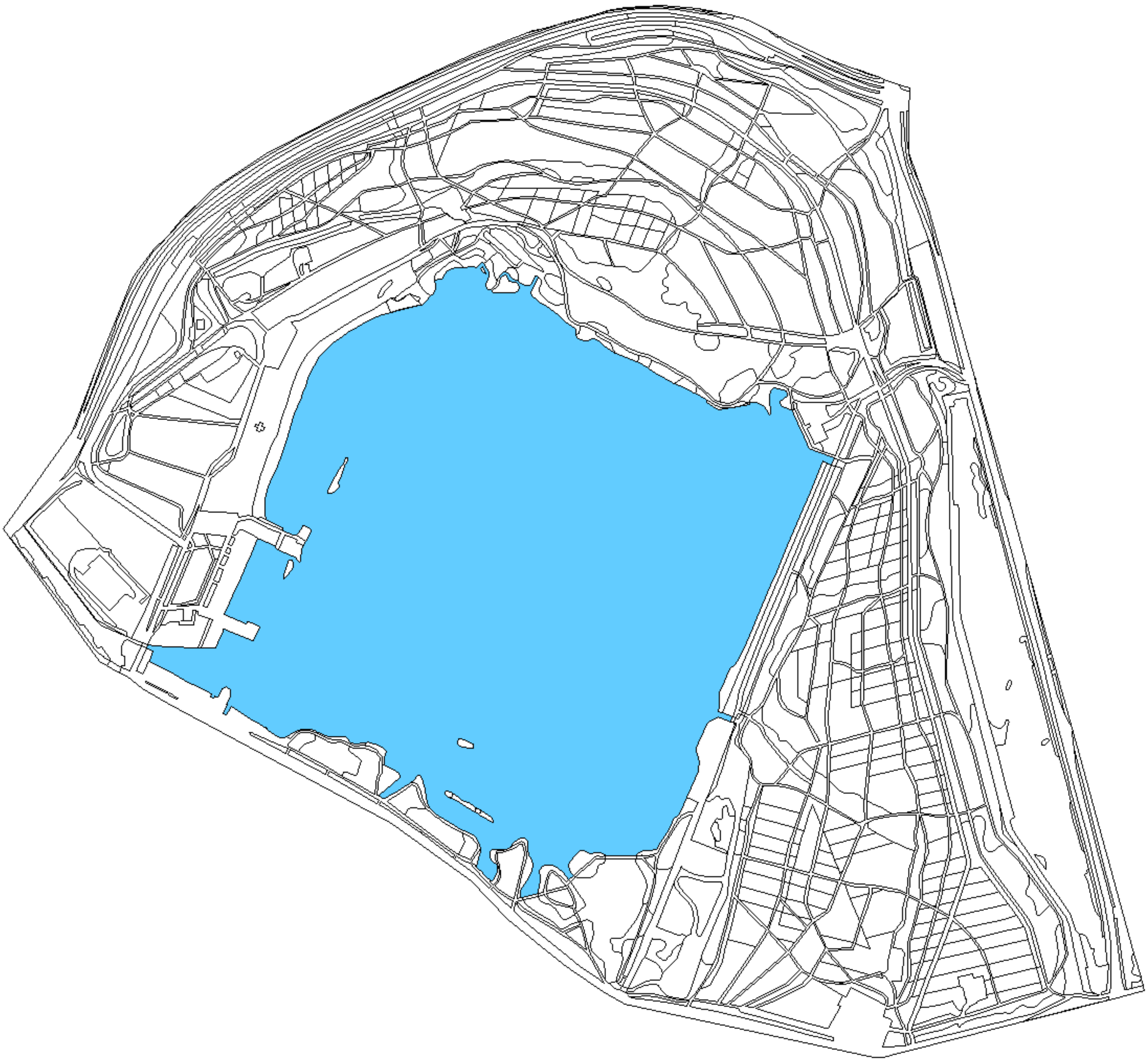
The Future Of City Parks

Case study: Kralingse Bos



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STERKER DOOR STRIJD

The Future Of City Parks

Bachelor Thesis

Forest and Nature Management

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Preface

As a Rotterdam born and raised child my fascination for nature was quite unique.

Rotterdam is the second biggest city in The Netherlands and has one of the biggest and most famous harbours in the world.

My fascination for nature brought me to Van Hall Larenstein for the Bachelor in forest and nature management. Soon, I realised my interest in tropical forests for their immense and complex role in climate regulation. This is why I started the major and minor in tropical forestry.

After being in the tropics for over a year in total I recognized how much my hometown, Rotterdam, meant to me and I wanted to investigate the possibilities for a green Rotterdam.

Within a week I faced many initiatives that were already working on a sustainable Rotterdam to come to the conclusion that now is the time.

Green roofs and urban gardening are two of many green initiatives in Rotterdam. With my background in tropical forests, I found the role of ecosystem services (such as carbon storage and air filtration) of a city park in The Netherlands to be interesting. Ecosystem services provided by city parks are not seen as important as ecosystem services supplied by tropical forests.

With this in the back of my mind and knowing that urbanisation is a fact, causing increasing value for land to build on rather than for nature, this seemed as an important time to research the value of city parks and their future potentials.

With this idea I stepped towards the municipality whom reacted very enthusiastic and immediately put me to work. C.A. de Vette helped me from the beginning till the end, introducing me to many interesting and inspiring people, arrange materials and documents and guiding me through the office life. I want to express my gratitude towards F. van Keulen for his management and S.H. Kemp-Chung for her guidance in the professionality aspect of this research. I want to thank R. Loch for his support from Urban Management and I also want to acknowledge P. van der Meer for his assistance, feedback and instructions from Larenstein.

Wouter van den Berg
Rotterdam
06-07-2018

Summary

Climate change is an ongoing worldwide event with visible effects in all levels and divisions of society. Large scaled projects to counter climate change are mostly investing in industrial programmes or outsourced projects to foreign (mostly third-world) countries.
The world is undergoing an urbanisation process where it is expected to account for 68% of the total world population to be living in urban areas by the year 2050. This means that urban areas are going to be much more important hotspots for climate change mitigation and human wellbeing.
At present, urban green areas are undervalued and should be reviewed on all their potential values to society and climate change. Urban green provides multiple ecosystem services which are to the utmost importance in cities as its effect to human well-being is most evident there.

The method used is field and desk research. Field data was collected in 45 (0,04ha) plots in the Kralingse Bos, Rotterdam (The Netherlands). Trees with a dbh >5cm and height >1,30m were measured. The biomass was used to calculate carbon stock and sequestration from the aboveground vegetation. Within every individual plot a soil sample (0-15cm) was taken and send to Omegam (laboratory) where soil organic material was measured. From this data soil organic carbon content was calculated. In partnership with K. Smit (Wageningen University) other ecosystem services were quantified and financially valued. Additionally a small survey (108 participants) was held for an indication of the citizens thoughts on urban green. Based on the collected data four districts were selected where implementation of urban nature seemed most beneficial.

The results found that the Kralingse Bos has a similar aboveground C stock as a tropical forest and a higher C stock in the soil. Nevertheless carbon sequestration rates are higher in tropical forests due to faster biomass growth. But, recent research shows that tropical forest might be a net source of C emissions due to deforestation and forest degradation.

Apart from carbon sequestration, the Kralingse Bos visibly renders its ecosystem services with €6 million yearly and €141 million onetime value. Air filtration and labour loss prevention were found to be the most valuable. In addition, financial benefits were found to be transcendent of the costs. Therefore it is concluded that urban nature is relevant in a national and international context.

Urban nature can contribute to a green, healthy and futuristic city when implemented in climate sensitive areas that directly benefit citizens.

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List of terms and abbreviations

ACS	Aboveground Carbon Storage
BD	Bulk density
C	Carbon
C stock	Quantity of carbon in a carbon pool
C storage	Process of capturing carbon dioxide by transporting it to where it will not enter the atmosphere
Carbon pool	A system with the capacity to storage or release carbon
Carbon sink	A natural environment with the ability to absorb carbon from the atmosphere
CO2	Carbon dioxide
COP	Conference of Parties
Cseq	Carbon sequestration - process by which carbon dioxide is removed from the atmosphere
CW	Weight of carbon dioixde sequestered
DBH	Diameter breast hight
DW	Dry weight
ES	Ecosystem service
GHG	Greenhouse gas
GW	Green weight
Mt	Mega ton
OM	Organic Material
SCS	Soil Carbon Storage
SD	Sampling depth
SOC	Soil Organic Carbon
SOM	Soil Organic Material
Stdev	Standard deviation

1. Introduction

Recent research shows a rapid decrease in tropical forest area. Alarming rates of 9% decrease in Latin America to 12% decrease in the South of the African Sahara (Steijaert, 2018). Forests are important systems for climate change mitigation (Gill, Handley, Ennos, & Pauleit, 2007). Research has shown their capacity to accumulate or release carbon (FAO, 2003). Forests also play a part in global carbon sequestration, creating “carbon pools” (Karsenty, Blanco, & Dufour, Forest and climate change, 2003). In the 2015 Global Forest Resources Assessment of The Food and Agricultural Organization of the United Nations (FAO) the mitigation potential of forests is emphasized: “forests can play a significant role in the mitigation of climate change” (Federici et al., 2015).

Apart from carbon sequestration forests contribute with multiple other Ecosystem Services (ES), benefits that are freely gained by humans from the natural environment and ecosystems. Ecosystem Services are described as “the provision of a product (e.g. drinking water), a regulatory authority (e.g, pollination of crops), a cultural service (e.g, providing opportunities for recreation), or a service that supports the services mentioned earlier (e.g the cycle of nutrients in an ecosystem)” (Hendriks, 2017).

Since the Millennium Ecosystem Assessment of 2005 global trends show increasing interest in ES. The search term ‘ecosystem services’ has been doubled since 2004 (Google Trends, 2018). ES have extensive potential to moderate climate change impacts and improve citizen well-being (Bolund & Hunhammar, 1999; Chiesura, 2004; Derkzen, van Teeffelen, & Verburg, 2015; Dobbs, Escobedo, & Zipperer, 2011; Escobedo, Kroeger, & Wagner, 2011).

Nevertheless, where tropical forest area is decreasing there is an increase in temperate forest area. Rich industrial countries are becoming increasingly more green (Steijaert, 2018). Noteworthy to mention is the urban prospect of rich industrial countries. In the 2018 United Nations Revision of World Urbanization Prospects, rapid increase in urban population is specified. In 2018, 55% of global population lived in urban areas and is estimated to reach 68% in 2050 (United Nations, 2018). Consequently, nature in these urban areas is going to be of much more value. Future predictions seem to visualize a picture where there is hardly any untouched forest left and urban nature is going to be the only accessible nature to society.

Urban nature benefits society in a comprehensive way, from environmental and ecological services to important social and psychological benefits (Gill, Handley, Ennos, & Pauleit, 2007; Rosenzweig, Solecki, & Slosberg, 2006; Baró, et al., 2014; Millar, Stephenson, & Stephens, 2007; Bolund & Hunhammar, 1999; Federici et al., 2015).

Social and psychological benefits to human society have been acknowledged by the European Union (EU) as results from an EU-funded project made believe that, due to an improvement of health and wellbeing of individuals, the community at large is more sustainable (Chiesura, 2004).

National level

The Netherlands set up a climate policy (Het Klimaatbeleid) in order to meet their climate objectives. Part of their policy is carbon dioxide (CO_2) emission compensation. This will be done in several ways, of which one is to create new forest areas (Ministerie van Infrastructuur en Milieu, 2013). A major governmental agency of The Netherlands is Rijksinstituut voor Volksgezondheid en Milieu (RIVM), or The National Institute for Health and Environment. One of their projects 'Atlas Natural Capital' is investigating the potential use of ES and benefits for society.

Nationally it is agreed that the city of Rotterdam is going to be an example city where new sustainable concepts get the space to experiment (Ministerie van Infrastructuur en Milieu, 2013).

Rotterdam

"Sustainable, you just do it", is the motto of Rotterdam. A sustainability programme is set up by Rotterdam, containing multiple ambitions to meet the climate goals and set an example of a circular city. Ambition 1 of the programme "closer to the Rotterdam citizen" (dichter bij de Rotterdammer) is: a green, healthy and futuristic city (Gemeente Rotterdam, 2015).

In order to meet this ambition the following themes are treated:

1. Clean air: optimize sustainable mobility, focussed on less polluting transport in the city centre and increasing use of public transport and bike
2. More green: increase of useable green in and around the city
3. Dry feet: a combination of fortifying the water security and resilience of the city
4. Sustainable areas: for every area development plan there are standard frameworks and goals for sustainability

All of these themes are relatable to ES provided by urban nature.

1.1 Problem statement

The City of Rotterdam has the ambition to become a green, healthy and futuristic city but there is a lack of detailed information on local scale effects of urban nature. Rotterdam is one of biggest harbour cities and located below sea level, therefore it is very sensitive for climate change. Additionally, it is the second biggest city of The Netherlands and prospects show increasing population density. Therefore urban nature and its ES for climate change mitigation and human wellbeing are to utmost importance here.

1.2 Objectives

This research aims to obtain knowledge and insights on local scale effects of urban nature for the City of Rotterdam in order to select potential areas for urban nature implementation which can be used for their ambition "a green, healthy and futuristic city".

- Increase in knowledge of the actual effects of urban green in Rotterdam
- Increase in information of existing ecosystems services
- Increase in awareness of economic benefits from urban green

1.3 Research questions

How can urban nature contribute to “a green, healthy and futuristic city”?

- ∞ How relevant is carbon stock in the Kralingse Bos in a national and international context?
- ∞ What is the current financial value of ecosystem services provided by the Kralingse Bos?
- ∞ Where are possibilities for implementing urban nature in Rotterdam?

1.4 Significance of study

This research study could provide information on the actual effects of city parks and their ecosystem services. This information can be used by governments for future development areas in order to meet the COP21 agreement for decreasing carbon dioxide levels and increasing overall human well-being. This study would be beneficial for the City of Rotterdam as detailed information is gathered on ecosystem services of the Kralingse Bos, which can be used for their sustainability and resilience programme. Furthermore this research study can be interesting for other cities with a similar climate as the results would be comparable.

2. Methodology

Detailed information was provided by the Municipality of Rotterdam and the National Institute for Health and Environment (RIVM). Some if this information is confidential and therefore not explicitly named or used in this report. The research area "Kralingse Bos" is located in Rotterdam, The Netherlands (Appendix III). The Kralingse Bos is a recreational park with an area of around 250 hectares. The lake, located in the south-west corner, is 100 hectares large. Forested area is around 100 hectares with open fields covering up around 50 hectares. The park is used for all kinds of recreation such as jogging, cycling, tree climbing, swimming and festivals. A sampling percentage of 1% is used (1,5 hectares for the total green area).

This research consists of (1) field data, (2) desk research and (3) interviews. The field data was collected from 22-01-2018 till 22-02-2018. Collected field data is used to calculate carbon stock and sequestration in order to visualise its relevance in a national and international context. Additional desk research is done for information on financial value of existing ES and to find locations for possible implementation of urban nature. Interviews are held to indicate a relative perspective of the citizens opinion on public green.

Based upon the results, interests of stakeholders (urban nature, government and citizens) are visualised and a recommendation is given on possible contribution of urban nature in the ambition for a green, healthy and futuristic city.

2.1 Field data

This research contains two types of field data from the Kralingse Bos.
(1. Aboveground carbon storage; 2. Soil carbon storage). See Appendix IV for the plot locations and coordinates (coordinates are in decimal degrees).

2.1.1 Aboveground carbon storage (ACS)

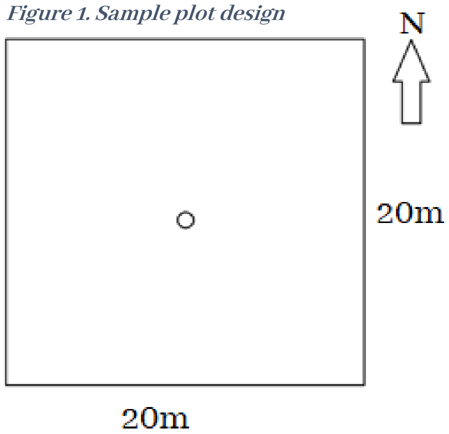
Aboveground carbon storage is measured with 45 square plots (20x20m) of 0,04 hectares each (figure 1). The plots are randomly selected using ArcMap tool "Create Random Points".

Only trees with height >1.3m and a DBH >5cm are measured (MacDicken, 1997).

Information is gathered on:

1. Location
2. Species
3. Stem diameter (DBH, 1,3m above ground)
4. Tree height

Figure 1. Sample plot design



This data is used to calculate the weight of carbon dioxide sequestered in the trees. The “4-step” formula is used (adapted from U.S. Department of Energy, 1998):

1. Calculate the total (green) weight (GW)
f = form factor, in this research a factor of 0,5 is used (paraboloid)
DBH = diameter breast height (1,30m) in cm
H = Height tree in meters

$GW = f \times \pi \times (DBH/200)2 \times H$

2. Calculate dry weight of the tree (DW)
DW = GW x 0,725
The factor 0,725 is used as a tree contains of 72,5% dry matter on average

3. Calculate weight of carbon in the tree (C)
C = DW x 0,5
The factor 0,5 is used as the average carbon content of a tree is 50%

4. Calculate the weight of carbon dioxide sequestered in the tree (CW)
CW = C x 3,6663
The factor 3,6663 is used as the CO_2 to C ratio is 3,6663

For trees in poor or dying condition the results of the biomass equation is reduced with 25% and 50% for dead trees (Hoehn, 2010).

Averages are used in the formula in order to keep within the available time and budget terms. General formulas tend to have an acceptable standard error of 2% (Nowak & Crane, 2002).

For every plot the total aboveground carbon storage will be calculated by summing up the total aboveground carbon stock of all the individual trees in the plot. The weight of carbon dioxide is divided by 70 (the average tree age in the forest) in order to calculate the weight of carbon sequestered per year.

2.1.2 Soil carbon storage (SCS)

In the plot centre a soil profile of 0-15cm beneath the surface is taken to measure carbon content. This is sampling depth which is recommended by DEFRA (2012). The soil sample is brought to the laboratory (Omegam) where the percentage of soil organic material (SOM) is measured. To calculate the soil organic carbon (SOC) the results of Omegan are multiplied by 0,58 as SOC content is 58% of the organic matter (FAO, 2017).

SOC stock is calculated by the formula SOC (kg/ha) = SOC (%) x BD (g/cm3) x SD x 1000

Where: BD; Bulk density, SD; Sampling depth (cm)

Due to a limitation in assets the bulk density values per sample were not measured. Therefore the average bulk density of 1,3 g/cm3 is used (Pribyl, 2010).

2.2 Financial Value of Ecosystem Services

In partnership with K. Smit (Wageningen University) ecosystem services are quantified and valued. The results gathered by K. Smit in his report "The Quantification and Valuation of Ecosystem Services in the Kralingse Bos" (2018), are used as an indication in this research and therefore not broadly discussed.

2.3 Interviews

Information on this topic and current state with stakeholders is not collected quantitatively or structured but in informal, non-research methods, and are therefore not used as factual data. This information is used as indication.

Ventures and networking events are visited to gather information with informal interviews on possible stakeholders and ongoing trends. Area committees, Venture Café, Blue City, M4H and De Groene Connectie are parties that were visited to get insight in current, young and hip trends in sustainability and circularity.

CLM, Qurrent, Shell, Port Of Rotterdam and Heineken are contacted to learn more about the current sustainability trends of big companies and polluters.

An online survey was published on multiple online platforms ranging from sustainability groups to young entrepreneurs to gather data of desires of citizens on urban green.

2.4 Possibilities for implementation

Ambitions from other cities such as Vancouver, who aim to be the greenest city by the year 2020, are used as an example.

One of the targets that defines a green city is the access to public green. Almost every citizen (95%) should live within a five-minute walk of a park, greenway or other green space. A five-minute walk is equal to 400m distance (City of Vancouver, 2012)

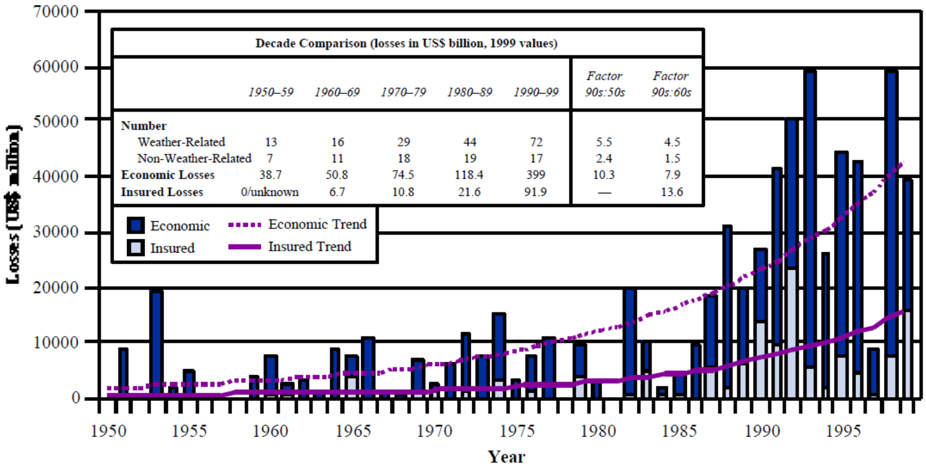
Areas with the highest population density are selected in order to increase the percentage of citizens that live within a five-minute walk of an urban green space. These areas should have the main focus for implementing new public green spaces in the future.

Maps for visualisation and calculations are made using ArcMap. Stakeholder interests are taken into account for selecting possible implementation areas.

3. Literature review

Global warming is a worldwide recognized event. The Earth's temperature is rising due to excessive amounts of, human induced, greenhouse gas emissions. This causes enormous environmental disasters (NASA, 2017). These environmental disasters are harmful for people all over the world. Extend of climate change effects are not restricted to the environmental sector but also affects the economic (figure 2) and social sector (European Parliament, 2017; Goulder & Pizer, 2006; Laczko & Aghazarm, 2009; McCarthy, Canziani, Leary, Dokken, & White, 2001). "Global economic losses from catastrophic events increased 10,3-fold from 3,9 billion US$ per years in the 1950s to 40 billion US$ per year in the 1990s" (McCarthy et al., 2001). In addition, since 1970 only 6 of the 40 worst insured losses were not weather related (McCarthy et al., 2001).

Figure 2. The costs of catastrophic events (McCarthy, Canziani, eary, Dokken, & Whitte, 2001).



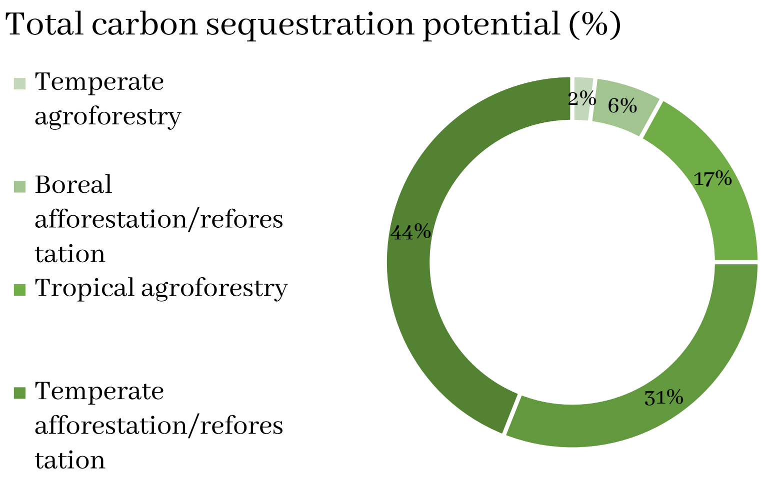
One of the most affecting greenhouse gases is carbon dioxide (CO2). The concentration of carbon dioxide in the atmosphere has increased by 31% since 1830 (NASA, 2017). Naturally this carbon dioxide transfers from the world's forests and oceans into the atmosphere and vice versa. However, with the current rising trend of carbon dioxide in the atmosphere, increasing global temperature and the decrease of natural carbon pools, the carbon dioxide situation reached beyond natural proportions (NASA, 2017).

With new information on the current global carbon cycle, the role of global forests and their capacity of reducing the level of carbon dioxide in the atmosphere (also known as carbon sequestration) is now being recognized as a tool that is used to meet the climate goals that were agreed on with the Paris Climate Conference or 21st Conference of the Parties (COP21).

According to FAO, forests cover 31% of the total land area. Temperate forest area accounts for 26%, boreal forest for 22%, and sub-tropical forest for 8%, the largest area of forest are found in tropical countries (44%).

Tropical afforestation/reforestation and agroforestry practices have the highest carbon sequestration potential (75%), leaving boreal afforestation/reforestation and temperate agroforestry with a small 25% (graph 1).

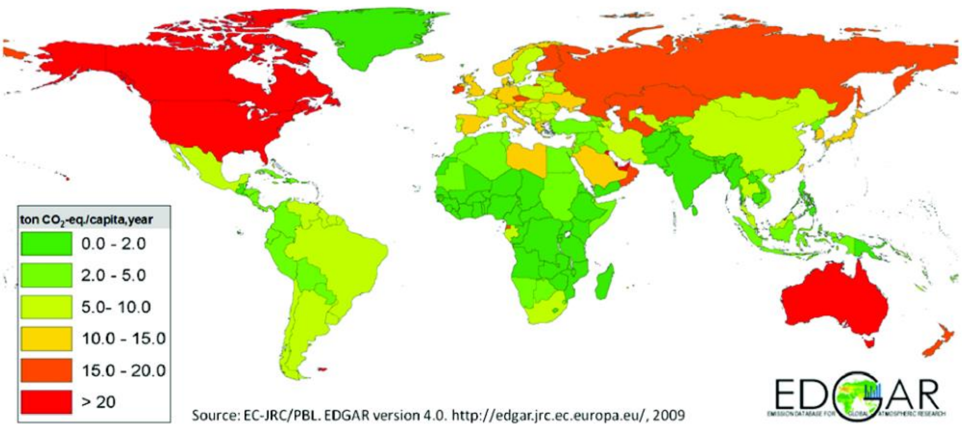
Graph 1. Total carbon sequestration potential, Brown et al (1996)



Tropical forests are thought to be one of the most potent ecosystems for storing carbon due to their ascendency in area and fast biomass growth. But, in a long-term research of 12 years by A. Baccini et al. (2017) the net carbon source of the world's tropical forests was found to be 452,2 ± 31,0 Tg C per year (Baccini, et al., 2017). Where gains are most likely the result of forest growth and losses the result of deforestation, degradation and disturbance (Baccini, et al., 2017). According to their research: "the latter accounts for 68,9% of overall loss".

Tropical countries are not the major contributors of carbon dioxide emissions per capita. As can be seen in figure 3, the main contributors of carbon dioxide emissions per capita are countries with the largest area of boreal or temperate forests (North-America, Russia, Europe). Where CO2 emissions in tropical areas are mostly caused by deforestation, CO2 emissions in boreal and temperate countries are mostly caused by industries and urban areas (European Parliament, 2017).

Figure 3. Global carbon dioxide emissions per capita (EDGAR, 2009)



Urban areas have the potential to play a significant role in mitigating climate change (McCarthy, Canziani, Leary, Dokken, & White, 2001). As urban area increases so does their role in mitigating climate change. In 2018 the world's population consisted of 55% urban habitants (UN, 2018) and by 2050 the world's urban population is estimated to be 68% (UN, 2018). As natural area decreases and urban area increases their potentials to mitigate climate change are becoming very valuable.

Urban forests deliver multiple ecosystem services. These services have been described by a great variety of literature and scientists (Escobedo, Kroeger, & Wagner, 2011). Urban forests deliver services such as; air pollution removal, storm water interception, tree shading, benefits for human well-being, ecological economics, agricultural economics, biodiversity conservation and carbon storage (Bolund & Hunhammar, 1999; Dobbs et al., 2011).

Although city parks have a generally lower tree cover than forest stands, their possible carbon storage and gross sequestration per unit may be greater (Nowak & Crane, 2002). According to Nowak & Crane (2002); "individual urban trees, on average, contain approximately four times more carbon than individual trees in forest stands".

This difference is mainly because trees in urban areas have a more open forest structure and faster growth rates. The difference in tree density, which give urban trees the ability to grow a higher diameter, causes the difference in carbon stored per unit (Nowak & Crane, 2002). Therefore, the difference in carbon sequestration between urban forests and forest stands are not directly comparable.

For example, natural green areas (such as agricultural land, dunes, salt marshes and forests) in The Netherlands sequester around 3,6 megaton (Mt) of CO2 from the atmosphere, accounting for 2% of national emissions (Lof, et al., 2017). Forests in The Netherlands sequester 60% (2,7 Mt), accounting for 1,3% of national emissions (Lof, et al., 2017).

As can be seen in Appendix I, most carbon is sequestered in areas with a high percentage of forest area; Gelderland, Utrecht, Noord-Brabant. Lower carbon sequestration areas are; Zealand, Flevoland and the urban agglomeration. Zealand and Flevoland have a low carbon sequestration rate due to a high area percentage of arable land and a low percentage of forest.

When scoping into the urban agglomeration (figure 4) it is visible that there are some dark blue spots, indicating carbon sequestration of more than 4 tonne C per hectare per year. Circled in red is the Kralingse Bos area, located in the township Rotterdam.

This is one of the areas within the urban agglomeration where carbon sequestration rates are relatively high.

This high carbon sequestration area is unique from other areas within the urban agglomeration as it is located near the city centre and within livelihoods.

City park 'Kralingse bos' is the most important ecosystem service area in Rotterdam, The Netherlands (Derkzen et al., 2015). As can be seen in Appendix II central north-east, the Kralingse Bos (indicated with the red dot) scores on every ecosystem service the maximum.

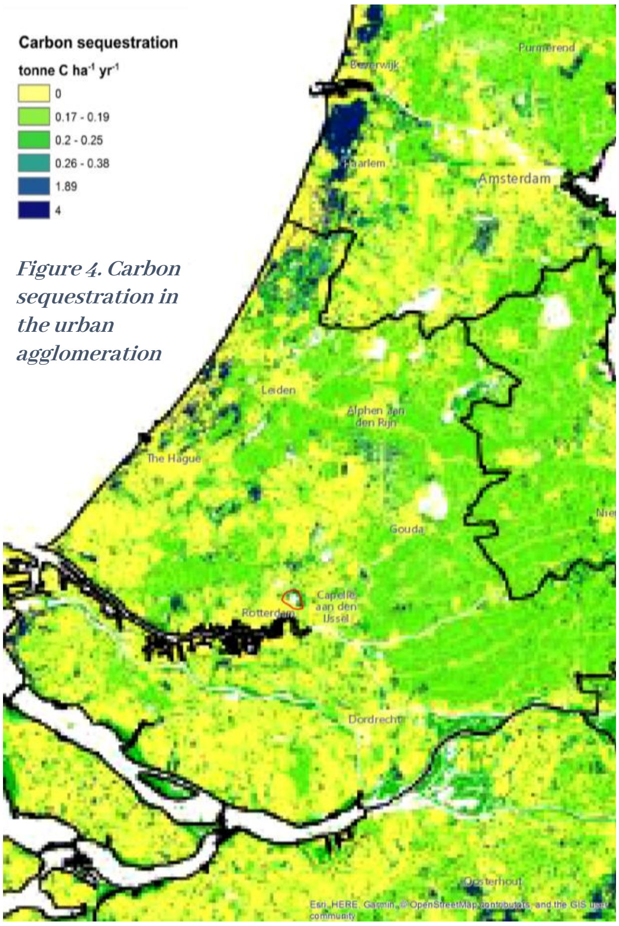


Figure 4. Carbon sequestration in the urban agglomeration

As described by the Dutch Institute for Public Health and Environment (RIVM) and Atlas Natural Capital (Atlas Natuurlijk Kapitaal) there are several services provided by urban forests. RIVM divided these services into 4 categories(CICES-Classification, EU):

1. Production: Timber, fibre, genetic sources, biomass for energy, drinking water, food
2. Cultural: Recreation, natural heritage, symbolic value, science and education, therapeutic value, labour loss prevention, increase in property value
3. Abiotic: Renewable energy sources, non-renewable energy sources, mineral sources
4. Regulating: Erosion control, soil fertility, water storage, cooling, sound absorption, biodiversity conservation, cleaning air, water and soil, pollination, carbon storage

Different assessments exist for the classification and valuation of ecosystem services, the most commonly used are the Millennium Assessment and The Economics of Ecosystems and Biodiversity.

With this research the potentials of a 70 years old city park, with an area of 250 hectares and main use recreation, are quantified. It is hoped that this information can motivate cities to create new parks, for not only recreation but also as a climate adaptation strategy, improve human wellbeing and to meet the desires of citizens.

4. Results

A total of 45 plots (1,8 hectare) were measured. Within these plots a total of 709 trees were measured and 45 soil samples were taken and analysed on percentage organic material (OM). A complete list of the field data results presented in Appendix X. A list with the most important data is shown in the table below. Average tree density is 400 trees/ha, average ACS is 122,3 t/ha, average SCS is 75,3 t/ha and average Cseq is 6,4 t/ha/y.

Table 1. List with most important field data of the Kralingse Bos

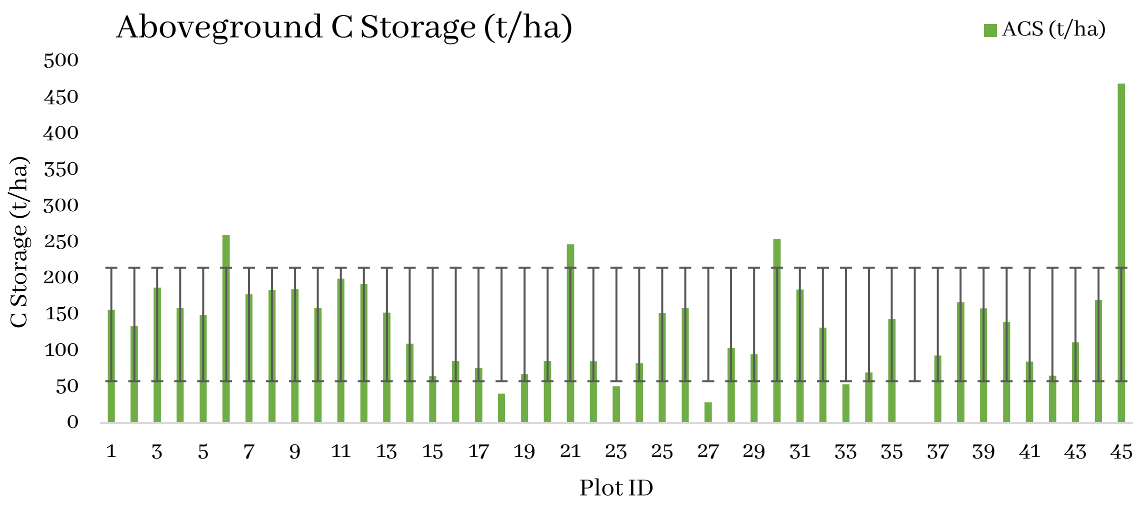
Plot ID	# Tree	Tree density (trees/ha)	GW (t/ha)	C (t/ha)	CW (t/ha)	Cseq (t/ha/y)	OM (%)	SOC (t/ha)
1	21	525	432	156	574	8	4,8	36,2
2	20	500	369	134	491	7	6,6	49,8
3	26	650	516	187	686	10	8,1	61,1
4	21	525	438	159	582	8	9,6	72,4
5	25	625	412	149	548	8	9,3	70,1
7	21	525	491	178	652	9	11	82,9
8	12	300	506	184	673	10	11,5	86,7
9	15	300	510	185	677	10	18,7	141
10	15	375	439	159	584	8	8,1	61,1
11	25	625	550	199	731	10	9,2	69,4
12	21	525	530	192	704	10	8,2	61,8
13	9	225	421	152	559	8	11,7	88,2
14	12	300	302	109	401	6	6,9	52
16	8	200	236	86	314	4	6,7	50,5
19	14	350	186	67	247	4	10,9	82,2
20	8	200	236	86	314	4	2,9	21,9
22	10	250	235	85	312	4	2,5	18,9
23	28	700	140	51	186	3	5,8	43,7
24	12	300	227	82	302	4	4,6	34,7
25	27	675	419	152	557	8	5,3	40
26	15	375	439	159	584	8	4,4	33,2
27	4	100	79	29	105	2	1,9	14,3
28	18	450	287	104	381	5	6,4	48,3
29	14	350	262	95	348	5	16,8	126,7
31	16	400	509	184	676	10	9,4	70,9
32	19	475	364	132	483	7	5,1	38,5
34	12	300	192	70	255	4	20	150,8
35	19	475	397	144	527	8	12,9	97,3
37	11	275	257	93	342	5	12,9	97,3
39	14	350	436	158	580	8	15,6	117,6
40	14	350	385	140	511	7	9,7	73,1
41	17	425	234	85	311	4	19,7	148,5
42	17	425	181	65	240	3	12,7	95,8
43	30	750	307	111	409	6	11,4	86
44	14	350	470	170	624	9	14,9	112,3

4.1 Aboveground Carbon Storage

Average aboveground carbon storage was found to be 122,3 t/ha. Minimum aboveground carbon storage was calculated to be 29 t/ha. Near minimum or minimum values were measured near or around open fields and areas with buildings. Maximum aboveground carbon storage was measured to be 199,3 t/ha. Near maximum or maximum values were measured in the southern corner (Appendix VI).

Plots 6, 21, 30, 36 and 45 significantly exceed the standard deviation error bar (graph 2). Therefore the comparison of the maximum measured C storage is not seen as credible and named “error plots”. These “error plots” were deleted to form a new dataset. This new dataset was compared with the old dataset to see whether or not there was a significant difference.

Graph 2. Aboveground Carbon Storage (t/ha) per plot, location: Kralingse Bos



As there is no significant difference (p>=0,05) between the old and new dataset, the probability for a coincidental difference is 33% (table 2), plot number 6, 21, 30, 36 and 45 are not taken into account for comparison and map making.

Table 2. T-test for old values (all plots) and new values (40plots)

T-test	Old	New
Mean	136,06	122,32
Variance	6169,46	2384,88
Observations	45	40
P(T<=t) two-tail	0,33	
t Critical two-tail	1,99	

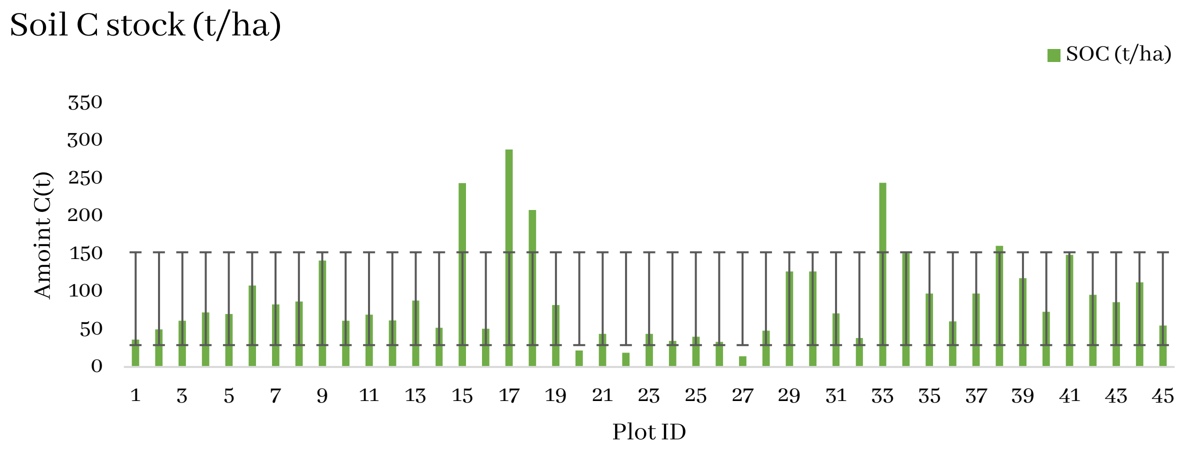
4.2 Soil Carbon Storage

Average soil carbon storage was found to be 75,3 t/ha. Minimum soil carbon storage was calculated to be 14,3 t/ha. Near minimum or minimum values were measured in non-forest areas such as open grasslands and building sites. Maximum aboveground soil carbon storage was measured to be 150,8 t/ha. Near maximum or maximum values were measured in the Southern and North-Western corner (Appendix VII).

Appendix VIII shows a map with total carbon storage (vegetation + soil) of the Kralingse Bos.

Plots 15, 17, 18, 33, 38 significantly exceed the standard deviation error bar (Graph 3). Dutch forests rarely exceed 150 t/ha (Nabuurs & Verkaik, 1999). Therefore these plots are not seen as credible and are taken out of the database for comparison and mapping.

Graph 3. Soil Carbon Storage (t/ha) per plot, location: Kralingse Bos



As there is no significant difference (p>=0,05) between the old and new dataset, the probability for a coincidental difference is 33% (table 3), plot number 15, 17, 18, 33, 38 are not taken into account for comparison and map making.

Table 3. T-test of soil samples and samples w/o error samples

T-test	Old	New
Mean	90,51	75,34
Variance	3785,54	1430,59
Observation	45	40
P(T<=t) two-tail	0,17	
t Critical two-tail	1,99	

4.3 Carbon Sequestration

Average carbon sequestration in the Kralingse Bos is calculated to be 6,4 ton/ha/year (Appendix IX). This results in a total average of 640 ton/year for the whole park.

In the current European Emissions Trading System (EU ETS) the value of one ton C is now €9,56 (27-02-2018). This results in a total yearly value of €6.118,40.

Carbon sequestration is calculated by dividing the current CO2 content by the average age of the forest (70 years). This method is very general and not detailed enough for a realistic future prediction as the annual increment cannot be calculated with the inventoried data. This was done on purpose as there were not enough assets to measure in such a detailed way.

4.4 Financial Value of Ecosystem Services

The park contains around 36600 trees and sequesters a total of 640 ton/year, which compensates around 88 households every year, or around 200 persons. It has no significant production, abiotic, noise reduction and run-off retention value.

Though, the Kralingse Bos provides other ES and has been reviewed by Derkzen et al. (2015) and K. Smit (2018). The main topics discussed in their research are; air purification, carbon storage, noise reduction, run-off retention, cooling and recreation.

When looking at ecological profitability a financial assessment is made with the TEEB-tool. Giving financial value to certain ecosystem services provided by urban nature is useful for value indication to those who relate value to financial value.

The TEEB-tool calculates with trees higher than 10 meters. In the 45 plots measured there were a total of 659 trees higher than 10 meters. This is an average number of trees on an area of 1,8 hectares. The total forested area is 100 hectares. This results is an estimated total of 36611 trees.

Results of the desk research are presented in table 4. Where ES provided by the Kralingse Bos are visualised with Total Economic Value (TEV) and Net Present Value (NPV).

Table 4. Results of desk research to Financial Value of ES Kralingse Bos (k. Smit, 2018)

Service	TEV one time (Million euro)	TEV yearly (Million euro/year)	Total 30 years NPV (Million euro)
Air filtering	(-)	2.35	65.32
Carbon sequestration	(-)	0.91	25.38
Water retention	(-)	0.14	3.09
Medical value	(-)	1.27	35.28
Labour loss value	(-)	3.50	97.13
Cooling	(-)	0.067	1.86
Property value*	193*	(-)	155.50*
Maintenance costs	(-)	-1.9	-51.3
Investment costs*	-51.9*	(-)	-42.1*
Totals	141.1	6.37	228.90

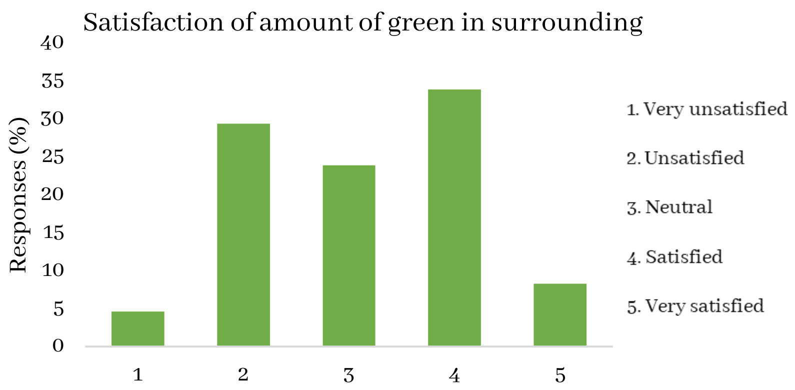
Labour loss prevention is the biggest contributor to yearly ecosystem service benefits of the Kralingse Bos. This is a result of the high assessed costs related with 9 diseases weighed within the TEEB tool. Next highest values are the maximum potential of air filtering and the flood damage prevention. Total ES value was calculated to be €6,37 million per year, with a onetime property value increase of €141 million.

4.5 Interviews

Interviews were held with citizens throughout whole Rotterdam in order to collect a broad scaled impression of the urban nature value. Scale 1 to 5 respectively represent 'very unsatisfied to very satisfied'.

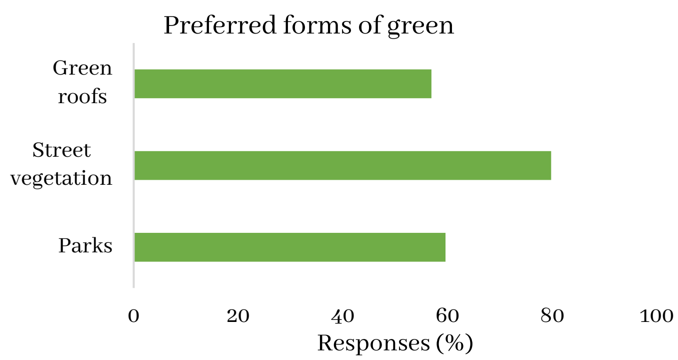
In a survey with 108 applicants (0,02% of Rotterdam population) opinions on the sufficiency of "green" in the surrounding varied greatly. Though most (34%) applicants replied to be satisfied with the amount of green in their surroundings, second most (28%) applicants replied to be unsatisfied with the amount of green in their surroundings (figure 5).

Figure 5. Responses to survey question 1



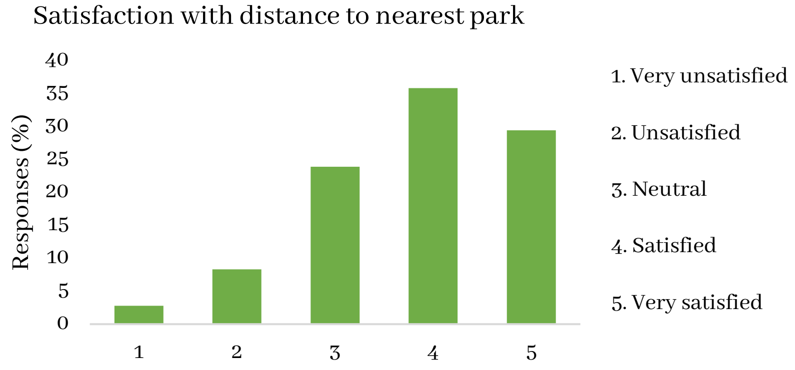
Applicants would like to see more green in the form of parks (60%), street vegetation (80%) and roof vegetation (57%) (figure 6).

Figure 6. Responses to survey question 2



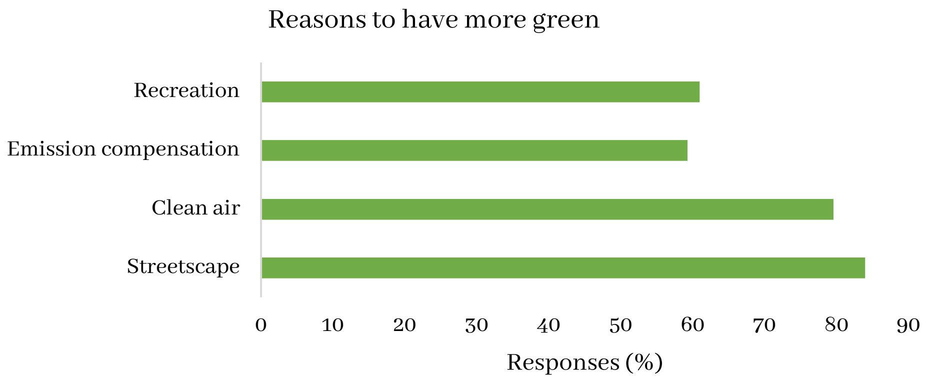
When asked if the applicants thought the distance to the nearest park was reasonable, most applicants (36%) agreed and second most (29,6%) applicants were very satisfied with the distance to the nearest park (figure 7).

Figure 7. Responses to survey question 3



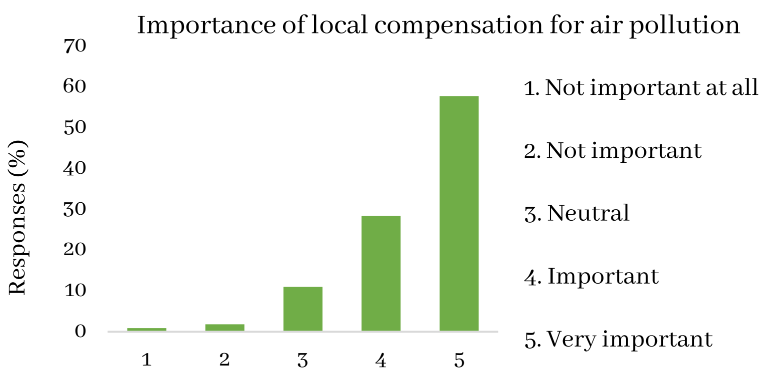
The main reasons to have more "green" are: streetscape (84%) and clean air (79,6%). Emission compensation (59,3%) and recreation (including walking the dog) are mentioned by 61% of the applicants (figure 8).

Figure 8. Responses to survey question 4



The applicants mostly agreed to find local compensation for air pollution very important (figure 9).

Figure 9. Responses to survey question 5



4.6 Possibilities for implementation

The total area of Rotterdam located within a five-minute walk from a public green space is 165 km2. This covers 50% of the total area, including the harbour. Excluding the harbour, 83% of the area has a public green space within a five-minute walk (figure 9).

Figure 10 visualises accessibility to public green space in the City of Rotterdam. An enlarged version of this map is attached in Appendix XII.

Figure 10. Map with visualisation of access to public green in the City of Rotterdam

5. Discussion

The field data that was gathered during this research should be seen as an indication rather than detailed data. Plot locations were probably not securely set on the exact coordinates as there was no GPS available and a mobile phone was used. Tree height was estimated as it would take too much time within the available assets to measure the exact height of each individual tree. Furthermore, a very general formula is used to calculate carbon stock of the trees. For the soil samples an average bulk density was chosen to calculate SOC as there were not enough assets to measure bulk density for each individual sample.

Comparing satellite data from CBS with field data from this research resulted in a significant difference, indicating that the difference in results are not based upon coincidence. This difference is probably not solely due to vegetation growth in the 3-4 years difference in measurement, but rather caused by a great variety of unknown factors. The most likely factor for causing this difference is the calculation used on the field data. Cseq was calculated by dividing the current carbon stock with the average age of the forest (70 years). This is a very general calculation and does not account for biomass growth per tree.

Therefore, the conclusions drawn from these results are rather an indication. When conclusions should be drawn on a city-wide scale it is important to realize that urban green comes with many variables. In example, pruned trees, lawns, and flower beds generally do not sequester much CO_2 and its maintenance can even emit sizeable amounts of CO_2 and N_2O through fertilization practices (Jo & Mcpherson 1995; Escobedo, Seitz & Zipperer 2012).

5.1 Relevance carbon stock

As the Kralingse Bos has more resemblance with a forest than a park, comparisons in this chapter are not made with parks but with similar forests. Open data on similar city parks, such as Central Park (New York) was not found and could therefore not be compared.

5.1.1 National

The data collected in the Kralingse Bos is compared with estimated carbon stock in a Dutch oak forest with a circulation of 120 years (Nabuurs & Verkaik, 1999).

5.1.1.1 Aboveground Carbon Storage

The estimated C stock in a 70 year old (age of the Kralingse Bos) Dutch oak forest is between 120 and 180 t/ha (Nabuurs & Verkaik, 1999). The mean C stock of the Kralingse Bos is 122,2 which matches the estimation of Nabuurs & Verkaik (1999). The reason why C stock in the Kralingse Bos is on the lower side of this estimation is probably due to the estimation of Nabuurs & Verkaik was for a monoculture Oak forest as where the Kralingse Bos is a mixed, not cultured forest.

As mentioned by Nowak & Crane (2002); “individual urban trees, on average, contain approximately four times more carbon than individual trees in forest stands”. This statement was found to be true in this research.

When looking at the results of plot 45, where Cseq rate was calculated to be 25 t/ha. Plot 45 contained 3 large solitary trees, causing a very high biomass. These three individual trees contained a total green weight of 51751 kg, comparing with the average measured green weight of 14179 kg per plot, this is 3,65 times higher. This confirms the statement "city parks have a generally lower tree cover than forest stands but their possible carbon storage and gross sequestration per unit may be greater".

5.1.1.2 Soil Carbon Storage

The soil C stock in oak forest is generally around 100 t/ha (Nabuurs & Verkaik, 1999). Taking into account that the Kralingse Bos has a very complicated history with its soil, exceeding C stock values (such as plot 30; 150 t/ha) are not seen as incredible. The forest has a rich and very complicated history. The soil has only been stable since around the 1970's. Before this time the forest was used for dumping debris from the war and it was used as a work provisioning project after the second World War.

Soils in a temperate ecosystem generally have a SOC of 96-147 tons C/ha (Lal, 2004). This is comparable with the sample data from the Kralingse Bos.

5.1.1.3 Carbon Sequestration

Carbon sequestration data of the year 2013 on a national scale has been made available by Centraal Bureau Statistiek (CBS). An online map was created by making calculations from satellite images and the ecosystem unit map. This map can be found on Atlas Natuurlijk Kapitaal (www.atlasnatuurlijkkapitaal.nl/kaarten). ArcMap is used to intersected CBS data with the plot locations to generate a table with information on carbon sequestration information calculated by CBS per plot (Appendix XI).

The error plots (6, 21, 30, 36 and 45) are not used for comparison.

Data from CBS shows a more even scale in comparison with the data collected in the field (Appendix XI). This is probably due to the scale in which the data is collected. CBS used calculations from a national scale and the field data was collected on site. The year in which the data was collected probably also influences the results as there is a 3-4 year difference. In 3-4 years vegetation grows, causing carbon stock to increase (which in this research influences the amount of carbon sequestered).

The Kralingse Bos consists mostly of forest-stand like areas and, according to this research, sequesters a yearly average of 6,4 t/ha. To illustrate the impact of a similar city park on a city-wide scale the emission per capita is used. An average Dutch person emits 3,2 ton CO_2 on a yearly basis (Planbureau voor de Leefomgeving, 2002). Thus, every half hectare of a similar city park sequesters the emissions of one person. Rotterdam counts 630.000 inhabitants (Halkes, 2016), hence a total of 315.000 hectares of a similar city park is needed to sequester the emissions of all the residents. In comparison, this equals 315 times the forest area of the Kralingse Bos. In addition, traffic, industries and such are not taken into account. This makes it very unrealistic to significantly compensate emissions locally with urban parks.

Then there is the "bigger picture" in carbon sequestration. Urban green will not sequester as much carbon as industrial alternatives or intact tropical rainforests. In example, the sustainable hydrogen power plant project 'C. GEN' will emit 2.5 Mt (2.500.000 ton) less than regular power plants on a yearly basis (Rotterdam Climate Initiative, 2010). This is 3.906 times more than the

Kralingse Bos sequesters yearly (640 ton). In comparison, Dutch forests sequester a total of 2,7 Mt C per year. There are multiple similar ongoing projects like C. GEN that have significantly more effect on CO2 concentrations in the atmosphere than urban parks will ever have.

5.1.2 International

Results of a similar case study in Surinam are used for comparison (Crabbe, 2012).

The C stock in a tropical rainforest in Surinam does not differ too much from the carbon stock in an urban forest. Important notice here is that carbon stock only indicates the amount of carbon that is stored in the aboveground vegetation. Yearly biomass growth is higher in tropical areas causing these areas to have a higher potential for sequestration of carbon (Baccini, et al., 2017).

Nevertheless, new research indicates that, due to deforestation and land degradation, tropical areas are now “a net source of carbon emissions” (Gaworecki, 2017).

5.1.2.1 Aboveground Carbon Storage

Although ACS in Surinam has a higher minimum and a higher maximum than ACS in the Kralingse Bos, the mean ACS is comparable. A higher minimum ACS in the tropics is probably due to fast biomass growth in, for example, canopy gaps. A higher maximum ACS in the tropics is relatable to the size and growth speed of older trees when compared with older species in the Kralingse Bos. Trees in the Kralingse Bos would likely not exceed 70 years of age with a height of 35m and dbh of 130cm as where this is more common to tropical areas.

5.1.2.2 Soil Carbon Storage

An important note to this comparison is the difference in the sampling method used. The case study in Surinam took samples 0-30cm , 0-60cm and 0-100cm in three different forest types.

The maximum C storage was found in Marshforest at a sampling depth of 0-100cm. The Surinam caste study found a maximum mean of 48,9 t/ha and a minimum mean of 8,7 t/ha at a sampling depth of 0-30cm in a low xerophytic forest.

The results of the Surinam study case are therefore in a great variance.

The minimum amount of C stored in the soil is relatively the same between the tropical forest in Surinam and urban forest Kralingse Bos. In contrast, the maximum amount of carbon stored in the soil of the Kralingse Bos is 300% of the maximum amount of C stored in the Surinam soil.

5.1.2.3 Carbon Sequestration

The potential contribution of afforestation/reforestation and agroforestry activities to global carbon sequestration were found to be the highest in tropical (44%) and temperate (31%) regions (Brown et al, 1996).

When temperate afforestation/reforestation and agroforestry practices are combined with urban nature, they can participate in 37% of the global carbon sequestration potential (Brown et al, 1996).

Intact tropical rainforests have shown to have a greater potential in carbon sequestration (Baccini, et al., 2017). But, the net amount of carbon sequestration has been shown to actually emit sizeable amount of CO_2 due to deforestation and degradation (Baccini, et al., 2017). Apart from carbon sequestration, the amount of carbon stored in the Kralingse Bos is comparable with the amount of carbon stored in a tropical forest. Though maximum aboveground carbon storage was found to be 1,18 times higher in a tropical rainforest, average soil carbon storage was found to be 2,8 times higher in the Kralingse Bos.

5.2 Financial Value of Ecosystem Services

Open data on financial valuation of similar urban parks was not found and could therefore not be discussed in this chapter.

When taking other ES provided by urban nature into account, it benefits to citizens and governments in extra ways that industrial projects and tropical forests can't. Even though financial benefits are considerably higher than the costs, financial value of ES are not widely accepted. Financial valuation of ES is still relatively new and remains difficult.

5.3 Possibilities for implementation

Vancouver wrote an action plan where they worked out how they are going to be the greenest city by the year 2020. In their plan they adapted urban nature solely as a target for "access to nature". Other goals and targets such as; clean air and zero carbon are not significantly affected by the potentials of urban nature. This corresponds to the results of this research.

The City of Rotterdam already set up a climate adaptation strategy where urban nature is included but not worked out in detail. According to the results 83% of the cities area is located within 400m distance from a public green space. This does not directly corresponds to percentage of inhabitants.

Nevertheless, taking "the greenest city in 2020" (Vancouver) as an example who aim to provide at least 95% of its citizens a public green space within 400m, Rotterdam can still make some improvements.

6. Conclusions

Carbon stock in the Kralingse Bos was found to be relevant in a national and international context. But, due to large local emissions, carbon sequestration by urban nature does not contribute significantly in comparison with industrial alternatives. On the other hand, financial benefits of other ecosystem services were found to be transcendent of the costs. Where air filtration and labour loss prevention are highest contributors to financial benefits and human wellbeing. In addition, urban citizens show to have interest in urban nature and local air pollution compensation.

6.1 Relevance carbon stock

Carbon stock in The Kralingse Bos is relevant in a national and international context. The Kralingse Bos stores around the same amount of C as a Dutch forest and tropical forest (compared with the case study in Surinam). Although, the amount sequestered per year in a tropical forest is higher.

In addition, the total green area in urban areas is lower than in tropical areas. This results in a higher competence for large scaled emission compensation in the tropics or industrial alternatives rather than local urban compensation. Alternatively, for smaller scaled emission compensation urban green does have a certain potential. Individual urban trees were proven to contain almost four times more biomass than trees in a forest stand.

The Kralingse Bos compensates emissions from 88 households, or 200 persons. Showing that every hectare of a similar city park can compensate around 2 persons every year. The total derelict area in The Netherlands is 505.000 hectares (Rijksoverheid, 2016), which can sequester 3 million tons of C per year when planted similar as the Kralingse Bos. In other words, compensate the yearly emissions of 1,01 million persons (6% of total population). This interpretation is rather unrealistic, knowing that sustainable alternatives for industries are almost 4.000 times more effective.

Alternatively, urban forests can be valued on more topics than just carbon sequestration. It provides regulating services that considerably have an effect on the negative aspects that come with urban areas such as air pollution and labour loss.

6.2 Financial Value of Ecosystem Services

It can be concluded that ES provided by the Kralingse Bos considerably benefits the surrounding neighbourhoods with a yearly value of €6 million and onetime value of €141 million. “Depending on the investment cost per municipality, the payoff time of an urban forest similar in size of the Kralingse Bos is approximately 7-8 years” (Smit, 2018). A similar urban park can pay off itself instantly “through the 6 to 8% increase in real estate value” (Smit, 2018).

6.3 Possibilities for implementation

The City of Rotterdam does have some open spaces left and can still make some improvements in the accessibility of public green. This would not only be beneficial to obtain one of the targets that defines a green city. Urban nature has shown to store a relevant amount of carbon in a national and international context. Furthermore, ES deliver benefits to human wellbeing, causing financial costs to be lower than the financial benefits. Additionally, citizens seem to mind a greener surrounding.

7. Recommendations

In order to holistically create a recommendation, interests of the stakeholders (figure 10) are taken into account. Figure 10 represents the correlation between stakeholders and their interest. Blue represents the government, their benefits consist of creating a climate resilient city in order to reduce climate-related costs, reduce costs by improving human wellbeing and serve citizen's needs. Orange represents the citizens, their benefits consist of a healthy and green environment for human wellbeing. Green represents urban nature, which needs a healthy ecosystem services in order to maintain itself.

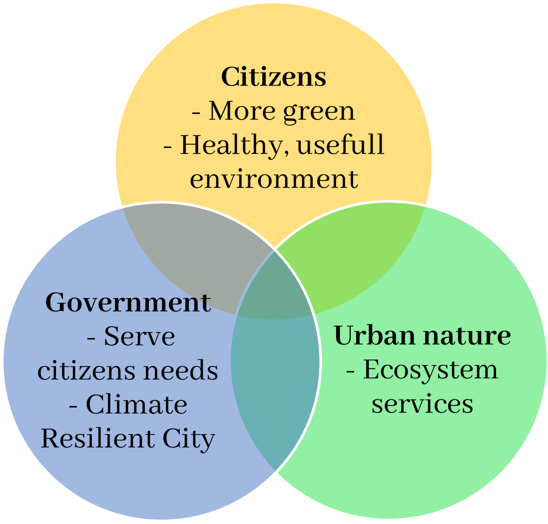


Figure 11. Stakeholder interests

Accordingly the intersection in figure 11, the government should create more green in climate sensitive areas that directly benefit citizens (figure 12).

As recommendation 4 districts are selected where there is a need for extra public green, based upon Appendix XII. These areas consist mostly of buildings and infrastructure but do contain some open spaces (marked blue). Due to a lack of information on future construction planning, open spaces are selected as potential zones for new public green (Appendix XIII).

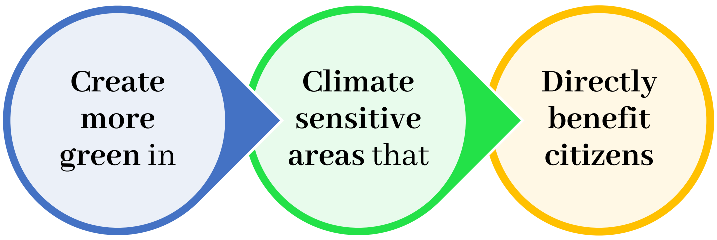


Figure 12. Recommendation

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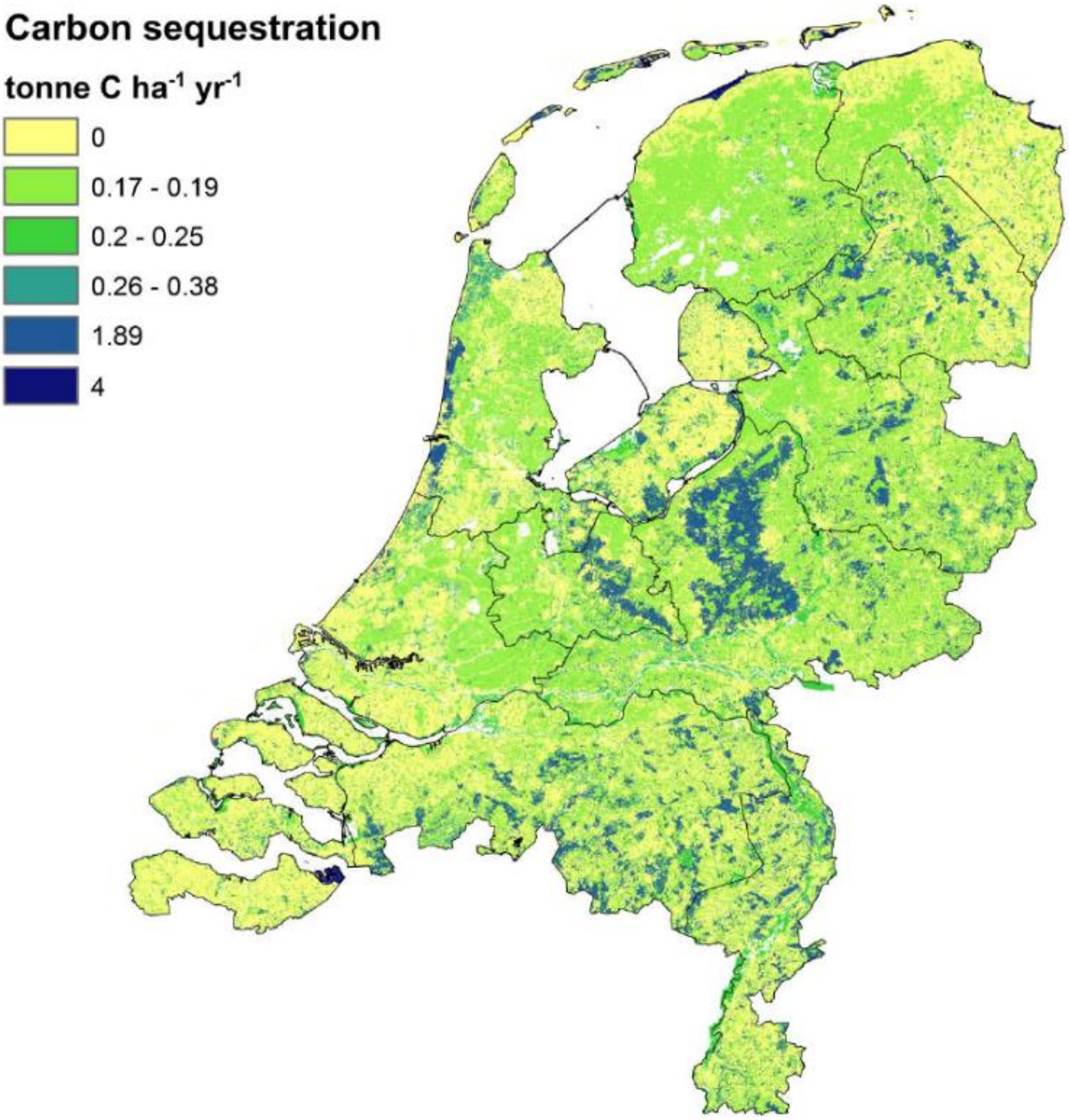
Appendix I



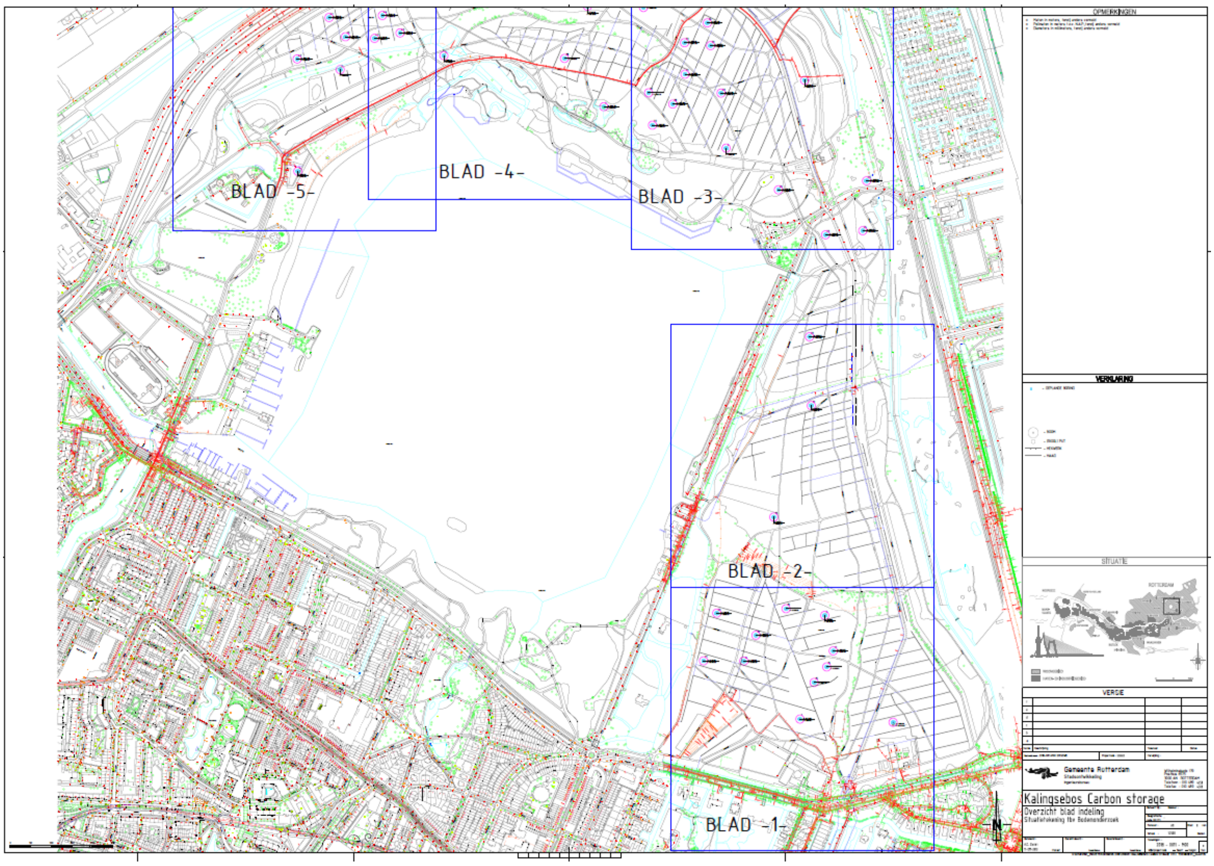
Carbon sequestration
tonne C ha-1 yr-1
0
0.17 - 0.19
0.2 - 0.25
0.26 - 0.38
1.89
4

Appendix II


N
Max
Min
Air purification
0 0.5 1 2 3 4 kilometers
Carbon storage
Noise reduction
Run-off retention
Cooling
Recreation

Appendix III

Appendix IV



ID	X	Y	ID	X	Y	ID	X	Y
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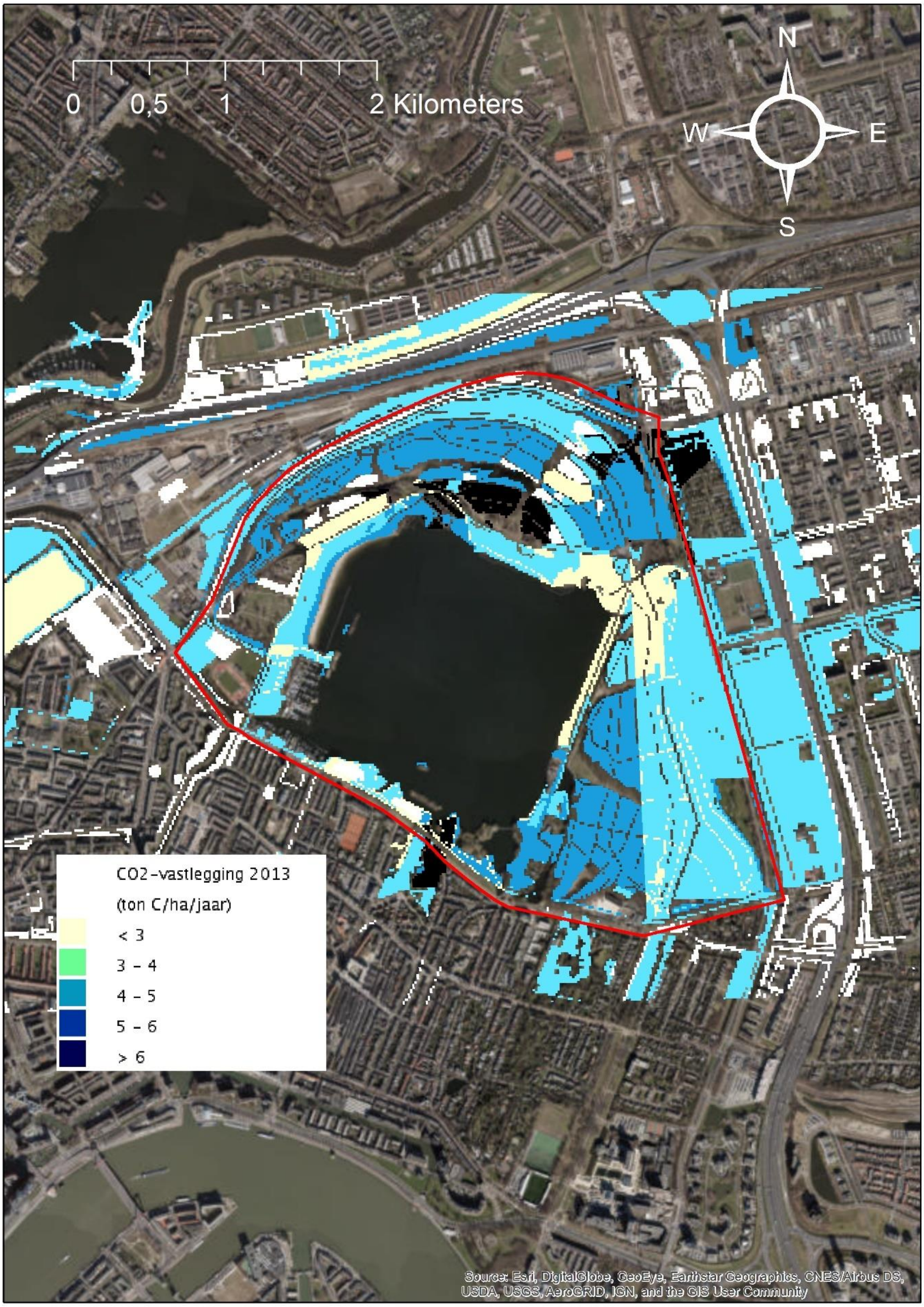
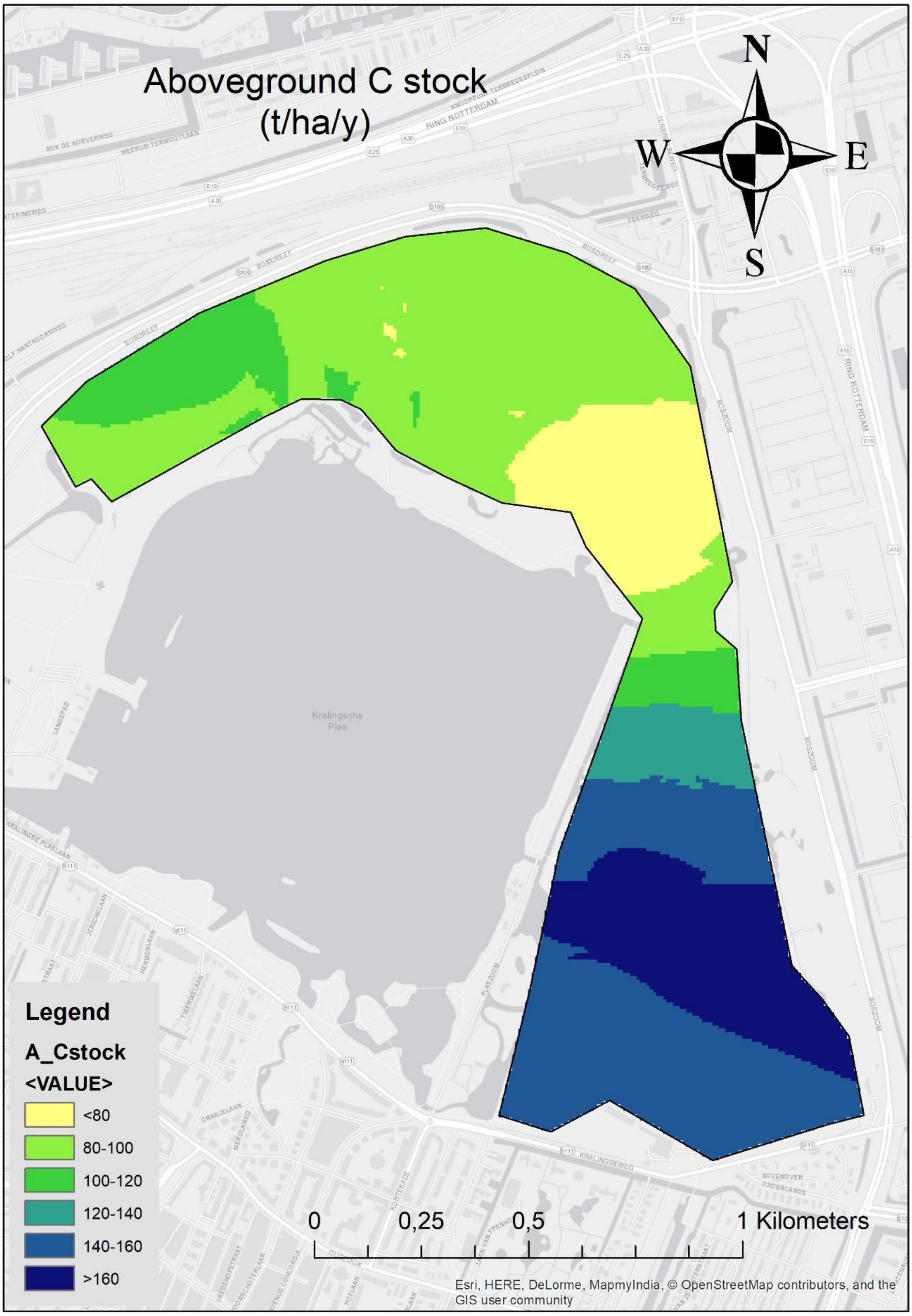
2	4.526169	51.928304	17	4.528125	51.940123	32	4.519116	51.941933
3	4.526665	51.929115	18	4.52502	51.939882	33	4.516426	51.944781
4	4.527096	51.929466	19	4.523126	51.940762	34	4.514805	51.945006
5	4.527306	51.929806	20	4.525852	51.942285	35	4.514588	51.944301
6	4.524153	51.929566	21	4.522887	51.941969	36	4.51305	51.942662
7	4.522722	51.929556	22	4.520484	51.941237	37	4.512165	51.943817
8	4.523128	51.9306	23	4.521198	51.941709	38	4.511486	51.943126
9	4.524557	51.930126	24	4.521617	51.942368	39	4.510832	51.943502
10	4.52562	51.930711	25	4.522497	51.943003	40	4.510596	51.942996
11	4.526984	51.930593	26	4.522349	51.943497	41	4.509517	51.943045
12	4.52513	51.932721	27	4.521573	51.943053	42	4.508924	51.94344
13	4.526342	51935186	28	4.520332	51.94194	43	4.509456	51.942136
14	4.526208	51.936682	29	4.52008	51.943803	44	4.507842	51.942511
15	4.526715	51.93892	30	4.518125	51.943817	45	4.509388	51.940612

Appendix V

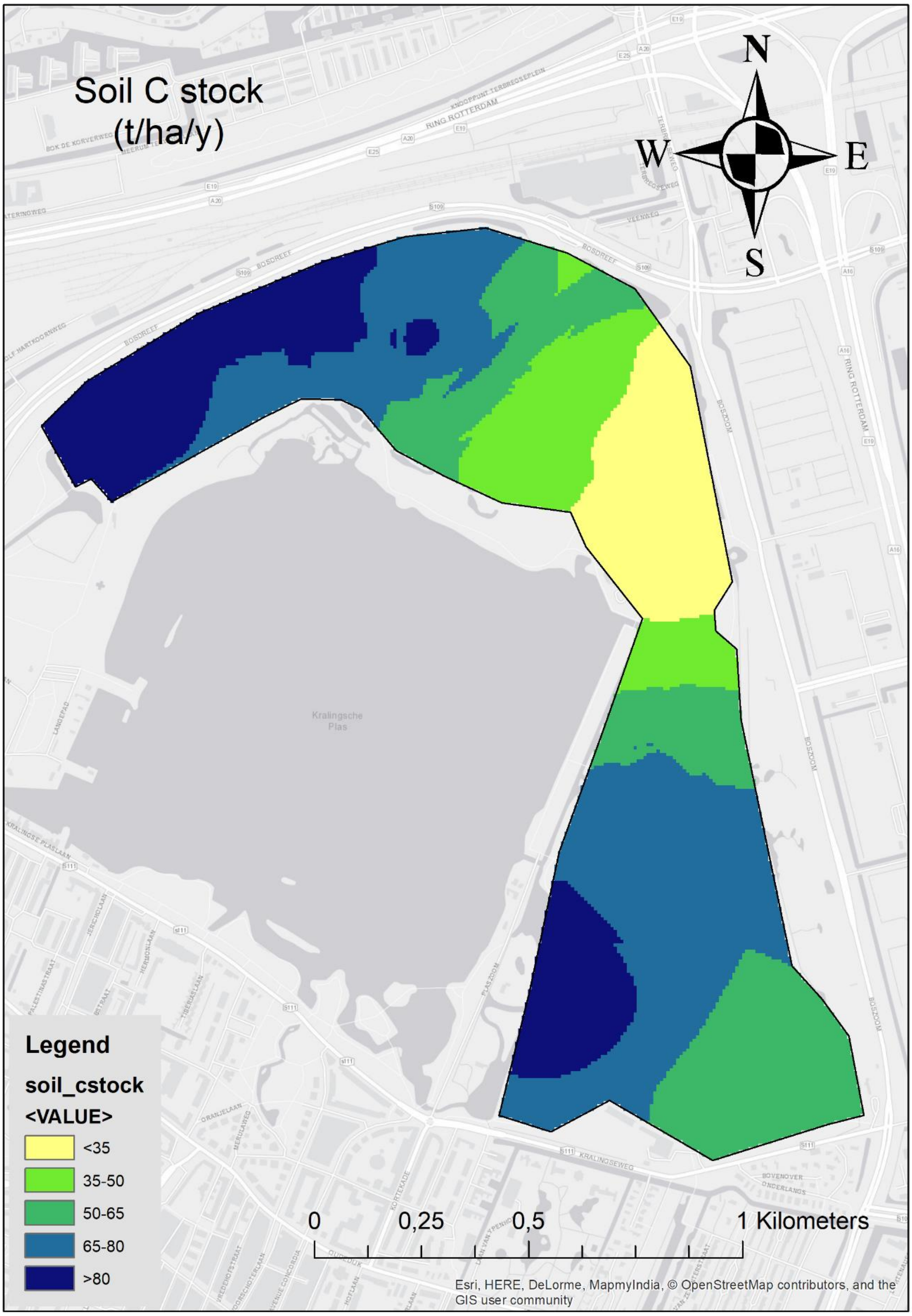

0
0,5
1
2 Kilometers
N
W
E
S
CO2-vastlegging 2013
(ton C/ha/jaar)
< 3
3 - 4
4 - 5
5 - 6
> 6
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix VI

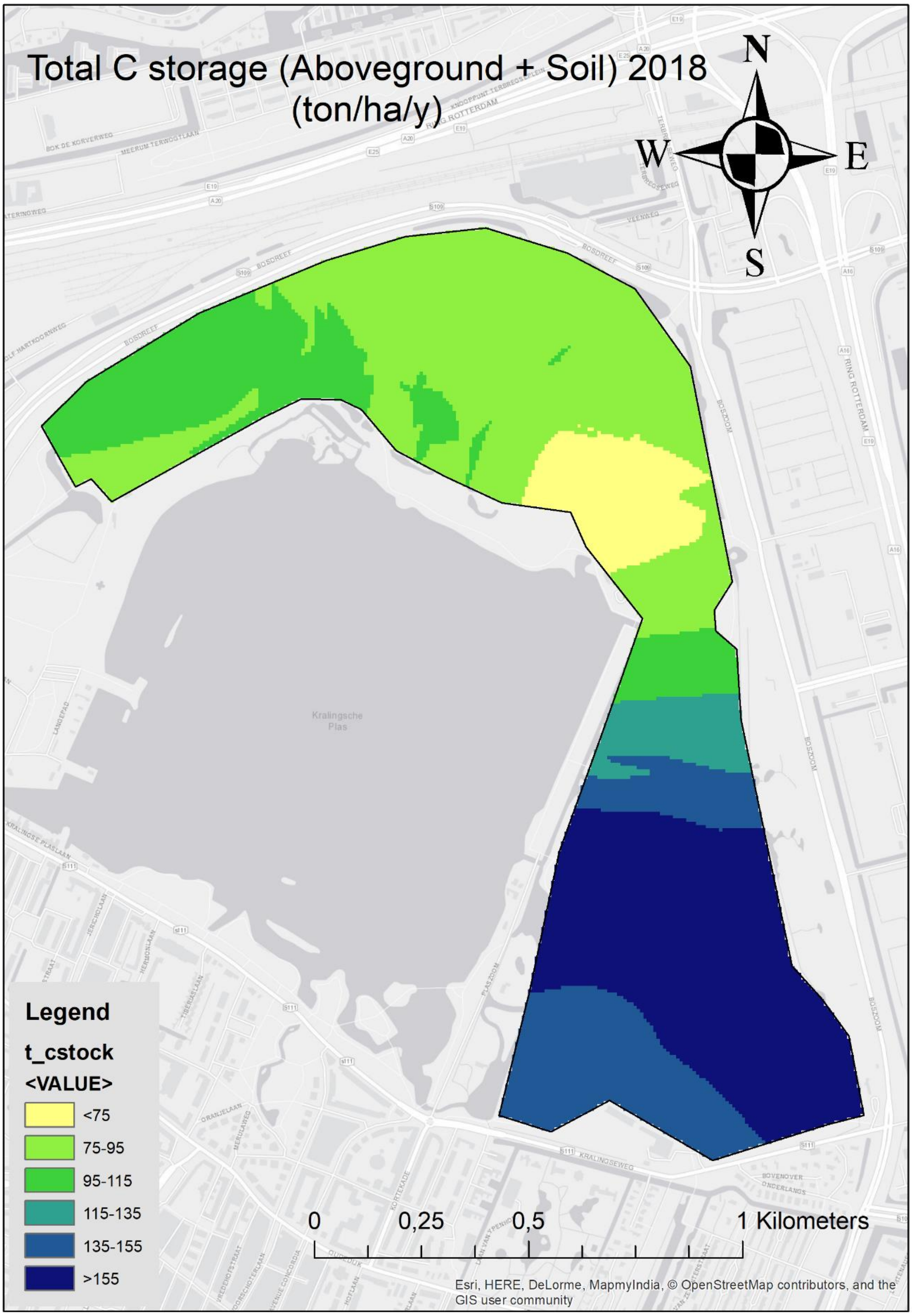


Aboveground C stock
(t/ha/y)
N
W
E
S
Legend
A_Cstock
<VALUE>
<80
80-100
100-120
120-140
140-160
>160
0
0,25
0,5
1 Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

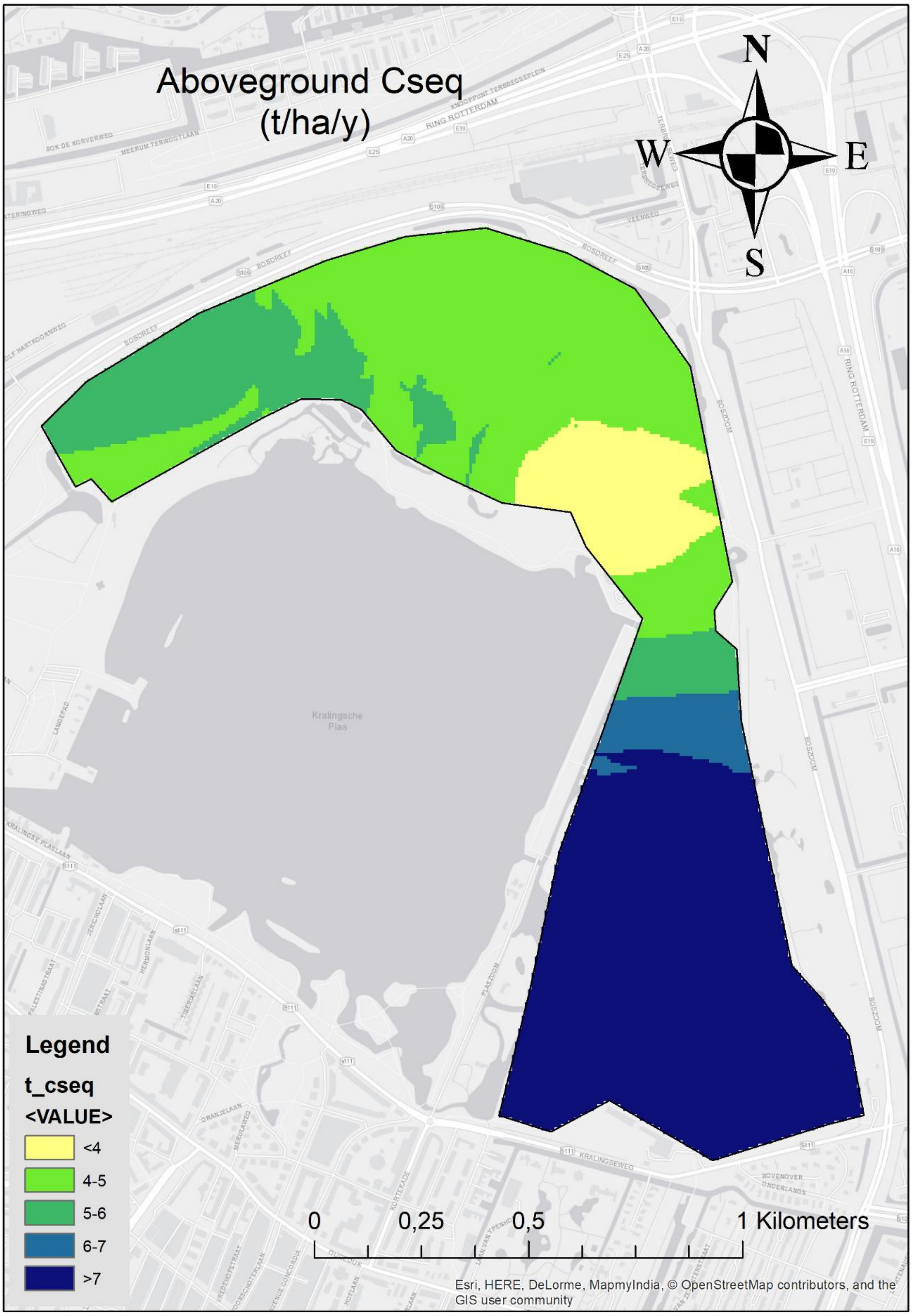
Appendix VII



Appendix VIII



Appendix IX


Aboveground Cseq
(t/ha/y)
N
W
E
S
Legend
t_cseq
<VALUE>
<4
4-5
5-6
6-7
>7
0
0,25
0,5
1 Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Appendix X

Plot ID	# Tree	GW (t/ha)	C (t/ha)	CW (t/ha)	Cseq (t/ha/y)	OM (%)	SOC (t/ha)
1	21	432	156	574	8	4,8	36,2
2	20	369	134	491	7	6,6	49,8
3	26	516	187	686	10	8,1	61,1
4	21	438	159	582	8	9,6	72,4
5	25	412	149	548	8	9,3	70,1
6	33	716	260	951	14	14,3	107,8
7	21	491	178	652	9	11	82,9
8	12	506	184	673	10	11,5	86,7
9	15	510	185	677	10	18,7	141
10	15	439	159	584	8	8,1	61,1
11	25	550	199	731	10	9,2	69,4
12	21	530	192	704	10	8,2	61,8
13	9	421	152	559	8	11,7	88,2
14	12	302	109	401	6	6,9	52
15	9	179	65	238	3	32,3	243,5
16	8	236	86	314	4	6,7	50,5
17	10	209	76	278	4	38,2	288
18	14	112	40	148	2	27,6	208,1
19	14	186	67	247	4	10,9	82,2
20	8	236	86	314	4	2,9	21,9
21	25	681	247	906	13	5,8	43,7
22	10	235	85	312	4	2,5	18,9
23	28	140	51	186	3	5,8	43,7
24	12	227	82	302	4	4,6	34,7
25	27	419	152	557	8	5,3	40
26	15	439	159	584	8	4,4	33,2
27	4	79	29	105	2	1,9	14,3
28	18	287	104	381	5	6,4	48,3
29	14	262	95	348	5	16,8	126,7
30	6	702	254	932	13	16,8	126,7
31	16	509	184	676	10	9,4	70,9
32	19	364	132	483	7	5,1	38,5
33	11	147	53	195	3	32,4	244,3
34	12	192	70	255	4	20	150,8
35	19	397	144	527	8	12,9	97,3
36	0	0	0	0	0	8	60,3
37	11	257	93	342	5	12,9	97,3
38	14	459	166	610	9	21,3	160,6
39	14	436	158	580	8	15,6	117,6
40	14	385	140	511	7	9,7	73,1
41	17	234	85	311	4	19,7	148,5
42	17	181	65	240	3	12,7	95,8
43	30	307	111	409	6	11,4	86
44	14	470	170	624	9	14,9	112,3
45	3	1294	469	1719	25	7,9	55

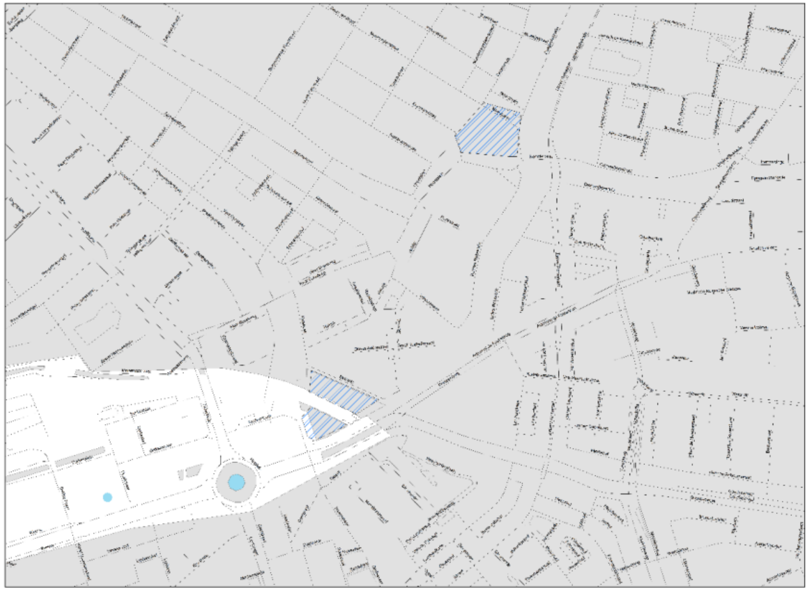
Appendix XI

ID	RIVM	Field
1	5	8
2	6	7
3	5	10
4	5	8
5	5	8
7	6	9
8	6	10
9	6	10
10	6	8
11	5	10
12	6	10
13	6	8
14	4	6
15	3	3
16	4	4
17	0	4
18	4	2
19	5	4
20	5	4
22	6	4
23	6	3
24	2	4
25	4	8
26	0	8
27	4	2
28	6	5
29	6	5
31	7	10
32	7	7
33	6	3
34	6	4
35	6	8
37	6	5
38	3	9
39	6	8
40	3	7
41	6	4
42	6	3
43	2	6
44	6	9

CBS		Field data	
Mean	4,80	Mean	6,41
Standard Error	0,27	Standard Error	0,40
Median	5,99	Median	6,96
Standard Deviation	1,73	Standard Deviation	2,56
Range	6,60	Range	8,94
Minimum	0,00	Minimum	1,50
Maximum	6,60	Maximum	10,44
Sum	191,92	Sum	256,28

Appendix XII

Appendix XIII



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