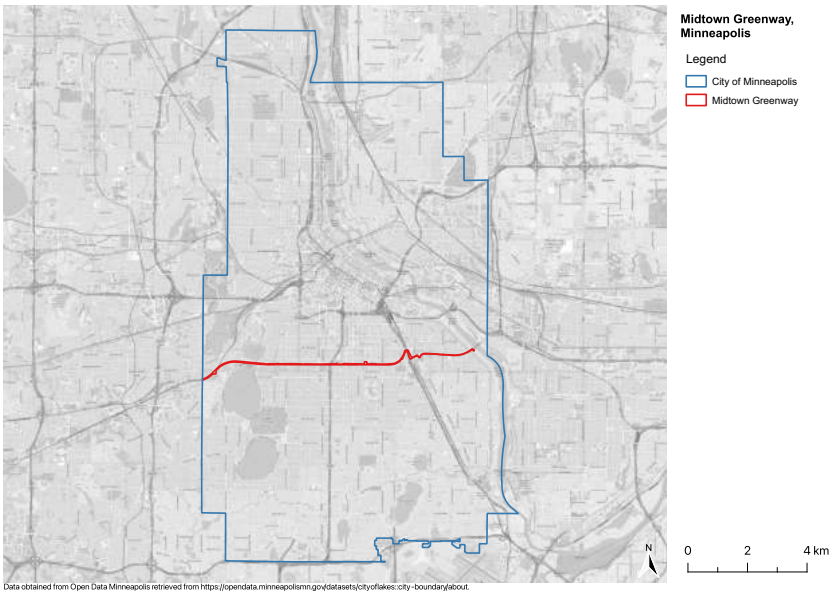


Figure 4: Location of the Midtown Greenway in Minneapolis

In 2000 the first segments of the Midtown Greenway opened (Midtown Greenway Coalition, 2025b). Today it is an 8.85 km long UGC serving for active mobility (Damon Farber Landscape Architects, 2021, p. 5), while it serves as most important commuter trail with environmental benefits as mentioned by Expert E (p.c., 2025b, pp. 5–6). It has been developed on a former commercial railway trench that runs from the east to the west through the urban area of

Minneapolis, presents one of the key features of the city integrated into the city's cycling network (Damon Farber Landscape Architects, 2021, p. 5). The former railway corridor was built for transport, while encouraging industrial development along the corridor. Due to significant traffic congestion along the railway, the railway line has been depressed to allow the uninterrupted movement of rail wagons under road traffic (Brown, 2010, pp. 19–20). Accordingly, most of the Midtown Greenway is below grade providing a safe environment for cycling (Sant, 2022, p. 34), providing connectivity to the surrounding areas (Damon Farber Landscape Architects, 2021, pp. 5–6). The Midtown Greenway is visualized in Figure 5.

Figure 5: Impressions of the Midtown Greenway (Photograph by Expert E, used with permission, 2025)

6.1.2 Identification of key stakeholders

Various stakeholders are involved in the development and management of the Midtown Greenway, as mentioned during the interview with Expert E (p.c., 2025b, p. 3). This section highlights the key stakeholders involved in the project, while highlighting the role of the local community.

The City of Minneapolis is maintaining and operating the Midtown Greenway (City of Minneapolis, 2019, p. 8; Minneapolis Park and Recreation Board, 2025). According to Expert E (p.c., 2025b, pp. 2–3), the City of Minneapolis is primarily managing the physical active mobility corridor in terms of emergency call boxes, lightning, video cameras, signage, snow removal, and trail maintenance. The Hennepin County Regional Railroad Authority owns the Midtown Greenway and is responsible for the green space management. However, Expert E (p.c., 2025b, pp. 2–3) argues that the management of the active mobility pathways is insufficient due to a lack of resources. Therefore, tree specialists are contracted to manage the green spaces. Hennepin County owns this green corridor with the objective to preserve it for a future development of a commuter rail line. However, the development of the future commuter rail line is stagnating, as there is no active progress on the project. Also, the demand remains low, since the regular transit is not at pre-pandemic ridership levels, as highlighted by

Expert E (p.c., 2025b, pp. 1–4). Hennepin County is paying less attention to the active mobility corridor, which is also highlighted by the development of green spaces such as parks and urban gardens in the northern side of this UGC to preserve the southern area for the future development of the rail line (Expert E, p.c., 2025b, p. 23).

The non-profit organization Midtown Greenway Coalition, formed in the late 1980s, has been initiating the transformation of the railway corridor into an active transportation corridor. Through the collaboration of the Midtown Greenway Coalition with Hennepin County and other public agencies this UGC has been developed. For ensuring the protection and improvement of this UGC, the non-profit organization is engaging with residents, businesses, and private stakeholders (Damon Farber Landscape Architects, 2021, p. 5). Besides this, the Midtown Greenway Coalition is actively involved in enhancing this UGC in terms of installing public art that reflects the diversity of the community, cleaning the trail, planting vegetation and encouraging the use of this green corridor for active mobility (Midtown Greenway Coalition, 2025a). Also, the Midtown Greenway Coalition is trying to initiate the extension of the green corridor across the Mississippi River to further enhance this green corridor, as highlighted by Expert E (p.c., 2025b, p. 25). The Midtown Greenway Coalition is only supported by donations and grants without receiving operational financial support from the government (Midtown Greenway Coalition, 2025a). The development of this green corridor has been significantly dependent on the grassroots efforts of the Midtown Greenway Coalition. Also, today the Midtown Greenway Coalition is actively involved in the improvement of the Midtown Greenway.

The Midtown Greenway became a regional trail in 2024 (Minneapolis Park and Recreation Board, 2025). Expert E (p.c., 2025b) noted that the Midtown Greenway Coalition initiated the Midtown Greenway to become a regional trail, with the goal of receiving funding for maintenance and further enhancing the management of this green corridor through the involvement of the Minneapolis Park Board. Also, Expert E (p.c., 2025b, p. 21) argues that the ownership and management of the Midtown Greenway is critical due to the lack of knowledge in managing this green corridor as a park. Therefore, the involvement of the Minneapolis Park Board can contribute to enhance the green corridor. Expert E (p.c., 2025b, p. 22) also mentioned that the involvement of the Minneapolis Park Board in earlier stages of the UGC development may have contributed to the development of a more park-like UGC with better wayfinding signage and furnishings. Regional funding, for which the Minneapolis Park Board is the only agency within the City of Minneapolis eligible, can be used to fund the Midtown Greenway as a regional trail and further enhance this green corridor (Minneapolis Park and Recreation Board, 2025).

However, conflicts have been identified, including those arising from economically driven developments in the surrounding area that could negatively impact the Midtown Greenway. Additionally, conflicts have emerged during the implementation and management of this green corridor such as between Hennepin County, which prioritizes infrastructure connectivity, and local gardeners, who prioritize nature preservation. Also, the planned commuter rail line has raised concerns, as the space reserved for it limit alternative uses, such as community gardens, as highlighted by Expert E (p.c., 2025b, pp. 10–12). Overall, in the context of the Midtown Greenway, it appears that infrastructure is prioritized over ecological considerations. The Midtown Greenway Coalition is playing a crucial role for the improvement of the Midtown Greenway and engagement with the local community.

6.1.3 Urban ecosystem services of Midtown Greenway

This UGC primarily aims to provide connectivity and opportunities for active mobility. According to Expert E (p.c., 2025b, pp. 6–7), urban ecosystem services did not play a significant role in the initial development of the Midtown Greenway. However, various types of greenery as response to urban challenges related to climate change have been subsequently incorporated, as highlighted by Expert E (p.c., 2025b, pp. 15–16). Trees, pollinator gardens as well as other green elements have been incorporated into this UGC providing ecosystem services, while contributing to public health (Expert E, p.c., 2025b, pp. 5–7). The urban ecosystem services that can be supplied by the Midtown Greenway are explored in this section. Figure 6 shows the western part of the Midtown Greenway with its different land cover classes. The other parts with the different land cover classes are shown in Appendix C.

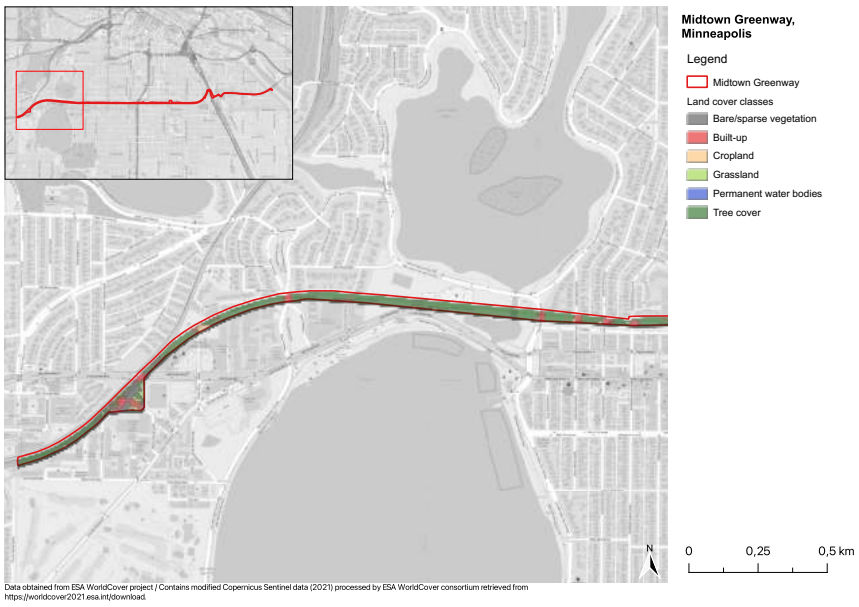


Figure 6: Land cover classes of the western part of the Midtown Greenway, Minneapolis

The Midtown Greenway consists primarily of the land cover classes tree cover with 46%, built-up with 37%, and grassland with 14%. The land cover classes bare/sparse vegetation, cropland, and permanent water bodies make up only a small portion of this UGC. While permanent water bodies are classified as water bodies and grassland is classified as green urban area. The area covered by the different land cover classes of the whole green corridor is visualized in Figure 7.

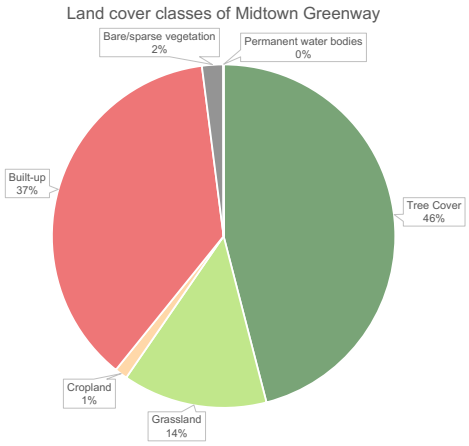


Figure 7: Proportion of land cover classes in the Midtown Greenway

Since Minneapolis is facing urban challenges such as rising temperatures, flood risk, air pollution, and declining biodiversity the focus of the ecosystem service assessment is on local climate regulation, flood protection, air quality regulation, and pollination. The summarized ecosystem service supply values of the different land cover class are visualized in Figure 8, Figure 9, and Figure 10.

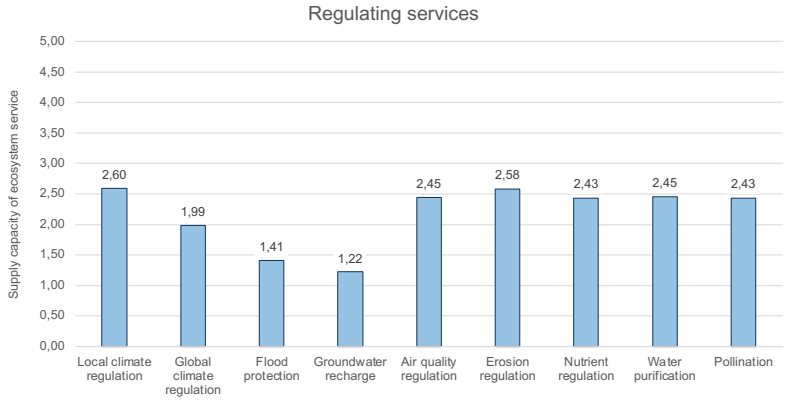


Figure 8: Overview of regulating services provided by Midtown Greenway

The Midtown Greenway can provide several regulating services. The land cover classes that characterize this UGC can supply primarily local climate regulation, erosion regulation, air quality regulation, water purification, nutrient regulation, pollination, and nutrient regulation with supply values ranging from 2.43 to 2.60 with a medium relevant capacity. In particular,

the abundant tree cover covering 46% within the Midtown Greenway can provide local climate regulation, air quality regulation, flood protection, and pollination. Also, grassland, cropland, and permanent water bodies, classified as water bodies, can contribute to local climate regulation, although the contribution is significantly lower than by tree cover. Local climate regulation can be attributed to the cooling provided by trees, while trees can also sequester carbon and filtrate air pollutants that can contributing to air quality regulation (Grylls & van Reeuwijk, 2022, pp. 1–2). The contribution of vegetation such as grassland and cropland to air quality regulation has also been highlighted by Expert E (p.c., 2025b, pp. 6–7 and pp. 15–16). Besides this, the vegetation within this UGC such as trees, grassland and cropland can supply pollination that can address the loss of biodiversity (Katumo et al., 2022, pp. 429–430). Also, Expert E (p.c., 2025b, pp. 6–7 and pp. 15–16) highlighted the contribution of the vegetation within this UGC to pollination. Also, global climate regulation, flood protection, and groundwater recharge can be supplied by this UGC with supply values ranging from 1.22 to 1.99 with a relevant capacity. Primarily tree cover can contribute to the regulating service flood protection. Cropland, bare/sparse vegetation, and permanent water bodies only contribute a small amount due to their small coverage area in this UGC. In comparison to the other ecosystem services flood protection has a lower potential supply, although Minneapolis is facing flood risk due to heavy precipitation. The Midtown Greenway is partially below grade and Expert E (p.c., 2025b, p. 14) emphasized that the UGC itself floods and that the incorporated vegetation partially absorbs water. The former rail line infrastructure is limiting the infiltration rate due to its non-permeable surface, as highlighted by Expert E (p.c., 2025a). According to Brown (2010, p. 103), stormwater management strategies are increasingly integrated into this green corridor. Therefore, the Midtown Greenway may have the potential to contribute to flood protection for the surrounding areas. However, to determine this, it may be necessary to further investigate the flood risk in the surrounding area and the capacity to supply flood protection. Overall, the regulating services that can be supplied by this UGC range between relevant and medium relevant capacity. This highlights the need for enhancing the supply of ecosystem services such as through the incorporation of vegetation for addressing the challenges Minneapolis is facing.

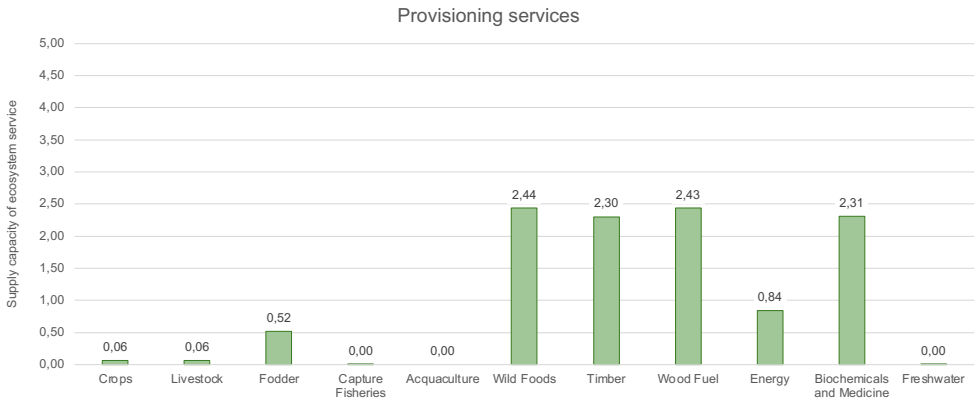


Figure 9: Overview of provisioning services provided by Midtown Greenway

The Midtown Greenway has the potential to supply provisioning services, as visualized in Figure 9. The supply capacity of provisioning services by the Midtown Greenway significantly differs ranging from no relevant capacity to medium relevant capacity. Primarily, wild foods, timber, wood fuel, and biochemicals and medicines can be supplied by this UGC. Mainly due to the large amount of tree cover in this green corridor can supply provisioning services. However, due to the small amount of permanent water that can supply freshwater and the small amount of cropland that can supply crops, livestock and fodder, these provisioning services have a significantly lower supply potential than the ones that can be supplied by tree cover. According to Expert E (p.c., 2025b, pp. 6–7) urban gardens are incorporated into different parts of the Midtown Greenway. These supply provisioning services such as foods. Most of these urban gardens are formal ones and have been installed partly by the Midtown Greenway Coalition and the majority by other individuals (Expert E, p.c., 2025a). The incorporation of urban gardens can enhance the supply of provisioning services, while this contributes to encouraging the community participation. Also, trade-offs such as the potential unintended decline in regulating services due to the supply of provisioning services need to be taken into consideration (Evans et al., 2022, pp. 1–2). Overall, the provision of regulating and cultural services can be impacted by the consumption of provisioning services, representing one of the most frequent trade-offs (Lu et al., 2021, p. 79). However, due to the lack of detail, this analysis is limited to identify these potential trade-offs.

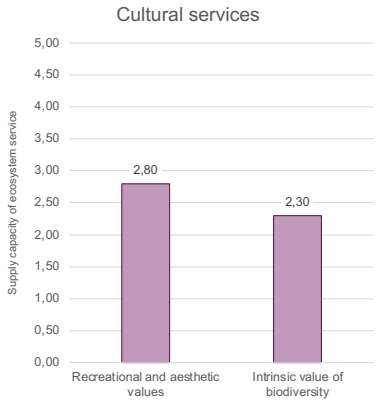


Figure 10: Overview of cultural services provided by Midtown Greenway

The Midtown Greenway has the potential of supplying cultural services with a medium relevant capacity. Particularly, tree cover, grassland, bare/sparse vegetation and permanent water bodies have the potential to supply recreational and aesthetic values. Also, Expert E (p.c., 2025b, pp. 5–6) pointed out that the Midtown Greenway is characterized by various ecosystem services, such as cultural services related to aesthetics. Public art installations in terms of murals and different types of benches are also incorporated into this green corridor for representing the diverse communities along the Midtown Greenway and enhancing the racial equity facilitating inclusivity. Besides this, cultural services such as opportunities for recreation are provided by this green corridor such as incorporated football fields (Expert E, p.c., 2025b, pp. 6–7). Overall, the aesthetic quality of the Midtown Greenway is contributing to recreational opportunities (Hermes et al., 2018, pp. 259–260). Also, the intrinsic value of biodiversity has been identified to have the potential of being supplied by this UGC, as shown in Figure 10. However, only tree cover, the dominant land cover class, and permanent water bodies, although it's making up a limited area of the Midtown Greenway, are valued as having a non-anthropocentric or so-called intrinsic value of biodiversity. This highlights biodiversity's worth of existing independently from human valuation and perception (Burkhard et al., 2012, p. 20; Pascual et al., 2017, p. 9).

The Midtown Greenway's tree cover with approximately 46% has the potential to supply urban ecosystem services such as regulation, provisioning, and cultural services. However, the Midtown Greenway is characterized by built-up area, accounting for approximately 37% of the total area, that is reducing the potential of this UGC to provide urban ecosystem services. The great amount of built-up area with its impervious surfaces in the UGC can contribute to urban heat and reduce the infiltration rate of water (Shi et al., 2023, pp. 1–2; Sohn et al., 2020, pp. 1–2). The regulating and cultural services have a greater potential supply than provisioning services by the Midtown Greenway. Synergies between regulating and cultural services may emerge through the potential supply of these services since local climate regulation can

enhance the recreational value of the Midtown Greenway. However, to address Minneapolis' urban challenges, regulating services need to be enhanced. Particularly flood protection needs to be improved due to limited supply capacity.

6.1.4 Multifunctionality of Midtown Greenway

The quantification of the Midtown Greenways' ecosystem services highlights the supply capacity for various ecosystem services that contribute to the quality of life in Minneapolis. Tree canopy, which is making up nearly half of the Midtown Greenway, is crucial for supplying ecosystem services such as local climate regulation, air quality regulation, flood protection, and pollination. Expert E (p.c., 2025b, pp. 15–16) further highlighted that pollinator gardens are planned to be incorporated into this green corridor to enhance pollination. Also, cultural services can be supplied by this UGC such as recreation and aesthetic values. This can promote the use of this UGC, although the supply capacity by this UGC has only a medium relevant capacity. The relevant ecosystem services for addressing Minneapolis' urban challenges have a supply potential ranging from relevant to medium relevant capacity highlighting the need to enhance the supply.

According to Expert E (p.c., 2025b, p. 15), the Midtown Greenway is primarily used for active mobility in terms of walking and cycling. This use of the green corridor is further promoted through the cultural service aesthetic and recreational value that can be supplied and is impacting the quality of life (Romanazzi et al., 2023, pp. 1–2). This UGC is used for net-zero transportation contributing to the reduction of carbon emissions (Kiel, 2017, p. 6), while providing a protected environment that can encourage active mobility and the use of alternative, sustainable transportation (Expert E, p.c., 2025b, pp. 18–19). However, park amenities such as benches are limited in this UGC due to the prioritization of Hennepin County to preserve space for a future rail line (Expert E, p.c., 2025b, p. 15).

The Midtown Greenway has significantly increased development in the surrounding area, while rising property values have been detected (Damon Farber Landscape Architects, 2021, p. 6). According to Expert E (p.c., 2025b, pp. 8–9), green gentrification may not be that much of a negative consequence for this development due to the different economic circumstances and affordable housing units along the green corridor. In the western and eastern part of it wealthier and less diverse neighborhoods are located, while lower income and diverse neighborhoods characterize the middle of this UGC (Expert E, p.c., 2025b, pp. 8–9). According to Expert E (p.c., 2025b, pp. 6–7), the Midtown Greenway contributes to the quality of life enhancing human well-being and public health, while providing economic benefits through an inexpensive way to commute around Minneapolis. Also, this UGC contributes to diverse neighborhoods in the surrounding areas (Damon Farber Landscape Architects, 2021, p. 6).

Particularly during periods of increasing economic disparities the green corridor facilitates social cohesion including high- and low-income community members (Damon Farber Landscape Architects, 2021, p. 27).

Overall, the Midtown Greenway aims to strengthen the human-nature relationship, while serving as multifunctional space (Brown, 2010, p. 103). According to Expert E (p.c., 2025b, pp. 17–19) the Midtown Greenway is contributing to sustainability due to its importance as active mobility corridor in Minneapolis and its multiple benefits. This UGC presents an example that is inspiring other green corridors such as the Lafitte Greenway in New Orleans and the Atlanta Beltline. The primary objectives of this UGC are the provision of active mobility opportunities and the associated reduction of carbon emissions. These align with the actual use for active mobility that is encouraged through the supply of recreational values. This green corridor has the potential to provide multiple ecosystem services simultaneously, highlighting that the Midtown Greenway serves as multifunctional space within Minneapolis. However, as previously mentioned, this green corridor has been primarily developed to serve as commuting trail instead of actively considering ecosystem services that can enhance urban livability. The subsequently incorporated vegetation significantly enhances the supply of regulating and cultural ecosystem services, while urban gardens encourage the community participation and provide educational opportunities. Nevertheless, it is important to note that this UGC receives limited support from Hennepin County due to its objective of a future rail line that is limiting the opportunities to enhance the vegetation. Through efforts of the Midtown Greenway Coalition, vegetation has been and will be integrated into this green corridor such as pollinator gardens for addressing Minneapolis' urban challenges. The protection and improvement of this UGC depends on the efforts of this non-profit organization and engaged individuals. Also, the involvement of the park department provides opportunities to further enhance this UGC and its ecosystem services.

6.2 Cooks to Cove GreenWay, Sydney, Australia

Australia is characterized by a significant warming trend leading to more frequent and more intense extreme weather events such as heatwaves, severe storms, flooding and droughts. Also, Sydney's Inner West is impacted by climate change and is projected to be impacted even more. It will be particularly impacted in terms of poor air quality due to bush fires as well as rising sea levels (Inner West Council, 2024b, pp. 10–14). Pressure is put on the natural areas of the Inner West due to climate change (Inner West Council, 2024a, p. 30). Also, urban development is significantly impacting Inner West's natural areas resulting in a decline of biodiversity, land fragmentation, and changes in local climate. The Inner West is projected to experience further population growth that is putting pressure on biodiversity and green spaces (Inner West Council, 2024a, p. 9). Overall, the Inner West is facing a significant decline of tree

and shrub cover, as well as a loss of green spaces. Significant population growth is projected for the Inner West. The needs of the growing population including the increasing demand for recreational opportunities (Inner West Council, 2024a, p. 29). Accordingly, the incorporation of measures for conservation of habitat and protection of biodiversity is essential for enhancing the quality of life and local environment health (Inner West Council, 2024a, pp. 10–11). Overall, the Inner West Council aims to incorporate multifunctional green spaces providing various functions and services simultaneously for addressing these challenges (Inner West Council, 2024a, p. 30), such as the Cooks to Cove GreenWay.

6.2.1 Development of Inner West Cooks to Cove GreenWay

In the 1990s the Cooks to Cove GreenWay concept in the Inner West of Sydney was initiated through the grassroots efforts of community-based environmental and active transportation groups who saw the potential for an environmental, cultural, and sustainable transportation corridor (Hes & Hernandez-Santin, 2019, p. 141; Inner West Council, 2018, p. 4). Concerns have been raised about the environment, including the degraded canal, the abandoned freight railway line, and the surrounding green space by community-based groups (George et al., 2015, p. 190; Inner West Council, 2018, pp. 40–41). Due to its long history of vegetation clearance and disturbance, the vegetation surrounding the GreenWay has been significantly modified (Inner West Council, 2021, p. 53). The natural asset of the GreenWay has been characterized by soil sealing and clearing of native vegetation. A certain level of biodiversity has been preserved due to the inaccessibility and lack of maintenance (Hes & Hernandez-Santin, 2019, p. 149). Therefore, this development is aiming to enhance biodiversity and connectivity between the northern area, the Bay Run, and the southern area, the Cooks River, encouraging for active mobility and the movement of flora and fauna, as mentioned by Expert F (p.c., 2025b, pp. 2–3). This green corridor is going to run through the three Local Government Areas (LGA) Leichhardt, Ashfield and Marrickville, while it touches upon the Canterbury LGA (Ashfield Council & Eco Logical Australia Pty Ltd, 2011, p. 9). Accordingly, this development is guided by jointly effort of the different LGAs (Rauscher, Raymond & Momtaz, 2017, p. 170). In 2002 the local Councils agreed on supporting the vision of this development, although limited financial resources presented critical barriers for it (Inner West Council, 2018, p. 10). However, different grants were obtained for the development due to the different involved projects such as the creation of a green link and an active mobility corridor (Inner West Council, 2018, p. 10). The development of this green corridor started around 15 years ago as state government-funded project and by that time it has been developed along an active freight railway line, as mentioned by Expert F (p.c., 2025b, pp. 1–2). With a length of 5.8 km, once its completed, it will follow the abandoned freight railway line and heritage-listed Hawthorne Canal (Hes & Hernandez-Santin, 2019, p. 141; Inner West Council, 2021,

p. 1; Rauscher, Raymond & Momtaz, 2017, pp. 170–171), serving as connection of Sydney's two main waterways, the Cooks River and Iron Cove Bay, part of Sydney Harbor (Rauscher, Raymond & Momtaz, 2017, p. 170).

Overall, the Cooks to Cove GreenWay project aimed to redevelop the disused freight rail corridor for creating a light rail connecting the area as well as active mobility corridor running through regenerated bushland and urban parks (Expert F, p.c., 2025b, p. 8). The official construction of this UGC was planned to start when the freight railway line closes. However, the bush care programs for developing the biodiversity corridor started while this freight railway line was still running, as highlighted by Expert F (p.c., 2025b, pp. 1–2). On the disused freight rail corridor, a light rail line has been developed that runs between Lilyfield and Dulwich Hill and officially opened in 2014, providing connectivity (Inner West Council, 2018, p. 20 and p. 41). Already today, the Cooks to Cove GreenWay presents the main environmental asset of the Inner West (Rauscher, Raymond & Momtaz, 2017, p. 170), incorporating native vegetation, walkways and a distant watercourse (Rauscher, Raymond & Momtaz, 2017, p. 170). However, this UGC is impacted by various urban infrastructures such as interruptions due to roads and rail tracks that fragment the green corridor hindering the achievement of a continuous green corridor (Hes & Hernandez-Santin, 2019, p. 146). The location of the Cooks to Cove GreenWay is visualized in Figure 11.

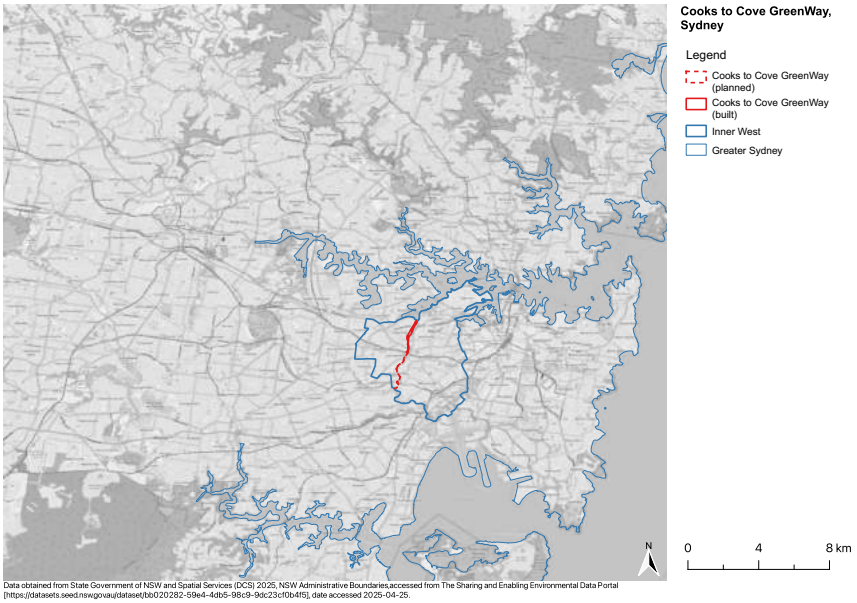


Figure 11: Location of the Cooks to Cove GreenWay

Overall, this ecological and active transportation corridor aims to create synergies between active mobility, recreational and cultural experience, public health and sports, protection of biodiversity and ecology, as well as climate change resilience and water management (Hes & Hernandez-Santin, 2019, p. 146; Inner West Council, 2021, p. 1). Along the Cooks to Cove

GreenWay there are various parks and open spaces such as the Hawthorne Reserve, Richard Murden Reserve, Gardigal Reserve, Hoskins Park, and Johnson Park (Inner West Council, 2018, p. 38), while this green corridor encompasses various bush care sites (Ashfield Council & Eco Logical Australia Pty Ltd, 2011, p. 12).

However, the Cooks to Cove GreenWay is an evolving project facing challenges related to urbanization, gentrification processes and socio-demographic changes. For the implementation of the missing links of the corridor the NSW state government made funding available and a new masterplan for this green corridor has been adopted by the Councils (Hes & Hernandez-Santin, 2019, p. 142). Today, the Cooks to Cove GreenWay has currently a length of about 1.4 km out of 5.8 km once its completed (Expert F, p.c., 2025a). The northern part of this green corridor has been completed and is open to the public, while the remaining parts are under construction and some are still unbuilt (Inner West Council, 2025b). The parts that are currently being constructed such as along the Gadigal Reserve as well as the completed northern part of this green corridor are visualized in Figure 12.

Figure 12: Impressions of the Cooks to Cove GreenWay (Photographs by Expert F, used with permission, 2025)

6.2.2 Identification of key stakeholders

This development is characterized by complex governance arrangements due to the four LGAs the corridor is running through resulting in multiple landowners and different stakeholder interests (George et al., 2015, p. 188). Various stakeholders are involved in the Cooks to Cove GreenWay project. In this section the key stakeholders and the role of the local community in this project are outlined.

The land along this UGC is owned by different parties such as the Rail Corporation NSW, the Inner West Council, Canterbury Bankstown Council and other State Government entities (Inner West Council, 2018, p. 44). According to Expert F (p.c., 2025b, p. 3), Transport for NSW and Transdev present key stakeholder for the management of the train and its entities in this UGC. Transdev has been contracted by Transport for NSW for the operation of the light rail in terms of maintenance and management (Inner West Council, 2018, p. 45). For the

construction of the pathways going through this UGC, Transport for NSW undertook efforts to minimize disturbance to the bush care sites (Ashfield Council & Eco Logical Australia Pty Ltd, 2011, p. 12). However, Expert F (p.c., 2025b, pp. 7–8) highlighted that the construction of the infrastructure including the light rail caused a significant decline in biodiversity of this UGC. The parks department is maintaining most of the native plantings. However, the lack of knowledge regarding the maintenance is an issue, as the use of herbicides is a low-time, low-cost management rather than a long-term, sustainable management approach, as highlighted by Expert F (p.c., 2025b, pp. 16–17).

Overall, the local community has a key role in the development of this green corridor due to its initiatives as it has been advocating for the development and approached the Inner West Council with their desires, as highlighted by Expert F (p.c., 2025b, p. 3). The local community initiated the establishment of bushland restoration areas that are also managed by them. These community efforts encouraged other stakeholders to join the project, including local authorities and various state agencies such as the railway and river authorities (Hes & Hernandez-Santin, 2019, pp. 141–142). Different community groups have been formed such as the Inner West Environment Group establishing bush care sites and the Friends of the GreenWay that have been advocating for this green corridor (Inner West Council, 2018, p. 10). Nine of the bush care sites have been established by community groups like the Inner West Environment Group (IWEG), the Cooks River Mudcrabs, and the Friends of Ewen Park (Ashfield Council & Eco Logical Australia Pty Ltd, 2011, p. 12). However, despite the initiatives of local communities, the masterplan that has been adopted in 2018 has limited community involvement in the implementation practices and management of the GreenWay (Hes & Hernandez-Santin, 2019, p. 145). This highlights that the maintenance of this UGC may be critical due to the lack of community interaction and involvement in the implementation process (Hes & Hernandez-Santin, 2019, p. 151). According to Expert F (p.c., 2025b, pp. 16–17), the local community will continue to be involved in the conservation of this green corridor on a volunteer basis. A program called GreenWay Bushcare has been established by the Inner West Council for maintaining the bush care sites along the green corridor with community volunteers (Inner West Council, 2025a). Besides this, the IWEG, as volunteering bush care group, is maintaining some of the bush care sites along this green corridor, while also engaging with the local community for the protection and improvement of biodiversity (Inner West Environment Group).

The Cove to Cooks River GreenWay project has gained considerable attention due to its good governance and best practices, while it has the capacity to adapt to changing external conditions (Hes & Hernandez-Santin, 2019, p. 142). Hes & Hernandez-Santin (2019, p. 134) point out the collaboration between local community, Councils, and other agencies presenting

an example for the development of an ecological corridor aiming the connection of Sydney's two important water catchments. This development facilitates the exploration of long-term environmental management processes initiated by the local community. Due to changing external conditions, the project has been adapted, resulting in the continued relevance of the project (Hes & Hernandez-Santin, 2019, p. 134). Hes & Hernandez-Santin (2019, pp. 152–153) point out that active participation of the local community can make a significant contribution addressing the challenges emerging from rapid urban change.

However, conflicts between stakeholders emerged in the context of this UGC due to the differing stakeholder objectives in this highly contested land tenure, as highlighted by Expert F (p.c., 2025b, p. 4). The incorporation of the light rail has raised concerns on limiting the ecological potential of this green corridor (George et al., 2015, p. 197). According to Expert F (p.c., 2025b, pp. 4 and pp. 8–9), competing interests due to the required space for infrastructure as well as for biodiversity and habitat connectivity cause conflicts, although biodiversity is a key concern of the local community. Also, the hierarchy of the three initial main objectives of this UGC including the light rail, the active transportation corridor and biodiversity corridor have shifted particularly due to the completed light rail resulting in a prioritization of the active mobility corridor over biodiversity. Also, conflicts of interest emerge between engineers and ecologists, as ecological consultation is ignored due the priority on economic benefits and limited knowledge on habitat conservation, as highlighted by Expert F (p.c., 2025b, pp. 4–5). Overall, infrastructure is being prioritized over habitat and ecology in the context of this UGC, as highlighted by Expert F (p.c., 2025b, p. 14), which is critical due to its potential negative impacts on biodiversity.

6.2.3 Urban ecosystem services of Cooks to Cove GreenWay

The Cooks to Cove GreenWay aims to provide a green blue link within the Inner West, enhance connectivity, and provide benefits to society (Inner West Council, 2021, p. 22), while addressing the biodiversity decline. According to Expert F (p.c., 2025b, pp. 11–12), the local community promoted the consideration of ecosystem services in the planning process of this UGC. Since the Cooks to Cove GreenWay is an ongoing development project, it is important to note that the quantified ecosystem services do not represent the potential supply of the completed UGC. The land cover classes of the completed northern part of this UGC are visualized in Figure 13. Appendix D visualizes the land cover classes of the other parts of this UGC.

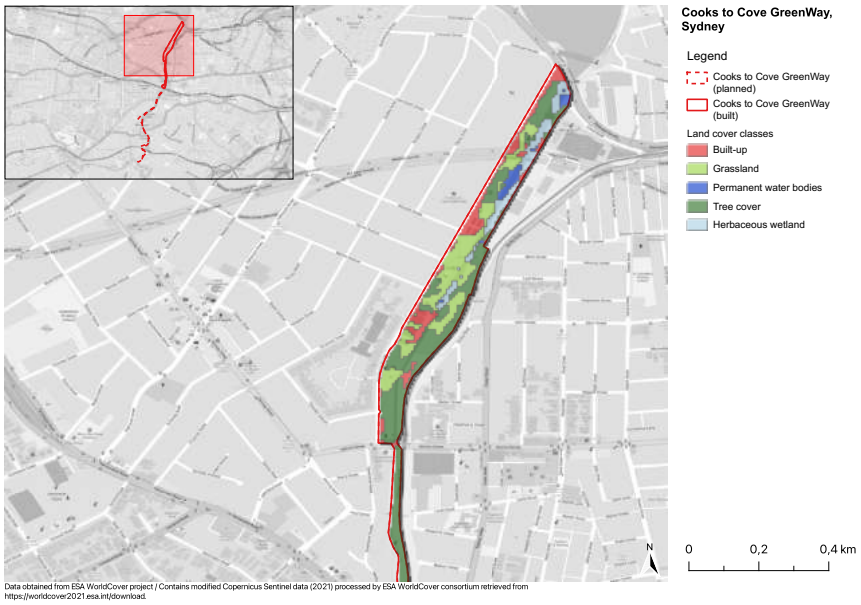


Figure 13: Land cover classes of the northern part of the Cooks to Cove GreenWay

The area covered by the different land cover classes of the whole Cooks to Cove GreenWay is visualized in Figure 14. This UGC consists primarily of tree cover with 38%, grassland classified as green urban area with 24%, built-up with 18%, herbaceous wetland with 14%, as well as permanent water bodies classified as water courses with 10%.

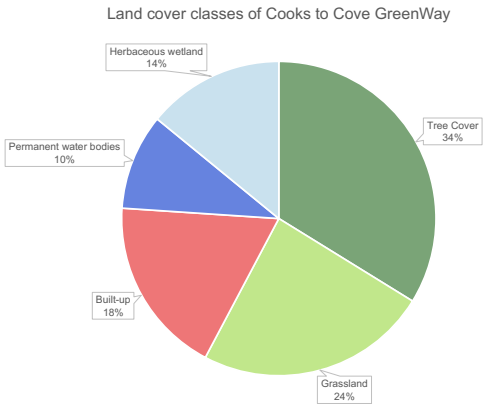


Figure 14: Proportion of land cover classes in the Cooks to Cove GreenWay

The Inner West faces urban challenges, including a decline in biodiversity, rising temperatures, flooding, and air pollution, while the growing population has increased the demand for recreation. Therefore, the relevant ecosystem services to address these challenges are explored. The summarized ecosystem service values for the Cooks to Cove GreenWay are visualized in Figure 15, Figure 16, and Figure 17.

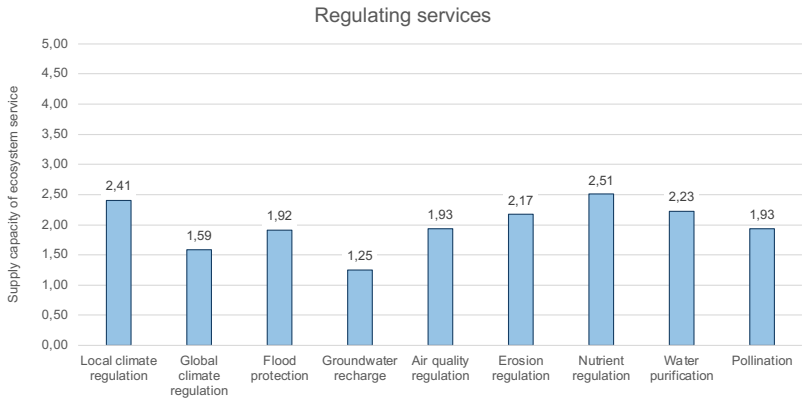


Figure 15: Overview of regulating services provided by Cooks to Cove GreenWay

The Cooks to Cove GreenWay has the potential to supply regulating services, ranging from relevant capacity to medium relevant capacity. Local climate regulation can mitigate the urban heat risk in the Inner West and has the second highest potential supply rate with a supply value of 2.41 as medium relevant capacity. Tree cover and grassland are the main potential suppliers, while permanent water bodies, and herbaceous wetlands, translated into “salt marshes”, are also contributing, although to a lesser extent due to their smaller portion in this UGC. This urban heat mitigation has also been highlighted by Expert F (p.c., 2025b, pp. 9–10), while the shading through the vegetation can also protect the community from excessive exposure to UV radiation (Inner West Council, 2021, p. 22). Air quality regulation, flood protection, and pollination have a relevant capacity to be supplied by this UGC. This UGC has an increasing rate of carbon sequestration (Expert F, p.c., 2025b, pp. 9–10), which contributes to improvement in air quality and global climate regulation (Burkhard et al., 2012, p. 20). Particularly, the great amount of tree cover can mitigate air pollution, while grassland can only contribute to a significant lesser extent. Also, this green corridor has the potential to supply flood protection, addressing flood risk in the Inner West. Salt marshes, classified as herbaceous wetlands, have the highest potential for providing this regulating service, although they only account for 14.08% of the area. Tree cover and permanent water bodies also contribute to the potential supply of flood protection. According to Hes & Hernandez-Santin (2019, p. 149), water sensitive design has been incorporated into this UGC for addressing water management issues and flood management. Also, pollination is essential for addressing the critical biodiversity decline in the Inner West caused by urban development. The abundant tree cover in this UGC can primarily contribute to the potential supply of pollination, while grasslands can provide this service only to some extent. As regulating service, pollination highlights the availability of pollinators and the distribution of plants, which can enhance biodiversity (Burkhard et al., 2012, p. 20). However, it is important to acknowledge that the supply of relevant services for addressing the Inner West's urban challenges is limited and need to be enhanced such as through the completion of this UGC. Further regulating services

can also be supplied including nutrient regulating, with the highest potential supply, and erosion regulation. The supply of nutrient regulation by this green corridor has also been highlighted by Expert F (p.c., 2025b, pp. 9–10). According to Expert F (p.c., 2025b, pp. 9–10), bush care sites can decrease erosion that has been caused through the degraded canal and impacted land due to intense anthropogenic land use. Additionally, Expert F (p.c., 2025b, p. 10) points out that the Cooks to Cove GreenWay provides the benefits of natural pest control, balanced ecosystems, climate adaptation, and land value.

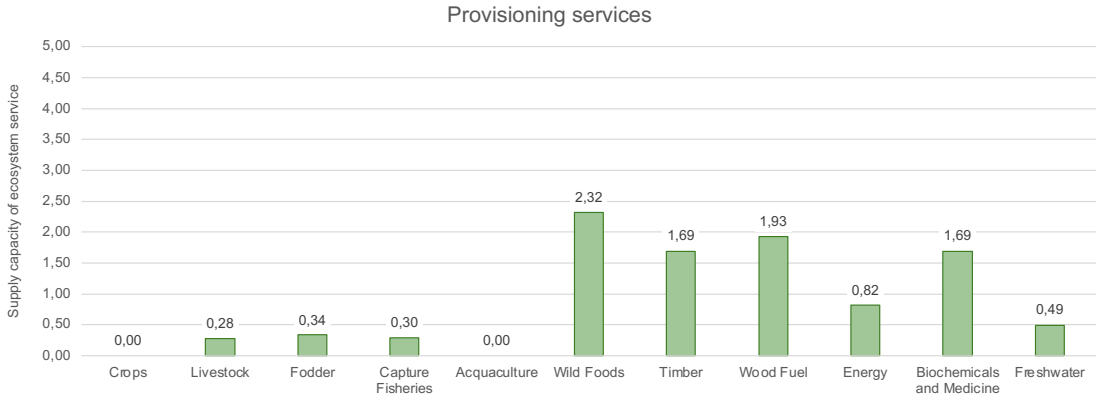


Figure 16: Overview of provisioning services provided by Cooks to Cove GreenWay

The Cooks to Cove GreenWay has the potential to supply provisioning services, ranging from no relevant to medium relevant capacity. Particularly wild foods, wood fuel, timber, and biochemicals and medicine have the potential to be supplied by this UGC. Tree cover and permanent water bodies have the highest rate to potentially supply wild foods, while grassland only contributes to a significant smaller extent. Also, the tree cover of this UGC has the potential to supply timber, wood fuel as well as biochemicals and medicine. Overall, provisioning services were not highlighted in the interview with Expert F (p.c., 2025b) or mentioned in the reviewed literature. This may be due to a lack of focus on these services or their limited supply by this green corridor. Additionally, it appears that urban gardens have not been incorporated into this UGC, that could enhance the supply of provisioning services.

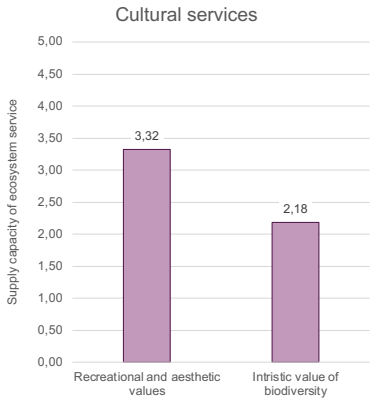


Figure 17: Overview of cultural services provided by Cooks to Cove GreenWay

Cultural services can also be supplied by this UGC with a high relevant capacity of supplying recreational and aesthetic values. Particularly tree cover, permanent water bodies, grassland, and herbaceous wetland have the potential to supply this service with a high relevant capacity. This can promote the use of this green corridor such as for recreational purposes. Also, the Inner West Council (2021, p. 22) points out the provision of recreational opportunities by this UGC. However, the enhanced recreational use of green spaces can lead to increased pressure on biodiversity, representing a potential trade-off (Pauleit et al., 2017, p. 39).

Overall, the highest potential supply of ecosystem services has tree cover with its coverage of 34% in the Cooks to Cove GreenWay. The built-up area, with 18% area coverage, has no supply capacity for ecosystem services except of energy as provisioning service. This amount of built-up area in this UGC may intensify urban heat and decrease the infiltration rate of water contributing to flooding. However, this potential trade-off requires site-specific studies. The supply capacity of ecosystem services by this UGC can contribute to human well-being and improve quality of life, as highlighted by Expert F (p.c., 2025b, pp. 10–11). Flood protection, pollination and air quality regulation appear to have a low potential supply, although these services are essential for the urban challenges the Inner West is facing. Also, the decline in biodiversity in the Inner West needs to be addressed through pollination. Overall, the relevant ecosystem services that can be supplied by this UGC need to be enhanced due to their limited supply capacity to mitigate and address the urban challenges of the Inner West.

6.2.4 Multifunctionality of Cooks to Cove GreenWay

The Cooks to Cove GreenWay has the potential to supply ecosystem services, while some regulating and cultural services have the potential to be supplied to a greater extent than provisioning services. Local climate regulation, flood protection, air quality regulation, pollination, and recreational and aesthetic values can be supplied by this UGC to address the urban challenges of the Inner West and the objectives of this UGC. The provision of the multiple ecosystem services, particularly regulating and cultural services, are also highlighted

by the Inner West Council (2021, p. 1 and p. 22). However, it is important to note that this UGC is an ongoing project, and the incorporation of greenery can result in an enhanced supply of ecosystem services. This UGC has a crucial biodiversity value, especially given the high urban density in Sydney's Inner West, by providing habitat for various species, including common and endangered ones (Ashfield Council & Eco Logical Australia Pty Ltd, 2011, p. 9). Ecological sensitive design strategies are incorporated into this UGC to protect these habitats and reduce the total disturbed area (Inner West Council, 2021, p. 71). The recreational and aesthetic value can encourage the use of this UGC, serving for recreation (Inner West Council, 2021, p. 1 and p. 22). Besides this, regulating services may enhance the provisioning of cultural services by improving environmental quality, thus creating a synergy. This may enhance the recreational value of this green corridor through the reduction of urban heat, improved air quality and pollination. However, the Inner West Council (2021, p. 22) highlights its currently low usage rates due to the incompleteness, while Expert F (p.c., 2025b, p. 15) pointed out a significant increase in active mobility in the realized parts of this UGC. Overall, this green corridor is of regional importance, while it functions as an ecological corridor with cultural significance (Inner West Council, 2021, p. 1 and p. 22).

Besides this, Expert F (p.c., 2025b, pp. 9–10) noted that this UGC provides educational opportunities that raise awareness the importance of biodiversity and ecology particularly in an urban setting. Also, this UGC strengthens the human-nature connection through enhancing ecological knowledge and encouraging the interaction with nature, while this UGC is contributing to human well-being and public health. Educational programs with schools and universities are conducted to further educate on the importance of nature. However, Expert F (p.c., 2025b, p. 15) highlighted the critical public's perception regarding to the unconscious use of this green corridor that has significant impacts on biodiversity. Particularly, the use of bush care sites is critical with regards to its impacts on site condition, habitat condition, and potential damages (Expert F, p.c., 2025b, p. 7). Also, the interest on enhancing biodiversity significantly differs among the local community, as mentioned by Expert F (p.c., 2025b, pp. 4–5). This highlights the need for raising ecological awareness.

Furthermore, the transformation of the commercial railway into a light passenger railway has raised concerns for the local community regarding conflicting objectives and a focus shift of the project (Hes & Hernandez-Santin, 2019, p. 145). According to Expert F (p.c., 2025b, pp. 11–12) considerations of constructing the light rail and active mobility corridor in the same space as the biodiversity corridor have been limited in the planning process. This resulted in significant impacts such as the loss of biodiversity and bush care sites due to the construction of infrastructure, as highlighted by Expert F (p.c., 2025b, p. 6 and p. 12). According to Expert F (p.c., 2025b, p. 18-20), a more detailed strategy for the development of this UGC could have

reached the objectives in a more balanced way. Also, the maintenance and conservation of this UGC presents a significant challenge due to its several bush care sites and native plantings that require high maintenance and expertise. The prioritization of other developments and projects presents challenges to the conservation. Besides this, land values are increasing due to this UGC (Expert F, p.c., 2025b, pp. 10–11). According to Expert F (p.c., 2025b, pp. 10–11), green gentrification can be a critical consequence, although other factors including population growth and the integrated light rail that is enhancing connectivity are also impacting it. To date, gentrification has not been as much of a consequence of this UGC, although it can be a critical challenge in the future and needs to be addressed.

Overall, the development of the Cooks to Cove GreenWay has been planned to be multifunctional from early stages on addressing environmental, recreational, and public health issues (Hes & Hernandez-Santin, 2019, p. 145). This UGC as an ongoing project has the potential to provide multiple ecosystem services as well as opportunities for recreation, active mobility, and education. Although the development is ongoing, it already provides multiple functions that can be further enhanced by its completion. Also, this UGC is partly addressing the primary objectives such as enhanced connectivity and biodiversity. However, this UGC had critical impacts such as the loss of biodiversity, while this UGC can enhance long-term biodiversity in a highly contested area of Sydney. Nevertheless, long-term conservation and prioritization of infrastructure over ecology present critical challenges for the future. Also, community participation in the conservation of this UGC and its bush care sties is essential due to the limited conservation efforts of the parks department.

6.3 The Meadoway, Toronto, Canada

Toronto is in the north shore of Lake Ontario in Canada in a region that is particularly rich in biodiversity (City of Toronto, 2019, p. 16). Due to climate change Toronto is expected to experience more frequent and intense extreme weather events including heat waves, droughts, and heavy rainfall resulting in flooding and erosion. This is putting pressure on native species and habitats (City of Toronto, 2019, p. 31). Toronto, as fourth largest city in North America, is expected to experience significant population growth (City of Toronto, 2019, p. 8). Toronto’s urban development is putting pressure on urban green spaces through land fragmentation and degradation of urban ecosystems through sealing of surfaces (City of Toronto, 2019, p. 8 and p. 17; Qin et al., 2023, p. 1200; TRCA, 2022, p. 4). This is causing the loss of natural habitats including meadow habitat, resulting in a decline in biodiversity, including native species and pollinators (Kotsopoulos et al., 2024, p. 421; TRCA, 2022, p. 4). Besides this, Toronto is characterized by urban air pollution particularly due to traffic as well as industrial activities (City of Toronto, 2025). Also, the Greater Toronto Area is characterized by a complex network of linear infrastructure corridors, including power lines, pipelines and

buried sewers as underutilized areas that provide limited biodiversity and ecosystem services (Qin et al., 2023, p. 1200; TRCA, 2022, p. 4). However, these spaces require extensive management and contain mainly non-native species with low habitat and functional value (Kotsopoulos et al., 2024, p. 421). These linear corridors can provide opportunities for green space restoration that can provide greater ecosystem functions, while enhancing connectivity (Qin et al., 2023, p. 1200). TRCA (2019b, pp. 1–2) highlights the potential of the space beneath Toronto's hydro corridors providing solutions to the challenges related to urbanization, such as traffic congestion and loss of open space. The transformation of these underutilized green spaces has the potential to enhance biodiversity, climate change resilience, and opportunities for active mobility (TRCA, 2022, p. 5). The Meadoway restoration project is one such example of rethinking urban and suburban green spaces with native meadow habitats (TRCA, 2022, p. 5).

6.3.1 Development of The Meadoway

The Gatineau Hydro Corridor in Scarborough has been established in the 1920s due to its agricultural context, while its surrounding urbanized and developed in 1950s (TRCA, 2019a, p. 4). Over the decades it has remained manicured and has been one of the most important transmission lines (TRCA, 2019a, p. 4, 2019b, pp. 1–2). In 2012, the idea of rethinking underutilized space below this hydro corridor and transforming it into a meadow with native plantings gained increasing attention (TRCA, 2025a, p. 4). Expert G (p.c., 2025, pp. 1–2) pointed out that the Scarborough Center Butterfly Trail (SCBT) pilot project, with its 3.5 km length, was initiated to explore the restoration of meadows in the underutilized spaces below hydro corridors (Expert G, p.c., 2025, pp. 1–2). The SCBT project has been transformed into a native meadow, active mobility corridor, and recreational space for community gathering and educational purposes (TRCA, 2019b, pp. 1–2, 2022, pp. 2–6). Based on the success of this pilot project the idea of transforming the Gatineau Hydro Corridor into a native meadow has been established further (TRCA, 2019b, pp. 1–2, 2022, pp. 2–6; Expert G, p.c., 2025, pp. 2).

Figure 18: Impressions of The Meadoway (Photographs by TRCA, used with permission, 2025)

Today this hydro corridor has been transformed into a vibrant 16 km UGC named The Meadoway, that is visualized in Figure 18. The Meadoway is a key component of Toronto and Region Conservation Authority's (TRCA) Trail Strategy for the Greater Toronto Region, that is going to link Rouge National Urban Park and downtown Toronto including more than 15 green spaces and seven watercourses, while passing through 13 neighborhoods (TRCA, 2022, pp. 2–6). The location of The Meadoway in Toronto is visualized in Figure 19.

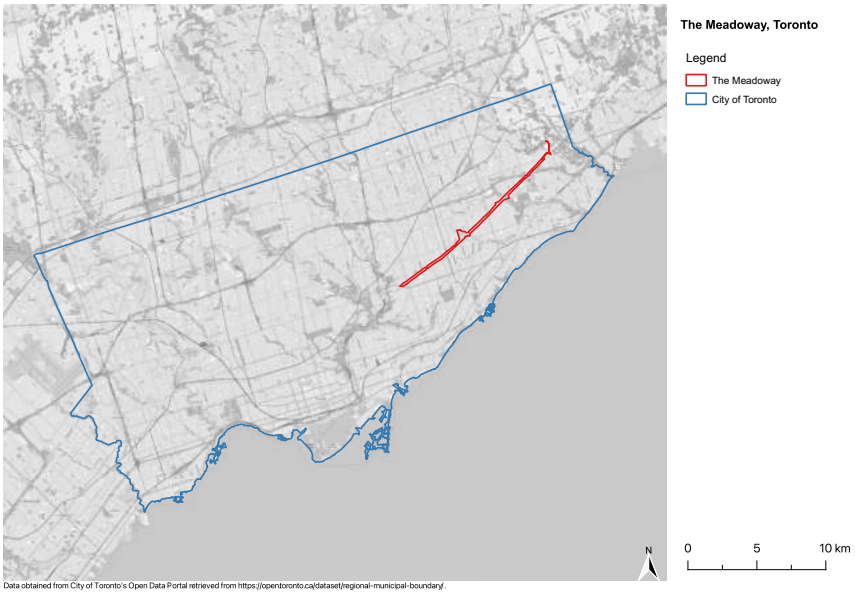


Figure 19: Location of The Meadoway

In 2018, The Meadoway project officially launched aiming to provide active mobility opportunities. The entire length of the utility corridor has been planned to be planted with native meadow species (TRCA, 2022, p. 6). Expert G (p.c., 2025, p. 6) pointed out that the incorporation of native plantings is nearly done with 100 hectares out of 104 hectares due to the last trail segment that has to be finished. Once completed this green corridor is going to be the largest linear urban park in Canada, serving as a multi-use trail to improve connectivity as low-impact transportation, with the restoration of meadow habitat (TRCA, 2022, pp. 2–6). TRCA (2019a, p. 5) highlights the importance of The Meadoway as part of a larger network of hydro corridors connecting Toronto's natural heritage system.

According to Expert G (p.c., 2025, p. 3), the lack of connectivity was a major challenge that led to the development of The Meadoway project, as some of the existing trails within the corridor were fragmented. Also, limited biodiversity due to mowed grass below the hydro corridor and Toronto's vulnerability to flooding due to the low infiltration rate have been factors for the development of this project. The primary objectives of this development are the promotion of community connectivity, recreational and active mobility opportunities, and biodiversity through the restoration of meadow habitat (TRCA, 2022, pp. 8–9; Expert G, p.c.,

2025, p. 7). Additionally, this green corridor aims to strengthen the diverse and unique local character of the various neighborhoods and communities along this green corridor (TRCA, 2019a, p. 8).

6.3.2 Identification of key stakeholders

The transformation of this hydro corridor involves a variety of stakeholders, including the Hydro One Networks Inc., Infrastructure Ontario, the City of Toronto, Toronto and Region Conservation Authority (TRCA), and the Western Family Foundation (TRCA, 2022, p. 6).

According to Expert G (p.c., 2025, p. 4), The Meadoway project has been initiated by the councilor of the City of Toronto that had the idea of transforming the corridor into a green space. Through discussions between the City of Toronto and TRCA about vegetation, it has been decided on incorporating native plantings that enhance biodiversity and species richness, while providing habitat for wildlife. Also, Expert G (p.c., 2025, p. 4) pointed out that Infrastructure Ontario is owning the land of The Meadoway. The management of the land and the towers is conducted by Hydro One Networks Inc (HONI) (TRCA, 2022, p. 10; Expert G, p.c., 2025, p. 4). For the development of The Meadoway the City of Toronto is leasing the land through a Master Park License Agreement with HONI (TRCA, 2022, p. 10; Expert G, p.c., 2025, pp. 4–5). The trails and some of the plantings are maintained by the City of Toronto (Expert G, p.c., 2025, p. 12).

TRCA is the contractor for the development of The Meadoway and responsible for the meadow management (Expert G, p.c., 2025, p. 4 and p. 12). However, the management of native meadows in an urban context is challenging due to the resource intensity and time-consuming characteristics, as highlighted by Expert G (p.c., 2025, p. 12). Overall, the focus of TRCA's work is on flood attenuation and restoration work in terms of forests, wetlands, and meadow habitat. TRCA is engaging with the public and compensating ecosystems for mitigating and restoring impacts on ecosystems. Overall, the various stakeholders involved in The Meadoway make approvals for measures for this UGC complex, as highlighted by Expert G (p.c., 2025, p. 2-4).

Particularly the Western Family Foundation and Environment and Climate Change Canada as well as the Housing Infrastructure and Community Canada have been supporting the development of The Meadoway in terms of funding, as highlighted by Expert G (p.c., 2025, p. 5). Municipal and City of Toronto funding has also supported the Meadoway project (Expert G, p.c., 2025, pp. 9–10).

Overall, the development of this meadow restoration project is based on ecological community efforts due to the support of the local community and community engagement (TRCA, 2022, p. 2, 2025a, p. 4). The planning and design of The Meadoway has included an environmental

class assessment that engaged with the local community to integrate community interests and maximize benefits. Also, in terms of infrastructural aspects such as trails and bridges the local community had an important role in developing The Meadoway (Expert G, p.c., 2025, pp. 5–6). Through educational programs and other initiatives, the local community participates in The Meadoway including hands-on activities, field trips, and conservation work, which further promotes an understanding of local ecosystems and environmental stewardship (TRCA, 2025a, p. 5; Expert G, 2025, p. 6). Furthermore, community events are held by an established educational team. Residents can become ambassadors, representing the community through initiatives and ideas, as highlighted by Expert G (p.c., 2025, p. 6). Besides this, the public is partly taking the role of watchdogs providing TRCA with information on this UGC (Expert G, p.c., 2025, pp. 13–15).

To create a balance between ecology and infrastructure, a Safe Harbor Agreement has been established, that is protecting The Meadoway for around five to six years. This agreement is preserving the UGC, while it provides opportunities for development (Expert G, p.c., 2025, pp. 6–7). Expert G (p.c., 2025, p. 16) further highlighted the need for collaboration among the different stakeholders for addressing future changes such as due to Toronto's development. However, the reliance on funding for the conservation of this UGC presents a long-term challenge, as highlighted by Expert G (p.c., 2025, p. 9).

6.3.3 Urban ecosystem services of The Meadoway

The Meadoway primarily aims to enhance connectivity, provide opportunities for recreation and active mobility, and enhance biodiversity, while it aims to provide multiple ecosystem services by the incorporated native meadow (Qin et al., 2023, pp. 1200–1201). Toronto is facing urban challenges including flood and heat risk due to climate change and air pollution that need to be addressed. The relevant ecosystem services are explored in this section. The land cover classes comprising the south-western part of The Meadoway are visualized in Figure 20, while the other parts of The Meadoway are visualized in Appendix E.

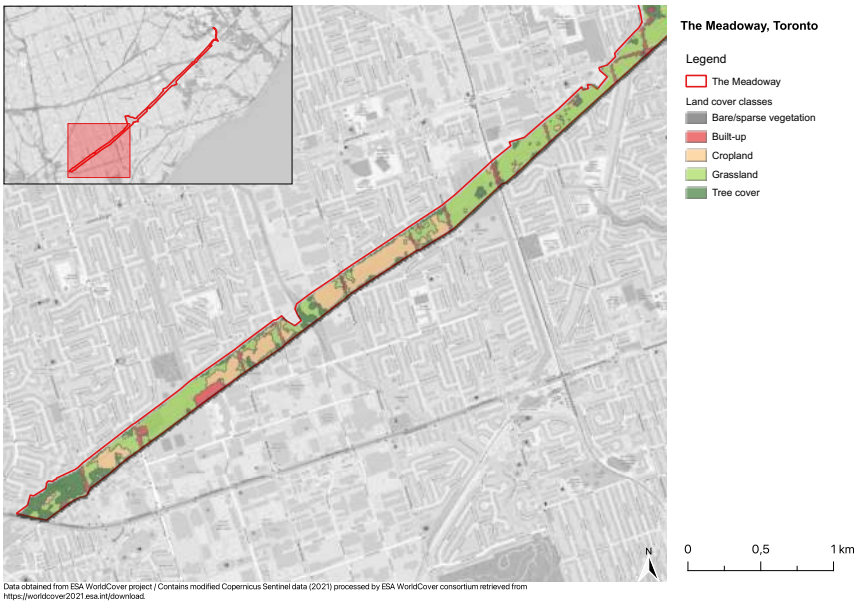


Figure 20: Land cover classes of the south-western part of The Meadoway

The area of The Meadoway is characterized by the different land cover classes that are visualized in Figure 21. This UGC consists with 55% primarily of grassland, that has been categorized as CORINE land cover class “natural grassland”. This is due to the native meadow that characterizes this green corridor, which is primarily inaccessible and without significant activity by humans. In addition, this UGC is characterized by land cover classes such as tree cover with about 26%, cropland with about 11%, and built-up area with about 8%, while only a small area is covered by bare/sparse vegetation.

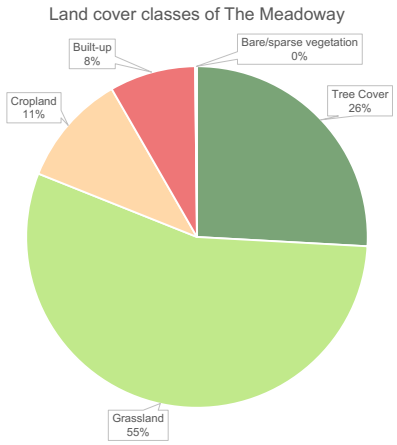


Figure 21: Proportion of land cover classes in The Meadoway

The Meadoway has the potential to provide various ecosystem services. Particularly local climate regulation, flood protection, air quality regulation, pollination and recreation are relevant for addressing the urban challenges Toronto is facing, while also addressing the primary objective of this UGC. The summarized ecosystem service values based on the land

cover classes of The Meadoway for the different ecosystem service categories are visualized in Figure 22, Figure 23, and Figure 24.

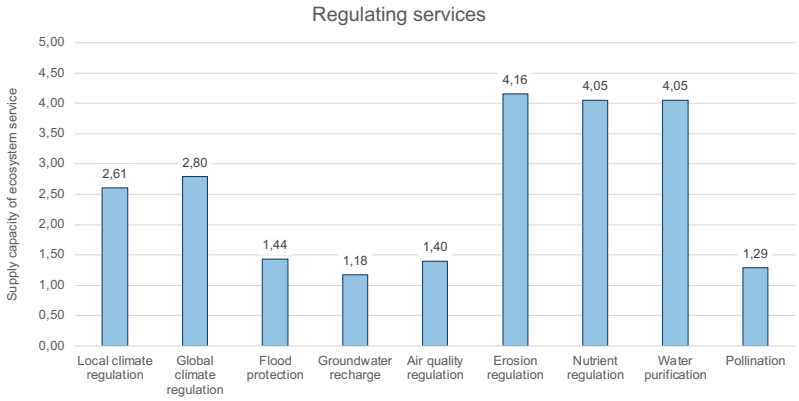


Figure 22: Overview of the regulating services provided by The Meadoway

The Meadoway has the potential to supply regulating services although these significantly differ ranging from relevant capacity to very high relevant capacity. The regulating service local climate regulation is essential for mitigating urban heat in Toronto with medium relevant capacity. Grassland, tree cover, and cropland have the potential to supply local climate regulation for mitigating urban heat through shading and evapotranspiration. Also, a conducted study detected the mitigation of urban heat by The Meadoway (Expert G, p.c., 2025, p. 8). This UGC can sequester carbon that contributes to the regulating service air quality regulation with a relevant capacity and a supply value of 1.40. This can partially address the air pollution Toronto is facing. However, The Meadoway has even a greater potential to supply global climate regulation with a medium relevant capacity to which carbon sequestration contributes. Also, flood protection has only a relevant capacity with a supply value of 1.44, while tree cover primarily supply this regulating service. However, tree cover is not as prevalent as grassland in this UGC, which is due to safety restrictions within a hydro corridor, as highlighted by Expert G (p.c., 2025, p. 8). Also, grassland, cropland, and bare/sparse vegetation can supply flood protection. Field investigations and analysis of soil samples from The Meadoway revealed the enhanced hydrological regulation functions of this UGC, such as reduced surface runoff and infiltration capacity (Qin et al., 2023, pp. 1217–1218). The contribution of this green corridor to flood attenuation has also been highlighted by Expert G (p.c., 2025, pp. 3–4 and p. 7–10). For addressing the decline of biodiversity and pollination in Toronto, pollination is a critical ecosystem service that must be supplied by The Meadoway. However, this ecosystem service has only a supply value of 1.29 as relevant capacity according to the method after Burkhard et al. (2009). Tree cover is the only land cover type that can supply pollination in The Meadoway. This seems to be critical since this green corridor is primarily characterized through native meadow covering about 55% of The

Meadoway and the incorporated native meadow into this UGC aims to enhance biodiversity and pollination. Roguz et al. (2023, pp. 1–2 and p. 11) point out that urban meadows can significantly contribute to biodiversity, while urban meadows can be attractive for urban pollinators. Also, through the annual monitoring of The Meadoway a significant increase in pollination that evolved over time has been detected (TRCA, 2025a, p. 4). This contradicts the potential supply value of the method after Burkhard et al. (2009), as the supply value of 1.29 for pollination appears to be significantly lower than the actual pollination supply of this UGC. The Meadoway can supply groundwater recharge with a relevant capacity, that has also been highlighted by Expert G (p.c., 2025, pp. 7–10). Also, the restored meadow in Toronto contributes to erosion regulation and nutrient regulation as detected through a conducted study (Qin et al., 2023, pp. 1217–1218). This is also visualized in Figure 22 with a very high relevant capacity, while primarily tree cover, and grassland have the potential to supply these regulating services.

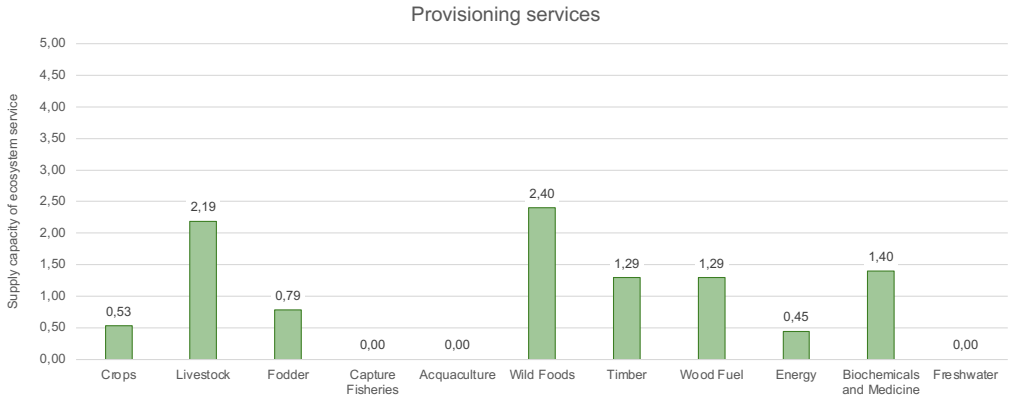


Figure 23: Overview of the provisioning services provided by The Meadoway

The Meadoway has the potential to supply provisioning services ranging from no relevant capacity to medium relevant capacity. Tree cover, and cropland have the greatest potential to provide provisioning services, while grassland making up the biggest portion of The Meadoway, has limited supply capacity. Wild food and livestock have the greatest potential be supplied by this UGC with a medium relevant capacity. However, it is important to mention that the provision of livestock depends on the type of cropland and for The Meadoway livestock provision appears to not be relevant. Also, according to Expert G (p.c., 2025, pp. 13–14), urban gardens that have been incorporated into this UGC can supply provisioning services, while encouraging the community participation and providing educational opportunities (TRCA, 2025b).

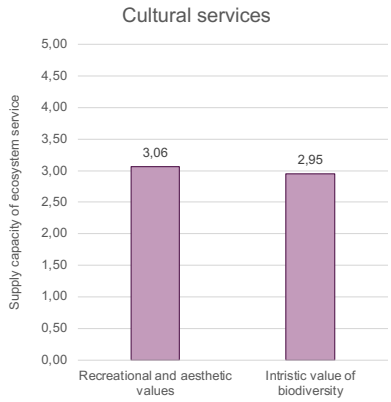


Figure 24: Overview of the cultural services provided by The Meadoway

Cultural services can also be provided by this UGC, while particularly tree cover, and grassland contribute to the potential supply of recreation and aesthetic values with a supply value of 3.06 as high relevant capacity. Also, cropland and bare/sparse vegetation can contribute to the supply although only to a limited extent. The Meadoway has a high relevant capacity to supply this cultural service. Also, Expert G (p.c., 2025, p. 10) noted that the Meadoway provides cultural services, such as enhanced interaction between humans and nature. This ecosystem service can promote the use of this UGC for recreational purposes. In addition, this UGC has a medium relevant capacity to provide an intrinsic biodiversity value, which tree cover and grassland can supply.

Overall, this UGC is characterized by 55% grassland and 28% tree cover, which are the main contributors to the supply capacity of ecosystem services. Built-up area in this UGC is making up a portion of about 8%, while it is not contributing to the supply of ecosystem services and potentially decreasing the supply of ecosystem services. The supply capacity of provisioning services is lower than that of regulating and cultural services. This may be due to the small amount of cropland that characterizes this UGC. However, the supply capacities of the relevant ecosystem services are overall lower than other services such as erosion regulation and nutrient regulation highlighting the need for investigating these services in more detail for enhancing these. In addition, regulating and cultural services may provide synergies with respect to heat mitigation, which can enhance the recreational value of this UGC. Overall, the assessment of ecosystem services for this UGC is not aligning with the results of the annual monitoring and field investigations. Therefore, an in-depth ecosystem service assessment may be necessary.

6.3.4 Multifunctionality of The Meadoway

The Meadoway has the potential to supply ecosystem services that can address Toronto's urban challenges. Flood attenuation and prevention, heat mitigation, pollination, recreation, and carbon sequestration are provided ecosystem services by The Meadoway, as highlighted

by Expert G (p.c., 2025, pp. 7–10). However, the calculated supply capacity of flood protection, air quality regulation and pollination are significantly lower than other ecosystem services such as erosion regulation and nutrient regulation, highlighting the need for enhancing these services for addressing Toronto's urban challenges. Although the supply capacity of local climate regulation is higher than of flood protection, air quality regulation and pollination, it is still limited and need to be enhanced to mitigate urban heat. Besides this, the recreational and aesthetic values supplied by this UGC can encourage the use for recreational purposes. According to Expert G (p.c., 2025, p. 10), The Meadoway is used for educational activities encouraging social interaction, while educational programs include hands-on activities, field trips, and conservation work (TRCA, 2025a, p. 4). Also, the human-nature relationship can be strengthened through dynamic learning environments such as The Meadoway, while it can contribute to a resilient urban environment (TRCA, 2025a, p. 36). Additionally, incorporated urban gardens encourage the community participation, while having the potential for provisioning services.

Besides this, through the annually monitoring it has been detected that the meadow restoration is positively impacting pollinators, wildlife, biodiversity and species richness. This highlights the successful transition to native plant meadows as species-rich plant communities (TRCA et al., 2025, pp. 70–72; TRCA, 2025a, p. 4). However, invasive flora species have still been detected, although their extent is being successfully reduced (TRCA et al., 2025, p. 70; Expert G, p.c., 2025, p. 8). Also, The Meadoway is providing migratory stopping ground and allows for east-west movement of wildlife, although Toronto is characterized by north-south ravines (Expert G, p.c., 2025, p. 7). The diversity in the planted meadow of The Meadoway is visualized in Figure 25.

Figure 25: Impressions of the native meadow of The Meadoway in Toronto (Photographs by TRCA, used with permission, 2025)

Also, opportunities for active mobility are provided by incorporating trails into this green corridor for promoting active mobility among the community and strengthening community connectivity (TRCA, 2025a, p. 4 and p. 30; Expert G, p.c., 2025, pp. 13–14). The Meadoway has experienced a significant increase in active mobility such as cycling and walking

(Expert G, p.c., 2025, pp. 13–15). The City of Toronto's Bicycle Plan also highlights the importance of The Meadoway as a critical link between various bike lanes, cycle tracks, trails and quiet lanes (TRCA, 2019a, p. 18). However, The Meadoway is characterized by road and creek crossings impacting the connectivity (TRCA, 2019a, p. 22). A signage and wayfinding program is being developed for enhancing safety and accessibility to this green corridor (TRCA, 2025a, p. 4), while additional features are being incorporated for enhancing the trail user experience (TRCA, 2025a, p. 32). According to Expert G (p.c., 2025, pp. 13–14), the public consciously uses this green corridor and they primarily stay on the trails. This may be due to the meadows' partial height of eight feet, which is preventing the disruption of the meadow.

The transformation of hydro corridors has great potential for the development of UGCs and provision of multiple benefits, including habitat, flood mitigation, and cultural services including education, while the human-nature relationship can be strengthened through community events (TRCA, 2019a, p. 12). Meadow restoration in these spaces can decrease the maintenance costs due to the low need for maintenance (Expert G, p.c., 2025, p. 8 and p. 19). Particularly, the compatibility of a meadow ecosystem with the management requirements of the hydro corridor has been found to be ecologically beneficial, while reducing the frequency and extent of mowing (TRCA, 2022, p. 10). However, challenges in terms of long-term management and funding for conserving this UGC emerge (Expert G, p.c., 2025, p. 18). These can have significant impacts on the long-term success of this UGC.

Overall, The Meadoway can supply multiple ecosystem services simultaneously. Flood protection and air quality regulation that are necessary for addressing Toronto’s vulnerability to flooding and its air pollution have a significant lower supply capacity compared to other regulating services. Besides this, local climate regulation can only be supplied to a limited extend, although a conducted study on temperature reduction detected a significant temperature reduction through the incorporated meadow. Also, pollination has been identified with a limited supply capacity. However, annually monitoring detected a significant increase in pollinators. The Meadoway can supply recreational and aesthetic values that can promote the use of this UGC. Additionally, the UGC provides educational opportunities that can raise awareness. This highlights the multifunctionality of this UGC in terms of addressing Toronto’s urban challenges and the primary objectives. However, it is important to note that the mapping of this UGC may not represent the current land cover classes, since the used dataset has been published for the year 2021 and it is an ongoing development project that is nearly completed. Also, the classification of the “grassland” translated into the CORINE land cover class “natural grassland” that is classified as supplying no pollination after Burkhard et al. (2009) may not represent the native meadow that is incorporated into The Meadoway due to

the contradiction with the monitoring. Although the City of Toronto initiated the development of this UGC, the local community participated in the planning process. The community is also involved in the project through educational programs and urban gardening. However, The Meadoway's success depends heavily on funding, while long-term management and funding present challenges for the conservation of this UGC. Therefore, the local community's participation in ensuring the corridor's long-term management may be necessary.

6.4 Eastside Trail of Atlanta Beltline, Atlanta, United States of America

Atlanta, located in the state of Georgia in the United States of America, is experiencing climate-related challenges such as rising temperatures, droughts and flooding (EPA, 2017, p. 1). Particularly the urban heat island effect impacts Atlanta and is presents a significant challenge for Atlanta since it is intensifying extreme heat events (Muse et al., 2022, pp. 1–3). Atlanta is not located around a major waterbody making it particularly prone for droughts, while it is experiencing extreme precipitation events resulting in flooding (100 Resilient Cities, 2017, p. 25). These extreme precipitation events are expected to further intensify and occur more frequent (Pallathadka et al., 2022, p. 3). The city is expected to experience population growth, while this further contributes to land fragmentation and the sealing of surfaces resulting in significant impacts on the environment including loss of habitat and biodiversity decline (Miller, 2012, pp. 171–172). Although Atlanta is characterized by its great urban tree canopy, its urban development has resulted in forest fragmentation and loss of forest (City of Atlanta, 2015, p. 41; Miller, 2012, pp. 171–172). Besides this, Atlanta is characterized by limited green space (Atlanta Beltline, 2025d; Miller, 2012, p. 171). Also, overburdened, insufficient infrastructure and air pollution are urban challenges of Atlanta. Therefore, measures are being implemented to address these challenges, including the expansion of bicycle and pedestrian infrastructure (100 Resilient Cities, 2017, pp. 25–26; Palardy et al., 2018, p. 253). As a brownfield redevelopment and a sustainable recreation and transportation corridor, the Atlanta Beltline project aims to address Atlanta’s urban challenges (100 Resilient Cities, 2017, p. 60; Palardy et al., 2018, p. 253).

6.4.1 Development of Eastside Trail of Atlanta Beltline

The development of Atlanta Beltline is based on the idea of a master student’s master thesis from 1999 that has gained public enthusiasm for repurposing the disused railroad tracks (Expert H & Expert I, p.c., 2025, p. 2). The architecture and urban planning student, Ryan Gravel, emphasized the development of transportation and public space for enhancing connectivity and revitalizing previously industrial land, while enhancing economic development. The recognized potential of transforming the abandoned railroad tracks by a member of the Atlanta City Council led to political attention. The grassroots efforts for this UGC have been initiated by the Friends of the Beltline, as they advocated for this

transformation leading to the expansion of the project's scope beyond the initial transit-oriented redevelopment to include public green space, affordable housing, and public art. The movement gained the support of Mayor Shirley Franklin and resources have been committed to this project. In 2005, Atlanta Beltline was officially launched, and the Beltline Tax Allocation District (TAD) was created to fund this development (Atlanta Beltline, 2025d). The implementation began in 2011 and is still ongoing (Immergluck, Dan & Balan, 2018, p. 548). The Atlanta Beltline is about 85% complete (Atlanta Beltline Inc., 2025, p. 5 and p. 15). By 2030 the Atlanta Beltline project is planned to provide a 35 km loop around the city including a regional light-rail transit system, 53 km of multi-use trails and various green spaces connecting the neighborhoods in Atlanta (100 Resilient Cities, 2017, pp. 60–61; Byahut et al., 2020, p. 81).

This green corridor is primarily developed on old, abandoned freight railroad corridors from the late 19th century that formed a bypass around Atlanta (Expert H & Expert I, p.c., 2025, p. 2). Atlanta Beltline is one of the largest UGC and redevelopment projects. The aim of this redevelopment is to enhance the quality of life of Atlanta, improve human well-being and public health (Byahut et al., 2020, p. 74), while increasing the green space with about 40%. This UGC aims to connect over 40 parks that provide environmental, recreational and economic opportunities (Byahut et al., 2020, p. 77; Palardy et al., 2018, p. 251). Besides this, it aims to provide pollinator habitats for various species in Atlanta (100 Resilient Cities, 2017, pp. 60–61). Since the scale of Atlanta Beltline is exceeding the case study selection criteria of this thesis, the focus is set on the Eastside Trail of Atlanta Beltline. The location of the Eastside Trail of the Atlanta Beltline is visualized in Figure 26.

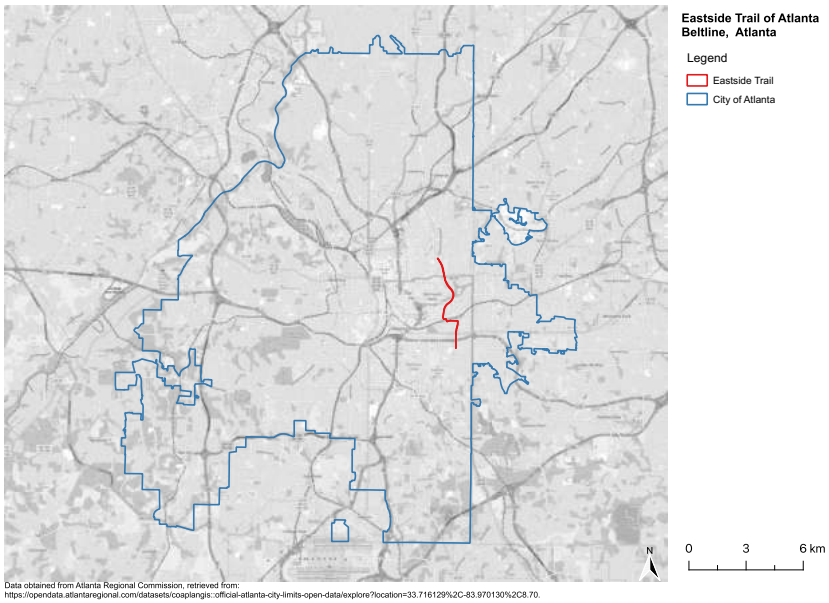


Figure 26: Location of the Eastside Trail of Atlanta Beltline

The Eastside Trail of the Atlanta Beltline has been the first part that has been completed (Expert H & Expert I, p.c., 2025, pp. 2–3), opened in 2012 and is 3.6 km long running from the north to the south (Atlanta Beltline, 2025d; Palardy et al., 2018, p. 253). This part of the Atlanta Beltline is running through neighborhoods with high population densities (Larson et al., 2016, p. 112), while it is linking the neighborhoods in East Atlanta, enhancing accessibility to green spaces and providing transportation opportunities (Atlanta Beltline Inc., 2025, p. 12). Impressions of the Eastside Trail are shown in Figure 27.

Figure 27: Impressions of the Eastside Trail (Photographs by Expert I, used with permission, 2025)

6.4.2 Identification of key stakeholders

This green corridor was developed through public-private partnerships (Atlanta Beltline, 2025f; Mell, 2022, p. 16). Financing for the development, management, and maintenance of the Atlanta Beltline is based on a TAD (Expert H & Expert I, p.c., 2025, p. 4). This TAD presents a local funding source that facilitates the implementation of this project (Invest Atlanta, 2025).

The City of Atlanta represents a key stakeholder, including the parks department, which is responsible for maintaining the Atlanta Beltline (Expert H & Expert I, p.c., 2025, p. 4). However, limited financial resources limit the ability of the parks department to maintain the Atlanta Beltline, as highlighted by Expert H & Expert I (p.c., 2025, p. 4). The organization Atlanta Beltline Inc. (ABI), formed in 2006, is presenting another key stakeholder in this project that is responsible for the planning, development, and implementation of this project, while ABI is coordinating the financial resources (Atlanta Beltline, 2025a, 2025d). As an evolution of the Friends of the Beltline, the Atlanta Beltline Partnership was formed to coordinate the efforts of the various organizations involved in the project (Atlanta Beltline, 2025d). The Atlanta Beltline Partnership supports the realization of the Atlanta Beltline through fundraising, advocacy efforts, and increasing public engagement with this project (Atlanta Beltline, 2025b, 2025e).

The Atlanta Beltline project aims to integrate sustainable tree management as a proactive approach to replacing removed trees (Atlanta Beltline, 2024b). Therefore, ABI collaborates with Trees Atlanta to plant most of the trees, grasses and shrubs (Expert H & Expert I, p.c., 2025, p. 4). Trees Atlanta, a non-profit organization, is playing a critical role in the Atlanta

Beltline project with the objective of protecting and conserving vegetation, replacing trees that have been removed due to development, and contributing to educate the local community about nature (Landscape Architecture Foundation, 2014, p. 2). The planting of the Eastside Trail of the Atlanta Beltline has been supported by the collaboration between Trees Atlanta and ABI encouraging community participation (Landscape Architecture Foundation, 2014, pp. 2–3). Trees Atlanta is maintaining the Atlanta Beltline Arboretum and educating on native trees and plants as well as architectural interests through guided walks through the Atlanta Beltline Arboretum (Atlanta Beltline, 2024a; Trees Atlanta, 2025). The nonprofit organization manages approximately 85 acres of green space using sustainable land management practices, including the Eastside Trail (100 Resilient Cities, 2017, pp. 60–61; Trees Atlanta, 2025).

The development of the Atlanta Beltline evolved from the grassroots efforts of local communities and civic leaders (Inner West Council, 2018, p. 74). The local community plays an important role in the Atlanta Beltline project. The areas of the UGC have been divided into 10 sub areas to enhance local community involvement into the planning process. The local community is partially involved in the maintenance of this UGC through volunteer projects in partnership with Trees Atlanta (Expert H & Expert I, p.c., 2025, p. 5). However, it is important to note that concerns have been raised about a focus shift of this UGC project towards economic development, potentials resulting in diminishing voices of the local community (Immergluck, Daniel, 2016, p. 414; Inner West Council, 2018, p. 74). This limited community participation may be attributed to several factors including the large scale of the project, several involved stakeholders and the required knowledge for maintenance.

6.4.3 Urban ecosystem services of Eastside Trail of Atlanta Beltline

Through the incorporation of a secondary corridor next to the trail ecosystem services have been actively integrated into the development of the Atlanta Beltline (Expert H & Expert I, p.c., 2025, pp. 8–9). The Atlanta Beltline Arboretum, as the longest linear Arboretum in the world once completed, consists of various plants including trees, shrubs, grasses, vines (Expert H & Expert I, p.c., 2025, p. 1; Trees Atlanta, 2025). Therefore, the Atlanta Beltline including the Eastside Trail has the potential to supply ecosystem services. The potential supply of ecosystem services by the Eastside Trail is explored in this section. The different land cover classes that characterize the northern part of the Eastside Trail are visualized in Figure 28. The remaining parts of the Eastside Trail are visualized in the Appendix F.

Figure 28: Land cover classes of the northern part of the Eastside Trail

The percentage distribution of the different land cover classes is visualized in Figure 29. The Eastside Trail consists primarily of 43% tree cover, 35% built-up, and 21% grassland classified as green urban area, while bare/sparse vegetation and cropland make up a small portion.

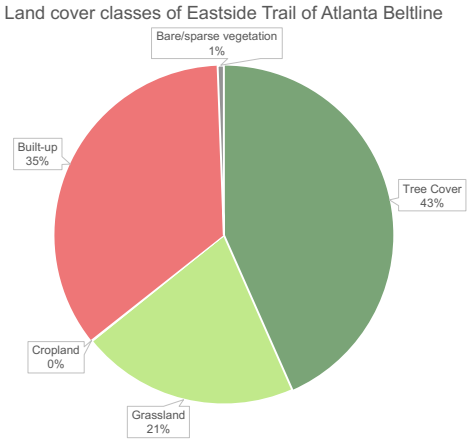


Figure 29: Proportion of land cover classes in the Eastside Trail

The primary focus of this ecosystem service assessment is on the most relevant ecosystem services for addressing Atlanta's urban challenges and the primary objectives of this UGC. The summarized supply values for the different ecosystem services are visualized in Figure 30, Figure 31, and Figure 32.

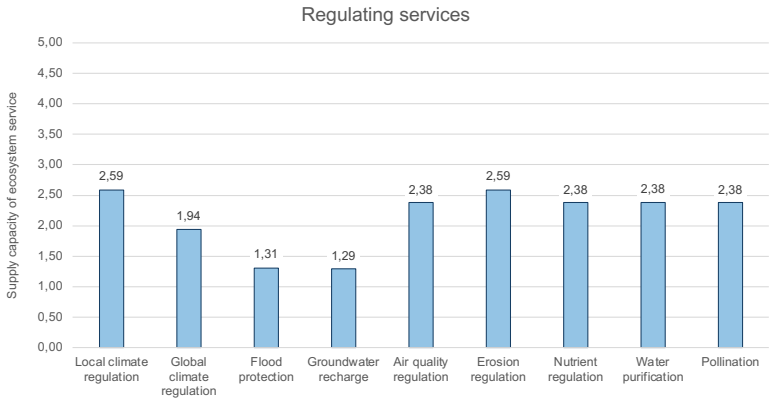


Figure 30: Overview of regulating services provided by Eastside Trail

The Eastside Trail of Atlanta Beltline has the potential to supply regulating services ranging from relevant capacity to medium relevant capacity. This UGC is intended to provide environmental benefits such as local climate regulation, stormwater management, and pollination (Atlanta Beltline, 2025c). With regards to Atlanta's urban challenges different regulating services are essential to be supplied by this UGC. Particularly, local climate regulation and erosion regulation have a great potential supply with a supply value of 2.59 as medium relevant capacity, as shown in Figure 30. Local climate regulation is essential for mitigating urban heat that can have significant impacts and result in droughts. Primarily tree cover, such as the Atlanta Beltline Arboretum, and grassland have the potential to supply this service and contribute to urban heat mitigation (Atlanta Beltline, 2024a). Also, air quality regulation, nutrient regulation, water purification and pollination have a great potential supply with 2.38 as medium relevant capacity. Air quality regulation and pollination can primarily be supplied through tree cover that is comprising the largest portion of the Eastside Trail. Also, grassland and cropland can supply these services, although to a lesser extent. A conducted study that monitored the landscape performance benefits highlights the environmental benefits such as carbon sequestration by the Eastside Trail (Landscape Architecture Foundation, 2014, p. 2). Carbon sequestration contributes to global climate regulation and air quality regulation. Particularly, the planted native trees and grasses enhance pollination (100 Resilient Cities, 2017, pp. 60–61). Also, a conducted study revealed Atlanta Beltline is providing biodiverse meadows with a variety of pollinators (100 Resilient Cities, 2017, pp. 60–61). This significant increase of pollination has also been highlighted in an interview with Expert H & Expert I (p.c., 2025, pp. 2 and pp. 8–9). Since Atlanta is prone to flooding due to extreme precipitation events, the supply of flood protection is essential. Flood protection has a supply value of 1.31 as relevant capacity, while primarily tree cover can supply it. Cropland and bare/sparse vegetation have a significantly lower supply, which is also due to their low portion in the Eastside Trail. Overall, the vegetation of this UGC can contribute to stormwater management (Atlanta Beltline, 2024a). However, the extent of its contribution to flood

regulation needs further investigations. Overall, the regulating services that can be supplied have the potential to address Atlanta's urban challenges, although the relevant services have limited potential supply capacity and need to be further enhanced.

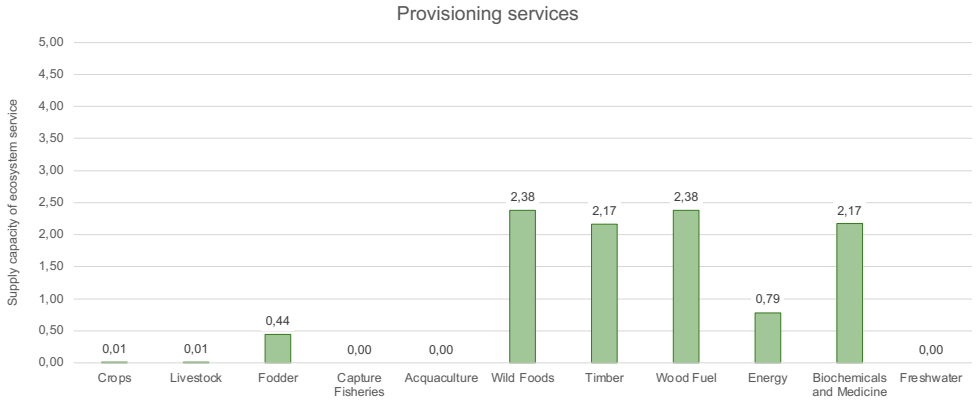


Figure 31: Overview of provisioning services provided by Eastside Trail

The Eastside Trail has the potential to supply provisioning services with capacities ranging from no relevant to medium relevant capacity, as visualized in Figure 31. Primarily, wild foods, wood fuel, timber, and biochemicals and medicine have the potential to be supplied. Particularly tree cover contributes to the supply capacity of these services. Also, cropland has the potential to supply provisioning services, although this land cover class only accounts for a small portion of this UGC. Grassland can supply provisioning services to a limited extent. According to a conducted interview and the review of literature, urban gardens appear to not be incorporated, although it can encourage community participation and engagement, while strengthening the human-nature relationship (Camps-Calvet et al., 2016, pp. 14–16).

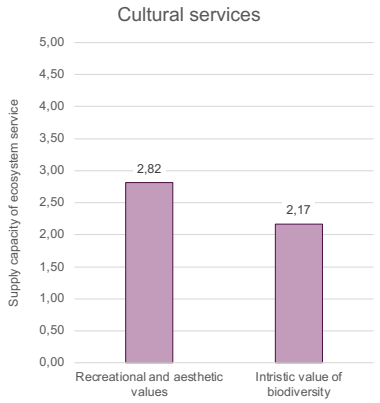


Figure 32: Overview of cultural services provided by Eastside Trail

In addition, the Eastside Trail of the Atlanta Beltline has the potential to supply cultural services. Specifically, tree cover, and grassland can provide recreational and aesthetic values. However, cropland and bare/sparse vegetation can potential these services, although these cover only a small portion limiting the potential supply. Particularly with regards to the aim of

providing recreation with this green corridor, the potential supply of this service can promote recreation with a medium relevant capacity. Also, the conducted study by Larson et al. (2016) highlight the provision of recreational opportunities of the Eastside Trail as one of the primary ecosystem services provided, while it facilitates social cohesion within communities (Larson et al., 2016, pp. 113–114). Also, Expert H & Expert I (p.c., 2025, p. 6) highlight the provision of recreational opportunities by this UGC, while providing a safe environment and enhanced connectivity within Atlanta.

Overall, the Eastside Trail has the potential to provide several ecosystem services that can contribute to address Atlanta's urban challenges. Particularly tree cover has a great potential to supply ecosystem services in this UGC. However, it has been detected that the potential supply of regulating services, particularly flood protection, is limited. This UGC has a greater potential to provide regulating and cultural services than provisioning services that are limited to timber-related services. However, it is important to note that built-up area with 35% is significantly limiting the potential supply of ecosystem services by this UGC.

6.4.4 Multifunctionality of Eastside Trail of Atlanta Beltline

The Eastside Trail has the potential to supply ecosystem services such as regulating and cultural services including local climate regulation, pollination, flood protection, air quality regulation and recreational values. These ecosystem services can contribute to addressing Atlanta’s urban challenges, while meeting the objectives of this UGC. This UGC is characterized by the Atlanta Beltline Arboretum that incorporates a variety of trees, that provide pollination and biodiversity (Expert H & Expert I, p.c., 2025, pp. 8–11). Particularly opportunities for recreation are provided by this UGC (Atlanta Beltline, 2024a), while the Atlanta Beltline Arboretum provides opportunities for scientific research and education on native plants, ecological restoration, and the reconnection of fragmented communities (Inner West Council, 2018, p. 74; Trees Atlanta, 2025). According to Expert H & Expert I (p.c., 2025, p. 9) various educational initiatives are being undertaken to enhance the human-nature connection including informal and educational events (Expert H & Expert I, p.c., 2025, p. 9). Besides this, opportunities for conservation practices are offered, including sustainable landscape practices, as highlighted by Expert H & Expert I (p.c., 2025, p. 15). Also, the conducted study by Landscape Architecture Foundation (2014, pp. 6–8) reveals that this green corridor is promoting active mobility. This UGC caused a significant increase in active mobility, both for commuting and recreational purposes (Expert H & Expert I, p.c., 2025, p. 7), while the Eastside trail is primarily used for active mobility (Byahut et al., 2020, p. 79). However, the intensive use of this UGC is critical and presents a critical challenge for the maintenance of this UGC, as highlighted by Expert H & Expert I (p.c., 2025, pp. 2–3). Particularly the

increasing use of electric bicycles is causing user conflicts due to the different levels of speed (Expert H & Expert I, p.c., 2025, pp. 12–13).

This UGC is contributing to economic development in its surrounding (Atlanta Beltline, 2025d). However, concerns have been raised about prioritizing catalyzing economic development over ensuring affordability (Byahut et al., 2020, pp. 75–76 and p. 92). A conducted study investigated the economic effect of this UGC focusing on housing affordability and gentrification (Bressane et al., 2024, pp. 1–2; Immergluck, Dan & Balan, 2018, pp. 546–547). It has been detected that particularly, lower-income communities in the surrounding neighborhoods are negatively impacted due to increasing property values resulting in displacement of residents (Byahut et al., 2020, p. 98; Immergluck, Dan & Balan, 2018, pp. 559–560). According to Expert H & Expert I (p.c., 2025, pp. 7–8), rising property values resulted in green gentrification, although initiatives are being taken to minimize the impact, such as through philanthropic donations. Furthermore, concerns are raised regarding the incorporation of the light rail due to its potential impact on biodiversity and removal of the meadow. Therefore, efforts are underway to maintain ecological services, such as planting short vegetation between the tracks (Expert H & Expert I, p.c., 2025, pp. 13–14).

Overall, the Eastside Trail of Atlanta Beltline can be considered as multifunctional UGC that can supply multiple ecosystem services and provide opportunities for active mobility and educational purposes, while it contributes to public health (Atlanta Beltline, 2024a). The incorporated Atlanta Beltline Arboretum can supply essential ecosystem services for addressing urban heat, air pollution, and pollination. However, the supply capacity is limited, especially flood regulation can only supplied to a limited extend. Economic development in the surrounding areas of Atlanta Beltline is a primary objective of this UGC, although it can result in the critical process of green gentrification. Also, community involvement appears to be limited and needs to be encouraged to raise public awareness and promote the conscious use of this UGC. The initial goals of this UGC including the enhanced connectivity, provision of active mobility opportunities, and the supply of pollination align partially with the ecosystem services and use of this UGC, although further investigations on the ecosystem services are necessary to enhance the supply. In addition, encouraging the community involvement is essential to promote environmental stewardship. Immergluck & Balan (2018, p. 548) highlight that this UGC is representative for the growing trend of large-scale projects involving the reuse of abandoned infrastructure.

6.5 Parkland Walk, London, Great Britain

London, located in Great Britain, is facing critical environmental challenges including air pollution, pressure on urban green spaces and more frequent and extreme weather events

due to climate change (Greater London Authority, 2018, p. 4 and p. 13, 2020, pp. 16–18). Climate change is exposing London to an increasing risk of flooding, which is further exacerbated due to impervious surfaces and lack of green space. Also, London is exposed to heat due to rising temperatures, more frequent extreme heat waves and the urban heat island effect with significant impacts on the public (Greater London Authority, 2018, p. 13, 2020, p. 42). Rising temperatures are resulting in an increasing drought risk (Greater London Authority, 2020, pp. 18–22). The loss of urban green spaces and decline of urban biodiversity are critical consequences due to London's urban development (Greater London Authority, 2018, p. 13). London will continue to urbanize, which will increasingly pressure London's environment. Therefore, the access to green spaces and incorporation of green infrastructure is essential to enhance London's resilience and sustainability (Greater London Authority, 2018, pp. 18–21). London is aiming to become the world's first national park city, with more than half of its area as green space (Greater London Authority, 2018, p. 29). Preserving and protecting London's urban green spaces, such as the UGC Parkland Walk.

6.5.1 Development of Parkland Walk

In northern London, the Parkland Walk runs along the old railway line between Finsbury Park and Alexandra Palace (Haringey Council, n.d., a; Islington Council n.d.). The former railway line was disused in the 1970s, resulting in a neglected piece of land that developed as natural green space. This space was used by the local community for walking and other activities. Despite opposition from the local community the Council initiated ideas for land use plans such as housing and a highway. This led to a community campaign to preserve the Parkland Walk resulting in a development rejection in 1979 due to the ecological value going beyond community interests. The Council began strengthening the bridges as well as enhance accessibility of this green corridor (Haringey Council, 2023b, p. 44; Expert J & Expert K, p.c., 2025, pp. 1–2). In 1990 this UGC has been designated as Local Nature Reserve and is one Site of Metropolitan Importance for Nature Conservation (Haringey Council, 2023b, p. 8). Also, this green corridor is part of London's Capital Ring Walk providing opportunities for active mobility (Haringey Council, 2023b, p. 22). Today, it presents London's longest Local Nature Reserve with its 3.5 km and is in the dense urban area Inner London running through London's two boroughs Haringey and Islington (Haringey Council, 2023b, pp. 6–8, n.d., a; Islington Council n.d.,). While most of the Parkland Walk is in Haringey, a short section is in Islington. This green corridor is split up into Parkland Walk South running from Finsbury Park to Highgate and Parkland Walk North running from Cranley Gardens to Alexandra Palace Park. The Parkland Walk is primarily surrounded by adjacent privately owned properties, while it is characterized by bridges and underpasses (Haringey Council, 2023b, pp. 8-10). The location of the Parkland Walk is visualized in Figure 33.

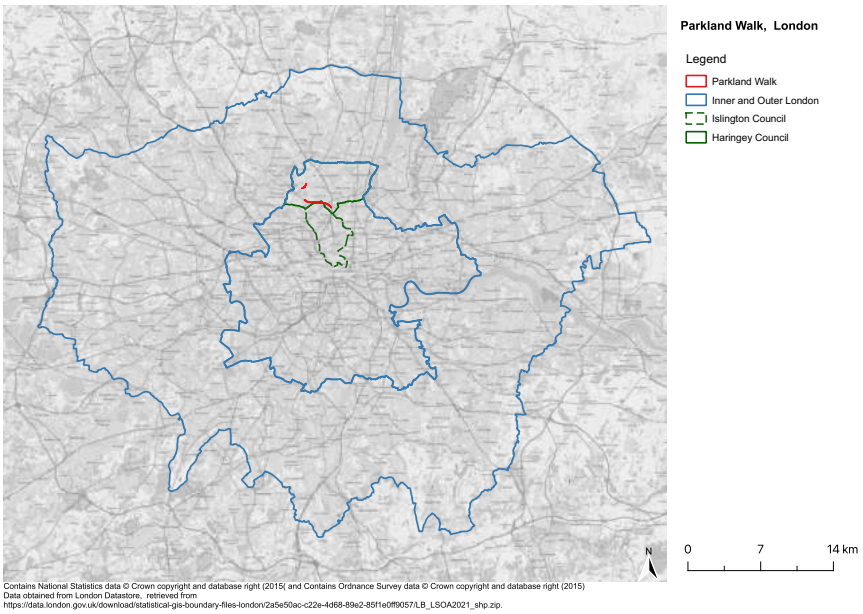


Figure 33: Location of the Parkland Walk

The Parkland Walk has a great importance for the urban area of London as it provides connectivity of green spaces, an ecological link for biodiversity, habitat, and opportunities for recreation and active mobility, as highlighted by Expert J & Expert K (p.c., 2025, p. 5). This green corridor is statutory designated for nature conservation, while it has a great importance for wildlife and diversity (Haringey Council, 2023a, pp. 19–20). Also, it compromises various species as well as buildings and other structures (Haringey Council, 2023b, p. 42; Islington Council, 2020, p. 18). Impressions of the Parkland Walk are visualized in Figure 34.

Figure 34: Impressions of the Parkland Walk (Photographs by Expert K, used with permission, 2025)

It is important to mention that London's boroughs are overall characterized by limited green spaces such as Haringey that is lacking open spaces such as public parks, highlighting the importance on conserving the Parkland Walk (Haringey Council, 2023b, p. 7). In Islington the Parkland Walk comprises the largest area of woodland in this borough, highlighting its importance (Islington Council, 2020, p. 18). Due to its designation as Local Nature Reserve this green corridor prioritizes pedestrians and permits only considerate cycling, while the

operation of service vehicles within the Parkland Walk is kept to a minimum (Haringey Council, 2023b, p. 15).

6.5.2 Identification of key stakeholders

The Parkland Walk is owned by both Haringey and Islington Council. Both Councils are responsible for the management (Islington Council; Expert J & Expert K, p.c., 2025, pp. 2–3). Haringey Council is managing the Parkland Walk in terms of the heritage of the railway line, ecology, and infrastructure (Haringey Council, 2023b, p. 7, n.d., b). Also, Haringey Council is funding The Conservation Volunteers (TCV) group to manage the green spaces of the Parkland Walk in Haringey Council (Expert J & Expert K, p.c., 2025, pp. 8–9; The Conservation Volunteers, 2025). Therefore, TCV is conducting activities with local community volunteers in terms of cutting back of invasive species, establishment of dead hedges, and wildlife surveys (Haringey Council, 2025; Parkland Walk, 2025a). Volunteering and community involvement in the Parkland Walk is encouraged and supported by Haringey Council (Haringey Council, 2023b, p. 39). Islington Council manages its nature reserves, including the Parkland Walk, through Islington Council's Nature Reserves Volunteer Group (Islington Council, n.d.). This volunteer group meets weekly to carry out conservation work on Islinton's nature reserves, including meadow mowing, tree cutting, bramble cutting and weeding wildlife gardens (Islington Council, 2022). According to Expert J & Expert K (p.c., 2025, pp. 3–5), collaboration between the department that is responsible for infrastructure and the department that is responsible for ecology is limited. Overall, infrastructure is prioritized over ecological concerns, as highlighted through the replacement of bridges with highly engineered bridges and the construction of ramps for wheelchair accessibility requiring an extensive vegetation removal. Also, Islington Council is prioritizing decision-making within its conservation and parks department, despite its great concentration of bridges in the part in Islington of this UGC. Haringey Council is prioritizing decision-making in its infrastructural department although its section is characterized by a large amount of greenery. These differing priorities present critical factors for the conservation and protection of the Parkland Walk.

The Friends of the Parkland Walk is a voluntary community group that advocates for the enhancement and protection of the Parkland Walk (Islington Council), although it has no legal responsibilities over the Parkland Walk (Parkland Walk, 2025b). However, this organization is collaborating with the Councils to encourage the protection and conservation of the Parkland Walk, as pointed out in an interview with Expert J & Expert K (p.c., 2025, p. 1). According to Expert J & Expert K (p.c., 2025, pp. 8–9) Islington Council manages the Parkland Walk adequately. However, the Friends of the Parkland Walk consult Haringey Council regarding decision-making about this UGC. Also, conservation and light maintenance work is undertaken by the Friends of the Parkland Walk aiming to achieve a balance between the

ecology and usage of this green corridor. Different surveys focusing on wildlife and path usage have been conducted by the Friends of the Parkland Walk. Additionally, this voluntary community group incorporated a wildlife trail as conservation project at the end of the Parkland Walk South for encouraging the use of this UGC for educational purposes (Haringey Council, 2023b, pp. 40–41).

According to Expert J & Expert K (p.c., 2025, p. 9), the conservation of this UGC is challenged due to limited resources for developing an updated management plan since the management plan from 2008 has not been adopted due to limited resources. However, the current Conservation Officer at Haringey Council is committed to developing a new management plan for the Parkland Walk, although funding remains a challenge. The Friends of the Parkland Walk are gathering information and data on the current condition of this UGC through surveys to attract external funding for conservation work (Expert J & Expert K, p.c., 2025, pp. 9–10). Accordingly, the active involvement of this voluntary community group can enhance the conservation of this UGC.

6.5.3 Urban ecosystem services of Parkland Walk

In this section the ecosystem services that can be supplied by the Parkland Walk are quantified with the focus on the ecosystem services that are relevant for addressing London's urban challenges. The land cover classes of the northern part of the Parkland Walk are visualized in Figure 35, while the other parts are visualized in Appendix G.

Figure 35: Overview of the land cover classes of the northern part of the Parkland Walk

Through the mapping of the Parkland Walk it has been detected that it is characterized by the two land cover classes tree cover and built-up, as shown in Figure 36. The Parkland Walk consists primarily of tree cover with 98%, while only 2% are covered by built-up.

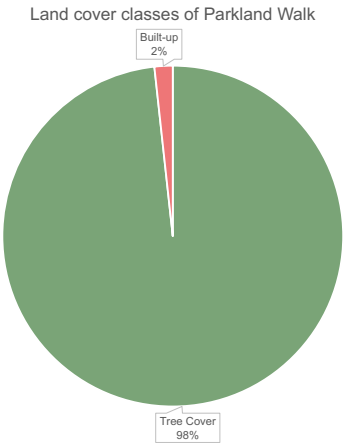


Figure 36: Proportion of land cover classes in the Parkland Walk

London is facing various urban challenges such as heat risk, flood risk, air pollution, and biodiversity decline. Particularly ecology has a high priority for this UGC due to its designation as Local Nature Reserve. The potential supply for regulating, provisioning, and cultural services are visualized in Figure 37, Figure 38 and Figure 39.

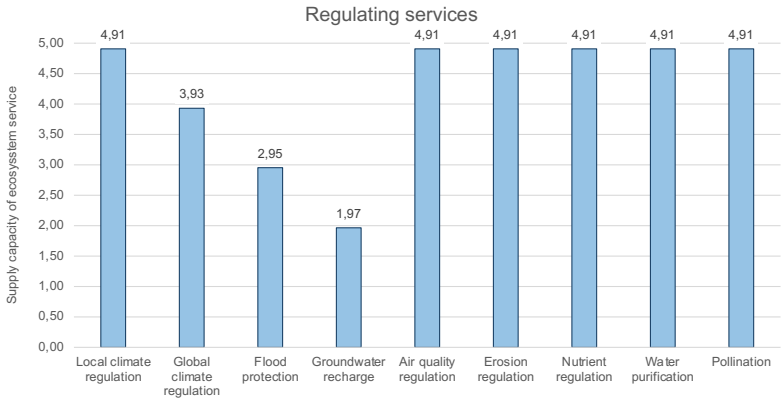


Figure 37: Overview of regulating services provided by Parkland Walk

The Parkland Walk has the potential to supply regulating services, while only the tree cover has the potential to provide regulating services. The supply values for regulating services range from relevant capacity to very high relevant capacity. The most relevant regulating ecosystem services are local climate regulation, air quality regulation, flood regulation and pollination for addressing London's urban challenges. Local climate regulation, air quality regulation, erosion regulation, water purification, and pollination have the greatest supply value with 4.91 as very high relevant capacity. Particularly urban heat mitigation and air quality improvement can be facilitated by this UGC. Also, Haringey Council (2023b, pp. 10–11) highlight that the Parkland Walk is characterized by a great tree canopy that provide urban heat mitigation through shading. The potential of improving air quality is also emphasized in Figure 37 with a very high relevant capacity. This supply is essential due to London's poor air

quality. Also, carbon sequestration contributes to air quality regulation and to global climate regulation with a high relevant capacity to supply by the Parkland Walk. This contribution has also been highlighted by Expert J & Expert K (p.c., 2025, pp. 7–8), as the vegetation contributes to carbon sequestration. Pollination, which is crucial for addressing biodiversity loss, has the potential to be provided by this UGC with a very high relevant capacity. Overall, pollination plays a key role for enhancing biodiversity and addressing London's decline in biodiversity, while it impacts human health and food security (Vanbergen & Initiative, 2013, p. 251). Flood protection can also be supplied by the Parkland Walk with a supply value of 2.95 as medium relevant capacity. However, this supply value is significantly lower than the other relevant regulating services. This is critical due to London's vulnerability to flooding. Further determining this regulating service requires site-specific studies, as well as investigating the flood risk to analyze the demand for it and potentially enhancing this service.

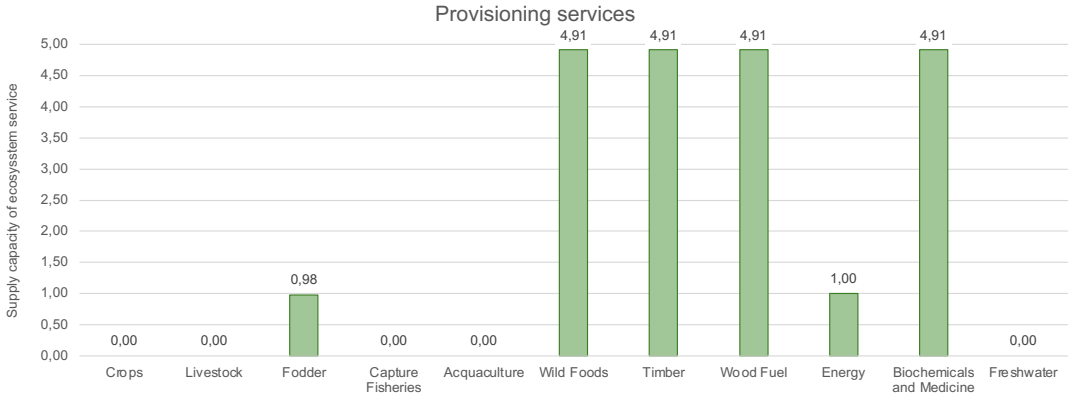


Figure 38: Overview of provisioning services provided by Parkland Walk

The Parkland Walk can provide provisioning services ranging from no relevant capacity to very high relevant capacity. The most relevant ecosystem services are wild food, timber, wood fuel, and biochemicals and medicines that can be provided by the abundant tree cover. The built-up area does not contribute to the provisioning values except to the ecosystem service energy, although only to a limited extent. Overall, the supply of provisioning services depends on the abundance of tree cover of the Parkland Walk and its potential to provide these services. Besides this, through the conducted interview and review of literature the Parkland Walk it has been detected that it lacks urban gardens that can enhance the provision of provisioning services.

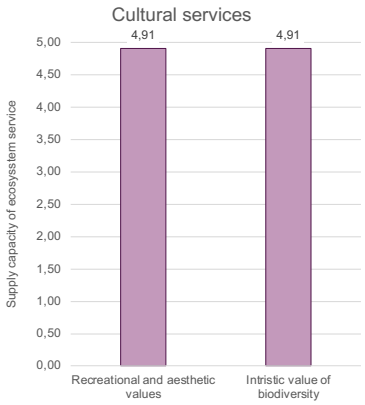


Figure 39: Overview of cultural services provided by Parkland Walk

Cultural services can be supplied by the Parkland Walk with a very high relevant capacity including recreational and aesthetic values as well as an intrinsic value of biodiversity due to the abundant tree cover. This can encourage and promote the public's use of this green corridor. According to Expert J & Expert K (p.c., 2025, pp. 7–8), the Parkland Walk has become popular for its recreational opportunities. Besides this, this UGC has the potential to provide an intrinsic value of biodiversity with a very high relevant capacity. This highlights the independent value of the Parkland Walk from its biodiversity benefits to the public (Ghilarov, 2000, p. 411).

Overall, the Parkland Walk is characterized by 98% tree cover that is significantly influencing the potential supply of ecosystem services since the built-up area with 2% is not contributing to the potential supply except of a low potential to supply energy. According to Expert J & Expert K (p.c., 2025, pp. 7–8), the great tree canopy of the Parkland Walk is critical due to the unbalance between tree cover and open space and requires woodland management. Nevertheless, the Parkland Walk has a great potential to supply regulating ecosystem services that can address London’s urban challenges, while cultural services can promote the use of this green corridor such as for recreational purposes. However, it is crucial to consider and address potential trade-offs, such as the increasing use of this UGC, which can lead to a decline in biodiversity.

6.5.4 Multifunctionality of Parkland Walk

In the Parkland Walk tree cover is making up about 98% with the potential to supply ecosystem services that are crucial for London’s urban challenges including local climate regulation, air quality regulation, flood protection, and pollination. Also, recreational and aesthetic values can be supplied, while this UGC provides various habitats, wildlife and species (Haringey Council, n.d., a). Acidic grassland that is characterizing the Islington section of the Parkland Walk is supporting several rare species (Islington Council, n.d.). However, this land cover type is not mapped previously which is due to the limited resolution and accuracy of the used dataset.

Also, this green corridor offers educational opportunities, such as the integrated wildlife trail (Haringey Council, 2023b, pp. 40–41), which is shown in Figure 40. This has the potential to encourage public engagement and raise awareness on the importance of nature.

Figure 40: Impressions of the wildlife trail of the Parkland Walk (Photograph by Expert K, used with permission, 2025)

Currently, the Parkland Walk is used for active mobility such as cycling, walking, and running. Particularly pedestrians are prioritized due to its designation as Local Nature Reserve (Haringey Council, n.d., a). According to Expert J & Expert K (p.c., 2025, pp. 12–13), this UGC is primarily used for running. However, emerging user conflicts due to different speeds have been raised (Expert J & Expert K, p.c., 2025, pp. 12–13). Also, the use of electric bikes presents a critical factor in the Parkland Walk due to the demand for less natural surfaces. This is in contradiction with the designation of this UGC as Local Nature Reserve, which is intended to be close to nature (Expert J & Expert K, p.c., 2025, p. 6). The priority of this green corridor should focus on the conservation instead of remodeling it for active mobility purposes, as highlighted by Expert J & Expert K (p.c., 2025, p. 6). The Parkland Walk is significantly affected by the intensive use by the public for active mobility, resulting in ecological degradation (Haringey Climate Forum, 2020). Particularly the decline of wildlife has been highlighted by Expert J & Expert K (p.c., 2025, p. 6), although there has been no scientific proof for it.

The conservation of this UGC depends on financial resources to carry out conservation work. In recent years, the use of this site as a public amenity and its lack of management have significantly impacted biodiversity. The current management plan prioritizes park facilities such as enhanced accessibility and the incorporation of sport facilities over nature conservation. This is critical for the conservation of the Parkland Walk, as pointed out by Expert J & Expert K (p.c., 2025, pp. 5–6). Also, limited financial resources of Haringey Council and limited expertise on the conservation of such Local Nature Reserve present barriers for

an updated management plan. Therefore, the Friends of the Parkland Walk are engaged to promote its conservation and consult with local councils. Surveys are conducted by this volunteering community group to attract external funding for conservation work (Expert J & Expert K, p.c., 2025, pp. 9–15). In the recent years, damages of bridges and subsidence caused a critical removal of trees (Haringey Council, 2023b, pp. 10–11). This underscores the prioritization of infrastructure over ecological concerns in the context of the Parkland Walk by the local councils, as highlighted by Expert J & Expert K (p.c., 2025, p. 12). The Friends of the Parkland Walk advocate for changing the critical public's perception on the Parkland Walk as Local Nature Reserve. This is particularly crucial since the Parkland Walk's biodiversity and nature have been impacted due to the volume of users and unconscious use such as residents using informal accesses through their garden. Also, invasive species due to surrounding gardens impact the biodiversity and require management efforts, as highlighted by Expert J & Expert K (p.c., 2025, pp. 5–8).

The Parkland Walk has the potential to supply essential ecosystem services with a high relevant capacity, while it provides opportunities for active mobility and education. Particularly educational opportunities have the potential to raise awareness on the importance of nature. This is particularly essential due to the critical publics' perception resulting in significant impacts on biodiversity. Overall, this UGC offers opportunities to engage the public with nature and to enhance the relationship between people and nature, as highlighted by Expert J & Expert K (p.c., 2025, pp. 17–19). Also, Expert J & Expert K (p.c., 2025, pp. 17–19) highlight that the Parkland Walk, as a Local Nature Reserve, has the potential to be perceived as a great example of a successful UGC within a dense urban area, however its conservation presents a critical factor due to the limited resources and limited efforts particularly by Haringey Council. This UGC serves as multifunctional space through the provision of multiple ecosystem services and opportunities for active mobility as well as education. Also, the primary objectives of this UGC in terms of supplying pollination and recreational opportunities align with the identified ecosystem services and use of it. However, the supply capacity of flood protection appears to require further measures to be enhanced for addressing London's flood risk. Particularly the Friends of the Parkland Walk as voluntary community group play a crucial role in the conservation of this UGC by conducting studies that are fundamental to obtaining potential funding for conservation work.

7 Discussion

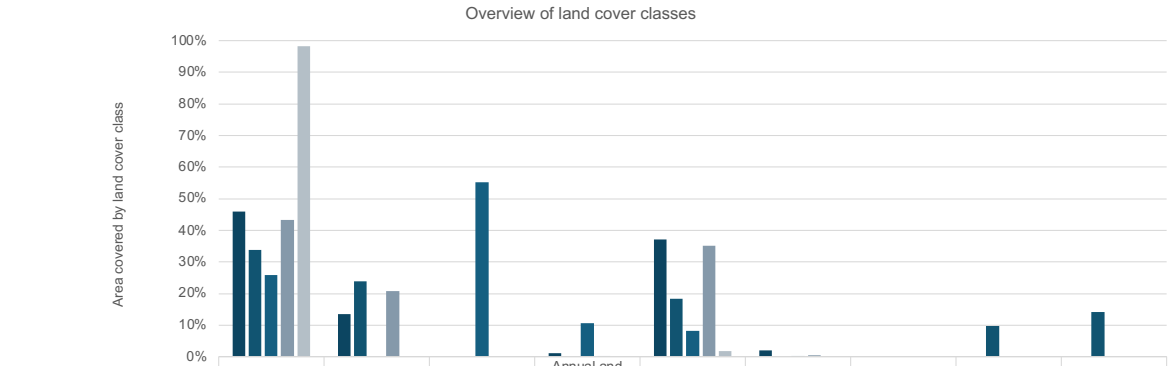
In this chapter the results of the analyzed UGCs are interpreted with regards to the main research question to explore the contribution of UGCs to sustainable urban environments through the supply of ecosystem services. Therefore, a comparative case study analysis is conducted for identifying similarities and differences. Besides this, the limitations of this thesis are highlighted.

7.1 Comparative case study analysis

In this section the quantified ecosystem services through the conducted ecosystem service assessment of the UGCs are compared, while the multifunctionality of the UGCs is discussed. Emerging trade-offs and conflicts of the analyzed case studies are also outlined in this section. Moreover, the role of the local community in the various UGCs is examined to highlight how community participation influences and contributes to their success.

7.1.1 Ecosystem service assessment

To compare the quantified ecosystem services of the UGCs, it is essential to understand their underlying land cover composition. Therefore, Figure 41 visualizes the distribution of the land cover classes of the UGCs.



	Mixed forest	Green urban areas	Natural grassland	Annual and permanent crops	Continuous urban fabric	Bare rock	Water bodies	Water courses	Salt marshes
Midtown Greenway	45,98%	13,61%	0,00%	1,21%	37,17%	2,00%	0,00%	0,00%	0,00%
Cooks to Cove GreenWay	33,80%	23,94%	0,00%	0,00%	18,31%	0,00%	0,00%	9,86%	14,08%
The Meadoway	25,87%	0,00%	55,18%	10,64%	8,14%	0,17%	0,00%	0,00%	0,00%
Eastside Trail of Atlanta Beltline	43,38%	20,85%	0,00%	0,14%	35,04%	0,59%	0,00%	0,00%	0,00%
Parkland Walk	98,27%	0,00%	0,00%	0,00%	1,73%	0,00%	0,00%	0,00%	0,00%

Figure 41: Overview of land cover classes of the selected UGCs

The Parkland Walk has the highest percentage of tree cover, classified as mixed forest after CORINE land cover classes, with 98%, while The Meadoway has the lowest percentage with 26%. However, The Meadoway has the greatest percentage of natural grassland with 55%, as it is characterized by a native meadow that has been planted to increase biodiversity and pollination. Additionally, this green corridor has the greatest percentage covered by cropland with around 11%. The Cooks to Cove GreenWay and Eastside Trail of Atlanta Beltline has

similar amount of green urban areas with 21% to 24%. The Midtown Greenway and the Eastside Trail of Atlanta Beltline have the largest built-up portions classified as “continuous urban fabric” according to the CORINE land cover classification system with 35% to 37%. In comparison to this, the Parkland Walk has the lowest built-up area with 2%. The Cooks to Cove Greenway is the only green corridor with area covered by water courses and salt marshes.

However, it is important to note that the length of the selected green corridors varies from 3 to 16 kilometers. The analysis of the case studies indicates that the Parkland Walk has great potential to supply ecosystem services due to its substantial tree cover. The Meadoway is characterized by a substantial potential for ecosystem services, attributable to its natural grassland and tree cover. Besides this, the distribution of the land cover types of the Midtown Greenway and Eastside Trail of the Atlanta Beltline have similar portions.

For the comparative case study analysis an overview of the supply capacities of the selected UGCs is provided in Table 7. Therefore, Table 6 provides a legend that explains the color scheme used to visualize the ecosystem service supply capacities of UGCs.

Table 6: Legend to the ecosystem service supply capacities of UGCs after Burkhard et al. (2009)

Legend	
0	no relevant capacity
(0,1]	low relevant capacity
(1,2]	relevant capacity
(2,3]	medium relevant capacity
(3,4]	high relevant capacity
(4,5]	very high relevant capacity

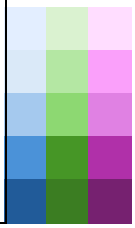


Table 7: Overview of ecosystem service supply capacities of the case studies

Ecosystem service after Burkhard et al.		Midtown Greenway	Cooks to Cove GreenWay	The Meadoway	Eastside Trail of Atlanta Beltline	Parkland Walk
Regulating services	Local climate regulation	2,60	2,41	2,61	2,59	4,91
	Global climate regulation	1,99	1,59	2,80	1,94	3,93
	Flood protection	1,41	1,92	1,44	1,31	2,95
	Groundwater recharge	1,22	1,25	1,18	1,29	1,97
	Air quality regulation	2,45	1,93	1,40	2,38	4,91
	Erosion regulation	2,58	2,17	4,16	2,59	4,91
	Nutrient regulation	2,44	2,51	4,05	2,38	4,91
	Water purification	2,46	2,23	4,05	2,38	4,91
	Pollination	2,44	1,93	1,29	2,38	4,91
Provisioning services	Crops	0,06	0,00	0,53	0,01	0,00
	Livestock	0,06	0,28	2,19	0,01	0,00
	Fodder	0,52	0,34	0,79	0,44	0,98
	Capture Fisheries	0,00	0,30	0,00	0,00	0,00
	Acquaculture	0,00	0,00	0,00	0,00	0,00
	Wild Foods	2,44	2,32	2,40	2,38	4,91
	Timber	2,30	1,69	1,29	2,17	4,91
	Wood Fuel	2,44	1,93	1,29	2,38	4,91
	Energy	0,84	0,82	0,45	0,79	1,00
	Biochemicals and Medicine	2,31	1,69	1,40	2,17	4,91
	Freshwater	0,00	0,49	0,00	0,00	0,00
Cultural services	Recreational and aesthetic values	2,80	3,32	3,06	2,82	4,91
	Intristic value of biodiversity	2,30	2,18	2,95	2,17	4,91

Significant differences in the supply capacities of the different UGCs are highlighted through Table 7. Particularly the Parkland Walk has a high supply capacity of ecosystem services due to its abundant tree cover. In comparison, the Cooks to Cove GreenWay has the lowest supply potential in comparison to the other UGCs. However, this green corridor is an ongoing development that may have higher supply capacities once completed through the incorporation of greenery. The Midtown Greenway and Eastside Trail of the Atlanta Beltline have similar supply capacities, which is due to their similar objectives with a primary focus on enhancing connectivity and providing active mobility opportunities. However, the vegetation of the Midtown Greenway, that has been subsequently planned, has higher supply capacities than the Eastside Trail. The incorporation of the linear Atlanta Beltline Arboretum is particularly noteworthy, as it is designed to have a substantial impact on pollination and biodiversity. Nevertheless, the Atlanta Beltline Arboretum does not provide significantly higher supply capacities than the vegetation comprising the Midtown Greenway. This is due to the similar portion of tree cover in both UGCs. In addition, The Meadoway, which consists primarily of meadows, has great potential to provide regulating services although the supply capacity significantly differs.

The five UGCs are located in cities that are facing critical impacts due to climate change such as rising temperatures and flood risk making the supply of local climate regulation and flood protection essential. Local climate regulation can be supplied by the different UGCs with supply values ranging from 2.41 to 2.61 as medium relevant capacity, except of the Parkland Walk with a supply value of 4.91 as very high relevant capacity due to its tree cover. However, the uneven distribution of tree cover and open space has been highlighted as critical and requires woodland management. Nevertheless, as Minneapolis, Sydney's Inner West, Toronto, and Atlanta face rising temperatures, supplying local climate regulation by the UGCs is essential. Therefore, efforts should focus on enhancing the supply of this regulating service. Besides this, flood protection can only be provided to a limited extent by the different UGCs, making it essential to further investigate the flood risk in these areas and potentially adapt these UGCs to supply flood regulation. The supply of flood protection of the selected UGCs ranges from relevant to medium relevant capacity, while the Parkland Walk is characterized by the highest potential supply of this regulating service with a value of 2.95 as medium relevant capacity. The other UGCs have a limited capacity to supply flood regulation with values ranging between 1.31 to 1.92 as relevant capacity. Also, parts of the Midtown Greenway are constructed below grade, which can contribute to flood protection in the surrounding areas. Overall, increasing extreme weather events due to climate change, highlight the importance of flood protection through UGC. Therefore, further investigations on the flood risk in the UGCs including the area's vulnerability and topography is necessary.

However, it is important to note that field investigations of The Meadoway revealed the contribution of this green corridor to flood attenuation and temperature regulation. Therefore, it is important to note that the conducted assessment is a simplification with limited accuracy due to the lack of site-specific, primary data. Accordingly, the ecosystem services supply by this UGC may not be accurately represented through the conducted ecosystem service assessment and necessitates further investigations.

Besides this, air pollution is an urban challenge making the supply of air quality regulation by UGCs crucial. The calculated supply values of the different UGCs vary significantly and range from relevant to very high relevant capacity with supply values between 1.40 to 4.91. The Cooks to Cove GreenWay and The Meadoway are characterized by relevant capacity, highlighting the need to investigate how air quality regulation can be enhanced such as through the incorporation of vegetation. The Midtown Greenway and Eastside Trail are both characterized by medium relevant capacity primarily due to their abundant portion of tree cover with about 45%, while the Parkland Walk has a very high capacity to supply this regulating service. Overall, enhancing the supply of this regulating service by UGCs is essential due to its significant impact on public health.

Additionally, the decline in biodiversity as urban challenge highlights the importance for the regulating service pollination. The potential supply of this service ranges from relevant to very high relevant capacity. The Meadoway and Cooks to Cove GreenWay are characterized by the lowest supply capacity with supply values ranging from 1.29 to 1.93 as relevant capacity. However, it is crucial to note that both developments are ongoing projects that may not be fully displayed through the conducted ecosystem service assessment. Particularly, the Cooks to Cove GreenWay has been initiated due to environmental concerns aiming to enhance biodiversity and pollination. Through annually monitoring of The Meadoway a significant increase in pollination and biodiversity has been detected in the recent years. This UGC is characterized by a native meadow that has been categorized as natural grassland. However, the identified potential supply is in contradiction with the annual monitoring that detected a significant increase in pollination in the recent years. The Midtown Greenway and Eastside Trail of Atlanta Beltline have a medium relevant capacity for supplying pollination. This is primarily due to the 43% to 46% of tree cover in these green corridors, although these two green corridors are characterized by the greatest amount of built-up area with 35% to 37%. The Atlanta Beltline Arboretum aims to provide pollination, while it has only a medium capacity as detected through the assessment. The incorporation of pollinator gardens into the Midtown Greenway can enhance pollination. However, except for the Parkland Walk, that has a very high capacity for pollination with a supply value of 4.91, the other UGCs have limited potential for pollination. Therefore, it is necessary to consider ways to enhance pollination in UGCs.

Besides this, the selected UGCs are characterized by different supply values for the supply of provisioning services. The Parkland Walk, Midtown Greenway, and Eastside Trail have the greatest potential to supply these services due to their great tree canopy cover. The Meadoway and the Midtown Greenway are characterized by urban gardens that have the potential to enhance the supply of provisioning services, while these encourage the active involvement of the local community. Besides this, it has the potential to raise awareness and promote environmental stewardship. Community participation in urban garden practices can strengthen the nature-human relationship. However, the consideration of provisioning services supplied by the selected UGCs is limited, with the exception of these two UGCs due to the incorporated urban gardens.

The supply of cultural services such as recreational and aesthetic values for ensuring the urban livability is crucial. Particularly active mobility opportunities such as cycling and walking, is an objective of the analyzed UGCs that can be enhanced through recreational and aesthetic values. The UGCs have the potential to supply recreational and aesthetic values with a supply capacity ranging from medium to very high relevant capacity, highlighting the promotion for using these spaces for recreational purposes. The Midtown Greenway and Eastside Trail of Atlanta Beltline have a medium relevant capacity to supply recreational and aesthetic values with values ranging from 2.80 to 2.82. The Cooks to Cove GreenWay and The Meadoway have a high relevant capacity to supply recreational and aesthetic values with supply values ranging from 3.06 to 3.32. However, the Parkland Walk has the highest supply capacity with a value of 4.91 as very high relevant capacity, that is due to its abundant tree cover. Through the involvement of the parks department in the Midtown Greenway, due to its designation as regional trail, can enhance its recreational value through the incorporation of greenery and other elements. Also, the ongoing development of The Meadoway and Cooks to Cove GreenWay can enhance recreational values of these UGCs. Today, all of the selected UGCs serve as active mobility corridors primarily for cycling and walking.

For some of the selected UGCs educational opportunities such as for the Parkland Walk, The Meadoway, the Cooks to Cove GreenWay and the Eastside Trail have been highlighted by the interview partners. The conservation project incorporated into the Parkland Walk provides educational opportunities. Also, educational programs have been established for the Cooks to Cove GreenWay to educate on the importance of nature. The Meadoway serves for educational purposes such as hands-on activities, field trips as well as conservation work through education programs. Besides this, the Atlanta Beltline Arboretum serves for educational purposes as well as scientific research, while guided walks educate on native species. This raises awareness on the importance on nature, while further strengthening the human-nature connection.

The supply capacities of ecosystem services by the Cooks to Cove GreenWay and The Meadoway are limited although the built-up area is lower in comparison to the Midtown Greenway and Eastside Trail of Atlanta Beltline. Particularly, tree cover of the Midtown Greenway, Eastside Trail of Atlanta Beltline and Parkland Walk enhance the supply capacity of ecosystem services including local climate regulation, air quality regulation and pollination. Although the Parkland Walk has only a length of 3.5 km, it has the highest overall supply capacity of ecosystem services compared to the other UGCs, which vary in length between 3 and 16 km. However, further site-specific studies are needed to explore the actual supply of ecosystem services. The condition of the UGC is a critical factor that impacts the supply of ecosystem services and needs to be taken into consideration. Also, investigations going beyond the supply of these services are essential, including the demand of ecosystem services to highlight which ecosystem services are needed for addressing the needs of society and environmental challenges. Therefore, the spatial scale of UGCs and analyzing of the surrounding areas needs to be considered, including demographics, urban structure, topography, proximity to green spaces, and accessibility. Particularly, the Parkland Walk has a high supply potential that benefits urban residents. However, the decline in biodiversity and the great tree canopy is critical and needs to be addressed through conservation and wood maintenance work. Furthermore, it is essential to adapt UGCs including its vegetation to future changes due to its significance for urban areas its residents and environment. Also, the supply of ecosystem services that can adapt and mitigate climate change must be considered so that the UGCs serve as climate-effective spaces.

This thesis partially highlights the synergies and trade-offs, such as the potential enhancement of recreational values of UGCs through the supply of regulating services, which may result from a more comfortable climate, as evidenced by temperature regulation. Moreover, the provisioning services may result in a reduction of regulating services, such as pollination. Further site-specific studies are needed to identify synergies and trade-offs in greater depth. This is because it is not possible to identify these phenomena at a more detailed level using the publicly available data and information collected throughout this thesis project.

Besides this, the public use of UGCs is critical due to limited public's awareness on nature and its importance. The overuse and unconscious use of these spaces can result in a significant loss of biodiversity. Particularly the Parkland Walk that is designated as Local Nature Reserve has experienced an intensive use leading to a critical decline in biodiversity. Also, conflicts such as between users due to different speed levels have been highlighted for different UGCs including a critical rise in electric bikes. Therefore, it is important to raise awareness on the importance of nature and encourage the conscious use of these spaces

through different initiatives that can facilitate changing the public's perception such as the encouraged use of these spaces for educational purposes and urban gardening.

Emerging conflicts have been highlighted through the conducted analysis of the UGCs. Particularly the prioritization of infrastructure over ecology due to conflicting interests of the involved stakeholders has been highlighted during interviews about the Midtown Greenway, Cooks to Cove GreenWay and the Parkland Walk. This prioritization is critical due to limited financial resources and in general limited efforts for conservation that is essential for enhancing the supply of ecosystem services and biodiversity. Also, ensuring the long-term management and maintenance of these UGCs is challenging. This is primarily due to the prioritization of other developments, limited expertise, and limited financial resources. The incorporation of large-scale UGI such as UGCs catalyzes the economy that can result in critical consequences such as gentrification and environmental impacts due to new developments. These consequences need to be mitigated.

The aim of the creating multifunctional UGCs has been integrated from early stages on into the development of the Cooks to Cove GreenWay, The Meadoway, and the Eastside Trail. The Parkland Walk was also planned as multifunctional UGC, although ecological priorities initially guided its development. In contrast, multifunctionality appears to have been incorporated into the Midtown Greenway to a limited extend, as it was intended to serve as active mobility corridor. However, subsequently incorporation of elements such as vegetation, urban gardens, and public art has enhanced its multifunctionality. Through the analysis of the UGCs it has been detected that these serve multifunctional spaces. The UGCs have the potential to supply multiple ecosystem services simultaneously that can address urban challenges such as flooding and urban heat, while also providing opportunities for recreation, active mobility, education, and scientific research. Additionally, it is important to note that some of the ecosystem services may need to evolve over time to get mature such as pollination and this evolution must be considered during the monitoring of ecosystem services. Also, the UGCs have the potential to supply a wide range of ecosystem services including global climate regulation, groundwater recharge, nutrient cycling, and erosion regulation, although these services are not further discussed in this thesis since the focus is set on the most relevant ecosystem services for addressing the urban challenges the cities in which the selected UGC are located.

Overall, it is important to note that the importance of incorporating UGCs go beyond the supply of ecosystem services that are benefitting urban residents, while enhancing the urban livability. These spaces address social needs and environmental challenges such as the provision of habitat and enhancement of connectivity for human and wildlife. The supply of temperature

regulation, social interaction, flood mitigation, pollination, air quality regulation, and opportunities for recreation, scientific research and education highlight the multifunctionality of UGCs that is crucial to ensure sustainable urban environments. However, the extent to which ecosystem services are supplied impacts the benefits that urban residents derived from ecosystems and therefore further efforts should focus on the enhancement of these services.

7.1.2 Role of the local community

UGCs involve various stakeholders impact the provision of ecosystem services due to their decision. Also, the local community plays a crucial role in the development and management of UGCs, while UGCs directly impact the local community by providing ecosystem services, enhancing connectivity, and providing active mobility opportunities. Therefore, the role of the local community is discussed in this section.

The development of the Midtown Greenway, the Cooks to Cove GreenWay, and Atlanta Beltline have been initiated by grassroot efforts, that shaped the initial idea of these UGCs. As nonprofit organization, the Midtown Greenway Coalition played a crucial role in the development of the Midtown Greenway due to its grassroots efforts and advocacy for the trail. Today, the protection and improvement are encouraged by this organization, while it is installing public art in this UGC for representing the local community. Hennepin County is making limited efforts to manage the Midtown Greenway, which highlights the importance of the efforts of the Midtown Greenway Coalition. Similarly, the Atlanta Beltline was driven by grassroots efforts by local communities and civic leaders. To ensure the involvement of local communities, the project area has been divided into sub-areas, facilitating the community participation and integration of the community's interests in the planning of this UGC. The local community is partially involved in volunteer projects for maintenance in partnership with Trees Atlanta. Due to environmental concerns, the local community has been advocating for the development of the Cooks to Cove GreenWay. Community-driven bush care sites along this green corridor have been established by voluntary community groups, while these bush care sites are partially maintained by voluntary community groups. These community efforts are crucial due to the limited conservation of this UGC by the council due to limited expertise to maintain native planting.

In contrast, the development of The Meadoway has been initiated by a local councilor, building on the success of the SCBT pilot project. The planning process included public input and local needs through an environmental class assessment to maximize the benefits to the local community. However, the community involvement in the ongoing management is limited, although the local community is participating in The Meadoway through educational programs.

The Parkland Walk has developed as natural green space on a disused railway line. Local community efforts have been crucial for encouraging the local councils to enhancing accessibility and strengthening bridges that comprise the Parkland Walk. Local community volunteer groups partially manage the habitat and conduct conservation work within the Parkland Walk. The voluntary community group Friends of the Parkland Walk collaborates with the local councils to encourage the protection and conservation of this UGC, while also conducts light maintenance and conservation work. Particularly due to limited financial resources and expertise in managing the Parkland Walk as Local Nature Reserves, community efforts are crucial for the conservation of this green corridor.

Overall, the analyzed UGCs have different levels of community involvement. However, the analysis of the case studies highlights that community involvement throughout the planning, implementation, and management is crucial for meeting the needs and interests of the local community and delivery of social benefits (Inner West Council, 2018, p. 72). Also, limited financial resources for ensuring the long-term management can be overcome with community involvement. Particularly, the public's perception has been highlighted as critical during the conducted interviews, making it essential to actively involve the local community for raising awareness. Particularly, educational initiatives and programs enhance environmental stewardship and strengthen the human-nature relationship, while it encourages the conscious use of UGCs preventing ecological damages. Also, the incorporation of urban gardens, such as in the Midtown Greenway and The Meadoway, can encourage the community participation, and enhance inclusivity in UGCs. However, knowledge-sharing is essential for the conservation of UGCs among the involved stakeholders including the local community. Additionally, ecosystem service provision can be enhanced by collaborating with the local community to identify the demand for meeting the needs of the local community, while it encourages social interaction and supports the long-term success of these projects. Community involvement promotes the responsible use of UGCs and facilitate the protection of UGCs due to increased interest in these spaces.

However, large-scale green infrastructure projects such as UGCs can have consequences. UGCs have the potential to catalyze economic development in the surrounding areas, causing green gentrification resulting in rising property values and displacement of urban residents. Projects like the Atlanta Beltline have catalyzed economic development, resulting in green gentrification leading to displacement of residents in the surrounding neighborhoods. As the focus shifted towards economic development, community participation eventually decreased due to the large scale of this project. This underscores the need to ensure the inclusive and equitable development of such large-scale green infrastructure projects, while ensuring

community participation to prevent such consequences and establishing initiatives to address these consequences.

7.2 Limitations

The present thesis has limitations that are further highlighted in the following including methodological limitations that affect the comprehensiveness of the findings and analysis of this thesis.

This thesis is inspired by transdisciplinary and phronetic planning research. Transdisciplinary research involves multiple disciplines including non-academic and academic stakeholder to bridge the gap between science and practice. In this thesis project, expert interviews were conducted to gain a general understanding of UGCs and ecosystem services as well as interviews with practitioners involved in the selected UGCs to gain case-specific insights. However, the involvement of both non-academic and academic actors remained limited due to limited scope and time of this project, which limited the application of transdisciplinary research principles. The limited information gained on ecosystem services by UGCs highlight the need for transdisciplinary research efforts. This thesis is also inspired by phronetic planning research with regards to its value-rational perspective for ensuring the public interests. However, it is important to note that the perspective and interests of the local community are incorporated only to a limited extent. Insights have been gained through the conducted interviews, instead of direct interviews and surveys with the local community. Also, the examination of the phronetic planning research question “Who gains and who loses, and by which mechanisms of power?” proved to be challenging due to limited information and data on the UGCs and their involved stakeholder as well as the actual supply of ecosystem services by the UGCs. The concept of multifunctionality is constrained by the lack of a clear definition regarding which ecosystem services must be considered for spaces to be classified as multifunctional. This is complicating the exploration of multifunctionality of the case studies.

The large amount of literature on ecosystem services and the various terminologies of UGCs increase the likelihood that literature has been overlooked, while this underscores the need for a comprehensive overview of the different terminologies for UGCs. The literature and documents reviewed and analyzed for this thesis are limited to English and German publications, which limit comprehension.

The selection of UGCs as case studies is based on the criteria outlined in Chapter 5.3. However, since various implemented UGCs meet these criteria, the selection process was challenging. Besides this, the available publications on the selected UGCs and their ecosystem services are limited due to the limited research and lacking detail on the actual ecosystem service supply and use of the UGC. This resulted in limited detail due to the limited

publicly available information as well as scope of this thesis. Therefore, conducting interviews about the UGCs was essential for gathering relevant insights. This thesis excludes case studies from which no response was received regarding the conduct of interviews. Besides this, analyzing multifunctionality of the case studies was complex due to the limited conceptual clarity and data availability of multifunctionality. Also, the analysis of the involved stakeholder remains limited, primarily due to lack of comprehensive publicly available information on stakeholders that are involved in the UGCs. Additionally, the analysis of the local community's role is based on information obtained through interviews and available publications on UGCs. However, this may not fully reflect the community involvement and participation. For gaining a more comprehensive understanding of the role of the local community further investigations are needed, such as through community surveys or field studies. Also, the comparative case study analysis is complicated by the unique characteristics of the case studies and differing local contexts.

Semi-structured interviews have been conducted for the case studies. These have limitations including the subjective perspective of the interview partners. However, these interviews provided valuable insights into the selected UGCs and their ecosystem services, although only to a limited extent. The information gained through the conducted interviews have been highlighted as those. Additionally, transitions between questions and follow-up questions during the interviews highlight inconsistency in the interview guide, while not all questions have been answered to the same extent, which is also due to the individuality of the case studies and limited knowledge of some of the interview partners. Nevertheless, the conducted interviews provided a comprehensive understanding of the UGCs, and its use and function.

The mapping of the location of the selected UGCs is based on OpenStreetMap, Google Earth and municipal documents that may have inaccuracies. Therefore, it may be essential to map the UGCs more accurately based on the knowledge on the exact boundaries. Moreover, the identified land cover classes are inaccurate, as the WorldCover 2021 dataset is limited to 11 classes. Also, its overall global land cover accuracy of 76.7% with a 10 m resolution appears to be insufficient for the ecosystem service assessment. Further investigations of the land cover classes are necessary for the identification of the actual ecosystem services supplied by these UGCs, while an up-to-date dataset should be utilized for the mapping of UGCs since the used dataset is from 2021. Additionally, local datasets can facilitate detailed mapping of UGCs.

For conducting an ecosystem service assessment, the method after Burkhard et al. (2009) has been applied that is based on the mapped land cover types of the UGCs. Although this method requires low primary data, it has limitations such as its simplification. For addressing

the simplification of this method, semi-structured interviews and publicly available publications have been analyzed, although data and information on the provided ecosystem services is overall limited. Therefore, the detailed analysis of ecosystem services that are supplied by UGCs require site-specific research, since the applied assessment method after Burkhard et al. (2009) is based on expert knowledge instead of primary data. The ecosystem services that have been identified through the ecosystem service assessment method are supply capacities and do not represent the actual supply. Also, the condition of the ecosystems is not included in this assessment, making the results inaccurate necessitating further studies on the actual supply and the state of the UGCs. Besides this, the analysis of the demand of ecosystem services is essential to further enhance relevant ecosystem services and needs to be studied in more detail. In addition, the different ecosystem services of the three categories regulating, provisioning, and cultural services in the applied method do not reflect the full range of ecosystem services that can be supplied by UGCs. This is highlighted through educational values that are not included in the assessment method after Burkhard et al. (2009). Also, the applied assessment method is only considering recreational and aesthetic values without considering the human-nature relationship and the perception of the environment, while may overlook the actual contribution of nature to human well-being (Korkou et al., 2025, p. 2). However, it is important to note that the quantification of ecosystem services is inherently complex (Ma & Yang, 2025, p. 12). Overall, an in-depth analysis of the UGCs is necessary for the assessment of ecosystem services including the local context in terms of proximity to other green spaces, surrounding demographics, and typography. Further aspects need to be taken into consideration including the type and condition of the ecosystems as well as site-specific studies. Also, surveys with the local community can support the analysis particularly of cultural services and provide an understanding of the perception of the corridor. Therefore, information on the ecosystem services should be collected from expertise of stakeholders from different sciences.

Although the applied research methods have certain limitations such as restricted data availability and subjectivity of the interviewees, valuable insights into the selected UGCs and their ecosystem services have been gained to address the research objective. However, it is important to note that a large volume of data and information has been generated through the applied mixed methods, while not all of these are relevant for this thesis making it challenging to summarize and present them in a consistent and structured way.

8 Conclusion and outlook

The degradation of ecosystems and urban challenges related to climate change and urbanization make it essential to ensure the multifunctionality of urban green spaces, such as UGCs, for meeting the demand for ecological, recreational, and infrastructural space. Scientific knowledge is combined with practical insights through the inspiration of this thesis by transdisciplinary research to highlight real-world challenges and the potential of UGCs and their ecosystem services. In this thesis, diverse characteristics and potentials of UGCs worldwide are explored, aiming to answer the main research question: *How do urban green corridors contribute to sustainable urban environments through the provision of urban ecosystem services?*

This thesis analyzes five UGCs as case studies including the Midtown Greenway (USA), Cooks to Cove GreenWay (Australia), The Meadoway (Canada), Eastside Trail of Atlanta Beltline (USA), and Parkland Walk (Great Britain). These UGCs have the potential to supply multiple ecosystem services including regulating, provisioning, and cultural services, as detected through an ecosystem service assessment. Particularly regulating and cultural services are relevant to address the urban challenges related to climate change and urbanization including urban heat, flood risk, loss of pollination, air pollution and the demand for recreational space. However, the identified supply capacities significantly differ among the UGCs. The Parkland Walk has a high potential supply of ecosystem services due to its abundant tree cover that can supply urban cooling, pollination, and air quality regulation. Also, the Midtown Greenway and Eastside Trail of Atlanta Beltline have nearly half of the area covered by tree cover highlighting the potential supply of these services, despite their high portion of built-up area. In contrast, the Cooks to Cove GreenWay and The Meadoway are characterized by less tree cover and a greater portion of grassland, although a partially lower supply capacity has been detected, while the built-up area is making up a lower portion than in the Midtown Greenway and Eastside Trail. However, the relevant regulating services need to be enhanced to address the urban challenges, while particularly flood protection has a lower overall supply capacity compared to other ecosystem services, which is critical due to the increasing flood risk. This may be less necessary for the Parkland Walk, given its high overall supply capacity, except in terms of flood protection. Provisioning services can also be supplied by the UGCs, although the potential supply is limited. The incorporation of urban gardens in some of the UGCs can enhance the supply of provisioning services, while it encourages community participation and social interaction. Also, cultural services such as recreational and aesthetic values can be supplied to a greater extent than other relevant ecosystem services. Recreational values encourage and promote the use of UGCs such as for active mobility. Besides this, the UGCs partially provide educational and scientific opportunities. Also, this

thesis aims to identify synergies and trade-offs among ecosystem services, although this has only been possible to a limited extent. The supply of regulating services such as local climate regulation has the potential to enhance the recreational value, representing a potential synergy. However, enhancing the supply of provisioning services may decrease pollination. Overall, the UGCs can supply multiple ecosystem services providing a foundation for human well-being, while providing benefits that go beyond this, such as enhanced social and ecological connectivity, emphasizing the multifunctionality of UGCs.

UGCs benefit urban residents through social, environmental, and economic impacts including opportunities for social interaction and active mobility as well as the catalyzation of economy. However, identified challenges include limited stakeholder collaboration, long-term management, funding, and a tendency to prioritize infrastructure over ecology. These challenges can limit the environmental benefits and reduce the supply of ecosystem services. Large-scale green infrastructure projects such as UGCs can have critical consequences such as green gentrification, where economic impacts in terms of rising property values cause displacement. This needs to be mitigated and prevented. Urban planning decisions and funding allocations can influence these outcomes. Also, the long-term success of UGCs is dependent on stakeholder collaboration, which must be encouraged. Stakeholder priorities must focus on the improvement and conservation of UGCs to ensure the supply of ecosystem services, while ensuring a balance between ecology and infrastructure. Also, community involvement and inclusive urban planning are essential for mitigating consequences and to ensure the benefits of UGCs.

In the analyzed case studies, the local communities play a crucial role as users, participants, and advocators. However, it is essential to note that the public's perception of UGCs is critical highlighting the need for raising awareness on the importance of nature and conscious use of these spaces, such as overuse and disturbances to nature highlighting the need for greater environmental awareness. Community involvement in the development and maintenance of UGCs can enhance environmental stewardship and encourage social interaction, while meeting the needs of the local community. Community-based ecosystem management can enhance the provision of ecosystem services and mitigate anthropogenic pressures, while educational programs can facilitate the prevention of unconscious use of these spaces and disruptions to biodiversity. Also, voluntary community involvement can address limited financial resources for conservation of UGCs. Strengthening the relationship between people and nature through the active participation of the local community in UGCs can improve the urban livability through the active perception of ecosystem services. Active community engagement and transdisciplinary collaboration are essential to ensure the long-term success and multifunctionality of UGCs.

This thesis project encounters methodological and data limitations. Its scope is limited to investigating multifunctionality through the supply potential of ecosystem services and the use of UGCs. Due to its lack of a clear definition, applying the concept of multifunctionality is challenging, highlighting the need for further efforts to establish an operational definition. The CORINE land cover classes that are used for the ecosystem service assessment after Burkhard et al. (2009) may not represent the land cover types that characterize the UGCs. This is highlighted through the analysis of The Meadoway since it is characterized by a native meadow, where a significant increase in pollination, heat mitigation and flood attenuation were detected through monitoring and field investigations. However, through the applied assessment method this UGC has only a limited supply capacity of pollination, local climate regulation and flood regulation. This highlights the limitations of this method and the need for site-specific studies. Nevertheless, the applied ecosystem service assessment method facilitates an understanding of the supply capacity of ecosystem services by UGCs. For a detailed assessment of ecosystem services, the supply and the demand of ecosystem services need to be investigated including the ecosystem type and condition. Also, mapping of UGCs with a dataset that has a high resolution can advance the identification of the land cover types. A deeper understanding of the spatial scale and urban context including the proximity to other green spaces, local demographics and the topography should be incorporated for the assessment of ecosystem services of UGCs. Thus, future research efforts should combine the mapping and assessing ecosystem services with local studies to investigate the supply and demand of ecosystem services, including emerging trade-offs and synergies. This approach can facilitate to address urban challenges and the needs of the local community in a more targeted way.

In summary, this thesis presents the diverse characteristics of UGCs and their potential to supply multiple ecosystem services, while serving as multifunctional green spaces. Due to the increasing pressures on urban areas, UGCs play a crucial role in providing multiple ecosystem services and benefits beyond that for urban residents and the environment. However, their potential depends on appropriate management, conservation efforts, stakeholder collaboration, and active community engagement. Further exploration of the multifunctionality and ecosystem service supply by UGCs will require transdisciplinary stakeholder collaboration and community involvement. Future research efforts should prioritize the detailed mapping and assessment of ecosystem services of UGCs to enhance their provision including a detailed analysis of the urban context, high resolution mapping and site-specific studies. Moreover, given their significance for urban areas, UGCs must be adapted to future changes to ensure their resilience and supply of ecosystem services.

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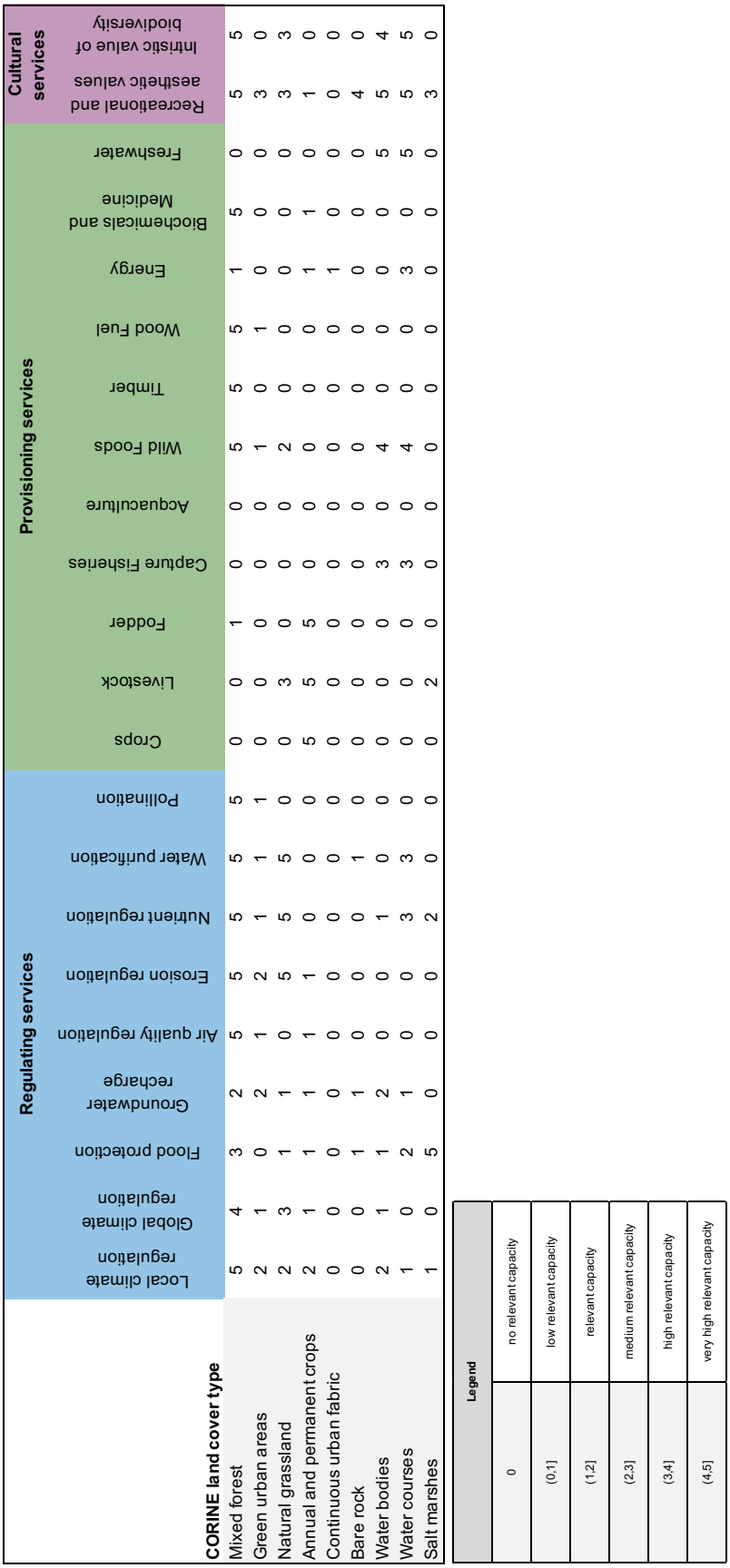
Appendices

Appendix A Ecosystem service assessment matrix after Burkhard et al. (2009)



	Regulating services										Provisioning services										Cultural services	
CORINE land cover type	Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air quality regulation	Erosion regulation	Nutrient regulation	Water purification	Pollination	Crops	Livestock	Fodder	Capture Fisheries	Aquaculture	Wild Foods	Timber	Wood Fuel	Energy	Biochemicals and Medicine	Freshwater	Recreational and aesthetic values	Intrisic value of biodiversity
Mixed forest	5	4	3	2	5	5	5	5	5	0	0	1	0	0	5	5	5	1	5	0	5	5
Green urban areas	2	1	0	2	1	2	1	1	1	0	0	0	0	0	1	0	1	0	0	0	3	0
Natural grassland	2	3	1	1	0	5	5	5	0	0	3	0	0	0	2	0	0	0	0	0	3	3
Annual and permanent crops	2	1	1	1	1	1	0	0	0	5	5	5	0	0	0	0	0	1	1	0	1	0
Continuous urban fabric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Bare rock	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Water bodies	2	1	1	2	0	0	1	0	0	0	0	0	3	0	4	0	0	0	0	5	5	4
Water courses	1	0	2	1	0	0	3	3	0	0	0	0	3	0	4	0	0	3	0	5	5	5
Salt marshes	1	0	5	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0

Legend	
0	no relevant capacity
(0,1]	low relevant capacity
(1,2]	relevant capacity
(2,3]	medium relevant capacity
(3,4]	high relevant capacity
(4,5]	very high relevant capacity

Appendix B Interview guides

Appendix B.1 Interview with experts

Urban ecosystem services

- Which ecosystem services are particularly relevant in urban areas and what role do they play in sustainable urban planning?
- In your opinion, to what extent are ecosystem services integrated into urban planning and decision making?
- How has the perception and importance of ecosystem services in urban planning changed in recent years?
- What are the barriers to integrating ecosystem services into urban planning? How can these barriers be overcome?
- Which actors (e.g. urban planners, environmental authorities, citizens) are particularly important for implementing ecosystem services in urban planning?

Ecosystem services in urban green corridors

- How do you assess the relevance of urban green corridors for sustainable urban planning, especially regarding the provision of ecosystem services?
- What are the benefits of urban green corridors for the provision of ecosystem services?
- To what extent are ecosystem services integrated into the planning and management of urban green corridors?
- What are the trade-offs between the provision of ecosystem services and the promotion of active mobility in urban green corridors?
- How can a balance between active mobility and ecosystem services be ensured in urban green corridors?
- What challenges do you see for the future development of urban green corridors regarding the provision of ecosystem services?
- What conflicts of interest do you see regarding the provision of ecosystem services in urban green corridors?
- Are there any international cities or projects that could serve as models for integrating ecosystem services into urban green corridors?
- How do and will climate change and urbanization affect the provision of ecosystem services in the future?

Further questions

- Where do you see a need for further research on urban ecosystem services and/or urban green corridors?
- How can research on ecosystem services improve the planning and management of urban green corridors?
- Do you have any further advice or comments on ecosystem services in urban green corridors?

Appendix B.2 Interview with practitioners involved in case studies

Urban green corridor

- What challenges or needs led to the decision to develop this green corridor?
- Who initiated the development of this green corridor?
- Who are the key stakeholders involved in developing and implementing this green corridor?
- What role did the local community play in the development?
- Which interests have been prioritized in the development from your perspective and what conflicts of interest do you see among the stakeholders involved?
- What is the primary objective of this green corridor?
- What are the challenges regarding the development and implementation of this green corridor?

Urban ecosystem services

- What role did urban ecosystem services play in developing this green corridor?
- Which ecosystem services are anticipated with this green corridor?
- Which urban ecosystem services does the green corridor provide to the urban residents?
- How is the urban green corridor currently managed to ensure the provision of ecosystem services?
- Who is involved in the management of this green corridor?

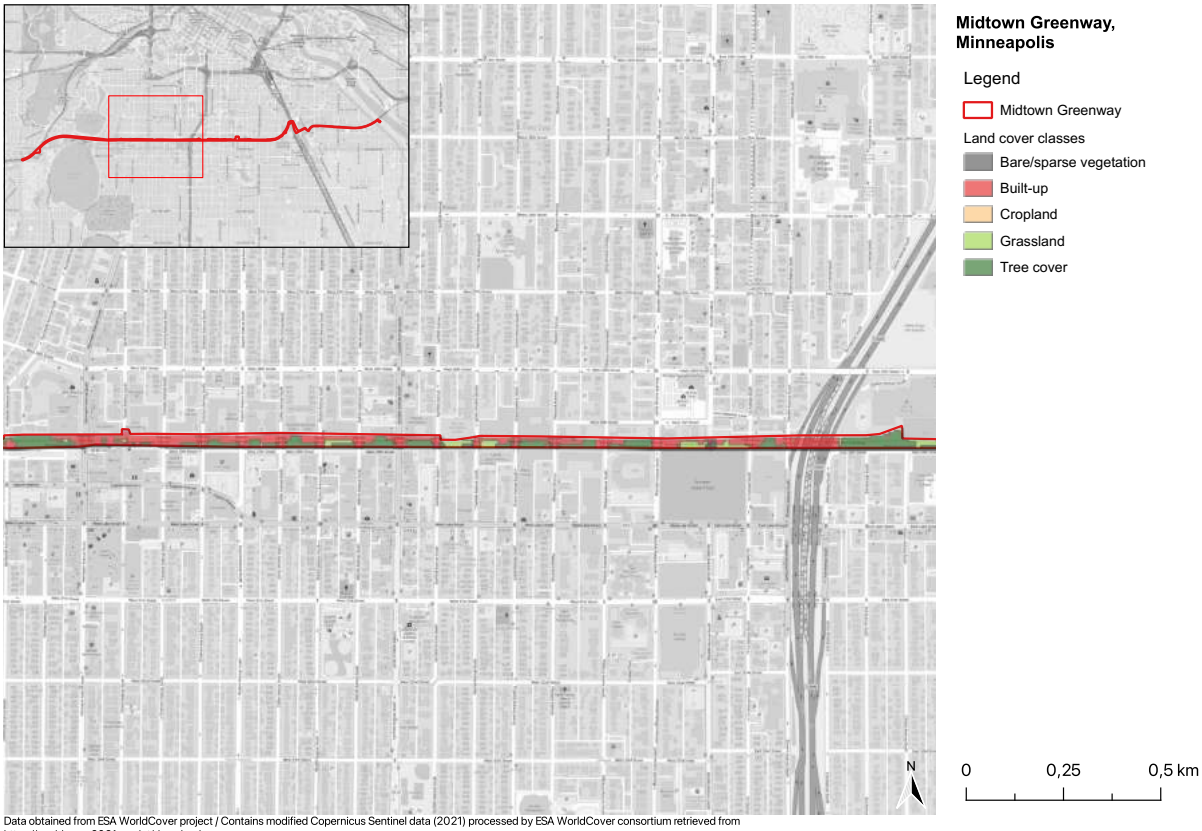
Active mobility

- To what extent was active mobility a key factor in the planning and development of this urban green corridor?
- How do people use this green corridor for active mobility (e.g. cycling, walking)?
- Have there been changes in active mobility patterns in the urban green corridor?
- What are factors that influence the use of this urban green corridor?

Further questions

- What conflicts do you see between urban ecosystem services and active mobility? How can a balance be achieved?
- Would you say that the implementation of this urban green corridor has been successful?
- What challenges do you see for this urban green corridor, particularly regarding urban ecosystem services and active mobility, both now and in the future?
- Do you have any additional suggestions or comments on urban green corridors and their role in sustainable urban development?

Appendix C Mapping of land cover classes of Midtown Greenway



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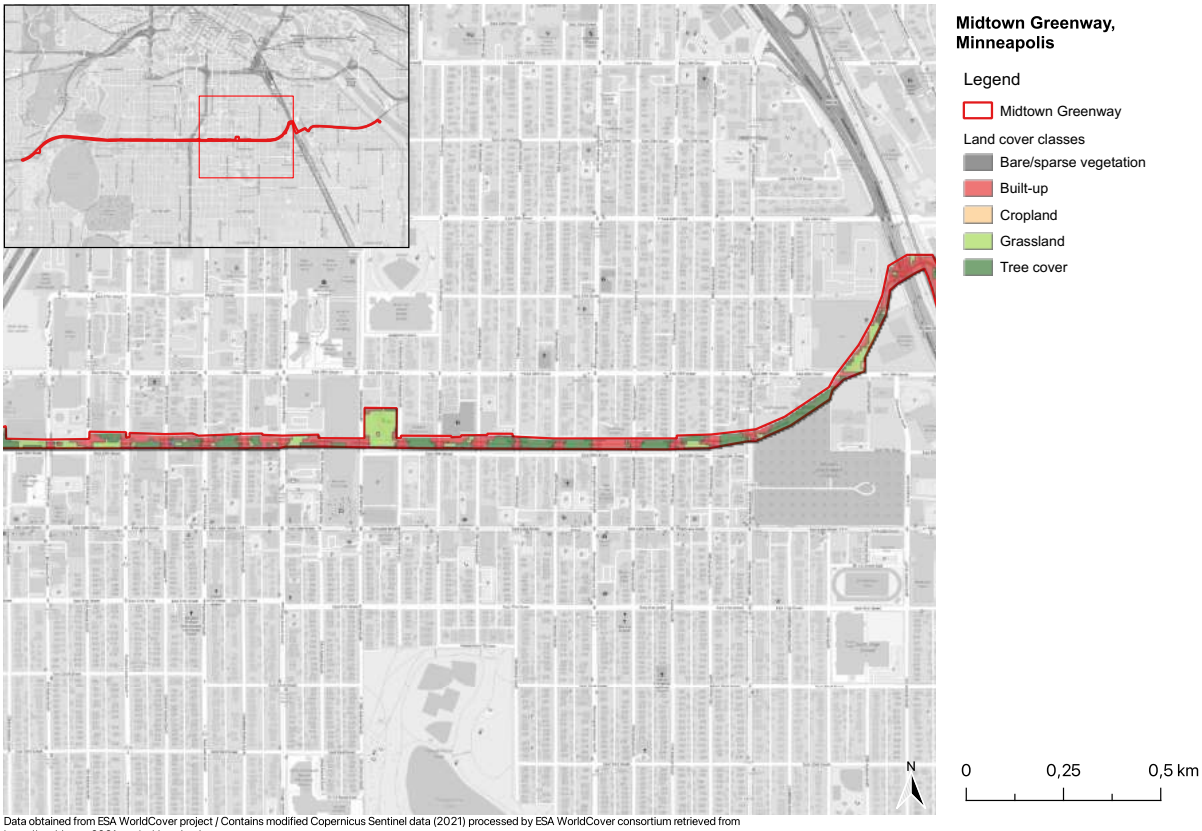

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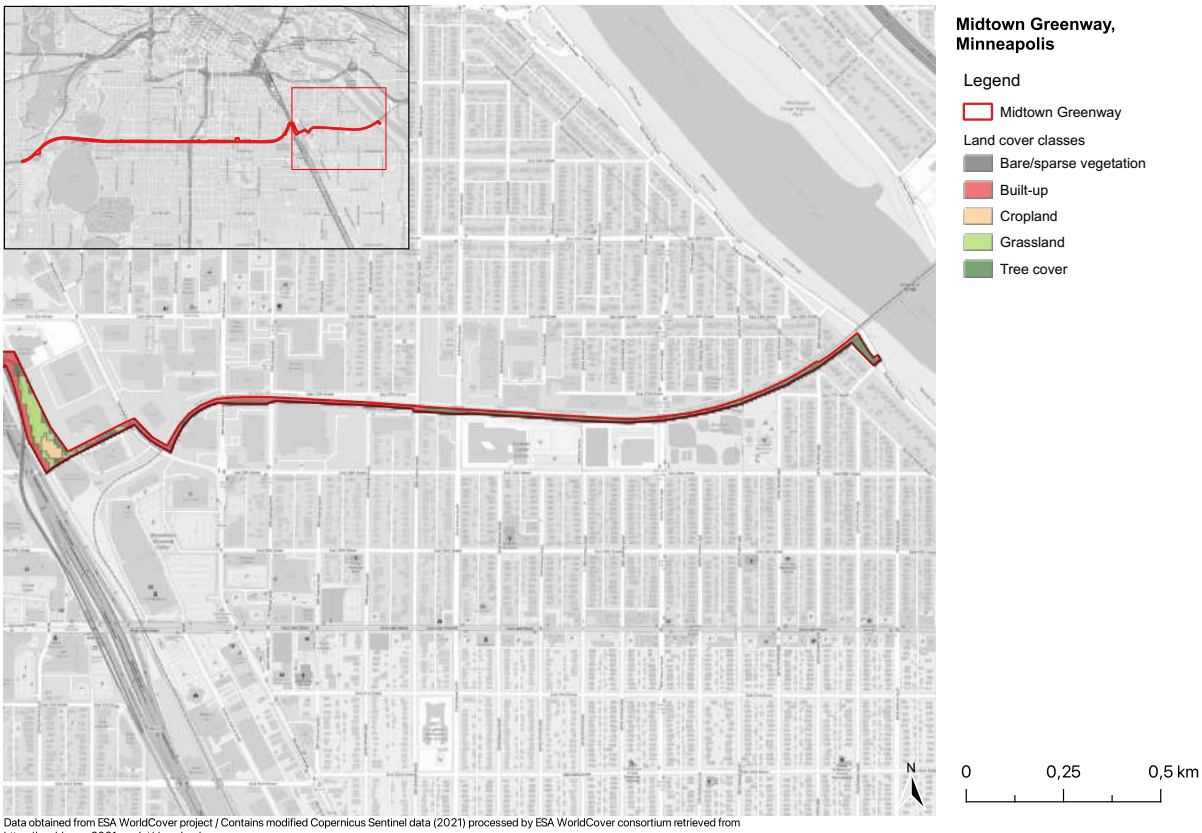

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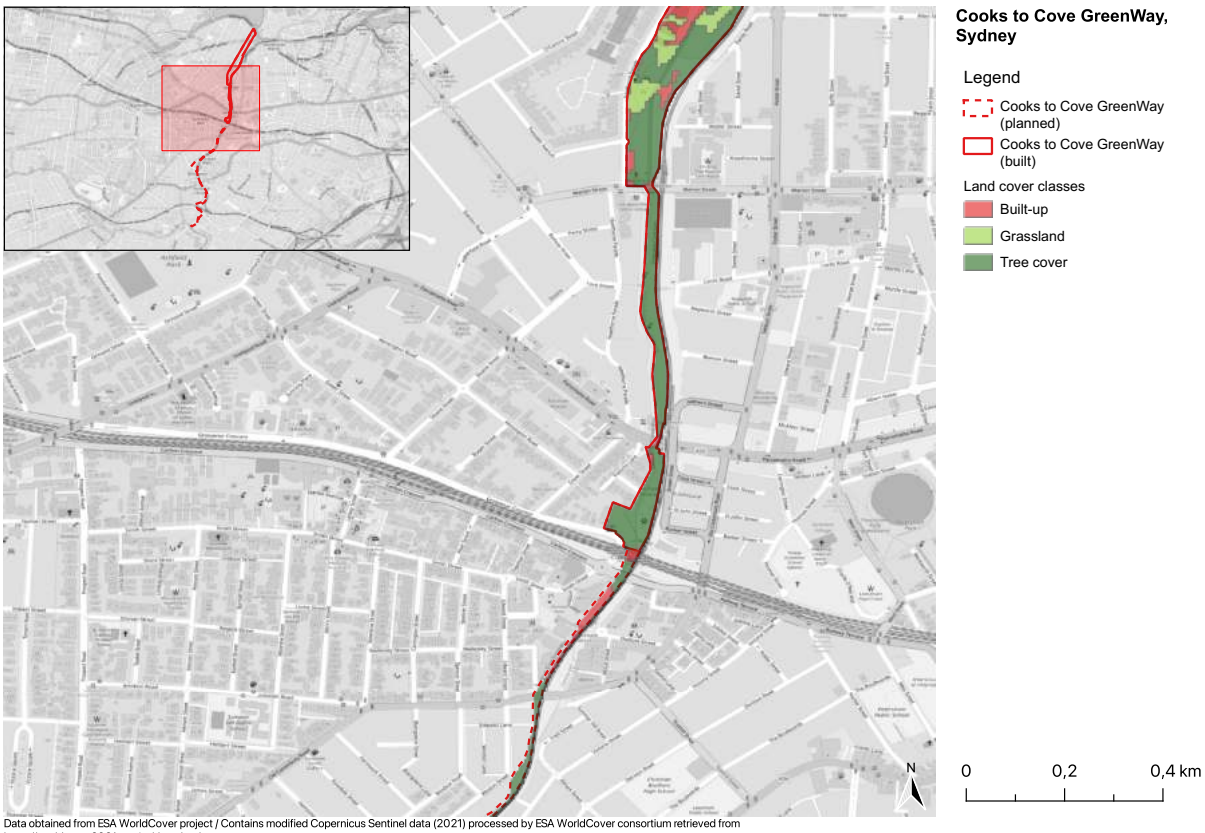
Appendix D Mapping of land cover classes of Cooks to Cove GreenWay



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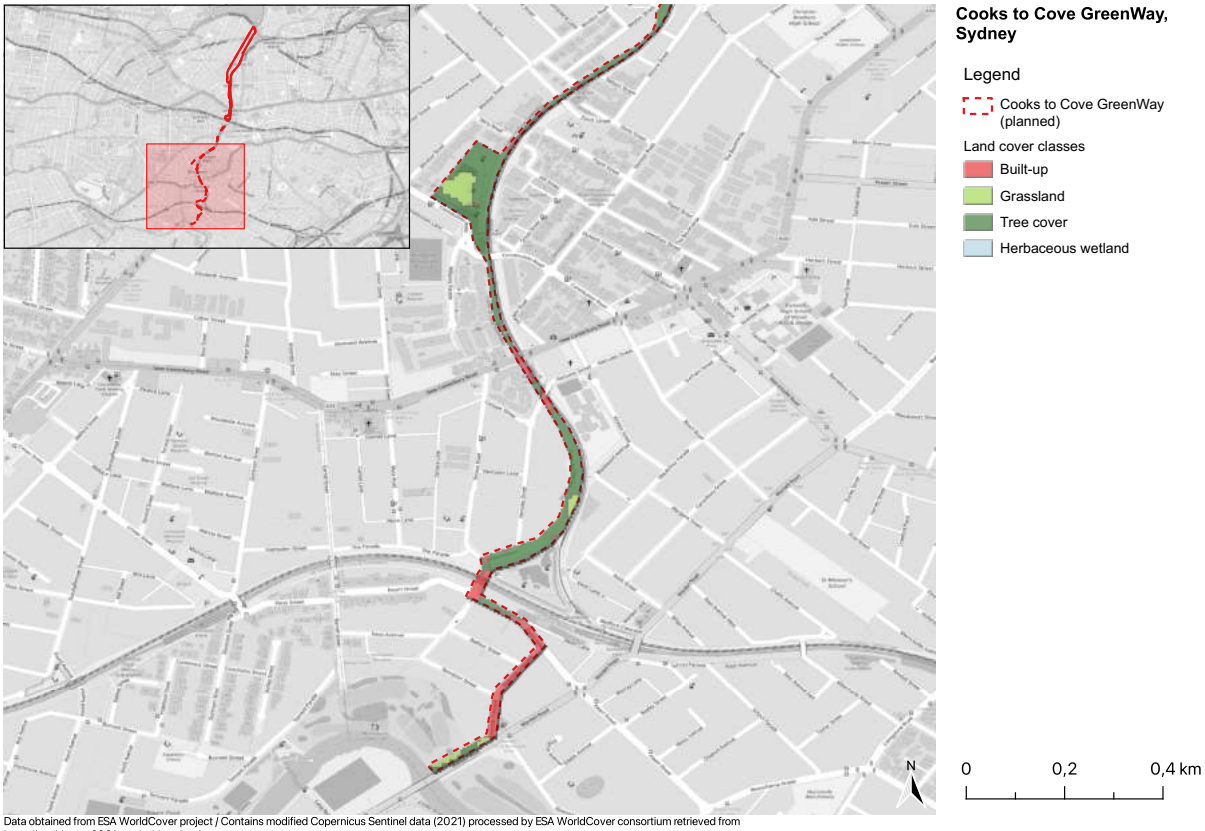

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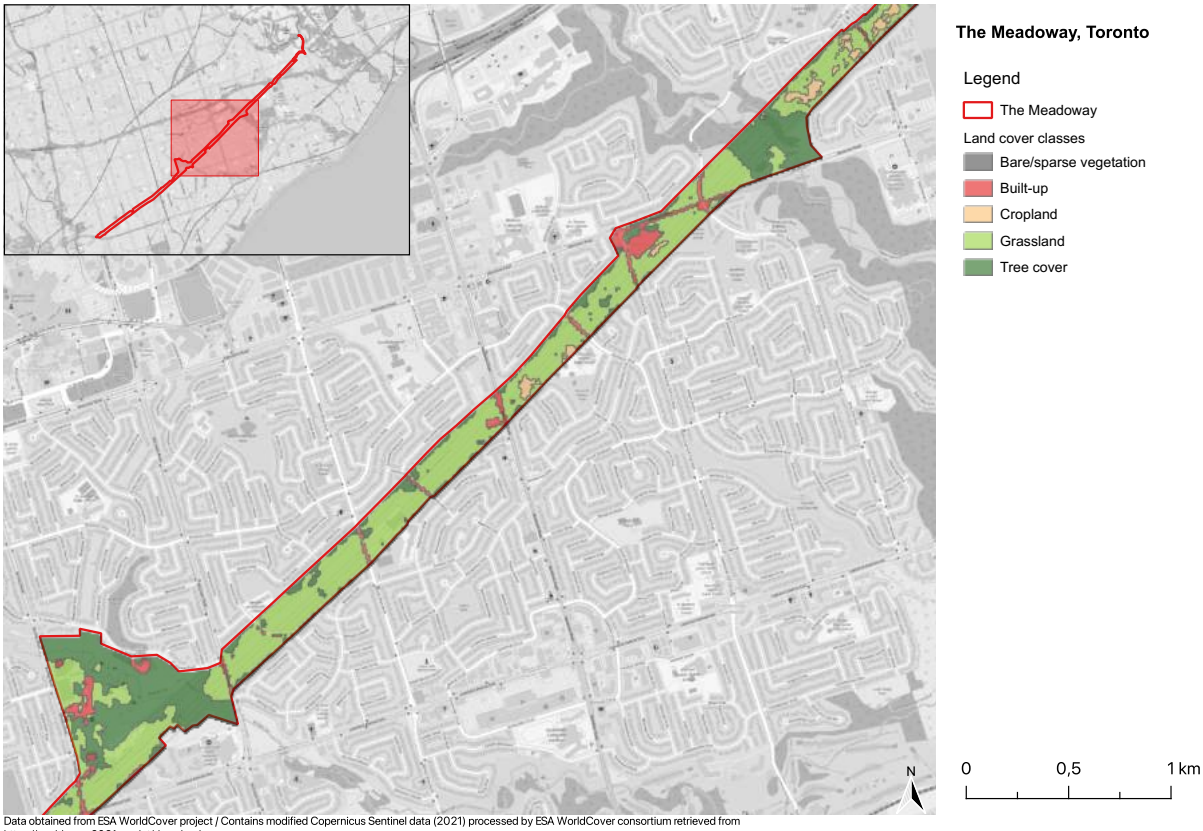
Appendix E Mapping of land cover classes of The Meadoway



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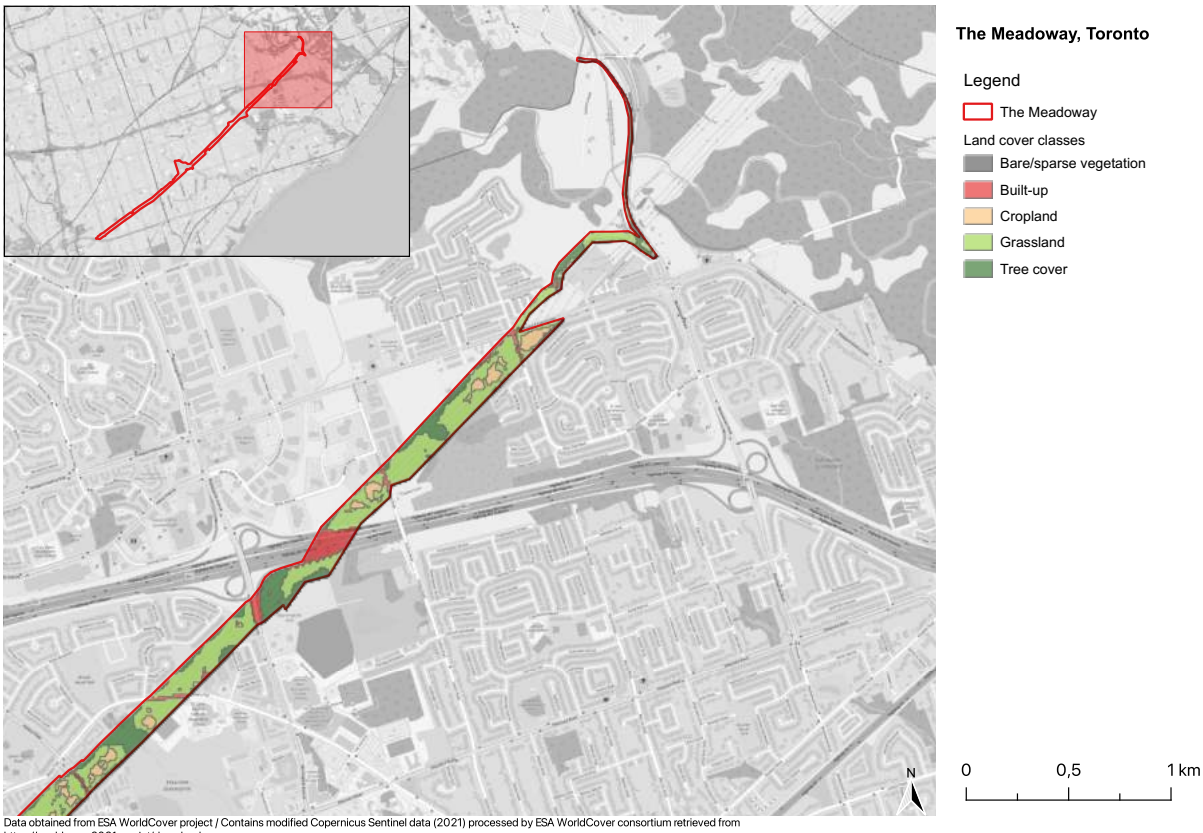

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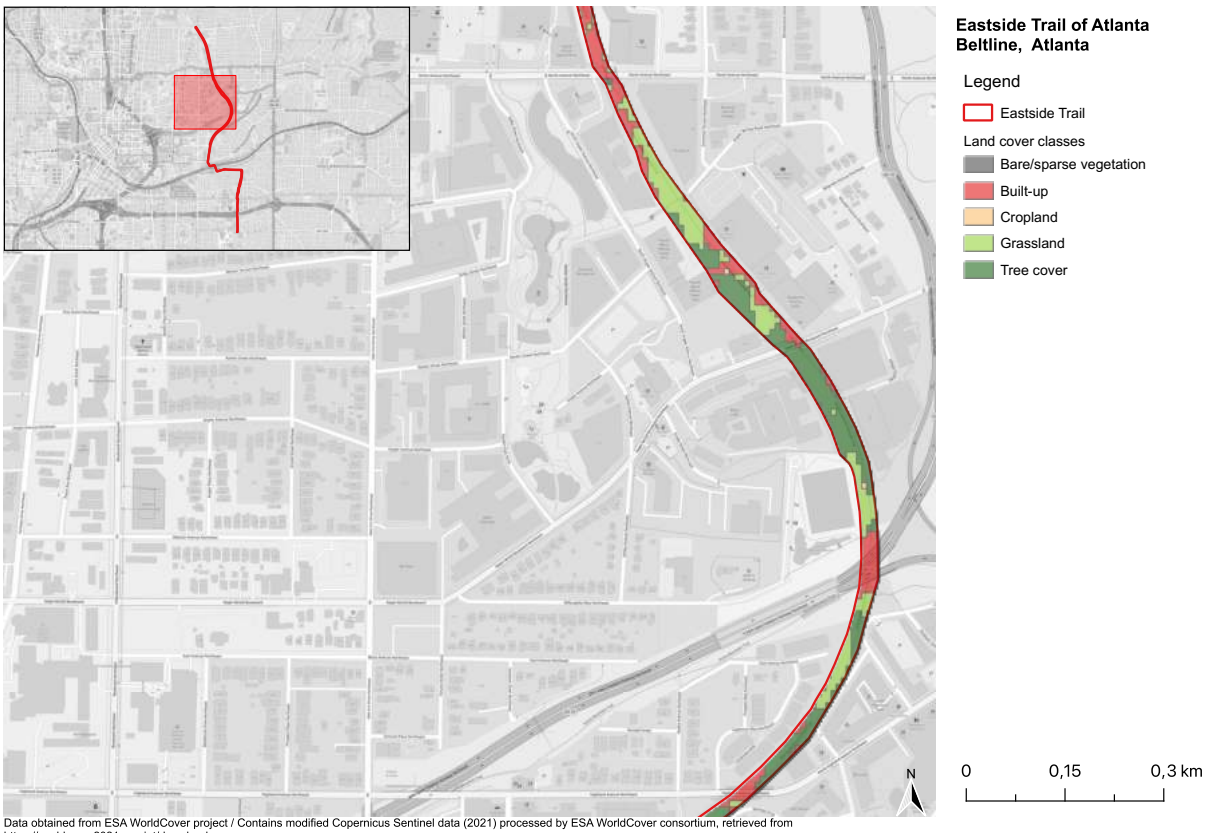
Appendix F Mapping of land cover classes of Eastside Trail of the Atlanta Beltline



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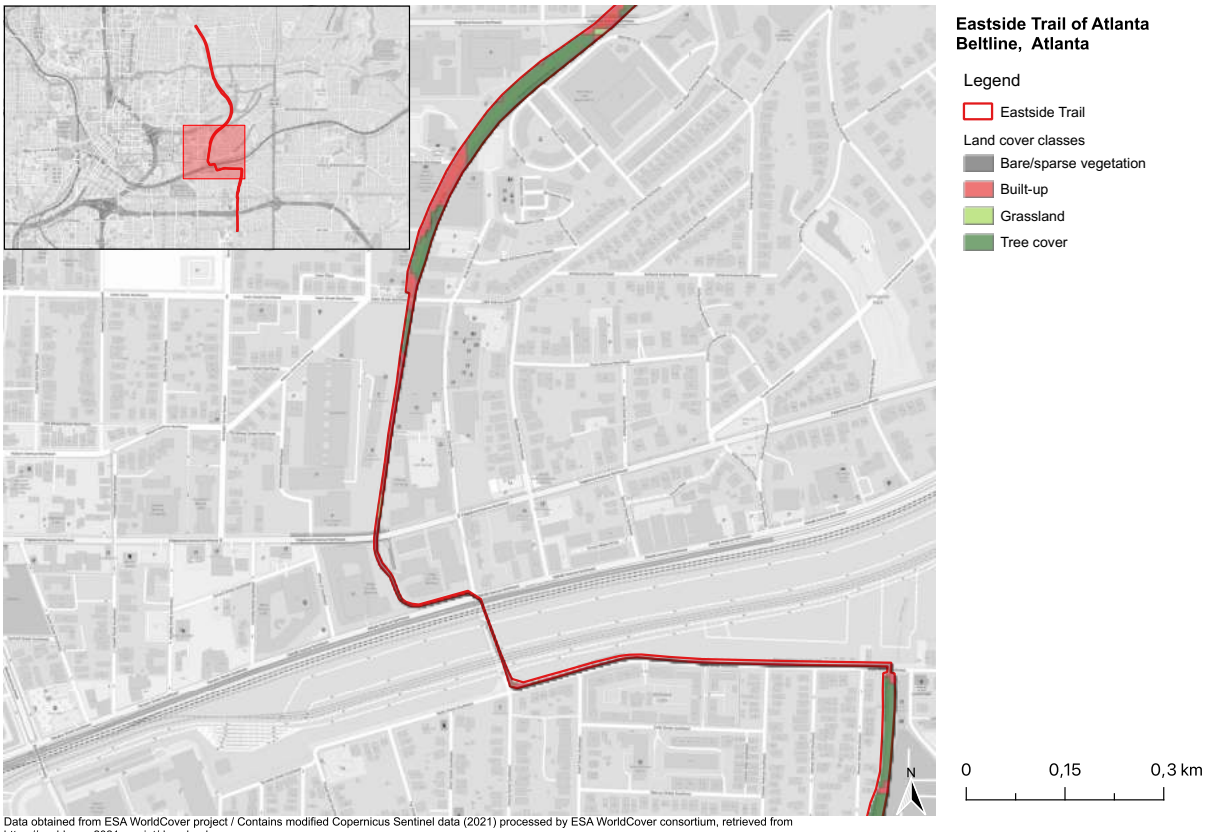

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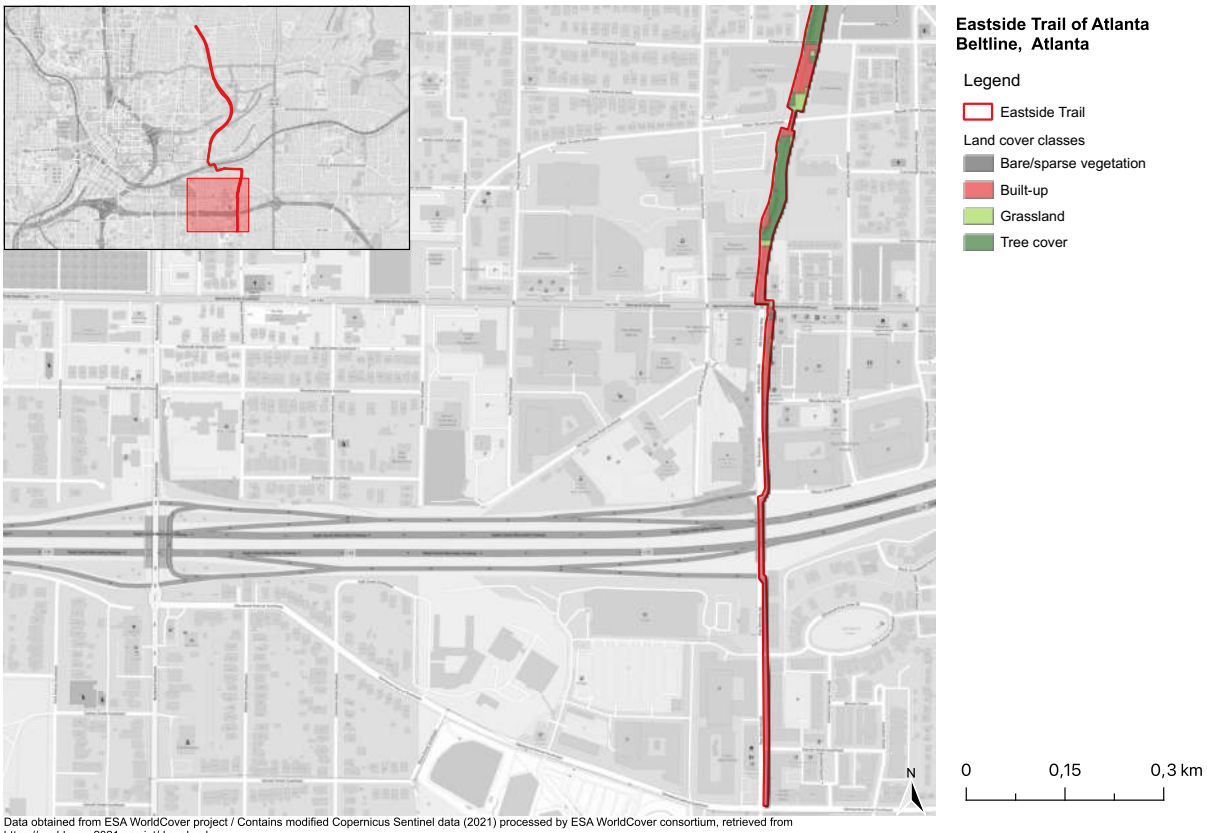
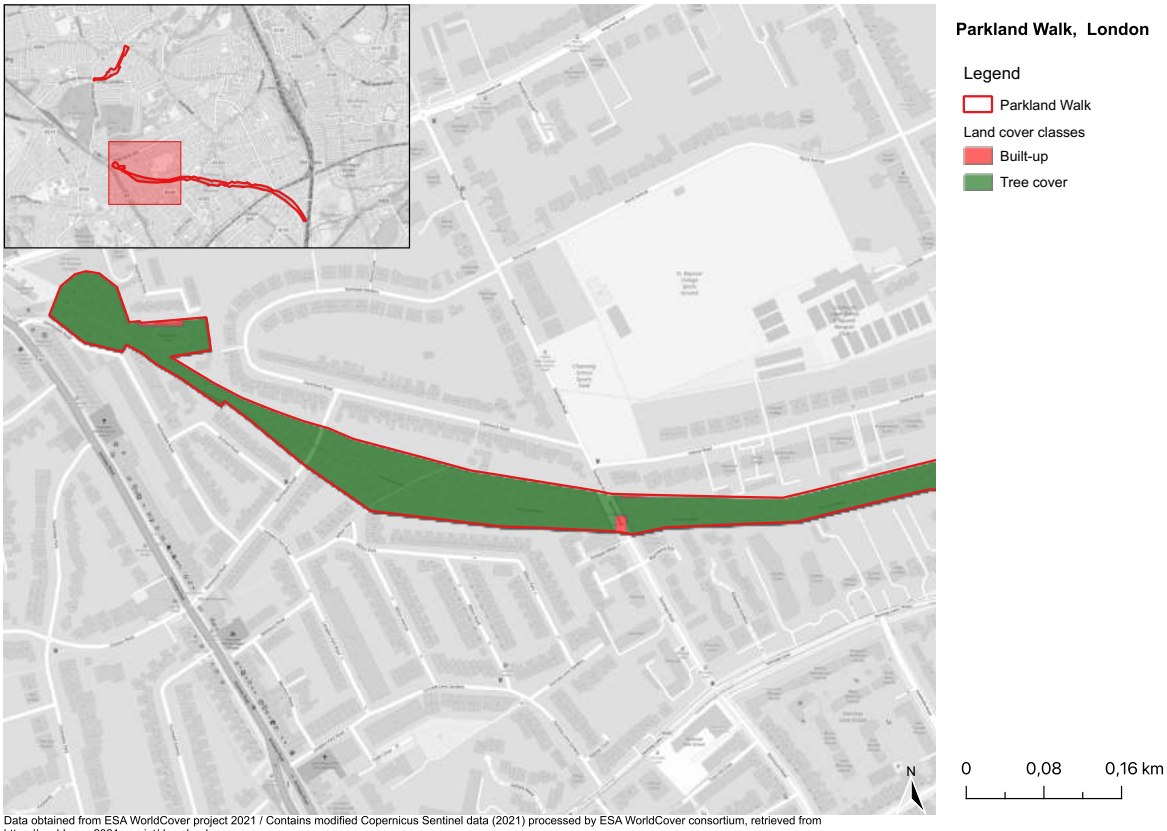
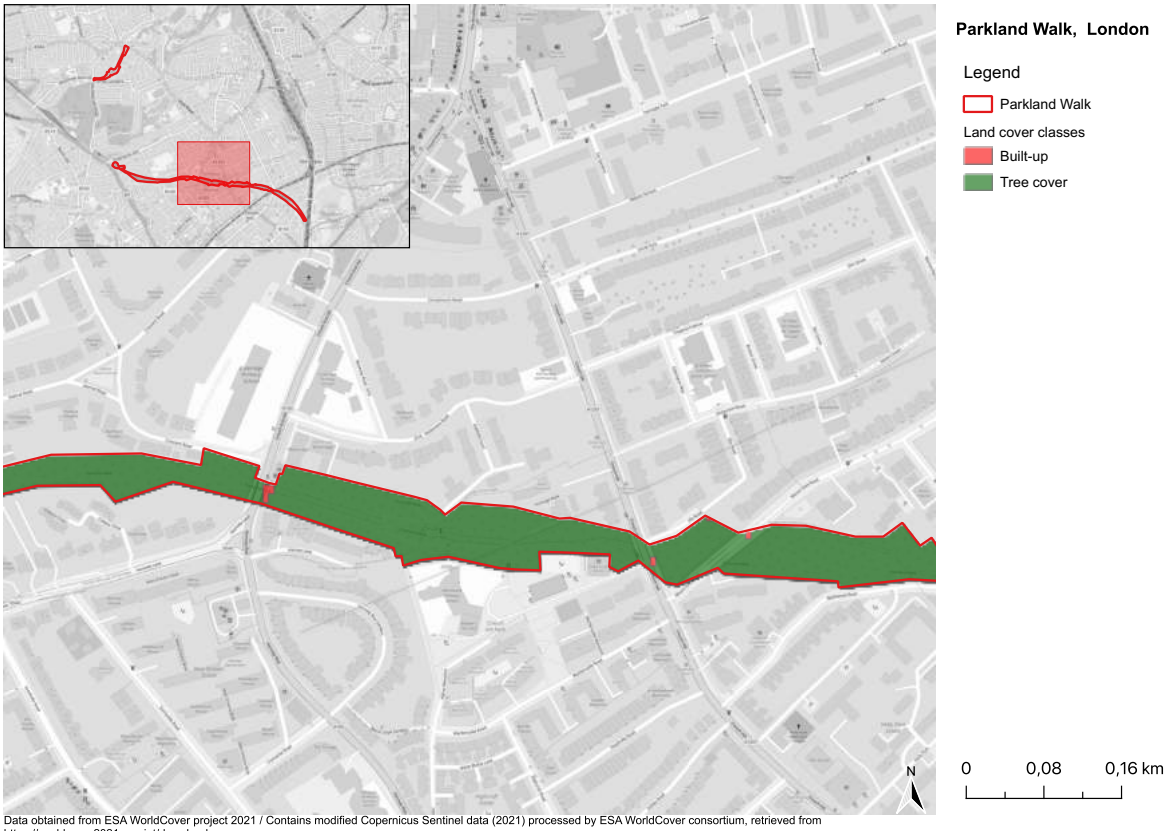


Data obtained from ESA WorldCover project / Contains modified Copernicus Sentinel data (2021) processed by ESA WorldCover consortium, retrieved from https://worldcover2021.esa.int/download.

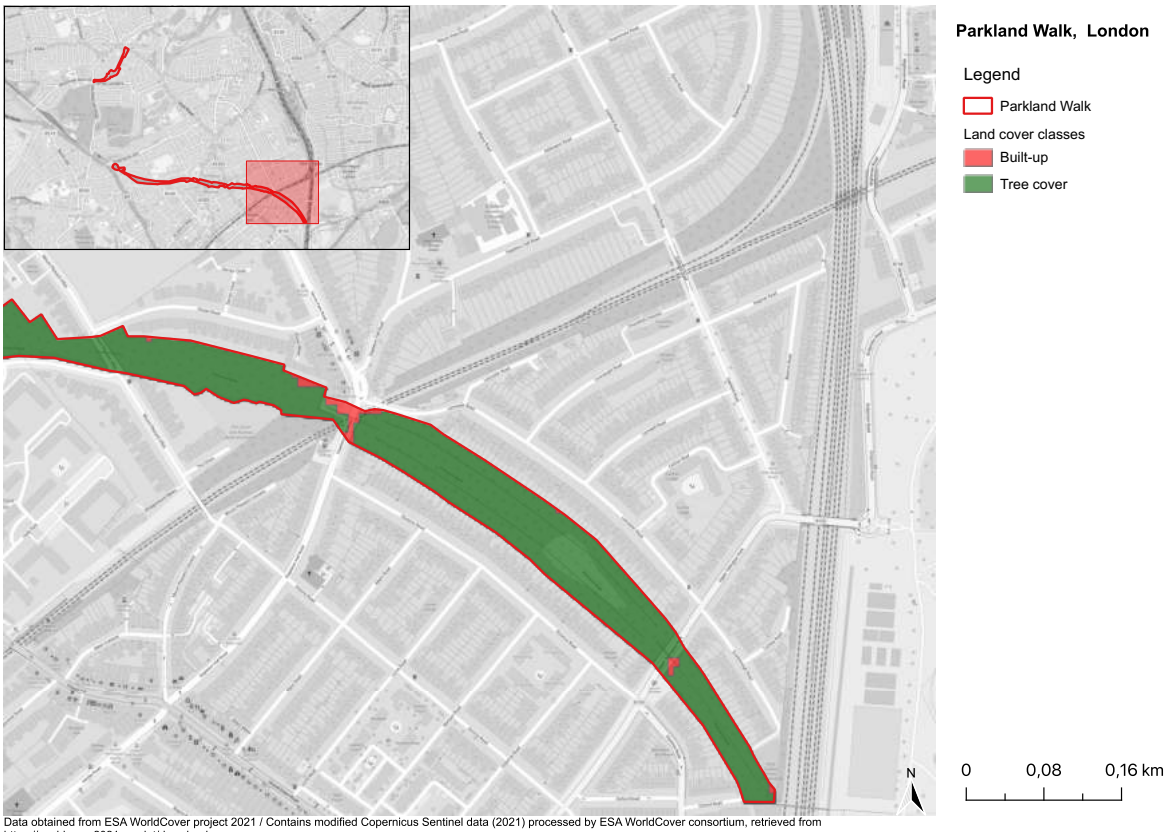
Appendix G Mapping of land cover classes of Parkland Walk



Data obtained from ESA WorldCover project 2021 / Contains modified Copernicus Sentinel data (2021) processed by ESA WorldCover consortium, retrieved from https://worldcover2021.esa.int/download.



Data obtained from ESA WorldCover project 2021 / Contains modified Copernicus Sentinel data (2021) processed by ESA WorldCover consortium, retrieved from https://worldcover2021.esa.int/download.



Data obtained from ESA WorldCover project 2021 / Contains modified Copernicus Sentinel data (2021) processed by ESA WorldCover consortium, retrieved from https://worldcover2021.esa.int/download.