ÅRSTASKOGEN

Foreword

This report is the result of the project part of the advanced course "Environmental Management in Planning". The course is a mandatory part of the Master Programme Environmental Management and Physical Planning at the Dept. of Physical Geography, Stockholm University. The programme is multidisciplinary with Swedish as well as international students. The Environmental Management in Planning course comprises 15 HEC, i.e. ten weeks of study and is open for students from natural as well as social science. The project part takes five weeks and the aim is to give the students a possibility to analyse an actual planning problem from a systems perspective as well as knowledge about urban and community planning on the national to the local level.

This spring, 2018, the projects have focused on "Densification in relation to green infrastructure – How to build and rebuild a sustainable city" using three areas in the southern part of Stockholm as cases. The areas are Stora Sköndal, Årstaskogen and Hagsätra-Rågsved. Stockholm is growing rapidly and the planning strategy aims at building 40 000 new residences in 2020 and another 100 000 in 2030. The vision is to build sustainable, dense and green city districts. The areas chosen for the projects have different characteristics but also have much in common. Today, they are sparsely settled or, as in the case of Årstaskogen, is dominated by a natural reserve. A densification of Stora Sköndal and Hagsätra-Rågsved include a high risk of gentrification as new constructions with high quality green infrastructure often increase the house prices. The focuses of the four projects are:

1. Stora Sköndal – Green infrastructure and ecosystem services

2. Stora Sköndal - Densification and social sustainability

3. Årstaskogen – Exploitation and high nature values

4. Hagsätra-Rågsved – Densification and gentrification

The project applies a critical systems perspective on the official planning visions and the practical complexity in creating a sustainable city area. Owing to the short time span available to the project work it is not possible to fully include all aspects in the analysis but the reports gives a good overview of the environmental effects of future developments.

The students are alone responsible for the results and conclusions given in the reports. It is not a position of Stockholm University and cannot be used or referred to as such. The project work supervisors have been Salim Belyazid, Bo Eknert, Peter Schlyter and Ingrid Stjernquist.

We want to acknowledge all the persons who kindly have helped the students with information and materials as well as have been positive to give interviews and discussions. Without this help the project could not be realised.

Stockholm, March 16
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Project Årstaskogen

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List of actors

Bevara Årstaskogen – The Network Bevara Årstaskogen

City of Freiburg – Municipality of Freiburg

Ekologigruppen – The Ecology Group

Länsstyrelsen Stockholm – Stockholm County Administrative Board

Naturskyddsföreningen – Swedish Society for Nature Conservation

Naturvårdsverket – Swedish Environmental Protection Agency

Riksantikvarieämbetet - Swedish National Heritage Board

Stockholms län – Stockholm County

Stockholms stad – Stockholm Municipality/Stockholm City

Sveriges Lantbruksuniversitet - Swedish University of Agricultural Sciences

Glossary

English	Swedish	Definition
Accessibility	Tillgänglighet	Defined as the ease with which a place can be reached from one or several other places. Also refers to physical accessibility, such as roads and paths.
Areas of certain ecological importance	Ekologiskt särskilt betydelsefulla områden (ESBO)	Årstaskogen and Årsta Holmar are defined as an area of certain ecological importance. They include core areas, dispersal zones and habitats for species with high protection value.
Bioswale	Biodiken	The purpose of bioswales is to manage stormwater by leading the water away from buildings or absorbing it. Bioswales are designed landscape elements with a drainage course, sloped sides and vegetation surrounding it. It is also effective for pollution removal.
Child Impact Analysis (CIA)	Barnkonsekvensanalys	Method used to identify, assess and evaluate impacts on children that a proposed development or decisions has.

Directive species	Direktivsart	A species that is included in the EU species and habitats directive/birds directive. The species included in the directive are considered worth protecting in a European perspective.
Field layer	Fältskikt	One of the "layers" of woodland, also called herb layer. Other layers of woodland: ground layer, shrub layer etc.
Green areas	Grönområden	An umbrella term for all types of areas which consists of nature. Can be natural or man-made, accessible or not. Examples include parks, forests, green walls or roofs, urban gardens, lawns, allotments, shrubs, etc.
Green infrastructure	Grön infrastruktur	Based on the definition by Naturvårdsverket "Green infrastructure is an ecological network of habitats and structures, natural areas but also anthropogenic elements that are designed, used and managed in such a way that biodiversity is preserved and ecosystem services are promoted".
Green structures	Gröna strukturer	In this study we have concluded our own definition of green structure due to the lack of an agreed definition within the literature. We define green structures, also called green elements, as a structure containing nature which provides ecosystem services to humans. The structures can be man-made or natural. A green structure does not need to be included in a network of green infrastructure in order to be called a structure. They can be a part of the network, but they can also be a single lonesome element in an area without green infrastructure. For example, a green roof in a urban area without any other green areas.
Habitat	Naturtyp/biotop	In this study the English word habitat is used. It can refer to either *sv. biotop, habitat* or *naturtyp.* The Swedish words are more specifically defined than the English translation.
Habitat fragmentation	Habitatfragmentering	Based on the definition by Wilcove *et al.* (1986), habitat fragmentation is a process during which "large expanse of a habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original".

Indicator species	Indikatorart	Species that indicate a certain environment. For example, the fungus *Phellinus pini* in Årstaskogen is very unusual and it is related to the presence of old scots pine trees (*Pinus sylvestris)*. The fungus is used as an indicator for forests with a high protection value and high nature values.
Nature conservation species	Naturvårdsart	Nature conservation species are species that are either red-listed, signal species or directive species (or all at once). Nature conservation species have a high nature conservation value.
Nature value	Naturvärde	Forests with a great diversity of different species and nesting sites have a high nature value. These are areas that are not heavy exploited or included in the forestry. Forests with high nature values often include e.g. many old trees, a variation of tree-species, dead wood, hollow trees etc.
Potential Development Area (PDA)	Potentiella exploateringsområden	Potential Development Areas are areas which are not included in the nature reserve and subjects for potential development, a decision taken by the city of Stockholm. In this study, two of the biggest potential development areas are included in the planning proposals.
Red-listed species	Rödlistade arter	The national red-list system of Sweden is based on the international red-list system developed by the IUCN (International Union for Conservation of Nature). The red-list is a summary of species status and their risk for extinction. Several abbreviations of a species status are used throughout the study: Extinct (EX), Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least concern (LC) and (NA) Not applicable.
Signal species	Signalart	Signal species are nature value indicators. Species that are defined as signal species by the Swedish National Board of Forestry (*sv. Skogsstyrelsen*) are fungi, mosses and lichens. Bird species defined as signal species are based on ecological knowledge and accepted assessment within nature conservation.

Summary

The Stockholm Region is one of the fastest growing metropolitan areas in Europe. According to projections, the population of Stockholm will increase by approximately one million by the year 2050. Parallel to the increasing demand of urban dwelling, the City of Stockholm faces a housing shortage. In light of these issues, the City of Stockholm plans to construct new housing, which will cause stress on cultural and environmental aspects.

Årstaskogen, located south of Stockholm City, is one of several areas planned to be exploited. The plan is to construct 800-1 000 new residences. However, Årstaskogen is an important part of the city's green infrastructure, containing many important natural and cultural values, therefore, a decision to establish Årstaskogen and Årsta holmar as a nature reserve was taken in 2018. The Årstaskogen area is of utmost importance for children and other marginalized groups of society, who´s perspective was not taken into account by Stockholms stad during the planning process.

The aim of this study is to propose urban designs (high exploitation and low exploitation) for two residential areas (west and east), which takes environmental and cultural values and children into consideration, while facing the housing shortage. The main focus in terms of sustainable development will be on the social and environmental dimensions. The proposed urban designs for the new housing areas will therefore be environmentally-friendly and respectful of the ecosystem services as well as the ecological connectivity of the site, and considering different marginalized groups such as children.

- *How can the suggested designs and level of exploitation affect natural and cultural values and children*?

The redrawn boundaries of the new nature reserve have created two larger cohesive Potential Development Areas (PDAs), amongst other smaller areas. The two larger PDAs were chosen in this study for proposed urban designs since their size makes them likely to be exploited for new housing areas.

We have identified and compared the negative effects on the environmental and cultural values in the PDAs due to construction of new buildings in the two proposals; a high exploitation and low exploitation proposal. We have identified loss of habitats, dispersal corridors and the potential effect on biodiversity. The high exploitation proposal is based on the current plan to construct ca 800 residences. The low exploitation proposal is considering the nature and cultural values in the PDAs and the aim was to mitigate the negative effects as much as possible, this included a low amount of houses (ca. 130 residencies), as well as analysing the area's natural values. In order to analyse and understand how the planning proposals affects the cultural and natural values of Årstaskogen, a total of 9 methods were applied. The most important being the Value Rose and the Indicator Matrix.

The dominating nature type of Årstaskogen is scots pine forest (*Pinus sylvestris*) on bare rock or moraine ground. Årstaskogen have a high proportion of the fungus *Phellinus pini* which is considered near threatened according to national Red List. It is also related to the presence of old pine trees (*Pinus sylvestris).* The pine trees of Årstaskogen vary from 100-150 years old and the fungus is used as

an indicator for forests with a high protection value and high nature values. At least 80 observations of pines with the fungus *Phellinus pini* have been found in Årstaskogen. A total of 27 species that are on the national Red List have been observed in Årstaskogen.

The high exploitation proposal result in a large reduction of the habitats of the two PDAs. The six-storey high buildings are higher than the pine trees in the area, which would reduce the dispersibility of different species drastically even though some pines are preserved. Furthermore, the current main corridor in PDA East will be disrupted. The dispersal of the fungus *Phellinus pini* will likely be affected by the construction, since the quality of the forest and dispersal possibilities are important for preserving the species. Construction reduces the dispersibility for many species. For example, European crested tit (*Lophophanes cristatus)* is a species that unlikely fly in densely populated areas. This species would only fly a couple of hundred meters in a densely populated area but have no problem with traveling 3 000 meters in a coniferous forest. The broadleaved deciduous forest in PDA West will also likely be reduced in this proposal, a habitat that is important for many invertebrates and fungal species but also as nesting sites for birds and bats. Children will also be adversely affected by this proposal since lot of the green areas they use for recreational and educational purposes will be lost. Mitigating the negative effects of the nature value losses by adding green structures such as green roofs will not compensate the nature value losses enough. In the low exploitation proposal, the buildings are placed choicely in the southwest part of the east area to preserve as much as possible of the old pine forest. This proposal will preserve the accessible areas that are important for children.

In the low exploitation proposal, buildings in PDA East are carefully placed in the south-east part of the PDA with the aim to preserve the old pine forest in the area. Still, the broadleaved deciduous forest in PDA East will be reduced. Hence, by destroying the edge of the habitat correspondingly will shrink the natural buffer zone(edge) of Årstaskogen and will in summary have a negative effect on biodiversity.

By creating new buildings according to the high exploitation proposal, the current main dispersal corridor for pine associated species in PDA East will be hindered. PDA East is included in one of the most important areas for coniferous forest connectivity to the south. This current dispersal pattern is possible due to the low height of the houses in the area (lower than the pine trees). Adding higher buildings will likely reduce the dispersibility. The high exploitation proposal, the width between the houses will be about 15-20 meters wide (40 meters are a minimum for an eco-duct). Preserving as much of Årstaskogen as possible is also arguably important due to its narrow width, which will be reduced by any kind of construction.

Overall, we conclude that a development of Årstaskogen is not recommended because ecological aspects such as biodiversity and ecosystem services and social aspects of sustainability such as children will be adversely affected by a development. It is, thus, considered not in line with the National Environmental Quality Objectives and the UN Convention on the Rights of the Child.

Sammanfattning

Stockholmsregionen är idag en av Europas snabbast växande storstadsområde. Enligt prognoser kommer Stockholms invånarantal att öka med ungefär en miljon människor till år 2050. Parallellt med det ökade behovet av bostäder står Stockholm inför en bostadskris. Inför dessa utmaningar planerar Stockholms stad att bygga nya bostäder, som kan orsaka påfrestningar på kulturella- och miljömässiga aspekter.

Årstaskogen, belägen söder om centrala Stockholm, är ett av de områden som planeras för exploatering, med planer att bygga ca 800-1 000 bostäder. Årstaskogen är emellertid en viktig del i stadens gröna struktur och innehåller många viktiga natur- och kulturvärden, således beslutades 2018 att etablera Årstaskogen och Årsta holmar som naturreservat. Årstaskogen är ett särskilt viktigt område för barn, och andra marginaliserade samhällsgrupper, vars perspektiv inte togs hänsyn till av Stockholms stad under planeringsprocessen.

Syftet med denna rapport är att producera planeringsförslag (hög exploateringsnivå och låg exploateringsnivå) för två bostadsområden (väst och öst) som med hänsyn till miljö- och kulturvärden och barn, möter bostadsbristen. Huvudfokus inom hållbarhet är de sociala och miljömässiga dimensionerna. Planeringsförslagen ska därför vara miljövänliga och hänsynsfulla för ekosystemtjänster, platsens ekologiska konnektivitet samt olika marginaliserade grupper med fokus på barn.

- *Hur kan designen och exploateringsgraden påverka natur- och kulturvärden samt barn?*

De nya gränserna som skapades i samband med etableringen av naturreservatet har skapat två större sammanhängande områden för potentiell exploatering, utöver de flertalet små områden. De två större områdena valdes i denna rapport för studie och planeringsförslag eftersom deras storlek gör dem till sannolika val för bostadsbyggande.

Vi har identifierat och jämfört de negativa effekterna till följd av byggnation inom våra potentiella exploateringsområden (*eng. Potential Development Areas*) utifrån två alternativ; hög exploatering och låg exploatering. Vi har identifierat vilka naturtyper som inom dessa förslag kommer att minska/försvinna, vilka spridningssamband som kommer att påverkas alternativt blockeras, samt byggnationens effekt på biodiversitet. Högexploateringsförslaget innebär en byggnation baserad på dagens plan, vilket är närmare 800 lägenheter. Lågexploateringsförslaget tar mer hänsyn till de höga natur- och kulturvärdena som finns i områdena och syftet var att lindra de negativa effekterna av byggnationen så mycket som möjligt. Detta inkluderade att sänka antalet lägenheter till ca 120 samt att göra en analys av områdets naturvärden.

För att analysera och förstå hur planeringsförslagen påverkar Årstaskogens kultur- och miljövärden, användes totalt nio metoder. Den primära metoden är en Värderos (för att beskriva, diskutera och utvärdera hållbarhetsnivåerna i Årstaskogen) och en Indikatormatris (för att illustrera planeringsförslagens förmåga att möta Stockholms stads hållbarhetsmål och FN: s konvention om barns rättigheter.

Årstaskogen domineras av tallskog (*Pinus sylvestris*) på hällmark eller morän och det förekommer ett högt antal tallar med rödlistad tallticka *(Phellinus pini*), en art som växer på tallar som nått en ålder på 100-150 år. Många tallar i Årstaskogen är 100-150 år och tallticka är en indikatorart för skog med högt naturvärde och bevarandevärde. Det finns åtminstone 80 observationer av tallar med denna art. I övrigt så har 27 rödlistade arter samt 50 naturvårdsarter observerats i Årstaskogen.

Planeringsförslaget med hög exploateringsnivå resulterar i en stor reduktion av naturtyperna i båda projektområden. De fem våningar höga byggnaderna är högre än de lokala tallarna, vilket drastiskt reducerar flera arters spridningsförmåga, trots bevarandet av tallarna. Dessutom störs det nuvarande spridningssambandet för tall och tallskogsförknippade arter till söder i det östra projektområdet. Spridningsförmågan hos talltickan *Phellinus Pini* påverkas sannolikt av byggnationen, då skogens kvalité och spridningsförmåga är viktiga faktorer för artens bevarande. Byggnation inom de två exploateringsområdena innebär en reducerad spridningsförmåga för många arter. Tofsmes (*Lophophanes cristatus*) är en art som gärna undviker tätbebyggda områden. Arten kan utan problem flyga 3 000 meter i en barrskog men flyger högst ett par hundra meter i ett tätbebyggt område. Ädellövskogen i det västra exploateringsområdet skulle i högexploateringsförslaget även bli kraftigt reducerad. Ädellövskogen är viktig för många evertebrater, svampar samt som boplats för fåglar och fladdermöss. Barn påverkas också negativt av detta förslag då stor del av de plana grönområdena där de leker kommer att försvinna då de byggs på. De negativa effekterna av byggnationerna kan lindras genom att addera gröna strukturer som gröna väggar och tak, men det är viktigt att påpeka att naturvärdesförlusterna inte kan kompenseras tillräckligt. I planeringsförslaget med låg exploateringsnivå placeras byggnaderna i det östra projektområdet varsamt i den sydöstra delen för att bevara så mycket som möjligt av den gamla tallskogen. Med detta förslag bevaras även delar av de plana grönområdena som är viktiga för barnen.

Det östra projektområdet innefattar några av de viktigaste områdena för barrskogens konnektivitet från syd. Det nuvarande spridningsmönstret möjliggörs bland annat av byggnadernas låga höjd och en ökning av antalet byggnader minskar sannolikt spridningsmöjligheterna. I förslaget med hög exploatering så är avståndet mellan husen i det östra projektområdet ca 15-20 meter (40 meter är minimum för en ekodukt). Så stort bevarande av Årstaskogen som möjligt är även viktigt på grund av skogens smala bredd, som minskas av all typ av byggande.

Slutsatsen är att en exploatering av Årstaskogen inte är att rekommendera på grund av de viktiga natur- och kulturvärden som påverkas av detta. Eftersom ekologiska aspekter såsom biodiversitet och ekosystemtjänster samt sociala aspekter av hållbar utveckling som barn kommer påverkas negativt av exploateringen anses det inte vara i linje med Sveriges nationella miljömål eller FN:s Barnkonvention.

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1. Introduction

In today's increasingly global and interconnected world, more than half of the world's population live in urban areas. The trend of continuing urbanization coupled with population growth, will increase the urban population with an additional 2.5 billion people by 2050 (United Nations, 2014). Urbanization is also distinctive feature of population movements in Europe and it continues to be one of the most urbanized parts of the world (Nationalencyklopedin, 2018).

The Stockholm Region is one of the fastest growing metropolitan areas in Europe. According to projections, the population will increase by approximately one million by the year 2050 (Stockholms läns landsting, 2016). The growth rate shows no signs of decline, but is threatened by acute housing shortage. The Stockholm County municipalities are working vigorously with construction of new housing in order to meet the growing demand. This has resulted in an increased construction rate which, according to Länsstyrelsen Stockholm (2017), is an important part of sustainable development. Yet, the housing stock cannot grow indefinitely without placing stress on cultural and environmental aspects (Selman, 2009). How housing, infrastructure and green areas are organized and integrated is essential for Stockholm County to remain an attractive place to live in.

To solve the housing shortage, more residential areas needs to be constructed. The city is therefore investigating where new homes can be built. Årstaskogen is one of these possible areas. The planning concerning exploitation of this area is at an early stage. A final proposal or detail plan is yet to be presented and the work is expected to begin no earlier than autumn of 2018 (Stockholms stad, 2018a).

Årstaskogen is located south of Stockholm City, at the border where Lake Mälaren meets Lake Saltsjön. It is an important part of the city's green infrastructure, containing many important natural values (Stockholms stad, 2018b). In addition, the proximity to Södermalm and Årsta contributes to the high recreational values of the forest. The area also consists of many important cultural features such as Årsta gård and Dianelund's allotment gardens (*ibid.*).

In January of 2018, the formal decision to establish Årstaskogen and Årsta holmar as a nature reserve was made. At the same time, Stockholms stad is investigating the possibility to build an additional of 800-1000 residences in Årstaskogen, at the border of the nature reserve, close to the existing residential area (Stockholms stad, 2018b). This will, according to Exploateringskontoret (2017), likely affect the ecological and recreational values in Årstaskogen. Thus, the plan is to create a connection between the forest and the new residential area, enabling accessibility and improving attractiveness.

To this date, more than 10 000 people has signed the list of protests opposing the development of Årstaskogen. The network *Bevara Årstaskogen*, who are the initiators of these protest actions, argue that the areas to be exploited is worth preserving because they are the most easily accessible and thus the most visited areas of Årstaskogen (Bevara Årstaskogen, 2018a).

The development of Årstaskogen has proven to be a controversial topic. Partly, with respect to ecological and recreational values but

also due to the fact that Stockholms stad has made little conscious effort to include the views of marginalised quarters of society, such as children. The question is in what way this area could be exploited whilst still preserving the integrity and intrinsic values of the nature reserve as well as considering the views of children. Can people in Årsta, if a good planning proposal that smoothens the transition between development and nature reserve, express altruistic attitudes, whereby they accept solution that are of maximum aggregated benefit for the society as a whole.

1.2 Aim and research question

The overall aim of this study is to examine how the natural and cultural values of Årstaskogen are affected by a development. In this study two levels of exploitation are considered, one low and one high. The low exploitation proposal pays particular attention to the needs of children and aims to preserve as much of the nature values as possible. In comparison, the high exploitation proposal is designed from a developer's perspective with the goal of generating as many residencies as possible.

In this study a Visual Impact Analysis over the proposed architectural designs will be presented. The aim is to design a solution that is integrated with the nature reserve, enabling a smooth transition between nature and built-up areas. The main focus in terms of sustainable development will be on the social and environmental dimensions. This study also aims to include views of marginalized groups by carrying out a Child Impact Analysis over the exploitation proposals. The study intends to highlight the following question:

- *How can the suggested designs and level of exploitation affect natural and cultural values and children*?

1.3 Boundaries

This section describes the geographical, temporal and theoretical boundaries set for this study.

1.3.1 Geographical boundary

The area of investigation for this study is the northern parts of Årsta. Årsta is located south of Södermalm, on the opposite side of Årstaviken. It is connected to Södermalm in the west by Liljeholmsbron and in the east by Skansbron, Johanneshovsbron and Skanstullsbron. Årsta is located in-between two of the major transport nodes in Stockholm; Liljeholmen and Gullmarsplan.

The geographical boundaries coincide with the first planned nature reserve area of Årstaskogen. When the final decision regarding the establishment of the nature reserve was taken, the boundaries were tightened and the reserve area became smaller. The areas excluded in the final nature reserve were so because they are suitable to build on. In this study these areas will be named Potential Development Areas (hereafter: PDA). The nature reserve will be referred to by its name; Årstaskogen. Figure 1 shows a map over the study area.

Within the nature reserve there are three boat clubs and two allotment areas. Close to the shoreline is a popular walking path. The nature reserve also includes the islands of Årsta holmar, located in-between Södermalm and Årsta in the middle of Årstaviken (Stockholm stad, 2018b). In this study we will exclude these, mainly because they are not accessible from Årsta, but also because the islands are not suitable for exploitation.

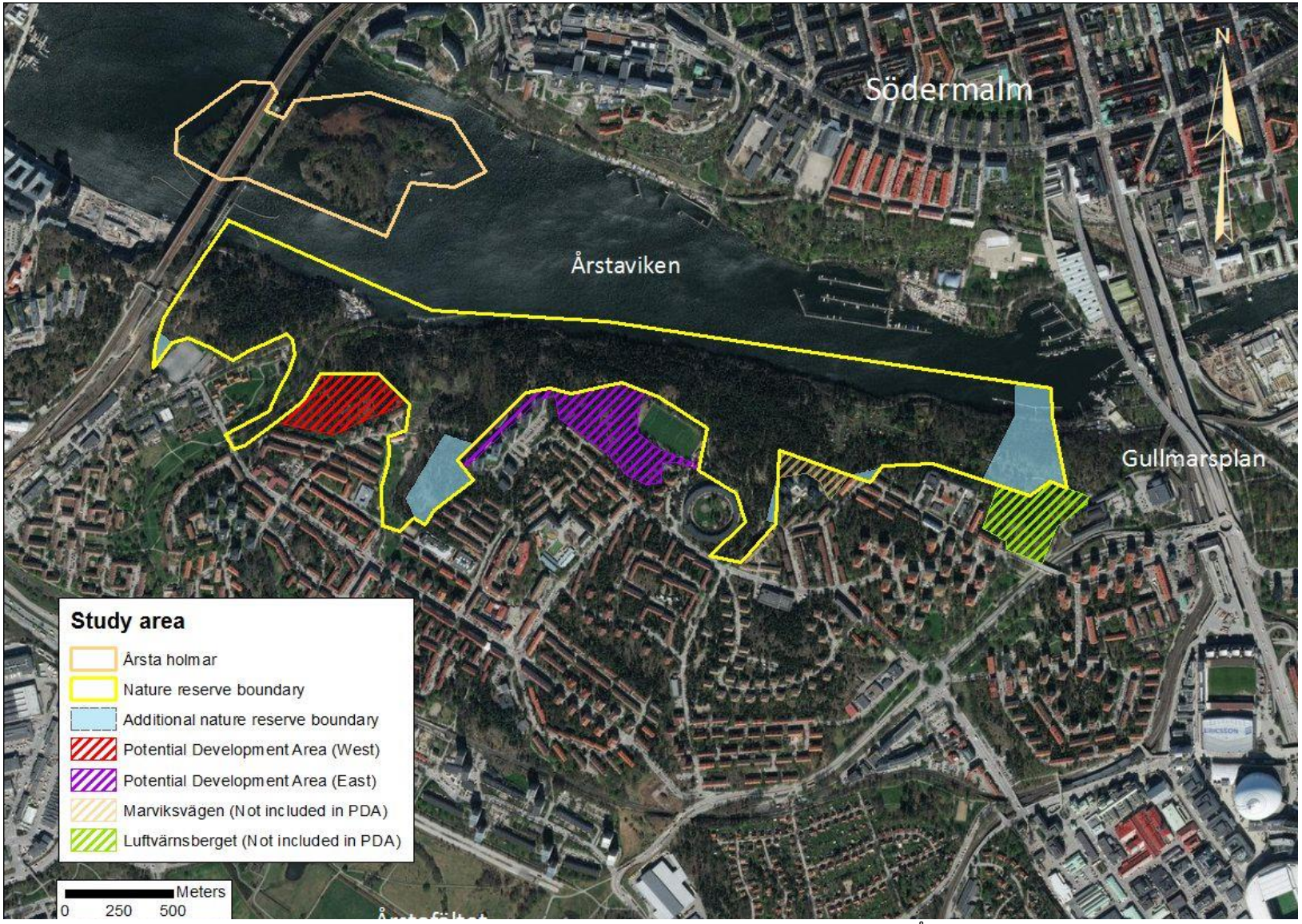


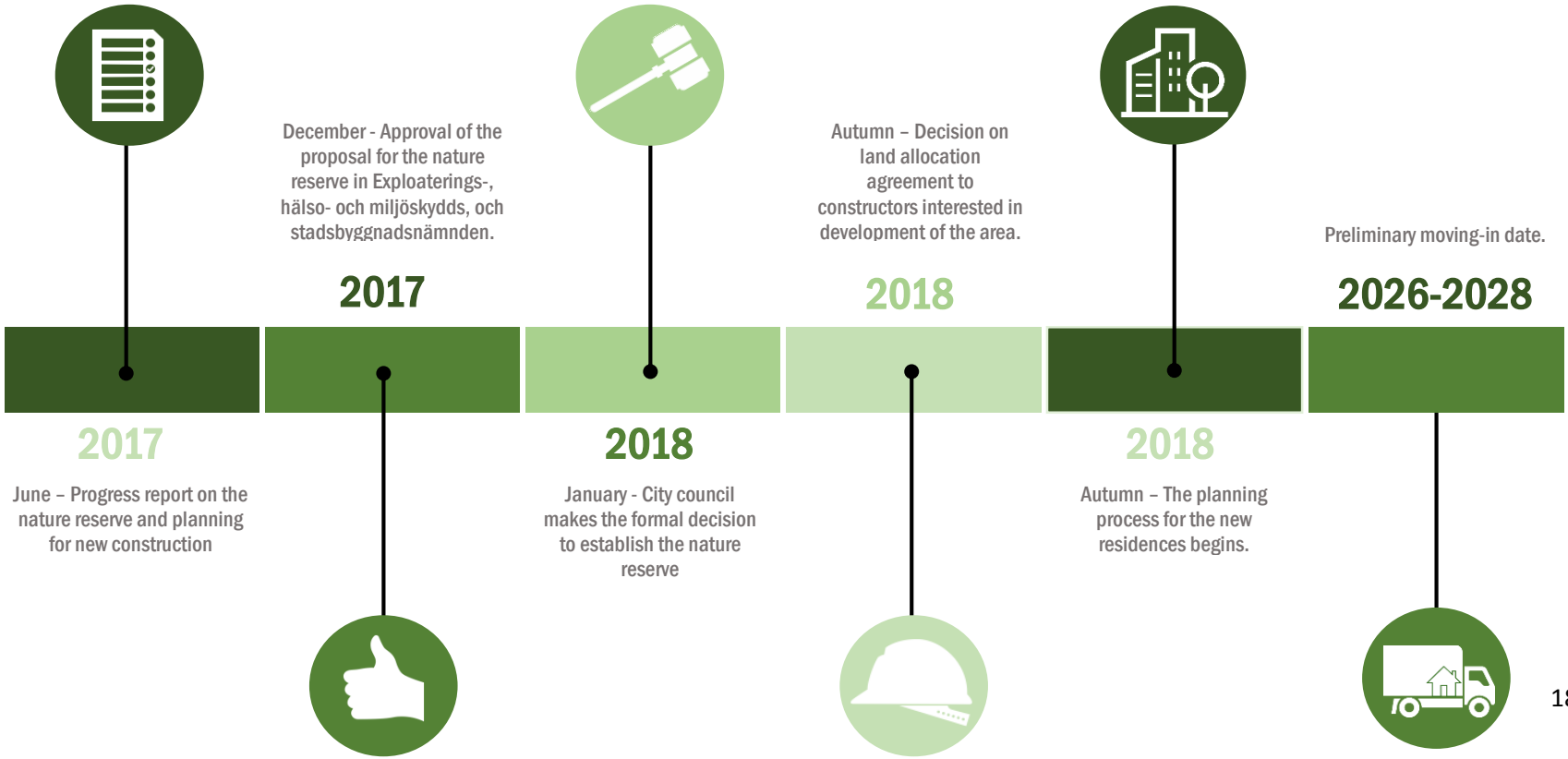
Figure 1. Map of the study area including the nature reserve boundaries and the Potential Development Areas (PDA). Årsta Holmar, Marviksvägen and Luftvärnsberget are included in the map although they will not be considered in this study. Based on Bevara Årstaskogen (2018c). (Visualization: Liam Martin, 2018)

In the eastern parts of Årstaskogen is Luftvärnsberget. This area is intended for exploitation. It is not, however, included in the original plans to build 800 - 1 000 residential units. (Nilsson, 2018, personal communication). For this reason, Luftvärnsberget will not be included in this study. East of Luftvärnsberget is a smaller area named Marviksvägen. This area will also be excluded because it is too small to enable the level of exploitation that this study intends to investigate.

Since 2011, more than 14 land allocation applications from eleven different constructors have been filed. The applications include preliminary development plans (Bevara Årstaskogen, 2018b). However, since no decision has yet been made these plans will not be considered. As seen in the timeline of next section, land allocation agreements will be decided in the fall of 2018.

1.3.2 Temporal boundary

The time boundary is based on the time it takes from when you start to formulate a plan until the project is finalized and the first people move in. According to Bo Hallqvist (personal communication, 14 February 2018) this takes about 8-10 years. In order to get reliable monitoring data, people should have lived there for at least two years. Thus, this study's time boundary will be from today and 15 years onward. In the timeline below the establishment and development of Årstaskogen is shown.



1.3.3 Theoretical boundary

In this study we exclude economic aspects of sustainable development. We thus assume that the architectural design we suggest is economically viable. With respect to social sustainability, only recreation and children will be included in order to limit the scope of the study.

By including the views of children, we hope to bring some clarity into the concept and also address some of the criticism directed at Stockholms stad for excluding such views. In this study, the main focus will be on preschool children from the ages three to six. The reason for this is the large number of preschools in the area. In addition, since great importance is given to recreation we see it as imperative to address this.

Considering environmental aspects, aquatic species will not be discussed even though parts of the nature reserve contains water. Yet again, Årsta holmar, Marviksvägen and Luftvärnsberget will be excluded independent of which sustainability aspect being discussed.

2. Theoretical framework

This chapter aims to clarify and explain concepts, together with their definitions and reference to relevant scholarly literature, underlying this study. The theoretical framework will be the lens through which we evaluate our research question.

2.1 Sustainable development

Sustainable development is a popular concept these days. Despite several decades of discussion, the concept of sustainable development still lacks a common definition. Thus, several different definitions are used depending on the disciplines working with the concept of sustainable development. The most common definition originates from the Brundtland report of 1987. It defines sustainable development as "[...] development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Benton-Short & Short, 2008, p. 232).

Due to global concerns about the continuity of poverty, increasing social inequalities, growing environmental problems worldwide and the realization of resource scarcity, publications regarding sustainable development have been promoted since the 1970s (Manzi *et al.*, 2010). However, international debates on sustainability became increasingly popular in 1992 due to the Rio Earth Summit and its main outcome; Agenda 21 (Benton-Short & Short, 2008). The Agenda 21 considers four main topics; the social and economic dimensions, conservation and management of resources for development, strengthening the role of major groups and means of implementation (United Nations, 1992). These topics and the fact that a sustainable development needs to be implemented at all scales already shows the complexity and the interdisciplinary nature of sustainability (James *et al.*, 2013; United Nations, 2015). Today, most researchers agree that sustainable development lies at the intersection of environmental, social and economic issues as seen in Figure 2 (Manzi *et al*., 2010).

The economic dimensions of sustainable development are often linked to economic growth (United Nations, 2015). However, it is important to consider that it is not possible to sustain long-term economic growth if social equity and environmental quality is decreasing (*ibid*.). However, sustainable development does in fact

require economic viability (James *et al*., 2013). In conclusion, this illustrates how complex and interlinked the term sustainability is with a variety of different disciplines.

This study focuses on the environmental and social aspects of sustainability with regards to urban planning. The decision to highlight the social and environmental dimensions is due the high likelihood of impacts occurring regarding these dimensions when transforming green areas into built up areas in Årstaskogen.

Figure 2. The three dimensions of sustainable development (International Energy Agency, 2017).

2.2 Social Sustainability

Social sustainability is one of the three dimensions of sustainable development. As with the concept of sustainable development, social sustainability lacks a common accepted definition (Manzi *et al.*, 2010). In consequence, included aspects of social sustainability are very diverse and sometimes inconclusive (*ibid.*). However, common contained aspects are participation, justice and equity, democracy, and social cohesion. These are also important against the background of sustainable urban planning (*ibid.*).

Sustainable urban planning should promote both social and environmental justice, which often overlap (Scottish Government, 2006). As a result, community planning needs to recognise the possibility of adverse impacts occurring as a consequence of planning decisions and their positive potential to address social injustices (*ibid*.). In contrast, developing new areas is relatively expensive. As a consequence, housing prices tend to be high which has the potential to cause segregation whereby low-income groups are generally excluded (Myers, 2004).

One interesting perspective taken by Somerville & Green (2015) is on how to educate children about social sustainability. They give examples and ideas on how to enhance the possibilities for young people to learn about sustainability and reinforce sustainable development.

In the search for possible conflicts between urban densification and the recently implemented nature reserve, it has become clear that conflicts exist between the increasing housing demand, the

conservation of nature values, and the future use of the nature reserve by children.

Investigations show that especially the provision of outdoor space is related to the quality of children's lives in dense city environments (Haaland & van den Bosch, 2015). Many authors emphasize the need of acknowledging the demands of different resident groups in all planning stages. Especially when it comes to urban congestion, public and private green areas often vanish and their services are diminished when they should in fact be enhanced (*ibid.*).

The UN explicitly includes children when formulating Sustainable Development Goals. One of the Sustainable Development Goals mentioning children concerns the need of green and public areas and a healthy environment for specific groups including children referring to the future. It says: "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities" (United Nations, 2015, p. 22).

Furthermore, the United Nations formulate the goal of protecting children from environmental impact: "Protect children from the effects of environmental and occupational toxic compounds" (United Nations, 1992, Ch. 6.27). A broader sustainable goal mentioned by the United Nations is "A world which invests in its children [...]" (United Nations, 2015, p. 4). As previously mentioned, children are important to take into consideration when it comes to social sustainability. As a result, the study focuses, amongst other things, on the target group of children.

Case study: Eco-neighbourhood Augustenborg, Malmö

Augustenborg has since the 1980s been socially impoverished and economically challenged, facing problems such as segregation, unemployment and an ageing housing stock. The area also experienced recurrent seasonal flooding due to an inadequate drainage system. In 1998 the city of Malmö initiated an extensive urban gentrification project of the area (World Habitat, 2018). The aim was to transform Augustenborg into an environmentally, socially and economically sustainable neighbourhood. It is one of the earliest examples of neighbourhood planning, emphasizing proximity to social services such as stores, cafés, cinemas and schools (Aunér, 2010).

The transformation began in early 1990s and has involved increasing the quantity of green spaces and enhancing natural values and biodiversity, while at the same time maintaining the character of the district. One of the main objectives has been climate adaptation trough green infrastructure and sustainable stormwater management. Green roofs, walls, trees and open stormwater management has been important tools (Malmö stad, 2018).

The project of Augustenborg has set high priority on local participation with residents and stakeholder of both the private and public sectors (World Habitat, 2018). Community deliberation approaches such as workshops, design and information sessions, festivals and other cultural events has been used in shaping the neighbourhood (Malmö stad, 2017).

The project has led to Augustenborg becoming a more attractive and multicultural neighbourhood, combating earlier segregation. It has also become an international example if retrofitting green space within an urban fabric (World Habitat, 2018).

2.3 Environmental Sustainability

Environmental sustainability is the third dimension of the term sustainability. In contrast to the economic and social dimensions of sustainability, environmental sustainability is often the dimension, which is most widely used.

Environmental sustainability includes the systematic conditions where human activities do not disturb the natural cycle more than the planetary resilience allows, and also do not demolish the natural capital which has to be shared with future generations (Vezzoli & Manzini, 2008). A third more ethical limitation refers to principle that every person, including those from future generations, should have the right to the same environmental space and access to the same amount of natural resources (*ibid*.).

Besides other, one concept of attribute a value to nature is to focus on the intrinsic value of nature which also strengthens an environmentally sustainable behaviour and serves as an argument for animal preservation and nature preservation. The concept of intrinsic value of nature is often used by philosophers and emphasises that the environment can have value in itself, and of independently valuing consciousness. The concept of intrinsic value of nature is interpreted in varied ways through a very wide range of possible priorities (naturistic or humanistic) (Vilkka, 1997). Furthermore, Rowlands (2000) describes that it is very difficult, if not impossible, to develop a satisfactory account of the value of the environment when viewing the mind as an inside and the environment as an outside. That is why intrinsic value is a notoriously difficult concept which can be seen as one point of criticism (Vilkka, 1997). However, the concept of intrinsic value of nature can lead to an environmentally sustainable future.

Global demands for energy, food, land, water and other resources have increased over the last hundred years, particularly due to the increasing population and the advancement of industrial societies (Rockwood *et al*., 2008; Vezzoli & Manzini, 2008). A current problem regarding environmental sustainability is the uneven use of renewable resources (Vezzoli & Manzini, 2008). Especially non-renewable and rare resources are being exploited at a too high pace, while some renewable resources have a low exploitation rate (*ibid*.). Another problem is the unwise consumption of non-renewable resources which also leads to an increase of environmental pollution through emissions of harmful substances and the creation of waste (*ibid*.).

To achieve an environmentally sustainable development, several different measures on various scales can be implemented. It could potentially involve implementation of environmental policies, such as taxes, subsidies or conservation methods. Another approach is promoting environmentally sustainable design through minimizing non-renewable energy consumption, increasing water conservation as well as using sustainable building materials appropriate to the location (General Services Administration, 2017). Emphasis, in the context of environmentally sustainable development, is placed on resource efficiency, and an overall decrease of resource exploitation (Rockwood *et al*., 2008; Vezzoli & Manzini 2008).

2.4 Green Infrastructure and Structure

Green infrastructure is defined by the European Commission (2013) as a "[...] strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings." (p. 7). The Swedish Environmental Protection Agency stresses the ecological importance of green infrastructure by defining it as an "ecologically functional network of habitats and structures, natural areas and physical structures that are designed, used and managed in way that preserves biodiversity and provides important ecosystem services for the society" (Naturvårdsverket, 2018c).

The importance of green infrastructure (GI) is further elucidated by the Stockholm County Council's ongoing project concerning GI in greater Stockholm region (Länsstyrelsen Stockholm, 2018). The project, which is currently on submission for comment, aims to identify and suggest conservation methods of GI with emphasis on ecosystem services, biodiversity and ecosystem resilience (*ibid.*).

One of the main features of green infrastructure is that it enables several different functions within the same area. It aims to provide economic, environmental and social benefits through the use of natural solutions (European Commission, 2016). More specifically, GI provides benefits from nature to people by increasing the ability of nature to deliver valuable ecosystem services, such as clean water or air (*ibid.*).

green infrastructure places emphasis on multifunctionality. According to Sandström (2002), GI can serve multiple purposes in the urban fabric (i.e. recreation, cultural identity and biodiversity), whereas engineering infrastructure traditionally are singled purposed. It is this multifunctionality that differentiates GI from grey infrastructure (*ibid.*). Grey infrastructure normally refers to physical and organisational structures and facilities, such as roads or buildings (Naumann *et al.*, 2011).

Green infrastructure as a concept is appearing more frequently in development discussions around the world. Knowing that GI can provide several tangible environmental benefits, including carbon sequestration, climate change adaptation, stormwater management and improved air quality through nature based solutions has led to the concept becoming more frequently recognized as vital in all stages of planning (Nowak & Dwyer, 2007; Pataki *et al.*, 2011). Recognition is also given to the fact that nature often can provide cost-effective and durable solutions (Benedict & McMahon, 2002). The concept of green infrastructure help decision-makers understand the value that nature provides society so that investments are mobilised to preserve and enhance them (*ibid*.).

Green structure is more difficult to define than green infrastructure, as the definition of the concept has been interpreted differently depending on the situation that the word is being used within (Lindholm, 2015). In this study, green structure will be defined based on the definition that the Swedish University of Agricultural Sciences use for the concept, which is a combination between Naturvårdsverkets and Boverkets definitions (Sandelin, 2012). According to them, green structure is defined as: "[...] all surfaces, both ground and water, that are not built-up or impervious regardless of ownership and scale, including single green elements." Where the green elements consist of all forms of greenery found

within an urban area, such as parks, green roofs, allotments and street trees to name a few (*ibid.*).

2.5 Ecological Connectivity

Ecological connectivity, also referred to as landscape connectivity, can be described as: "[...] physical or ecological events that allow materials or organisms to move between or influence habitats, populations or assemblages that are intermittently isolated in space or time." (Sheaves, 2009, p.108). Ecological connectivity between habitats enable species gene exchange which protects the species persistence and is therefore crucial for biodiversity (Stockholms stad, 2017d).

Connectivity as a term can be broken down into two categories: structural and functional connectivity. Structural connectivity can be defined as: "[...] the physical relationships between habitat patches (physical distances), and functional connectivity, i.e. an organism's behavioral response to both the landscape structure and the landscape matrix" (Taylor *et al*., 1993, 2006; Baguette, 2013, p. 326).

Ecological corridors connect different habitats/patches, creating linkages that enable dispersal of species (Bennet, 1999). In this study, we use the word "corridor" as a linkage between different habitats (*sv. spridningssamband*).

Dispersal patterns and dispersal capacity differs among species. Plant species could use animals for dispersal, e.g. by seeds being eaten and dispersed away from the mother plant (Stockholms läns landsting, 2012). Animal species have different dispersal strategies and capacity as well, species that easily disperse are among flying species such as birds and flying insects *(ibid.)*. This group of easily dispersed animal species also includes some of our large mammals such as Roedeer (*Capreolus capreolus) (ibid.)*. Species that disperse less easily have difficulties passing barriers, and this group includes many species that are on the national Red List *(ibid.)*. Areas with these kinds of species are often not suitable for any type of exploitation due to that the dispersal patterns are crucial for the survival of these species *(ibid.).*

2.6 Ecosystem Services

Ecosystem services are defined by Costanza *et al*. (1997) as "the benefits human populations derive, directly or indirectly, from ecosystem functions". This definition recognizes and provides a clear link to ecosystem functions as a provider of various services. In their definition, Fisher *et al*. (2009) makes a clearer connection between ecosystem services and its ability to produce human well-being. Meyer *et al*. (2015) draws upon Costanza *et al*. (1997) definition but adds the discussion regarding the economical values of ecosystem services.

Costanza *et al*. (1997) has identified 17 major categories of ES. Many of these are not consumed by humans directly, but rather they are needed to sustain the ecosystems themselves. They are normally referred to as indirect services and include pollination, soil formation, water and nutrient cycle (Bolund & Hunhammar, 1999). Ecosystem services can be divided in several ways. The most common division of ecosystem services is shown in Table 1.

Table 1. Division of ecosystem services (Stockholms läns landsting,2012).

Ecosystem service	Description
Provisioning services	The products people obtain from ecosystems, such as food, fuel, fibre, fresh water, and genetic resources.
Regulating services	The benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification.
Cultural services	The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.
Supporting services	Those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation.

Cities are centres of demand for ecosystem services (Elmqvist *et al*., 2015). With a projected rapid increase of the urban population in Stockholm there will likely be an accelerating demand for ES. Such a rapid growth presents fundamental challenges. At the same time there are also opportunities to restore and enhance ecological functions and values and to design a more resilient and liveable city (*ibid.*).

Urban green space, which include for example urban forest, parks and cemeteries, provide a range of different ecosystem services. Out of the 17 categories of ecosystem services identified by Costanza *et al*. (1997), six are considered to be of particular importance in urban areas: noise reduction, rainwater and climate regulation, air-filtering, sewage treatment, cultural and recreational values (Bolund & Hunhammar, 1999).

The importance of ecosystem services in Sweden is generally known and integrated into political considerations. Several of the National Environmental Objectives in Sweden recognizes the value of ecosystem services and especially the importance of biodiversity (Naturvårdsverket, 2016). A key challenge for sustaining ecosystem services is to address the differences between ecological and social governance processes (Ernston *et al*., 2010).

Concerning ecosystem services, Stockholm County Council has published two major reports; *Svaga Samband i Stockholmsregionens Gröna Kilar* and *Ekosystemtjänster i Stockholmsregionen* (Stockholms läns landsting, 2012; Stockholms läns landsting, 2013). The aim of the reports is to achieve a shared vision on how to integrate the concept of ES into regional planning.

The report *Svaga Samband i Stockholmsregionens Gröna Kilar* has investigated the importance of soft links (*sv. svaga samband*) between the regions cohesive green wedges and ecosystem services (Stockholms läns landsting, 2012). The green soft links are crucial in order to secure recreational areas and maintain species dispersal

(*ibid.*). Functional distribution links in the green wedges provides conditions that many ecosystem services are dependent on such as pollination, recreational experience and water cycle (*ibid.*).

More recently recognized are ecosystem disservices (EDS). According to Shackleton *et al*. (2016), ecosystem disservices are "the ecosystem generated functions, processes and attributes that result in perceived or actual negative impacts on human wellbeing" (p. 590). More simply, it is the negative effects of ecosystems on humans (Lyytimäki *et al*., 2007). Examples of EDS include health problems caused by exposure to pollen or safety concerns in dark parks (*ibid.*). Ecosystem disservices will not be addressed further in this study, rather we want elucidate their existence.

2.7 Cultural Values

Cultural values is a broad term, encompassing several aspects with social and historical dimensions. In this study the focus will be on historical remnants, social meeting points and recreation.

Learning about history is essential to individuals and societies because it offers information on how people and societies behave and evolve over time (Stearns, 1998). History enables the creation of place identity which has the effect of creating social capital and cementing communities (*ibid.*). For this reason, preservation of historical remnants is very important. According to the Swedish National Heritage Board (Riksantikvarieämbetet, 2017), historical remnants should in context of planning be handled in a way that ensures a long-term preservation.

Recreation is also considered a cultural value (Godbey, 2009). It is important both for the mental and physical well-being of individuals (*ibid.*) Recreational opportunities and parks are essential for strengthening and maintaining a healthy community (State of California Resources Agency, 2005). Proximity to recreational areas and facilities leads to safer, cleaner and livelier neighborhoods (*ibid*.). Children in particular benefit from recreation because direct contact with nature positively affects blood pressure, cholesterol levels and reduces stress (Godbey, 2009). Insufficient physical activity can lead to obesity and hyperactivity disorder (ADHD) (*ibid.*). A more detailed review on this will be given in section 2.8.

An important concept considering recreation is recreational carrying capacity. This concept is particularly important when areas available for recreation is reduced. According to Selman (2000, p. 193) the concept consists of four dimensions.

- Ecological capacity, the level at which unacceptable change starts to occur in floristic composition, soil structure and bird and animal populations;
- Physical capacity, the point at which site facilities (such as car parks, visitor centres) or access routes become congested;
- Social capacity, the point at which the recreational experience starts to deteriorate; this varies according to the ability of different types of environment to absorb visitors; and
- Economic capacity, the threshold beyond which the economic returns of the enterprises are diminished.

Since the economic dimensions of sustainability is beyond our boundaries, economic capacity will not be addressed further. The remaining three dimensions will be discussed in context of this study's exploitation proposals.

2.8 Children in Focus

The following section will examine the relationship between children and nature. Special focus will be given to the consequences that a lack of green space can lead to. The section concludes with a brief introduction to the concept of Child Impact Analysis (CIA).

2.8.1 Children and Green Areas

Natural environments provide children with many important opportunities. Access to green areas incites discovery, risk taking, creativity, strengthening the sense of self and inspiring emotional states such as sense of wonder (Dadvan *et al.,* 2015). This generally affects aspects of cognitive development positively (Kahn & Kellert, 2002). Dadvan *et al*. (2015) found that cognitive development improves when children are exposed to surrounding greenness and this was particularly evident in educational environments.

Studies by Grahn (1996) and Akpinar (2017) show that access to green areas is associated with health benefits for children. Grahn (1996) claims that children who have access to green outdoor environments have better concentration, motor function and are overall healthier compared to children that do not have access to green areas. In addition, proximity to green areas has been suggested by Dadvan *et al*. (2015) to increase physical activity. Pikora *et al*. (2006) confirms this statement by alleging that close proximity to green areas promotes walking for recreational and transport purposes. Easy access to parks is central to park use and to increase physical activity, especially when it comes to children. In a study conducted by Grow *et al*. (2008), it is suggested that children who travel to parks on foot are generally more active in the park setting compared to children having arrived by other means of transport.

Several studies show convincing evidence on the strong associations between green areas and the well-being of children (Wells, 2000; De Vries *et al*., 2003; Van den Berg *et al*., 2010). The research suggests that limited experiences with nature may lead to long-term consequences for children's physical and mental development and wellbeing (*ibid.*). Also, children with extensive contact with nature experiences less symptoms of mental diseases (*ibid.*). Research also find that proximity to green areas and residential green areas is perceived to lead to less emotional and behavioral problems of children (*ibid.*).

Keniger *et al*. (2013) indicates that exposure to green areas such as parks and gardens, as well as green elements such as trees, can potentially influence attention and emotional state in children. It can also lead to stress reduction. Maas *et al.* (2009) shows that prevalence rates of depression and anxiety disorders are higher in areas that have less green areas within a radius of one kilometer. The relationship between proximity to green areas and depression and anxiety is strongest for children (Balsevicene *et al*., 2014). This is generally due to the fact that children are more vulnerable to negative as well as positive effects of the environment compared to adolescents and adults (*ibid.*).

In addition, adults normally decide where, when and in what way children interact with nature, children have thereby not the same mobility as adults. This means that children's decreased contact with green areas is not solely because of their own interest but rather it may be that their parents are concerned with their safety and will thus not allow them to be outside, prohibiting them to play outdoors (Balsevicene *et al*., 2014). To summarize, it is evident that there are

several causal relationships between proximity and access to green areas and the overall well-being of children.

Green areas in close proximity to schools and housing are more frequently used than green areas located further away. If the distance to the green areas extends to over 300 meters the resident does not use it frequently (Boverket, 2007). This corresponds to a walking distance of 5 minutes. For children and the elderly closeness to these areas are even more important. 200 meters from a green area is a benchmark set by Boverket, it is the recommended max distance from such areas. The benchmark is enacted by several municipalities plans for green structure (*ibid*.).

The Plan and Building Act (25 February 2018, Lexino, SFS 2010:900, 8 Ch. 9 §) states that there should be ample space available for outdoor play and activities in close proximity housing, schools, preschools and daycares. If enough space is not available for both recreational purposes and for parking, recreation should according to the act always be prioritized.

2.8.2 Child Impact Analysis

Sustainable development is defined in the Brundtland report as: "[...] development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition clearly emphasises the importance of future generations (International Institute for Sustainable Development, 2018).

Analysing and assessing consequences for children is a complex process. By using a systematic approach, possibilities for a child's best interest may be included in decision-making at all scales (Barnombudsmannen, 2011). This may contribute to higher quality in activities that affects children.

The basis for Child Impact Analysis (CIA) is the UN Convention on the Rights of the Child. It consists of 54 articles concerning child advocacy. 41 of these establishes rights that every child should have (Barnsrättigheter, 2018).

Child Impact Analysis is a tool that can be used to convert the UN Convention on the Rights of the Child into action (Barnombudsmannen, 2011). Stockholms stad works actively to incorporate the convention into planning, mainly through the use of integrated CIA. According to Stockholms stad, there are six main principles from the UN Convention on the Rights of the Child that should always be regarded when it comes to questions concerning children (Stockholms stad, 2016a) and these are shown in Table 2 on the next page.

In context of planning, article 12 is particularly important. This article expresses children as individuals with the right to their own opinion about questions affecting them. However, it is important to recognize that children are not a homogenous group. Every child has different needs and requirements depending on age, gender, ethnic and cultural background, disabilities and socioeconomic status. It is important to bear in mind that what may be the best for a child in a given situation is not necessarily the best for another. It is therefore important to find ways to manage different perspectives in each individual situation (Barnombudsmannen, 2011).

Table 2. Articles from the UN Convention on the Rights of the Child important in the context of planning (UNICEF, 1989).

Articles	Description of the article
Article 2	No child may be discriminated due to decent, gender, religion, disability or other reasons
Article 3	The best interests of children must be the primary concern in making decisions that may affect them.
Article 6	Every child has the inherent right to life
Article 12	When adults are making decisions that affect children, children have the right to say what they think should happen and have their opinions taken into account.
Article 23	Children who have any kind of disability have the right to special care and support, as well as all the rights in the Convention, so that they can live full and independent lives.
Article 31	Children have the right to relax and play, and to join in a wide range of cultural, artistic and other recreational activities

2.9 Political Visions and Plans

This section considers political visions and plans that are of interest to this study.

2.9.1 National Environmental Quality Objectives

The Environmental Objectives system adopted in Sweden consists of one generational goal, 16 environmental quality objectives and a number of milestone targets (Naturvårdsverket, 2017b). The generational goal defines the overall direction of environmental efforts and declares according to Miljömål (2012) that:

> "The overall goal of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders".

With reference to the generational goal, environmental policy aims to focus on ecosystem restoration and preservation, so that the ecosystem services they provide are secured (Sveriges Offentliga Utredningar, 2010). Human health should be protected from exposure of negative environmental impacts whilst the positive impact of the environment on human health is promoted (*ibid.*). In addition, the generational goal emphasises resource efficiency, changed consumption pattern and that the proportion of renewable energy should increase (*ibid.*). To make the generational goal tangible

and actionable, 16 environmental quality objectives has been formulated.

The National Environmental Quality Objectives (NEO) describes the state that the environment in Sweden should have by the year 2020 (Naturvårdsverket, 2012). The goals cover everything from air without pollutants to streams and lakes that does not undergo eutrophication or acidification (*ibid.*). For each goal there are several specifications, which clarifies the environmental state to be achieved in different areas (*ibid.*).

To facilitate achievement of the generational goal and the NEOs, several milestones has been specified by the Swedish government (Naturvårdsverket, 2018a). These covers areas such as hazardous substances, air pollution and waste (*ibid.*).

The relevance of the different National Environmental Quality Objectives to the discussion of Årstaskogen differs. Some of the NEOs, such as a protective ozone layer, a varied agricultural landscape and thriving wetlands are not applicable in this situation. The most relevant NEOs in the context of this study are:


A Good Built Environment


A Rich Diversity of Plant and Animal Life


Sustainable Forests


Clean Air


Reduced Climate Impact

2.9.2 Regional Development Plan for the Stockholm Region (RUFS)

The guiding rationale for all development in the Stockholm Region is the Regional Development Plan, more commonly referred to as RUFS. The plan considers six strategies that provide key guidance on how the challenges in the region can be managed in order to fulfil the vision of becoming Europe's most attractive metropolitan area (Stockholms läns landsting, 2010). The present RUFS, adopted in 2010, spans until 2030. Work is currently underway to develop a new regional development plan, RUFS 2050. The final plan will be adopted by the County Council in the summer of 2018 (Stockholms läns landsting, 2018).

With reference to the Regional Development plan of 2010 (Stockholms läns landsting, 2010), there are several strategies that are particularly important in the context of this study and these are formulated as follows:

- Within the housing sector, a diversity of housing with a safe environment and adaptation to different groups of people (e.g. youth, disabled people and elderly) should be strived towards. From a business perspective, it is also important to provide attractive housing alternatives. Current housing alternatives, regarded as less attractive should be developed to improve the overall living environment. This could be done for example by constructing new housing and gentrifying worn-down areas.
- Much effort should be put into technological development to make housing more efficient with respect to energy use and transport in order to reduce emissions.
- The green infrastructure of the region should be multifunctional by enabling ecological, social, esthetical and economical functions. Guiding for the planning of green infrastructures

should be based on the principles of facilitating an urban environment with parks and green areas whilst preserving a coherent green infrastructure.

2.9.3 Comprehensive Plan

According to the Plan and Building Act (Ch. 3, 2 §), the comprehensive plan should specify the orientation for the long-term development of the physical environment (Stockholms stad, 2018c). It should provide guidance for decisions on how land and water areas will be used, including how the built environment will be used, developed and preserved (*ibid.*).

The comprehensive plan should be timely in order to provide guidance for subsequent planning (Stockholms stad, 2018c). In February of 2018, the Stockholm County Council adopted a new comprehensive plan based on the vision of 'a Stockholm for everyone' (*ibid.*). The comprehensive plan should cover both general and specific challenges of urban development, including the long-term objectives of the Stockholm region (*ibid.*).

Urban development in Stockholm should, according to the Comprehensive plan, emanate from the strategies of a growing city, a coherent city, a good public environment and a climate smart and durable city (Stockholms stad, 2018c). The planning proposals in this study will be evaluated against indicators derived from the four strategies.

2.9.4 The Stockholm Environment Programme

In addition to the Comprehensive plan, Stockholms stad (2016b) has developed an Environment Programme with a scope until 2019. It consists of six targets with 30 sub goals which are listed below.

Sustainable energy use

1. The City will strive to reduce greenhouse gas emissions to a maximum of 2.3 tons per resident by the year 2020
2. The City will by way of energy-efficiency measures reduce energy use in its own operations by at least ten percent by the year 2020
3. Far-reaching energy efficiency will be implemented in major renovations
4. For new constructions on land allocated by the City, energy use will be no higher than 55 kWh/m² and year
5. The City's own energy production based on solar energy will be increased

Environmentally friendly transport

1. Car traffic will be reduced
2. Stockholm will have clean air
3. Outdoor traffic noise will be reduced
4. The City's streets will be more appealing for walking and more liveable environments
5. Fossil energy in the transport sector will be reduced

Sustainable land and water use

1. Vulnerabilities in the urban environment as a result of climate change will be prevented
2. A healthy status will be achieved for the City's bodies of water
3. The City's bodies of water will be strengthened and developed for both recreation and biological diversity
4. In city development projects, ecosystem services will be supported in order to contribute to a sound living environment
5. The City will have a viable green structure with rich biological diversity
6. Stockholm residents will have good access to parks and nature with high recreational and nature values
7. Each City district will be planned with regard to a healthy urban environment

Resource-efficient recycling

1. The City's operations will prevent the generation of waste
2. Generated waste that emerges will be dealt with in a resource efficient way
3. Hazardous waste will not be present in household waste

A non-toxic Stockholm

1. The release of hazardous substances from households, commerce, construction and other sources will be reduced
2. The contents of substances that are hazardous to the environment and health in procured articles and services will be reduced
3. The use of construction goods containing hazardous substances will be reduced
4. The City's use of chemical products containing phase-out substances and prioritised risk-reduction substances will decrease
5. The occurrence of substances that are hazardous to health in preschool environments will be reduced
6. Negative impacts on animal life, the environment and people's health from the City's consumption of foodstuffs will be reduced

A healthy indoor environment

1. Indoor radon levels will be below 200 Bq/m³ of air in the City's multi-family housing developments and locales for work and education
2. Damages to buildings caused by moisture will be prevented
3. Indoor noise levels will be reduced
4. Indoor air quality will be improved

In the context of this study, eight of the sub goals will serve as indicators when evaluating the performance of the exploitation proposal.

2.9.5 A Greener Stockholm

'A Greener Stockholm' is a concept created by the Stockholm City Council to incorporate more green areas into the development of Stockholm (Stockholms stad, 2016d). The goal with "A Greener Stockholm" is to create a more long-term plan for how green areas in Stockholm should be managed and expanded in the future (*ibid.*). These green areas include parks, city squares and residential yards, as well as natural and aquatic areas (*ibid.*). Especially parks and natural areas are seen as crucial components for the future sustainable development of Stockholm, and thus these areas must be seen as especially important to preserve and expand (*ibid.*).

2.9.6 The City at Eye-level – Children perspective on Urban Development

The project 'the City at Eye-level' is the guiding concept for issues relating to children and urban development in Stockholm. The project intends to act as an incentive for promoting needs of children and strengthening their participation in the planning process (Stockholms stad, 2017h). As a basis for the project is 'Culture at Eye-level', which aims to enable children to enjoy a rich cultural life (*ibid.*). It is a steering document that all committees in Stockholm, working with children ought to use (Stockholms stad, 2009).

The Stockholm County Council decided, in November of 2013, to update the project with an additional target, which states the following: "the needs of children and young people are taken into account when it concerns the parts of the physical environment where they dwell" (Stockholms stad, 2015). This means that all urban development projects should consider views and needs of children and follow guidelines suggested by 'the City at Eye-level' (*ibid.*). Such guidelines seek to ensure that urban development projects consider the UN Convention on the Rights of the Child by emphasising the use of Child Impact Analysis (*ibid.*). 'The City at Eye-level' creates practical tools for knowledge acquisition and analysis of participation and

needs of children and how to implement these in urban development projects (Stockholms stad, 2017h). The district of Enskede-Årsta-Vantör are one of the participants in this project (Stockholms stad, 2015).

2.9.7 The Swedish Environmental Code

The ordinances of the Environmental Code aim to promote sustainable development in a way so that the present and future generations are ensured a safe and healthy environment. This is dependent on the insight that nature is worth protecting. The right to exploit nature is associated with responsibility of managing it wisely.

The Swedish Environmental Code (22 February 2018, Lexino, SFS 1998:808, 1 Ch. 1 §) shall be applied in a way as to ensure that:

1. Human health and the environment are protected against damage and detriment, whether caused by pollutants or other impacts;

2. Valuable natural and cultural environments are protected and preserved;

3. Biological diversity is preserved;

4. The use of land, water and the physical environment in general is such as to secure a long-term good management in ecological, social, cultural and economic terms; and

5. Reuse and recycling, as well as other management of materials, raw materials and energy are encouraged with a view to establishing and maintaining natural cycles.

Section 2-8, in Chapter 7 of the Environmental Code (22 February 2018, Lexino, SFS 1998:808) concerns nature conservation. The different sections clarify and explain the purpose of nature conservation. Much emphasis is placed on preserving biodiversity, nurturing valuable natural areas and promoting outdoor activities.

2.9.8 Protected Areas

The Environmental Code enables the right to create protected areas. It is the County Administrative Board and the Swedish Environmental Protection Agency that has the primary responsibility for establishing nature conservation areas (Wahlström, 2016).

About a tenth of Sweden's total land area constitute national parks, nature reserves, nature conservation areas or biotope protection areas (Naturvårdsverket, 2018b). National parks have the strongest protection (*ibid.*). These are generally large cohesive areas of a certain landscape type in a more or less natural state (Länsstyrelsen Stockholm, 2018a).

The most common form of protection of natural areas is nature reserves. The Swedish Environmental Code (22 February 2018, Lexino, SFS 1998:808, 7 Ch. 4 §) states the following reasons for establishing nature reserves:

- Preserving biodiversity
- Nurture and preserve valuable natural environments
- Accommodate outdoor activities
- Protect, restore and rehabilitate valuable natural environments
- Protect, restore and recreate habitats for protective species

There are approximately 4 500 nature reserves in Sweden (Naturvårdsverket, 2017c). Every nature reserve is unique and has therefore their own regulations to preserve nature (*ibid.*). The aim of the reserve is guiding to determine what restrictions to apply (*ibid.*).

In order to facilitate description and delineation of the nature reserve area, the 'functional concept' should be applied (Naturvårdsverket, 2008). According to this concept, the nature reserve should be divided into core area, support zones, developmental land (*sv. utvecklingsmark*) and zoning ground (*sv. arronderingsmark*) (*ibid.*). This division aims to protect the conservation value of the core area (*ibid.*).

A landscape perspective should be used when planning nature reserves to ensure that the reserve is thought of in a wider context where the surrounding environments are included (Naturvårdsverket, 2008). The aim is to reverse the fragmentation of landscapes by emphasising the importance to seek a holistic approach that looks at landscape elements as a mosaic, that together form one entity (*ibid.*). This means, amongst other things, that all parts of the nature reserve boundary should be based on sound reasoning, primarily when it comes to existing natural values, but also on a basis of recreational and cultural values (*ibid.*).

2.9.9 The Housing Situation in Stockholm

The population of the Stockholm Region is growing. During the last decade, the population has increased by an average of more than 15 200 inhabitants per year (Stockholms stad, 2017f). This has made the housing shortage in Stockholm even more evident (*ibid.*).

In light of this, Stockholms stad has set a goal that 140 000 new apartments will be built in the period of 2010-2030. Out of these, 40 000 will be constructed until 2020 and an additional of 80 000 more will be completed by the year 2025. The former corresponds to an average of 6 667 residential units per year whereas the latter corresponds to 8 000 units per year.

Stockholms stad aims to build attractive housing for the increasing population whilst improving environmental and social sustainability (Stockholms stad, 2017f). According to Länsstyrelsen Stockholm (2017), the construction rate in the region has been one of the largest in several years but the housing shortage still remains. They claim that the reason being high housing prices, which few can afford (*ibid.*). The solution relies on construction of attractive and affordable housing, available to all social groups (*ibid.*).

According to statistics, covering the wider district of Årsta-Enskede-Vantör, 1 018 residences were under construction in 2016 (Stockholms stad, 2017f). An additional of 1 064 is under so called land allocation agreement and 1 120 are in the process of beginning to work on a detail plan (*ibid.*).

3. Description of the Study Area

Årstaskogen and Årsta holmar are a part of the rift valleys of Mälardalen in the southern part of Stockholm (Stockholms stad, 2017d). The area of Årstaskogen is mostly located on steep slopes facing the water of Årstaviken (*sv. lake Mälaren*) creating an important landscape feature that is characteristic for Stockholm (*ibid*.). The area is emphasized for having both high recreational and ecological values (*ibid*.). Six areas of Årstaskogen have been identified as peaceful "quiet areas" of Stockholm City. "Quiet areas" are identified for having a combination of good sound quality and green experience values (Stockholms stad, 2018d).

In January 2018, the decision to establish Årstaskogen as a nature reserve was taken (Stockholms stad, 2018c). The primary cause for establishing Årstaskogen nature reserve is to protect the ecological

values and outdoor life due to the needs of the increasing population of Stockholm (Stockholms stad, 2017g). The nature reserves management plan, objectives and measures will provide to the long-time care of Årstaskogen (*ibid*.). The County Administrative Board of Stockholm has, on behalf of the Swedish government, developed a program for protection of urban nature in the greater Stockholm area. The aim is to protect the most valuable urban green areas. The programme contains proposals to establish 71 new nature reserves (Länsstyrelsen Stockholm, 2003). As of 2015, protection has been established for 44 of the proposed areas. In addition to this, 10 areas have been granted protection, although they were not included in the original programme. Årstaskogen was included as one of the proposed nature reserve areas in the programme (Länsstyrelsen Stockholm, 2018b).

The nature reserve regulations for Årstaskogen and Årsta holmar are listed by Stockholms stad (2017g). We highlight five regulations in this study below:

In order to meet the objectives of the nature reserve the City Council decides on the basis of Chapter 7, section 5, 6 and 30 of the Environmental Code (23 February 2018, Lexino, SFS 1998:808, 7 Ch. 5, 6 and 30 §) that the following regulations shall apply in the nature reserve.

A5. No roads for motor vehicles may be constructed, other than road covered by a license obligation under the reserve regulations A12.

A6. New buildings or facilities may not be constructed. The prohibition does not apply to a facility subject to a license obligation under reserve regulation A9.

A7. Permission is required to harvest trees or remove dead trees with a diameter greater than 20 cm or a circumference of 70 cm at chest height. Permits are not required for trees that have fallen or risk falling over a walkway, allotments or other facilities.

A9. Permission is required to construct small sized new buildings (maximum of 25 square meter surface and 4 meter in height) or new facility. To get permission the building or facility has to be in line with the aim of the reserve.

C1. It is forbidden to cut down or otherwise damage living or dead trees and shrubs, to damage vegetation by, for example, digging up bilberry sprigs, herbs, mosses, lichens or mushrooms, plants or taking branches and twigs from the ground in order to use as wood or fuel. Berry, flower and fungus picking is permitted, with the restrictions of the right of common and the species protection regulation (*sv. artskyddsförordningen*) (2007: 845).

C2. It is forbidden to interfere with or damage the wildlife, for example by climbing trees with nests, catching or killing mammals, birds, reptiles or amphibians.

3.1. Facilities and Activities in Årstaskogen

There are several facilities and ongoing activities adjacent to and within the borders of Årstaskogen nature reserve (Stockholms stad, 2017d). The ones connected to this study are described below.

Kullerbyttan preschool - The preschool "Kullerbyttan" is located within the borders of the Årstaskogen nature reserve (Stockholms stad, 2017d).

Boat clubs - Three boat clubs are located along the shore of Årstaskogen: Årstadals, Årsta gårds and Dianelund boat club (Stockholms stad, 2017d). The boat clubs are all included within the boundaries of the nature reserve (*ibid*.).

Allotments - Two allotment areas are located within the nature reserve. These are some of the oldest allotment areas located in Stockholm City, built in 1917 (Stockholms stad, 2017d).

Outdoor gym - There are two outdoor gym facilities located in Årstaskogen nature reserve (Stockholms stad, 2017d).

Rainwater and wastewater tunnel - Tunnels that lead rainwater from the elevated areas of Årsta lead through Årstaskogen nature reserve. The water flows out into lake Mälaren in the western parts of the forest (Stockholms stad, 2017d).

The playground Trollparken - Trollparken is a playground located on one of the flat areas of Årstaskogen. It is managed by the municipal district administration (*sv. stadsdelsförvaltningen*) (Stockholms stad, 2017d).

Jetties (*sv. bryggor*) - Along with the shoreline of Årstaskogen there are two jetties for recreation (Stockholms stad, 2017d).

Årsta IP (sports field) - Located adjacent to the nature reserve. Årsta IP is the main training resident (*sv. träningshemvist*) for the Hammarby football club. It is also partly used by the local schools, but it is closed for the public (Stockholms stad, 2017d).

Årstaskogen scout cottage - Located adjacent to the nature reserve near the IP. The scout cottage serves as a main hub for the Årsta scouts and a lot of the scout activities takes place here (Årsta scoutkår, 2018).

3.2 Green Infrastructure and Structure

Årstaskogen is one of the most important areas for green infrastructure in Stockholm City (Stockholms stad, 2014). Because of its relative location close to the city centre Årstaskogen is an important network for providing ecosystem services and green areas for the people living within the concrete jungle (*ibid*.). Together with other green areas in the region, Årstaskogen makes up the "green walk town" of Stockholm, which is part of the Stockholm Vision for 2030 (Stadsbyggnadskontoret, 2013). The vision states that "all Stockholm citizens should have close distance to an attractive green area […]" (p.4) and promotes the inclusion of green areas within the city (*ibid*.). For this reason, Årstaskogen is not only an important part of the green structure in Årsta but also for the whole region of Stockholm (Stockholms stad, 2017c).

Årstaskogen makes up an ecological core area (Stockholms stad, 2014). As biodiversity is important in supporting most other ecosystem services further stresses the importance of Årstaskogen as an integral part of the city's green infrastructure (*ibid*.). To preserve biodiversity at a sustainable level, Årstaskogen is managed in accordance to the management plan for nature reserve (Stockholms stad, 2017d).

Apart from being important for the green infrastructure of Stockholm, Årstaskogen also includes many important green structures. The many allotments in Dianelund (which is part of the nature reserve) is one example of such green structures. It has been a source of active urban gardening since 1917 (Koloniträdgårdsföreningen Skanskvarn, 2015b).

Trollparken is another green structure in Årstaskogen. Also, along the fringes of the forest there are multiple green patches that have been left untouched which contributes in a more gradual transition between the built areas and the nature reserve (Stockholms stad, 2017c).

3.3 Ecological Connectivity

Årstaskogen and Årsta Holmar are defined as an area of certain ecological importance, ESBO (*sv. Ekologiskt Särskilt Betydelsefulla Områden*) (Stockholms stad, 2016c). Areas of certain ecological importance include core areas, dispersal zones and habitats for species with high protection value (Stockholms stad, 2017d). The core areas of Stockholm are important for preserving biodiversity in the city due to its green continuity. Areas of certain ecological importance also include opportunities for species to disperse between different habitats (*ibid*.). Connectivity between habitats enable species gene exchange which protects the species persistence and is therefore crucial for biodiversity (*ibid*.). The dispersal-zones of high importance for Årstaskogen range from Majrosskogen in the south, to the Nacka nature reserve in the east and to the waterfront areas of lake Mälaren in the west (*ibid*.).

Many bird species that are associated with coniferous forests occur in Årstaskogen, such as several woodpecker species (Picidae sp.), Northern Goshawk (NT) (*Accipiter gentilis*) and several tit species (Paridae sp.) (Stockholms stad, 2017d). The connection to other coniferous forests, such as the dispersal through Hemskogen, Svedmyraskogen, Majskogen and Hanveden, is therefore important to maintain the bird populations of Årstaskogen (*ibid*.). There is a weaker connection to the Nacka reserve (ibid.). Because of the important ecological relationship between Årstaskogen and the Nacka nature reserve there is a great need to enhance the connectivity between the two areas (Stockholms stad, 2018c).

3.4 Nature Values

The dominating nature type of Årstaskogen is scots pine forest (*Pinus sylvestris*) on bare rock or moraine ground (Stockholms stad, 2017d). This nature type includes many old trees due to a long continuity and it is becoming more unusual in Swedish production forestry (*ibid.*). The pine trees of Årstaskogen vary from 150-250 years old (Stockholms stad, 2012). There is also a relatively high proportion of dead wood which favour many invertebrate, lichen and fungal species (*ibid.)*. Some areas of Årstaskogen have remnants of a more open landscape due to historical grazing and cultivation (Stockholms stad, 2017d). In these areas the broadleaved deciduous tree species such as older individuals of Common Oak (*Quercus robur)* occur (*ibid.*). The habitats of Årstaskogen are described below under 3.5 “list of the different habitats of Årstaskogen” (*ibid.)*.

3.5 Habitats

Årstaskogen have a wide variety of habitats but is dominated by coniferous forest, especially pine trees on bare rock ground (Stockholms stad, 2017d). Some areas in the south-west parts of Årstaskogen also include broadleaved deciduous tree species (*ibid.*).

Mixed forest **-** Areas that include: Scots pine (*Pinus sylvestris)*, Silver birch (*Betula pendula)* and European aspen (*Populus tremula)*. Often occurring on moraine ground (Stockholms stad, 2017d).

Broadleaved deciduous forest **-** Årstaskogen contain a wide range of broadleaved tree species including a small population of old oak trees (*Quercus robur*) (Stockholms stad, 2017d). The broadleaved deciduous forest is mostly located in the south-western part of Årstaskogen. These areas also include dead or dying trees which favour many invertebrate species (*ibid.*). The occurrence of older individuals of *Quercus robur* is highly correlated to biodiversity (Jonsson *et al.*, 2005). Structures that old oak trees develop benefit many invertebrates, lichens and fungal species (*ibid.*). Oak trees that are older than 100 years can include up to 1500 different species (Hultengren *et al*., 1997). Other tree species included in the broadleaved deciduous areas of the Årsta forest are: Scots elm (*Ulmus glabra),* Small leaved lime (*Tilia cordata),* Norway maple (*Acer platanoides)* and European ash (*Fraxinus excelsior).* The broadleaved deciduous trees are also important for many invertebrates and fungal species but also as nesting sites for birds and bats (Stockholms stad, 2017d).

Pine forest *(Pinus sylvestris)* on bare rock ground *(sv. hällmarkstallskog)* Årstaskogen have a long continuity of this habitat and it is well represented in the nature reserve (Stockholms stad, 2017d). Old pine trees (*Pinus sylvestris*) are dominating but deciduous tree species and a field layer with herbs also occurs. There have been at least 80 observations of pines with the fungal species *Phellinus pini* in Årstaskogen, which is listed on the Swedish National Red List. Historical grazing has left some of these areas sparse (*ibid.*).

Pinus sylvestris - pine forest on moraine ground **-** The pine forests on moraine ground have a ground layer dominated by Bilberry (*Vaccinium myrtillus)* and Lingonberry (*Vaccinium vitis-idaea)* together with Scots pine (*Pinus sylvestris)* (Stockholms stad, 2017d). Many old and thick trees with high ecological values (*ibid.*). In these areas there are observations of the fungus *Phellinus pini* (*sv. tallticka*), which is listed on the Swedish National Red List and the Coleoptera species *Nothorhina muricata* (*sv. reliktbock*) on old pine trees (*ibid.*).

The nature shore of Årstaskogen **-** The shore of Årstaskogen have been defined by the housing and urban development town building office (*sv. stadsbyggnadskontoret*) as an ecologically distinctly sensitive area according to Chapter 3, section 3 of the Environmental Code (28 February, Lexino, SFS 1998:808, 3 Ch, and *3 §).* This means that an area like this need to be protected to preserve biodiversity. The shoreline of Årstaskogen includes a mixed forest of the tree species Scots elm (*Ulmus glabra),* Common alder (*Alnus glutinosa)*, Bird cherry (*Prunus padus)*, Goat willow (*Salix caprea)* and Scots pine (*Pinus sylvestris)* but lacks of a shrub layer along the shore. The shores vary between bare rock that connects directly to the water and small sandy beaches closer to Gullmarsplan. The nature shore of Årstaskogen is important for many wetland species (Stockholms stad, 2017d).

Open areas (historically cultivated) **-** There is an open area close to the old Sköntorp croft (Stockholms stad, 2017d). The land has historically been cultivated and today the area is still open and include fruit trees (*ibid.*).

Other deciduous forest areas **-** In some parts of Årstaskogen that historically were more open, there is an occurrence of old populations of *European aspen (Populus tremula)* (Stockholms stad, 2017d). These have high ecological values and serve as important nesting-sites for birds (*ibid.*).

The Årsta stream **-** The Årsta stream (*sv. Årstabäcken*) are located in the south-western part of Årstaskogen, in the broadleaf deciduous area (Stockholms stad, 2017d). The habitat has a high importance for biodiversity (*ibid.*).

3.6 Flora and Fauna

The high ecological values of Årstaskogen are mostly associated to the tree species composition and the geographical location, creating important dispersal zones for many species (Stockholms stad, 2017d). The high proportion of the fungus *Phellinus pini* in Årstaskogen is very unusual and it is related to the presence of old pine trees (*Pinus sylvestris)* (*ibid.*). *Phellinus pini* is a parasitic fungus that lives on pine trees that has reached an age of 100-150 years old (*ibid.*). The fungus is used as an indicator for forests with a high protection value and high nature values. At least 80 observations of pines with the fungus *Phellinus pini* have been found in Årstaskogen (Appendix II) (Stockholms stad, 2012).

The population of broadleaved deciduous trees are co-related with high biodiversity and are therefore important to sustain. The broadleaved deciduous trees are important for many invertebrates and fungal species but also as nesting sites for birds and bats (Stockholms stad, 2017d). During an inventory of bats in Årstaskogen 2017 seven bat species were observed (Table 3) (Ecocom, 2017). Bat species have a high ecological value and are protected by the Swedish nature conservation regulations paragraph four (*sv. artskyddsförordningen*) and by the hunting legislations third clause (*sv. jaktlagstiftningen*) (Naturvårdsverket, 2017a). Bats are also protected by the European convention *Eurobats* which protects nesting sites and core habitats (*ibid.*). Due to a decrease of nesting sites, mostly hollow trees, bats often look for alternative nesting sites such as underneath the rooftops of buildings or residential houses (*ibid.*).

The fauna of Årstaskogen also includes Roe deer (*Capreolus capreolus),* European hare (*Lepus europaeus*), Red squirrel (*Sciurus vulgaris*), European hedgehog (*Erinaceus europaeus*) and European badger (*Meles meles*) (Stockholms stad, 2017d).

The field layer (flora) of Årstaskogen is in some areas species poor and the ecological values are often associated with the variety of tree species (Stockholms stad, 2017d). However, some species with a high protection value (*sv. skyddsvärda arter*) that are associated to old farm lands have been observed such as Field pepperwort (*Lepidium campestre*) (*ibid.*). Table 3 below present a summary of observed nature conservation species in Årstaskogen (27 species that are on the national Red List with a total of 50 nature conservation species). This summary is based on observations by members of the project group of Bevara Årstaskogen (2017a), including observations from Artportalen (mainly vascular plants) and a bat inventory by Ecocom (2017).

Figure 3. Picture of the fungus *Phellinus pini* on a pine tree (*Pinus sylvestris*) in Årstaskogen (Photo: Levan Kalatozishvili, 2018).

Table 3. Table with observations of species of Årstaskogen. Abbreviations: Extinct (EX), Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Data Deficient (DD), Least concern (LC) and Not applicable (NA).

No	English	Latin	Red-list category	Directive species	Signal species (forest)	Other associated species and nature types/biotopes
1	Lesser spotted woodpecker	*Dryobates minor*	(NT)		X	Deciduous forest. Breed. Dependent on large areal. Rare.
2	Black woodpecker	*Dryocopus martius*	(NT)	X	X	Pine-forest. Have been breeding. Dependent on large areal. Unsure status.
3	European green woodpecker	*Picus viridis*	(NT)		X	Deciduous forest. Have been breeding. Unsure status.
4	Northern goshawk	*Accipiter gentilis*	(NT)		X	Regionally unsure status. 200 pares in Sörmland.
5	Stare	*Sturnus vulgaris*	(VU)			Cultivated land, deciduous forest. Breed. Common species with a negative trend.
6	Gold crest	*Regulus regulus*	(VU)			Coniferous forest. Several breeding pairs. Common but with a negative trend.
7	Common swift	*Apus apus*	(VU)			Breeds under rooftops. Foraging in the forest.
8	Lesser black-backed gull	*Larus fuscus*	(NT)			Foraging. Breeding at Årsta Holmar.
9	European herring gull	*Larus argentatus*	(VU)			Foraging. Breeding at Årsta Holmar.
10	European crested tit	*Lophophanes cristatus*	(LC)		X	Deciduous forest. Breed (2-3 pares). Dependent on large forest areal.
11	Coal tit	*Periparus ater*	(LC)		X	Deciduous forest. Breed. Dependent on large forest areal.
12	Long-tailed tit	*Aegithalos caudatus*	(LC)		X	Deciduous forest. Visits during the winter.
13	Thrush nightingale	*Luscinia lischinia*	(LC)		X	Forest edges etc. N.B during breeding time.
14	The wood warbler	*Phylloscopus sibilatrix*	(LC)		X	Deciduous forest. Several breeding couples.
15	European goldfinch	*Carduelis carduelis*	(LC)		X	Breeding.
16	Red-backed shrike	*Lanius collurio*	(LC)	X		Staging by the allotments.
17	Hawfinch	*Coccothraustes coccothraustes*	(LC)		X	Deciduous forest. Breed. Dependent on large areal. Rare.
18	Eurasian oystercatcher	*Haematopus ostralegus*	(LC)			Shores. Foraging. Breeding nearby. Locally uncommon species.
19	Tawny owl	*Strix aluco*	(LC)		X	Deciduous forest.
20	Whiskered bat/Brandt's bat	*Myotis mystacinus/brandtii*	(NA)		X	Previously on the national Red List. Protected species. Very active.
21	Pond bat	*Mytis dasycneme*	(EN)			Protected species.
22	Soprano pipistrelle	*Pipistrellus pygmaeus*	(LC)			Protected species.

23	Common noctule	*Nyctalus noctula*	(LC)		Protected species.
24	Northern bat	*Eptesicus nilssonii*	(LC)		Protected species in Stockholms county. Very active.
25	Brown long-eared bat	*Plecotus auritus*	(LC)		Protected species.
26	Daubenton's bat	*Myotis daubentonii*	(LC)		Protected species. Very active in Årstaskogen.
27		*Nothorina muricata*	**(NT)**	X	On sunlit old pine-trees. High indicator value.
28	Six-spot burnet	*Zygaena filipendulae*	**(NT)**		High indicator value
29	White-letter hairstreak	*Satyrium w-album*	**(NT)**		High indicator value.
30	Purple-edge copper	*Lycaena hippothoe*	**(NT)**		High indicator value.
31	Scotch elm	*Ulmus glabra*	**(CR)**		Form stands but some loss due to the elm disease.
32	European ash	*Fraxinus exelsior*	**(EN)**		Form stands.
33		*Kickxia elatine*	**(EN)**		Probably introduced.
34	Broad-leaved thume	*Thymus pulegoides*	**(VU)**		Probably sown with grass seed.
35	Madwort	*Asperugo procumbens*	**(NT)**		Ruderal species.
36	Mountain clover	*Trifolium montanum*	**(NT)**		Dry slopes.
37	Breckland thyme	*Thymus serpyllum*	**(NT)**		Dry slopes.
38		*Helianthemum nummularium subsp. Nummularium*	**(NT)**		Dry slopes.
39	Bristly hawkbit	*Leontodon hispidus*	**(NT)**		Dry slopes.
40		*Bothrychium lunaria*	**(NT)**		Grassland.
41	Field maple	*Acer campestre*	**(CR)**		Introduced.
42	Anemone americana	*Hepatica nobilis*	(LC)	X	Protected (*sv. fridlyst*). Some indicator value.
43	Yellow anemone	*Anemone ranunculoides*	(LC)	X	Broad-leaved deciduous forest.
44	Common ivy	*Hedera helix*	(LC)	X	The stream by the broad-leaved deciduous forest of Årsta Gård.
45	Northern spleenwort	*Asplenium septentrionale*	(LC)		Bare rock areas.
46	Red ring rot	*Phellinus pini*	**(NT)**	X	At least 150-year old trees. >80 pines!
47		*Phellinus populicola*	**(NT)**	X	Older observation from ca 1984.
48		*Irpicodon pendulus*	**(NT)**	X	Older observation from ca 1984.

49	Fringed earthstar	*Geastrum fimbriatum*	(LC)	X	Highest indicator value!
50	Cauliflower fungus	*Sparassis crispa*	(LC)	X	Associated with *Pinus sylvestris*
51	Velvet-top fungus	*Phaeolus schweinitzii*	(LC)	X	Associated with *Pinus sylvestris*
52		*Auricularia mesenterica*	**(NT)**		Associated with *Ulmus glabra.*
53		*Inonotus ulmicola*	**(VU)**		Associated with *Ulmus glabra.*
54		*Tortella tortuosa*	(LC)	X	Associated with limestone.
55		*Homalia trichomanoides*	(LC)	X	Water course.
56		*Leucobryum glaucum*	(LC)	X	Forest.

Species defined as signal species by the Swedish National Board of Forestry are the fungus, mosses and lichens. Bird species defined as signal species, marked with X in the Table 3, are defined as such. This is based on ecological knowledge and accepted assessment within nature conservation (Bevara Årstaskogen, 2017a). The breeding birds in the table have been observed during the last 15 years (*ibid*.).

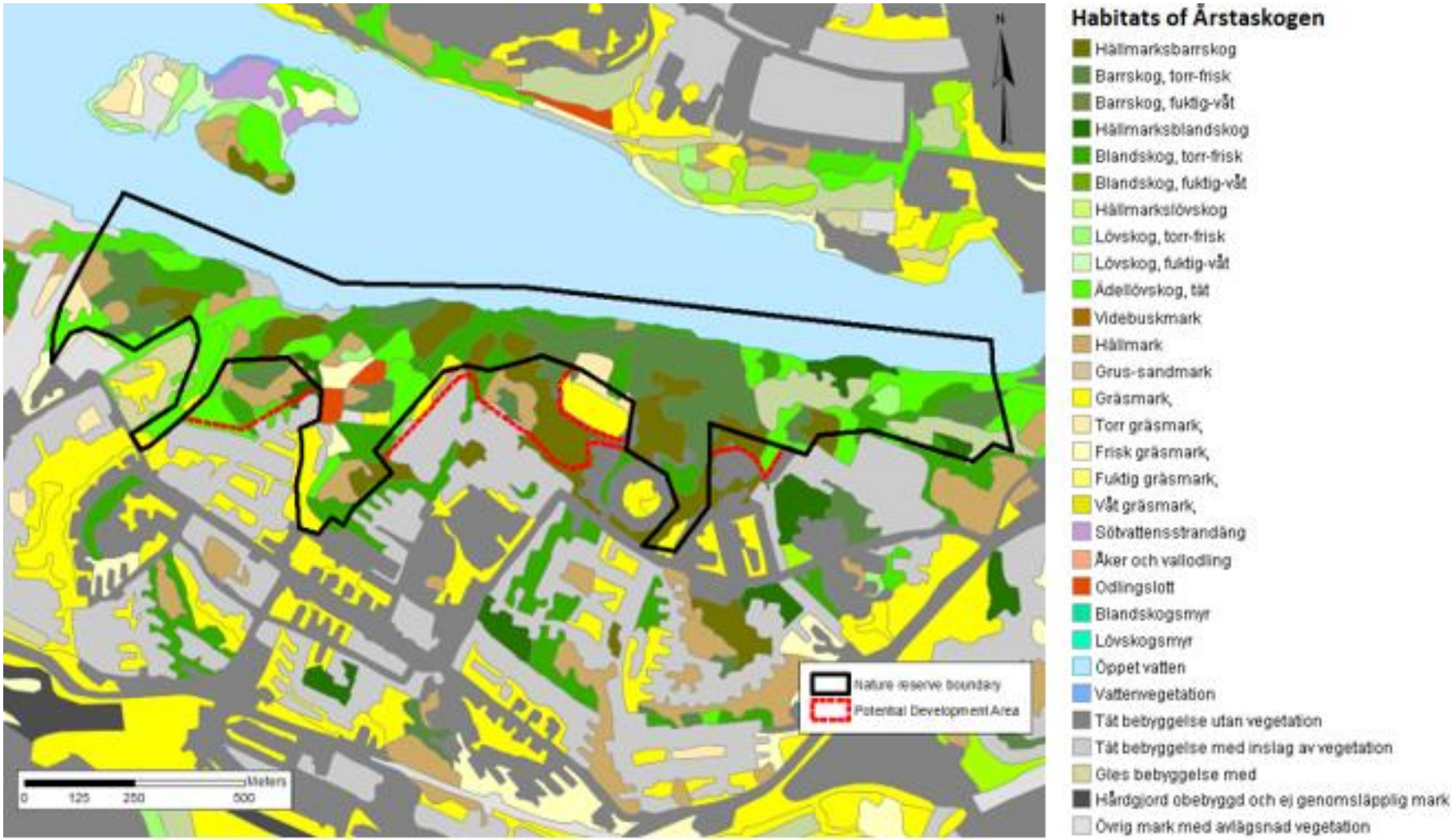


Figure 4. Map containing the habitats of Årstaskogen. Based on 'Biotopkartan (ytor)' from Miljödataportalen (2009). (Visualization: Liam Martin, 2018)

3.7 Ecosystem services

As a green area within an urban area, Årstaskogen offers a great amount of ecosystem services, many of them crucial for sustainability in the Stockholm urban area (Naturskyddsföreningen, 2017). Furthermore, all four categories of ecosystem services are represented to some degree within Årstaskogen, which creates a more diverse provision of services within the nature reserve itself (see Table 4).

Provisioning services: Provisioning ecosystem services are provided mainly by small scale gardening that takes place within the allotments present in the southeastern part of the preserve (Stockholms stad, 2017c). This contributes as a secondary income of food in the form of vegetables and root crops grown locally in the area (*ibid.*).

Regulating services: Regulatory services are widely represented within Årstaskogen; with the high amount of trees and plants, air pollutants will be reduced, but they also provide climate regulation, as well as reducing noise (Stockholms stad, 2017c). Pollination is also provided thanks to the numerous amount of pollinators (mainly insects) and plant species found within the nature preserve (*ibid.*).

Cultural services: The easily accessible Årstaskogen also provides certain cultural services. People in the Stockholm Region have stated that the main reasons for them to visit the nature preserve are the nature experience, the exercise and the peace and quiet provided by the forest and the well planned paths for walking and running (Stockholms stad, 2017a).

Supporting services: Supporting services are also provided in Årstaskogen in the form of a high biodiversity (Stockholms stad, 2017c). As a core area for biodiversity in Stockholm, Årstaskogen hosts a multitude of species that contributes to a better quality for the area's ecosystem, which also raises the quality of the ecosystem services (*ibid.*). Other present supporting ecosystem services are primary production processes (production of organic matter) and nutrient cycles such as carbon, nitrogen and water.

Table 4. The ecosystem services provided by Årstaskogen today, categorized based on the four ecosystem service categories.

Ecosystem service	**Type**
Provisioning	Food
Regulating	Clean air, clean water, pollination, noise reduction and climate regulation
Cultural	Nature experience, health, peace and quiet
Supporting	High biodiversity, nutrient cycles and primary production

3.8 Cultural Values

The two first paragraphs are in reference to a comprehensive management plan for Årstaskogen and Årsta holmar, published by Stockholms stad in 2006.

The newly established nature reserve of Årstaskogen inhabits a great deal of natural and cultural values. The cultural values originate from the historic land use, but also the current. Existing cultural elements are allotments, historic buildings and remnants, but also the whole forest as a recreational site with its walking paths, bathing sites and opportunities for outdoor training. One of the main objectives with establishing Årstaskogen as a nature reserve is to preserve and enhance the natural and cultural values of the forest. It creates a highly important landscape view with the rift valleys by lake Mälaren, the north-facing forest with coniferous and broadleaf trees, patches of open fields, the long naturally formed beach with walking paths and viewpoints, and the cultural-historical scenery of farms, gardens and historical remnants.

Big parts of Årstaskogens shore is natural, which is an unusual sight so close to the inner city since most shorelines are man-made. A part of the recreational values of Årstaskogen is the popular walking path along the shoreline, providing valuable contact with water.

Årstaskogen has been used as pastures in the past. Near Årsta gård and Sköntorp, the land has been used for fields and gardening (Stockholms stad, 2006). The history of Årsta gård is believed to have begun in the Iron age (*ibid.*). It is believed that farming was present in Årsta gård until the 1940s (*ibid.*). Today the historical building has a new purpose as a nursing home for young people with disabilities (Stockholms stad, 2006; Nilsson, 2018, personal communication).

Besides historical land uses and Årsta gård, many historical remnants and ancient relics are present (Stockholms stad, 2006). At Årsta gård and other sites in Årstaskogen, there are remnants of old gardens (*ibid.*). The allotments today present in Årstaskogen are some of the oldest in Stockholm (*ibid.*). West of Årsta gård there are 13 ancient graves from the younger Iron age (Stockholms stad, 2006; Stockholms stad, 2014). Also, stone axes have been found in the bay near Årstaskogen, however no objects or traces of settlement from the Stone age have been found in the nature reserve (Stockholms stad, 2017b). Besides these remnants, three additional historical remnants have been identified by the Swedish National Heritage Board. One is a medieval stone carving in the shape of a flower, the second is a four-meter-wide and four decimeters high grave from the Bronze- or Stone age, and the third is an anti-aircraft gun position from World War II, located on Luftvärnsberget (Riksantikvarieämbetet, 2017).

Årstaskogen have high recreational values and a high frequency of visitors. Several footpaths lead from the residential areas through the forest and are often used by dog-walkers, joggers and walkers. Due to the great elevation differences and the steep slopes of some parts of Årstaskogen, some areas are more valuable out of an ecological point of view (Stockholms stad, 2017d).

Due to its easy access, Årstaskogen has become a popular meeting point for social interaction, both for individuals as well as organizations and schools to visit for outdoor experience and relaxation (Stockholms stad, 2017c). People also visit Årstaskogen as a mean of exercise, by walking or running along the easily accessible paths that runs through the nature preserve, which reinforces a healthier lifestyle as well as a better connection to nature (*ibid.*). Two

outdoor gyms are also provided within the park for public use, which further induce people to participate in outdoor activity (Stockholms stad, 2017a).

The cultural values of Årstaskogen are also frequently used by children. An urban forest like Årstaskogen has high recreational and pedagogic values used by preschools and older children (Stockholms stad, 2006). Many school classes and preschool groups visit the area for shorter or longer excursions, which gives children the opportunity for outdoor activity and learning about nature (*ibid.*).

3.9 Children in Focus

Årstaskogen is an important recreational place for children living or going to school in the nearby area. Many of the schools and preschools visit the forest almost daily as means of including outdoor education. They use it for field trips and getting physical exercise into their educational programmes (Stockholms stad, 2017e). Årstaskogen is also an important resource for the schools in Södermalm, Johanneshov, Hammarby Sjöstad and Liljeholmen (Bevara Årstaskogen, 2017b). Figure 5 marks places in the forest frequently used for pedagogical reasons.

The parts of the forest that will be used for exploitation, can affect the recreational opportunities for several preschools. According to Bevara Årstaskogen (2017b) this will likely result in fewer visits to the forest. There are currently more than 35 preschools in Årsta and Årstadal. Out of these 35 only 2 are located in close proximity to green areas. The majority of the preschools have either no yard, or yards of varying size covered with asphalt or synthetic grass. In Årstadal, the situation is worse. The district was planned without public green areas, except for Årstaskogen (*ibid*.).

According to Stockholms stad (2016e) there are plans for an additional of 15-19 new preschools in the area. This will lead to a heightened interest in visiting Årstaskogen. Several of the detailed plans for the new schools mention the closeness to Årstaskogen as a resource for educational activities. A problem, however, is that a lot of the green areas they depend on for outdoor activities is public space (Bevara Årstaskogen, 2017b).

Årstaskogen has been identified as one of the most important outdoor destinations for families to use during weekends (Stockholms stad, 2017e). In a survey compiled by Stockholms stad (2017a), over half of the respondents stated that their main reason for visiting Årstaskogen was to experience nature and to exercise and play with their children.

The forest is also an important place for the Årsta scout troop. During leisure time, Årstaskogen offers meaningful outdoor activities for children. The troop has a cottage nearby Årstaskogen and much of their activities are centered around the forest (Årsta Scoutkår, 2018).

In 2015, Stockholms stad mapped park and nature access in Stockholm as a part of the study 'Recreation in Stockholm City'. The study found that Liljeholmen, Årstadal and Slakthusområdet were not living up to the international standards of proximity to green areas (Stockholms stad, 2010).

According to UN Habitat programme the ratio of green areas to built-up areas should be at least 15-20 percent (United Nations Human Settlements Programme, 2015). The World Health Organization recommends a green areas per capita ratio of 9 square meters (Stockholms stad, 2010). The areas of Liljeholmen, Årstadal and

Slakthusområdet fails to meet the UN Habitat and WHO recommendations, respectively.

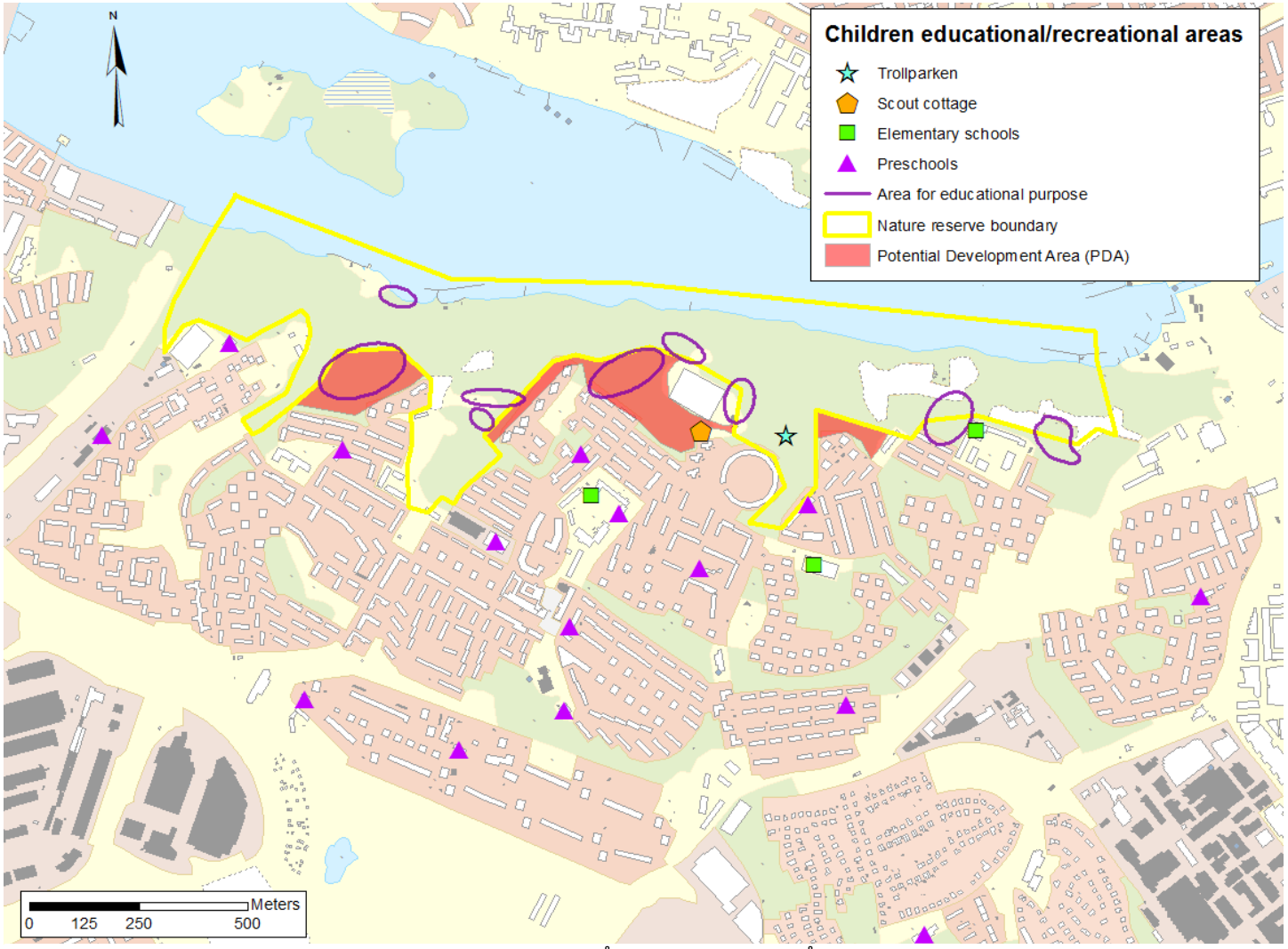


Figure 5. Map over educational and recreational areas for children in Årsta. Based on Bevara Årstaskogen (2017b). (Visualization: Liam Martin, 2018)

4. Methods

In this study, a systems perspective has been applied. According to Selman (2000), a system is a set of interacting components, which to some extent are enclosed with a boundary. It is defined by interdependency and interconnection of its variables, where relationships between them are built up by a series of causal links. A system analysis perspective is used in order to gain a holistic understanding of these relationships. Systems thinking, on the other hand, provides the means of understanding and analysing the organisation of variables in complex systems (Tate, 2009). The methods used for this is Indicator matrix and Causal Loop Diagram, more commonly referred to as CLD. A more detailed review on CLD methodology will be given in section 4.9. The system boundaries set for this study are defined and explained in section 1.3.

In order to assess and evaluate the impacts of this study's exploitation proposals on the environmental and social dimensions of sustainability, nine different methods have been used. A description of them will be given in this chapter.

4.1 Literature Review

As part of this study, a literature review has been carried out for the purpose of finding out what has previously been discussed on the subject by accredited scholars and researchers. Through the literature review, inconsistencies, gaps and contradictions in the literature can be identified (University of Guelph, 2018). Articles that have been of particular relevance and importance in this study are Dadvan *et al*. (2015), Pikora *et al*. (2006) and Costanza *et al*. (1997). There has also been an abundance of information published by Stockholms stad and Naturvårdsverket, which has been of great value for this study. The management plans for Årstaskogen has been of special importance, providing an overview of the nature values in the area.

In addition to these, a number of other articles, books and internet sources have been used to gather information about the study area, existing plans and ideas and the cultural and environmental conditions in and near Årstaskogen.

4.2 Field Study

As a part of this study, a one-day field study was carried out in Årstaskogen with the aim of collecting material and to gain an understanding of the study area. Magnus Nilsson, biologist and geoscientist at the consultancy firm Ekologigruppen, gave us a private guided tour in Årstaskogen and its vicinity. He shared his knowledge regarding the natural and cultural values of the area, with a special focus on the ecology of the forest. We visited the PDAs and viewed existing buildings near the nature reserve and looked at their positioning and design. Also, we identified some of the preschools that we are interested to incorporate into this study's Child Impact Analysis. The field study was of great value considering the knowledge gained and that a more accurate picture of Årstaskogen was achieved.

Field studies is a suitable method to get a better understanding of the study area, according to Gulliksen (2008). Yin (2013) emphasizes that collection of field data is crucial in order to fully grasp the context and circumstances of the research question. Whilst conducting field studies, the researcher unintentionally captures 'silent knowledge' which may be of great importance at a later stage (Gulliksen, 2008).

4.3 Interviews

Two semi-structured interviews were carried out in order to retrieve detailed information regarding some specific topics of interest for the study. Magnus Nilsson was interviewed in order to gain knowledge of the study area, particularly concerning its ecology and the resistance from the residences since he has been involved in trying to prevent the exploitation. Also, a telephone interview with Dr. Clemens Back was conducted with the intention of receiving more detailed information about this study's international example, Germany - Rieselfeld. Dr. Clemens Back worked for 21 years with the residents of Rieselfeld. He provided them information about the project and was also their contact person if they had questions about their neighbourhood. Through interviewing him, we achieved a greater understanding regarding the opinions of Rieselfeld residents. Interviews or surveys with citizens of Årsta has not been carried out because Stockholms stad (2017a) had already carried out a detailed survey in 2017. Thus, this could be used as a basis for further discussion.

Semi-structured interviews are defined by Justesen & Mik-Meyer (2011) as an interview where the interviewer follows a certain set of predefined questions and themes. If interesting topics are brought up, the interviewer can choose to pursue these. Yin (2013) emphasizes that the interview questions should be customized according the informants position in relation to the subject under investigation. Regardless, there is unanimity in the literature that semi-structured interviews are an appropriate method for exploratory investigations with the goal to assemble new knowledge (Gillham, 2000; Yin, 2013).

This study attempted to collect primary data from personnel and children at preschools in the area in order to have a greater basis for evaluating possible consequences for children. Unfortunately, we were unable to carry out this collection of data due to lack of response from the preschools.

4.4 GIS

The GIS software Arcmap 10.5 (ArcGIS, 2018) has been used to create seven maps to illustrate and analyse different aspects of the study area. The following paragraphs describes how each map was produced and what data that was used.

The map over the study are was created using a satellite image basemap with six different polygon layers. The coordinate system was converted from WGS84 to SWEREF 99_TM, mainly because it is more commonly used. All borders were drawn as polygons using an existing map over Årstaskogen (Bevara Årstaskogen, 2018a).

The ‘Slope grade’ map was created using a two-meter grid Digital Elevation Model (DEM), retrieved from the Swedish University of Agricultural Sciences (Sveriges Lantbruksuniversitet, 2017). The DEM showed the difference in elevation presented as a raster (.tif) file. To calculate the slope grade, the tool *Slope* was used. The DEM was used as the input raster and the slope grade was chosen to be presented in degrees (as to best show the difference in angles) (ArcGIS, 2018).

The ‘Children educational/recreational area’ map was based on an already existing map published by Bevara Årstaskogen (2017b). The base layer map was fastighetskartan, retrieved from Swedish University of Agricultural Sciences (Sveriges Lantbruksuniversitet, 2016). By using the existing map, polygons were drawn illustrating

the nature reserve boundaries, PDAs and areas used for educational purposes. Points were used to illustrate remaining objects.

The 'Habitat map' was collected using the already existing 'Biotopkartan (ytor)' from Miljödataportalen (Stockholms stad, 2009). As the map could not be downloaded, due to its large file-size, it instead had to be viewed as a shared file by connecting the Miljödataportalen server with our own ArcGIS server. This was done using Web Map Service (WMS) which is a program that is used to connect servers. Through this, the layer for 'Biotopkartan (ytor)' could be viewed and edited in our ArcGIS server. No changes were made from the original 'Biotopkartan (ytor)' except for the addition of the nature reserve border in order to show the boundaries of the reserve (ArcGIS).

The 'Access to Årstaskogen' map was created using the already existing map of the accessibility to Årstaskogen as a template (Andersson & Arfwedson, 2014). Fastighetskartan was used as the base layer map, retrieved from the Swedish University of Agricultural Sciences (2016). The nature reserve boundary and PDAs were reused from the study area map. Points were then used to mark out access points.

Lastly, two 'Housing proposal for PDAs' maps were made. One over the high and one over the low exploitation proposals. The base layer map Fastighetskartan, retrieved from the Swedish University of Agricultural Sciences (2016), was used. PDA East and West were illustrated as polygons. Buildings were added as polygons. A total of 29 buildings were added to the high exploitation proposal map whereas 8 were added in the low exploitation map.

4.5 Visual Impact Analysis

Visual impacts are changes in the landscape caused by the introduction of visual contrasts (Green Rhino Energy, 2016). To analyse visual impacts, Visual Impact Analysis (VIA) is used. VIA enables impacts on the landscape resulting from a proposed development or land management action to be identified and evaluated (Bureau of Land Management, 2018).

In this study, VIA is used to describe changes in the landscape caused by an exploitation of either high or low level. The two exploitation proposals were visualized using a modified version of Cities: Skylines, which is a city-building tool created by Colossal Order and published by Paradox Interactive in 2015. The program includes features such as noise, pollution, population dynamics etc. In this study it is used a visualization tool.

4.6 Child Impact Analysis

The Child Impact Analysis (CIA) is a tool used to put the UN Convention on the Rights of the Child into action. The convention clearly states what is the best interest of children (Skolverket, 2016). In 2011, the Swedish Children's Ombudsman developed a five-step model for CIA (Barnombudsmannen, 2011). The purpose of the model is to facilitate work on the needs of children in decision-making of municipalities and other governmental authorities (*ibid.*).

The following paragraph refers to Barnombudsmannen (2011). The five-step CIA model includes mapping, description, analysis, review and evaluation, as seen in Figure 6. Mapping includes gathering necessary information in order to get a basis for decision-making. It also involves identifying groups of children likely to be affected. The next step is to write a description on the information gathered during

the mapping phase. The third step consists of a problem analysis that seeks to describe the motives for the proposal and its consequences in more detail. The fourth step, reviewing, is the actual purpose of the CIA. It includes the overall assessment of all relevant factors from the previous steps. It is important to consider everything that can relate to the physical or mental well-being of children. Children Impact Analysis is concluded with an evaluation of the effects that the decision or plan led to. It is equivalent to auditing in the EIA process. By evaluating effects, the quality of the assumptions underlying the CIA can be assessed.

Figure 6. Steps in the CIA process.

4.7 Value Rose

Value rose is a tool that can be used to describe, discuss and assess level of sustainability of a city development project. It is illustrated as circle containing nine environmental and social aspects essential to the study. The aspects are derived from the new comprehensive plan for Stockholms stad, which is currently out on referral (Stockholms stad, 2018c).

The comprehensive plan states that urban development in Stockholm should be planned according to 4 main objectives. The objectives are: (1) A growing city, (2) A coherent city, (3) Good public environment, and (4) A climate-smart and durable city. From the four objectives, sub-goals were established. The exploitation proposals in this study will be evaluated against these sub-goals. In Figure 7 the value rose created for this study is illustrated.

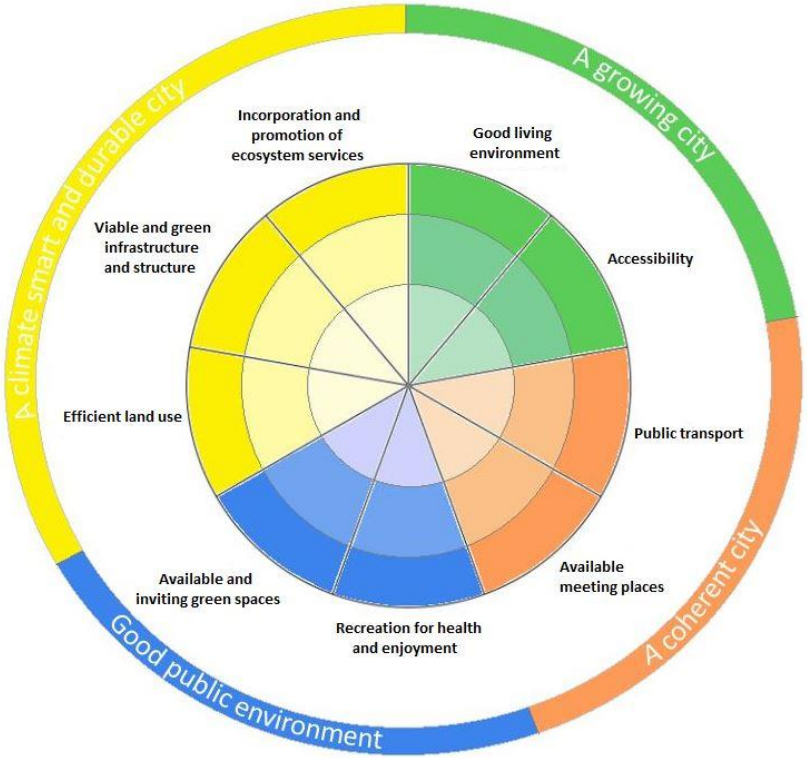


Figure 7. The value rose in which the different exploitation proposals will be evaluated

The scale for the value rose ranges from no achievement to low, moderate and high achievement. The value rose is based on an ordinal scale, which means that the different values can be ranked but not assigned numerical values. Thus, it is not possible to indicate differences between the values in a meaningful way. The scale is illustrated in Figure 8.

Figure 8. Scale for value rose. Each circle represents the level of achievement. At no achievement the circle is not coloured.

The four objectives derived from the comprehensive plan are assigned different colours without any underlying meaning. Each circle represents the level of achievement. The assessment of the objective achievement is based on a qualitative analysis made in this study.

4.8 Indicator Matrix

The indicator matrix is a systematic method used to elucidate how well this study's exploitation proposal correspond to the sustainability goals for Stockholms stad (Stockholms stad, 2016b) and Article 3 and 31 of the UN Convention on the Rights of the Child (UNICEF, 1989). The matrix consists of 10 indicators. Out of these eight are derived from the Stockholm Environment Programme and two from the UN Convention on the Rights of the Child. The indicators were chosen according to their relevance to the subject of this study.

The scale for the matrix ranges from achieved to partly and not achieved. The scale is ordinal. Thus, it is not possible to indicate

quantitative differences between the values. The result of the matrix is based on a qualitative analysis made in this study. The scale used for the matrix is illustrated in Figure 9.

Figure 9. Scale used in the indicator matrix.

4.9 Causal Loop Diagram

In system dynamics, a problem or a system can be represented in terms of a Causal Loop Diagram (CLD). A CLD visualizes causal relationships between variables in a system. The system of study is the area around Årstaskogen and the variables are made up of environmental and cultural aspects.

The Causal Loop Diagram was used to identify impacts on environmental and cultural aspects. These are further discussed in Chapter 8 of this study. A special focus is on the orange coloured arrow in the CLD. Depending on which level of exploitation studied the impact becomes greater. The CLD made in this study is shown in Figure 10.

The arrows are assigned different polarities (+ or -), depending on the causal relationship between two parameters. If the relationship entails a change in the same direction it is assigned a positive polarity (+), for example; the more *Construction of New Houses*, the more *Residencies*. But, if the relationship entails a change in the opposite direction it is assigned a negative polarity (-), for example; the more *Construction of New Houses*, the less *Historical Remnants*.

The CLD (see Figure 10) can be described in a step by step description;

Increased *Housing Demand* leads to an increase in the *Construction of New Houses.* Increased *Construction of New Houses* leads to an increase in *Residencies*, which in turn reduces the *Housing Demand.* Together they form the first balancing loop. A balancing behaviour tends to lead to a stable system. More *Construction of New Houses* leads to reduced amount of *Green Flat Areas. Green Flat Areas* is required for, and increases *Ecosystem Services*, which in turn leads to an increase in *Recreational Quality. Green Flat Areas* is required for, and increases *Ecological Connectivity*, which increases the *Recreational Quality*, and is required for *Ecosystem Services. Green Flat Areas* is required for *Recreational Opportunities* which in turn is a requirement for *Recreational Quality* as a limiting but not driving factor (grey coloured link).

Recreational Opportunities and *Recreational Quality* both increases *Human Health*. An increase in *Residencies* increases *Adults in Årsta* and *Children in Årsta*, i turn *Sqm Green Flat Area per Resident* decreases. More *Green Flat Areas* increases *Sqm Green Flat Area per Resident*, which in turn leads to better *Recreational Quality*.

More *Children in Årsta* increases the *Demand for Preschools/Schools*, which increases *Construction of New Preschools/Schools*. This leads to a reduced *Demand for Preschools/Schools.* This forms the second balancing loop. An increase in *Construction of New Preschools/Schools* decreases *Green Flat Areas*.

The link from *Construction of New Houses* to *Green flat areas* is marked red to highlight the importance of this specific link. This link represents the action of removing green areas and transforming it into built-up areas, which is the major driving action that causes all the impacts discussed in this study.

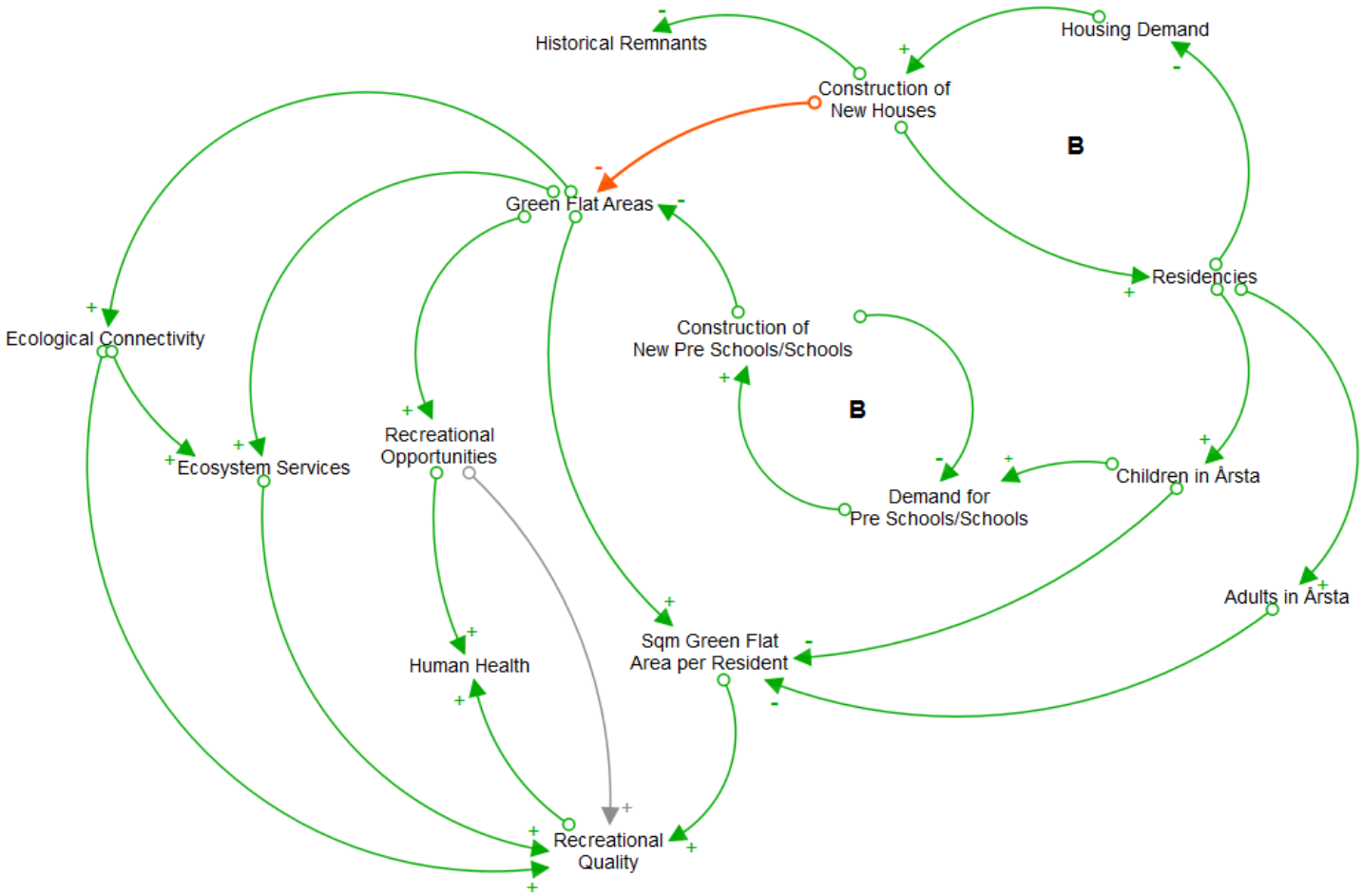


Figure 10. Causal Loop Diagram describing the effects of exploiting green flat areas. These are referred to as PDAs in this study.

5. International Example – Rieselfeld, Freiburg

Starting in 1995, the City of Freiburg have developed a new district of 78 hectares in the western part of the city. This was formerly a brownfield site (Medearis & Daseking, 2012). The eastern parts of the brownfield site have been redeveloped into a new city district, called Rieselfeld (*ibid.*). In addition, more than 240 hectares of the western parts of the brownfield area were established as nature reserve in 1995 (*ibid.*). To the west of Rieselfeld lies the nature reserve Freiburger Rieselfeld and to the north the animal enclosure Mundenhof is located. Two major roads, in the east and south, surrounds the area of Rieselfeld.

The development area is an extension of the urban core of the City Freiburg im Breisgau (Otto, 2006). In 2012, all four construction phases where finally completed. The City of Freiburg wanted to accommodate 12 500 new residents, create 1 500 new jobs and construct about 4 100 apartments (Medearis & Daseking, 2012). Nowadays, about 11 000 people are living in Rieselfeld (City Freiburg, 2015a).

5.1 Background

The pressure on the City of Freiburg continues to grow due to the high influx into the city (Lüdeke, 2004). The total city area of 15 306 hectares represents another obstacle, since only a quarter can be used for settlement and traffic areas (City Freiburg, 2006). The proportion of forest land is 42.5 percent and 25 percent is used for agriculture (*ibid.*). Other green areas and water areas make up the remaining 7.5 percent (*ibid.*).

5.2 Planning and Implementation

In 1992, an urban planning and landscaping competition was initiated for the development of the Freiburg district of Rieselfeld (Otto, 2006). The implementation of Rieselfeld was carried out in four stages over two-year intervals to ensure an environmental, social, and economic balance (*ibid.*). A concept for public participation was developed and carried out parallel to the city-planning process (Medearis & Daseking, 2012).

5.3 Main Objectives

The main objectives established by the City of Freiburg (2015b) regarding the development of Rieselfeld were as follows:

- Urban qualities with high density buildings,
- Mix of commercial and residential uses to enable housing and work in the same area,
- Small parcelling to avoid large blocks of flats (multi-storey apartment houses and multiple dwelling units of up to six-storey buildings),
- 100 residential units for 10-11 000 people,
- Good private and public infrastructure,
- Housing that is family-friendly and adapted for disabled people,
- Environmentally oriented planning and execution, and
- High recreational quality.

The environmental oriented planning, execution and emphasis on high recreational quality refers to the environmental dimension of sustainability (City Freiburg, 2015b). By establishing objectives such as family-friendly and disabled housing, social aspects were included in the development of Rieselfeld in Freiburg (*ibid.*).

5.4 Social Sustainability

Citizens and developers had equal opportunities to buy land available for development within the new district of Rieselfeld (City Freiburg, 2015c). If individual citizens come together to buy a parcel of land to develop it for themselves, they can get help during the construction phase through professional advice by the city (*ibid.*). Today there are about 100 private assemblies built in Rieselfeld (*ibid.*). In order to ensure healthy social structures, land for freely or publicly funded rental housing and property is not spatially separated (*ibid.*). Furthermore, the developers of the area had to meet the following three binding requirements: housing adapted for disabled people, a specific portion of barrier-free apartments, and participation in the shared block interior areas (Wirtschaftsministerium Baden-Württemberg, 2018). The goal of ensure a social diverse district was not fully met due to the provision of social housing for just 10 years (Dr. Back, 2018, personal communication).

The planning of Rieselfeld considered the needs of women, families, the elderly, and the disabled and focused mainly on a family-friendly management (Medearis & Daseking, 2012). Today, one third of all people in Rieselfeld are under 18 years old (City Freiburg, 2015d). A special feature of the surrounding area of Rieselfeld is the animal enclosure Mundenhof. It is frequently visited by families living in the area (City Freiburg, 2015f).

In 2010, two years before the final realisation of Rieselfeld, the City of Freiburg conducted a survey in order to understand how the residents perceived the area (City Freiburg, 2010a).

The results showed that residents were particularly satisfied the following aspects, listed in order of importance.

1. Social and cultural life
2. Position
3. Infrastructure
4. Child friendliness
5. Urban concept

This feedback can be explained through the following services, among other things. Rieselfeld's social infrastructure contains a wide range of services (City Freiburg, 2015d), including:

- Gymnasium;
- Elementary school; a school focused on the outdoors;
- Four preschools, of one of them focusing on sports;
- A lodging-house for children;
- Sports hall;
- Church;
- Library for children and young people;
- Fire station.

Additionally, the association K.I.O.S.K. carries out decentralized youth work on behalf of the City of Freiburg (City Freiburg, 2015e). Today 3 000 children are attending the preschools and schools located within Rieselfeld (City Freiburg, 2015a).

5.5 Environmental Sustainability

The area of Rieselfeld was, as mentioned earlier, a brownfield site. All sewage waste from the houses in the south-western parts of Freiburg was spread out over the area of Rieselfeld for about 100 years until 1985 (City Freiburg, 2004; City Freiburg, 2010b). After extensive soil testing permission to start developing the area was given (*ibid.*). The development of Rieselfeld aimed to achieve several

environmental objectives as established by the City of Freiburg (2010b):

- Low energy construction;
- Cogeneration for district heating;
- Usage of solar power;
- Concept for rainwater usage;
- Priority of the city tram.

Two of the objectives were aimed directly at constructors and were to be met during the construction phase. It was low energy construction and district heating schemes (Wirtschaftsministerium Baden-Württemberg, 2018).

5.5.1 Nature Reserve Freiburger Rieselfeld

Over 240 hectares of the brownfield site were dedicated and established as a nature reserve. In 1995 is was proclaimed as a conservation area (Medearis & Daseking, 2012). One part of the area is protected as a habitat area. Another part is an important bird sanctuary (City Freiburg, 2010b). Both these areas have since 2001 been part of the European protected area system Natura 2000 (*ibid.*).

The reasons to establish the nature reserve Freiburger Rieselfeld were as follows (City of Freiburg, 1995),

- Preservation of scenic and characteristic structures of the former Freiburger Rieselfeld as essential components of a historical cultural landscape and habitat of a typical community of animal and plant species,
- Conservation of natural wetlands as a habitat for rare and endangered animal and plant species,
- Conservation of populations of rare and endangered animal and plant species,
- Further development of the entire area with respect to the optimization of habitats for both open land species (Rieselfeld) and species of wetlands.

5.5.2 Green Infrastructure and Structure

The district park, located in the north of Rieselfeld, is an important part of the city's green infrastructure (City Freiburg, 2010b). The park intends to direct some of the recreational activities to the lowlands in the north, relieving and protecting the nature reserve adjacent to the district from excessive pressure from visitors (*ibid.*).

Green structures were implemented when planning Rieselfeld. Examples include green block interiors and a range of other high quality green areas (City Freiburg, 2010b). Common green structures in Rieselfeld are green roofs and tree pits (Dr. Back, 2018, personal communication).

5.5.3 Ecosystem Services

The area of Rieselfeld provides many different ecosystem services, especially regulating ones. Examples include stormwater management. In Rieselfeld stormwater is driven out through culverts but retained on-site (Medearis & Daseking, 2012). Stormwater is also managed naturally through a series of interconnected bioswales and wetlands (*ibid.*). The large amount of green roofs and lots in-between buildings facilitates stormwater management (*ibid*.).

Other aspects of regulating services were considered when planning Rieselfeld, especially regarding noise and air quality (City Freiburg, 2010b). For example, the preserved forest surrounding Rieselfeld

(see Figure 11) provides services such as mitigating urban heat island effect, noise reduction, and improved air quality through absorption of particles (*ibid.*).

Cultural services as scenic and characteristic structures are mentioned to be essential components of the Freiburger Rieselfeld (City Freiburg, 1995). The implemented nature discovery trail opened in 2001 gives information about the historical background of the site and the flora and fauna within the nature reserve (City Freiburg, 2004).

Figure 11. Aerial photograph of Rieselfeld from July 2011 (City Freiburg, 2015a).

5.5.4 Energy

The importance of reducing energy consumption is highlighted by the mandatory requirement to build low-energy housing (Medearis & Daseking, 2012). To reduce energy consumption and to increase the use of renewable energy sources, several measure were implemented. Examples include district heating schemes and use of solar energy by adding solar panels on the roofs (*ibid*.). Overall, this was intended to reduce energy consumption per capita by 20 percent compared to an average German citizen (*ibid*.).

5.5.5 Transport

Within Rieselfeld car use and parking is limited (Buehler & Pucher, 2011). Many neighborhoods are planned to be 'home zones'. In these zones priority is given to pedestrians, cyclists and children playing in the streets. The speed-limit is 7 kilometers per hour within these zones (*ibid*.). In the entire district of Rieselfeld cars are not allowed to exceed 30 kilometers per hour. There are also several streets were traffic is forbidden (City Freiburg, 2010b).

5.6 City Planning

Dense settlements are primarily located along the main streets of Rieselfeld (City Freiburg, 2010b). The six-storey houses are approximately 130 meters in length with a width of 70 meters (Medearis & Daseking, 2012). The level of density and height of the buildings decreases towards the fringes (City Freiburg, 2010b). The high density settlements are compensated by reasonable road width, several public squares and over 20 large inner community blocks which makes the area more attractive (*ibid*.). The planners of Rieselfeld aimed to create a multifunctional and diverse city district (see Figure 12 & 13) (Medearis & Daseking, 2012). This was achieved

by including small plots, shops, pharmacies, schools, preschools, and cultural and religious buildings into the urban fabric (*ibid*.).

Figure 12. Aerial photograph of Rieselfeld from May 2012 (City Freiburg, 2015a).

Figure 13. Aerial photograph of Rieselfeld from July 2011 (City Freiburg, 2015a).

6. Planning Proposals

The aim of this study is to exemplify how a development of the areas adjacent to Årstaskogen nature reserve can be carried out and then identify and discuss the effects of such exploitation. This study has compiled two proposals; one with a low level of exploitation, and another with a high level of exploitation. The proposal of low exploitation pays particular attention to the needs of children and aims to preserve as much of the nature values as possible. In comparison, the high exploitation proposal is designed from a developer's perspective with the goal of generating as many residencies as possible and where no consideration is given to children or nature values.

6.1 Low Exploitation Proposal

The low exploitation proposal contains a total of eight buildings and their location is illustrated in Figure 14. In the western PDA there will be four buildings with around 60 residencies, and in the eastern PDA there will be four buildings with around 70 residencies. The low exploitation proposal attempts to mitigate the negative impacts on the area as much as practically feasible.

Parking opportunities are not considered in neither PDA West nor East in order to reduce the use of cars, thus mitigating several of the adverse impacts that car use results in. Waste management is not represented in the graphical illustrations nor is any suggestions given besides that a centralized waste management system that includes recycling should be implemented.

6.1.1 PDA West - Low Exploitation

The western PDA is a green area with broadleaved deciduous forest, mixed forest, pine forest (>150 years) and bare rock (see Figure 4 and Figure 15). It is frequently visited by families for recreational activities (Stockholms stad, 2017a) and preschools for educational purposes (see Figure 5).

The low exploitation proposal in PDA West implies constructing a total of four buildings containing approximately 60 apartments. The amount of apartments varies depending on the individual size of the apartments. This study will not go into further detail concerning this, rather we emphasize a mixture to enable a diversity of residents. We also want to stress the importance of including both rental apartments and condominiums to further enhance social inclusion and counteract segregation.

The construction sites are located in areas that mostly contain broadleaved deciduous forest and mixed forest, reducing this type of habitats (see Figure 4). As a result, the areas with old pine trees in the PDA West can largely be preserved. Due to the low level of exploitation, large parts of the recreational and educational areas will also be preserved.

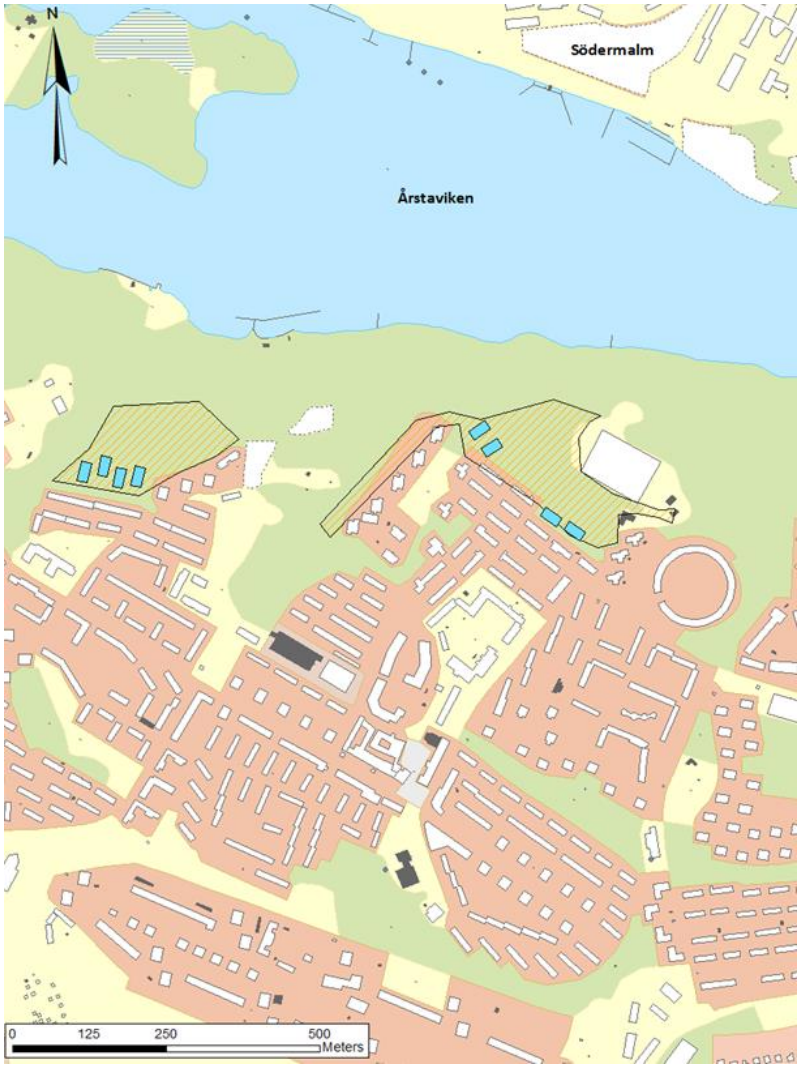


Figure 14. Overview of PDA West and PDA East with low exploitation, proposed buildings coloured blue. (Visualization: Liam Martin, 2018)

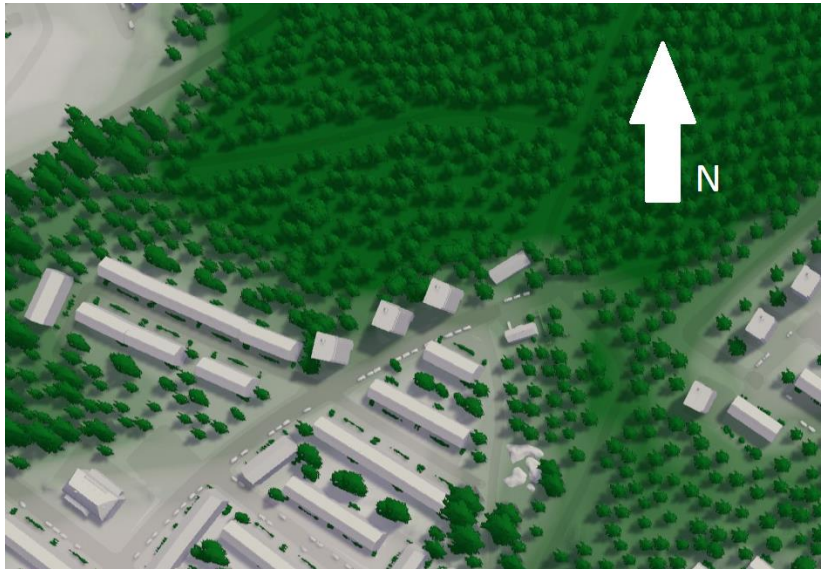


Figure 15. Aerial view of PDA West without proposed development. The vegetation is an estimation, not an exact representation. (3D visualization: Viktor Berglund)

Figure 16. Side view of PDA West with a low exploitation degree. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

Figure 17. Aerial view of PDA West with a low exploitation level. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

During construction, old trees and other types of vegetation should be preserved as so far it is reasonably practicable. In order to enable the migration of species, the height of the buildings should be lower than that of pine trees, so that animals can overcome the physical obstacle of the buildings. Therefore, the buildings in both PDA West and East within the low exploitation proposal are just three-storey high.

The buildings are arranged as to allow residents to pass easily between the houses as well as to create green pathways. Due to the relatively low level of exploitation large green areas in PDA west would be left, thus, preserving most of the educational areas for children (see Figure 5). Within the new district one new meeting

place will be constructed to improve the living environment and to promote social interaction between the residents.

The new buildings are placed in relation to the already existing ones in order to avoid a physical blockade to the nature reserve and also to minimize the consumption of land. By doing so, land can be preserved for other purposes. Also, it should be possible to easily pass between the buildings.

All rooftops are covered in green vegetation in order to reduce the impact on airborne species. It is also a climate change adaptation measure since it reduces stormwater. In addition, it improves air quality, enabling a healthier environment for people to live in. The roofs also include meeting places designed to facilitate social interaction between the residents. The facades are also covered in vegetation to reduce the visual contrast between nature and built-up areas and to reduce noise. Solar panels are installed on the roofs to reduce the electricity and contribute to a sustainable society.

Stormwater management is also considered. Because of the relatively low amount of buildings and paved surfaces in PDA West, it is not necessary to implement i.e. bioswales to divert water away from the buildings. Stormwater management is largely natural through infiltration and absorption in surrounding green areas and green structures such as green roofs.

Since the use of cars is largely restricted the planning proposal will not add parking spaces or roads in the area. Promotion is given to environmentally friendly modes of transport such as walking, cycling and public transport. The PDA is already providing a good public transport system with buses, which ensures mobility for residents and visitors.

Årstaskogen is frequently used by people living in the area and by other groups such as preschools. With Rieselfeld as inspiration, information signs will be set up to provide information about the flora and fauna of Årstaskogen.

6.1.2 PDA East - Low Exploitation

PDA East is a green area with pine forest (>150 years), bare rock with pine (70-150 years) and rejuvenating pine forest (< 70 years). It is today frequently visited by families for recreation (Stockholms stad, 2017a) and a part of the area is also used by preschools for educational purposes (see Figure 5). This study's proposal with a low level of exploitation includes four new buildings in the eastern PDA, containing approximately 70 apartments. Like PDA West, the buildings will be three-storey high.

The new buildings will be located in areas that mostly contain pine forest (>150 years) and rejuvenating pine forest (<70 years). Thus, reducing this type of habitats in Årstaskogen (see Figure 4). No habitats will be totally removed, but present habitats will be reduced and the dispersal corridors for pine associated species will decrease. The low exploitation leads to some adverse impacts on the area used for recreational purposes. The impact on the areas used for children's education is limited due to the placement of the buildings.

Figure 18. Aerial view of PDA West without proposed development. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

Figure 19. Side view of the low exploitation development in PDA East, with Ericsson Globe Arena visible in the background. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

Figure 20. Overview of PDA East - Low exploitation. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

With respect to the height of buildings, stormwater management and green structures, the same situation as for PDA West prevails.

The difference between a development of PDA West and East within the low exploitation proposal is the loss of habitats. The habitat losses in PDA West is mainly broadleaved deciduous forest and mixed forest, while the habitat loss in PDA East is mainly rejuvenating pine forest (<70 years) and pine forest (>150 years).

Another difference is the positioning of the buildings. Two of the buildings are located in the western parts and two buildings in the eastern parts of PDA East (see Figure 20). The buildings are, yet again, placed in relation to already existing ones to minimize sprawling development patterns and to remove as little as possible of the species dispersal corridor through the PDA East. The difference in width of the dispersal corridor before and after the development in PDA East is visualized in Figure 21 and 22.

The two buildings in the southern parts of PDA East will face in the same direction as the already existing ones in order to reduce the barrier effect for the current residents near Årstaskogen. The arrangement of the buildings in PDA East is therefore primarily based on the existing structure of housing and the intention to preserve the areas used for educational purposes and the will to protect as many pine trees as possible. The open spaces preserved in PDA East can be used in many different ways and serve multiple functions, such as meeting places for the new residents or playing areas for children.

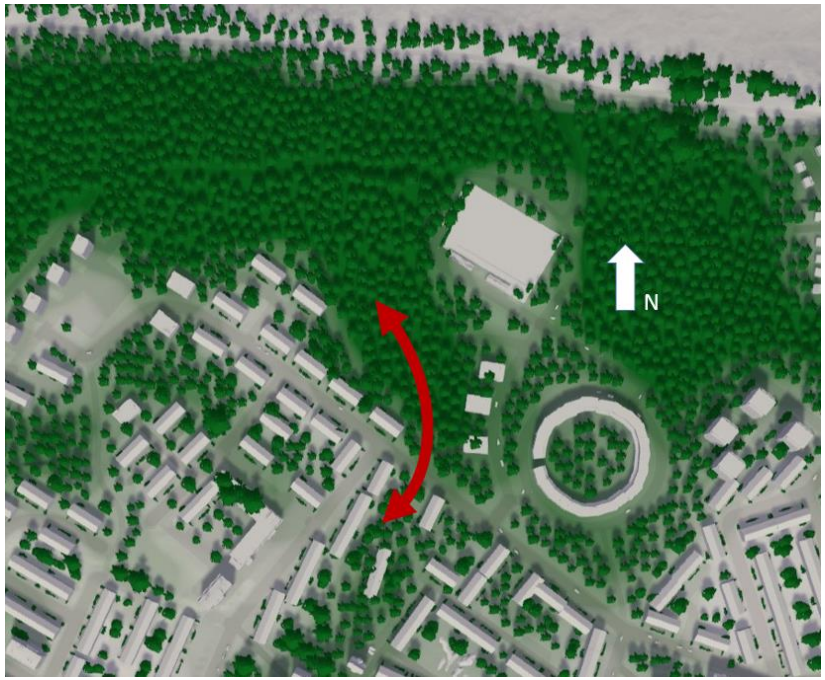


Figure 21. The migration pattern today, through the current undeveloped PDA East. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

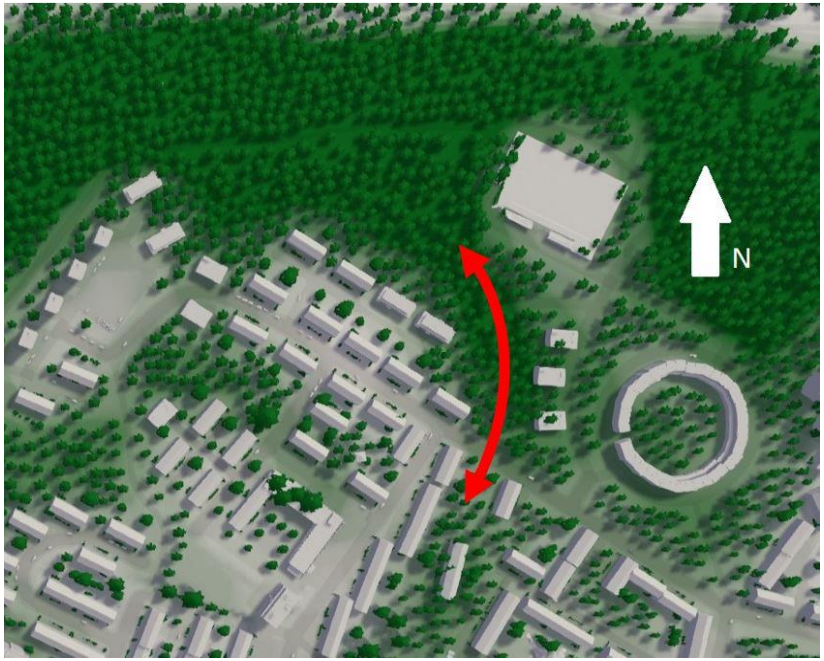


Figure 22. Potential migration paths through PDA East - Low exploitation. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

6.2 High Exploitation Proposal

The high exploitation proposal contains 29 buildings with various sizes and heights. The chosen PDAs are shown in Figure 23. In PDA West there will be seven buildings with approximately 260 apartments. PDA East will include 22 buildings with around 540 apartments.

This proposal aims to reduce the housing demand in Stockholm by constructing as many residencies as possible in the area around Årstaskogen. Thus, the loss of natural and cultural values is far greater than the low exploitation proposal.

As in the low exploitation proposal, parking spaces will not be considered in either PDA. Waste management is not represented in the graphical illustrations nor is any suggestions given besides that a centralized waste management system that includes recycling should be implemented.

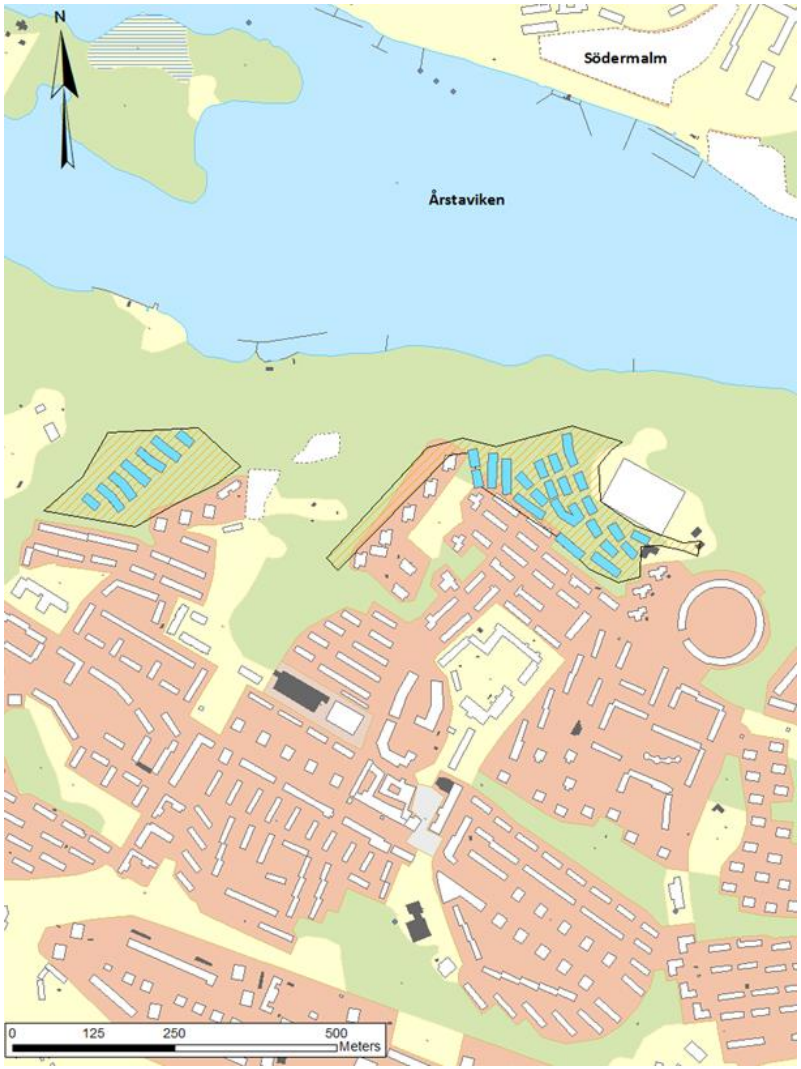


Figure 23. Aerial view of PDA West and PDA East regarding the high exploitation proposal where proposed constructions are coloured in blue. (Visualization: Liam Martin, 2018)

6.2.1 PDA West - High Exploitation

This study's high exploitation proposal includes seven buildings in PDA West, containing approximately 260 apartments (see Figure 24 and 25). The buildings are of the same width as the ones in the low exploitation proposal. However, they are longer and higher in the high exploitation proposal. Instead of three floors, the buildings are now six-storey high. This proposal is guided by the ambition to achieve as many residencies as possible. Thus no consideration is given to present habitats.

No habitats will be completely eliminated since they will partly be preserved in-between the buildings. Notwithstanding, greatly reducing habitats will have a severe impact of the nature values.

The PDA is included in a core area for broadleaved deciduous trees (Appendix I) which will be highly reduced due to construction. Pine forest (> 150 years) will be reduced, and pines with the fungus *Phellinus pini* will be removed or fully eliminated. The area will also cease to be a frequently visited area for recreational and educational purposes since it will be exploited.

The high exploitation proposal in PDA West consists of seven buildings. They are six-storey high and of the same size. Because of the height negative effects on species migration are more severe compared to lower buildings.

The buildings are arranged to allow residents to pass easily between the houses and to create green pathways

Figure 24. The western PDA, with Årsta Gård visible to the far left. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

Figure 25. The western PDA, with Ericsson Globe Arena visible in the far background. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

Parts of the floor on the ground level are elevated and stands on pillars. The reason for this is to increase accessibility to the nature reserve and enhance the feeling of nature. This was inspired by the architectural design of a building in Norra Djurgårdsstaden. The buildings are also arranged to avoid a physical blockade to the nature reserve. The north-south direction of the buildings reduces the barrier effect for species wanting to pass through the new district into the nature reserve.

In the new neighbourhood several meeting places will be constructed to facilitate social interaction between the residents. A good living environment is achieved by reducing the amount paved surfaces and increasing green structures. All roofs will be covered in vegetation to reduce the impact on airborne species. The facades are also covered in vegetation to reduce the visual contrast between built-up areas and nature. Allowing for more green structures improves air quality, reduces noise, minimises stormwater and increases CO_2 sequestration. The roofs will be multifunctional. By creating meeting places for resident's social interaction can improve. Solar panels will be installed on the roofs allow for a more self-sustaining energy consumption.

Stormwater management is also taken into consideration. Due to the high levels of exploitation there might be a need to implement stormwater management measures. Examples include bioswales, ditches or rooves next to pathways. No specific method is suggested but rather we want to emphasize that the natural stormwater management through infiltration and absorption in surrounding green areas and green structures may not be enough.

As in the low exploitation proposal car use is restricted and low-energy modes of transport such as pedestrian, cycling and walking is promoted. Thus, no parking spaces will be added. The area already has good connections to the public transportation system. Yet again, information signs will be put up providing information on the natural and cultural values of Årstaskogen. There will be less signs in the high exploitation proposal since green areas will be preserved.

Figure 26. High exploitation in PDA West. The vegetation is an estimation and not an exact representation. (3D visualization: Viktor Berglund)

6.2.2 PDA East - High Exploitation

This study's high exploitation proposal includes 22 buildings in PDA East, containing approximately 540 apartments (see Figure 27 and 28). The six-storey buildings differ in terms of length. The high exploitation proposal is steered by the ambition to achieve as many residencies as possible, thus no consideration is given to present habitats.

No habitats will be completely eliminated since they will partly be preserved in-between the new buildings. Notwithstanding, greatly reducing habitats will have a severe impact of the nature values. The most important dispersal zone for pine trees to/from the south will be highly reduced. Also, bare rock with pine (70-150 years), pine forest (> 150 years), and rejuvenating pine forest (< 70 years) will be highly reduced. The area will also cease to be a frequently visited area for recreational and educational purposes since it will be exploited.

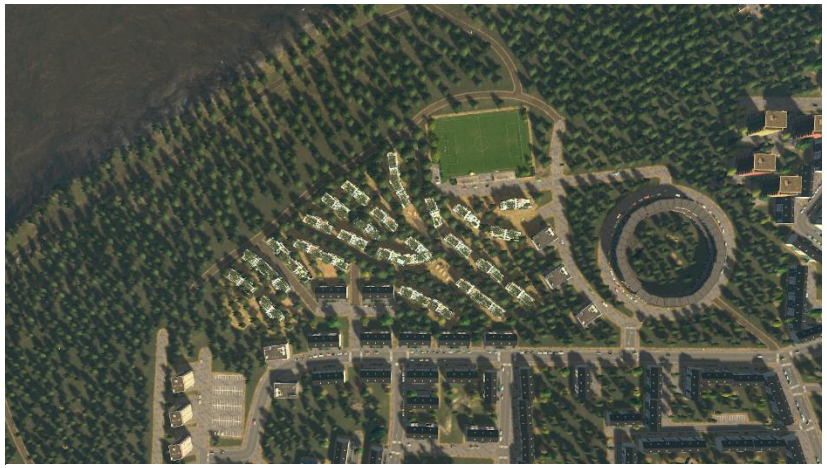


Figure 27. Overview of PDA East. (3D visualization: Viktor Berglund)

Figure 28. Close up on one of the meeting places in PDA East - High Exploitation. (3D visualization: Viktor Berglund)

With respect to the height and placement of the buildings, social meeting places, green structures, stormwater management, restriction of cars and information signs, the same situation as for PDA West prevails.

PDA East is included in one of the most important areas for coniferous forest associated species connectivity to the south (Appendix I). The current main corridor for pine associated species in PDA East (Figure 29) will be hindered by the new buildings and only narrow corridors will remain (Figure 30). The current dispersal pattern is possible due to the low height of the houses in the area (lower than most pine trees). Adding higher buildings will likely reduce the dispersibility (Conec, 2013). The width between the houses of PDA East will be about 15-20 meters wide, 40 meters are a minimum for an eco-duct *(ibid.)*

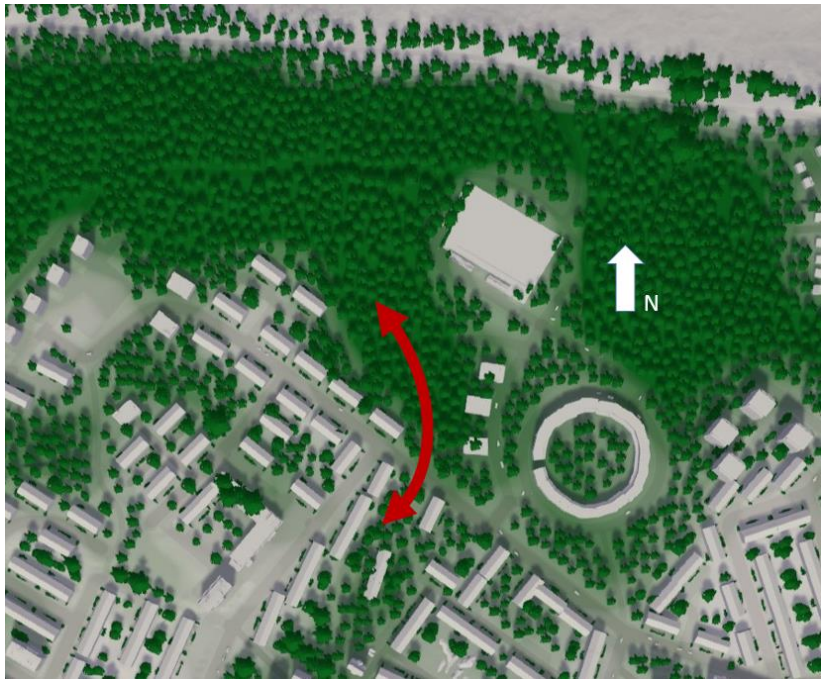


Figure 29. The migration pattern today, through the current undeveloped PDA East. The vegetation is an estimation and not an exact representation. Dispersal patterns based on Zetterberg (2012). (3D visualization: Viktor Berglund)

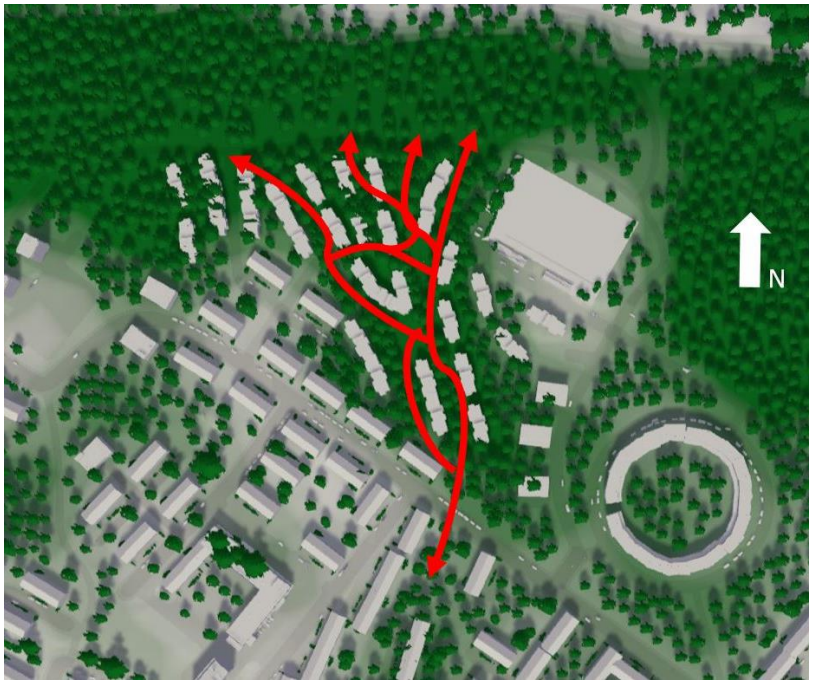


Figure 30. Potential migration paths through PDA East - High exploitation. The vegetation is an estimation and not an exact representation. Dispersal patterns based on Zetterberg (2012). (3D visualization: Viktor Berglund)

7. Results

The results in this study is an evaluation of the two exploitation proposals presented in the previous chapter. The indicator matrix and value roses are used to visualize how well the proposals correspond to the comprehensive plan for the Stockholm Region, the Stockholm Environment Programme and the UN Convention on the Rights of the Child.

7.1 Indicator Matrix

The indicator matrix is a systematic method that examines the relation of the exploitation proposals in regards to the Stockholm Environment Programme and Article 3 and 31 of the UN Convention on the Rights of the Child. The basis for evaluation is a comparison between the current state of the areas adjacent to Årstaskogen, and the possibility of the areas being exploited.

Indicator	**Low Exploitation Proposal**	**High Exploitation Proposal**
Energy production based on solar energy will be increased	Increased energy production through solar panels installed on the roof	Increased energy production through solar panels installed on the roof. More buildings enable more solar panels
Car traffic will be reduced	Car traffic will be restricted in the PDAs. Overall, car traffic may increase somewhat in the area because more people live there	Car traffic will be restricted in the PDAs. Overall, car traffic may increase somewhat in the area because more people live there. With more people there will likely be more cars
Vulnerabilities in the urban environment as a result of climate change will be prevented	The fraction of green spaces to built-up areas will be high which will decrease stormwater	The fraction of green spaces to built-up areas will be moderate which will partly decrease stormwater

In city development projects, ecosystem services will be supported in order to contribute to a sound living environment	Regardless of the degree of exploitation, ecosystem services will be adversely affected. By adding green structures, such as roofs and facades, some of the negative effects are mitigated. The low exploitation proposal is adapted after the capacity that can be sustained without severely affecting the ecosystem	The high exploitation proposal negatively affects ecosystem services, although the design does mitigate some of the adverse effects. The extensive transformation of green areas to built-up areas implies that a lot of services are lost
The city will have a viable green structure with rich biological diversity	The dispersal corridors that exists today will not be substantially affected by a development of this degree. At the same time, it will not be enhanced, thus moderate achievement is legitimized	Although the design considers the north-south dispersal corridors, these will be too narrow for species to migrate through which effectively limits species dispersal
Stockholm residents will have good access to parks and nature with high recreational and nature values	Low exploitation will not considerably affect accessibility for people living the area around Årstaskogen. Those moving into the PDAs will have good accessibility to green areas with high nature and recreational values	A high exploitation level will negatively affect accessibility to Årstaskogen, although the people moving into the PDAs can be positively affected. Also, the high exploitation proposal leads to reduced nature and recreational values

Each city district will be planned with regard to a healthy urban environment	Proximity to green areas has the potential to stimulate recreation, exercise and movement which benefits human health and well-being. In addition, a lot of green areas create healthy environments i.e. by improving air quality	Through a high exploitation level more recreation areas will be transformed into built-up areas. By more people moving into the area around Årstaskogen walkways used for exercise and movement can become congested. this can discourage engagement in such activities
Indoor noise levels will be reduced	Restricted access by car along with a lot of green areas for noise reduction provide conditions for quiet indoor environments	Restricted access by car along with a lot of green areas for noise reduction provide conditions for quiet indoor environments. More densely populated neighbourhoods can increase noise levels
Article 3 - The best interests of children must be the primary concern in making decisions that may affect them	The PDAs are the most easily accessible areas of the forest and are thus frequently used by preschools for educational and recreational purposes. Developing these areas will adversely affect children. With a low exploitation level, the affect will be kept at a bare minimum	The PDAs are the most easily accessible areas of the forest and are thus frequently used by preschools for educational and recreational purposes. Developing these areas will adversely affect children. A high exploitation level will more severely affect children because more green areas will be transformed
Article 31 - Children have the right to relax and play, and to join in a wide range of cultural, artistic and other recreational activities	The possibility for children to engage in activities in outdoor environments will be confined by a development of the PDAs	The possibility for children to engage in activities in outdoor environments will be severely confined by a development of the PDAs

7.2 Value Rose

This study's planning proposals are also evaluated against Stockholms stad main objectives within the newly compiled comprehensive plan (Stockholms stad, 2018c). The method of value roses was used for the evaluation, comparing the study's two proposals against each other regarding how well they perform considering to the Stockholms stad four main objectives; (1) A growing city, (2) A coherent city, (3) Good public environment, and (4) A climate-smart and durable city. The nine aspects in the value roses are based on the four objectives. A non-exploitation alternative, no construction at all, was also considered during the evaluation of the two proposals.

Figure 31 presents both value roses for the different planning proposals in order to display the difference of evaluation of the proposals. In the following two sections (7.2.1 and 7.2.2), the value roses and their basis for evaluation are presented individually.

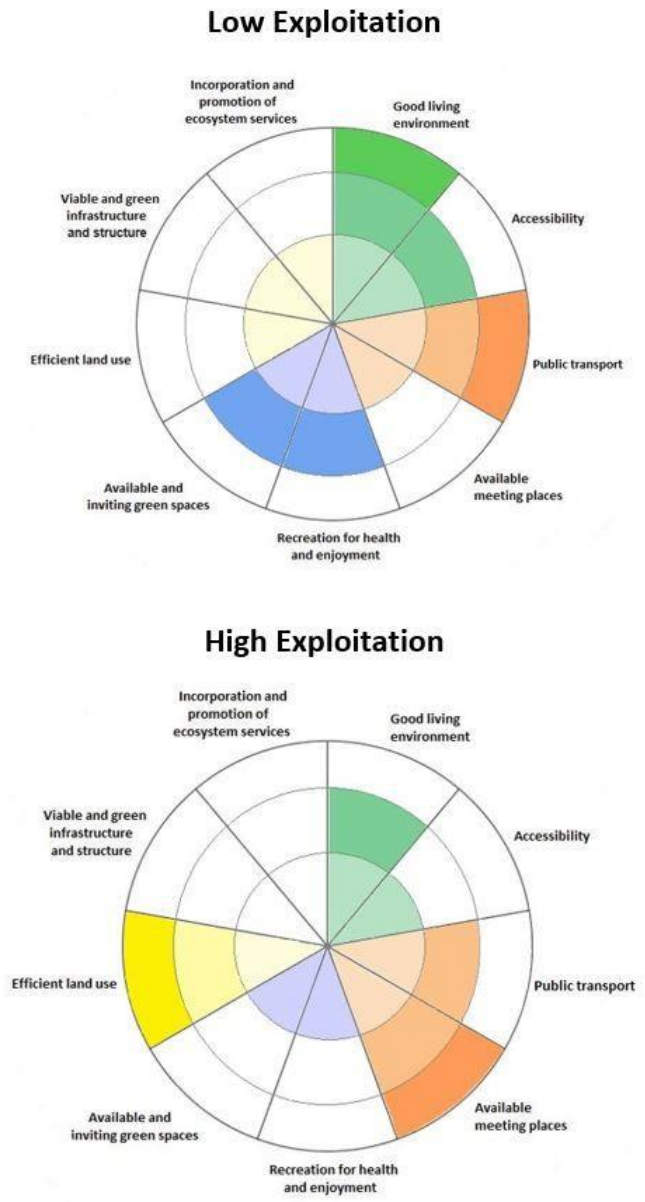


Figure 31. Value roses for both the high and low exploitation proposals.

7.2.1 Low Exploitation Proposal

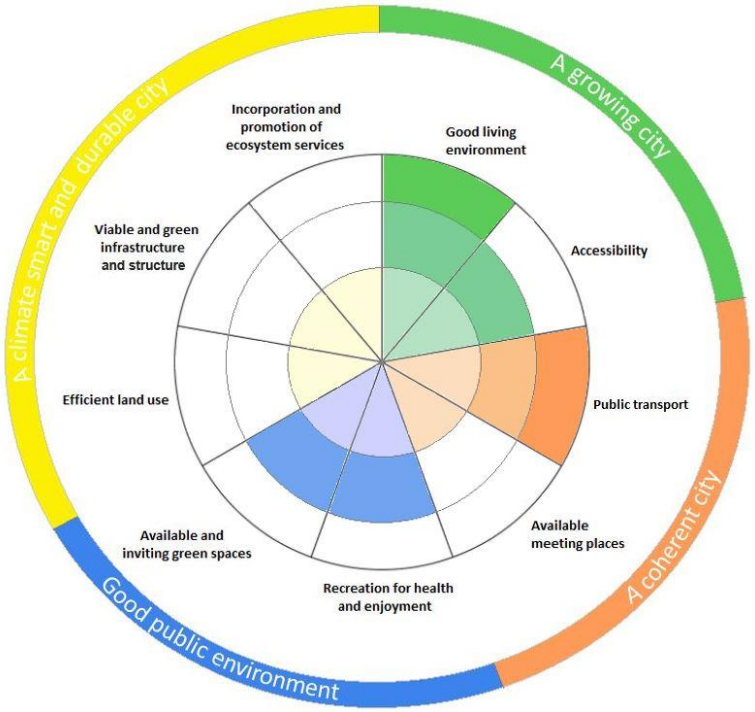


Figure 32. Value rose of this study's planning proposal with a low level of exploitation.

A Growing City

Good living environment: Valued as high achievement because of the proximity to a nature reserve, water, the city centre and since no cars are allowed in the new built up areas, there will be less noise since no cars will directly pass the new residencies. Compared to the planning proposal of high exploitation, the low exploitation proposal offers less densely populated neighbourhoods which can have a grave impact on the living environment. Although worth mentioning is that a resident's perception of what is a good living environment depends on the resident's previous residence.

Accessibility: Valued as moderate achievement. With respect to accessibility, this level of exploitation has a moderate achievement of the objective. The reason for this is that fewer access points are affected by exploitation, as seen in Appendix III. Also, since less space is made use of much of the easy accessible areas are left. Since car use will be restricted in the PDAs, accessibility is negatively affected, thus objective achievement cannot be high. However, there are two bus stations close to the respective PDAs.

A Coherent City

Public transport: Valued as high achievement. The PDAs are located near bus stops. Due to the accessibility to public transport and aim to reduce the use of fossil fuels, garages and parking lots are not included in the low exploitation proposal. On the contrary, due to the increase of citizens, there will be a higher load on the public transport in the area.

Available meeting places: Valued as low achievement, since the low exploitation proposal will offer much less meeting places than the high exploitation proposal due to that less green areas will become built up areas.

Good Public Environment

Recreation for health and enjoyment: Valued as generating a moderate achievement. This is because in the low exploitation proposal, less flat green areas will become built up areas than in the high exploitation proposal. In the low exploitation proposal, large

parts of the flat areas that are used by families and especially children for recreation and health are left.

Available and inviting green spaces: Valued as generating a moderate achievement. Regardless of the degree of exploitation, the amount of green areas will be reduced. Thus, objective achievement cannot be high with respect to available and inviting green spaces. Compared to the high exploitation proposal, and the fact that many green areas are maintained through the design of the buildings, a moderate achievement is legitimized.

A Climate Smart and Durable City

Efficient land use: Valued as low achievement since the low exploitation proposal is not using the land as efficient as the high exploitation proposal, due to the desire to firstly have ecological values in mind. In the low exploitation proposal there are less buildings planned in the PDAs and less floors per building, which makes the land use less efficient in this proposal if you look at it from the perspective of the more residencies, the better.

Viable and green infrastructure and structure: Valued as generating a low achievement. The low exploitation proposal takes into account the green infrastructure and structures by having a low amount of houses and identifying areas with less nature values for construction. The total of eight three-storey buildings enables some species to disperse between the pines. Still this proposal includes removal of habitats and narrowing dispersal corridors which will reduce biodiversity even though it is not to the same extent as in the high exploitation proposal.

Incorporation and promotion of ecosystem services: Valued as generating a low achievement. The negative effects on ES will be lower than in the high exploitation proposal. Still, removal of habitats and narrowing dispersal corridors will have a negative impact on mainly biodiversity, which could be mitigated but not totally compensated.

7.2.2 High Exploitation Proposal

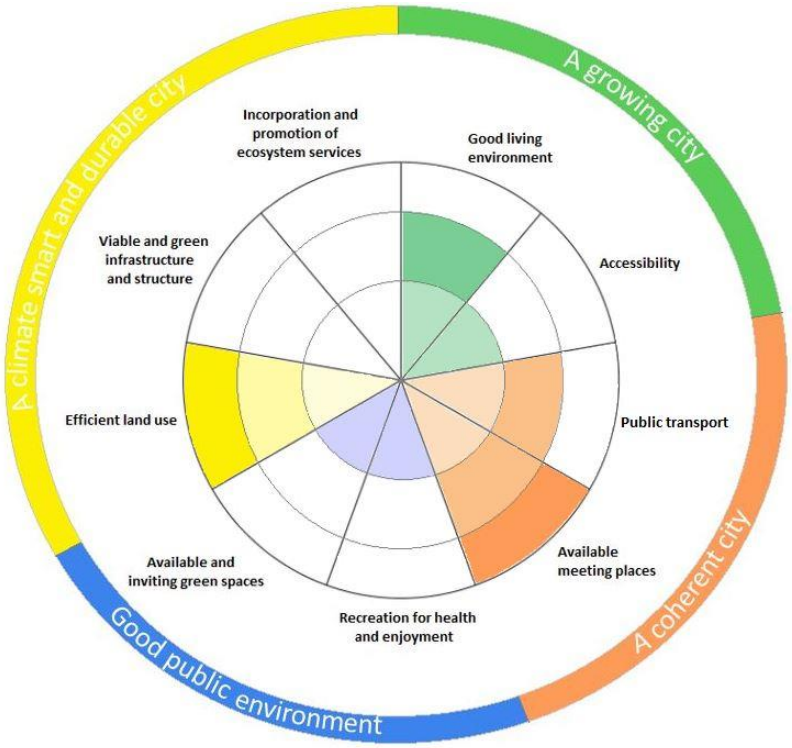


Figure 33. Value rose of this study's planning proposal with a high level of exploitation.

A Growing City

Good living environment: Valued as moderate achievement because of the proximity to a nature reserve, water, the city centre and since no cars are allowed in the new built up areas, there will be less noise since no cars will directly pass the new residencies. Compared to the planning proposal of low exploitation, the high exploitation proposal creates more densely populated neighbourhoods which can have a grave impact on the living environment. Although worth mentioning is that a resident's perception of what is a good living environment depends on the resident's previous residence.

Accessibility: The objective of availability is considered to be of low achievement at this level of exploitation for several reasons. First of all, many of the access points to the nature reserve will be lost because of exploitation, as seen in Appendix III. Due to the topography of the area, the high exploitation proposal takes much of the accessible land into use. Overall, accessibility in the nature reserve will be adversely affected for both children and others. Also, in order to maintain connectivity, car use has been restricted with the PDAs. Although this has several advantages, accessibility is not one of them.

A Coherent City

Public transport: Valued as moderate achievement. The PDAs are located near bus stops. Due to the accessibility to public transport and aim to reduce the use of fossil fuels, garages and parking lots are not included in the low exploitation proposal. On the contrary, due to the increase of citizens, there will be an even higher load on the public transport in the area compared with the low exploitation proposal.

Available meeting places: Valued as high achievement, since the high exploitation proposal will offer much more meeting places than the low exploitation proposal due to that more green areas will become built up areas.

Good Public Environment

Recreation for health and enjoyment: Valued as generating a low achievement. This is because in the high exploitation proposal a majority of the family-friendly flat green areas will become built up areas.

Available and inviting green spaces: Valued as generating low achievement. A high exploitation level entails a densely built-up area. This adversely affects the availability to the nature reserve. People that previously lived in close proximity to the nature reserve now has to cross a neighbourhood to get entry. Also, since the amount of green areas is reduced, there will be less green areas with a potential to be inviting. Overall, this proposal counteracts the objective of available and inviting green spaces.

A Climate Smart and Durable City

Efficient land use: Valued as high achievement if looking at it from the perspective of the more residencies, the better. Since the high exploitation proposal would generate a lot more residencies than the low exploitation proposal, the land use is valued as highly efficient.

Viable and green infrastructure and structure: Valued as generating no achievement. Adding green roofs, green walls and avoiding creating new flat areas (paved surfaces) could mitigate the negative effects of building in the PDAs to some extent. Still, building in areas with high nature values or dispersal zones will likely reduce the dispersibility for many species which could reduce biodiversity. PDA West is included in the most important dispersal zone for pine associated species to the south. The high exploitation proposal would likely create a dispersal barrier for many species. The compensation of adding green structures in the new residential area is too small compared to the loss of natural values.

Incorporation and promotion of ecosystem services: Valued as generating no achievement. The high exploitation proposal includes adding 29 buildings into the two PDAs. The buildings will cover a majority of the PDAs and many of the current ecosystem services will risk decrease or disappear completely. The compensation by adding green roofs, green walls etc. will not compensate the ES losses.

8. Discussion

In this chapter we aim to bring the previous sections together by discussing impacts on the environmental and social aspects of sustainability that the two different exploitation proposals will cause.

8.1 Discussion of Planning Proposals

The planning proposals of this study were created considering the Stockholm Environment Programme and Stockholms comprehensive plan, the UN Convention of the Rights of the Child, ideas and measures from the international example in mind, while simultaneously attempting to meet the growing housing demand in Stockholm.

The high exploitation proposal is an attempt to reach the goal of constructing 800 apartments while simultaneously minimizing impacts, which nevertheless are expected to be of significant magnitude on both natural and cultural values. On the contrary, the low exploitation proposal focuses on preserving as many natural and cultural values as possible while constructing an approximate amount of 130 residencies.

To construct buildings in previously non-exploited nature areas is destined to have negative effects. This study does not however discuss the placement of the new housing districts, but simply suggest how new residencies can be planned with sustainability in mind and simultaneously meet the demand for new housing. The goal of both planning proposals is to construct new housing next to a nature reserve, with focus on limiting the negative impacts.

This study has however illustrated that some impacts are not possible to avoid when building in the PDAs. Building a dense housing district is more efficient regarding land use compared to building a low density area. Constructing buildings with many floors is therefore more efficient, but comes with negative effects such as affecting the view of the nature reserve and destroying migration paths for species.

As many trees as possible should be preserved within the PDAs, the question is if it is possible to construct the housing area without first completely clearing the area of trees and planting new trees after the construction is completed. The old original trees have a higher ecological and cultural value compared to planting new trees. The

best alternative would be to preserve as many trees between the buildings as possible and to plant new trees as well.

The choice of not constructing new paved roads to the new buildings was made to avoid contamination of soil and groundwater, and also making walking and outdoor activities more appealing. Furthermore, a car-free area would lead to a safer environment for children and elderly people. The lack of paved roads could however reduce accessibility for disabled people, emergency vehicles and other services.

To make vegetation on rooftops and walls possible, the buildings might have to be constructed with a higher tolerance of stress and weight, which in turn would increase the costs and amount of construction materials. Solar panels on rooftops are not enough to make the houses self-sufficient but will reduce the electric demand from the grid.

The distance between the buildings, in combination with the amount of trees and bushes should facilitate movement of local species, and also making the area more attractive and accessible to pedestrians.

Since the removal of green areas is inevitable, both proposals go against the national environmental objectives of reducing climate impact and sustainable forests. All aspects considered, this study deems the areas adjacent to Årstaskogen as unfit for development. Despite this notion, a development of the PDAs could be inevitable due to the housing demand in Stockholm. Because of this, this study tries to identify and discuss possible impacts on the area due to a development and how to mitigate the effects.

8.2 Environmental Aspects

In this section the possible environmental consequences of a construction in the PDAs will be examined. We have identified which habitats that could be affected, the potential nature value and the ecosystem service losses and the effect on species connectivity due to construction.

As stated in section 4.5-4.10, Årstaskogen makes up an important part of Stockholms green infrastructure and structure, hosting an array of important ecological and environmental aspects that are necessary for the city's sustainability. Although a large part of Årstaskogen recently has been preserved as a nature reserve, the ecological and environmental aspects of the area might still be threatened due to the PDAs that are planned to be exploited on the very border of the nature reserve itself. According to a survey done by the group Bevara Årstaskogen, important natural values such as biodiversity, habitat, ecological connectivity and ecosystem services will be affected negatively and get partly reduced due to the construction of new buildings in the PDAs (Bevara Årstaskogen, 2017a).

As a mean to evaluate the potential effects that the PDAs might have on the environmental aspects of Årstaskogen, we will discuss what impact the PDAs might have on the environmental aspects that were presented in section 4.5-4.10. Section 8.1.2 will cover the loss of habitat when building on the PDAs, 8.1.3 will discuss the potential effect on connectivity between Årstaskogen and other green areas, and 8.1.4 will cover the potential effects on the ecosystem services provided by Årstaskogen today.

We also assess the contribution to The National Environmental Quality Objectives "Sustainable forests" and "A rich diversity of plant and animal life" (Naturvårdsverket, 2012), as well as the strategies of the Regional Development Plan of 2010 (Stockholms läns landsting, 2010).

8.2.1 Green Infrastructure and Structure

Årstaskogen is one of the most important areas for green infrastructure in Stockholm City (Stockholms stad, 2014). Promoting green infrastructure in the planning of new residential areas of Stockholm is important for the environmental sustainability of the city. Årstaskogen also makes up an ecological core area (Stockholms stad, 2014). As biodiversity is important in supporting most other ecosystem services further stresses the importance of Årstaskogen as an integral part of the city's green infrastructure (*ibid.*).

The high exploitation proposal includes hindering an important dispersal corridor for pine associated species from Årstaskogen to the south (Appendix I). Removal of important green structures and creating barriers in the connectivity network, is not in line with the Regional Development plan of 2010 (Stockholms läns landsting, 2010), that enhances the importance of preserving a coherent green infrastructure. The low exploitation proposal includes reducing habitats of the PDAs but not to the same extent as in the high exploitation proposal. Still, it effects the width of the dispersal corridor in PDA East and reduces a core area for broad leaved deciduous trees in PDA West.

Careful planning with the nature values in consideration is crucial to preserve as much of the green infrastructure of Stockholm as possible. By adding new green structures into the exploited areas such as green roofs, green walls, urban gardens etc. could mitigate the negative effects of removing valuable habitats due to construction, but it is important to enhance the notion that it is not entirely compensating the losses.

8.2.2 Habitat Loss

In this chapter we focus on the habitat loss in the two development areas, PDA East and PDA West, in our two building proposals. We have identified what kind of habitats that potentially will be reduced or removed and the potential nature value losses due to construction. The summary below is an estimation of the potential habitat losses in the two PDAs based on information from the habitat map (Figure 4), the map of observations of *Phellinus pini* in Årstaskogen (Appendix II) and the dispersal map (Appendix I).

To achieve the national environmental quality objective "Sustainable forests", great nature values must be protected and important forest environments must be preserved (Naturvårdsverket, 2012). Removing habitats with high nature values within the PDAs does not contribute to achieving this objective.

Proposal of low exploitation - PDA West
Core area for broadleaved deciduous forest will be reduced.
Mixed forest will be reduced.
One house is included the pine forest (>150 years), which will be slightly reduced.

Proposal of low exploitation - PDA East
The most important dispersal zone for pine associated species to the south will be reduced.
Parts of the rejuvenating pine forest (<70 years) will be reduced.
Parts of the pine forest (>150 years) will be reduced.

Proposal of high exploitation - PDA West
Pine forest (>150 years) will be highly reduced.
Pines with the species *Phellinus pini* (will potentially be reduced or removed.
Thick Pine trees will potentially be reduced or removed.
Mixed forest will be reduced.
Core area for broadleaved deciduous forest will be highly reduced.

Proposal of high exploitation - PDA East
The most important dispersal zone for pine associated species to the south will be highly reduced/hindered.
Pine forest on bare rock (70-150 years) will be highly reduced.
Pine forest (>150 years) will be highly reduced.
Rejuvenating pine forest (<70 years) will be highly reduced.

To remain the nature values associated with pines there need to be pine rejuvenation. One of the potential development areas (PDA East) are one of few areas in Årstaskogen with rejuvenating pines (< 70 years). As the pine forest is characteristic for the nature reserve and have high nature values with its wood composition and geographical position close the city, a loss of this habitat would most likely have a great negative impact on Årstaskogen overall (Stockholms stad, 2005). Most of the pine forest has also been shown to be over 100 years old, and act as an important refuge for old pine forest dependent species, such as *Phellinus pini* and the Coleoptera species *Nothorhina muricata* (Nilsson, 2018, personal communication).

Lack of rejuvenation of pine trees is mostly due to young plants not being able to bear root. This is mainly due to competition from other tree species like Aspen and Rowan tree growing under the old pine trees. As these tree species grow both quicker and denser than the pine plants, the pines, who is dependent on open space to grow, are not able to reproduce (Stockholms stad, 2014). Due to this competition from other tree species, rejuvenation of pine forests almost only occurs in areas where the land layer is exposed to some sort of regular disturbance, such as forest fires or forest grazing (Ekologigruppen, 2012). Historical findings have shown that the pine forests of Årstaskogen most likely have been exposed to forest grazing in the past, but after the grazing ceased the area slowly became overgrown and thus the rejuvenation of pines began to dwindle (Stockholms stad, 2014).

As a mean of increasing the rejuvenation of pine forest in Årstaskogen once more, there has been several proposals regarding suggestions on how to manage the forest in the future. Ekologigruppen (2012) concluded that the most advocated method from an ecological perspective would be to use controlled burning to clear specific spots where the pine tree can flourish. This method is advocated mainly due to the fact that it is the method that mimics natural ecological processes to clear vegetation the most. However, historical findings and nature paths close to the controlled burning patches have been shown to take damage from the fire, and in some cases even get destroyed if the fire gets slightly out of hand. Furthermore, controlled burnings so close to the Stockholm city centre pose a high risk for the health and safety of the public and thus is not advisable to use as a method (*ibid*.).

Another way to manage the pine forest rejuvenation is by cutting down trees under the older pines. This way the seedlings from the old pine trees can bare root without facing the risk of other tree species like Spruce or Aspen blocking the sun or taking up space. By only cutting down the trees below the old Pines the risk of damaging

other important nature values are significantly reduced, as this form of management will not impose that much on any other ecosystems present in Årstaskogen (Stockholms stad, 2014). After cutting down the trees, the ground vegetation can be kept at a controlled level by either implementing forest grazing or continuously cut down the vegetation by hand. Although grazing is more preferable from an ecological standpoint as it, in likeness with the controlled burning, is the method that mostly mimics the natural ecological process, the best method to implement in Årstaskogen from a realistic point of view would be to manually cut the vegetation. This conclusion is done mainly due to the fact that keeping animals within the boundaries of Årstaskogen will be hard, as parts of the area would have to be fenced off for the animals which will affect the recreational values negatively (Ekologigruppen, 2012).

The view of Årstaskogen will also be affected by the new residents. The buildings in our high exploitation proposal have their short side facing Årstaskogen, which will have less negative impact on the view than if we would have put them the other way around. Still, the buildings in this plan are six-storey high and this will reduce the forest view. This will likely affect the 'feeling of nature' of the closest paths in Årstaskogen. Building houses in PDAs will lead to a reduction of pine forest on one side of the paths leading through Årstaskogen (Figure 26 and 27).

There has been no overall inventory of the flora and fauna of Årstaskogen or any overall analysis of the potential nature value losses due to construction (Bevara Årstaskogen, 2017a). We identify the two PDAs as areas with low capacity to build due to the high nature values and recreational values in these areas.

Årstaskogen is already a narrow forest, and is on a regional level not included in the green wedges of Stockholm (Stockholms läns landsting, 2012). Narrow green wedges (lower than 500m wide) are defined as weak connections according to the report: *Svaga Samband i Stockholmsregionens Gröna Kilar* (*ibid.).* We identify the importance of preserving as much of Årstaskogen as possible due to its narrow width and believe that any kind of construction would reduce the width. By preserving the width of the forest, the nature values on a local level will remain.

8.2.3 Ecological Connectivity

It is important to have in consideration that the PDAs in Årstaskogen have high nature values and that the ecological connectivity will be affected negatively by construction. When creating a building plan, the aim should be to mitigate the negative effects as much as possible. In the case of Årstaskogen, the best alternative out of an environmental perspective would be not do build at all. We have identified the important dispersal zones in chapter 4.5. The dispersal-zones of high importance for Årstaskogen range from Majrosskogen in the south, to the Nacka nature reserve in the east and to the waterfront areas of lake Mälaren in the west. As mentioned above, the most important dispersal zone for pine associated species to the south is the area close to Årsta IP (PDA East). The habitats of PDA West have different characteristics and vary between mixed forest, coniferous and broadleaved deciduous forests (see Figure 4). The western part of Årstaskogen is important for dispersal of broadleaved deciduous trees to Gröndal (Stockholms stad, 2014).

To achieve the national environmental quality objective A Rich Diversity of Plant and Animal Life, actions that provide species long-term survival and genetic variation is crucial. Biodiversity is a

precondition for sustaining ecosystems and their functions. This also includes the benefits such as people's health and well-being (Naturvårdsverket, 2012).

Also, The Swedish Environmental Code (22 February 2018, Lexino, SFS 1998:808, 1 ch. 1 §) shall be applied in a way as to ensure that: Valuable natural and cultural environmental are protected and preserved; biological diversity is preserved; and the use of land, water and the physical environment in general is such as to secure a long-term good management in ecological, social, cultural and economic terms.

High Exploitation Proposal

The high exploitation proposal result in a large reduction of the habitats in the two PDAs. PDA East is identified as an important dispersal zone for pine trees to the south and it will be highly reduced in the high exploitation proposal. The six-storey buildings in this plan are higher than the pine trees in the area, which would reduce the dispersibility for pine associated species drastically even if pines are preserved in-between the houses.

PDA East is included in one of the most important connectivity areas for coniferous forest associated species dispersal to the south (Appendix I). The current main dispersal corridor in PDA East (Figure 29) will be hindered by construction and only narrow corridors will remain (Figure 30). The current dispersal pattern is possible due to the low height of the houses in the area, since it is lower than most pine trees. Adding higher buildings will likely reduce the dispersibility (Conec, 2013). The distance between the houses of PDA East will be about 15-20 meters, in comparison, the minimum for an eco-duct is 40 meters *(ibid.)*. To preserve coniferous associated bird species such as Lesser spotted woodpecker (*Dryobates minor*), Northern Goshawk (*Accipiter gentilis*) and several tit-species such as European crested tit (*Lophophanes cristatus*) there need to be good connections with surrounding coniferous forests (Stockholms stad, 2017d). The width of the dispersal corridor in PDA East will be reduced and divided into several smaller, more narrow corridors (Figure 30). This reduces the dispersibility for many species. For example, European crested tit is a species that easily could travel 3000 meter in a coniferous forest but would only fly a couple of hundred meters in a densely populated area (Zetterberg, 2012; Conec, 2013).

The dispersal of the fungus *Phellinus pini* will likely be affected by the construction. The quality of the forest and dispersal possibilities are important for preserving the species. Closeness to old pine trees are important for the dispersal and it is also important that the dispersal patterns are not hindered by construction (Hultman, 2009).

PDA West include a dispersal zone for broadleaved deciduous trees to the west, to Gröndal (Stockholms stad, 2014). The broadleaved deciduous forest in PDA West will likely be reduced in this proposal. Mitigating the negative effects of the nature value losses by adding green roofs etc. will not compensate the losses entirely.

Low Exploitation Proposal

The proposal of low exploitation is based on the building capacity of the areas, taking into account the high nature values and dispersal corridors. Despite the fact that it is low exploitation, it will still have negative effects even though they are lower than in the high exploitation proposal.

The buildings in PDA East are carefully placed in the south-east part of the PDA with the aim to preserve the old pine forest in the area.

Still, the broadleaved deciduous forest in PDA East will be reduced. This could have negative effects on the dispersal for broadleaved deciduous trees to the west. PDA West is, as mentioned before, one of the most important dispersal zones that allow dispersal to/from the south. The low exploitation proposal takes the corridor into account by only placing a few buildings in this area. The width of the corridor will still be reduced and this could have a negative effect on the dispersibility for many species.

Hindering dispersal corridors could potentially lead to habitat fragmentation. Habitat fragmentation is identified for having large negative effects on biodiversity (Fahrig, 2003).

8.2.4 Ecosystem Services - Gains and Losses

As part of fulfilling the climate goal 15.1 of Agenda 2030 "To preserve, re-create and sustain ecosystems on land and in freshwater and their ecosystem services, especially forests…" (Regeringskansliet, 2017), there is a need to preserve the ecosystem services present in Årstaskogen today, as well as try providing a good base for additional ecosystem services to develop in the future. However, with the plans of constructing new living quarters within the assigned PDAs, a few possible scenarios may play out which might yield a different outcome for the future ecosystem services present in the Årstaskogen today. We have evaluated the gains and losses of ecosystem services based on our two scenarios: high exploitation and low exploitation.

High Exploitation Proposal

With the high exploitation proposal, an addition of 29 six-storey buildings will cover almost all of the PDAs. Many of the ecosystem services today dependent on elements found in the PDAs will thus risk decrease in quality or disappear completely if these elements where to be erased when giving space to the new buildings. In a response to the new building plans of the PDAs, Swedish Society for Nature Conservation (*sv. Naturskyddsföreningen*) (2017) stated that a multitude of ecological values that are of importance to sustain the ecosystem services in the area risks being lost if the PDA will be used up for housing. All four of the ecosystem service categories will be affected to some extent by this proposal, and the impact that it will have on each category is listed down below:

Provisional services: Will be more or less unaffected by the high exploitation proposal. As none of the allotments (which are the primary provisional service) will be affected by the buildings in PDA West or PDA East, the provisional services will stay the same as today.

Regulating services: To give room to the 29 new buildings included in the high exploitation proposal, about one fifth (21 percent) of Årstaskogens trees will have to be cut down. Naturally, the loss of over a fifth of all trees as well as a large loss of other vegetation as well will lead to less vegetation which reduces air pollutants or regulates the climate by taking up climate changing gases such as CO_2. Furthermore, the loss of vegetation might also lead to a loss in pollinators that are dependent on plants present in the PDAs (Naturskyddsföreningen, 2017). On the other hand, by cutting down the trees, new open patches will be created that if cared for properly could be used as aesthetic flower patches within the PDAs. These flower patches might host a more diverse flora than the pine wood flora dominating today, which could make up for and even benefit the pollinators more than before.

Cultural services: The high exploitation proposal will also risk decreasing the cultural services' values. As much of the nature reserve border are drawn on the upper edge of very steep slopes (depicted in our Slope grade map) it makes it a lot harder to enter the reserve, especially as two of the three main entrances used today might get blocked by buildings with the high exploitation proposal. This might give people a negative view of the forest as they will be looking down upon it from atop the slope instead of being viewed from a plane surface, thus erasing the feeling of being "inside" a forest (Nilsson, 2018). This might affect the nature experience for people negatively and thus downgrade the cultural services of the area. As most people visiting Årstaskogen does so either for the nature experience or the peace and quiet, the addition of the PDA might risk the interest of the public to visit Årstaskogen, and even if some room where to be given to an entrance in the PDA, there might still be a risk that the area will feel too private and discourage people from visiting the area, thus driving down the cultural services exceptionally (Stockholms stad, 2017a).

Supporting services: The main supporting ecosystem service in Årstaskogen, biodiversity, will most likely also be affected negatively by the high exploitation proposal. As some of the forest's most important pine forest areas have been excluded from the nature reserve and instead been included in the PDA, all the species connected to this habitat will most likely heavily decrease or disappear when the forest gets cut down and built upon, including the fungus *Phellinus pini* and Northern Goshawk (*Accipiter gentilis*) (Nilsson, 2018). Some of Årstaskogens broadleaved deciduous forests will also be reduced and it will most likely effect species connected to that habitat (Bevara Årstaskogen, 2017a). With the loss of some of the most important pine forests in the area it is uncertain if the biodiversity will be able to keep up the same level as it is today (*ibid.*).

Low Exploitation Proposal

With the low exploitation proposal, eight buildings will be added to the PDAs. As this proposal also takes into account the protection of many of the elements important for ecosystem services sustainability the negative impact from this proposal will most likely be a lot less than with the high exploitation proposal. Also, with this proposal some of the ecosystem service categories might not be affected negatively at all. Nevertheless, the likely impact that this proposal will have on the four categories will be listed below:

Provisional services: As none of the buildings in the low exploitation proposal will be built where allotments are standing today, no allotment has to be demolished. Therefore, there would not be any decrease in the gardening and thus the provisional services will stay the same as today. In the future, there might even be the possibility to use parts of the unexploited PDAs as a mean to expand the allotments further, thus providing even more gardening and raising the provisional services in the area. However, expanding the allotments might be on the costs of other ecosystem services, and the proposal do not include any expansion on the allotments due to this (Bevara Årstaskogen, 2017a).

Regulation services: With only eight buildings being built in this proposal, a lot less trees will have to be cut down to make room for the buildings. This would leave a higher amount of trees and vegetation untouched that can contribute in keeping up the regulation services. As most trees will be left untouched, they will be

able to sustain regulation services such as noise reduction and air pollutant reduction. Other regulatory services such as pollination will also stay mainly the same as the ground vegetation will be mostly left untouched, with the buildings being placed in parts of the PDAs where vegetation in the field layer is sparser. However, some trees and vegetation will still have to be cut down to give space for the new buildings and although the negative impact from this will be a lot lower than that of the high exploitation proposal, the regulation services might still face a small negative loss (Naturskyddsföreningen, 2017).

Cultural services: Thanks to many of the regulation services being preserved in the new proposal, many of the cultural services will also be preserved as an effect of this. For example, the fact that more trees will be left and contribute to reducing outside noises from the city into Årstaskogen, there peace and quiet in the nature reserve will be retained to more or less the same level as today. Also, as less of the PDAs will get exploited, more of the natural areas will be preserved, contributing to maintain the nature experience in the area (Naturskyddsföreningen, 2017). The area will also keep retain all its main entrances as the placement of the houses have been chosen to not block these, and thus the nature reserve will keep on being easily accessed also in the future (Nilsson, 2018).

Supporting services: The placement of the buildings in the low exploitation proposal is based on the aim to only reduce small parts of existing habitats, and to remain the areas frequently used by children. The biodiversity will be less affected by this proposal compared to the high exploitation proposal. However, the dispersal corridor for pine associated species will be reduced in PDA East (including some of the rejuvenating pines), and some broadleaved deciduous forest will be reduced in PDA West, which will have negative effect on the biodiversity. In total, one house will be affecting the pine forest in PDA West. The biodiversity will potentially be affected negatively, although it can be presumed that the effect will be very minor compared to the high exploitation proposal (Nilsson, 2018).

Table 5. Summary of the potential effect on today's ecosystem services when building on the PDA in accordance to the low exploitation proposal.

Low Exploitation	
Provisioning (NL)	- Food (NL)
Regulating (GL)	- Clean air (SL) - Clean water (NL/SL) - Pollination (SL) - Noise reduction (SL) - Climate regulation (SL)
Cultural (GL)	- Nature experience (GL) - Health (NL) - Peace and quiet (NL)
Supporting (GL)	- High biodiversity (SL) - Nutrient cycles (NL) - Primary production (SL)

Table 6. Summary of the potential effect on today's ecosystem services when building on the PDA in accordance to the high exploitation proposal.

High Exploitation	
Provisioning (NL)	- Food (NL)
Regulating (GL)	- Clean air (GL) - Clean water (NL/SL) - Pollination (SL) - Noise reduction (GL) - Climate regulation (GL)
Cultural (GL)	- Nature experience (GL) - Health (SL) - Peace and quiet (GL)
Supporting (GL)	- High biodiversity (GL) - Nutrient cycles (SL) - Primary production (GL)

Abbreviations related to Table 5 and 6.

***NL** = No Loss; no part of the ecosystem service will potentially be lost.*

***SL** = Small loss; only a small part of the ecosystem service will potentially be lost.*

***GL** = Great Loss; a large part or all of the ecosystem service will potentially be lost.*

8.3 Cultural Values

The proposed plans to build new residential units within the PDAs will lead to an increase in the number of residents in the area. An increase of residents in Årstaskogens proximity should therefore increase the amount of visitors to the nature reserve. A large increase of visitors could result in the recreational carrying capacity of the forest being exceeded. This will lead to negative consequences for the forest itself, with nature paths getting worn down due to more people walking in the area, certain species being lost due to an increase of human disturbance, as well as visitor's recreational experience being compromised due to crowdedness and deterioration of the nature. With species disappearing due to human disturbance there might be a loss in biodiversity which effects the supporting ecosystem services negatively (Stockholms stad, 2017c; Nilsson, 2018). The site capacity of a Årstaskogen is an important factor to have in mind when deciding on the level of exploitation, since the decision should be in line with the national environmental objective of sustainable forests.

There are multiple ways to avoid exceeding Årstaskogens carrying capacity in order to evade the negative effect that comes with it. The easiest option would be to opt for no exploitation of the PDAs, although this option seems unrealistic due to the high demand for housing in Stockholm. The second best option would be to choose a development with a low level of exploitation, where indirect methods of site management in the nature reserve would be preferable in order to avoid exceeding the site capacity. The least favourable option would be this study's proposal of a high exploitation level, most likely leading to the cite capacity being exceeded if not strict direct site management would be implemented. In reference to Selman (2000, p. 201), indirect methods implemented in Årstaskogen could be limiting the provision of information about the area's recreational opportunities and carefully design the sites installations and access routes such as paths, entrances and location of nearby car parks. Direct methods implemented could involve regulations or possibly physical barriers to prevent access to sensitive sites or areas undergoing recovery (*ibid.*).

If the high exploitation proposal would be carried out, historical remnants in Årstaskogen will potentially be destroyed. Two of the remnants are old carvings, carved into the mountainside and thus cannot be easily moved. Loss of cultural values such as historical remains has the possibility to effect nearby resident's sense of place regarding their neighbourhood. Although there is no evidence for this to occur in residents of Årsta since there is no gathered data regarding if Årsta residents relates their sense of place to the areas historical remnants. In the proposal of low exploitation, the buildings have been placed were they won't risk the removal of any historical remnants.

The high exploitation proposal will also lead to the loss of two out of the three main entrances into Årstaskogen due to development. This could restrict visitors and residents access to the nature reserve, potentially leading to a decrease in recreational activity and social interaction. However, new cultural values might also be gained from the new built area, as our proposals include new meeting places and playgrounds that can benefit the social interaction in the area. In the proposal of low exploitation, the buildings have been placed were they won't risk the removal of any main entrances. A disadvantage with the low exploitation proposal from a social perspective is that only one new meeting place will be constructed, in comparison to the

study's proposal of high exploitation were several will be constructed. Also, since the high exploitation proposal contains more buildings and therefore more roofs with benches on them, the opportunities for social interaction could be considered as higher in the proposal of a high exploitation.

8.4 Child Impact Analysis

The basic idea that society should consider the best interest of the child is fundamental. When the UN Convention on the Rights of the Child was drafted, it was indisputable that the principle of the child's best interest was to be given a prominent position. Thus, the concept of 'best interest' should be a primary consideration in all decisions affecting children. The Swedish strategy for the UN Convention on the Rights of the Child places emphasis on the use of Child Impact Analysis (CIA). CIA can facilitate the expression of systematic approaches to the best interest of the child in ways which enables researchers to formulate and analyse the child perspective.

The Child Impact Analysis (CIA) has played an important role in this study, above all as to provide knowledge and serve as a basis for describing and evaluating consequences for children due to the proposed development. With reference to section 3.5 of this study, CIA includes mapping, describing, analysing, reviewing and evaluating impacts. In section 2.7 and 4.4, the first two steps of the CIA process are considered. This section will bring all the steps together by discussing and analysing the potential consequences on children that the development of Årstaskogen likely will cause.

The main impact on children that the construction of PDA West and East will entail is a loss of green flat areas. The Potential Development Areas are the flattest and easily accessible areas of the entire forest. The high exploitation proposal includes building in the areas that are frequently used for educational purposes by preschools or schools. As shown in Appendix IV, a development with high exploitation of PDA West will imply that only steep slopes will remain in this part of Årstaskogen. The same situation prevails for PDA East. Overall, this will adversely affect accessibility for children. Children and families visiting the forest are confined to using only the designated trails. The main trail is along the waterfront, which in itself is a safety issue for younger children due to steep slopes facing the water.

The low exploitation proposal will not interfere as much with the designated areas for educational purposes. Still, the new buildings will be close to these designated areas, and the feeling of nature (coherent forest) would be potentially be reduced.

Owing to the fact that it is the most easily accessible areas that will be exploited, it will impair the ability of children to play and exercise outside. Lack of physical exercise can lead to obesity problems among children. With reference to Pikora *et al*. (2006), accessibility is crucial to increase physical activity of children.

The PDAs coincide with the two most cohesive areas used for pedagogical purposes, as shown in Figure 5. There are overall only nine places of different sizes in the forest suitable for such purposes because of the inherent topography. Transforming two big areas of these into residential areas will lead to increased competition of the remaining ones. This will likely lead to a deterioration of the possibility to include outdoor education and physical activity. As there will be more preschools in the Årsta area, the competition can be expected to increase even more, which further inhibits the possibility for pre-schoolers to visit the forest.

The majority of the preschools in Årsta do not have satisfying yards. For this reason, Årstaskogen is an important resource for many of them, enabling children to experience nature. Årstaskogen is today already a relatively narrow forest. Allowing exploitation in the fringes reduces the areas of the forest that can be perceived as truly natural. This in turn will lead to children not experiencing the same feeling of nature which will inhibit discovery and sense of adventure. Preschool groups with older children can experience this elsewhere because they have the possibility to travel further distances than preschool groups with younger children. By not experiencing the feeling of nature, children's cognitive development will be adversely affected. At the same time, too considerable changes in scenery can affect children negatively by increasing the feeling of stress. This is particularly evident when environments that children feel comfortable in undergoes changes. Spending time in familiar outdoor environments reduces stress, conflicts and promote calm within the child.

As explained earlier in this study, outdoor activities bring several health benefits for children. This analysis shows that outdoor activities are likely to be fewer and of lower quality due to the development through increased competition of green areas and a reduced sense of nature. This affects school performance among children negatively because the ability to learn and concentrate deteriorates. In comparison, children who spend a lot of time outdoors exhibits improved motor skills and are generally healthier.

Similar to what the project 'the City at Eye-level' emphasises, needs of children should be considered in every decision that affects them. It is questionable, however, whether their views were taken into account when the final nature reserve boundaries were established as they are most adversely affected by them. The establishment of Årstaskogen are therefore considered by this study to not be in line with Article 3 of the UN Convention on the Rights of the Child.

Also questionable is the desire to transform green areas to build up areas in a district that already lies on the verge of meeting the minimum requirements set by UN Habitat programme. Overall, this contributes to the problem of reducing the amount of green areas available for preschools in Årsta. This limits children to engage in recreational activities which goes against the basic idea of Article 31 of the UN Convention on the Rights of the Child.

Children moving to the new residential areas could on the other hand be positively affected depending on where they moved from. The closeness to green areas offers several recreational opportunities for children. For example, Trollparken is within walking distance from PDA East. There are also several playing grounds within the areas.

The proximity to green areas, that these neighbourhoods entail, encourages a more frequent use of them by children. This closeness will likely stimulate more outdoor activities, enabling several health related benefits. By restricting the access of cars, a safe environment for children to reside in can be facilitated.

This study has attempted to include the child's perspective by identifying, analysing and evaluating possible consequences for children that the development of Årstaskogen will entail. However, this study has not collected any primary data from children or preschools in the area. Thus, the conclusions are rather general. One must be cautious in applying general conclusions to specific situations. Yet, in face of the limited information concerning the

relationship between children and Årstaskogen this study is considered to have contributed with new knowledge.

8.5 Lessons from International Example

First of all, it is necessary to keep in mind that the analysed sites of Årstaskogen and Rieselfeld have quite different backgrounds. In contrast to Årstaskogen the site of Rieselfeld has been a brownfield and is not facing any difficulties due to the geomorphological features of steep slopes as Årstaskogen does. Furthermore, Årstaskogen already inhabits residents while Rieselfeld was an open field without residential buildings within the area. The objectives on the amount of future residents also differs due to 4 100 apartments planned for the district of Rieselfeld (City Freiburg, 2015a) while the planning proposals for Årstaskogen entails approximately 130 or 800 residencies. Due to the mentioned characteristics, the two sites have to manage problems and challenges slightly different, but Rieselfeld is still considered as a suitable international example.

Due to the extensive research on both analysed sites it became clear that Årstaskogen and Rieselfeld have many similarities, despite their different characteristics. Firstly, Årstaskogen as well as Rieselfeld are located on the edge of a nature reserve. Secondly, the overall objectives of Årstaskogen and Rieselfeld both aim at the development of an urban area to meet the housing demand and achieve a sustainable development which meets the needs of specific citizen groups and to support and protect nature values of the site at the same time. To summarise, both sites have to deal with the conflicting concepts of creating new dense urban areas and protecting nature values.

In addition to the mentioned similarities which highlight the suitability of Rieselfeld as an international example, the results of a survey on the satisfaction of the residents in Rieselfeld from 2010 also shows that the used approach of sustainable urban planning was successful (City Freiburg, 2010a). The survey revealed that the residents are particularly satisfied with the social and cultural life, the geographical position, the infrastructure and the child friendliness as well as the urban concept of Rieselfeld (*ibid.*). Furthermore, over 90 percent of the respondent's state that the district of Rieselfeld is family-friendly, children-friendly, and handicapped accessible (*ibid.*). Many different measures which were taken while planning and constructing the district of Rieselfeld were also taken into consideration within the planning proposals for Årstaskogen. Although, a critique that can be directed at both of the study's planning proposals is that since the roads leading up to the buildings will not be paved, the new residential areas will not be fully accessible for handicapped people. Also, the restriction of cars in the area might create problems for residents when they have, for example, gone grocery shopping.

The implementation of Rieselfeld was carried out in four stages and spread out over two-year intervals to ensure environmental, social, and economic balance (Medearis & Daseking, 2012). The planning proposal of Årstaskogen will be implemented step by step as well.

To adjust the development of the site according to the needs of the future and former citizens, the planning process of Årstaskogen as well as Rieselfeld was on the one hand including the results of a citizen survey from the City of Stockholm and on the other hand the results of the survey conducted by the City of Freiburg (City Freiburg, 2010a; Stockholms stad, 2017a).

As mentioned before, two years before the final construction of the district Rieselfeld the City Freiburg conducted a survey which showed a great satisfaction of the residents (City Freiburg, 2010a). According to this approach, further participation of citizens and their needs will be realised after finishing the development of Årstaskogen to evaluate their satisfaction with the new developed buildings and surroundings.

While developing a new urban area, Årstaskogen and Rieselfeld are both taking different target groups into consideration. Rieselfeld took extra consideration to families, children and elderly people, whereas this study on Årstaskogen especially focuses on children and their needs. Measures which were implemented in Rieselfeld concerning children and families should also be applied in Årstaskogen in order to establish a family-friendly environment.

Furthermore, the district Rieselfeld provides different places to gather, such as the district park in the north and various public places and semi-public places as generous inner community blocks. These are important to support an attractive and social public life. Therefore, the planning proposal for Årstaskogen with a high level of exploitation will also contain a lot of meeting places accessible for everyone to enhance the social cohesion of the new districts. Also available for residents will be benches on the rooftops, implemented to strengthen the social interaction between neighbours.

In the area of Rieselfeld many social services and activities were implemented such as children care. These social infrastructure services are already generally given in Årstaskogen, although the demand for them may increase due to an increase of residents.

Even if the transport system can be highlighted within the scope of environmental aspects, it is also important when it comes to safety especially for young and elderly people. Different measures to increase the safety as well as reduce noise and harmful emissions were implemented while planning and constructing the district of Rieselfeld in Freiburg. These measures are for example the determination of a general speed limit of maximum 30 kilometres per hour in districts where a lot of children live, enabling them to safely play in the streets (City Freiburg, 2010b). Despite of the mentioned measures, the asked residents stated traffic and its negative effects such as noise and air pollution as the second most common reason for their dissatisfaction within the area of Rieselfeld (City Freiburg, 2010a).

Because of that, the planning proposals for Årstaskogen will even go further and will not contain parking areas and such, which leads to an environmentally-friendly mobility and a safe, quiet, and clean environment for all residents, especially for children.

To avoid social segregation within the district of Rieselfeld the City Freiburg determined that citizens and developers would have equal opportunities to buy land available for development and support citizens who want to develop a parcel through professional advice by the city. Moreover, the available land for rental housing and property is mixed within the district of Rieselfeld. But Rieselfeld is facing segregation due to the expired social housing contracts after ten years and an increase in condominiums (Dr. Back, 2018, personal communication). According to this study, the PDAs next to Årstaskogen should also entail a mix of rental housing and condominiums to achieve a sufficient mixing of residents and a

healthy social structure. Worth mentioning is that it is more common to buy a condominium in Sweden than in Germany.

The decision of developing small parcels on the area of Rieselfeld (Medearis & Daseking, 2012) as well as within the site of Årstaskogen was made due to the provision of a mixed environment. This generally allows green pathways between the buildings in Årstaskogen which also serves as corridors for migrating species due to the reduction of the barrier effect.

In addition, the district of Rieselfeld includes many buildings with green roofs which could favour different animals and plants and could provide different ecosystem services (City Freiburg, 2010b). The rooftops and the walls of the constructed buildings in Årstaskogen will also be covered with vegetation.

Besides preventing new artificial greening, the districts of Rieselfeld and of Årstaskogen are located right next to a nature reserve which is not only important for biodiversity but also for recreational purposes of nearby residents. To be able to maintain the quality and act within the carrying capacity of the nature reserve Freiburger Rieselfeld, a nature discovery trail was implemented to steer the visitors of the nature reserve (Medearis & Daseking, 2012). In the area of Årstaskogen the current pedestrian pathway will be preserved for the purpose of steering visitors of the nature reserve.

To ensure a balance between the district Rieselfeld and the surrounding area and to avoid a negative impact on the view, the height of the buildings is decreasing to the outer part of the district (City Freiburg, 2010b). While planning Årstaskogen, the impact on the view of the new buildings were also considered. Therefore, the buildings in our plan have their short side facing Årstaskogen to ensure their reasonable integration in the surrounding area. Furthermore, the planning proposal with low exploitation will only include three-storey buildings, a height chosen based on the height of existing trees in order to preserve migration paths for species. When establishing the height of the buildings in the high exploitation proposal, aspects such as view and migration paths was not considered due to the proposal being planned from a developer's point of view.

Solar panels are installed on all roofs in both planning proposals for Årstaskogen, as well as in Rieselfeld (City Freiburg, 2010b). These provide energy for the residents and reduce their dependency on other forms of energy, decreasing the usage of non-renewable resources in the new districts which is highly in line with environmental sustainability.

9. Final Reflections

In this section we conclude our work and give recommendations on what to include in further studies.

9.1 Conclusions

It is important to acknowledge that development cannot forgo without placing strain on social and environmental aspects of sustainability. Notwithstanding, there is an urgent need for housing in the Stockholm Region. We see it as a conflict between interest. On the one hand we have an area with high nature values and on the other there is a need to solve the housing shortage.

In the context of Årstaskogen we conclude that a development is not appropriate because of the many adverse impacts that this will entail. With respect to ecological aspects of sustainability, ecological connectivity, biodiversity and ecosystem services will be negatively affected. Developing in Årstaskogen is therefore considered by this study to not be in line with the national environmental quality objectives of Sustainable Forests and Rich Diversity of Plant and Animal life.

The UN Convention on the Rights of the Child clearly states that the best interest of the child should be considered in every decision that affects them. Since children will be the most severely affected by a development of Årstaskogen, this is considered to be against Article 3 and 31 of the UN Convention on the Rights of the Child. Thus, the claim not to develop in Årstaskogen is further supported by this.

Since the decision on whether to exploit this area or not is out of our hands we emphasis that nature, social and recreational values should be taken into consideration and where it is possible the negative effects should be mitigated as so far it is reasonably practicable. Through this ecosystem services and biodiversity can be preserved. It is also important to acknowledge the importance of green areas on people's health and well-being.

9.2 Recommendations

- Recommended for further studies is to include the views of children. This study has unfortunately not been able to interview any children likely to become affected by development. Before moving on in the planning process this should be done.

- There is an information gap regarding species inventory. An inventory on species in Årstaskogen would have been desirable to do to improve the quality of this study. We therefore recommend for such an inventory to be carried out.

- The economic dimension plays a major role in urban planning. It is therefore recommended to be included in further studies on the development of Årstaskogen.

- Our final recommendation is that further studies should be conducted before developing the areas near Årstaskogen. It is also important to ensure that all group’s views are taken into consideration.

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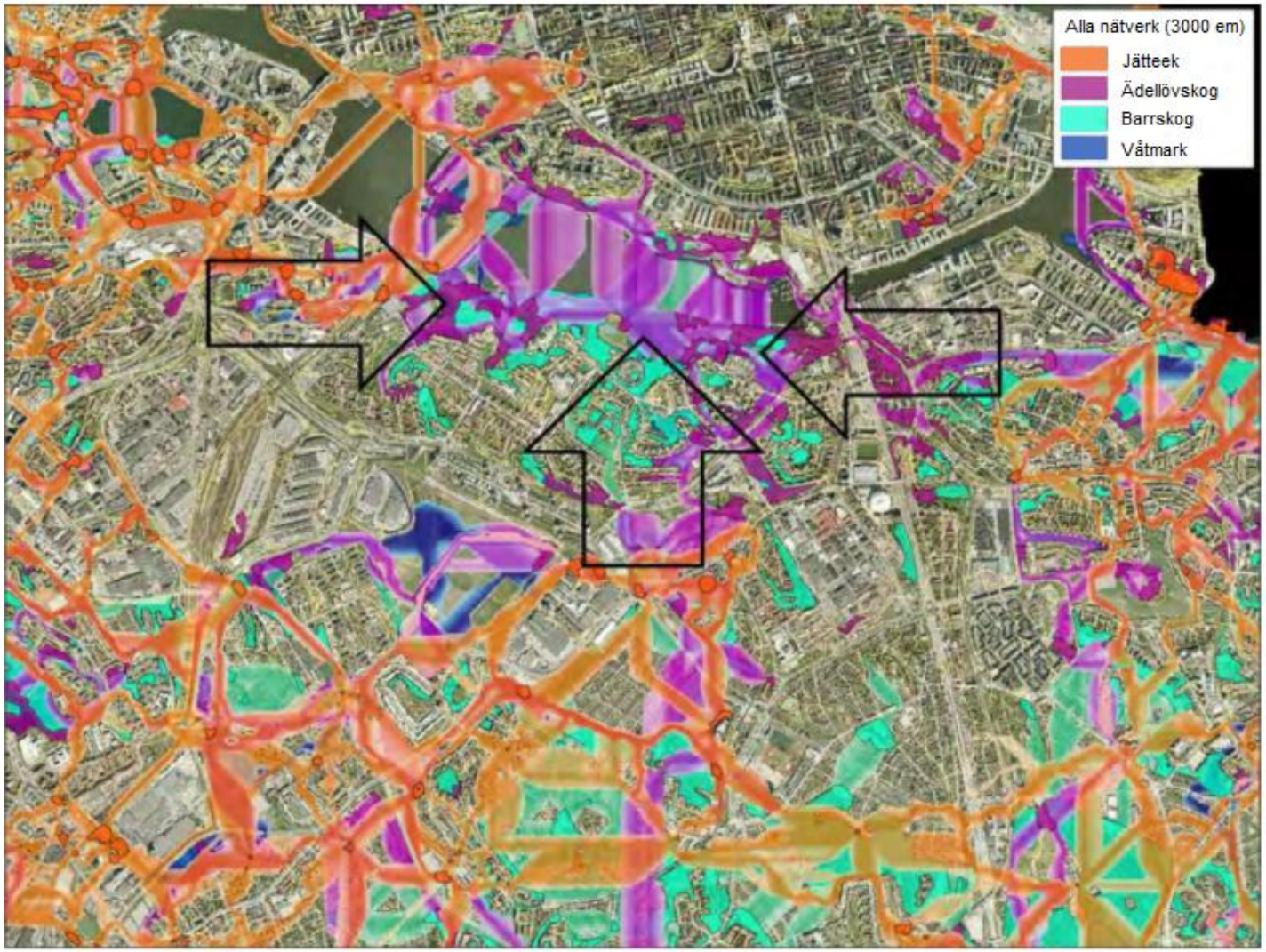
Appendix I

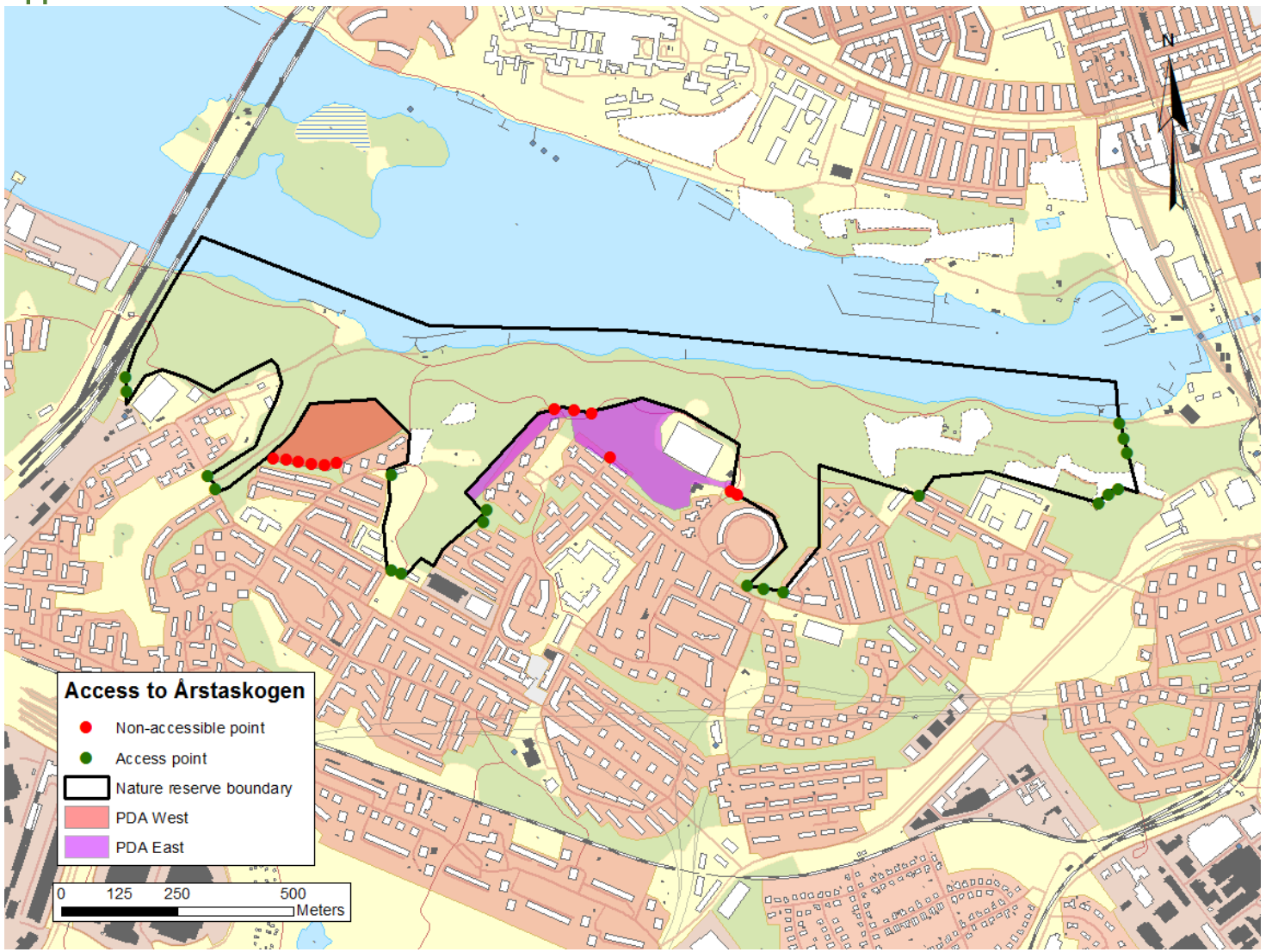


Map of dispersal patterns for species associated with old oak forest, broadleaved deciduous forest, coniferous forest and wetland. Based on the dispersal capacity of associated species, em is a Swedish abbreviation (*sv. effektiva meter*). According to this map, species can scatter 3 000 meter at the most. (Zetterberg, 2012).

Appendix II

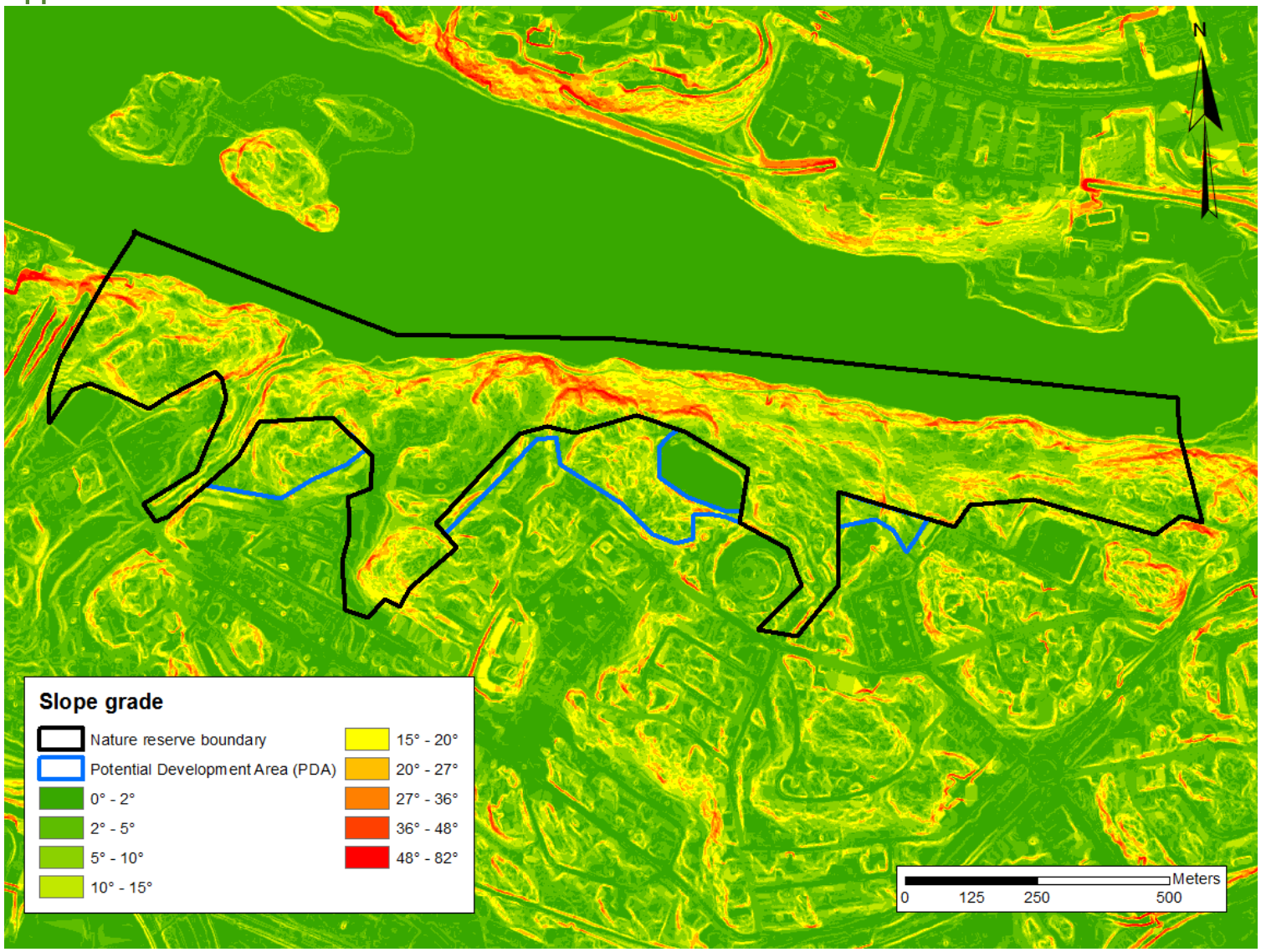
Observations of pines with the fungus *Phellinus pini* in Årstaskogen (Stockholms stad, 2012).

Appendix III



Map showing peoples current and potential non-accessible points to Årstaskogen due to the high exploitation proposal. Based on map created by the architectural firm Andersson Arfwedson (2104) for the construction form Erik Wallin AB. (Visualization: Liam Martin, 2018)

Appendix IV



Slope map of Årstaskogen. Created through accessed elevation data from Lantmäteriet (2018). (Visualization: Liam Martin, 2018)