Wildlife Passage;

Designing Functional Wildlife Passage for Roe Deer in Täby

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Swedish University of Agricultural Sciences, SLU
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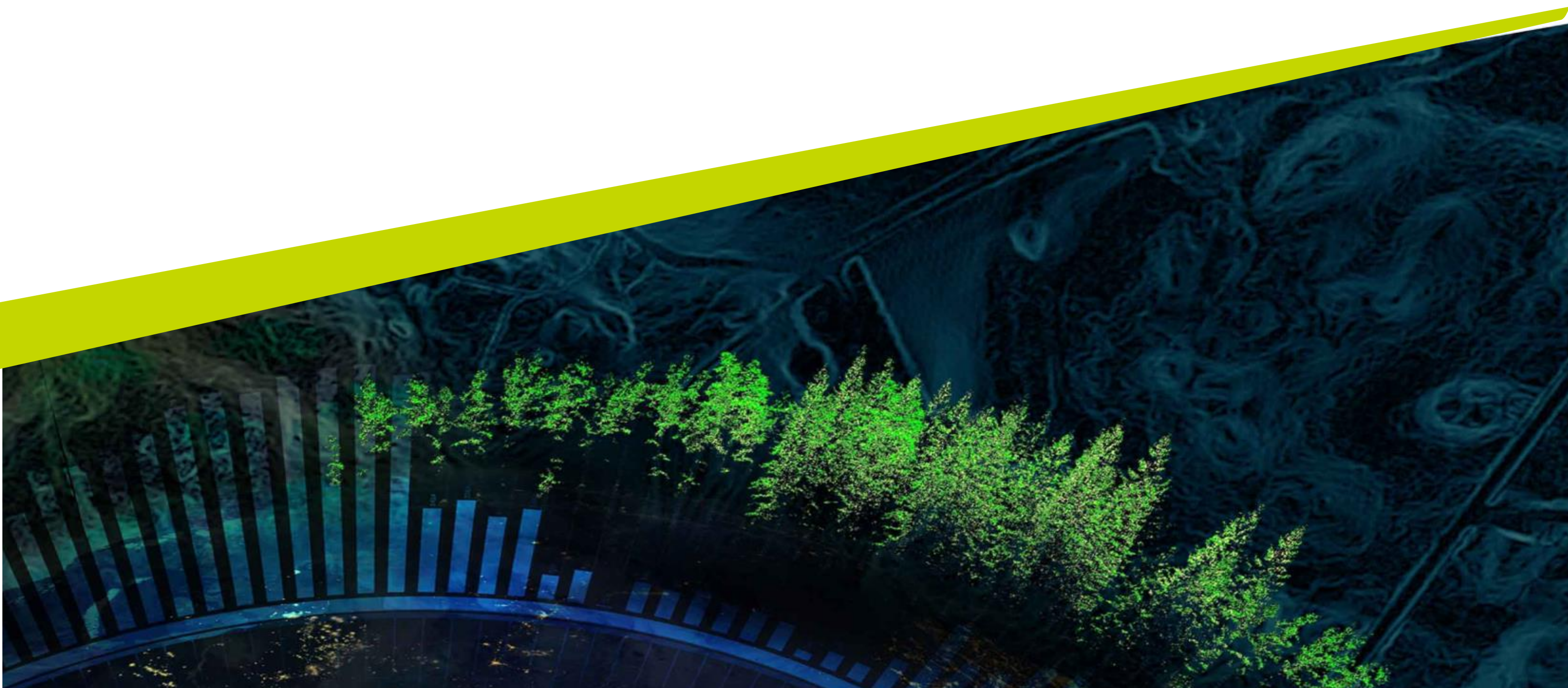

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Contents

Abstract

In the face of unavoidable urban development, preserving and restoring ecological networks is essential for the conservation of ecosystems. Wildlife passages are a solution for mitigating habitat fragmentation caused by urban infrastructure (Iuell et al. 2003). This master's thesis introduces a fragmented area that needs to be reconnected and proposes a multi-use overpass for both animals and people. The proposed study area is Hagby, the north of Täby municipality, Stockholm, Sweden, intending to reconnect fragmentation that occurs by Road 265 (Norrortsleden).

This project is inspired by the TRIEKOL research project (Helldin et al. 2024) and the GIS thesis project by Jonsson (2017). The project's main focus is designing a passage to mitigate the road's negative impacts on fauna, particularly roe deer, which are frequently involved in vehicle collisions in the study area. The objectives are to reduce wildlife-vehicle collisions and promote ecological connectivity by reconnecting fragmented habitats and facilitating safe animal movement.

Additionally, the proposed passage includes a dedicated path for pedestrians and cyclists, addressing the lack of a safe path across Road 265. Recognizing that human use of the passage is unavoidable, the design incorporates strategies to manage human presence and minimize disturbances to wildlife by employing "cues to care" techniques that discourage excessive human use of the passage.

The methodology combines theoretical research with practical design, involving literature review, landscape analysis through site inventory, document reviews, GIS and map studies, and field observations. In site analysis, the study utilizes the Landscape Character Assessment (LCA) tool to assess the landscape character types. The tool helps to choose a suitable location for the proposal.

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Firstly, I'd like to thank my supervisor, Tomas Eriksson, for his invaluable expertise, guidance, and ongoing support in shaping this project. Secondly, this thesis would not have been possible without the help of Jan Olof Helldin and the TRIEKOL project. I'd also like to thank Täby Municipality and the Swedish Transport Administration for providing important documents and information. I am also grateful to everyone who has supported me throughout this process, from the very patient staff at SLU to my family.

1. Introduction

Urban development, while necessary for human growth and progress, often comes at a significant cost to the environment (Iuell et al., 2003). As cities expand, natural habitats are increasingly fragmented by roads and other infrastructure, disrupting ecosystems and animal movements (Iuell et al., 2003). In particular, the construction of roads poses a severe barrier to wildlife movement, leading to habitat isolation and a higher incidence of animal-vehicle collisions (Iuell et al., 2003). In the face of these challenges, preserving and restoring ecological networks has become crucial for promoting animal movements and ecological values (Fredberg & Nylén, 2019).

This master's thesis addresses the issue of habitat fragmentation in Hagby, located in Täby municipality, Stockholm, Sweden. The focus is on the area surrounding Road 265 (Norrortsleden), a four-lane highway that cuts through two of the Stockholm green belts Rösjökilen and Angarnkilen, (Fredberg & Nylén, 2019), and agricultural lands of high ecological value (Täby Kommun, 2022). The road not only disrupts wildlife movement but also poses a significant threat to local fauna, particularly roe deer, which are frequently involved in vehicle collisions in the area (NVR).

My interest in this topic comes from a strong commitment to protecting the environment and a passion for blending creative design with ecological care. Growing up in a large city, I saw how urbanization harms ecosystems and wildlife, which inspired me to take responsibility as a landscape architect. Motivated by successful wildlife passages around the world, I hope to contribute to this field with my design. This thesis is not just an academic project; it’s a personal mission to support a balanced relationship between humans and nature.

1.1 Background

The study area is located in the north of Täby municipality (see Figure 1), it has significant natural value as it includes one of the largest green belts, Rösjökilen, in Stockholm (Vägverket, 1996b & Fredberg & Nylén, 2019). It is home to moose, deer, and smaller animals such as foxes, hares, badgers, martens, and various bird species (Vägverket, 1996b). Additionally, Hagby Eco Park, located in the north part of the area, hosts various bird and plant species, having a significant impact on biodiversity in the region (Paulin & Wallentinus, 2024).

In addition, In the Täby master plan for 2050, the primary goal is to create species-rich and healthy environments to enhance biodiversity (Täby Kommun, 2022). This includes developing and expanding green spaces, and ensuring that important habitats and wildlife pathways are protected and improved (Täby Kommun, 2022). The use of natural land will be minimized as much as possible, and careful planning will be used when developing valuable green areas (Täby Kommun, 2022). The green spaces in Täby, including parks, avenues, residential gardens, urban greenery, farmland, forests, waterways, lakes, and seas, form a connected network that supports the living and movement of various species. This network is crucial for maintaining wildlife habitats and providing essential ecosystem services (Täby Kommun, 2022).

Figure 1: The map shows Täby Municipality with the selected study area (Hagby) highlighted by a red circle in the northern part of Täby Municipality, Stockholm, Sweden. (Background ©Lantmäteriet).

Road 265 connects E4 and E18 (see Figure 2) and leads to fragmentation between the northern and southern parts of Täby municipality, the road speed limits vary along its length, ranging from 70 to 100 km/h (NVDB). The entire road was opened to traffic on October 4, 2008 (Vägverket, 1996b). Its location was reportedly selected with care to minimize impact on wildlife and preserve the area's natural and cultural values (Vägverket, 1996b). Efforts were made to avoid core areas of green wedges and other critical habitats as much as possible (Fredberg & Nylén, 2019). However, despite these measures, the road intersects two green wedges and disrupts the ecological movement of species within the landscape (see Figure 3) (Vägverket, 1996b).

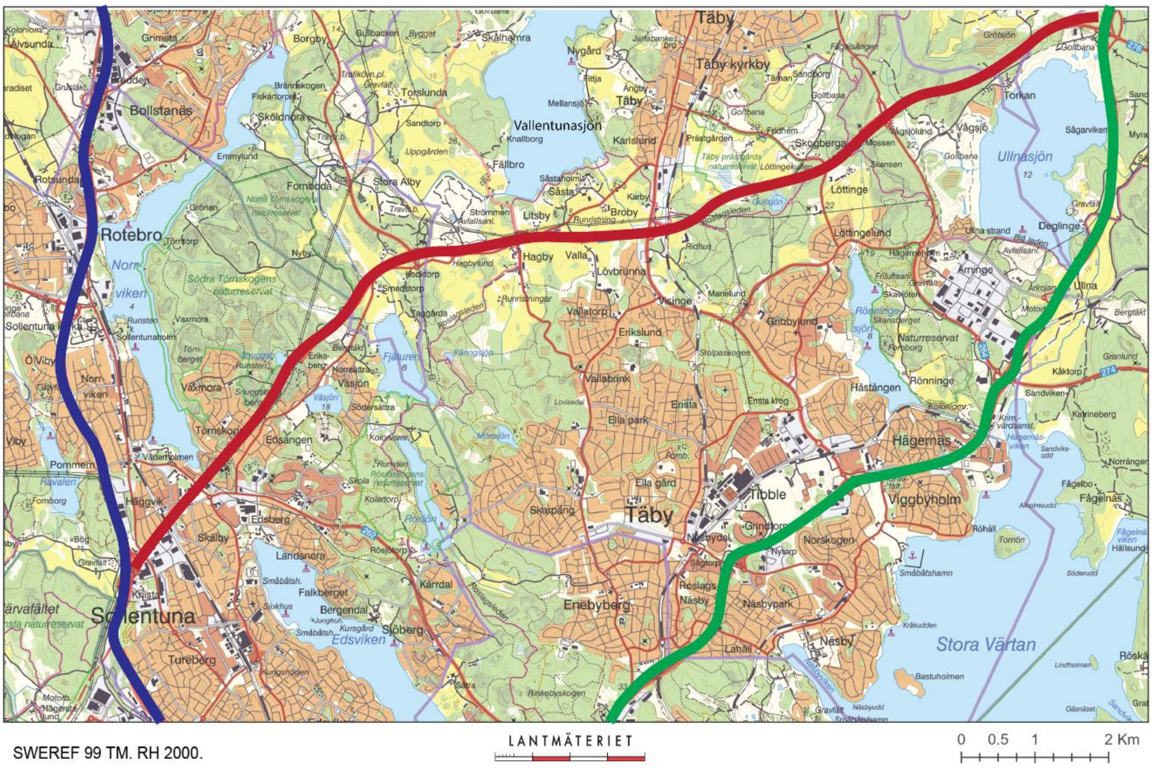

Figure 2: The map illustrates the full extent of Road 265 (red), which connects the E4 (blue) and E18 (green) roads. Road 265 leads to the fragmentation between the northern and southern parts of Täby municipality. (Background ©Lantmäteriet).

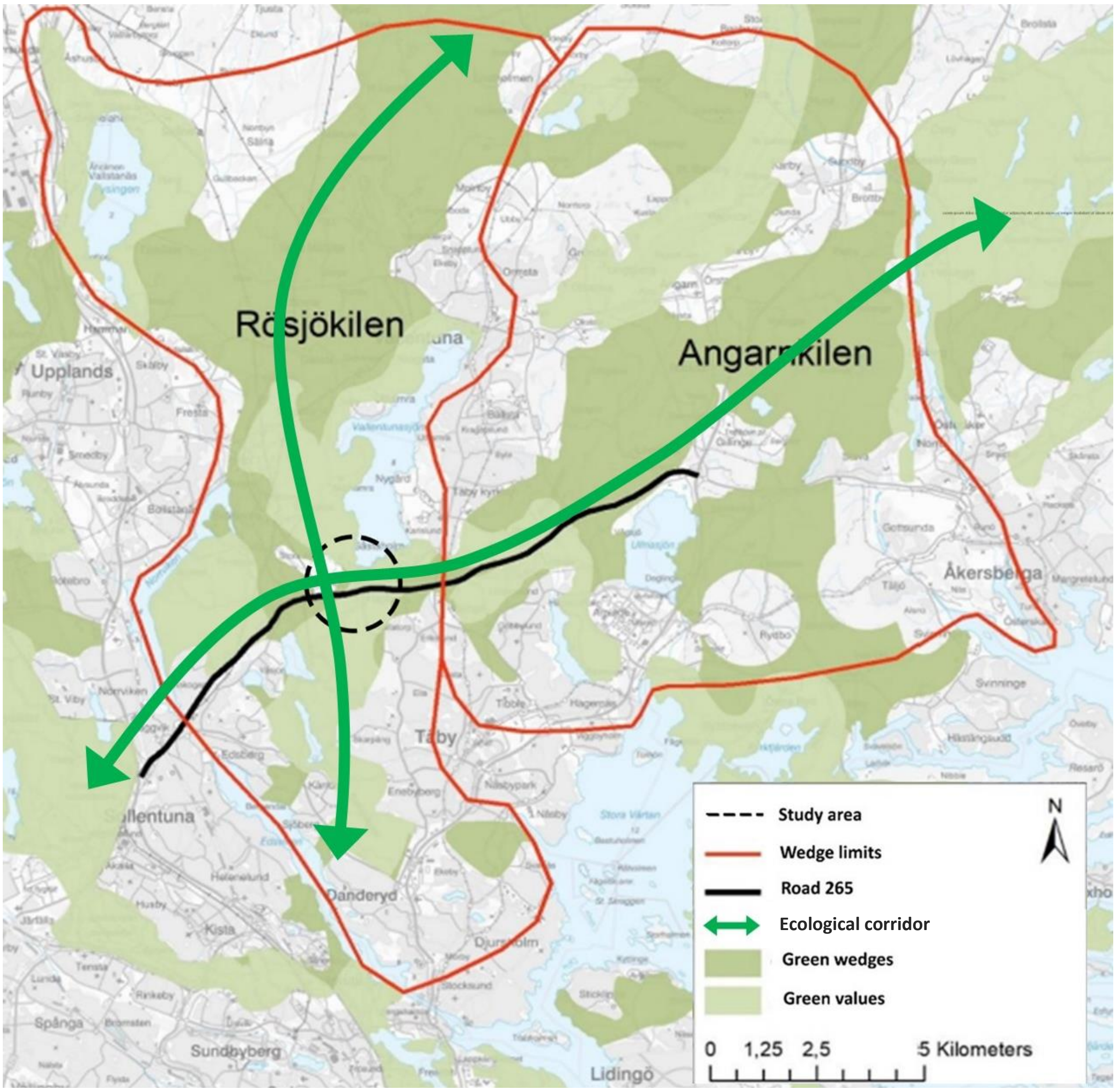

Figure 3: The map illustrates Road 265 passing through two green wedges in Stockholm, with the study area situated within one of these wedges. The road disrupts two key ecological corridors: one from north to south and another from east to west. This fragmentation negatively impacts the ecological values of the landscape (base map from Fredberg & Nylén, 2019).

Urban infrastructure, such as roads, has a negative impact on wildlife and their habitats. Four major impacts include (1) habitat loss due to the space occupied by roads; (2) the creation of barriers that fragment habitats, restricting access to resources, movement, and gene flow; (3) mortality from vehicle collisions; and (4) wildlife avoidance due to disturbances caused by traffic (Iuell et al., 2003; Seiler, 2003).

Road 265 has a daily traffic volume of more than 4,000 vehicles (AADT) and a speed limit exceeding 90 km/h (Vägverket, 1996b). Many animals tend to avoid roads with these characteristics (Fredberg & Nylén, 2019) due to disturbances such as vibration, noise, and light, which frighten them and alter their movement patterns (Rothman et al., 2017). Those that venture onto roads like Road 265, which lacks game fences, are at a high risk of being killed by traffic. This leads to a significant likelihood of fatalities and incomplete crossings (Fredberg & Nylén, 2019). Moreover, for many animals, an open corridor or disruptive traffic is enough to deter them from even attempting to cross (Helldin et al., 2023). While the infrastructure may not fully block their movement, it often creates a substantial barrier, limiting access to essential resources such as food, water, shelter, and potential mates (Helldin et al., 2023). The reaction of animals when encountering road infrastructure is illustrated in Figure 4.

Figure 4 illustrates how animals react when encountering traffic while attempting to cross roads. Factors such as traffic noise and lights serve to disturb and deter animals, while physical barriers like game fences and center rails, along with the risk of mortality, effectively prevent animals from safely reaching the opposite side of the road (illustration created by the author).

Apart from Road 265, there is a local road, Fresta, in the study area that runs parallel to Road 265 (Figure 5). With a speed limit of 60 km/h and an annual average daily traffic (AADT) of fewer than 1,000 vehicles (Fredberg & Nylén, 2019), it is not considered a significant barrier or danger for wildlife crossing (Fredberg & Nylén, 2019).

Figure 5: Fresta Road, which runs parallel to Road 265, is a local road with a traffic volume of fewer than 1,000 vehicles AADT and a speed limit of 60 km/h. These roads are not considered barriers to animal movements. (Photos by author, Summer 2024).

1.2 Purpose and research questions

This thesis aims to identify a suitable location within Täby municipality for a wildlife passage specifically designed for roe deer, to enhance animal movement and ecological connectivity in the landscape. Additionally, the thesis will present a design proposal for a multi-use passage that accommodates both human and roe deer movement.

Research question 1. Where can a wildlife passage be located in the northern part of Täby to enhance habitat connectivity and facilitate the movement of roe deer?

Research question 2. How can design elements and strategies be employed to effectively integrate both human and wildlife use in a multi-use passage?

1.3 Delimitation

Wildlife passages, also known as "fauna passages" or "wildlife crossings," are specialized structures designed to facilitate the safe movement of animals across or beneath transportation infrastructure (Iuell et al., 2003). Although thousands of such crossings have been constructed in recent decades, their success rates vary (Iuell et al., 2003). Some crossings fail to meet their objectives due to insufficient design considerations for specific animal species or disturbances from human activities, causing animals to avoid using them (Iuell et al., 2003).

Each wildlife passage is typically designed to accommodate the specific needs of particular species and is constructed in alignment with their natural habitats (Iuell et al., 2003). In this case study, the focus will be on roe deer. The study area urgently requires a wildlife passage due to the habitat's fragmentation and the high number of roe deer-vehicle collisions reported by the Swedish Transport Administration (Trafikverket, 2016). Additionally, the lack of safe passage for pedestrians and cyclists in the area may lead to human use of the wildlife passage, which could disrupt roe deer movement.

2. Methodology

This thesis uses a research-based design methodology that combines theoretical research with practical design solutions. The approach is guided by the ideas of Deming and Swaffield (2011), who view design as a way to explore and understand ecological issues, such as habitat fragmentation and the challenges faced by wildlife and ecosystems.

The framework emphasizes a repetitive process where the design proposal develops through several stages: literature review, landscape analysis, and design proposal. Each of these parts is interconnected, ensuring that the design is based on solid research and practical application. By treating design as a way to ask questions, the project provides insights into suitable locations and how to create an effective wildlife passage.

2.1 Literature and document reviews

The literature and document review forms the foundation of this project. It includes a careful selection of materials that highlight the challenges natural habitats face due to urban development and explores wildlife passages as solutions to reconnect ecosystems and improve animal movement.

A key source was the TRIEKOL research project (Helldin et al., 2024), which studies how transport infrastructure affects landscape ecology. This project provided valuable information about how roads disrupt habitats and lead to fragmentation. Understanding these impacts helped inform the design by highlighting the main issues to address on-site. TRIEKOL also offered guidance on different types of wildlife passages and how to choose the right one based on the target species and specific site conditions.

Other important articles, such as "Habitat Fragmentation due to Transportation Infrastructure" (Iuell et al., 2003) and "Roads and Their Major Ecological Effects" (Forman & Alexander, 1998), were reviewed to understand the strengths and weaknesses of various wildlife passages and the factors that affect their ability to reduce human disturbances and improve habitat connectivity.

2.2 Landscape analysis and proposed project location

The landscape analysis involved site visits, map studies, and reviews of historical and planning documents related to the study area, Hagby. Important documents, such as "Översiktsplan Täby 2050 – Staden på landet" (Täby Kommun, 2022), outlined future changes in the region, providing context for how development could impact the area. Additional reports, like "MKB Norrortsleden delen Väsjön – Täby kyrkby" (Vägverket, 1996b), offered insights into habitat conditions before the construction of Road 265, while "Norrortsleden, väg 265" (Trafikverket, 2016) highlighted current wildlife movement challenges and the limitations of existing crossings.

These resources helped identify a site that needed reconnection through a wildlife passage, both for ecological reasons and animal movement. Field visits included taking photographs and making observations to document current landscape conditions and key features. This analysis focused on determining how the proposed wildlife passage could fit into the existing landscape, considering its ecological potential and how it would integrate with the surrounding environment. The iterative design process (Deming & Swaffield, 2011) allowed the proposal to develop based on landscape analysis, ensuring that animal and ecological needs were met in the final design.

2.2.1 Landscape Character Assessment (LCA)

In this project, the Landscape Character Assessment (LCA) tool was applied to better understand the landscape's distinctive features. The LCA method, originally developed in the UK, offers a systematic approach to analyzing and categorizing the unique qualities and functions of different landscapes (Swanwick, 2002).

By offering valuable insights into the diverse characteristics of landscapes, the LCA tool was instrumental in selecting a suitable location for the proposed wildlife passage. The analysis included site visits, document reviews, and map studies to identify essential landscape attributes such as topography, geology, vegetation, and land use (Swanwick, 2002). This comprehensive approach helps that the selected site for the wildlife passage aligns with criteria for both the passage itself and roe deer requirements, as well as the landscape characteristics.

2.3 Design proposal

The design proposal for the wildlife passage combines insights from literature reviews, document analysis, and landscape evaluations. The process began with preliminary sketches that visualized how the passage could fit into the landscape while addressing critical issues such as habitat fragmentation and animal movement patterns.

An iterative design process allowed for refining initial sketches into detailed plans, sections, and 3D models. This method encouraged continuous feedback and adjustments to ensure that all design elements—such as dimensions, materials, and landscape integration—met both ecological needs and practical considerations.

The design also took into account human activity, incorporating features to minimize conflicts between pedestrians, cyclists, and wildlife. By using field observations and advanced tools, the final design aligns with the natural topography and existing land use, aiming to restore ecological connectivity while ensuring minimal disruption to local wildlife habitats.

3. Literature and document reviews

3.1 Overpasses versus underpasses

When a wildlife passage must be constructed in a particular site, there are several general considerations that determine the choice of either an overpass or an underpass, the most important being the local topography, target species requirements and budget availability (Iuell et al., 2003 & Helldin et al. 2024).

Underpasses are preferred for crossing over embankments In hilly areas due to their ability to integrate with the natural terrain and funnel animal movements through ecological corridors (Iuell et al., 2003), In contrast, overpasses are better suited for crossing large infrastructure between cuttings, where they can provide broader ecological connectivity and support a wider range of species and habitat types (Iuell et al., 2003).

Overpasses offer the benefit of enabling full restoration of vegetation and improving connectivity between habitats on either side of the infrastructure (Iuell et al., 2003). As a result, they are likely to attract a more diverse array of species while underpasses face challenges in vegetation growth due to limited moisture and sunlight, unless they are sufficiently tall, as seen under a viaduct. (Iuell et al., 2003).

The selection between constructing an overpass or underpass depends on the surrounding habitats that need to be connected (Iuell et al., 2003). Both underpasses and overpasses are suitable for ungulates, Studies suggest that in areas where both options are available, roe deer often prefer overpasses (Iuell et al., 2003).

3.2 Multiuse Wildlife Passages

Wildlife passages can be classified based on their primary purpose, either exclusively for wildlife or designed for both human and wildlife use (Iuell et al., 2003). Generally, passages constructed solely for wildlife achieve better outcomes in terms of usage by various species, particularly large ungulates that are typically wary of humans and traffic (Denneboom et al., 2021). Animals tend to avoid these passages during periods of human activity and are generally cautious and alert when approaching such sites (Knufinke, 2021; Iuell et al., 2003).

3.3 Target species (Roe deer)

Identifying target species is crucial when designing wildlife passages, although a multi-species approach is generally preferred (Iuell et al., 2003). Target species are the species primarily intended to benefit from the passages (Helldin et al., 2023). For larger passages, ungulates such as moose, roe deer, and reindeer are the main focus because they are frequently involved in wildlife accidents, leading to significant societal costs and causing suffering to both animals and humans (Helldin et al., 2023).

The locations and movement patterns of target species are crucial to identify when designing wildlife passages (Iuell et al., 2003). The movement pattern emerges as individuals seek and access essential resources for survival, such as food, shelter, and mates (Jägerbrand, 2020). Moreover, human activities impact animal movements, with animals often preferring to move undisturbed at night when traffic and outdoor activities are reduced (Helldin et al., 2023).

Roe deer, the target species in this project, have demonstrated remarkable adaptability to a range of habitats over the past few decades (Brucks et al., 2021). They exhibit digestive plasticity and their digestive systems vary according to the habitat and available food (Brucks et al., 2021). Recently, these species have extended their range into urban and agricultural areas (Brucks et al., 2021). While they were once known as solitary woodland species, they now form large aggregations in open habitats due to urban development (Brucks et al., 2021).

Roe deer are well-adapted to heterogeneous, human-dominated landscapes and can thrive in various habitat types (Schwegmann et al., 2023). Habitat selection by roe deer is driven by factors such as food availability, hiding cover, and thermal cover, and is influenced by predators and human activities like hunting, forestry, and outdoor recreation (Schwegmann et al., 2023). Despite their opportunistic feeding behavior, roe deer are generally considered concentrate selectors, preferring a high diversity of food plants (Schwegmann et al., 2023 & Brucks et al., 2021).

3.3.1 Roe deer-vehicle collisions

The necessity of establishing a wildlife passage is underscored by a GIS map from the Swedish Transport Administration (Trafikverket), which illustrates the high density of roe deer collisions within the study area (see Figure 6). Their report highlights Road 265 as a significant conflict zone impacting roe deer habitats on both sides (see Figure 7). This area is identified as one of the highest-priority conflict zones, with the Täby/Road 265 location, specifically the western part of object 29, projected to have an effectiveness rate of 75% to 100% in reducing accidents.

Supporting these findings, Jonsson (2017) has conducted a comprehensive analysis of roe deer mortality data in her bachelor's thesis. By integrating this data with relevant documentation and literature reviews, she developed a GIS report that emphasizes Täby as one of the most accident-prone areas for roe deer in Stockholm. Her research highlights the urgent need for a wildlife passage in Hagby to reduce the occurrence of collisions.

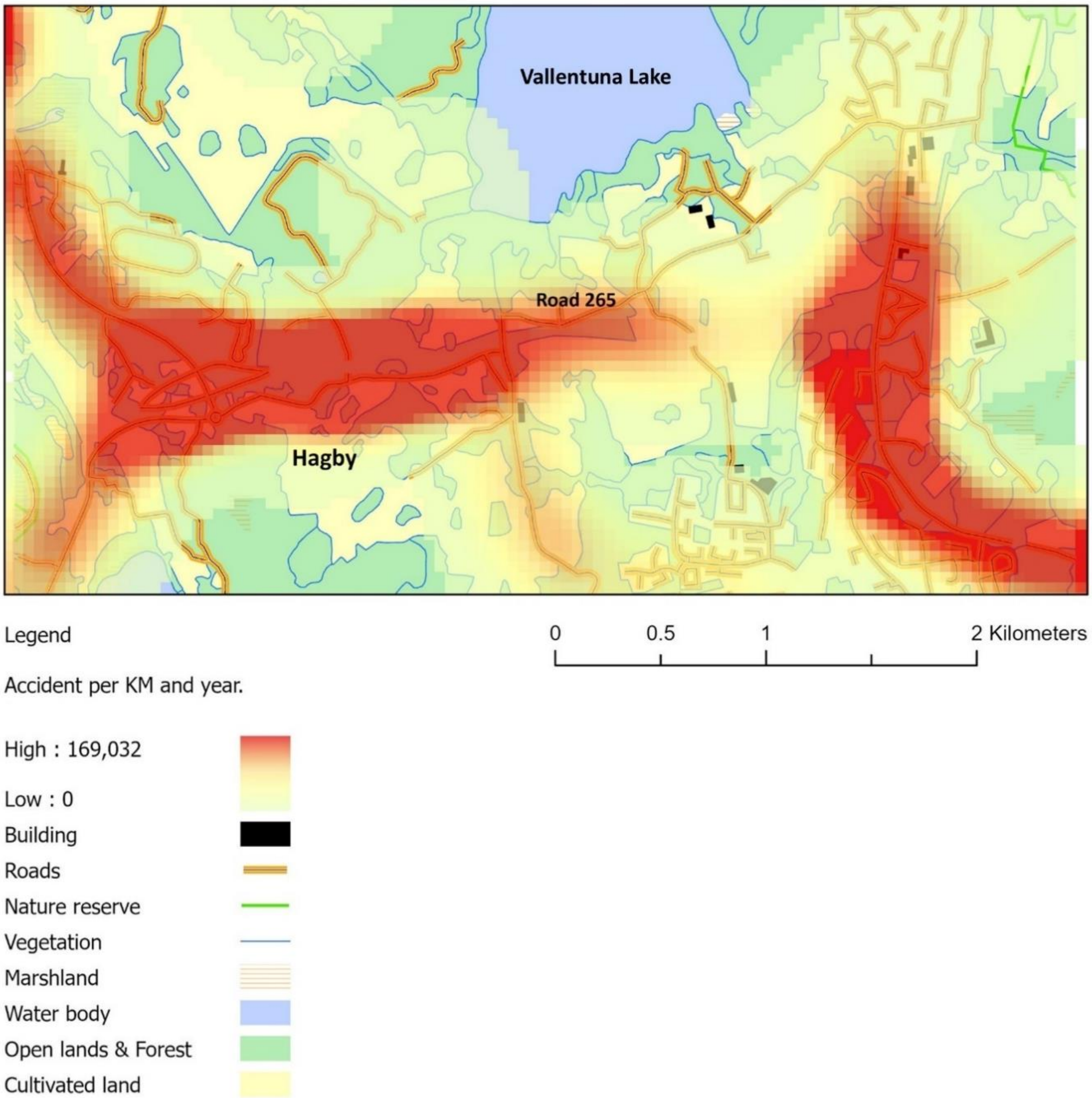

Figure 6: The map displays the density of roe deer accidents per kilometer per year in the north of Täby. Areas with a higher number of accidents are shaded in darker red. On the left side of the map, in the Hagby, the study area, there is one of the highest rates of deer accidents in Stockholm. (Background ©Lantmäteriet, 2024. GIS data from lastkajen.trafikverket.se)

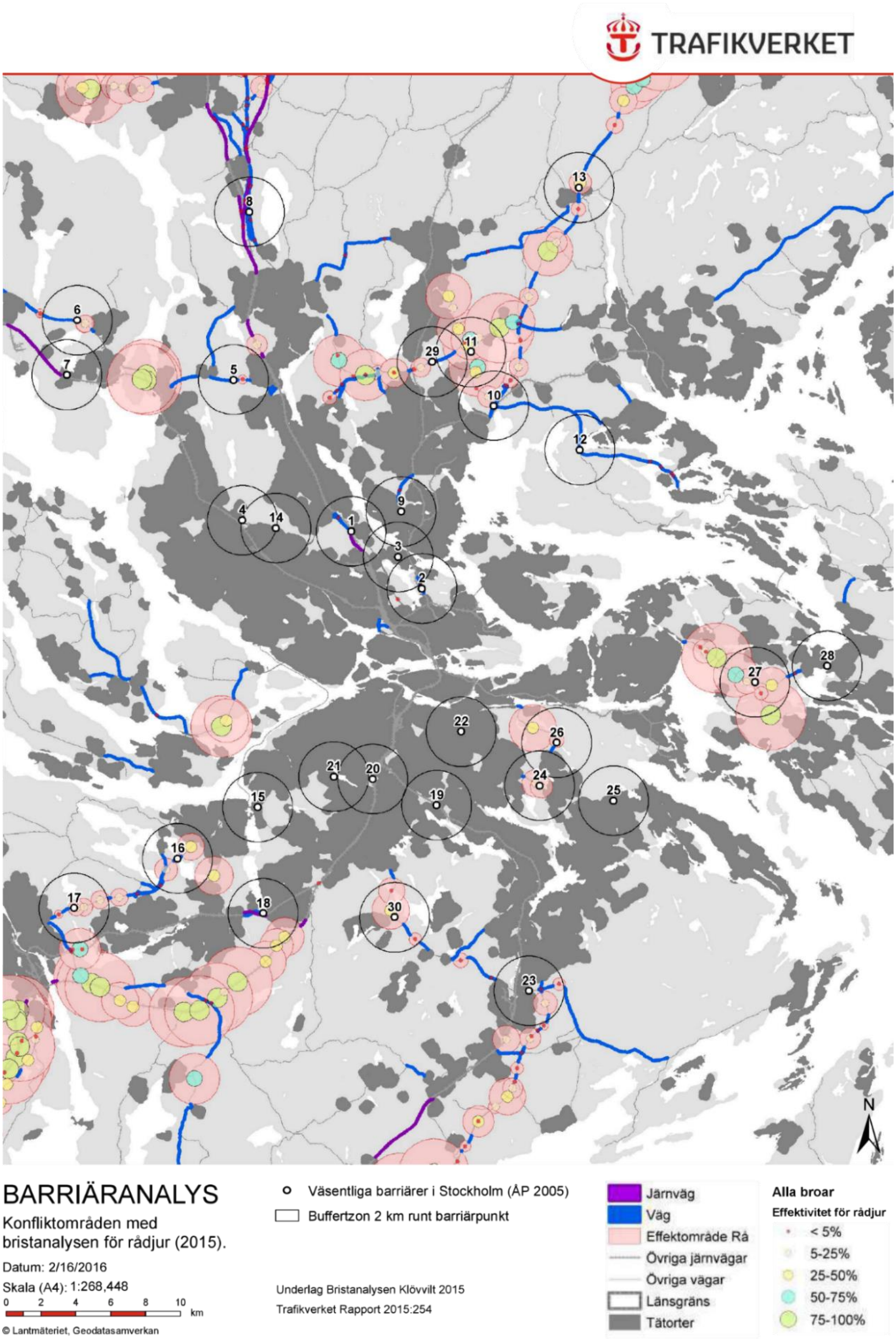

Figure 7: Barrier analysis showing conflict areas and deficiency analysis for roe deer. The study area is located in the western part of object 29, where the effectiveness of a wildlife passage is projected to reduce roe deer accidents by 75% to 100% (Tuvendal et al., 2016).

3.4 Dimension

The dimensions of wildlife passages play a crucial role in their effectiveness (Iuell et al., 2003). Larger structures generally attract a wider variety of species, including larger animals and a greater portion of target populations (van der Ree et al., 2007). For larger species, the width and placement of the passage in the landscape are more critical than specific design details (Rothman et al., 2017). In contrast, smaller animals prioritize design features and vegetation for cover (Rothman et al., 2017). The Swedish Transport Administration recommends a width of 30 meters for optimal wildlife passages to better integrate with the natural landscape (Rothman et al., 2017).

An effective wildlife passage must be sufficiently open to encourage animal use, which can be assessed using an openness index based on its length, width, and height (Iuell et al., 2003; Jägerbrand, 2020). European guidelines suggest that the width-to-length ratio for multiuse overpasses should be between 0.6 and 0.8, meaning the width should be 60-80% of the length. However, there is limited systematic research on the ideal dimensions for different animal groups and variations in effectiveness may also be influenced by structural attributes like shape, substrate, and construction material (Denneboom et al., 2021). Local factors, such as hunting regimes and human disturbances, can further impact the passage's effectiveness (Iuell et al., 2003).

3.5 Elements for Wildlife Passage Effectiveness

To ensure that a wildlife passage functions effectively and is utilized by animals, it is crucial to consider animal behavior and needs during the design phase (Helldin et al., 2023). In general, animals experience stress and anxiety due to human disturbances (Helldin et al., 2023). Therefore, the design of the passage should aim to minimize these stressors to reduce the negative impact of human presence. While stressed animals may still use the passage, it is more favorable if they can cross peacefully, as this increases the likelihood of their return and encourages use by other members of their species. This can be achieved by incorporating elements that mitigate disturbances, such as noise and light barriers at the edges of the passage, and game fences to prevent animals from entering the road. Like humans, large ungulates develop routines and habits over their lifetime, including learning to find and use bridges (Helldin et al., 2023).

Additionally, the use of natural materials and supplementary features can significantly enhance the effectiveness of wildlife passages by better addressing the needs of different species (Iuell et al., 2003). Elements like tree stumps, piles of branches and twigs, boulders, stone piles, and cold walls provide crucial refuges, offering temporary shelter for smaller animal species and birds, particularly during early stages of vegetation growth (Rothman et al., 2017). Moreover, shallow water bodies, ponds, and moist environments near or within the wildlife passage contribute significantly to the well-being of a wide range of animal groups (Rothman et al., 2017).

3.5.1 Noise and Light Screen

Human activity in and around wildlife passages can indeed be perceived as disturbing by wild animals, potentially leading to a longer period of time before they use the passage again (Helldin et al., 2023). Such disturbances can undermine the effectiveness of wildlife passages (Iuell et al., 2003), which are designed to facilitate animal movement and improve ecological connectivity. Given the significant costs and conservation objectives associated with these structures, it is crucial to implement strategies to minimize human and traffic disturbances that negatively impact wildlife use (Iuell et al., 2003 & Helldin et al., 2023).

To address these concerns, several mitigation measures can be considered. For instance, the installation of concrete barriers designed to block sound and light can help reduce disturbances (Shilling et al., 2018). These barriers can shield wildlife from noise and light pollution, which are known to affect animal behavior and passage use. Additionally, using quieter pavement materials in and around the wildlife passages can further minimize the impact of traffic noise. Such measures can help create a more conducive environment for wildlife, encouraging them to use the passages more consistently (Helldin et al., 2023 & Shilling et al., 2018).

The Washington State Department of Transportation (WSDOT) provides valuable insights into traffic noise mitigation strategies (Shilling et al., 2018). According to their guidelines, traffic noise can be significantly reduced through the construction of various types of noise barriers (Shilling et al., 2018). These barriers can be made from materials such as earth, concrete, wood, and masonry blocks, each offering different levels of noise reduction and durability (Shilling et al., 2018). Among these options, free-standing concrete walls are the most commonly used type of noise barrier. These walls typically range in height from 1.8 to 6 meters and are effective in diminishing the impact of traffic noise on adjacent areas, including wildlife passages (Shilling et al., 2018).

3.5.2 Game Fence

The combination of wildlife passages and fencing is widely recognized as one of the most effective methods for mitigating the negative impacts of transport infrastructure on wildlife by reducing habitat fragmentation and the barrier effects caused by roads and highways (Iuell et al., 2003). Setting up game fences has proven to be particularly effective in reducing wildlife accidents. In Sweden, for example, such fencing measures have been commonly employed to address the challenges posed by roads and traffic (Rothman et al., 2017). Game fences help prevent animals from crossing roads in unsafe areas, thereby reducing the likelihood of collisions. Research indicates that game fencing can lead to a reduction in deer collisions by approximately 55 percent (Rothman et al., 2017).

In addition to reducing accidents, game fences also play a crucial role in guiding animals toward designated wildlife passages (Rothman et al., 2017). By restricting the animals' movements to specific areas, fences help that wildlife are more likely to use the passages, rather than attempting to cross roads elsewhere. This guidance is essential for maintaining safe and efficient wildlife movement across transport infrastructure (Rothman et al., 2017).
Moreover, combining fencing with additional features such as light and noise barriers can further enhance the effectiveness of wildlife passages (Iuell et al., 2003). These barriers help to minimize disturbances from traffic, which can otherwise deter animals from using the passages (Iuell et al., 2003). By reducing noise and light pollution, these supplementary measures make the passages more attractive and usable for wildlife, thereby improving the overall success of the mitigation efforts (Iuell et al., 2003).

3.6 Maintenance

A wildlife passage is a long-term structure that requires regular maintenance, including the repair of fences and other physical elements, as well as vegetation management (Rothman et al., 2017). Monitoring the functionality and benefits of wildlife passages is crucial to ensuring their effectiveness (Rothman et al., 2017). The success of a crossing structure is typically measured by the number of animals that successfully use it (Denneboom et al., 2021). However, even a successful wildlife passage can face external threats, such as municipal development, that may compromise its functionality and are often beyond the jurisdiction of the Swedish Transport Administration (Helldin et al., 2023).

4. Landscape Analysis

In this project, I have used Landscape Character Assessment (LCA) as a key method for analyzing the study area and determining the best location for the proposed wildlife passage (Swanwick, 2002). The assessment process is divided into three main stages; The first stage involves conducting a site visit to gather preliminary observations. The second stage focuses on reviewing maps, documents, and reports to collect detailed information. In the third stage, various landscape character types are identified within the study area. These types are described using data related to geology, topography, vegetation, and land use obtained from the earlier stages.

Next, the project criteria, including the requirements for the wildlife passage and roe deer, are compared with the characteristics of three potential locations to determine which is most suitable for construction. In the final stage, once the location is selected, the potential impact of the wildlife passage on the surrounding landscape is assessed. According to Swanwick (2002), LCA helps us understand the current state of a landscape, how it developed, and how it might change in the future. The goal is to ensure that any changes or developments preserve what is important or valued in the landscape and explore ways to enhance its character (Swanwick, 2002).

4.2 Site visit and landscape experience

In Landscape Character Assessment (LCA), the first step involves conducting a site visit to gain an understanding of the landscape (Swanwick, 2002). This crucial visit allows for the collection of firsthand observations that yield insights not available through maps and documents alone (Swanwick, 2002). During my site visit, I observed that the area is open and quiet, with most of the vehicles and individuals passing through linked to the agricultural lands or the Hagby recycling center. The area primarily serves agricultural purposes, supplemented by several distinct green spaces predominantly featuring pine trees (Figure 8). Additionally, Figure 9 depicts two roe deer feeding on crops in agricultural lands. This observation highlights the importance of these lands as foraging sites for the deer.

Figure 8: The illustration shows different parts of the study area and indicates the locations where the pictures were taken to provide a better understanding of the landscape characters (photos taken by the author, summer 2024 & background image from Google Earth, 2012).

Figure 9: The illustration shows roe deer in the agricultural lands of the study area (photos taken by the author in spring 2024).

4.2.1 Existing passages cross the Road 265

During my site visit, I noted two passages across Road 265: one underpass and one overpass (see Figure 10). Observations during site visits indicate that these passages were not originally designed for animal use. However, a report by the Swedish Transport Administration (Trafikverket) notes that despite this, there is evidence of animal tracking showing that animals do use these passages (2019). Nevertheless, the passages are not entirely successful in facilitating safe wildlife movement across the road (Fredberg & Nylén 2019).

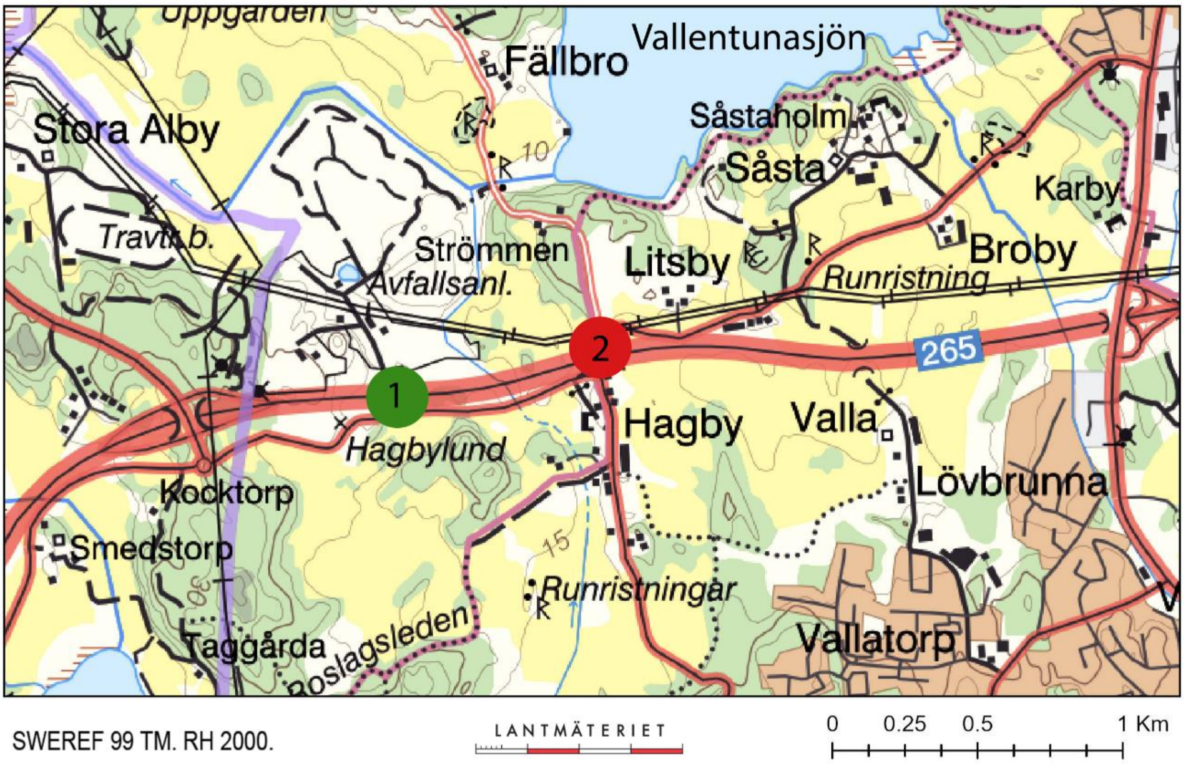

Figure 10 illustrates the existing passages within the study area. These are not designed for wildlife, but some animal footprints have been recorded there. The green point represents the underpass, while the red point indicates the overpass. (Background ©Lantmäteriet).

The underpass (passage number 1) is situated at the entrance of Hagby Recycling Center (Figure 11). There is no wildlife fence along the road to guide animal movements towards the passage. Instead, animals seem directed towards the Hagby interchange, where numerous wildlife accidents have been reported (Fredberg & Nylén 2019). Additionally, the constant flow of visitors to the recycling center appears to deter wildlife from using the passage (Fredberg & Nylén 2019). Without extending the wildlife fence along Road 265, animals circling the recycling center go onto the road, particularly at night when ungulates are more active (Fredberg & Nylén 2019). According to snow tracking by Ekologigruppen (2009), the majority of tracks and roe deer sightings were near this passage.

Figure 11 illustrates the underpass (passage number 1) at the entrance to Hagby Recycling Center. Animals can use the soil-covered part of the passage, but the high traffic in the area may scare them from using it. (Photos by author, Summer 2024)

Passage number 2, the overpass in the study area, is located in Hagby (Figure 12). It features an asphalt roadway with two lanes but lacks vegetation or gravel space for animal use. This passage is considered one of the less suitable options for wildlife crossing along Road 265 (Fredberg & Nylén, 2019).

Figure 12 illustrates the overpass (passage number 2). There are no spaces that animals can use to pass. (Photos by author, Summer 2024).

4.2.2 Lack of pedestrian and cyclist path

During my visit to the study area, I encountered challenges crossing Road 265 due to the absence of a designated walking path. The existing passages do not provide separate or safe areas for pedestrians and cyclists (Figure 13). Without safe walking paths, pedestrians, like myself, may resort to using the wildlife passage. If a wildlife passage were available, I would prefer to use it to cross Road 265 rather than the car road, which lacks pedestrian facilities and safety.

The Täby municipality's master plan for 2050 (Täby Kommun, 2022) emphasizes the need to improve local cycling and walking networks. While the plan suggests further developing the walking path network to enhance safety, accessibility, and attractiveness, it does not include any specific proposals for the study area (Täby Kommun, 2022).

Figure 13 illustrates the lack of safe space for cyclists and pedestrians in the study area. The images were taken at the junction of Fresta Road and the existing Overpass 1. The right image was taken from the entrance to Overpass 1, while the left image was taken from Fresta Road. (Photos by author, Summer 2024).

4.1 The structure of the landscape

After conducting a site visit and becoming familiar with the landscape and its characteristics, it is time to understand the structure of the study area by analyzing the maps, documents, and reports. This process involves reviewing relevant background materials, as well as other data and map information, such as topography, geology, and land use maps. This information and the data gathered during the site visit, will be used to create a series of map overlays that aid in identifying areas of common character, typically focusing on draft landscape character types.

4.1.1 The topography of the landscape

Topography is a key factor in identifying the structure of the landscape and understanding how the landscape has been shaped (Brämerson et al., 2020). Based on the site visit and the contour lines depicted in the topographic map provided by Täby Municipality, it is clear that the study area features varying ground levels (Figure 14).

In some sections, Road 265 is at the same level as the surrounding ground, while in others, it lies lower. The topography at the proposed location for the wildlife passage has played a significant role in determining whether to select an overpass or underpass for this project (Iuell et al., 2003).

Figure 14; The map illustrates the contours in the study area. Elevations along the road vary, with some areas higher than the road level, some at the same level, and others lower than the road level. (Contours from Täby Municipality; photos created by the author; background from Google Earth, 2012).

4.1.2 The geology of the landscape

Another important factor in understanding the structure of the landscape is geology, as it provides crucial insights into the foundation of a landscape (Brämerson et al., 2020). Geology determines the types of rocks, soil composition, and landforms in an area, all of which directly influence the landscape's topography, vegetation, and water systems (Brämerson et al., 2020). The landscape's form and soil types were analyzed through site visits and GIS data from Lantmäteriet (Figure 15). The area is predominantly composed of glacial clay, which supports agricultural lands, while separated bedrock formations create sloped and hilly terrain. The Hagby Recycling Centre, in contrast, features a man-made surface covered with asphalt.

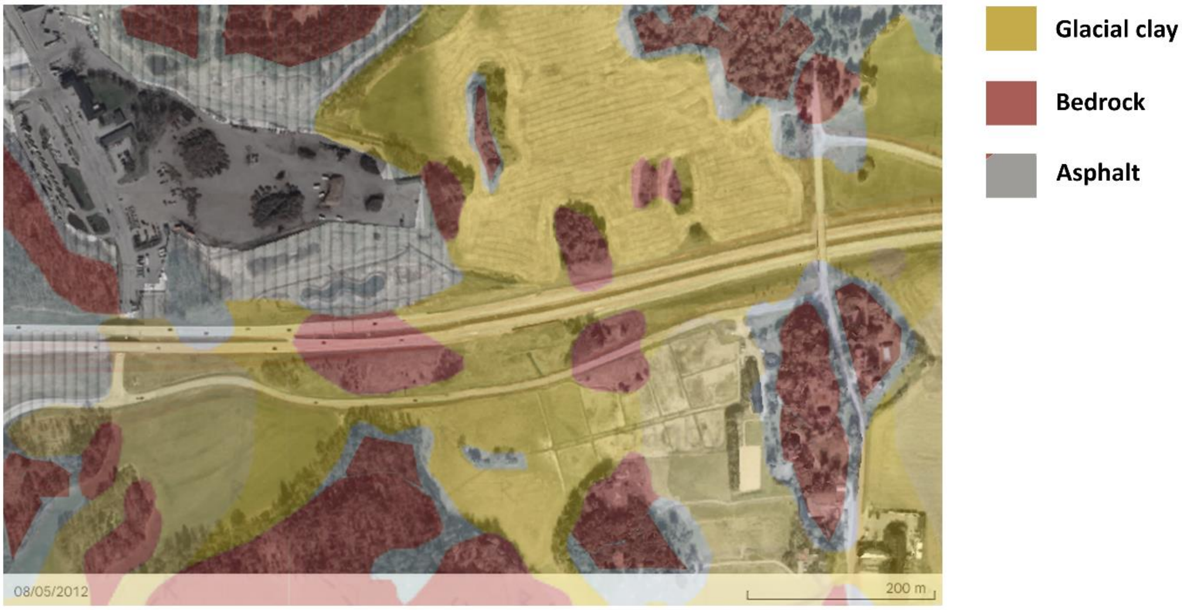

Figure 15: The map illustrates the different soil types in the study area, with glacial clay being the most predominant. (Data from Lantmäteriet, 2024; background from Google Earth, 2012).

4.3 The use of the landscape

Understanding how the landscape is used provides valuable insight into its functions and the relationship between people and their environment, highlighting its practical and social roles (Brämerson et al., 2020). GIS data from Lantmäteriet (Figure 16) reveals that the study area is predominantly agricultural, with scattered green spaces. Based on observations from the site visit, most of the local traffic is related to agricultural activities and the Hagby Recycling Centre, and the area lacks residential areas, entertainment or recreational facilities.

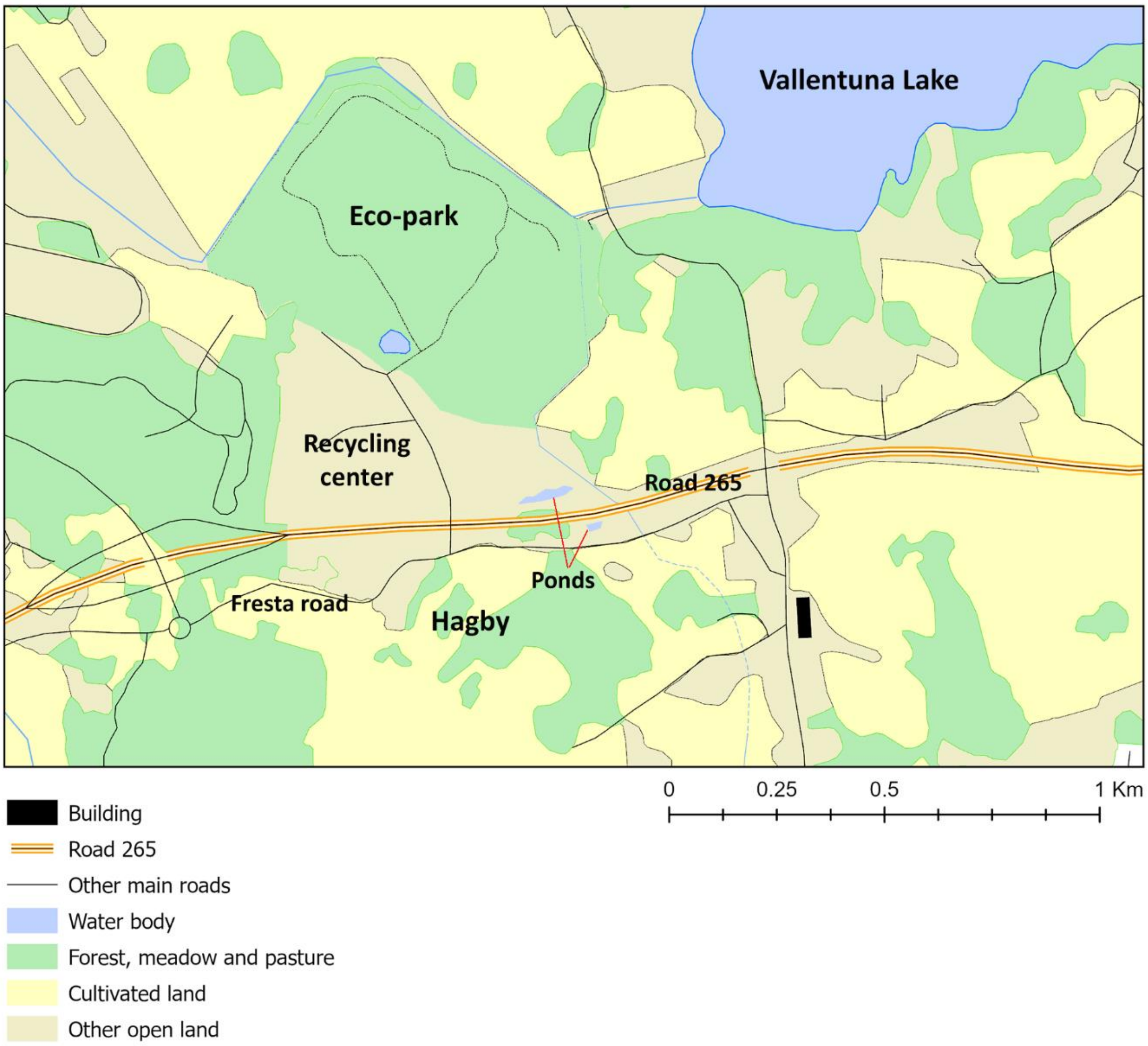

Figure 16: The study area is primarily agricultural, with some separate small green spaces, two small ponds, and an industrial site, but the main land use of the area remains agricultural. @Lantmäteriet (2024)

4.4 Ecology of the landscape

Another factor that needs to be considered is the landscape's ecology which helps identify its characteristics (Brämerson et al., 2020) and provides insights into how sensitive the environment is to changes and how we can enhance ecological connections and services (Noborn et al., 2018).

Most of the study area is covered by agricultural land, but there are some distinct forest areas with oak and pine trees. During the construction of Road 265, some large oaks were preserved, though many were affected by the roadwork (Vägverket, 1996b). Adjacent to the Hagby Recycling Center, a verdant eco-park has been developed from a former waste disposal site. Since 1978, coniferous and deciduous trees have been planted to promote biodiversity (Paulin & Wallentinus, 2024). The park features water elements such as ponds, open ditches, and cultivated islets designed to mimic the original natural landscape. Historically, this area was a diverse wetland known as Froden, which served as a nesting and resting site for migratory birds. Today, the eco-park's bushes, with their flowers and berries, attract insects, birds, and even roe deer (Paulin & Wallentinus, 2024).

The Hagby eco-park contributes to this diversity by maintaining a variety of vegetation, making the area a favorable habitat for many bird species (Paulin & Wallentinus, 2024). The ecological diversity in the area and the reconnection of habitats are beneficial for vegetation, birds, and insects. Additionally, during site visits, roe deer are frequently observed in the area and along the road, especially in the agricultural lands. Large animals like moose and roe deer, as well as smaller species such as foxes, hares, badgers, and martens, can be found in Hagby (Vägverket, 1996b).

Apart from Vallentuna Lake in the northern part of the study area, which helps improve the local ecology (Vägverket, 1996b), I also noted two existing ponds during my site visit. These are shown on the land use GIS map (refer to Figure 16), with one located on each side of Road 265 (Figure 17).

Figure 17: The left image shows the pond near the recycling center, while the right image shows the pond on the opposite side of the road. These ponds are also visible on Figure 10 (Photos by author, Spring 2024).

4.5 The landscape character type

One of the essential components of Landscape Character Assessment (LCA) is analyzing the various landscape character types within the study area, which are crucial for understanding the region as a whole (Swanwick, 2002). This process begins with characterisation, where practical steps are taken to identify areas of distinctive character, classify and map them, and describe their unique features. This stage aims to clarify what differentiates one area from another.

In this study, three key landscape character types were identified: the Glacial Clay Plains, the Pine-Covered Bedrock Hills, and the Industrial Fill Plateau (Figure 18). These designations highlight significant aspects of the landscape, such as topography (Figure 14), geology (Figure 15), land use (Figure 16), and vegetation. These characteristics were determined through site visits and map studies. The identified landscape character types, defined by their homogenous features, reflect particular combinations of landform and land cover that create a distinct sense of place within the region.

The Glacial Clay Plains landscape consists of flat or gently sloping land, where the soil is primarily composed of glacial clay. This fertile soil supports extensive agricultural activities, particularly crop farming, which dominate the landscape. The flat terrain allows for expansive, open views, with fields often bordered by hedgerows or tree lines. The combination of flat topography, fertile soil, and widespread agriculture defines the distinct character of this landscape, making it the most prevalent type in the study area.

The Pine-Covered Bedrock Hills are characterized by rolling, hilly terrain with exposed bedrock. The dominant vegetation here is pine forest, which thrives on the rugged terrain. The uneven topography creates a more enclosed and varied landscape, where views are frequently interrupted by the hills and dense forest. This mix of rocky soil, hilly land, and pine forests gives the landscape its unique visual and ecological character.

The Industrial Fill Plateau is a human-made landscape where flat land has been created through the use of artificial fill material (asphalt). It is primarily used for industrial purposes, such as the Hagby Recycling Center. The flat, hard surfaces, mostly covered with asphalt, define the landscape. Unlike the surrounding natural areas, the Industrial Fill Plateau lacks vegetation and is dominated by human-made structures, giving it a distinctly functional and industrial appearance.

Figure 18 illustrates an overlay map of geology, topography, vegetation, and land use layers to depict the different landscape character types of the study area. (Illustration created by the author, background image from Google Earth, 2012).

4.6 Proposed location for the wildlife passage

Selecting a suitable site for the wildlife passage needs to focus on identifying criteria and factors that influence site choice, considering both design and roe deer requirements and also characteristics of each landscape type in the study area (Stahlschmidt et al., 2017) (Figure 19).

Figure 20 is a map that presents current characters and elements in the study area and two proposed locations for the wildlife passage. The wildlife passage imposes certain requirements for the landscape, which are compared with the potential offered by the landscape. Similarly, the landscape imposes certain constraints on the wildlife passage, which are compared with the likely impacts of the wildlife passage on the site (Stahlschmidt et al., 2017). For instance, a wildlife passage at Location 1 has the potential to reconnect habitats fragmented by Road 265. It would link the Industrial Fill Plateau on one side with the Glacial Clay Plains on the other. This passage could help restore the ecological balance of the area while also enhancing the visual landscape around the Hagby Recycling Centre. The site is located in a zone with a high rate of roe deer accidents (Fredberg & Nylén, 2019) and is close to agricultural lands and ponds, providing ample food sources. However, the heavy human activity around the recycling center could disrupt roe deer movement, making them less likely to use the passage (Iuell et al., 2003).

In contrast, the wildlife passage proposed at Location 2, situated in the Pine-Covered Bedrock Hills, offers a significant opportunity to reconnect two fragmented green spaces, thereby enhancing both ecological integrity and roe deer movement. This area has strong potential for ecological improvement due to its elevated topography, which allows for the construction of an overpass an option preferred by roe deer. An overpass would facilitate better vegetation growth by allowing sunlight to reach the area (Iuell et al., 2003).

Moreover, the site is suitable for roe deer, with agricultural lands nearby, two ponds for water access, and ample cover provided by the surrounding pine trees. This location also experiences a high rate of roe deer collisions (Trafikverket & Fredberg & Nylén, 2019). The location is distanced from the activities at Hagby Recycling Centre, minimizing human disturbance. Additionally, it is not close to other busy passages primarily used by cars, which tend to be noisy. Overall, this site meets all the criteria for a successful wildlife passage and offers a positive impact on the landscape by promoting ecological values.

I combine wildlife passage and roe deer criteria with an evaluation of landscape potentials and constraints. The recommended location is derived from a careful synthesis of project requirements and landscape characteristics, ensuring a clear connection between the proposed design and the surrounding landscape, and highlighting supportive aspects from both perspectives (Stahlschmidt et al., 2017).

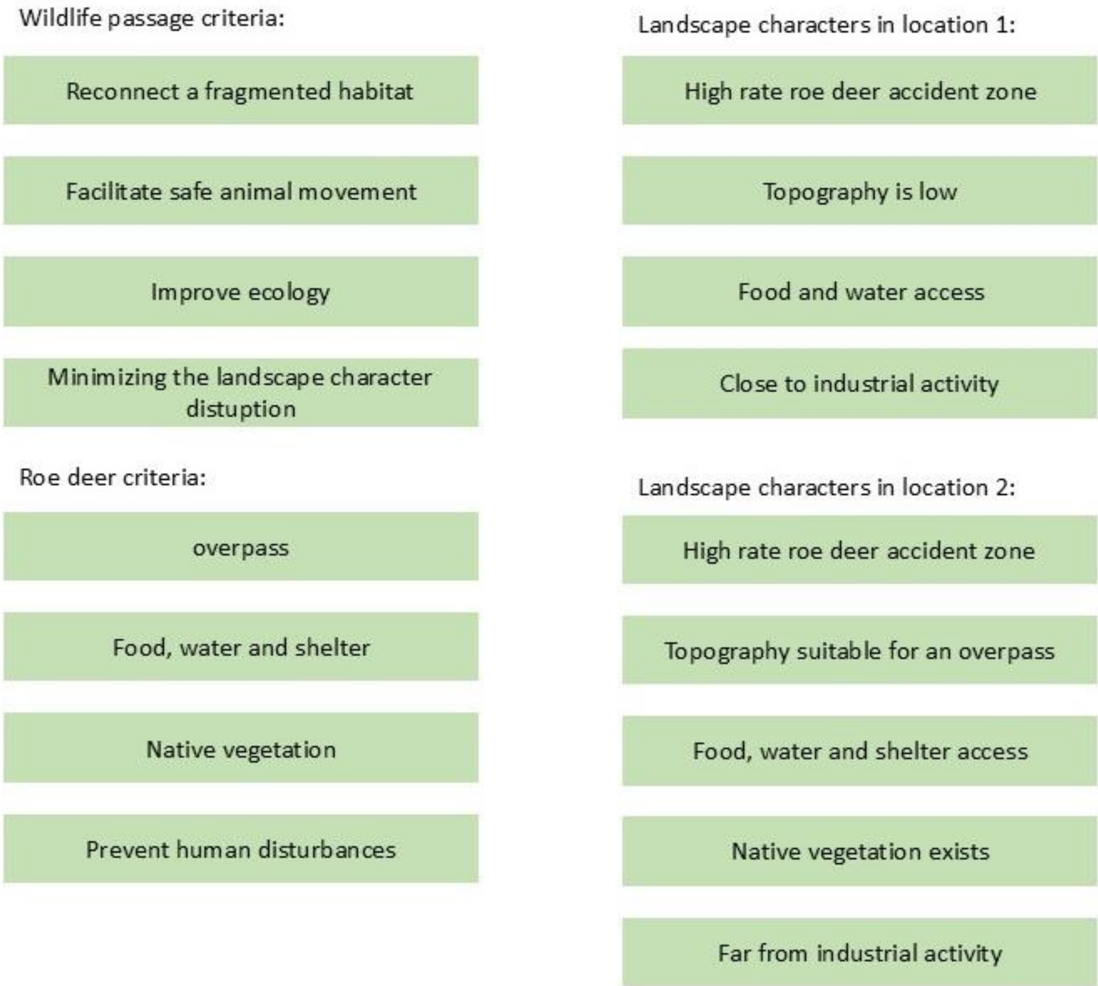

Figure 19 illustrates a list of wildlife passage and roe deer criteria, along with two alternative locations for the proposed design. The list shows that Location 2 meets both the wildlife passage and roe deer criteria, and as a result, Location 2 was selected as the final site for the project (Illustration created by the author).

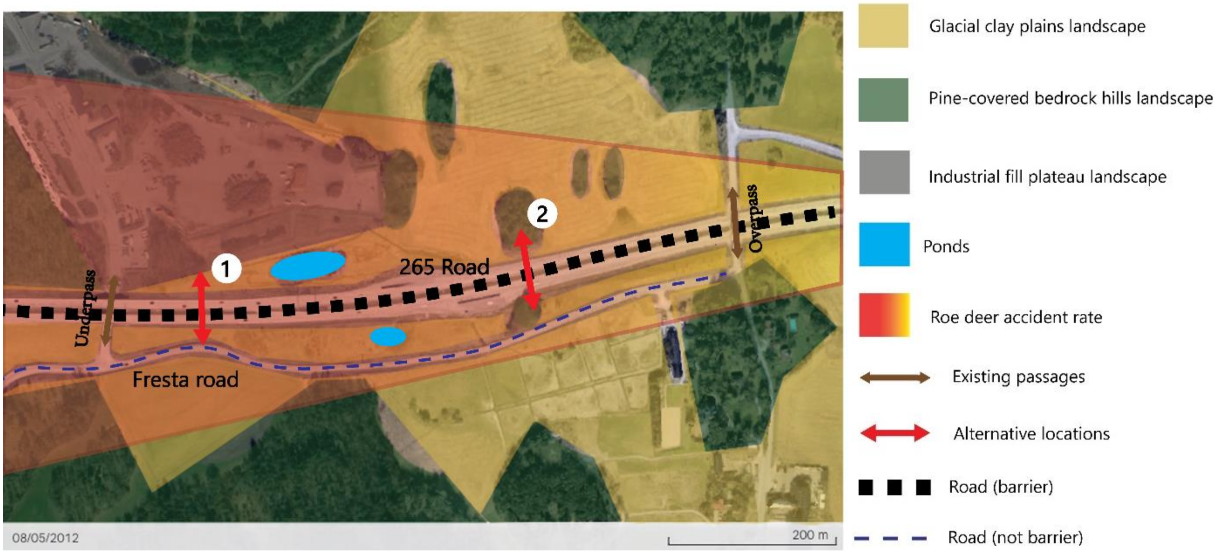

Figure 20: The map illustrates the landscape character types of the study area, the two proposed locations for the wildlife passage, and relevant study area information, including the roe deer accident rate. Road 265, which is a significant barrier for wildlife and ecology, and Fresta Road, a local road that is not considered a barrier. It also shows existing passages in the study area and nearby ponds. All these elements were considered to choose a suitable final location for the proposed wildlife passage. (Illustration created by the author; background image from Google Earth, 2012).

Figure 21: This illustration depicts the Pine-Covered Bedrock Hills landscape within the Glacial Clay Plains. The wildlife passage in this area enhances the ecological integrity of the landscape while preserving the primary agricultural lands. The trees at the entrance of the passage attract roe deer. (Photos taken by the author in summer 2024).

Figure 22: The illustration shows the small Pine-Covered Bedrock Hills landscape, which is situated at a higher elevation compared to the surrounding agricultural lands, providing the opportunity for an overpass structure. This design is more suitable for improving ecological connectivity and is preferred by roe deer. (Photos taken by the author in summer 2024).

4.7 Landscape Influence of the Wildlife Passage

When choosing a location for a design like the wildlife passage, it's important to consider not just the site itself but also the surrounding landscapes, as these can significantly impact site selection and overall effectiveness (Stahlschmidt et al., 2017). In this case, the proposed wildlife passage, located within the Pine-Covered Bedrock Hills will reconnect two fragmented green spaces that are currently divided by Road 265. This reconnection is expected to improve local ecology by enhancing habitat connectivity. Additionally, expanding vegetation along and near the passage could extend greenery along the road, potentially linking other disconnected parts of the Pine-Covered Bedrock Hills (Figure 23).

Since this forested area lies within The Glacial Clay Plains, the project's ecological benefits could also extend to the plains, improving ecology in that region as well. With agriculture being the dominant land use in the study area (Fredberg & Nylén, 2019), it's essential to both protect these agricultural lands and use the wildlife passage's ecological advantages to enhance them.

Although The Industrial Fill Plateau is located farther from the wildlife passage, the project may still have effects on this landscape. By improving wildlife movements and green networks, the project could eventually contribute to ecological restoration efforts even in distant landscapes, helping to mitigate the environmental impacts associated with industrial activity over time.

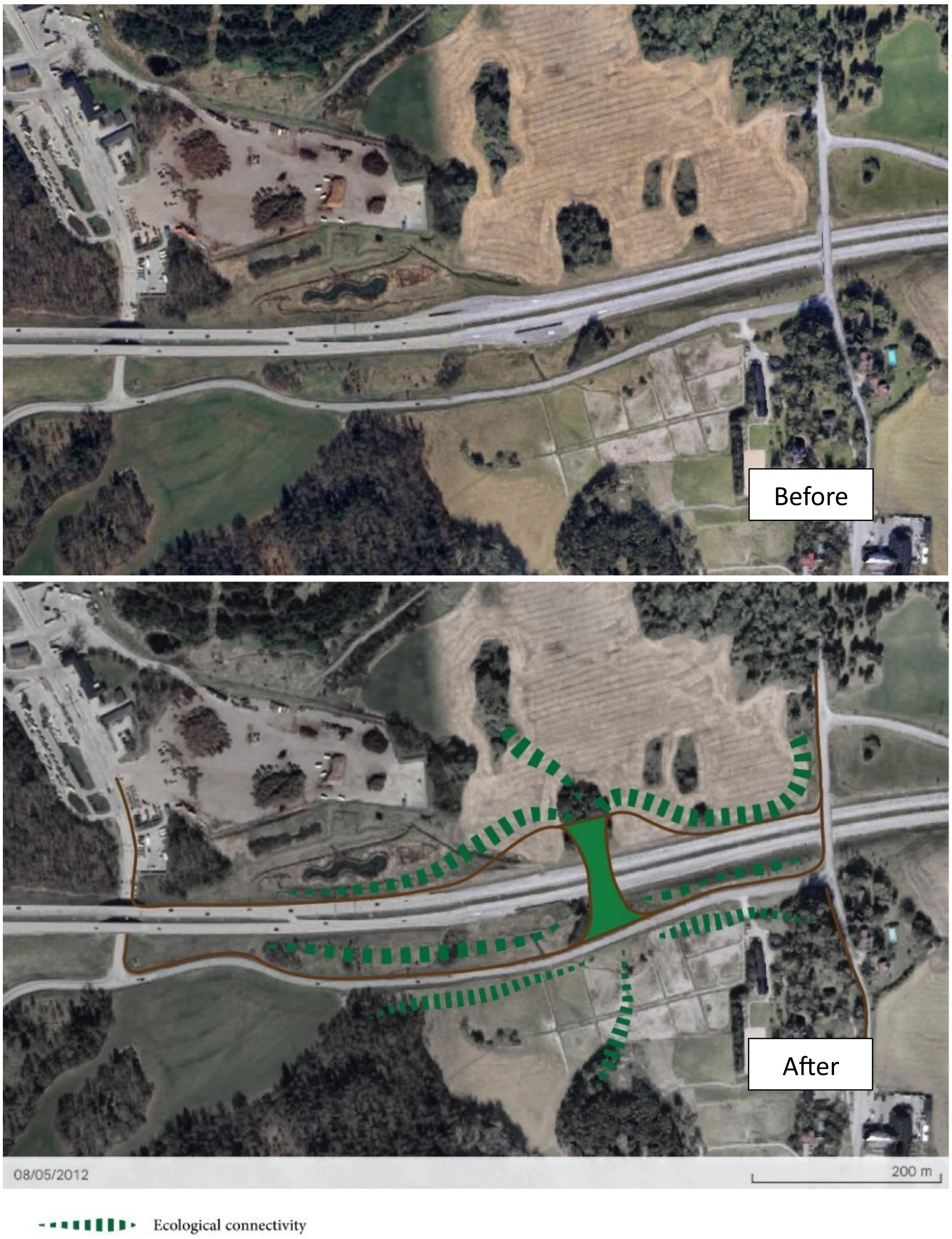

Figure 23 shows the situation in the study area before and after the construction of the wildlife passage. The ecosystems on both sides of Road 265 are reconnected and expanded, allowing animals to safely cross the road and improve the ecology. (Background map sourced from Google Earth, 2012)

5. Design proposal

The final design proposal presented in this chapter draws upon the knowledge acquired throughout this project. The proposal's location was assessed using the LCA tool to choose a site that meets wildlife passage requirements, roe deer needs, and aligns with the landscape's character. This project proposes a multi-use overpass on Road 265, aimed at enhancing biodiversity and ecology within the agricultural landscape.

5.1 Overpass

Based on the findings from the document, literature review, and landscape analysis that is mentioned in Figure 24, an overpass wildlife passage has been proposed for the project the situation of the proposal can be seen in Figure 25. This design utilizes the small hills on either side of the road, enabling a bridge height of 5 meters above the road surface to accommodate both car and truck traffic, as illustrated in the bridge section (Figure 26). This approach also eliminates the need for excavation for an underpass corridor.

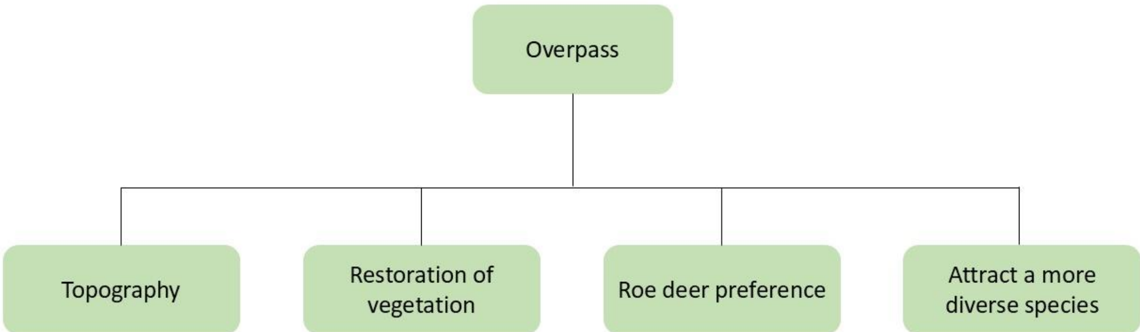

Figure 24 illustrates the features of the wildlife overpass, which are considered in choosing it for the proposal (created by the author).

Figure 25; illustrates the proposed location for the overpass on Road 265, situated between the existing overpass and underpass. (Photos by author, Summer 2024).

The elements that are typically essential for mitigating human disturbances or improving the quality of the wildlife passage are shown in this section (Figure 26). Detailed design considerations for these elements will be described more thoroughly in Chapter 3.7, "Enhancing the Ecological Performance of Passages."

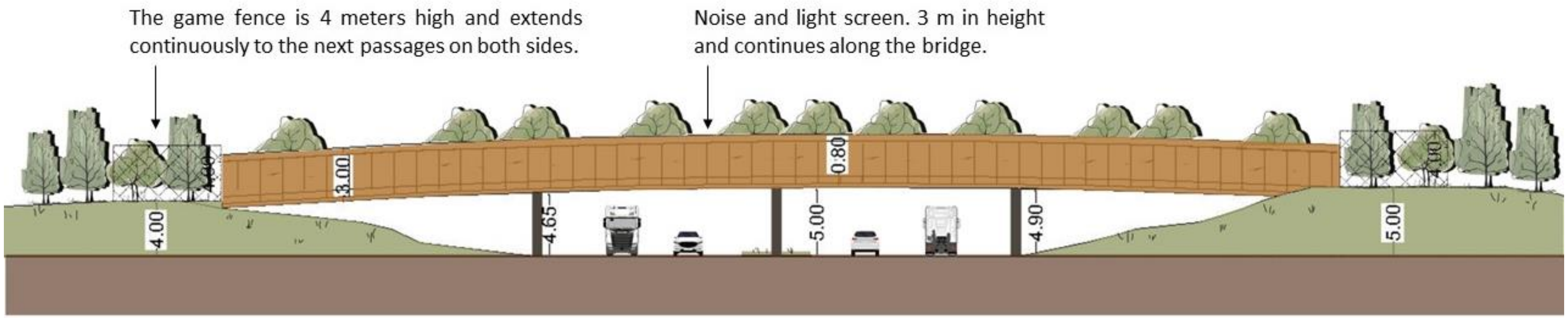

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Figure 26; illustrates the section of the proposed overpass located on the hills on both sides of Road 265. The lowest part of the bridge is 4.65 meters high, allowing sufficient height for trucks and tall vehicles to pass. The noise and light screens on both edges of the bridge are 3 meters high, designed to reduce light and noise disturbances on the bridge. The game fences, which are 4 meters high, extend along Road 265 to the next passages on both sides of the bridge (Created by the author).

5.2 Integrating the wildlife passage with the landscape

This similarity, both in terms of plant species and density, is crucial for harmonizing the passage with its surroundings (Westberg et al., 2021). This similarity helps roe deer perceive these passages as natural extensions of their habitat, encouraging their use. The proposed wildlife passage aims to not only be functional but also to blend seamlessly with the surrounding environment, enhancing its ecological and visual appeal. The Landscape Character Assessment (LCA) method supports this by focusing on the integration of the passage with the natural landscape, ensuring that both the ecological needs of wildlife and the characteristics of the environment are respected.

The proposal includes using natural materials and soil layers to encourage the growth of various vegetation species, making the bridge appear more like its surroundings (Iuell et al., 2003) and providing suitable habitat for roe deer (Strickland, 2019). Tall trees will be placed at the entrance of the bridge to attract roe deer, while on the bridge itself, vegetation will be kept lighter with small bushes and berries to avoid adding too much weight to the structure (Rothman et al., 2017).

5.3 Multiuse wildlife passage

The wildlife passage proposed in this project is primarily intended for wildlife but also accommodates pedestrians and cyclists. While the lack of specific safe pedestrian paths in the study area makes it reasonable to consider human use of the passage. Moreover, this proposal aligns with Täby municipality's development goals for improving the walking and cycling network (Täby Kommun, 2022), leading to the suggestion of a multiuse passage that serves both wildlife and humans (Figure 27).

Since animals typically avoid passages during periods of human activity (Helldin et al., 2023), integrating human use into wildlife passages is less likely to disturb the animals (Iuell et al., 2003). Additionally, no lighting will be considered that would make the passage usable at night by humans, to avoid conflicting with the times when roe deer use the passages. However, it is still crucial to design these passages carefully to minimize any potential negative impacts on wildlife. To achieve this balance, the "Cues to Care" strategy (Nassauer, 1995) is employed in this project.

In the proposal, the pedestrian path is situated exclusively on both sides of the bridge and continues to the next existing passages: the underpass (Passage 1) on the left and the overpass (Passage 2) on the right (refer to Figure 28). The path is designed to encourage humans to stay within their designated area, thereby minimizing their presence in sections reserved for wildlife. This separation is reinforced by vegetation, which serves to visually isolate human commuters from the wildlife section of the bridge. The pedestrian pathway is specifically covered with materials like wood that mimic natural elements, making it more appealing for people to use, while the wildlife section is covered with soil and rocks (Nassauer, 1995).

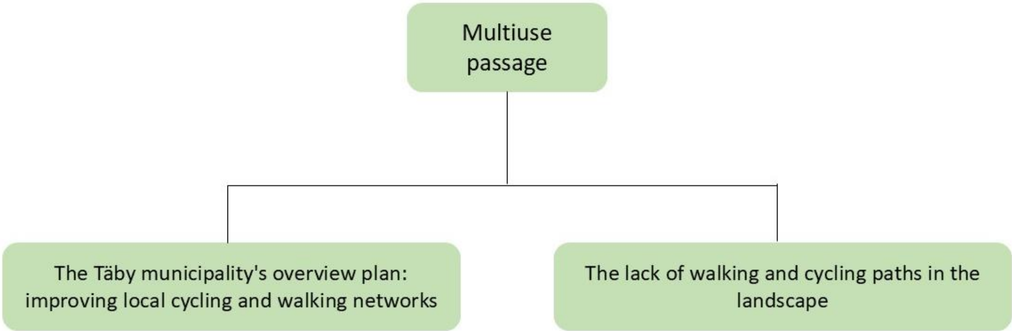

Figure 27; The diagram illustrates the reasons for implementing the multiuse passage (created by the author).

Figure 28; The map illustrates the proposed route for pedestrians and cyclists. The red arrows indicate the path guiding users over Road 265 on the proposed passage and to the existing overpass (Passage 2). The purple arrows show the path leading under Road 265 to the existing underpass (Passage 1). (Background map sourced from Google Earth, 2012).

5.4 Dimension and shape of passages

The proposed overpass on Road 256 is designed to be 55 meters long and 36 meters wide (see Figure 29). The width includes 30 meters dedicated to wildlife use, with 3 meters on each side allocated for pedestrians and cyclists (refer to Figure 30). Its hourglass shape helps animals perceive the bridge as wider than its actual width (Rothman et al., 2017). To accommodate both wildlife and human use, the design ensures a minimum width for animal passage before integrating features for human access (Jägerbrand, 2020). Physical barriers are also employed to minimize human interference and prevent people from using the full width of the bridge (Jägerbrand, 2020).

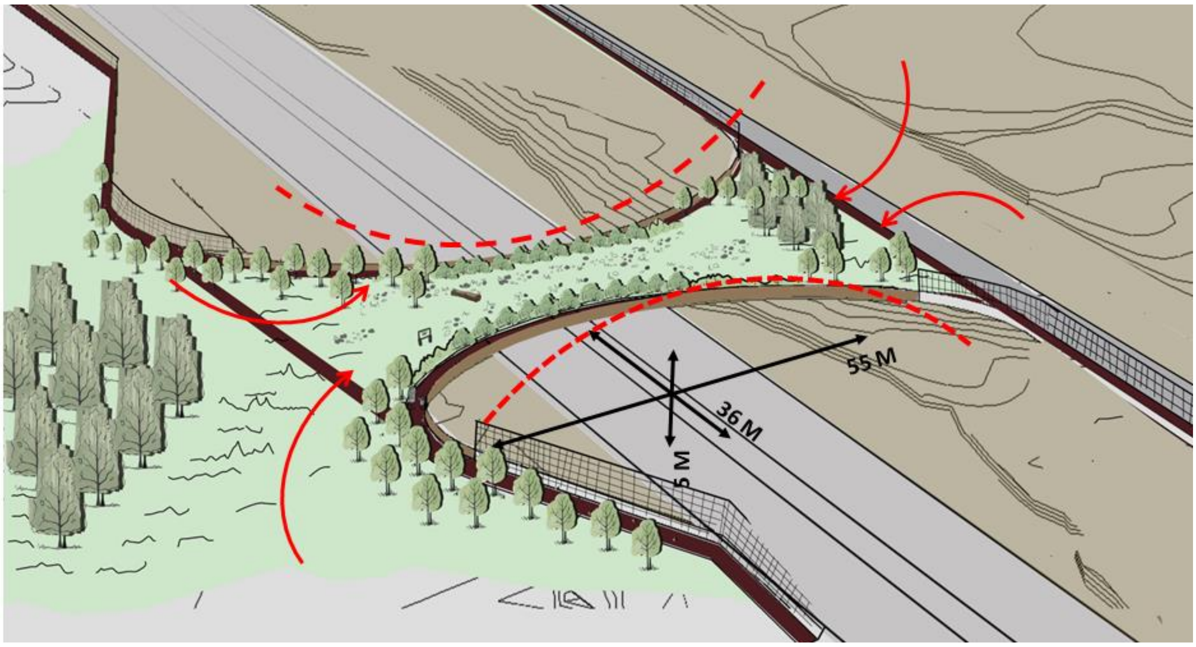

Figure 29; illustrates the proposed bridge dimensions. The bridge is 55 meters long and 36 meters wide, based on the width-to-length ratio for multiuse overpasses, which should be between 0.6 and 0.8. This means the width should be 60-80% of the length. The bridge has an hourglass shape with wider entrances, making it more attractive for animals (Created by the author).

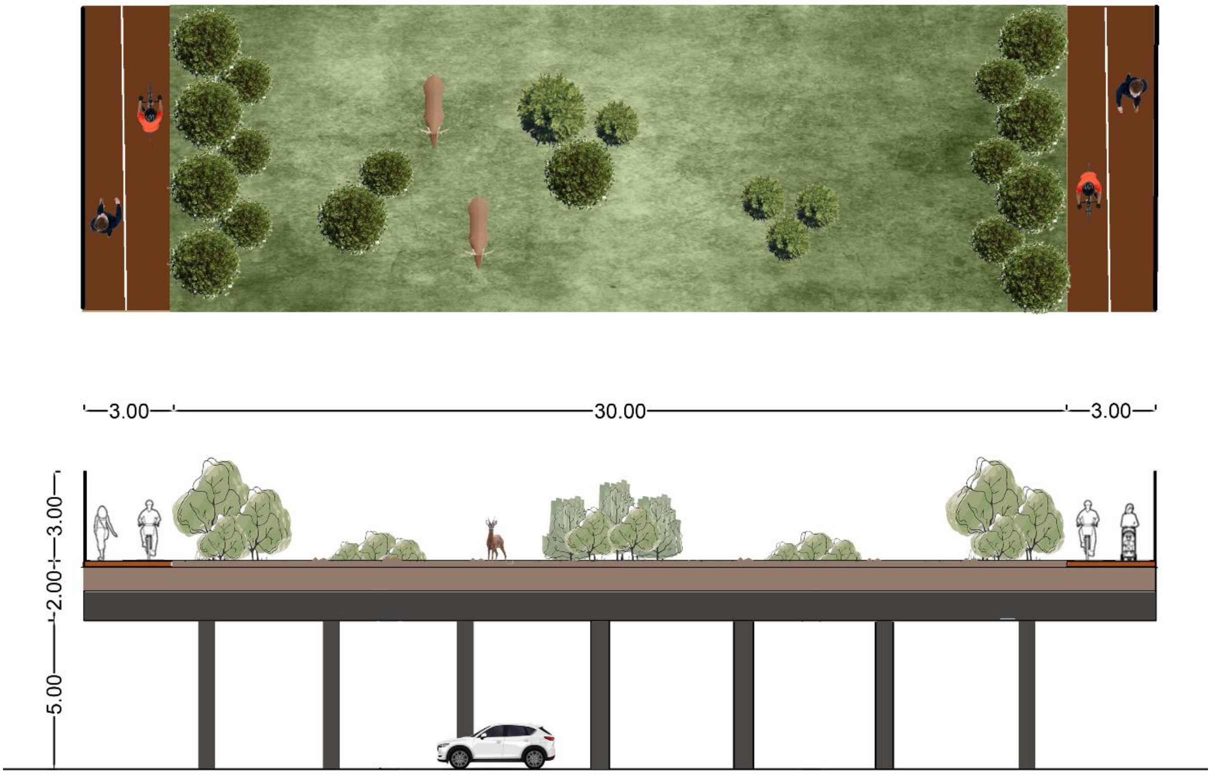

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Figure 30 illustrates a plan and section from the width of the proposed overpass, highlighting the integration of humans and wildlife in the design. Two dedicated areas, each 3 meters wide, are provided for human use (walking and cycling), separated by vegetation from the wildlife section of the bridge. The surface material of the pedestrian path is wood, mimicking nature and providing a convenient route for human use, while the wildlife area consists of soil and rocks, closely resembling their natural habitat (Created by the author).

5.5 Enhancing the ecological performance of passages

Several key characteristics, beyond just location and dimensions, can significantly enhance the ecological effectiveness of wildlife passages (see Figure 30) (Iuell et al., 2003). For instance, many animal species prefer passages with vegetated entrances and short distances between the crossing structure and surrounding vegetation (Iuell et al., 2003). To accommodate this, native vegetation such as pine trees, European gooseberry, wood dock, and coltsfoot has been incorporated at the entrances and across the bridge, making the passage blend seamlessly with both sides of Road 265. Additionally, elements like deadwood, stones, and specific plants that roe deer feed on have been included to create a familiar and inviting environment for the animals (Iuell et al., 2003).

To reduce human disturbances, the design includes noise and light screens. These 3-meter-high screens are installed on both sides of the passage, helping to minimize noise and block artificial light, which could otherwise deter wildlife from using the crossing (Shilling et al., 2018).

Another crucial element in the design is the game fencing (Rothman et al., 2017). These fences are essential for guiding animals toward the bridge and preventing them from straying onto the road. In this proposal, the fences extend along Road 265, connecting to existing passages. On the right, the fence continues to Overpass 1, while on the left, it extends to Underpass 2, ensuring a comprehensive and safe crossing system for wildlife.

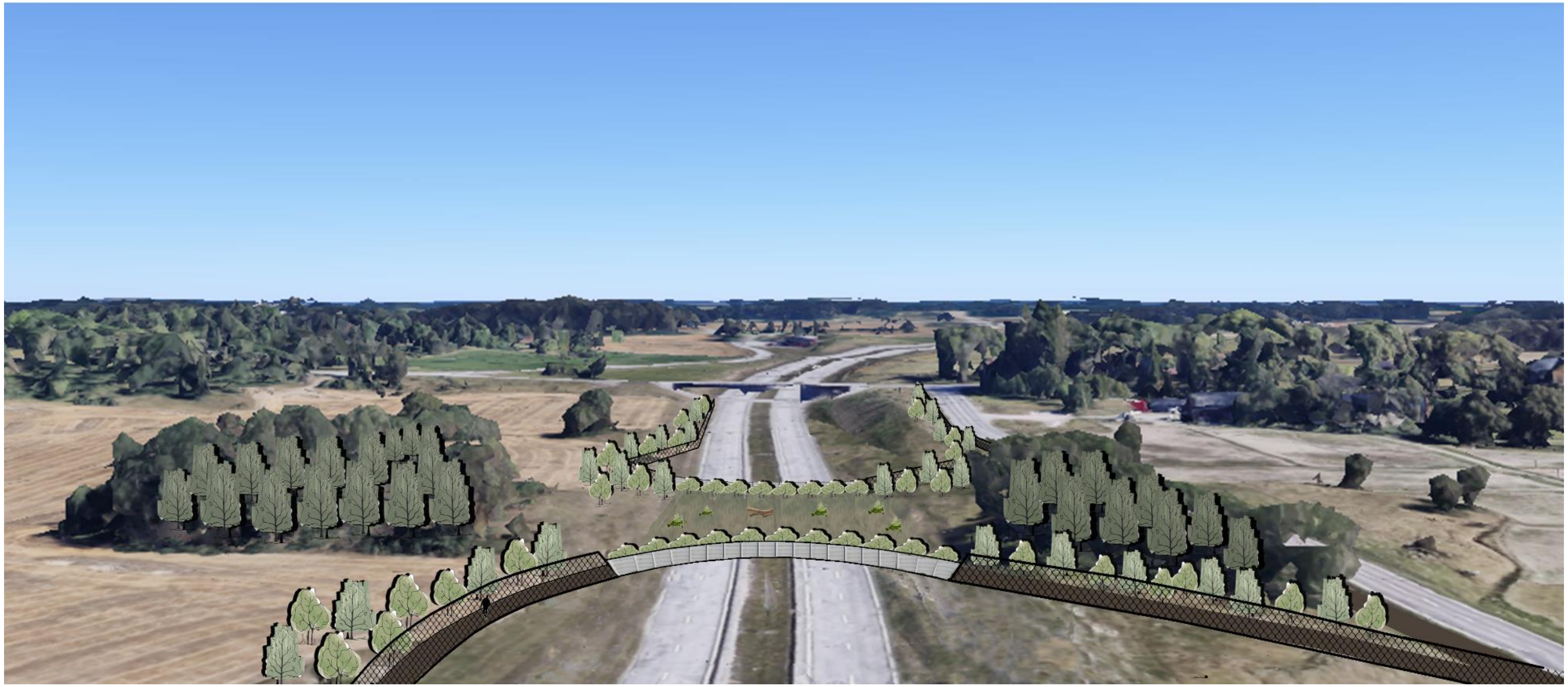

Figure 31 shows the proposed overpass designed for both roe deer and human use. The green bridge on Road 265 is made to meet the needs of roe deer by including vegetation, stones, and dead wood that resemble their natural habitat. The wide entrances, with vegetation that attracts roe deer, encourage them to use the bridge. Noise and light screens on both sides of the bridge reduce disturbances from passing vehicles. A game fence directs roe deer to the bridge and prevents them from wandering onto Road 265. There are two separate paths for humans on either side of the bridge, intended for cyclists and pedestrians only—no vehicles are allowed. These paths are separated from the animal area by vegetation. The human paths are covered with wooden boards, making them smooth and easy to walk or cycle on, in contrast to the soil and rocks in the animal section. These pathways extend along Road 265 and connect to the next passage (Created by the author).

6. Discussion

6.1 introduction

This project aims to address the fragmentation caused by Road 265 in Täby by constructing a wildlife passage. The road is a huge barrier that disrupts ecological connections and the movement of both animals and humans in the landscape. There are no designated spaces for animals, which prevents them from safely crossing the road, putting them at greater risk of being killed by vehicles. Additionally, there are no specific paths for pedestrians and cyclists; they are forced to use the vehicle lanes, which can be dangerous and stressful.

The primary goal is to improve roe deer movement and enhance ecological connectivity in the landscape. The first question that arises is: Where should the wildlife passage be located? To answer this, a thorough review of relevant literature and documents, along with a landscape analysis using the Landscape Character Assessment (LCA) tool, to identify different landscape characters and choose a suitable location for the proposed passage.

Additionally, during the site visit, it became clear that the area lacked a safe, dedicated passage for pedestrians and cyclists. This observation led to the idea of creating a multi-use passage that could serve both wildlife and humans. Consequently, the second question arises: How can the passage be designed to facilitate roe deer movement while also accommodating human use without deterring animals?

The proposal tries to consider the features that make the passage more effective for animals. While many wildlife crossings have been built in recent years, not all have worked well (Iuell et al., 2003). This often happens because the crossings are not designed with the specific needs of the animals, or because human activities around the crossings make animals wary of using them (Iuell et al., 2003).

6.2 Reflections

From the literature and document reviews, it shows that human activities have a profound impact on the natural environment. As populations grow, urban areas expand to accommodate the increasing number of people, leading to the creation of new infrastructure such as roads, buildings, and other developments (Iuell et al., 2003). While these developments are necessary for human habitation and progress, they also create significant barriers for wildlife. These barriers can disrupt the natural movement of animals, severing ecological connections that are vital for animal movement and ecological networks (Iuell et al., 2003).

When these habitats are fragmented by roads and urban areas, it becomes difficult for animals to move freely (Helldin et al. 2024 & Iuell et al., 2003). This can lead to increased risks of wildlife-vehicle collisions and reduced access to essential resources. Over time, these effects can severely harm wildlife and ecology.

To mitigate these negative impacts, it is essential to implement reconnecting structures like wildlife passages (Iuell et al., 2003 & Fredberg & Nylén, 2019). These passages, such as overpasses and underpasses specifically designed for animals, help restore the connectivity that urban development disrupts (Fredberg & Nylén, 2019).

In the context of this project, it is crucial not only to choose the appropriate type of passage (overpass or underpass) but also to select the right location for it. The ideal site would be one with high ecological value that is currently at a significant risk for animal collisions. Hagby is situated within one of the Stockholm green wedges that have been fragmented by Road 265 (Fredberg & Nylén, 2019). This area once provided crucial animal connectivity, which needs to be restored to benefit wildlife and support ecological values. By addressing this approach, the wildlife passage can contribute to protecting wildlife and enhancing ecological connectivity.

When designing a wildlife passage, it's also important to carefully choose the target species. Prioritizing species that are most frequently involved in collisions helps address the immediate problem of roadkill.

From my experience with the landscape, it appears that human activity on the bridge is inevitable, as pedestrians and cyclists will need to pass through the area. Just as animals require pathways to move through their environments, people also need designated routes. To reduce conflicts between human activities and wildlife needs, it is important to design separate pathways for pedestrians and cyclists. These dedicated routes should guide people along specific paths, minimizing the chances that they will enter areas intended for wildlife crossings (Nassauer, 1995).

6.3 Results

The project identified a suitable location for a wildlife passage in the study area, focusing on wildlife passage and roe deer criteria, as well as the different landscape characters, to assess the potential of the location. The wildlife passage is designed in a location where these criteria and landscape characteristics align.

The proposed overpass includes paths for both pedestrians and cyclists, addressing the need for safe crossings in the area while aiming to reduce disturbances to wildlife. This multi purpose design approach is intended to improve roe deer movement and support ecological connectivity. By considering the needs of both wildlife and humans, the project aims to promote a more balanced relationship with Täby municipality's goals by improving ecology while also enhancing the local pedestrian and cycling network. This approach seeks to strike a balance between urban development and natural ecosystems.

6.4 Limitations and recommendation

This project focuses on meeting the needs of roe deer. While this approach may not fully address the needs of other animals, such as foxes, hares, badgers, birds, and insects, the design is intended to benefit the species most likely to use the crossing. However, if the needs of these other species were also considered, the bridge could enhance ecological connectivity, allowing more animals to use it and improving biodiversity in the area.

Regarding the inclusion of a walking and cycling path, Ideally, understanding whether residents would prefer to use these crossing points, interviews and surveys to gather their input and identify existing challenges. In the time limitation for interviews, personal observations from the study area have shown that pedestrians and cyclists currently face difficulties crossing the road.

Lastly, while this thesis focuses on the landscape architectural aspects of designing a combined wildlife and human overpass, successfully implementing such a project requires collaboration with professionals from various fields. Civil and construction engineers are needed to address the structural construction of the overpass, traffic engineers to manage its consequences with existing roads and passages and, and agricultural engineers to assess and mitigate any impacts on surrounding agricultural lands. Engaging experts from these disciplines would help ensure that all aspects of the overpass are thoroughly planned and executed.

6.5 conclusion

Urban development, while essential for human growth, often comes at a significant cost to the environment, particularly through the fragmentation of natural habitats by roads and other infrastructure. This project addresses such challenges in Hagby, located in Täby Municipality, where Road 265 (Norrortsleden) disrupts ecological connectivity, particularly affecting roe deer populations, which are frequently involved in vehicle collisions.

The proposed solution is a multiuse overpass designed to reconnect the fragmented habitats on either side of Road 265, improving ecology and reducing the risk of wildlife-vehicle collisions. The selected location is characterized by high ecological value and a pressing need for improved wildlife movement due to the frequent collisions involving roe deer.

The design of the overpass not only serves roe deer but also addresses the need for safe pedestrian and cyclist pathways in the area. By integrating human and wildlife pathways, the overpass aims to reduce human-wildlife conflicts while promoting safe crossings for both.

The proposed overpass is a step towards restoring ecological networks disrupted by urban expansion, contributing to the long-term sustainability of both local wildlife and human communities. Through a thoughtful planning and design, the project seeks to create a balanced relationship between urban development and environmental conservation.

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