Tiny Forest, big impact?

The contribution of Tiny Forest to carbon storage, biodiversity and human well-being in Amsterdam.

Photo: Tiny Forest (IVN, 2020)

Borensztajn, Eva	Political Science	11299576
Jurrius, Lobke	Biology	11258780
Marteijn, Laura	Earth Science	11575212
Tjoelker, Tijn	Earth Science	11706317

Class	Interdisciplinary Project, Future Planet Studies
Expert:	Burdfield Steel. E
Tutor:	Uilhoorn. A
Word count:	~8000 (excluding abstract, tables, references and appendices)

ABSTRACT

Worldwide urbanization led to the loss of ecosystems and the services they provide, creating a big threat to nature, climate and human well-being, including Amsterdam. Due to their well-known contributions to ecosystem services, urban forests could offer great opportunities to mitigate the loss of nature. An upcoming concept within urban forestry is that of Tiny Forests: forests the size of a tennis-field, with high diversity and density of native species, implemented with the Mirayaki forestry method. By using an interdisciplinary approach, using regulating, supporting and cultural ecosystem services as measures, we are able to determine whether this approach to urban forestry is applicable to Amsterdam. In this paper we will further elaborate on carbon storage, species diversity and human-nature interactions. A theoretical framework is established, followed by methods, results and discussion. From our review it is concluded that implementation of Tiny Forests in Amsterdam could help reduce the negative effects of urbanization, by increasing biodiversity, carbon storage and human-nature connection (e.g. citizen-involvement in nature conservation and education). Moreover, management of a Tiny Forest is relatively low-cost and low-effort compared to other traditional urban parks. Nevertheless, due to its novelty, further research on the short- and long term effects, including potential disservices of Tiny Forests is desired.

TABLE OF CONTENTS

1 INTRODUCTION

The share of people living in urban areas worldwide, is expected to increase from 29% in 1950 to 60% in 2050 (United Nations, 2018). This trend is highly driven by the economic opportunities these cities provide (Steeneveld, et al., 2011). Despite the numerous benefits of urban living, this revolution caused several negative side-effects, shown in Table 1.

Table 1: Negative effects of urbanization

Effect	**Supporting evidence**	**Reference**
Loss of biodiversity	Biodiversity in urban areas is complex, since urban spaces can show high species count. However, native species are often endangered due to fragmentation and habitat loss resulting in poorer quality ecosystems	McKinney, 2006
Reduced water storage capacity	Due to a more built-environment, less water can infiltrate in soils. Furthermore, soils are often of poor quality due to compaction, leading to less water retention in urban soils.	Leslie et al., 2017; Schets, et al., 2008, McPherson, 2006
Noise disturbance	Noise disturbance in communities is increasing due to urbanisation which has a negative effect on residential, social and learning environments. This noise disturbance also has effects on species such as birds.	Salter et al., 2015; Leslie et al., 2017; Schets, et al., 2008; McPherson, 2006
Water pollution	There is a positive correlation between urbanization, especially when urbanization levels are higher than 25%	Ren et al., 2014; Leslie et al., 2017; Schets, et al., 2008, McPherson, 2006
Increased water runoff	Urbanization changes hydrological processes, some including reducing infiltration, baseflow, lag times, increasing storm flow volumes, peak discharge, frequency of floods and surface runoff	Espey et al., 1966; Dai, et al., 2018
Air pollution	Urbanization goes hand in hand with increases in emissions which lead to poorer air quality which has negative effects on human health.	Moore et al., 2003; Koolen & Rothenberg, 2019, Fenger, 1999; van der Zee, et al., 1998; Broddin, 1980)

Urban heat island effects	Urbanisation leads to more heat stress which is related to increased human mortalities.	Oleson et al., 2015; Steeneveld, et al., 2011
Reduced human-nature interaction	Due to urbanization, less green space is available or nearby which reduces human-nature interaction	Guilland et al., 2018

To remedy these negative effects of rapid urbanization, policymakers are increasingly leaning towards the concept of a *sustainable city*, where people and nature coexist (Guilland et al., 2018). Urban forests (UF) could be part of the solution, since they provide ecosystem services (ES), including climate regulation (reduce urban heat waves, carbon sequestration), air filtration, water runoff regulation, noise reduction, habitat provisioning, recreation and education (Escobedo et al., 2011; Gómez-Baggethun & Barton, 2013; Livesley, McPherson & Calfapietra, 2016). Moreover, UF enable several human benefits as well, such as providing an opportunity for citizens to get included with greenery in their neighbourhood, as well-being aesthetically pleasing and offering a space for recreation (Fraser, 2002). Hence increasing green spaces within the built environment is desired, so that human well-being and ES are safeguarded (Darkwah, 2014).

In the Netherlands 92% of the population is currently concentrated in urban settlements (United Nations, 2018). Whilst the occurrence of counter-urbanization has recently been acknowledged in the Netherlands (Bijker and Haartsen, 2012), this percentage is expected to increase to 96.6% in 2050 (United Nations, 2018). Moreover, urban green spaces per unit urbanized area is decreasing in the Netherlands (Farjon, et al., 1997; Giezen et al., 2018). Furthermore, Amsterdam deals with negative effects of urbanization and is looking for ways to incorporate nature in the city (Sol & Belgers, 2014; Farjon et al., 1997). Green spaces are almost absent in the city centre (Figure 2). Amsterdam compiled a Green Agenda (Figure 1), in which the importance of green spaces is emphasised (Gemeente Amsterdam, 2018).

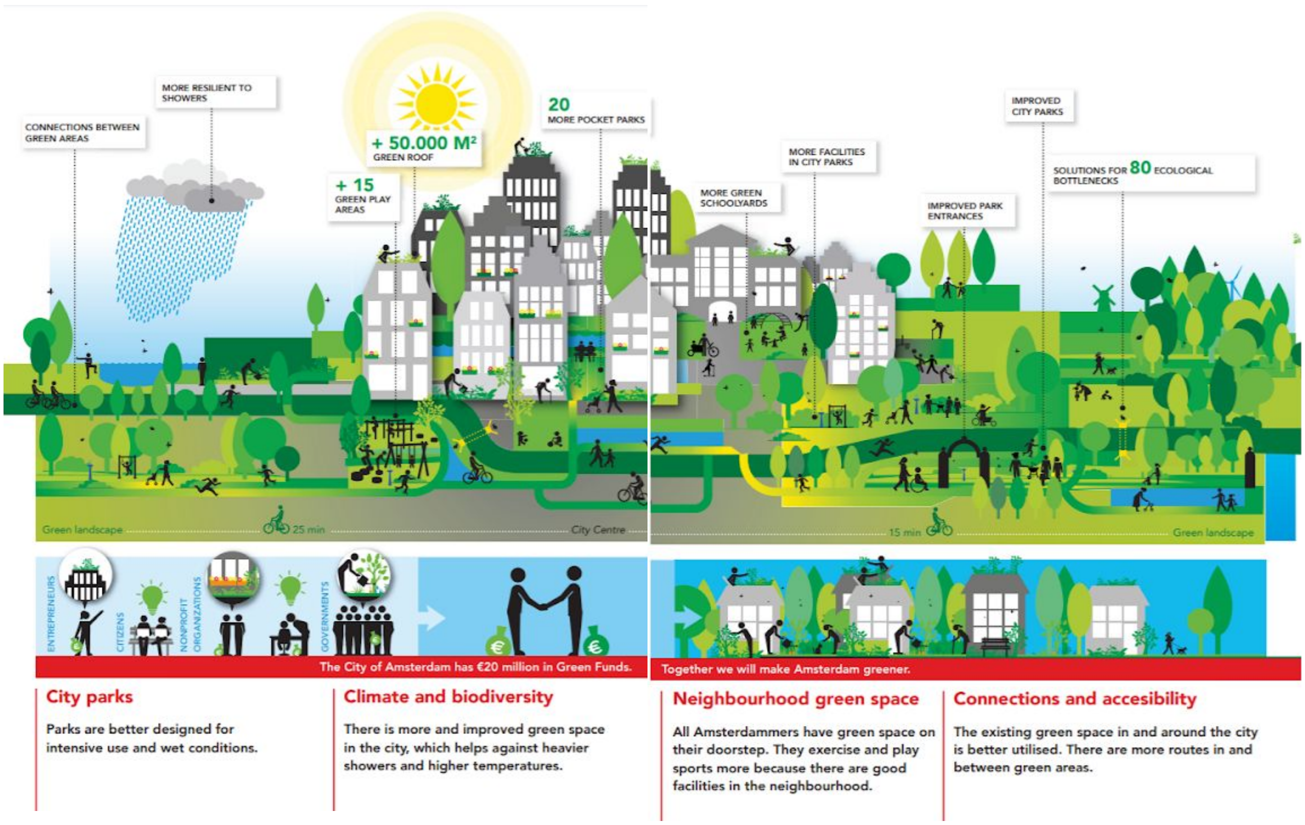

Figure 1: A global overview of the Green Agenda of the city of Amsterdam. Left to right: City parks, Climate and Biodiversity, Green in the Neighbourhood, Connections and Accessibility, from Green Agenda 2015-2018 (City of Amsterdam, 2015).

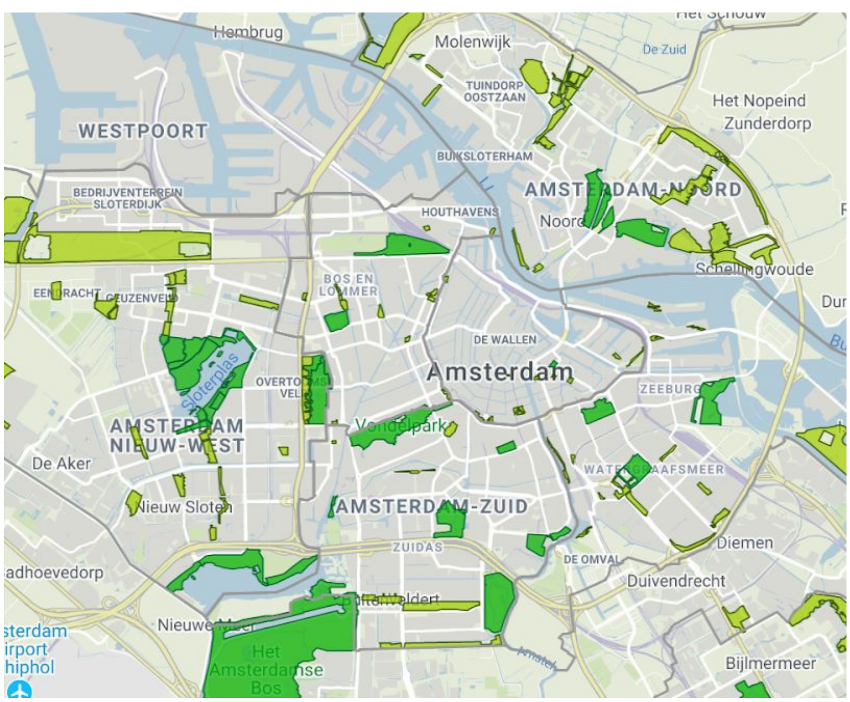

Figure 2: Above, urban forests (dark green) and other green spaces in Amsterdam (light green) (maps.amsterdam.nl, 2020)

An popular project in the Netherlands Tiny Forests (TF): high-density and species-rich forests, the size of a tennis-field. Already 64 have been established in the Netherlands (IVN, 2020). These forests are planted according to the "Miyawaki method", which is a forestry method developed for restoring natural, indigenous forests (IVN, 2020; Miyawaki, 2004). They are thought to increase (local) biodiversity despite requiring low maintenance levels, while increasing the human-nature interaction through educational purposes (IVN, 2020). Small forests like TF could play a major role in maintaining networks for biodiversity in highly fragmented landscapes (Götmark & Thorell, 2003).

Although TF have not been incorporated in Amsterdam yet, they could meet the aforementioned requirements to shift towards a sustainable city, since the list of ES UF provide is impressive (Patarkalashvili, 2017). However, uncertainty remains to what extent TF could contribute to ES in Amsterdam. Due to the increasing effects of human influences on the urban ecology and lifestyle, ES that could increase climate adaptation and human-nature connectivity are considered most valuable ES for Amsterdam, as is also mentioned in the Green Agenda (Gemeente Amsterdam, 2018). Therefore the services carbon storage, biodiversity and social well being will be extensively researched.

Whilst there is a comprehensive body of research on UF, specific studies on TF within urbanized ecosystems are rare. When studying a complex ecosystem such as TF, an integrated approach is desired of individual services in order to be able to understand the system in its entirety. For TF the disciplines of biology, earth sciences and political science are considered as the most important disciplines to comprehensively tackle this problem, since these disciplines are able to unravel the complexity of the natural and societal aspects.

Finally, the connections between these disciplines need to be investigated in order to achieve a full understanding of the system, i.e. interdisciplinarity is paramount. Therefore, this research examines the interdisciplinary dynamics of a TF. This approach will allow us to make a full assessment of whether TF can be a significant contribution to sustainable urban developments in Amsterdam. By analysing the new and popular concept of TF, a beginning is made to get a better grasp of the benefits, disadvantages and knowledge gaps within UF. Firstly, a theoretical and conceptual framework is given to provide the underlying pre-existing knowledge on TF that will be used. Thereafter, the ES that TF can provide are analyzed, in particular supporting, regulating and cultural ES. Subsequently, TF are compared to characteristics of other green spaces to shed light on possible advantages and disadvantages of TF. Lastly, current policies regarding implementation of TF in Amsterdam are discussed to investigate whether TF suits the Green Agenda.

1.1 Problem definition

The urgency to protect and support biodiversity and ES is getting increasingly important since urban ecosystems deal with the consequences of urbanization (Table 1) (Rockström, 2009; Havlicek & Mitchell., 2014). UF have been suggested as a solution to mitigate the effects of urbanization. The concept of TF is growing popularity in the Netherlands and is expected to have positive impacts on an urbanized environment. However, Amsterdam has not yet planted any TF, despite their 'Green Agenda' and general goals to become a *sustainable city.* We therefore want to answer the question and its corresponding sub-questions:

How can Tiny Forests contribute to ecosystem services in Amsterdam, in particular carbon storage, biodiversity and social well-being?

1. *To what cultural, supporting and regulating ecosystem services could Tiny Forest contribute in an urbanized environment and how are these connected?*
2. *What are possible benefits and complications of TF compared to other urban green spaces?*
3. *Do current policies in Amsterdam facilitate and stimulate implementation of TF in Amsterdam?*

1.2 Theoretical framework

A theoretical framework is established, to dive deeper into the theories and concepts underlying the effects of urbanization and the resulting need for initiatives such as urban forests, e.g. in the form of TF. The three aforementioned research disciplines, ES, the effects of TF and their connections are integrated in Figure 3.

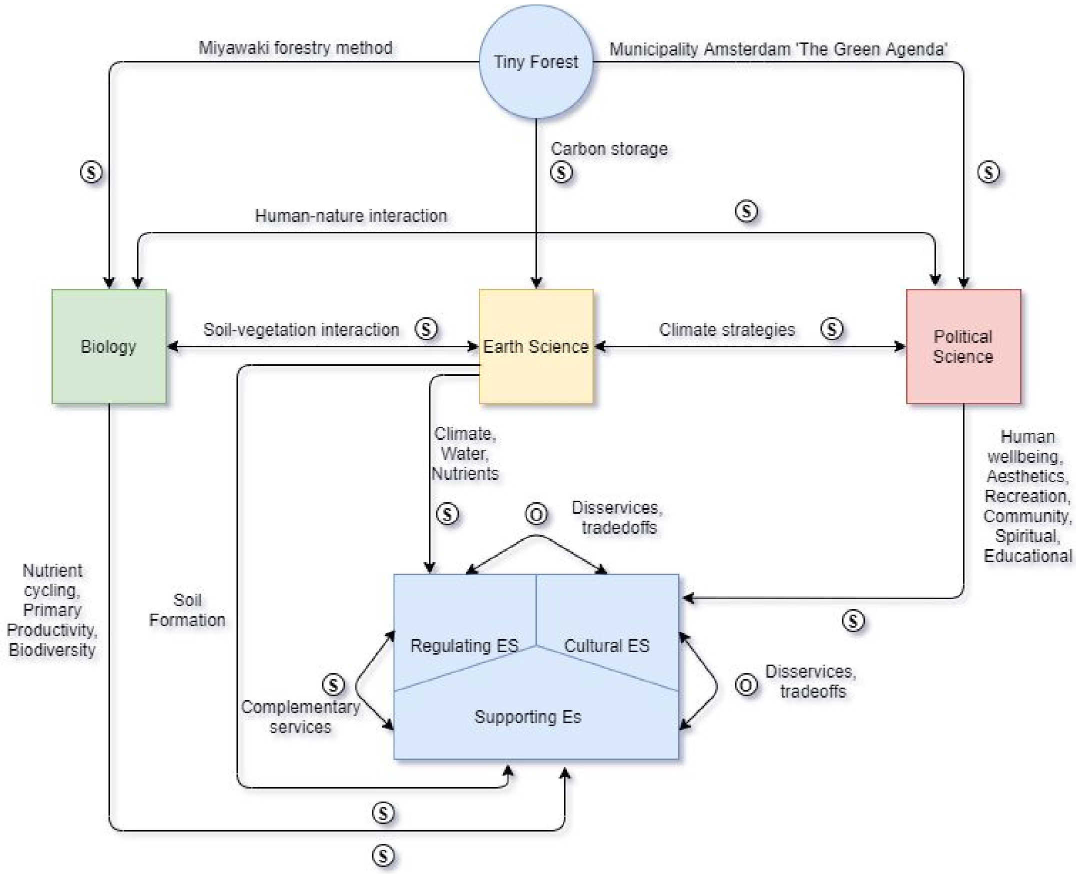

Figure 3: Visualization of the integration of the disciplines Biology, Earth Science and Political Science and the interactions between TF and ecosystem services (ES), where S = same direction and O = opposite direction.

1.2.1 Urban ecosystem services

ES are defined as the benefits humans derive from ecosystem functions (Constanza et al., 1997). These are generally divided into providing, regulating, supporting and cultural services. An overview of the ES that UF are able to provide are shown in Table 2.

Furthermore, the potential negative consequences or trade-offs of implementing TF, the so called "ecosystem disservices" need to be taken into account as well, in order to conduct a thorough assessment of TF (Pataki et al., 2011; Lyytimäki et al. 2008).

Table 2: ecosystem services provided by urban forests divided in supporting, cultural and regulating services

Ecosystem service division and definition (from the Millennium Ecosystem Assessment, 2005)	**Ecosystem service provided by urban forests**
Supporting services are the services that support other ecosystem services. These services have indirect impacts on humans that last over a long period of time.	• *Biodiversity* • *Habitat provisioning* • *Soil formation* • *Primary production* • *Nutrient cycling* • *Water cycling*
Cultural services are the non-material benefits ecosystems provide for humans	• *Education* • *Community participation* • *Public meet-up point* • *Improve physical well-being* • *Improve mental well-being* • *Reduce crime and violation* • *Improve cognitive development children* • *Host a place for recreation* • *Spiritual activities*
Regulating services are the benefits provided by ecosystem processes that moderate natural phenomena	• *Carbon sequestration and storage* • *Temperature regulation* • *Stormwater regulation* • *Air purification* • *Noise mitigation*

1.2.2 Forestry method: Miyawaki

A natural forest cycle can take up to two centuries, where annual plants on barren land are succeeded by perennial grass, sun-tolerant shrubs, light-demanding, fast-growing trees, and finally natural forests (Figure 4 and 5a) (Clements, 1916; Connell & Slatyer, 1977). Nowadays, most forest reforestation programs plant one or more early successional species and gradually replace them by intermediate species, until late successional species arise (Figure 5b). TF on the other hand, are planted according to the Miyawaki method, which means planting simultaneously intermediate and late successional native species. This is known to accelerate natural succession and to enable interactions and cooperation with several organisms living in the same habitat (Miyawaki, 2004) (Figure 4 and 5c). With this forestry method a dynamic equilibrium is reached more quickly compared to other forestry methods (Schirone et al., 2011).

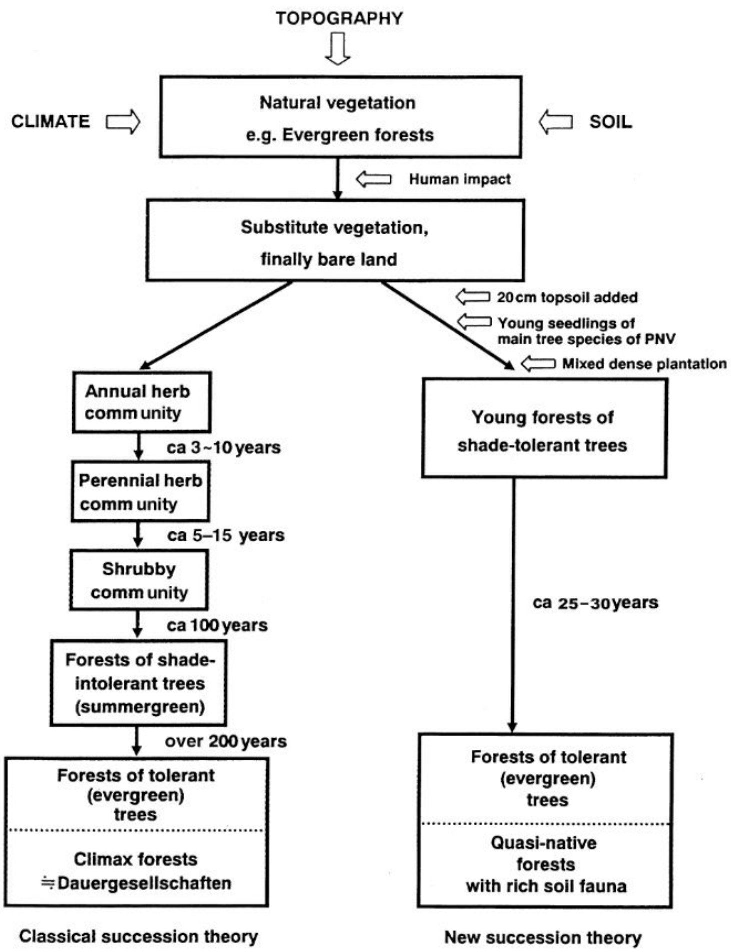

Figure 4: Comparison between classical and new succession theory, of which the latter is incorporated into the Miyawaki method (Miyawaki, 2004).

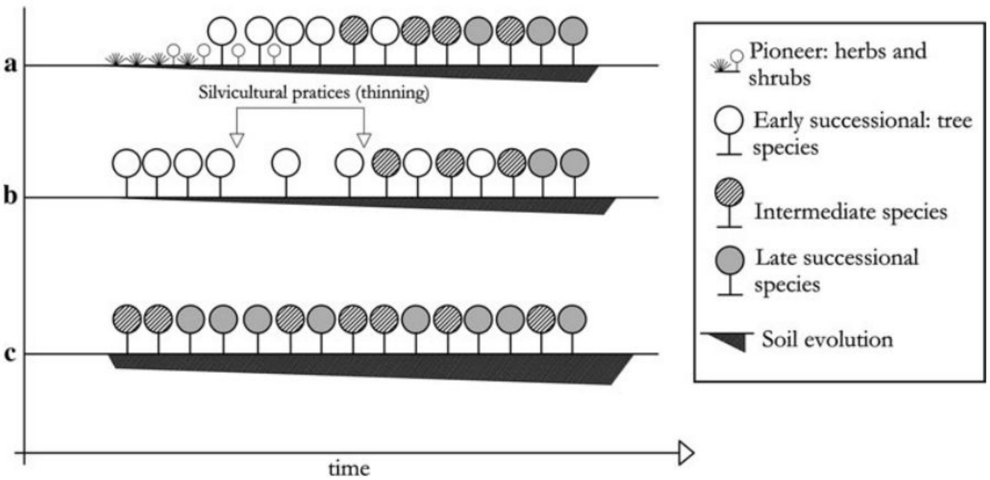

Figure 5: Successional stages in (a) natural conditions, (b) traditional reforestation methods and (c) the Miyawaki method (Schirone et al., 2011).

1.2.3 Supporting ecosystem services: Biodiversity

Biodiversity is one of the most affected ES due to human activities, including urbanization. Decreased biodiversity appears to have catastrophic effects for human well-being, stressing the importance of protecting or restoring ecosystems (Rockström, 2009). In order to measure biodiversity, it is crucial to understand the concept. Biodiversity is the amount of species present in an ecosystem and is often used to measure the quality of an ecosystem (Purvis & Hector, 2000). In general, an ecosystem with high biodiversity is often regarded as high quality. However, especially in urban environments this is not always true, since biodiversity is not the only measure for ecosystem quality (Havlicek & Mitchell, 2014 and explained more thoroughly in 3.5). Urban ecosystems often support high amounts of species, although the overall quality can be quite poor compared to adjacent agricultural landscapes (Havlicek & Mitchell, 2014). Hence looking at species-richness alone is not sufficient to determine ecosystem quality, since the individual contribution per species to ecosystem quality also has to be taken into account.

Biodiversity plays an important role within Amsterdam's Green Agenda. Increased biodiversity might be established by replacing stone surfaces with green spaces or creation of ecological connecting routes, i.e. corridors (Gemeente Amsterdam, 2018). Establishing corridors connecting green spaces can support and strengthen the existing biodiversity in Amsterdam (Gemeente Amsterdam, 2018).

1.2.4 Cultural ecosystem services: Human-nature interaction

Ecosystems services can often not be monetarily valued, since people believe nature provides services for free (Summers et al., 2012). However, we do deal with ES losses, such as increased illnesses, moratoriums on greenhouse gasses and loss of nature around us that contributes to our basic happiness (Summers et al., 2012). UF, like TF, offer important cultural services, since they have positive effects on human well-being of citizens (Table 3). These cultural services vary from long- to short term effects on personal health and the community in general. Amsterdam attaches a lot of value to the connection between citizens and green spaces, because of the positive relation with human well-being (Gemeente Amsterdam, 2018).

Table 3: Effects of green spaces on human well-being

Effect	**Supporting evidence**	**Reference**
Mental illnesses	Green spaces have positive effects on numerous mental illnesses	Groenewegen et al., 2006; Gidlöf-Gunnarsson & Öhrström, 2007; Summers et al., 2012
Physical health	Green spaces have positive effects on physical health, since it offers a place to walk, cycle or do sports. Green spaces are related to reduced obesity numbers	Groenewegen et al., 2006; Gidlöf-Gunnarsson & Öhrström, 2007; Summers et al., 2012
Crime and violence	Green spaces reduce crime and violence	Summers et al., 2012
Employment	Green spaces offer a wide range employment, ranging from farming food to maintenance of parks and gardens to research	Summers et al., 2012
Development of children	Having access to green spaces have positive effects on the cognitive development of children, especially on their problem-solving abilities	Summers et al., 2012
Stress	Green views reduce people's stress levels. In the long term visiting green spaces regularly also reduced stress levels.	Groenewegen et al., 2006; Lafortezza et al., 2009
Feeling safe	People tend to feel safer in their environment when surrounded by green spaces	Groenewegen et al., 2006

Noise disturbance	Green spaces have a positive effect on nearby communities, since the reduced stress results in decreased noise-responses as well	Gidlöf-Gunnarsson & Öhrström, 2007
Heat stress	Green spaces have positive effects on mortality rates related to heat-stress, since they offer comfortable outdoor situations through trees and water which is especially important since more heat-stress is expected due to climate change.	Lafortezza et al., 2009

1.2.5 Regulating ecosystem services: Carbon storage

Many cities worldwide are reducing greenhouse gas emissions in response to climate change, both voluntarily and enforced (Betsill, 2001). Carbon sequestration into vegetation and soils has been suggested as a potential mitigation tool for mitigating emissions (McHale, McPherson & Burke, 2007; Edmondson et al., 2012). Different methods and management practices mainly affect the principal factors that contribute to long-term soil organic carbon (SOC) storage (Whitmore et al., 2015). Therefore, these factors will be used to evaluate the potential of TF to store carbon, by using the Miyawaki method. These principal factors are:

(a) increasing the total soil volume

(b) increasing the carbon stabilization rate

(c) increasing the organic matter input

(d) decreasing the decomposition rate

When the inputs of carbon exceed the carbon losses, the SOC will increase. This soil carbon balance is highly influenced by photosynthesis, respiration and decomposition (Figure 6) (Ontl & Schulte, 2012). Photosynthesis is the atmospheric CO_2 fixation into plant biomass, which results in organic matter production (Wilkes et al.,2018; Lange et al., 2012; Reich et al., 1998). Through soil microbial respiration, biomass is subsequently decomposed and is released as CO_2 back into the atmosphere (Chapin et al., 2002). However, a small amount of the carbon in the organic matter is retained through humus formation, which is produced through the decomposition of the roots and shoots of plants by soil fauna and microbes (Ontl & Schulte, 2012). Because humus is hard to decompose (recalcitrant), it serves as long-term SOC storage, in contrast to the short-lived plant debris, which is less recalcitrant (Ontl & Schulte, 2012).

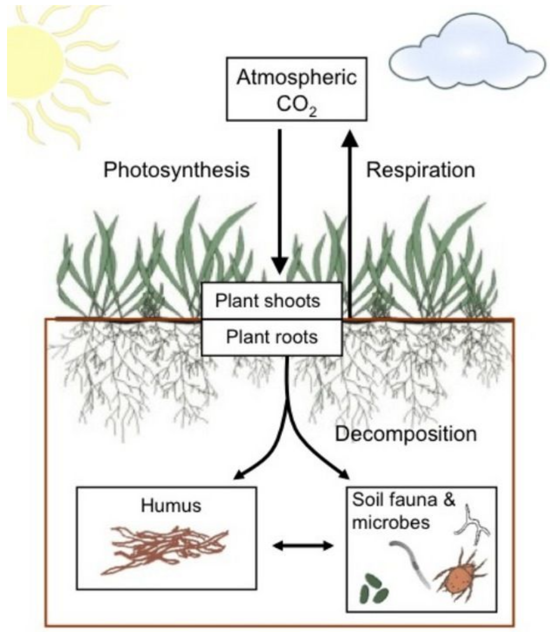

Figure 6: The soil carbon balance, controlled by CO_2 *inputs from photosynthesis and* CO_2 *losses through respiration (Ontl & Schulte, 2012).*

Because fungi and bacteria are the dominant decomposers in soil, the fungal-to-bacterial ratio (F : B) highly influences rates of ecosystem carbon cycling and storage (Waring, Averill & Hawkes, 2013; Bailey, Smith & Bolton, 2002). A higher F : B ratio will be favourable for carbon sequestration, because fungi have a higher carbon to nitrogen biomass stoichiometry, broader enzymatic capabilities, slower biomass turnover rates and greater carbon use efficiency than bacteria (Wallenstein et al., 2006; de Boer et al., 2005; Rousk & Bååth, 2011; Six et al., 2006). Moreover, the symbiotic relationships between roots and fungi, better known as mycorrhiza, reduce soil carbon loss and enhance soil carbon sequestration (De Deyn, Cornelissen & Bardgett, 2008; Averill, Turner & Finzi, 2014). Therefore, the effect of TF on the F : B ratio and the symbiotic relationships should be investigated as well.

Table 4: Important concepts concerning urban green spaces and Tiny Forests

Concept	**Definition**
Urban green spaces	*"all urban land covered by vegetation of any kind. This covers vegetation on private and public grounds, irrespective of size and function, and can also include small water bodies such as ponds, lakes or streams ("blue spaces")."* (WHO, 2017)
Tiny Forest	*"A Tiny Forest is a dense, native forest the size of a tennis field established by IVN in the Netherlands to create a favorable environment for a variety of species and a place to meetup for the neighborhood."* (IVN, 2020)
Miyawaki planting method	*"An innovative reforestation approach to restore indigneous ecosystems and maintain global environments. This method accelerates the successional times of native species thus enabling dense forest to grow faster, even in highly degraded areas' ' (Shirone et al., 2011).*
Biodiversity	*Definition by the UN is as follows: "variability among living organisms [..] and the ecological complexes of which they are part (includes diversity within species, between species and between ecosystems)".*
Urbanization	"*Urbanization is the process through which cities grow, and higher and higher percentages of the population comes to live in the city (National Geographic, 2019)."*
Carbon sequestration	Forest management has an impact on carbon sequestration in the forest ecosystem. On the one hand, a growing forest captures atmospheric carbon, which is stored for a long time in branches, trunks and roots (Lange et al., 2012). On the other hand, the decomposition of fallen leaves and twigs, dead roots and eventually fallen dead trees leads to the build-up of a carbon stock in the soil (Ontl & Schulte, 2012).
F:B ratio	Soil micro-organisms are organized in fungi and bacteria and have distinct physiological and ecological characteristics and investigate the fungal:bacterial ratio is therefore used in many studies (Wang et al., 2019).
Citizen science	Research that is partly or fully performed by citizens or non-professional scientists (WUR, 2019).

2 METHODOLOGY

The basis of this research consists of a literature review, in which all disciplines are taken into account. We have analysed just over 100 articles on the topic. The papers consist of scientific articles that presented their own data, meta-analysis, literature reviews and policy reports. We have used these sources to compile the current knowledge and knowledge gaps on UF, mainly by reviewing outcomings of research and comparing articles. Main search terms to find suitable articles were: urban forests, Miyawaki method, urban ecology, Tiny Forest and urban biodiversity. Both primary and secondary data is used and reviewed.

Additionally, a number of interviews were carried out, written out and analysed. Due to the COVID-19 virus, interviews were conducted through Skype (the possibility of surveying, to measure the cultural value of TF (such as Amsterdamse Bos) for local citizens is therefore cancelled). The interviews conducted were:

- Alina Salomon, employed at IVN (Institute for Nature-education) and particularly active for Tiny Forests (Appendix I).
- Anne Mara Sillevis Smitt, project leader at IVN and active for Tiny Forests (Appendix II).

Table 5 shows the focus of the research for each chapter and methods that were used.

Table 5: Focus of different aspects of research per chapter

Aspect	**Ch.**	**Focus of research**
Tiny Forests in relation to ecosystem services	3	Ecosystem services nowadays are one of the most-used measures for quality of ecosystems and is common language in current research (Escobedo et al., 2011). Extensive literature comparison of the ecosystem services TF can provide will therefore be the main method, mostly focusing on carbon storage, human well-being and biodiversity. The impact of TF on these have not been investigated in Amsterdam specifically, but case studies of other cities (i.e. Zaandam) can be used to get an indication of possible effects and can be useful to foreshadow the outcome of a hypothetical TF in Amsterdam. An interview with Alina Salomon can give an insight in current practices and ecosystem services provided by these TF as well.
Tiny Forests in comparison to	4	Urban forests all around the world adopt different forestry methods. A literature review on comparison of these forestry types, in particular in comparison to TF will

other urban forestry types		be assembled. The focus will be on management, biodiversity, size and human-nature interaction.
Tiny Forests in relation to (urban) policy	5	Current policy and future plans from the municipality of Amsterdam will be collected from reports. The opinions and current policies of the municipality of Amsterdam concerning green spaces matter, since we are interested in the feasibility of a possible TF in the city. The 'Green Agenda', and the homepage 'Following the policy: green' will be used to investigate the local developments concerning Green in Amsterdam.

3 TINY FORESTS AND THEIR ECOSYSTEM SERVICES

As mentioned in the theoretical framework, urban forests contribute to a variety of ES (Table 2). It should be emphasized that ES are often a complex network of interactions and feedbacks and the services we focus on are connected to many other ES which together determine the state of an ecosystem.

3.1 Supporting

Reduction of green space and fragmentation is often accompanied with loss of urban biodiversity (Giezen et al., 2018). One of the main goals of TF is to increase biodiversity.

TF and the implemented Miyawaki method focus on both below- and aboveground biodiversity. This starts by improving the soil to increase the belowground biodiversity. Soils are a major contributing factor to the complexity of ecosystems and that complexity is the key to their important role supporting biodiversity (Havlicek & Mitchell, 2014). Production, habitat provisioning and decomposition are the main functions of soils in ecosystems (Havlicek & Mitchell, 2014). TF acknowledges the important role of belowground biodiversity by investigating the soil and intervening by adding straw-rich manure, wood chips and other organic matter (IVN, 2020). By adding organic matter to soils, the soil quality often improves which is especially important in cities where poor soil conditions are observed (Kumar & Hundal, 2016; Patterson et al., 1980). UF methods almost always improve several soil properties, having a positive effect on both the below- and aboveground biodiversity (Upton et al., 2019; Havlicek et al., 2014; Guo, 2018, Patarkalashvili, 2017; Escobedo et al., 2019). This indicates TF could possibly lead to increased biodiversity in Amsterdam as well.

Research, conducted by the University of Wageningen on two pilot TF planted in 2015 in Zaandam confirms this (Ottburg et al., 2017). It demonstrates higher biodiversity compared to the surrounding forests for both the groups of species as well as the number of individuals (Ottburg et al., 2017). Rich microbial communities were measured that can be compared to numbers in full-grown forests, which can be attributed to the amount of organic matter and straw-rich manure. Since vegetation is still young and dominated by undergrowth, many pollinating species are currently occupying these TF. This is expected to change as the forest matures, since there is less undergrowth which reduces the amount of pollinating species. As TF follows the natural processes of ecological succession, from pioneer species to climax vegetation, TF are expected to host more birds as breeding grounds increase when trees grow bigger (Shirone et al., 2010; Ottburg et al., 2017).

The Miyawaki method implemented in TF appears to use a high diversity of plant species (Shirone et al., 2010). Plant biodiversity is important since it influences the overall ecosystem functioning (Tilman et al., 1997). Plant diversity can contribute to ecosystem functioning by providing resources for other species (Hooper, 1998). A high plant diversity method, such as the Miyawaki method, can therefore contribute to increased biodiversity, compared to more monotonous planting techniques. Research also demonstrates that invasive species can often lead to negative effects on ES, compared to native plant species (Haines-Young & Potschin, 2010; (McKinney, 2006). TF only uses native trees and plants which likely results in less negative effects on ES. TF partly prevents the invasion of exotic species by implementing local species. However, specific research on the Miyawaki-method in relation to overall biodiversity is lacking. Nevertheless, forestry-methods such as Miyawaki contribute to nature restoration, which enhances biodiversity (Shirone et al., 2010).

3.2 Cultural

Human-nature interaction depends on the access people have to urban green spaces and urban citizens often do not have green spaces nearby or sufficient proportion of green in their neighbourhoods (Nutsford et al., 2013). Amsterdam shows a decrease in urban green and an increase in the built up environment, making urban green less available for citizens (Giezen et al., 2018). This is problematic, since a decreased distance from urban green is associated with reduced anxiety and mood disorder treatment counts (Nutsford et al., 2013). TF aims to provide green in urban areas including space for recreation for human-nature interaction. This would reduce the distance from urban green for citizens.

Lower socioeconomic classes are less often in contact with urban green spaces, as there is injustice in the distribution between citizens in most cities (Groenewegen et al., 2006). Citizens with higher incomes can afford to live in a favorable environment (Groenewegen et al., 2006). This inequality leads to health differences where people living in greener areas tend to perceive their physical and mental health status as better than their counterparts living in less green areas (Groenewegen et al., 2006). However, in the city centre of Amsterdam, higher socioeconomic classes also deal with a loss of urban green in their environment (Giezen et al., 2018).

TF can improve solidarity in neighborhoods by offering a place to meet which is accessible for everyone (Rosol, 2010). According to Fraser (2002), community-based urban environmental management projects can build a bridge between NGOs, local governments and citizens, this is in line with the strategy of TF. TF contributes to this idea by actively involving citizens to volunteer during the process of designing, planting and maintaining as well as offering a recreational space and applying citizen science (Table 3). Taken together, these initiatives often lead to a significant positive effect on human-nature interaction. The connection between TF and the municipality of Amsterdam is further discussed in Chapter 5.

3.3 Regulating

With the Miyawaki method, firstly, the soil is investigated, ploughed and enriched according to its needs (IVN, 2020). This loosens up the soil up to one meter deep and makes enough organic material available for rapid establishment of a fungal network (IVN, 2020). This increases natural soil formation rates, as has been noticed in the TF in Zaanstad, where the soil volume (Table 6a) increased in a short period of time after this soil treatment (Ottburg et al., 2017).

Subsequently, the soils are left alone indefinitely, benefiting the carbon stabilisation rate (Table 6b) in urban soils (Lorenz & Lal, 2009). Moreover, plants with deep root systems are selected that are optimized to transfer root-derived carbon into stable SOC in TF, additionally contributing to carbon stabilisation (Kell, 2012). However, it remains uncertain whether root systems of the native plants in the Netherlands are suitable as well. Further research on the carbon stabilisation rate is therefore required.

The Miyawaki method enables the rapid establishment of a native multi-layered forest. Because vegetational succession is generally accompanied with an increase in diversity and productivity, the organic matter input (Table 6c) is simultaneously enhanced and leads to higher F:B ratio (Sachs et al. 2004; Zhao et al., 2019; Frouz et al., 2016; Yoshitake et al. 2013; Ladygina & Hedlund, 2010; Susyan et al., 2011). This corresponded to the TF in Zaanstad, which had a F:B ratio similar to natural mature forests, i.e. a relatively low decomposition rate (Table 6d) (Ottburg et al., 2017; Six et al., 2006). Moreover, vegetational succession leads to increased mycorrhizal diversity and quantity (Fujiyoshi et al., 2005). An increase in symbiotic relationships between roots and fungi also reduces the decomposition rate (Table 6d), which contributes to soil carbon sequestration (De Deyn et al., 2008; Averill et al., 2014).

Concludingly, the Miyawaki method used for TF is beneficial for carbon sequestration. To make it more concrete, it is estimated that the establishment of a new forest sequesters around 9 tonnes of CO2/ha/year and that TF can sequester around half of that (VBNE, 2020). A single UF in Amsterdam the size of a tennis-field would sequester around 0.25 tonnes of CO2/year (VBNE, 2020). Due to the beneficial characteristics of the Miyawaki method for carbon sequestration, this number is likely to even exceed 0.25 tonnes of CO2 per year.

Table 6: Scoring TF in terms of carbon storage: (a) increasing the total soil volume; (b) increasing the carbon stabilization rate; (c) increasing the organic matter input; (d) decreasing the decomposition rate. Scoring: ++ is a high increase, + is an increase, +- is no/uncertain effect, - is a decrease , -- is a high decrease in carbon storage.

Factors influencing soil carbon sequestration	**Effect TF**	**Explanation**
(a) increasing the total soil volume	++	TF soils are ploughed and enriched according to their needs, which enhances the natural soil formation.
(b) increasing the carbon stabilization rate	+/-	After initial soil treatment, the soils remain undisturbed indefinitely, which is beneficial for the carbon stabilisation rate in urban soils. However, it remains uncertain whether the root systems of the native plants used in the Netherlands are optimized to transfer root-derived carbon into stable SOC.
(c) Increasing the organic matter input	++	Vegetational succession increases the diversity and productivity of vegetation.
(d) decreasing the decomposition rate	++	Vegetational succession leads to a higher F : B and to an increase in mycorrhizal types and quantities, which both decrease the decomposition rate.

3.4 Disservices

Also the potential negative consequences or trade-offs of implementing TF, so called "ecosystem disservices", need to be taken into account when assessing the potential benefits of TF (Figure 8) (Pataki et al., 2011; Lyytimäki et al. 2008).

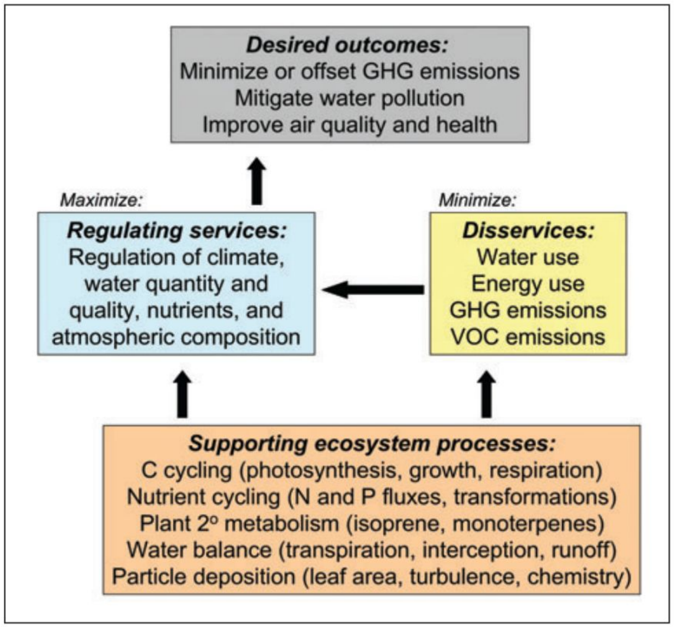

Figure 8: Framework for incorporating ecosystem services into improving environmental outcomes in cities, where both ecosystem services and disservices (benefits and costs of green space) must be identified for a given desired outcome (Pataki et al., 2011).

The urban forest disservice that is mentioned most often in literature, is the contribution to respiratory illnesses through the emission of biogenic volatile organic compounds (BVOCs) by certain trees (Davies et al., 2017). These trees contribute to smog or ozone formation, which are harmful for people and their environment. However, there are also tree species that actually contribute to ozone removal from the atmosphere, and whether TF includes BVOC emitting trees is yet to be investigated (Calfapietra et al., 2016).

Furthermore, urban trees can contribute to the release of allergenic pollen, whilst more and more people are getting susceptible to tree-derived pollen and about one-third of the world's population already experiences an allergic response to these pollen (Cariñanos et al., 2016). This tradeoff has to be taken into consideration when planting TF. Moreover, the establishment of an urban forest can facilitate the spread of pests and diseases (Lyytimäki et al. 2008). However, this spread is most often occurring with the establishment of non-native species, which is not the case in TF. In fact, many of these disservices can be attributed to only a couple of specific tree species, whilst the TF tree species are always selected with care by experts, preventing these disservices altogether (Davies et al., 2017; IVN, 2020).

Many of the ES can be in conflict with each other, resulting in tradeoffs. For example, the sheer density and diversity of TF can be beneficial for educational purposes, but might not be compatible with other recreational activities, due to their small size and density. On the other hand, children can 'recreate' too much in a TF, like in Utrecht, where a TF was used so intensively that it eventually degraded (Anne Mara Sillevis Smitt, Appendix II). Fallen leaves, branches or seeds from the trees and excretions like bird droppings or honeydew have been reported as potential disservices of urban trees (Davies et al., 2017). The municipality of Amsterdam is specifically cautious that the wild vegetation cover could attract unwanted people (Anne Mara Sillevis Smitt, Appendix II). However, according to Alina Salomon (Appendix I), this is usually not a problem for TF, because these forests are maintained by an active community of volunteers, resulting in an attractive, pleasant and welcoming environment. But the "not in my back yard" (NIMBY) effect can always occur, which materializes more often in crowded cities, like Amsterdam (Anne Mara Sillevis Smitt, Appendix II).

It is also suggested that UF in general is not an effective means for climate mitigation, due to its negligible contributions as compared with the total urban GHG emissions (Pataki et al., 2011; Strohbach et al., 2012). However, biogenic exchange through vegetation and soils within urban areas can significantly influence local atmospheric mixing ratios and can sequester the local, abundant emissions (Coutts et al., 2007; Raciti et al., 2012; Briber et al., 2013; Rogers et al., 2015; Seto et al., 2014). This means that urban green does have a significant effect on the urban carbon cycle (Churkina, 2016). However, compared to natural areas, the management of urban trees also requires more energy for planting, pruning, watering, fertilizing and maintenance (McPherson et al. 2005; Pataki et al. 2006; Escobedo et al., 2011). TF on the other hand can minimize these ecosystem disservices, because after a TF is planted, it becomes a self-sustaining forest (IVN, 2020).

Moreover, research shows that urban trees are the most effective and least costly approach to urban heat island mitigation and adaptation, reducing building energy use by lowering temperatures through shading during the summer, and blocking winds in winter (Norton et al., 2015; Solecki et al., 2005; Nowak, 2002). This means that urban green can have a significant impact on reducing the GHG emissions indirectly. However, these indirect effects also depend on the location of the trees and no particular research has been done towards the contribution of TF to these indirect effects, so again, further research is required.

3.5 Connectedness

Despite the individual contributions of the aforementioned ES, it is important to critically view the system as a whole, to understand how ES enhance one another or result in trade-offs.

Biodiversity may be a key driver of ES. However, the understanding of how biodiversity is connected to other ES remains incomplete (Duncan et al., 2015). Links between biodiversity are often poorly understood, because biodiversity and ES are often not jointly used research, but separately investigated (Duncan et al., 2015). However, there have also been simple, linear relations between biodiversity and ecosystem functions such as productivity, biomass, nutrient cycling, carbon flux and nitrogen use (Haines-Young & Potschin, 2010).

Research also found links between biodiversity and social well-being (Haines-Young & Potschin, 2010; Bennett et al., 2015). According to Carrus et al. (2015) biodiversity has a positive effect on individuals. The richer the amount of species in an urban area, the higher the individual well-being. Carrus et al. (2015) therefore emphasizes that biodiversity should always be taken into account in urban planning. The concept of Service Providing Unit (SPU) was introduced, where the species contributing to an ecosystem service are combined and their ecological footprint measured (Haines-Young & Potschin, 2010). Methods to value species are important since sometimes higher biodiversity does not necessarily improve social well-being (Haines-Young & Potschin, 2010). There are always social and economical restrictions that need to be considered in managing ecosystems (Haines-Young & Potschin, 2010). TF deals with these considerations as well since biodiversity is probably highest if the TF is not accessible for everyone while the recreational and educational part of TF is important for human well-being especially in urbanized areas.

Implementing TF can also improve nature awareness and children in cities can appreciate nature more, when they are actively involved in the planting process, which can lead to more nature preservation actions and eventually could increase urban ES in the future.

The need to be part of a community, improve individual well-being and contribute to improving ecosystems are also important factors in urban human-nature interaction (Dennis & James, 2016). Civic ecology has therefore been a popular topic in research and urban management (Dennis & James, 2016). The strategy of TF is based on this interaction since TF are planted together with the community, maintained by volunteers and around $50m^2$ of the TF is reserved for educational or recreational purposes. Furthermore, TF and the University of Wageningen apply citizen science to the ongoing research on TF. Citizen science is research that is partly or fully conducted by volunteers (Louv & Fitzpatrick, 2012). Citizen science has the benefits that large-scale research can be conducted while deriving social benefits as well for people from many backgrounds and ages, by using science to address community-driven questions (Bonney et al., 2014). Moreover, citizen science could help with carbon accounting the forests, to quantify how much additional CO_2 will be stored, which will be beneficial to prove the impact of the forests.

Taken together, regulating, supporting and cultural services are all interconnected. Focusing on improving solely one ecosystem service, almost always results in trade-offs (Robinson et al., 2013).

4 TINY FORESTS IN COMPARISON TO OTHER URBAN GREEN SPACES

As described by the World Health Organisation, urban green spaces (UGS) are nature-based solutions increasing the quality of urban life and improving climate resilience, but can take all kinds of forms (WHO, 2017). There is a high diversity in the shape that UGS can take, ranging from roadside greenery and green roofs, to parks and playgrounds. As the WHO states, all UGS contribute to a healthy city, irrespective of whether they are private or public (WHO, 2017). In this paper, the focus will lay on intentionally implemented urban green spaces that are available for human use, such as public parks (Figure 9), not including green roofs, roadside greenergy and natural wildlife areas for example.

The choice on what type of urban green space to implement within a city can be facilitated by considering the level of maintenance, the extent to which an urban green space is able to contribute to the aforementioned ES and its sustainability (see Chapter 3). From this, the suitability of a TF within a highly urbanized environment can be examined as well. The benefits and complications of TF in comparison to traditional urban parks, will be critically explored. In specific, the concepts of management requirement, biodiversity level, possible human-nature interaction and the size of urban green space are discussed.

Figure 9 and 10: on the left the Amsterdam Vondelpark, on the right a TF in the Netherlands (Citynieuws, 2020; WUR, 2020)

4.1 In terms of management

Under ‘traditional management’ of UGS we now focus on urban recreational parks. Overall, traditional management of these parks did not take the true complexity of nature into account, which led to high demand for management due to its homogeneity (Kennedy, et al., 1998). As a consequence, Kennedy (1998) stated implementing more *organic* UF methods was needed. An example of the big difference between traditional and more recent nature-based management of UGS, is the fight against spontaneously developed plants, which in traditional methods are completely worked against (Messelink, 2002).

TF are the size of a tennis field (Figure 10). This small size may make it easier to implement such an urban green space, as opposed to a large city park that has to facilitate many recreational activities. The bottom line of the TF is to create a self-sustaining ecosystem. For TF implementation, a horticulturist that has been trained to implement the Miyawaki method, works the soil intensively and plants the approximately 600 different trees with the help of all kinds of volunteer groups and schools (Alina Salomon, pers. comm., 23/04/2020). After this intensive start-up only little maintenance is required, making it a very low-demand urban green space.

4.2 In terms of biodiversity

Studies have shown that cities are able to sustain high levels of biodiversity (Farjon, et al., 1997), even though the urban environment does not necessarily radiate this. However, we must consider that contributions to species richness in Amsterdam were assigned to spontaneously generated UGS (i.e. fallow land and unused railways) and not intentionally constructed UGS (Farjon, et al., 1997). Traditional forestation methods within urban environments were primarily focussed on aesthetics and human use (Walker, 2004). This approach is characterized by low species-diversity and wide open spaces, neglecting natural-based factors (Messelink, 2002). Consequently, over-simplified forests were established, barely corresponding with characteristics of wild ecosystems (Pinto-Correia et al., 2006, Hladnik & Pirnat, 2011).

Biodiversity can be stimulated by providing a more heterogeneous landscape and species composition (Messelink, 2002). TF are in principle always constructed of native species according to the surrounding environment and usually consist of over 300 species, which leads to a very diverse species contribution and heterogeneous forest. This results in high biodiversity levels within this small forest, compared to homogeneous traditional parks.

On the other hand, cities create unnatural conditions which do not always match native habitats (Sæbø, et al., 2003). It could be discussed whether the plants that thrive best in these urban circumstances are actually natives. Natives have decreased chances of self-sustaining population development on man-made sites, due to high disturbance levels such as pollution, limited space and vandalism (Alvey, 2006; Kowarik, 2011). Non-native species are often more tolerant to urban conditions (Elmqvist, 2016). Moreover, non-native species are often introduced during urbanization, sometimes even increasing biodiversity levels (McKinney, 2006). To counter argue this, IVN has pointed out the fact that so far no such negative effects were noticed within the TF implemented in the Netherlands, and that native species are growing successfully within urbanized areas so far (Alina Salomon, Appendix I). However, in the aforementioned research on TF Zaandam these 'true' urbanized circumstances are not completely investigated, since it is situated in a rather open urban space, without high levels of traffic, high buildings and street run-off (Ottburg et al., 2017)

4.3 In terms of patch size

Collinge (1996) states that landscape fragmentation due to urbanization inhibits species to disperse, hinders populations to connect and results in microclimatic shifts at the edges of remaining patches affecting present species. The latter are called habitat edge-effects. Remaining or intentionally created green spaces within cities are often very distinct and located in the hostile urban environment (Collinge, 1996). Due to habitat-edge effects, bigger patches are expected to support higher species numbers (Collinge, 1996). Messelink (2002) agrees by saying that the more habitat area, the higher the species holding-capacity is. Moreover, Messelink (2002) states that the bigger the urban green space, the bigger the environmental variability, thus leading to a more diverse ecological support for species.

Furthermore, the bigger an urban green space is, the more water holding capacity it is expected to have due to the overall higher soil content and lower solid ground coverage. This also accounts for carbon storage, provided that the present number of trees, shrubs and other greenery is correlated to the size. That is to say, when an urban green space is relatively large but does not provide much greenery to extract carbon out of the air, it does not necessarily contribute more to carbon storage than small foress This is also true for heat-stress mitigation and species holding capacity (see 4.2).

Nevertheless, some research also argues that ‘positive edge-effects’ can arise for small urban green spaces or ecosystems in general. For example, recent research by Valdés et al. (2020) mentions the increase in light penetration at the edge of a small forest and an increased input regarding nutrients from surrounding areas, such as agricultural lands. It has to be taken into account that these circumstances differ from the urban situation (not always higher light penetration, no nutrients from agricultural lands) in which TFs are implemented.

4.4 In terms of human-nature interaction

Traditional UF has resulted in human-based decision making, without looking at broader ecological potential. Traditionally, UGS are part of human culture instead of having its own identity, to be manipulated by humans (Messelink, 2002). From this we can conclude that these parks are designed for human use, showing a high degree of open-spaces that can be used for sports or picnics, small lakes with fountains, benches and hiking trails.

Figure 11 and 12: on the left are children planting tulip bulbs in the Vondelpark, on the right are children planting tree seedlings at the start of creating a Tiny Forest in Utrecht (Bennink, 2018; IVN, 2020)

In contrast to these highly aesthetic parks, a TF is an incredibly dense forest with little to no trails (Alina Salomon, Appendix I). Nevertheless, one main goal of implementing TF, is reconnecting humans with nature (Alina Salomon, Appendix I). TF involve schools and citizens in the process of designing, planting and maintaining the forests (Alina Salomon, Appendix I) (Figure 12). This could increase human-nature interaction (Figure 11).

Moreover, in addition to the earlier implementation of TF due to its small size (4.1), realizing a TF in a city can reduce the distance between the urban population and UGS. Subsequently, more people will have easier access to nature.

Lastly, Alina Salomon (Appendix I) points out the ultimate goal of TF by IVN, namely using these forests for educational and cultural purposes (e.g. classroom, tiny concerts). Despite its small size, a TF can be morphed in various shapes, so little open spaces are realizable. Providing that most of these TF are close to schools and located in the middle of residential areas, this goal is highly realistic.

4.5 In conclusion

As stated by the WHO (2017), a high diversity in UGS within a city is recommended, to match the varying demand from urban citizens. Nevertheless, some types of UGS might be more suitable in some situations than others. Table 7, a reflection on the aforementioned four factors (management, biodiversity, human-nature interaction and patch size) is given, together with a score on the suitability of the UGS type in terms of the factor. TFs are compared with bigger traditional parks here.

Based on these four factors, an TF could be very suitable to be implemented in a highly urbanized area due to its relatively low management, easy implementability, location nearby citizens and high biodiversity. These are all factors contributing to urban health. Tiny Forests could therefore be a good contribution to the overall UGS network in a populous city as Amsterdam.

Table 7: scoring of two urban green space types (Tiny Forests and bigger traditional parks) in terms of management, biodiversity, human-nature interaction and patch size. Scoring: ++ is highly prefered, + is prefered, +- no particular preference, - not recommended, -- strongly discouraged. For instance, management/maintenance are costly activities and could reduce sustainability of a UGS when lacking this attention. Therefore, the less management required, the higher the score.

	Tiny Forest	**Traditional park**	**Explanation**
Management	+ +	- -	Since TF only require intense management when implemented and the short period hereafter (about one year), management efforts are low. Traditional parks and their aesthetic aim and open-wide spaced ask for monitoring, removal of unwanted species and management efforts such as mowing.
Biodiversity	+ +	-/+	The aim of TF is to implement solely native species in a high diversity and high density manner, in order to increase biodiversity within an urban environment. Around … species are implemented. Traditional implemented urban green spaces, such as parks are often very homogeneous and do not provide the heterogeneity that is needed to attract all sorts of species such as butterflies, birds and ground organisms.
Human-nature interaction	+	+	Human-nature interaction is provided in both shapes of urban green space, TF and traditional park. In a traditional park, the space for recreation (hiking trails, picnic areas, sport areas, benches, etc.) are provided in a high amount. Nevertheless, these often relatively huge parks can not always fit within highly urbanized areas. TF are small-sized patches that could easily be implemented within urbanized areas since they require way less space. Therefore, the connection between urban citizens living far away from the big parks are now provided with a patch of greenery nearby. This also accounts for schools that can use this TF as a classroom in the neighbourhood.

Patch size	-	-/+	Since habitat edge-effects are created in an extreme manner in the urban environment (due to pollution, noise, heat, human interaction, etc.), small patches could suffer from these impacts. This could lead to lower species support and subsequently to lower species diversity and abundance. The bigger the patch, the less impact edge-effects could have on the urban green space. Moreover, water holding capacity increases with size. On the other hand, size is not always completely correlated with carbon sequestration, heat-stress mitigation and species holding capacity when managed in the right manner.
Total	**++++**	**-/+**	

5 CURRENT POLICIES REGARDING IMPLEMENTATION OF TINY FORESTS IN AMSTERDAM

The city of Amsterdam published the *Green Agenda* in 2015, in which they explain what their current policy plans are regarding a green city of Amsterdam, for 2015 until 2018. In the *Green Agenda*, the main goals and criteria of this green city are also explained. (Gemeente Amsterdam, 2018).

In the first part of the *Green Agenda*, it becomes clear that Amsterdam wants to have green spaces in the city to improve the life quality of those who live, stay and work in Amsterdam. Besides this, Amsterdam has to be a healthy city to live in, and the biodiversity also has to be maintained (Gemeente Amsterdam, 2018, p. 3).

Another important point made in the *Green Agenda*, is that people (living and working) in Amsterdam have to manage the green space together. It is seen by the city of Amsterdam that inhabitants, NGOs and local businesses have become more and more interested in green spaces in their neighborhoods, and this is also highly welcomed (Gemeente Amsterdam, 2018, p. 7). TF fits well to this idea, as it has the goal to design, plant and maintain the TF with local residents (Alina Salomon, Appendix I).

The city of Amsterdam has 20 million euros available for the maintenance and development of green spaces in Amsterdam. In the *Green Agenda* it is stated that money for green space can be applied for by both government organisations and others. Some of the important criteria for this budget are that the project has to contribute to biodiversity, a climate resistant city, a healthy living space, and it must also be accessible, reachable and usable by various groups (Gemeente Amsterdam, 2018, p. 45). TF seems to meet the requirements of these criteria. TF also has its own budget, obtained from the *Postcodeloterij*, meaning that additional costs for the municipality can be often avoided.

As for now, TF has not yet been implemented in Amsterdam. In an interview with Alina Salomon (Appendix I), it becomes clear that IVN, the organization behind TF is very enthusiastic about a TF in Amsterdam. An interview with Anne Mara Sillevis Smitt (Appendix II), who is working at IVN, revealed that there is an ongoing consultation with the city of Amsterdam. There are possible plans to plant a TF at a school in the southeast of the city. The school was very enthusiastic about this, and so was IVN, because the education part of TF is very important to them. Because of Covid-19 this project is temporarily at a standstill, but that can be picked up again after this. (Anne Mara Sillevis Smitt, Appendix II). The city of Amsterdam also prefers to call TF “Mini bossen”, mini forests, because TF has specific requirements they can’t always meet. (City of Amsterdam spokesperson, pers. comm., 11 May 2020); (Anne Mara Sillevis Smitt, Appendix II).

A downside, is that the city of Amsterdam is in the case of TF not necessarily positive about the fact that TF needs little or no maintenance. The reason for this, is that the little maintainance could turn TF into a dense, dark hangout spot where it is not possible to supervise. Also, a TF in the city centre may not be desirable, because residents may see the many trees as a limitation of their light and view, in the already cramped city centre. (Anne Mara Sillevis Smitt, Appendix II).

Therefore, TF seems to be the best fit for the edges of the city, or at least at a place where more space is available. The combination of TF with a school fits perfectly as the nature education part of green space is important for both the city of Amsterdam as IVN. (Gemeente Amsterdam, 2018, p. 7); (Anne Mara Sillevis Smitt, Appendix II).

6 CONCLUSION

As has been recognized in this literature review, TF establish biodiversity-hotspots, sequester carbon through vegetation and soils, and increase human-nature interaction within urbanized areas. TF contribute to biodiversity by implementing the Miyawaki planting method, which hosts a diversity of local plant species which create a favorable environment for many other species. In the first stage of planting TF the soil is cultivated as well, which results in an abundance of microorganisms playing an important role in carbon sequestration, as well as supporting the fast growth of trees which reduce atmospheric carbon. Human-nature interaction is also expected to increase, since more people have access to green spaces in their nearby neighbourhood where otherwise green spaces would be absent. This can improve physical and mental health as well as offering a place for recreation, education and community participation. However knowledge on the extent to which these tennis-field sized forests contribute to the aforementioned services in an urban environment remains to be uncertain.

Compared to other urban green spaces, TF require lower levels of management and maintenance once the setup phase has passed; and have overall higher biodiversity levels in comparison to simplified classical urban parks. However, human-nature interactions are not expected to be higher for TF, since the small size does not allow activities that an urban park might be able to host (e.g. sporting activities, picnicking, walking the dog). Nevertheless, the aim behind TF is to place them in neighbourhoods where greenery is mostly absent and close to schools, thus increasing the chance of human-nature interaction by people who were previously very distanced from greenery. Habitat-edge effects (air pollution, litter, polluted water run-off) might negatively influence species within the TF. Nevertheless, the small size of TF make implementation of such an urban green space relatively easy in highly urbanized environments, since less free space has to be created. Partly for this reason, the demand for TF is very high from Amsterdam and other Dutch cities, although some rebuttal has been heard according to IVN.

Concludingly, TF meet the requirements of implementing more green in the city of Amsterdam described in their Green Agenda, since it contributes to biodiversity, climate resistance, healthy living spaces, and it is accessible, reachable and usable by various groups. TF are most suitable for places such as school yards and more spacious neighborhoods. To conclude TF can be a suitable form of urban green space, which meet the green goals of the municipality of Amsterdam. It should be emphasized that implementing TF should not restrict the implementation of other green spaces, since different urban ecosystems offer different services which should all be taken into account.

7 DISCUSSION

Supporting services

The results on biodiversity do have to be treated with care, because both TF in Zaandam are planted in other parks and not in an urban environment (Ottburg et al., 2017). Researchers therefore expect lower biodiversity in more urbanized areas and these TF will most likely be colonized by mobile species transporting themselves through air first (Ottburg et al., 2017). Another point of discussion is the method of measuring biodiversity. This is done through citizen science, where volunteers observe and count species. A large group of volunteers is needed with the adequate taxonomic knowledge, which is not always easy to find or maintain (Ottburg et al., 2017). The nature experience aspect of TF also needs to be taken into account, since TF will eventually contribute to education and recreation as well possibly disturbing species. Alina Salomon stated that: *TF can provide a place to meet-up for locals as well* (Appendix I).

As mentioned before, it should be emphasized that biodiversity is not always a suitable method for measuring ecosystem quality. Urban ecosystems often have a higher species-count than adjacent agricultural ecosystems, but these species do not necessarily contribute to the quality of the ecosystem (Havlicek & Mitchell, 2016). TF can however contribute to the quality of urban ecosystems by introducing new species that specifically occupy urban forests and cannot be found in city parks, gardens or lakes.

Regulating services

The common controls over photosynthesis are atmospheric CO_2 concentrations, air temperature and humidity, light, soil water availability, nitrogen supply, and tropospheric ozone concentrations (Larcher, 1995). These factors have not been discussed in this research, because it was assumed that differences in management strategies don't have a major impact on these factors. It is recommended that these factors are discussed in further research towards the carbon storage ability of TF.

Question remains whether the size of a TF can store significant amounts of carbon, compared to bigger patched parks. Moreover, current forest carbon accounting methodologies are often highly complex, expensive and time-consuming, which results in a lack of research towards smaller projects, like TF (Wise et al., 2019). TF can be considered to be even more complex than the usual forest, due to their diversity and stratification, making a thorough assessment of their carbon storage capacity even more challenging. Especially changes in SOC typically take decades before they materialize, making these changes difficult to measure. Therefore, further research on the carbon storage of TF will be necessary before giving definitive conclusions. Luckily, in 2020 11 TF will be monitored, after which the CO2 sequestration per TF can be accurately determined (VBNE, 2020). After these measurements a prediction is given how much CO2 a Tiny Forest will store after 5, 10, 25, 50 and 100 years (VBNRE, 202).

Cultural services

One implication for measuring cultural services is that these ES are not monetarily measured but are considered to have an intrinsic value. Nevertheless, many studies nowadays focus on the positive effects of urban green on human well-being. A few studies suggested that TF can possibly increase citizen participation and improve community networks. However, research is less to be found on the influence of green space on increasing community feeling or participation (Rosol, 2010). The other way around, active participation of a community in managing urban green increases the success of green spaces (Rosol, 2010). This suggests that the success of a TF is dependent on the community. Implementing TF in active communities willing to participate can increase the chance of becoming a successful green space.

Disservices

Whilst trees can be net CO_2 emitters over their life cycle by accounting for all energy and fuel inputs, the social benefits provided by urban forests often outweigh the environmental and economic costs of maintaining them (Jo & McPherson, 1995; Nowak et al., 2002; Dobbs et al., 2011). This is especially true for TF, because it is expected they minimize ecosystem disservices through their small size and self-sustaining nature, whilst providing numerous other environmental benefits. However, it must be said that thorough research towards the ecosystem disservices of TF is currently lacking, so further research is required, like to the species-specific BVOC emission factors.

Tiny Forest compared to other green spaces

Although this research focuses mainly on the implementation of TF in urbanized areas and the use and preference of this method, it should not delete the options of implementing other green spaces. All urban green spaces contribute to ecological connectedness within a city. The realization of green corridors can contribute to ecological sustainability of species.

Recommendations for further research

This study shed light on knowledge gaps on urban ecosystems, in specific TF, as well. Firstly, while biodiversity levels have been measured in TF, research on other ES that TF may provide remains non-existent due to its recent popularity gain and short history of large scale implementation. However, gathering more information on the importance of urban-biodiversity, carbon storage (by urban soils and vegetation) and the extent of contribution to human well-being by TF is needed to completely understand its potential. Secondly, we recommend more stakeholder involved research on the current management within Amsterdam and how TF implementation could be further facilitated. Thus far, several conflicting interests have been found in the debate on TF, such as light limitation and subsidy schemes. Furthermore, since Amsterdam is a dense city in terms of built-environment and population, it would be useful to further research the social effects of TF in a highly urban area. Thus far this is lacking, due the majority of TFs being implemented in medium urbanized areas. This research could moreover focus on the accessibility and degree of appeal of TFs to citizen groups, so that a pleasant and safe feeling can be safeguarded in the future.

8 REFERENCES

Alvey, A. A. (2006). Promoting and preserving biodiversity in the urban forest. *Urban Forestry & Urban Greening*, *5*(4), 195-201.

Averill, C., Turner, B. L., & Finzi, A. C. (2014). Mycorrhiza-mediated competition between plants and decomposers drives soil carbon storage. Nature, 505(7484), 543-545.

Bailey, V. L., Smith, J. L., & Bolton Jr, H. (2002). Fungal-to-bacterial ratios in soils investigated for enhanced C sequestration. *Soil Biology and Biochemistry*, *34*(7), 997-1007.

Bennink, P. (2018). Amsterdamse kinderen planten tulpenbollen in Vondelpark [photo]. Queried from *https://www.hortipoint.nl/vakbladvoordebloemisterij/vakbladvoordebloemisterij/evenementen/amsterdamse-kinderen-planten-tulpenbollen-in-vondelpark/ on 27/05/2020*

Betsill, M. M. (2001). Mitigating climate change in US cities: opportunities and obstacles. Local environment, 6(4), 393-406.

de Boer, W. D., Folman, L. B., Summerbell, R. C., & Boddy, L. (2005). Living in a fungal world: impact of fungi on soil bacterial niche development. FEMS microbiology reviews, 29(4), 795-811.

Bijker, R. A., & Haartsen, T. (2012). More than counter-urbanisation: Migration to popular and less-popular rural areas in the Netherlands. *Population, Space and Place*, *18*(5), 643-657.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics*, *29*(2), 293–301. https://doi.org/10.1016/S0921-8009(99)00013-0

Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., & Parrish, J. K. (2014). Next steps for citizen science. *Science*, *343*(6178), 1436-1437.

Briber, B. M., Hutyra, L. R., Dunn, A. L., Raciti, S. M., & Munger, J. W. (2013). Variations in atmospheric CO2 mixing ratios across a Boston, MA urban to rural gradient. Land, 2(3), 304-327.

Broddin, G., Cautreels, W., & Van Cauwenberghe, K. (1980). On the aliphatic and polyaromatic hydrocarbon levels in urban and background aerosols from Belgium and the Netherlands. *Atmospheric Environment (1967)*, *14*(8), 895-910

Salter, C. M., Ahn, R., Yasin, F., Hines, R., Kornfield, L., Salter, E. C., & Burke, T. F. (2015). Community Noise, Urbanization, and Global Health: Problems and Solutions. In *Innovating for Healthy Urbanization* (pp. 165-192). Springer, Boston, MA.

Cariñanos, P., Adinolfi, C., Diaz de la Guardia, C., De Linares, C., & Casares-Porcel, M. (2016). Characterization of allergen emission sources in urban areas. Journal of environmental quality, 45(1), 244-252.

Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., ... & Sanesi, G. (2015). F., ... & Sanesi, G. (2015). Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. Landscape and Urban Planning, 134, 221-228.

Chapin, F. S., Matson, P. A., & Vitousek, P. (2011). Principles of terrestrial ecosystem ecology. Springer Science & Business Media.

Churkina, G. (2016). The role of urbanization in the global carbon cycle. Frontiers in Ecology and Evolution, 3, 144.

City of Amsterdam (2015). *Green Agenda 2015-2018: Investing in the Amsterdammers garden (Summary)*. https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/groen/agenda-groen/?PagClsIdt=12790365#PagCls_12790365

Citynieuws.nl (z.d.). *Op expeditie in het Vondelpark* [Photo]. Queried from https://www.citynieuws.nl/op-expeditie-in-het-vondelpark/ on 25/04/2020.

Clements, F. E. (1916). Plant succession: an analysis of the development of vegetation (No. 242). Carnegie Institution of Washington.

Collinge, S. K. (1996). Ecological consequences of habitat fragmentation: implications for landscape architecture and planning. *Landscape and urban planning*, *36*(1), 59-77.

Connell, J. H., & Slatyer, R. O. (1977). Mechanisms of succession in natural communities and their role in community stability and organization. The American Naturalist, 111(982), 1119-1144.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & Raskin, R. G. (1997). The value of the world's ecosystem services and natural capital. *nature*, *387*(6630), 253-260.

Coutts, A. M., Beringer, J., & Tapper, N. J. (2007). Characteristics influencing the variability of urban CO2 fluxes in Melbourne, Australia. Atmospheric Environment, 41(1), 51-62.

Dai, L., Wörner, R., & van Rijswick, H. F. (2018). Rainproof cities in the Netherlands: Approaches in Dutch water governance to climate-adaptive urban planning. *International journal of water resources development*, *34*(4), 652-674.

Darkwah, R. M., & Cobbinah, P. B. (2014). Stewardship of urban greenery in an era of global urbanisation. *International Journal of Environmental, Ecological, Geological and Geophysical Engineering*, *8*(10), 671-674. biodiversity gain in woodlands. *Forest ecology and management*, *238*(1-3), 7-23.

Davies, H., Doick, K., Handley, P., O'Brien, L., & Wilson J. (2017). Delivery of ecosystem services by urban forests. Forestry Commission: Edinburgh.

De Deyn, G. B., Cornelissen, J. H., & Bardgett, R. D. (2008). Plant functional traits and soil carbon sequestration in contrasting biomes. Ecology letters, 11(5), 516-531.

Duncan, C., Thompson, J., & Pettorelli, N. (2015). The quest for a mechanistic understanding of biodiversity-ecosystem services relationships. *Proceedings. Biological Sciences*, *282*(1817), 20151348. https://doi.org/10.1098/rspb.2015.1348

Edmondson, J. L., Davies, Z. G., McHugh, N., Gaston, K. J., & Leake, J. R. (2012). Organic carbon hidden in urban ecosystems. Scientific reports, 2, 963.

Elmqvist, T., Zipperer, W., & Güneralp, B. (2016). Urbanization, habitat loss, biodiversity decline: solution pathways to break the cycle. *In, Seta, Karen; Solecki, William*

D.; Griffith, Corrie A.(eds.). Routledge Handbook of Urbanization and Global Environmental Change. London and New York: Routledge., *2016*, 139-151

Escobedo, F., Kroeger, T., & Wagner, J. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution*, *159*(8-9), 2078–2087. https://doi.org/10.1016/j.envpol.2011.01.010

Espey Jr, W. H., Morgan, C. W., & Masch, F. D. (1966). *Study of some effects of urbanization on storm runoff from a small watershed*. Texas Water Development Board.

Farjon, J. M. J., Hazendonk, N. F. C., & Hoeffnagel, W. J. C. (1997). Verkenning natuur en verstedelijking 1995-2020. Ikc Natuurbeheer.

Fenger, J. (1999). Urban air quality. *Atmospheric environment*, *33*(29), 4877-4900.

Fraser, E. D. (2002). Urban ecology in Bangkok, Thailand: Community participation, urban agriculture and forestry. *Environments*, *30*(1), 37-50.

Frouz, J., Toyota, A., Mudrák, O., Jílková, V., Filipová, A., & Cajthaml, T. (2016). Effects of soil substrate quality, microbial diversity and community composition on the plant community during primary succession. Soil Biology and Biochemistry, 99, 75-84.

Fujiyoshi, M., Kagawa, A., Nakatsubo, T., & Masuzawa, T. (2005). Successional changes in mycorrhizal type in the pioneer plant communities of a subalpine volcanic desert on Mt. Fuji, Japan.

Gemeente Amsterdam. (2018). Volg het beleid: groen. *Agenda Groen.* Retrieved 5 March 2020, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/groen/

Gidlöf-Gunnarsson, A., & Öhrström, E. (2007). Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas. Landscape and urban planning, 83(2-3), 115-126.

Giezen, M., Balikci, S., & Arundel, R. (2018). Using remote sensing to analyse net land-use change from conflicting sustainability policies: The case of Amsterdam. *ISPRS International Journal of Geo-Information*, *7*(9), 381.

Gómez-Baggethun, E., & Barton, D. (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, *86*(C), 235–245. https://doi.org/10.1016/j.ecolecon.2012.08.019

Götmark, F., & Thorell, M. (2003). Size of nature reserves: densities of large trees and dead wood indicate high value of small conservation forests in southern Sweden. Biodiversity & Conservation, 12(6), 1271-1285.

Groenewegen, P. P., Van den Berg, A. E., De Vries, S., & Verheij, R. A. (2006). Vitamin G: effects of green space on health, well-being, and social safety. BMC public health, 6(1), 149

Guilland, C., Maron, P. A., Damas, O., & Ranjard, L. (2018). Biodiversity of urban soils for sustainable cities. *Environmental Chemistry Letters*, *16*(4), 1267-1282

Haines-Young, R., & Potschin, M. (2010). The links between biodiversity, ecosystem services and human well-being. *Ecosystem Ecology: a new synthesis*, *1*, 110-139.

Havlicek E., Mitchell E.A.D. (2014) Soils Supporting Biodiversity. In: Dighton J., Krumins J. (eds) Interactions in Soil: Promoting Plant Growth. Biodiversity, Community and Ecosystems, vol 1.

Springer, Dordrecht

Hladnik, D., & Pirnat, J. (2011). Urban forestry—Linking naturalness and amenity: The case of Ljubljana, Slovenia. *Urban Forestry & Urban Greening*, *10*(2), 105-112.

Kennedy, J. J., Dombeck, M. P., & Koch, N. E. (1998). Values, beliefs and management of public forests in the Western world at the close of the twentieth century. Unasylva (English ed.), 49(192), 16-26.

Kell, D. B. (2012). Large-scale sequestration of atmospheric carbon via plant roots in natural and agricultural ecosystems: why and how. Philosophical Transactions of the Royal Society B: Biological Sciences, 367(1595), 1589-1597.

Koolen, C. D., & Rothenberg, G. (2019). Air pollution in Europe. *ChemSusChem*, *12*(1), 164-172.

Kowarik, I. (2011). Novel urban ecosystems, biodiversity, and conservation. *Environmental pollution*, *159*(8-9), 1974-1983.

IVN, (2020). Tiny Forests. IVN Natuureducatie. Retrieved from https://www.ivn.nl/tinyforest

Lange, O. L., Nobel, P. S., Osmond, C. B., & Ziegler, H. (2012). Physiological plant ecology I: Responses to the physical environment (Vol. 12). Springer Science & Business Media.

Ladygina, N., & Hedlund, K. (2010). Plant species influence microbial diversity and carbon allocation in the rhizosphere. Soil Biology and Biochemistry, 42(2), 162-168.

Leslie, H. A., Brandsma, S. H., Van Velzen, M. J. M., & Vethaak, A. D. (2017). Microplastics en route: Field measurements in the Dutch river delta and Amsterdam canals, wastewater treatment plants, North Sea sediments and biota. *Environment international*, *101*, 133-142.

Livesley, S. J., McPherson, E. G., & Calfapietra, C. (2016). The urban forest and ecosystem services: impacts on urban water, heat, and pollution cycles at the tree, street, and city scale. Journal of environmental quality, 45(1), 119-124.

Lorenz, K., & Lal, R. (2009). Biogeochemical C and N cycles in urban soils. Environment International, 35(1), 1-8.

Louv, R., & Fitzpatrick, J. W. (2012). *Citizen science: Public participation in environmental research*. Cornell University Press.

Lyytimäki, J., Petersen, L. K., Normander, B., & Bezák, P. (2008). Nature as a nuisance? Ecosystem services and disservices to urban lifestyle. Environmental Sciences, 5(3), 161-172.

Maclaurin, J., & Sterelny, K. (2008). *What is biodiversity?*. University of Chicago Press.

Maps.amsterdam.nl (z.d.). *Stadsparken, plantsoenen en recreatief groen* [Kaart]. Queried from https://maps.amsterdam.nl/stadsparken/?LANG=nl on 04/04/2020

McHale, M. R., McPherson, E. G., & Burke, I. C. (2007). The potential of urban tree plantings to be cost effective in carbon credit markets. Urban Forestry & Urban Greening, 6(1), 49-60.

McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological conservation*, *127*(3), 247-260.

McPhearson, T., Pickett, S. T., Grimm, N. B., Niemelä, J., Alberti, M., Elmqvist, T., ... & Qureshi, S. (2016). Advancing urban ecology toward a science of cities. BioScience, 66(3), 198-212.

McPherson, E. G. (2006). Urban forestry in north america. *Renewable Resources Journal*, *24*(3), 8.

Messelink, R. (2002). Functies in stadsparken: literatuuronderzoek naar mogelijkheden voor afstemming van natuur, landschap en recreatie in stadsparken (pp. 1-57). Wetenschapswinkel Biologie, Universiteit Utrecht.

Miyawaki, A. (2004). Restoration of living environment based on vegetation ecology: theory and practice. Ecological Research, 19(1), 83-90.

Moore, M., Gould, P., & Keary, B. S. (2003). Global urbanization and impact on health. *International journal of hygiene and environmental health*, *206*(4-5), 269-278.

Norton, B. A., Coutts, A. M., Livesley, S. J., Harris, R. J., Hunter, A. M., & Williams, N. S. (2015). Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. Landscape and urban planning, 134, 127-138.

Nowak, D. J. (2002). The effects of urban trees on air quality. USDA Forest Service, 96-102.

Oleson, K. W., Monaghan, A., Wilhelmi, O., Barlage, M., Brunsell, N., Feddema, J., ... & Steinhoff, D. F. (2015). Interactions between urbanization, heat stress, and climate change. *Climatic Change*, *129*(3-4), 525-541.

Ontl, T. A., & Schulte, L. A. (2012). Soil carbon storage, Nature Education Knowledge, 3 (10), 35.

Ottburg, F., Lammertsma, D., Bloem, J., Dimmers, W., Jansman, H., & Wegman, R. (2017). Tiny Forest Zaanstad: citizen science en het bepalen van biodiversiteit in Tiny Forest Zaanstad (No. 2870). Wageningen Environmental Research.

Pataki, D. E., Alig, R. J., Fung, A. S., Golubiewski, N. E., Kennedy, C. A., McPherson, E. G., ... & Romero Lankao, P. (2006). Urban ecosystems and the North American carbon cycle. Global Change Biology, 12(11), 2092-2102.

Pataki, D. E., Carreiro, M. M., Cherrier, J., Grulke, N. E., Jennings, V., Pincetl, S., ... & Zipperer, W. C. (2011). Coupling biogeochemical cycles in urban environments: ecosystem services, green solutions, and misconceptions. Frontiers in Ecology and the Environment, 9(1), 27-36.

Patarkalashvili, T. (2017). Urban forests and green spaces of Tbilisi and ecological problems of the city. *Annals of Agrarian Science*, *15*(2), 187–191. https://doi.org/10.1016/j.aasci.2017.03.003

Pinto-Correia, T., Gustavsson, R., & Pirnat, J. (2006). Bridging the gap between centrally defined policies and local decisions–Towards more sensitive and creative rural landscape management. *Landscape ecology*, *21*(3), 333-346.

Purvis, A.,; Hector, A. (2000). Getting the measure of biodiversity. Nature, 405(6783), 212-219.

Raciti, S. M., Hutyra, L. R., Rao, P., & Finzi, A. C. (2012). Inconsistent definitions of "urban" result in different conclusions about the size of urban carbon and nitrogen stocks. Ecological Applications, 22(3), 1015-1035.

Reich, P. B., Walters, M. B., Ellsworth, D. S., Vose, J. M., Volin, J. C., Gresham, C., & Bowman, W. D. (1998). Relationships of leaf dark respiration to leaf nitrogen, specific leaf area and leaf life-span: a test across biomes and functional groups. Oecologia, 114(4), 471-482.

Ren, L., Cui, E., & Sun, H. (2014). Temporal and spatial variations in the relationship between urbanization and water quality. *Environmental science and pollution Research*, *21*(23), 13646-13655

Robinson, D. A., Hockley, N., Cooper, D. M., Emmett, B. A., Keith, A. M., Lebron, I., Reynolds, B., Tipping, E., Tye, A. M., Watts, C. W., Whalley, W. R., Black, H. I. J., Warren, G. P., and Robinson, J. S, (2013), Natural capital and ecosystem services, developing an appropriate soils framework as a basis for valuation, Soil Biol. Biochem., 57, 1023–1033

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., ... & Nykvist, B. (2009). A safe operating space for humanity. nature, 461(7263), 472-475.

Rogers, K., Sacre, K., Goodenough, J., & Doick K. (2015) Valuing London's urban forest. Results of the London i-Tree eco project. London: Treeconomics. p. 82. https://www.itreetools.org/resources/reports/Valuing-Londons-Urban-Forest.pdf

Rosol, M. (2010). Public participation in post-Fordist urban green space governance: The case of community gardens in Berlin. International Journal of Urban and Regional Research, 34(3), 548-563.

Rousk, J., & Bååth, E. (2011). Growth of saprotrophic fungi and bacteria in soil. FEMS Microbiology Ecology, 78(1), 17-30.

Sachs, J. L., Mueller, U. G., Wilcox, T. P., & Bull, J. J. (2004). The evolution of cooperation. The Quarterly review of biology, 79(2), 135-160.

Sæbø, A., Benedikz, T., & Randrup, T. B. (2003). Selection of trees for urban forestry in the Nordic countries. *Urban Forestry & Urban Greening*, *2*(2), 101-114.

Schets, F. M., Van Wijnen, J. H., Schijven, J. F., Schoon, H., & de Roda Husman, A. M. (2008). Monitoring of waterborne pathogens in surface waters in Amsterdam, The Netherlands, and the potential health risk associated with exposure to Cryptosporidium and Giardia in these waters. *Appl. Environ. Microbiol.*, *74*(7), 2069-2078.

Schirone, B., Salis, A., & Vessella, F. (2011). Effectiveness of the Miyawaki method in Mediterranean forest restoration programs. Landscape and ecological engineering, 7(1), 81-92.

Six, J., Frey, S. D., Thiet, R. K., & Batten, K. M. (2006). Bacterial and fungal contributions to carbon sequestration in agroecosystems. Soil Science Society of America Journal, 70(2), 555-569.

Sol, A. J., & Belgers, J. D. M. (2014). *In de ban van de Waterleliegracht: naar een schone en aantrekkelijke Waterleliegracht in hartje Amsterdam* (No. 314). Wageningen UR, Wetenschapswinkel.

Solecki, W. D., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J., & Wiencke, M. (2005). Mitigation of the heat island effect in urban New Jersey. Global Environmental Change Part B: Environmental Hazards, 6(1), 39-49.

Steeneveld, G. J., Koopmans, S., Heusinkveld, B. G., Van Hove, L. W. A., & Holtslag, A. A. M. (2011). Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. *Journal of Geophysical Research: Atmospheres*, *116*(D20).

Strohbach, M. W., Arnold, E., Vollrodt, S., & Haase, D. (2012). Carbon sequestration in shrinking cities–potential or a drop in the ocean?. In Urban Environment (pp. 61-70). Springer, Dordrecht.

Summers, J. K., Smith, L. M., Case, J. L., & Linthurst, R. A. (2012). A review of the elements of human well-being with an emphasis on the contribution of ecosystem services. *Ambio*, *41*(4), 327-340.

Susyan, E. A., Wirth, S., Ananyeva, N. D., & Stolnikova, E. V. (2011). Forest succession on abandoned arable soils in European Russia–Impacts on microbial biomass, fungal-bacterial ratio, and basal CO2 respiration activity. European Journal of Soil Biology, 47(3), 169-174.

United Nations. (2018). World urbanization prospects: The 2018 revision (online edition).

Van Der Zee, S. C., Hoek, G., Harssema, H., & Brunekreef, B. (1998). Characterization of particulate air pollution in urban and non-urban areas in the Netherlands. *Atmospheric Environment*, *32*(21), 3717-3729.

Valdés, A., Lenoir, J., De Frenne, P., Andrieu, E., Brunet, J., Chabrerie, O., ... & Ehrmann, S. (2020). High ecosystem service delivery potential of small woodlands in agricultural landscapes. *Journal of Applied Ecology*, *57*(1), 4-16.

VBNE (2020) Klimaatslim Bos- en Natuurbeheer. Retrieved from https://www.vbne.nl/klimaatslimbosennatuurbeheer/maatregel/tiny-forests

Walker, C. (2004). *The Public Value of Urban Parks.* Urban Institute

Wallenstein, M. D., McNulty, S., Fernandez, I. J., Boggs, J., & Schlesinger, W. H. (2006). Nitrogen fertilization decreases forest soil fungal and bacterial biomass in three long-term experiments. Forest Ecology and Management, 222(1-3), 459-468.

Wang, X., Zhang, W., Shao, Y., Zhao, J., Zhou, L., Zou, X., & Fu, S. (2019). Fungi to bacteria ratio: Historical misinterpretations and potential implications. *Acta oecologica*, *95*, 1-11.

Waring, B. G., Averill, C., & Hawkes, C. V. (2013). Differences in fungal and bacterial physiology alter soil carbon and nitrogen cycling: insights from meta-analysis and theoretical models. Ecology letters, 16(7), 887-894.

Whitmore, A. P., Kirk, G. J. D., & Rawlins, B. G. (2015). Technologies for increasing carbon storage in soil to mitigate climate change. Soil use and management, 31, 62-71.

Wilkes, P., Disney, M., Vicari, M. B., Calders, K., & Burt, A. (2018). Estimating urban above ground biomass with multi-scale LiDAR. Carbon balance and management, 13(1), 10.

World Health Organization (WHO). (2017). Urban green spaces: a brief for action. *World Health Organization, Regional Office for Europe: Copenhagen, Denmark*.

WUR (2018). *Urban tiny forests are good for biodiversity. Queried from* https://www.wur.nl/en/newsarticle/Urban-tiny-forests-are-good-for-biodiversity.htm *on 27/05/2020*

Yoshitake, S., Fujiyoshi, M., Watanabe, K., Masuzawa, T., Nakatsubo, T., & Koizumi, H. (2013). Successional changes in the soil microbial community along a vegetation development sequence in a subalpine volcanic desert on Mount Fuji, Japan. Plant and soil, 364(1-2), 261-272.

Zhao, C., Long, J., Liao, H., Zheng, C., Li, J., Liu, L., & Zhang, M. (2019). Dynamics of soil microbial communities following vegetation succession in a karst mountain ecosystem, Southwest China. Scientific reports, 9(1), 1-10.

9 APPENDICES

Appendix I: Summary Interview Alina Salomon: IVN

23 April 2020

Hoe ben je bij TF terecht gekomen?
Ik werk nu 7 jaar bij het IVN. Sinds drie jaar ben ik bezig met TF. Een collega en projectleider had namelijk een college gezien van Indiase Shubhendu Sharma. Die methode kon ook in Nederland worden toegepast en daarom zijn we in 2015 met een pilot in Zaandam gestart. Dat was een geslaagd project en daarom zijn we er later een programma omheen gaan creëren. We gingen hierin voor een aanpak waarbij mensen uit de wijk en de lokale scholen betrokken waren. Educatie is een belangrijk speerpunt bij het aanleggen van deze TF. Het sociale deel van een TF is een erg belangrijk onderdeel. Maar dit project is pas echt groter geworden toen de postcodeloterij TF ging financiëren op grote schaal. Er zijn inmiddels minstens 100 TF de grond in gegaan in Nederland.

Kun je iets meer vertellen over wat er allemaal komt kijken bij het aanleggen van een TF?
We werken vooral met partnergemeenten. We hebben twee aanmeldrondes, één in 2018 en één in 2019 gehouden. Gemeenten die het leuk lijkt een TF aan te leggen kunnen zich dan aanmelden. De leukste gemeenten worden dan gekozen. Het gaat er dan ook om dat de gemeente uiteindelijk het beleid zal leiden en de TF zal verzorgen. Per ronde kozen we dan 24 gemeentes eerlijk verdeeld over onze provincies. We planten de TF dan samen met die gemeentes. Deze aanpak staat ook in een handboek. Vervolgens wordt er in de gemeente bij een aanvraag ook naar wijkbewoners of initiatiefnemers gezocht. We houden hierin ook rekening met wat de leukste aanvraag is en welke plekken de beste kans van slagen hebben. De gemeente moet ook akkoord gaan met de aanvraag om technische redenen, zoals is er ruimte voor een TF. Daarna ontwerpen we de TF met wijkbewoners samen. Die kunnen dan meedenken over hoe het eruit moet zien, daarin is namelijk best wat vrijheid.

Klopt het dat er dan niet één strak plan is voor TF die jullie volgen?
Ja dat klopt deels ja. TF zijn er in alle soorten en maten. In Nijmegen werd bijvoorbeeld de focus gelegd op veel bijenplanten en veel boomstammen. In andere steden kunnen de TF er weer heel anders uit zien. Er zijn wel een aantal ontwerpprincipes waar je je aan houdt. Zo zijn de TF niet groter dan 240m2 en moet het altijd minstens 4 meter breed zijn. Verder gebruiken ze altijd inheemse bomen anders mag het ook geen TF genoemd worden. De grond wordt verder ook flink bewerkt, omdat de bomen dan super snel groeien en het bos zichzelf ook goed in stand kan houden. Er zijn verder ongeveer 3 bomen per m2, dat is heel anders dan in een stadspark bijvoorbeeld, een TF wordt uiteindelijk dichtbebost. Niet alle bomen overleven het, maar minstens 550 van de 600 bomen die worden geplant overleven het. Deze regels hebben we vastgesteld zodat niet iedereen een TF kan beginnen, het moet aan bepaalde voorwaarden voldoen.

Is een TF anders in een stad dan een TF buiten een stad of aan de rand van een stad?
Hier heb ik geen zicht op. Ik probeer alle gemeenten een kans te geven, maar de meeste TF zijn wel in een urbane omgeving of een dorp, waar het groen echt nodig is. Inmiddels zien we ook wel dat TF in het midden van een stad erg divers zijn. De meeste TF zijn echt een oase van biodiversiteit.

Wij onderzoeken of TF een geschikt project zou zijn voor Amsterdam om te verduurzamen en als invulling van de plannen uit de Groene Agenda, waarom is er nog geen TF in Amsterdam? *We proberen al heel lang Amsterdam te stimuleren om een aanvraag in te dienen. De gemeente heeft beide jaren geen aanvraag ingediend. We krijgen wel heel veel berichten van organisaties en bewoners die dit heel graag zien gebeuren. Er is nu wel weer een projectleider mee bezig (hier kon ze nog achteraan gaan voor ons). Verder is er ook een potje met subsidie voor TF in achtertuinen. Als iemand dit in Amsterdam zou willen, zou dat ook kunnen, maar grote tuinen in Amsterdam zijn een zeldzaamheid. Als iemand uit Amsterdam een particuliere aanvraag zou indienen, zouden we het meteen goedkeuren. We willen natuurlijk dolgraag een TF in onze hoofdstad en veel organisaties en bewoners dus ook. We willen alle gemeenten een gelijke kans geven, maar grote steden hebben stiekem wel een beetje voorrang. We merken alleen wel dat de samenwerking met kleinere gemeenten vaak soepeler loopt.*

Voedselbossen zijn ook een huidige trend, kunnen TF ook worden ingericht als een voedselbossen?
Ja, dat kan mits ze de eetbare planten inheems zijn. We krijgen ook vaak de vraag naar een voedselbos. In Ede hebben we een tiny food forest aangelegd. Later hebben we besloten dat dit stom was, want de principes van een TF staan vaak haaks tegenover de de principes van een voedselbos. Een voedselbos is er vooral voor de mens, maar dit bos is juist een keer niet voor de mens, maar een voedselbos voor de diertjes die in de TF leven. Er loopt alleen een pad door het TF en door de rest kan je niet eens lopen. Daarin is een TF erg verschillend met een voedselbos.

Zijn de condities in een stadscentra niet heel anders dan wat inheemse soorten gewend zijn? Zien jullie dat effect, dat de condities slecht zijn voor het planten van bomen?
Het is nu nog te kort om dat soort verschillen echt te vergelijken. Daarvoor moeten gegevens over jaren worden vergeleken. Eén ding wat we doen is flink ingrijpen in het bodemleven. We verrijken de bodem en zorgen ervoor dat de wortels van de bomen diep worden geplant. Op die manier krijgen de bomen de beste kans om groot te worden en dat is belangrijk voor de lange termijn. Een TF moet namelijk minstens 10 jaar blijven, het liefst natuurlijk nog langer, 100 jaar is ideaal.

Je vertelt dat de grond wordt bewerkt, op welke manieren?
We beginnen met veldverkenning. We kijken wat voor inheemse vegetatie rond de kilometers om de locatie groeit. Die doen het waarschijnlijk goed in het TF en daarop wordt een plantenlijst gebaseerd. Daarnaast is er ook een bodemonderzoek, in Utrecht midden in de stad was er bijvoorbeeld een slechte zandgrond op een oude parkeerplaats beschikbaar. Ze kijken naar wat voor grondsoort het is, in Nederland zijn er maar ongeveer 4 waar ze mee te maken hebben. Ze kijken dan hoeveel organisch stoffen en mest moet worden

toegevoegd. Bij leemgronden moet je bijvoorbeeld veel luchtig materiaal toevoegen. Daarin is ieder TF dus ook anders. Voor dit veldonderzoek en bodemonderzoek is er ook een handleiding op de website.

Je benoemt net al dat jullie metingen doen, wat voor metingen zijn dat en wie onderzoeken TF?
Er loopt al twee jaar onderzoek. Een deel van het onderzoek wordt uitgevoerd door de groene tellers. Dit zijn vrijwilligers van het IVN. Die gaan op 10 locaties maandelijks soorten in kaart brengen. WUR doet ook onderzoek en de groene tellers volgen ook de methodes die de WUR onderzoekers toepassen. Dit onderzoek van de WUR is ook voor minstens 5 jaar en wordt ook aangevuld met citizen science, dat zijn dus ook vrijwilligers uit bijvoorbeeld de wijk die helpen soorten in kaart brengen.

Worden andere ecosysteemdiensten buiten biodiversiteit ook gemeten?
De vrijwilligers dragen vooral bij aan het meten van biodiversiteit. Ik geloof dat de WUR ook kijkt naar wateropslag/drainage. Verder wordt er ook gekeken naar CO_2*-opslag en worden hier modellen voor gemaakt. Laatst kwam hier ook iets over op de website van TF. Kijk in de nieuwsbrief (IVN) voor meest up-to-date nieuws.*

Zijn er nog andere groepen die betrokken zijn behalve gemeente en scholen? *De initiatiefgroep in de wijk is buiten de vrijwilligers heel belangrijk. Na de aanleg van de TF trekken wij ons namelijk terug. De gemeente kan bijvoorbeeld een beheersovereenkomst met scholen sluiten die dan het TF onderhouden. Als IVN langzamer en nu door corona kunnen ze ook niet zoveel planten als ze normaal kunnen. Op de lange termijn wil IVN zich terugtrekken en op dit moment is TF een populair concept, maar ze weet nog niet of het ook echt zal worden opgepakt en onderhouden in de jaren die volgen. Wat gebeurt er bijvoorbeeld als initiatiefnemers verhuizen? Hoe veel moeite willen bewoners dan echt besteden aan een TF? Dat is een uitdaging en tijd moet ook uitwijzen of dit een probleem gaat zijn.*

Zijn er wetten die in de weg zitten?
Nee niet echt eigenlijk, het gaat echt maar om de grootte van een tennisbaan. Het is piepklein. Soms willen mensen het wel op een hele specifieke plek, maar heeft de gemeente al plannen daar, zoals de bouw van huizen. Sommige gemeenten zijn ook bang voor hangjongeren. Maar dan kan je bijvoorbeeld een ander ontwerp kiezen, waardoor je dan geen last daarvan hebt.

Er moet natuurlijk ook ruimte voor zijn, zijn er ooit huizen weggehaald voor TF?
Nee dat niet, maar op een muziekplein in Utrecht is een reuzen parkeerplaats deels weggehaald (bij Terwijde). In Nijmegen is ook een TF te vinden op een industrieterrein. We willen het juist op zulke stedelijke plekken. Het is namelijk zo belangrijk dat kinderen toegang hebben tot natuur. Veel kinderen mogen tegenwoordig niet verder dan 500m van huis, dat is heel anders dan vroeger. Daardoor komen veel kinderen maar weinig in aanraking met de natuur. Als een TF voor de deur ligt, komen een stuk meer kinderen in aanraking met de natuur.

Is er ook sociaal-wetenschappelijk onderzoek gedaan?

Er was iemand mee bezig, van de WUR, maar dit ging uiteindelijk niet door. Een onderdeel van het WUR onderzoek is hier wel mee bezig. Verder komen veel groepjes, zoals jullie, met onderzoeken. Dit hou ik alleen niet heel erg bij, omdat er vaak ook weinig wordt teruggekoppeld.

Het is een nationaal bedrijf, maar hoe zit het met TF in het buitenland?
Er komen veel Europese partners komen naar ons toe. Het is echt een wereldwijde trend en in NL is het nu al heel groot. Er is nu ook een eerste TF in Engeland aangelegd en een paar in België. Er is ook interesse vanuit Spanje, Portugal en Denemarken. Vanmiddag heb ik toevallig ook een gesprek met Duitsland om te kijken of we TF ook daar kunnen realiseren.

Kunnen mensen zomaar een TF beginnen?
Het concept van TF is beschermd in de Benelux, maar we hebben wel veel connecties met andere organisaties ondanks dat het een NL project is. Veel projecten lopen momenteel, zo is er ook eentje in Pakistan en in Suriname. En voor die particulieren is er ook een cursus om de tuin om te toveren tot een TF. Hier worden cursussen voor gegeven elk jaar.

Heeft een TF ook een groot effect voor andere ecosysteemdiensten of heeft zo een klein bos weinig effect? In vergelijking met een groter stadspark bijvoorbeeld?
Goede vraag. Kijk iedere boom is mooi meegenomen ten eerste. In een park staan de bomen bijvoorbeeld veel verder uit elkaar. Stadsparken zijn ook lastiger voor gemeenten, omdat ze zoveel ruimte innemen. Hoe kleiner je ze houdt, hoe meer kans je hebt om een TF te realiseren. Zoveel mensen willen ook mee met deze trend. Het is namelijk dichtbij mensen hun huis, het is concreet, weinig onderhoud en het is een manier voor mensen om betrokken te zijn bij ons klimaat. Stadsbeheer willen de meeste mensen niet, maar een TF die na een paar jaar haar eigen gang gaat is iets heel aantrekkelijks. Er is uiteindelijk veel minder management en elk TF krijgt trouwens ook 50m2 voor educatie. Hier kan dan ook een bbq worden georganiseerd, of een yogales. Hiermee hebben we een kleine plek als eventueel klaslokaaltje. Het dient daarmee als een soort ontmoetingsruimte omdat dit het concept van een TF nog aantrekkelijker maakt en meer mensen de natuur laat ervaren. Ik geloof ook dat veel meer kleine TF een grotere impact hebben dan 1 stadspark. We hadden de afspraak met de postcodeloterij om 100 TF aan te leggen, maar het is echt een trend geworden waardoor veel gemeenten het ook op eigen initiatief aanleggen. En dan heb je ook nog eens veel particulieren. Het is niet de Veluwe, maar daarmee hebben we bij elkaar veel groen gecreëerd.

TF zijn nu wereldwijd aan het verschijnen, is de methode en de handleiding die jullie hebben gecreëerd een voorbeeld voor andere projecten?
Een manier om voedselbossen op te zetten kent ze niet goed, maar ze weet dat één van de grootste voedselbossen in Nijmegen ook goed werkt, maar daar is een ontzettend betrokken wijk. Ik denk dat één belangrijk aspect van TF is dat we de school betrekken en ook echt kijken wat wijkbewoners willen. Ik denk dat dat mooie manieren zijn om projecten aan te pakken. Als over 10 jaar blijkt dat vijvers belangrijk zijn en veel bijdragen, dan is het makkelijk om met intiatiefnemers en scholen dit te realsiren op dezelfde manier als we TF hebben gerealiseerd, echt samen met de gemeenten. Mensen laten meebeslissen en betrokken te laten zijn bij projecten zou veel projecten goed doen.

Wat is jouw rol bij TF en het IVN?

Ik ben één van de projectleiders. Ik ben altijd bezig met meerdere projecten met een groot landelijk team. Onze hoofdprojectleider die heeft het concept uit India gehaald en mijn taak is nu vooral alles coördineren rondom vrijwilligers. Per provincie hebben ze dan ook weer meerdere projectleiders, in Noord-Holland is dit Paul. Ik ben ongeveer 1 van mijn 3 dagen bezig met TF. Ze is ook een belangrijk aanspreekpunt, omdat ze contact houd met onderzoekers en de administratie van de mail doet. Als het goed is hoort ik ook vandaag of Duitsland akkoord gaat met een nieuwe samenwerking, daar ben ik dus ook bij betrokken. En goed voor jullie om misschien te weten. We bouwen nu ook aan een soort online-community om te testen wat de TF initiatieven opleveren zetten we deze op een platform en dan kun je daar opzoeken hoe het werkt en hoe je het zelf kan opzetten.

Appendix II: Summary Interview Anne Mara Sillevis Smitt: IVN

14 May 2020

Wat is je rol binnen TF?
Projectleider, voornamelijk in Provincie Noord-Holland. Ik ben al jaren actief in Amsterdam sinds ik begon aan mijn studie aan de UvA. Er zijn meerdere TF projecten in NH, maar ik ben nu betrokken bij Zaanstad. Hier waren vorig jaar twee TF projecten actief, en nu weer twee. Ik ben daarnaast betrokken bij paar MOGELIJKE projecten in Amsterdam. De gemeente zelf is niet meteen enthousiast, dat maakt het lastiger. Er zijn nog meer collega's die ermee bezig zijn. Ik heb zelf een achtergrond in educatie, en heb veel met kinderen in de natuureducatie gedaan. Zelf ben ik betrokken bij een natuur-educatie project in de bossen bij Baarn, maar dit is veel minder makkelijk bereikbaar voor kinderen! TF juist heel dichtbij en hierdoor ontstaat een band met de kinderen en de boompjes, want die gaan groeien en dat maken ze mee. Het liefst willen we een basisschool in de buurt, dat is namelijk een voorwaarde. We willen dat iedereen er in de pauze naartoe kan lopen.

Waarom gaat het nu zo moeizaam in Amsterdam?
Met de gemeente is er nog niet sprake van een samenwerking met IVN. Er is wel binnen de gemeenteraad (oorspronkelijk initiatief van PVDD) een motie aangenomen waarin ze zeggen dat ze vinden TF een heel mooi concept is. Dat heeft de Groen-afdeling/stadsecolooloog onderzocht en er is al met een middelbare school om de tafel gezeten, maar er werden nog veel haken en ogen gezien. Zoals: onbeheersbaar groen, trekt dat junks aan? Ze zijn bang dat bepaalde groepen uitgenodigd worden die niet wenselijk zijn. Maar ik zeg dan: "Wat is het anders dan een plantsoen?" De gemeente ziet zelf niet direct meerwaarde van TF, ze hebben wel een heel bomenplan in Amsterdam, maar dat draait om enkele bomen in tuinen bijvoorbeeld, dus een heel ander beleid. Het hele concept van TF is dat je het overlaat aan de natuur en dat het z'n gang mag gaan, juist niet veel beheer. Maar dat vindt de gemeente niet wenselijk, maar daar hebben ze in sommige opzichten wel gelijk in. Bijvoorbeeld in Zaanstad werden al hangjongeren gesignaleerd, en daar heeft het bosje ook onder te lijden.

Kun je ons wat meer vertellen over eventuele ecosysteem disservices?

Zoals hiervoor benoemd kunnen de bosjes ook ongewenste partijen aantrekken wat voor de buurt én het bosje niet fijn is. Daarnaast kunnen kinderen er ook weer te veel gebruik van maken, bijvoorbeeld in Utrecht: daar werd een TF zo intensief gebruikt dat het degradeerde, wat aan de ene kant positief is voor de connectie met de natuur, maar dan wordt het wel weer meer een plantsoen. Het maakt TF een kwetsbaar concept, wij als IVN willen heel erg biodiversiteit maar ook dat kinderen betrokken worden. Ik wil dat kinderen er wel in kunnen spelen, maar hoe kan dit in een heel dichtbegroeid bos? Vooral de beginfase is de kwetsbaarste fase, maar dit is ook het moment dat kinderen hebben onthouden (ze mogen zelf planten en het is JOUW boompje, naam geven, etc). Om ze er daarna er weer uit te houden is een lastige kwestie. We zetten meestal een hekje eromheen, maar ook om te zorgen dat een voetbal er niet in terecht komt is lastig.

De gemeente heeft dus haar eigen ideeën, of eigen versie "minibossen"? Zouden jullie dat ondersteunen?
Dit speelt inderdaad in Haarlem, waar ze het idee van mini-bossen hebben geïntroduceerd. Het is daar toch uiteindelijk wel weer een TF genoemd. Maar toch waren we vanuit TF niet heel blij met de gang van zaken als eerst. Ondanks dat het concept heel erg gewaardeerd wordt en snel verspreidt over het land, moet het wel aan veel voorwaarden voldoen om een TF te mogen zijn. Het is meer dan alleen "een klein bosje". Wat voor plannen moet je kijken naar Haarlem zelf, maar er zat wel een spanningsveld vanwege gedoe.

We kijken pas naar locaties als er samenwerking met gemeente is. We zijn zelf dus niet actief aan het kijken (uitzondering is Zaanstad). In Amsterdam is er nu ook via het concept Groene Schoolpleinen iemand die flinke subsidie regelt voor basisscholen, zo ook een school in Zuidoost die kijkt naar TF als vorm van vergroening. Maar hiervoor is wel additionele financiering nodig, want die subsidie is net genoeg om te vergroenen, <u>maar niet genoeg voor implementatie TF.</u> Zo een school mag zich inschrijven voor regeling en die krijgen ze daarna toegewezen. Daarna wordt een tuinarchitect met affiniteit voor TF werd ingeschakeld, en die bepaalt hoeveel % van het schoolplein groen wordt. Deze tuinarchitect werd helaas te veel onder druk gezet, daarom is hij gestopt.

TF worden zowel in grotere gemeenten als in steden als kleinere gemeenten geplaatst, heeft de plek van plaatsen invloed op de mate van succes?
We zitten nu eigenlijk midden in de metingen, er is iemand van WUR die dat soort dingen bijhoudt, dus professioneel. Er zijn ook vrijwilligers actief (meerjarig + langdurig). Ik denk dat je op papier kunt stellen dat het in sommige buitengebieden makkelijker is om voor beestjes een TF te koloniseren, dan in stedelijk gebied. Maar tegelijkertijd, biodiversiteit rondom de stad is weer veel sterker dan op boerenland (o.a. door spuiten van insecticiden). Het biodiversiteits netwerk aan rand van Amsterdam is weer heel groot. Er bestaat dus onzekerheid over hoe het nu precies zit.

Even over de betrokkenheid van bewoners, in mate van implementeren en designen van een TF. Is deze betrokkenheid makkelijker in bepaalde gebieden?
Moeilijk om uitspraak over te doen. In Amsterdam leeft het idee van een TF wel degelijk, zo ook Alkmaar. Deze motivatie vanuit de bevolking helpt wel in de selectie, zeker wanneer zo een draagvlak groter is. Juist stadsmensen (ook juist tijdens corona) streven naar direct groen in de omgeving, maar soms is er gewoon geen directe ruimte beschikbaar. We moeten dan echt met een vergrootglas gaan zoeken en afwachten of dit nog steeds kan. We

krijgen met verschillende soorten mensen te maken, ook "NIMBY" gedachtes, die mensen ervaren bomen als overlast. Dat soort dynamiek speelt wel sneller in steden, er is een meer gescheiden geest. In dorpen hebben we daar minder snel last van.

In Amsterdam zijn er nog geen TF, wat denk jij dat de doorslaggevende factor gaat zijn?
Groot gedeelte draait om geld. Het moment dat de gemeente het idee ondersteunt, zullen veel locaties direct gevonden worden (nieuw-west en zuid-oost, ruim opgezet dus kan makkelijk). Een andere succesfactor is wanneer mensen zelf gaan ondernemen. Wanneer de buurt enthousiast is, helpt dit het implementeren van een TF ontzettend. Ze gaan zelf kijken naar additionele financiering etc. Bijv in Utrecht blijkt het best taai om genoeg locaties te vinden. In de eerste ronde (eind 2018), dmv nationale postcode loterij, kwam er een samenwerking met Utrecht, maar het was een taaie gemeente. Dit ligt soms aan ambtelijke organisatie, dan gaan processen heel stroef, maar het zit ook meestal in de knoop met andere bewoners die er niet op zitten te wachten. Het moet gewoon passen in een omgeving en dat maakt het vinden van een locatie lastiger. Wat betreft Zaanstad, er is intentie om meer in een wijk te doen die het nodig hebben, zoals versteende wijken, maar daar blijkt het gewoon moeilijker! Een ander voorbeeld is wanneer er vooral kleinere en oudere huizen zijn, die dicht op elkaar zijn gebouwd, dan is het ook moeilijker om een TF te plaatsen..

Wat betreft de vergelijking tussen traditionele parken en TF: wat is de meerwaarde in Ams?
Allereerst is er voor biodiversiteit veel te bereiken. TF is een eigen ecosysteem of kan het in ieder geval worden. Daarnaast is TF is kleiner, dus heeft meer kans om aangelegd te worden. Het hoeft maar 20 bij 20 te zijn, en dat mag ook wel op een net iets andere manier, dus is eigenlijk veel flexibeler dan een groot park. We zijn in gesprek met Gemeente Amsterdam, maar daar is qua beheer veel minder focus op groene gebieden, d.w.z. veel meer management. Een TF heeft dat niet, maar de gemeente vindt het ook weer spannend om dit weer helemaal los te laten, juist omdat er dan weer mistige bosjes ontstaan waar dingen gebeuren die het licht niet kunnen verdragen. In TF is er hoogstens beheer zoals water geven in eerste jaren, maar daarna kan het losgelaten worden. Jonge boompjes zijn goed in staat om droge periodes te weerstaan. In stedelijke gebieden aan de randen van TF nog wat snoeiwerk, maar dat is het. Bomen heel dicht op elkaar, dat vindt de gemeente juist lastig. De huidige regeling in Amsterdam is "subsidie voor 1 boom in 1 tuin", daar geven ze ook 5000 euro voor.

Wat betreft koolstofvastlegging en waterberging, zijn er studies?
Nee, dat kunnen we nog niet zo zeggen. Dit is duidelijk wel een argument voor gemeenten om te gedragen zoals ze dat nu doen. Maar ja, bomen verdampen zo ontzettend veel water, dat is waanzinnig! Ze houden ook veel vast. Er zijn geen duidelijke gegevens nog helaas. Met zware hoosbuien komt een probleem in versteende gemeenten, terwijl een TF er super blij mee is. Het is niet duidelijk vanuit mij of er onderzoek naar komt. Een TF maakt van allerlei dingen gebruik en wil van allerlei dingen gebruik maken. Het is lastig te onderzoeken, vanwege een onduidelijke 0 situatie en vergelijkbare situaties (bijv. controle groep). Er is een gat in de wetenschap, dus het is "best wel een kluif" om de effecten op wetenschappelijke kwantificeerbare manier duidelijk te maken. Een versteende omgeving

rondom TF krijg ook water en kan dat ook tot zekere mate verwerken, dus daar ontstaat ook veel onduidelijkheid over.

Je praat over citizen science studies naar biodiversiteit.. Legt TF vooral nadruk op biodiversiteit?
Het is een combinatie. Wij zijn super blij met argumenten voor CO2 en watervastlegging, maar die zijn er ook minder aangezien dit moeilijker te onderzoeken is (kwantificeerbaar en meetbaar). We kunnen met biodiversiteit makkelijker de effecten roepen, vandaar dat dat meer overheerst. Welke beestjes leven er? Hoeveel? In volkskrant is laatst weer artikel over bomen en klimaat gepubliceerd, dus het is allemaal zo divers in deze richting. Het is ook lastig qua status quo: wat is goed? wat is niet goed? IVN is niet wetenschappelijk instituut, we willen bijdragen aan biodiversiteit en aan de educatie over natuur aan mensen. Dat zijn onze hoofdlijnen en ze horen voor ons bij elkaar. Anders kan je het gewoon een bosje noemen.

Dat Project in Zuid-oost, hoever staat dit?
Er is nog net geen ontwerp, wel een idee over welk stuk van het schoolplein. In die zin is het vrij ver. Uithoorn is ook een partnergemeente (initiatief vanuit Schiphol fonds, compensatie voor overlast van Schiphol) en daar zijn ze ook bezig met aanvraag. In het najaar gaan ze daar al planten. Helaas heb ik sinds corona geen contact meer gehad. Nu de kinderen net weer naar school zijn,, is het niet de tijd om hier op te hameren. Dus misschien wordt het toch pas volgend jaar.

Zijn er nog meer partijen betrokken naast scholen?
Ja, er zijn soms ook individuen, bijv. uit Amsterdam, geïnteresseerd in bosje. Maar daar kunnen we niet veel mee. Het moet toch door de gemeente ondersteund worden. Scholen zijn in zekere zin ook particulier, maar dat is toch anders dan één persoon.

Een voedselbos is ook een leuk concept, zien jullie daar potentie in?
Ja, zijn we mee bezig! We kijken nu of we voedselbossen bij scholen kunnen aanleggen. We vinden dit een leuke manier om kinderen in contact met natuur te brengen. Het vergt veel minder beheer dan een moestuin, dus is veel makkelijker om te "hebben". Maar verder is voorlopig TF nog zo hot-topic dat dit nog wel blijft spreiden en de kaart van NL alleen maar groener wordt. Na volgend jaar is het geld van de postcode loterij wel een beetje op, maar er is nog steeds vanuit gemeentes vraag naar TF. Ze willen geld voor een TF en we hopen dat dat blijft. Ons doel: iedere gemeente een TF.

Wat betreft een middelbare school midden in de Jordaan.. hier wordt waarschijnlijk geen TF geïmplementeerd (vanwege grootte) maar de wens was er wel! In hele dichtbevolkte steden is een bos creëren lastig: het wordt donker in huizen en heeft dus ook negatieve gevolgen voor de omgeving. Hier kan je kritisch op zijn! De bomen gaan toch ooit de hoogte in, al zien ze er eerst heel schattig uit. Er is een groep mensen in NL die daar heel erg achter staan, dat het overlast geeft. Het verschilt natuurlijk waar je woont, er is een verschil tussen de begane grond of op 3-hoog. Soms geeft het een beschermend gevoel, soms zorgt het alleen maar voor schaduw overlast.