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THE CHALLENGES OF PLANNING AND DESIGNING URBAN GREEN NETWORKS IN SCANDINAVIAN AND CHINESE CITIES

Na XIU[a], Maria IGNATIEVA[b], Cecil Konijnendijk van den BOSCH[c]

[a] Landscape planning, Urban and Rural Development, Ulls väg 27, P.O. Box 7012, Uppsala, 75007 Sweden
[b] Swedish University of Agricultural Sciences, Urban and Rural Development, Ulls väg 27, P.O. Box 7012, Uppsala, 75007 Sweden
[c] Swedish University of Agricultural Sciences, Landscape Architecture, Planning and Management, Alnarp, Se-23053 Sweden
E-mails: [a]na.xiu@slu.se (corresponding author); [b]maria.ignatieva@slu.se; [c]cecil.konijnendijk@slu.se

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Abstract. During the 20th century, a variety of concepts were developed aimed to provide frameworks for green space planning and design in urban areas. Both China and Scandinavia represent important experience in green space planning and management. However, none of the current concepts is generated based on the explicit combination of both a Western and Eastern context. In this paper, based on the analysis of various green space planning concepts and their development, a novel "hybrid' approach is introduced. This "Green Network' concept focuses on green and blue connectivity in urban areas and comprises the network of green spaces and the surface water system within and around settlements. The concept offers a platform for integrating best practices from Scandinavian and Chinese open space planning and can provide a guiding tool for sustainable urban development.

Keywords: city structure, fragmentation, green-blue space planning, green concepts, landscape connectivity, network analysis.

Introduction

In urban areas, habitat fragmentation is usually considered as a major threat to biodiversity and a contributor to the present species extinction crisis (Collinge 1996; Adriaensen *et al.* 2003). Fragmentation has dramatic impacts on landscape structure and landscape connectivity (McGarigal, Cushman 2002; McKinney 2003; Pauchard *et al.* 2006; Hamer, McDonnell 2008; Vergnes *et al.* 2012), while also hampering the provision of essential ecosystem services by urban green spaces (Harman, Choy 2011). In order to deal with this challenge, communities, decision makers and researchers have attempted to provide better urban planning initiatives and approaches. One of the widely accepted concepts today is that of green corridors – a linear landscape element that connect isolated habitat patches (Viles, Rosier 2001). Similar to green corridors, greenways provide connectivity between urban places through the establishment of green spaces along transport arteries in the form of boulevards and parkways (Parker *et al.* 2008). Green infrastructure, in its turn, encompasses the conservation planning aimed at integrating and expanding open space within an urban framework in order to ensure the protection of natural and cultural resources (McMahon 2000). All of these green concepts have become widely applied in both Western and Eastern cities and have influenced current open spaces planning and design practice to differing degrees.

In the light of challenges such as fragmentation and the loss of ecosystem services, cities in both developed and developing countries are searching for more integrative and effective green space planning approaches. Moreover, these approaches have to address specific local ecological and cultural histories (Ignatieva *et al.* 2011).

China is one of the countries that look for novel green-blue space planning approaches due to rapid urbanization and green space fragmentation (Jim, Chen 2003; Li *et al.* 2005; Yu *et al.* 2005; Kong *et al.* 2010; Ren *et al.* 2011). One of the parts of the world that provides inspiration for this is Scandinavia, as this region is well

known and recognized by urban planners and ecologists for its successful green space planning approaches (Lahti *et al.* 2006). For example, well-known Swedish architect and urban planner Professor Ulf Ranhagen from consultancy company SWECO and the Royal Institute of Technology brought the idea of the Sustainable City to China during the year 2000. He was subsequently hired then to implement new town planning in several Chinese cities, such as Caofeidian Eco-city in Tangshan city and Luodian Swedish Town in Shanghai. Planning and design of these cities is inspired by the model of Hammarby sjöstad in Stockholm and has become an influential green-blue space planning principle, namely that of the Sino-Swedish eco-city planning (Yin, Feng 2012). On the other hand, Scandinavian countries like Sweden are also facing new challenges, as they are going through a phase of urban densification and are looking for new models for sustainable green infrastructure (Berg, Rydén 2012). Thus China cannot only learn from Scandinavian experiences, but Scandinavia can also benefit from the Chinese experience of dealing with green areas establishment in compact, rapidly urbanizing environments.

The purpose of this paper is to review the emergence and implementation of 20th century green space planning concepts and approaches in Western (and primarily Scandinavian) and Chinese cities, namely the concept of greenbelt, green wedges and fingers, greenway, green corridor, and green infrastructure. Based on this review of concepts and approaches in both China and Scandinavia, a "hybrid' and innovative approach is discussed in the form of the Green Network concept.

Framework for comparing green concepts

In describing and comparing concepts of green space planning, the paper starts from a worldwide perspective and then zooms in on Scandinavian and Chinese examples. Based on the international literature and general recognition of major concepts, three of these green space planning approaches are in focus – greenbelt and green wedges (fingers), greenways and green corridors, and green infrastructure. Three key components of each concept are discussed: their structural elements, functional focus, and the methods (or experience) it comprises. These components exist in all green space planning concepts but are highly dependent on regional, historical and cultural contexts. The assessment of green concepts based on international literature and novel projects focuses on China and Scandinavia. In both of these parts of the world, the three major concepts and approaches are widely used but with local adaptation.

Development and implementation of the green concepts in the twentieth-century

Greenbelt and green wedge (fingers)

"Greenbelt" is the first comprehensive concept for a green space planning (Cohen 1994) originating from Europe. The greenbelt of London, for example, has a long history but was formalised in the 1940s. As a policy and a city and regional planning approach, the greenbelt concept has been used to retain areas of city and largely undeveloped land surrounding or neighbouring urban areas. In greenbelt planning areas, many different urban construction activities are strictly limited in order to prevent an urban expansion. The main function of a greenbelt thus is controlling further urban sprawl. But greenbelts such as the Greater London greenbelt are also aimed at nature conservation and providing recreation opportunities (Amati 2008).

Over time, greenbelts have become more multifunctional. Notable examples are Stockholm's National City Park and the European Green Belt. As a Royal National City Park, the Ulrisksdal-Haga-Djurgården-Brunnsviken area in Stockholm was connected and designated as a greenbelt comprising a unique historical landscape of national importance from a cultural heritage and ecological perspective, but also having high importance for recreation (Fig. 1). On a larger, international scale, the European Green Belt aims to integrate the entire strip of land from the Barents Sea to the Black Sea from a landscape perspective. Its key value is for nature conservation and sustainable development with habitats and ecological areas as part of an international network of valuable ecosystems in 24 countries. The European Green Belt contributes to safeguarding Europe's natural heritage and helping fulfil

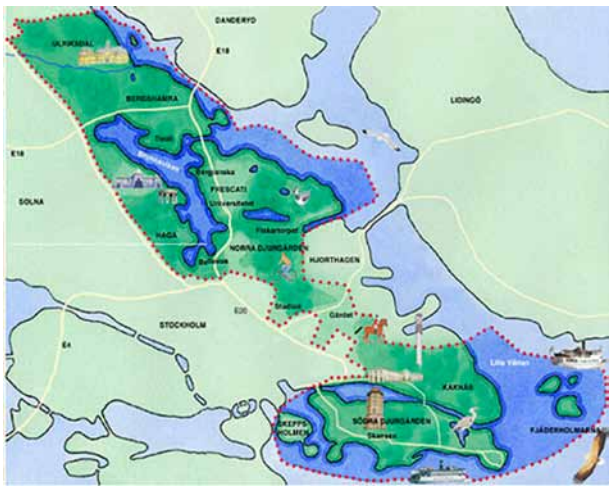

Fig. 1. Greenbelt of the Stockholm National City Park, with its wide range of significant natural, cultural and recreational values (Reproduced by Ann Nyström for Association of Eco-park, Förbundet För Ekoparken)

the commitments to halting biodiversity loss by 2010 (Riecken *et al.* 2006).

One noticeable point in both the European Green Belt and Stockholm's Royal National City Park is that their emphasis is on remnants of native vegetation. Moreover, both are combining human activities with ecological protection. For instance, the Royal National City Park was the first national park of its kind located within the city boundaries, and it includes existing building, infrastructure, parks, waters, flora and fauna. As for the European Green Belt, its northern part is a wild belt comprising of vast coniferous forests along the former no-man's land of the Iron Curtain (physical boundary divided Europe as Soviet Union and its satellite and non-Soviet-controlled areas from 1945 until end of cold war in 1991) and the Baltic Green Belt constitutes the seaside belt. The Central European Green Belt is made up of a variety of cultural landscapes such as agricultural fields and memorial landscapes, and the southernmost part is a mountainous belt with heterogeneous mosaics of natural landscapes, forests and stepping habitats, and the like.

In China, the concept of greenbelt was borrowed from Europe after 1949 and has become one of the planning concepts integrated in master plans. For example in Xi'an, Beijing and Shanghai, urban-encircling greenbelts were established or are being developed (Qiu 2010). In Beijing, the current spatial concept of greenbelt is based on the 1958 Master Plan, which was confirmed in 1992 (Li *et al.* 2005). It consists of two greenbelts: the inner greenbelt and the outer greenbelt. However, nowadays both the two greenbelts are of greater importance for city greenery and recreation than for controlling urban sprawl (its original function). On the other hand, the concept of greenbelt was introduced as an approach to restrict urbanization, but it eventually failed because of the acceptance of market economy followed by tremendous growth in traffic. In Xi'an, the current and updated green space plan (2008–2020) divides the greenbelt into two categories: greenbelts along the highways and greenbelts along the river. Green belts are both circular (along the ring-road) and linear (along the waterways) in configuration. The city greenbelt of Shanghai is 98 km long with an area of 6208 km^2 (Fig. 2). Different from traditional greenbelts in Europe that retain the undeveloped areas surrounding urban areas, the Shanghai greenbelt is mainly artificial in nature through tree-planting combined with construction of parks outside the city. The purpose of this greenbelt is to control urban sprawl and divide urban and neighbouring fringe areas to improve the urban ecological environment and provide recreational areas for citizens. An example of a greenbelt of an equivalent scale to the European Green Belt is the Three-North Shelter Forest Program, also known as the Green Great Wall, which covers 40% of the land area of China. This program comprises a series of planted forest strips at national scale designed to prevent the expansion of the Gobi Desert. Sand-tolerant vegetation is selected in order to suit desert condition and stabilize the sand dunes (Wang *et al.* 2010).

"Green wedge" is a concept that originated from Scandinavia (Sweden and Denmark). During the 1990's, the Regional Planning Office in Sweden launched the concept of Stockholm's Green Wedges (Fig. 3). It derives from the star-shaped settlement pattern in between the urban areas which form a system of parks and open spaces that make up a region-wide system linked by paths and green arterials. These are setting off from the rural parts of the region and leading right

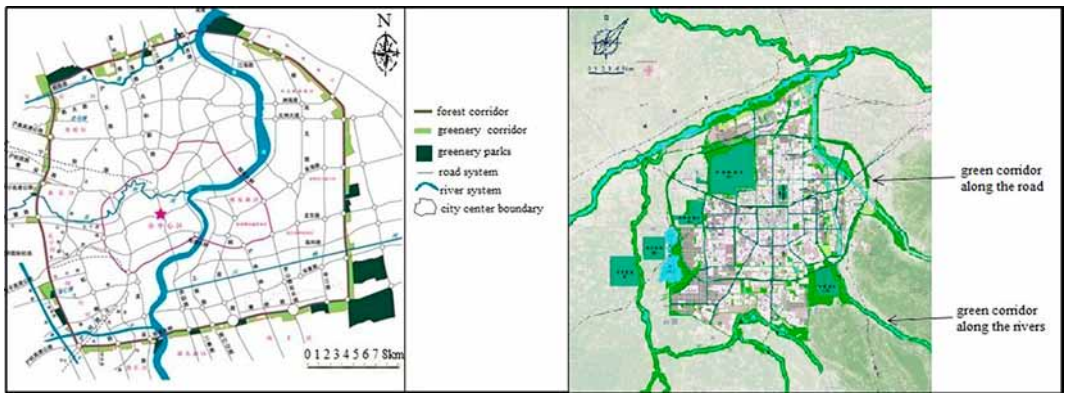

Fig. 2. Greenbelt plans of Shanghai (left) and Xi'an (right). Based on the road system, the Shanghai Greenbelt Plan was categorized into two main belts. The first is the forest belt, 100 meters wide with trees to build a stable environment for ecological communities, and the second is the greenery belt, 400 meters wide with productive nurseries, memorial landscape and agricultural fields. Another notable point in the Shanghai Greenbelt Plan is that parks are designed as connectors of different greenbelt areas served for recreational function (Shanghai City belt Institution of Construction and Management and Xi'an Urban Planning and Design Bureau)

into the city centre. Several factors lead to extensive implementation of green wedges in Stockholm, the foremost one of which is as a result of Stockholm's unique topography. Fourteen isolated islands are intertwined by common structures such as settlements, industries, infrastructure and urban forests. This complex planning context has been a subject for an integrated spatial planning approach on a regional level. Under this circumstance, the concept of green wedges was first put forward for urban growth. It means that urban growth followed the public transportation system and then formed long built areas with wedge-style open spaces left in between. This radial pattern enables ten accessible, ecologically beneficial long green wedges with differentiated functions: recreational, connecting and ecological (Höjer *et al.* 2011) (Fig. 3).

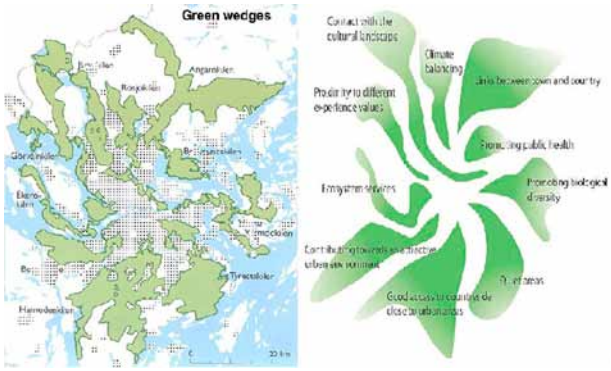

Fig. 3. Map of Stockholm's Green Wedges, comprising 10 wedges with a number of benefits (Lahti *et al.* 2007 (left-hand part)) and RUSF Stockholm County Council, Growth and Regional Planning management, 2010 (right-hand part))

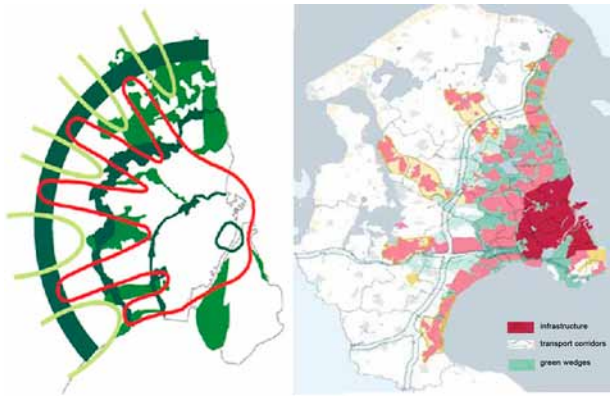

Fig. 4. Copenhagen Finger Plan. The left part of the figure shows the five fingers, green wedges and greenbelt in Copenhagen, 2007 (the hand shape – the urban fabric and its infrastructure, the wedge shape- green wedges between urban settlements and the arc shape- greenbelt around Copenhagen). On the right the updated plan from 2013 is shown green wedges are between urban settlements and infrastructure and transport corridors (Danish Nature Agency)

The Five Finger Plan in Copenhagen, Denmark, forms a network that penetrates urban fabrics at a regional scale (Vejre *et al.* 2007) (Fig. 4). Jørgensen (2004) noted that the main principle of the Finger Plan is to think about future city development along existing and future public transport corridors such as railways. Green wedges are preventing urban development and become important urban corridors. The ecological diversity and functionality of the landscape is guaranteed in the Finger Plan by a heterogeneous structure of the fingers pattern. From a natural perspective, it is also trying to incorporate a settlement structure and a system of intensified agricultural areas in an ecological system. Until 2007, the Copenhagen plan was one of the models that incorporated greenbelts and green wedges together aiming to control urban sprawl, for nature protection and recreational purposes.

In the updated Copenhagen plan of 2013, green wedges are still an important part, but the greenbelt is gradually disappearing (Fig. 4). This shows that urbanization will have an important impact and development will be in favour of slender fingers along the railways and other transport arteries. Hence, the concept of greenbelt which was widely utilized through the 20th century is challenged by the needs of current city development.

Greenways and green corridors

The concept of "greenways" was generated in North-America at the beginning of the 20th century. Fabos (1995) noted three benefits of greenways: ecological, recreational, as well as historical/cultural. From urban planning and landscape architecture point of view, greenways also relate to visual connections in broad spatial dimensions (Ignatieva *et al.* 2011). These were created to develop greenway systems that interconnected cities and natural areas or forest zones in metropolitan areas e.g. in US and other cities (Jongman *et al.* 2004; Zhang, Wang 2006). For example, as a result of the challenge of competing land uses and high density urban living, Singapore's greenway movement started in the late 1980's with the aim to create an island-wide network of greenways using parks as the connectors (Tan 2006). Greenways in Singapore inherited more to the approach of American cities due to the city states intensive traffic situation and dense highway network.

In Europe at the beginning of the 1990s, societal and scientific discourses changed as conceptual approaches were developed that embraced new nature conservation strategies (Jongman *et al.* 2004). Green corridors were designed as habitat areas for connecting wildlife populations (through e.g. colonization,

migration, interbreeding and so forth) that had become fragmented by human activities or structures (habitat fragmentation). The length and the width of green corridors have varied from regional to local level.

In Copenhagen, a plan for a network of green paths was approved in 1936 (Jongman *et al.* 2004) and the city's Finger Plan of the 1940s (see previous section) includes an important component of green corridor planning. The plans aimed at accommodating demands of urban growth, recreation and infrastructural functions in urban and rural areas on the urban fringe (Vejre *et al.* 2007). Corridors can be found to various degrees in a number of cities in Scandinavia, for example in Helsinki where the Central Park (Keskuspuisto) has served as an important green corridor which penetrates straight into the city-center (Beatley 1999). Green corridors provide important connection between places with high biodiversity, as stepping stones, as well as recreational places for millions of city residents (Barthel *et al.* 2005).

As for Chinese cities, the concept of greenways was introduced from United States in the 1990s. However this introduction could build on a Chinese tradition of contextual greenway planning extending for more than 2000 years according to Yu *et al.* (2006). It is different from modern Western greenway planning, but shares some similar principles. For example greenway was used to enrich the visual effects along transport corridors in urban areas, and greenway was regarded as good blessing to local people in feudal China from culture's perspective. Yu *et al.* (2006) also characterized the evolution of greenway planning and implementation in China mainly as a "top-down" approach; planning and management of greenways were normally done by a centralized administrative system (e.g. the empire dynasty) without a scientific basis or public participation. The functions of the greenways in China have primarily been directed towards ecological protection and nursery production, with little concern for human uses such as recreation by cyclists and pedestrians.

He *et al.* (2010) noted that the traditional Chinese planning and design philosophy (Fengshui) inspired the planning of the Pearl River Delta Regional Greenway (PRD) (Fig. 5). For example the two greenways in Pearl River are two energetic sources that can help revitalize overall regional energy and bring fortune to the cities in this region. The PRD project has referred to European and North American models of regional scale, such as the London Greenbelt and American greenway networks. Its main principle is to link major green areas in the region through greenways along riversides, valleys, ridges and man-made corridors like railways. The conservation wildlife and ecological conservation at large can be guaranteed by the integration of fragmented green spaces, including parks, nature reserves, scenic areas, historical and cultural relics.

In contrast with the application of the greenway approach in Western countries, close-to-natural planning is the concept advocated by Chinese designers and planners in recent years. It corresponds to the principle of respecting and learning from nature and emphasizes the protection of both the natural ecosystem and the social and cultural values of landscapes (such as the sociocultural and educational meanings of landscape). An example is the Qinghai-Tibet railway (QTR), the world's highest-elevation and the longest highland railway with total length of 1956 km (Fig. 5). Several green aspects were implemented during its construction and resulted in the QTR project's new name: the Green Railway. First, more than 33% of total budget was allocated to ecosystem restoration and environmental protection of natural ecosystems, such as water and soil conservation. Second, in order to avoid disrupting the seasonal migration routes of wild animals and also protect the rare and fragile vegetation, planners carefully selected locations where it was necessary to remove earth and establish construction sites (Peng *et al.* 2007). Third, efforts were made to reduce noise of construction work in order to avoid the alarming of animals. But such a large proportion of budget and the serials of approaches for ecological restoration are not common in China. The potential negative national and international media attention concerning construction impact on the fragile plateau environment may have influenced the decision of the central government. These programs, together with Three-North Shelter Forest Program, have been proposed and implemented by central Chinese government. However it is complex behind the decision of these expensive and grandiose green space planning interventions.

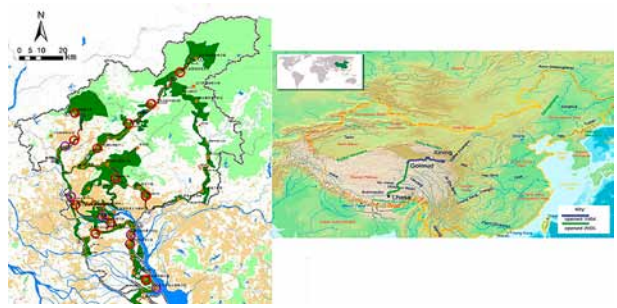

Fig. 5. Map of Pearl River Delta Regional Greenway (PRD, left) and Qinghai-Tibet railway (QTR, right) in China (Guangdong Provincial Department of Housing and Urban-Rural Development and Tibet Railway Bureau of China)

Green infrastructure

Like the greenway concept, the green infrastructure concept also originates from the United States (in the mid-1990s). It is appearing more and more frequently in land conservation and development discussions around the world. Benedict, McMahon (2002) emphasised that green infrastructure refers to an ecological framework needed for achievement of environmental, social and economic sustainability. It encompasses a wide variety of natural and restored native ecosystems and landscape features that make up a system of "hubs" and "links" in regional or city scale. In a Chinese context, Alan *et al.* (2009) used the term "green infrastructure" to describe all the green spaces within and surrounding an urban settlement as a single entity, whose planning, design, management and maintenance should be integrated and continuous. Zhang *et al.* (2009) consider green infrastructure as a combination of hubs (core area that provide space for native flora and fauna, including a variety of open space and green areas), links and corridors (connect the core areas together that can be used for movement and spread of species) represented by greenways, rain gardens, wetlands, green roofs, swales, porous pavement and so forth. Although definitions of green infrastructure differ, one commonality for Western and Chinese definitions is that green infrastructure in an urban context refers to all of a city's green and open spaces.

In recent years, there has been a growing awareness amongst local governments of the need to plan for green infrastructure. Since 1992, Swedish legislation has been modified to pay special attention to sustainability, including the importance of green infrastructure in and around urban areas. According to the revised planning legislation, Swedish towns and cities are recommended to develop a green infrastructure plan as an essential part of the mandatory structure plan (Sandström 2002). In Stockholm, green infrastructure was integrated in the Regional Development Plan for Stockholm (RUFS) from 2010. Hammarby Sjöstad and Norra Djurgårdsstaden as a part of green wedges of Stockholm are two examples that implemented green infrastructure planning on a smaller, neighbourhood scale (Fig. 6). The former environmental program emphasizes environmental issues during the planning and implementation stages. An ecosystem with an on-site sewage works was officially opened in 2003. Sewage and waste water are treated, heating energy recovered and nutrients extracted via new technology for use on farmland. Norra Djurgårdsstaden is still in its planning stage since 2001 and its development is expected to run until the year of 2020. It is targeted to accommodate approximately 5000 housing units, commercial, social services and so on. Its planning considers a continued presence of energy providing functions in the vicinity as a result of its original function as a gas works and industrial area.

In China, the green infrastructure concept is still in an earlier stage of development since its initial introduction in the 2000s. Zhang *et al.* (2009) refer to green infrastructure as a promising new approach aimed at city planning and ecological protection. Government officers and planners in different fields are trying to integrate the concept of green infrastructure into a Chinese context and some initial experiences have been obtained. First, apart from city master planning, most cities in China have established special parts for green space system planning, including Beijing, Xi'an, Shanghai and

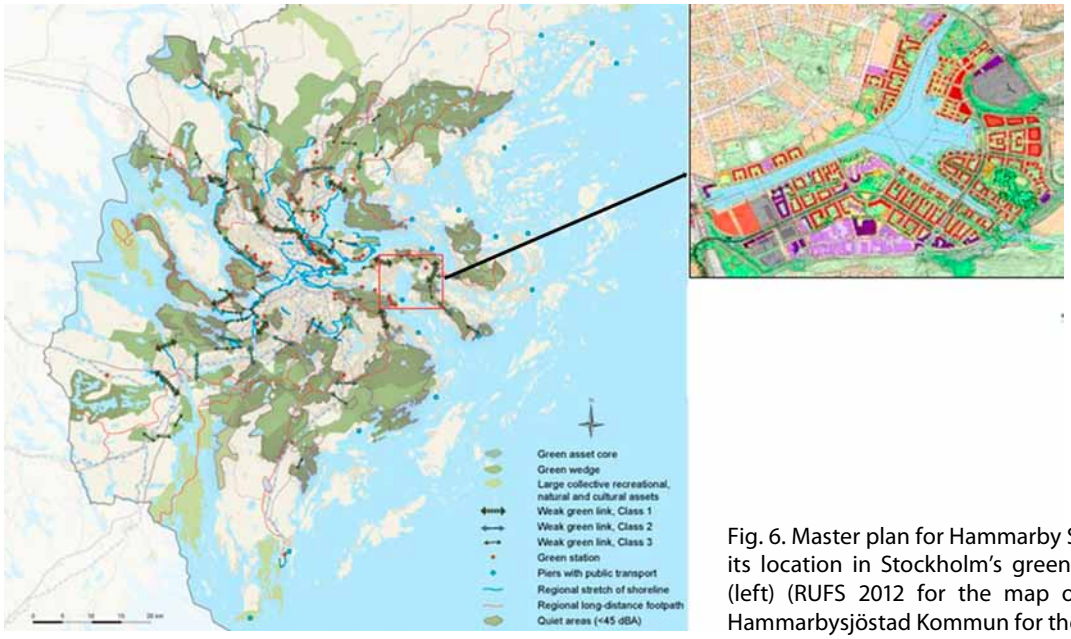

Fig. 6. Master plan for Hammarby Sjöstad (right) and its location in Stockholm's green wedge structure (left) (RUFS 2012 for the map on the right, and Hammarbysjöstad Kommun for the left-hand map)

Fig. 7. Map of West Lake Scenic Area in Hangzhou. It shows West Lake as a scenic area that serves as a "stepping stone" to link up surrounding green spaces (China Tourist Map)

Shenzhen. Second, establishing and spreading the concept of green infrastructure is occurring first in scenic spots (Qiu 2010), taking scenic areas as the "stepping stones" to connect other landscape patches together. (In 1982, the concept of scenic spots was established. It is similar to national parks in Western countries but with focus on the visual values of places. Scenic spots are managed areas that attract visiting domestic and international tourists and should meet the needs of sightseeing, recreation and entertainment, sports and fitness, as well as knowledge distribution through appropriate facilities and services). For instance Hangzhou West Lake Scenic Area is an important stepping stone that links surrounding small tracts of green space, such as parks and gardens (Fig. 7). Third, close-to-nature (near-nature) and low-carbon city planning are two approaches led by the government, focusing on improvement of green space rate and living standard of people. The master plan of Taizhou (Yu *et al.* 2005) is based on the concept of green infrastructure on regional, medium and small scales in order to resolve issues of urban sprawl and heavy flooding. Three types of processes are targeted to be safeguarded: abiotic process (flood control), biotic process (native species and biodiversity conservation) and cultural process (heritage protection and recreational need) (Yu *et al.* 2005).

Comparison of green space planning concepts in China and Scandinavia

Based on different city structure and context, green space planning and management vary both across China and Scandinavia. However, in spite of variation within these two regions, overall differences between the two can be noted. Table 1 provides a comparative overview of these differences. All of the mentioned concepts were initiated and developed in the 20th century, and subsequently implemented throughout Scandinavia and China, but under very different economic, environmental, political and social conditions. As is evident, green space planning and management no longer refer only to "green" space but extend to blue spaces and urbanized areas as well.

Greenbelt was the first concept in green space planning that took urban development into consideration. It tried to achieve control urban sprawl through green space planning. After its introduction in China, Beijing was the first city that implemented this concept but presently its application seems to deviate from its original principles of urbanization restriction towards more focus on recreation and environment protection. As for other cities, greenbelts are always along the outer highway around the city and because of the city's typical "pie-expansion", the form of the greenbelt is generally circular (Xi'an, Shanghai, and Beijing). Apart from its common functions (controlling urbanization, recreation and environment protection), China uses the greenbelt approach for desert restriction as well (3-North Forest Program). Meanwhile, greenbelt in Scandinavian countries has experienced another situation due to their unique city topology, and greenbelts were altered to slender green fingers or green wedges. The concept of green wedges is based on the hypothesis that urbanization will develop in a thin radial pattern where greenbelts cannot meet the city's needs. Green wedges in different locations serve varied functions (recreation, biodiversity conservation, connection of city and suburbs, etc.) but with the common goal to provide urban inhabitants with good and nearby access to open spaces. Greenbelts and green wedges have in common that their spread and development often follows (public) transport corridors, and especially railways.

While the greenway concept emerged in North America and the green corridor concept derives from Europe and specifically Scandinavia, both originated from a different ambition and emphasis. China applies the concept of greenways more than that of green corridors due to its traffic situation (construction of highways in city and regional level). From a historical perspective, greenways have existed in China for more than 2000 years, but were not formulated as such a specific concept for planning and design. Rather they served the purposes of production and protection with little concern for scenery and recreation. At present,

Table 1. Comparison of the application of green space planning and management concepts in China and Scandinavia

Green concepts		China	Sandinavia
Green Belt/ Green Wedges	Structure		
	Function	Controlling urban sprawl, nature conservation, woodland harmony, controlling desert expansion, biodiversity conservation	Controlling urban sprawl, nature conservation, untouched green space, woodland harmony, biodiversity, cultural history, living environment, and lessons from nature
	Planning Methods	Ring-road planning, aerial seeding and cash incentive for planting trees	Stakeholders from nature conservation and sustainable development
	Scale and Example	City scale (Green belt plan of Beijing) and Regional scale (Three-North Shelter Forest Program)	Local scale (Eco-park in Stockholm), City scale (ten Green Wedges of Stockholm) and Regional scale (European Greenbelt)
Greenway/ Green Corridor	Structure		
	Function	Aesthetic, educational, productive, ecological, historical heritage and cultural values	Aesthetic, recreational, ecological, historical and cultural values
	Planning Methods	"Top-down" approach, Fengshui Theory, Conservation planning, Near-nature planning	Different people together in co-modality and advanced technology in the freight transport
	Scale and Example	Regional level (Pearl River Delta Regional Greenway (PRD) and Qinghai-Tibet railway (QTR))	Local scale (Eco-park of Stockholm) and Regional level (Green Corridor in Sweden)
Green Infrastructure	Structure		
	Function	Recreational, nature conservation, habitat and biodiversity, health improvement, better connection to nature and sense of place, cleaner air and water	Recreational, nature conservation, habitat and biodiversity, health improvement, better connection to nature and sense of place
	Planning Methods	Special part of green space system planning, green infrastructure in scenic spots first, close-to-nature city planning	Combination of conservation biology and landscape ecology, urban and regional planning, and geographic analysis and information system (GIS).
	Scale and Example	City scale (The Growth Pattern of Taizhou City)	Local scale (Hammarby Sjöstad Community Program) and City scale (Stockholm Green Infrastructure)

the concept of greenways is widely accepted in Chinese cities and many cities have their own greenway network that is designed for both scenery and environment. The concept not only involves the planning and design of green spaces along roads but also encompasses the need for construction processes to be "green".

Green corridors in the Scandinavian countries usually remain at a low level compared to the implementation of green wedges and green infrastructure, something which is influenced also by topography since cities expand linearly along traffic roads. Multifunctional foci are stressed in spite of the starting point for green corridors being environment conservation. Since the Second World War nature and biodiversity conservation have had a central role in Nordic planning, but in China these aspects were not considered until the 1980s. Present cases have however evolved with an increasingly biological and environmental focus.

Green infrastructure is a current concept that is still under development, and both China and Scandinavia have their own understanding and practice with an overall point of view. Like the Taizhou in China ecological infrastructure plan in China, city growth patterns are analysed from regional to city to neighbourhood scales. Hammarby Sjöstad in Sweden is a good example of urban development that has integrated environmental goals from the very start, with focus on waste, energy, water & sewage management. It embodies a combination of planning, design, engineering, and environmental management. Compared with other concepts presented and discussed in this paper, green infrastructure is no longer a concept that focuses only one aspect, but rather takes an overall view of planning and design including recreation, culture, ecology, energy, sewage, flood control, storm water management and so on. It also reflects that a new multidisciplinary or even transdisciplinary approach to the planning and design of green space requires integration between the above aspects and well as the various disciplines and professionals involved.

Towards an integrated Green Network approach

For all the mentioned concepts that have been implemented in China and Scandinavia, open space is always defined by its single specific shape (belt, corridor, wedge, finger, way and infrastructure). The presented green concepts have been discussed and used extensively by city planners around the world as a tool for solving a problem of habitat and landscape fragmentation. However, in spite of more comprehensive planning and management, an increasing amount of green spaces become the victim of urban development and urban sprawl. Linkages between green and blue spaces are often ignored by planners, although green and blue connectivity is important in habitat conservation. Individual green concepts were developed for resolving particular urban problems, e.g., the greenbelt concept was geared towards urbanisation control, even though its function was broadened afterwards according to social and ecological processes. There is lack of an overall picture and concrete approaches emphasising the entire city's habitat connectivity.

Different countries developed green concepts under their own context (based on their economic, social and cultural peculiarities) and formulated different focusing points of green space planning and management. However, none of the existing concepts combined a balanced approach that takes into account both the demands of ecological conservation and social requirement, both in a Western and Eastern context.

We therefore introduce a new concept, that of integrated Green Networks, as a way to meet the needs for international harmonization of terminology, with an approach that takes connectivity into consideration when planning and designing public communal places. Our definition of the green network concept is based on the needs of both humans and the nature. We define urban green networks as a set of networks of social and ecological functions, linked into a spatially coherent entity through flows of organisms, and interacting with the landscape matrix. Urban green network is based on spatial structure and function of the area + the patch-corridor- matrix model (Forman 1995) + the dot-line-network model (Cantwell, Forman 1993). Green structure as well as surface and ground water occurring in the urban landscape link to the surrounding landscape. Green areas may advantageously be interconnected by themselves but sometimes stretch in combination with a road route. Hence, the definition is based on three categories of networks: river (or blue) network (served as corridors and lines), green space network (served as patches and dots) and transport greening network (served as corridors and lines as well). The ultimate aim is the combination of the three networks as an overall green network (served as matrix and network) (Fig. 8).

1) River network – river or water system and runoff in urban surface, including all types of rivers and other waterways within the city green spaces that provide possible habitat refuge and scenic places for humans. They link ecological habitats and social scenery, as well as green spaces.

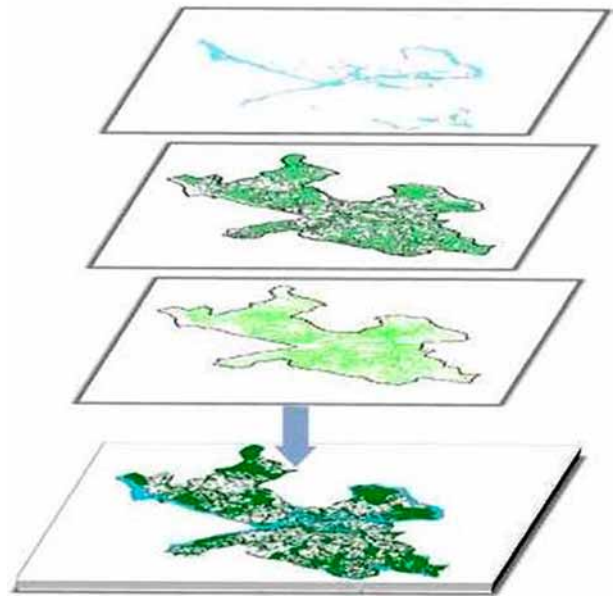

Fig. 8. The structure of the Stockholm green network

2) Green space network – protected natural and man-made green areas, such as parks, gardens, woodland, swales, preserved or natural areas. These provide the space for plants and animals to flourish while serving as landscape scenery spots. Green space network here is defined as vegetated land within or adjoining a city except greenery along the transportations.
3) Transport greening network – plantings and street greening on and along transport corridors within and around settlements, including sidewalks, bicycle lanes, railroads, etc. Transport greening offers a functional support system of urbanized areas, following transport corridors which can link out into the urban area and help enhance the area's biodiversity, quality of life and sense of place through connecting green-blue spaces in the city. The transport greening network is critical from an engineering, industrial, and public safety point of view. It provides for the linkage of the green space network and the river network.
4) Integrated green networks – a concept that integrates the above concepts, but analyses and addresses the entire city's green and blue structure. In this approach, landscape architects and urban designers shift their attention from single-shaped planning (green corridor, green belts and so forth) to a big-pictured, multi-functional planning (green infrastructure). However, specific ways to bridge and integrate current green concepts together are often still missing, as for example the link between green and blue spaces. Green networks use network connectivity as a tool for integrating the concepts discussed above with ecological and social functions; jointly rather than separately for ecology (green corridor) and recreation (greenways). One of the characteristics of a network is that even if an individual uses only a small part of the network, he or she gains access to a system and knows that he/she can use all of its parts. The "individual' here is not only referring to human being but also flora and fauna. Green networks can be designed to shape city structure and provide a framework for future growth- a framework to connect the green space and blue space in the future.

This definition embodies a strategic approach to the problems of intensified land use and fragmentation in urban areas. Green network is a multi-scaled concept and tries to refer to the function and the structure of the network, as a key feature of networks is that they can have different configurations and still serve the same goal (Opdam *et al.* 2006). Its aim is to achieve connectivity in urban landscape and to provide attractive and high quality environments for people live, visit and work on the one hand, and for connecting habitats for plants and animals on the other. Another attractive element of green network is its sim to integrate green and blue spaces. Green space is not a lonely island that is isolated from blue space, neither spatially, socially nor ecologically. Both green and blue spaces play the same significant role in offering wildlife habitats as well as, social, recreational, educational and historical places. No species lives in one without the other. Moreover, China and Scandinavia are heading in the direction of green-blue integration as well. For example the proposal for greenbelt plan in Xi'an highlights the importance of river belt at the same level as the green belt. Hammarby Sjöstad as a successful model of modern town planning also combines both green and blue spaces into one approach. In order to analyze and realize the concept into a practical network approach, visualization from actual green-blue spaces in a city should be accomplished first. Graph theory then could be a suitable method to convert geographical landscape into a visualized representation. Dots and lines are two important components of graphs. Corresponding to the definition of green network in this paper, dots can be defined as important habitat patches and lines represent species dispersal in between. Habitats are usually plants communities that located in green space network (Kong *et al.* 2010) and lines are those linear characters of river and transport greening networks. For analyzing and selecting important habitat patches in green space network, not only ecological but also social functions, such as connection to nature, species dispersal, etc. should be considered since we assume that various users should share benefits of green networks fairly. So sociotope and biotope maps could be valuable references since they provide varied values of areas for differentiated groups (sociotope for human and biotope for wildlife). Based on the work of Ståhle (2006) on multiple use values of sociotope mapping, a series of maps have been created in many Swedish municipalities (including Stockholm, Uppsala and Gothenburg) focusing on the commonly perceived direct open use values of specific open space by groups of citizens. Similarly, a biotope is an area of uniform environmental conditions that provides a living place for flora and fauna (Shih *et al.* 2009). Its subject is a biological community and biotope mapping is the collections of biotopes serving different species (Fig. 9).

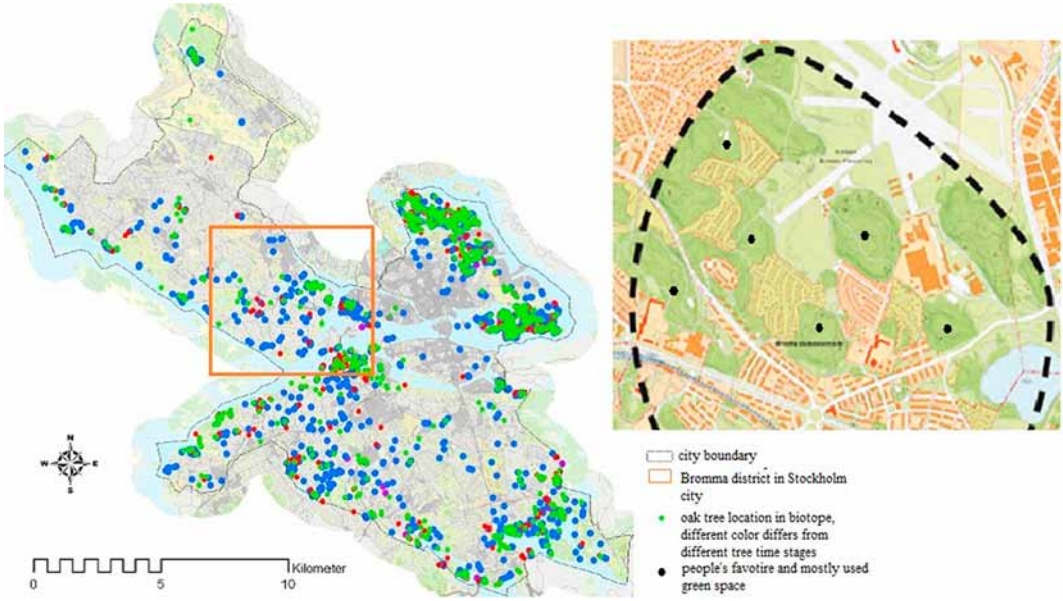

Fig. 9. Biotope (left) and sociotope (right) map of Bromma, Stockholm. Biotope mapping in Stockholm uses oak trees as one of the important habitats that provide refuge, reproduction and connection areas for many fauna species. A sociotope map is based on people's perception of green spaces. The dark green color represents the favorite and most frequently used places by residents (Stockholm Municipality)

Parallel maps of dots for social and ecological functions of green space network are then merged with the river and transport greening system and elaborated into green network maps. Strategies for connected social and ecological referencing maps will be created based on green and blue recourses collections, analysis and evaluations of green network afterward. Priority principles, landscape pattern analysis based on landscape metric, and network structure analysis will be combined as well in subsequent empirical case studies. Since green network will be a practical framework with concrete approach that provide valuable references to local and international planners, case studies in different regions, such as Western and Eastern, and Scandinavian and Chinese cities would be necessary to see how green network would be generated as a concept and then implemented as a method.

Furthermore, in this globalized world all urban dwellers require adequate opportunity for interaction with urban green networks and urban open spaces, in all geographic locations. In this respect, the concept of green network mapping represents an interesting and valuable opportunity for both Scandinavian and Chinese city planners, and international scholars, although its implementation as a new approach will be challenging. Strategies towards elaborating both social and ecological functional maps of green network also need to be tested and implemented since we hypothesize that this working model needs differentiated adjustment in attempt to apply into different contexts. Experience and models from both regions can provide a range of navigation tools and can strengthen understanding between the two regions. The interaction and comparison of implementation methods can be highly beneficial for sustainable urban development in both West and East. Through comparing and contrasting, we can obtain better understanding of the cases in different country, draw lessons and identify good practices, and provide guidance to planners.

Conclusions

Modern green space planning has different roots and paths in West and East. Scandinavia and China are two examples that demonstrate how green space concepts differ in two regions. Europe including Scandinavia of course has had a longer time of planning development than China. Different planning schemes and driving forces have resulted in similar concepts with differing implementations. In Western countries some of green space concepts were proposed and supported by local organizations following bottom-up grassroots movements (a political movement from the local by the fundamental constitutes of a community to affect change at the local, regional and even larger level) before becoming mainstream government policy. Examples of this are the Council for the Preservation of Rural England in the case of the greenbelt, and greenway organizations to implement greenway ideas. However, the Chinese top-down planning system is central-government led. It may be effective in grandiose mega-

scale projects like Three-North Shelter Forest Program and the QTR. But for localized green space planning, it lacks consideration of important aspects. The feasibility of Sino-Swedish eco-city planning in China is also as a result of Ulf Ranhagen's idea of Sustainable City that was accepted by central government. In this sense, it is necessary from a landscape architect's (and also grassroots') perspective to propose a planning concept and strategy in consideration of contexts in both regions.

Green networks then encompass a comprehensive and integrative approach to green and blue spaces management and network planning. They can be utilized in urban areas fulfilling at least two roles, namely geared towards connecting habitats for wildlife and for human beings respectively. Green networks help facilitate wildlife movement and connect wildlife populations between habitats in human dominated areas (Kong *et al.* 2010), upgrading and connecting green and blue space into a unified framework; and thus making an important contribution to creating sustainable cities. In this system, plants and animals can support ecological flow by increasing the area of core habitat relative to edge habitat. As for communities, green networks' trees and other vegetation can increase the amount of publicly available recreation areas (Bolund, Hunhammar 1999), allowing urban communities to enjoy greenery within the city. More connected green networks will encourage the creation of accessible open areas for outdoor physical activity, which will increase both physical and psychological well-being (Bolund, Hunhammar 1999).

In this paper, we reviewed a series of leading green space planning concepts that aim to reduce habitat fragmentation and have had following in both Scandinavian and Chinese cities. Conclusions from the analysis and comparison between the two regions show that all the green concepts are usually originate from Western (including Scandinavian) countries. Second, China imported these green space planning concepts and integrated them within its own tradition and context. Hence the application of green concepts in China developed in a different direction, meeting different needs. Third, and not only in China, green space planning concepts experienced multiple functional transformations even in their region of origin. For example, greenbelt was altered to green wedges and green fingers, and from a single shape (greenbelt, green corridor and greenway) to a larger picture (green infrastructure). Fourth, modern technology and the widespread use of GIS in particular, have created new opportunities for green space planning and management, and also for specific concepts and approaches.

However, none of the past green space planning concepts was created based on the overall perspective to specifically address the fragmentation problem in urban areas. Each concept has its disadvantages in terms of how landscape connectivity is addressed. Moreover, every green concept is designated to resolve one aspect of city challenges (ecological or social) but none of them initially considered a fully socio-ecological approach, although several concepts (e.g. green infrastructure) have gradually developed in this direction. Another issue that green networks deal with is integration of green and blue spaces, although neither Scandinavia nor China considered it before. Both have been heading in this direction recently since more and more people and governments have become aware of the realized benefits and indispensability of green-blue connections. Hence, the new concept of green network offers potential for a more comprehensive analysis and promotion of green and blue spaces' connectivity and landscape integration. Implementation of sociotope and biotope mapping, as well as other elements of the new approaches, offers opportunities for combining state-of-art knowledge from both China and Europe.

The development of green networks will be an ambitious undertaking which will link green space, road systems and river networks as elementary components in built-up urban areas. The planning and design of green networks can be seen as multidisciplinary or even transdisciplinary endeavor, involving a wide range of ecological and recreational public open spaces within the city. Its implementation will require cooperation of different disciplines and fields, such as landscape architecture, city planning, forestry, nature conservation, environmental management, and the like.

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NA XIU

PhD student of Landscape Planning, Department of Urban and Rural Development, Swedish University of Agricultural Sciences, P.O Box 7012, Se-75007 Uppsala, Sweden. E-mail: na.xiu@slu.se
Research interests: landscape architecture, green structure and landscape history.

MARIA IGNATIEVA

Doctor and Professor in Landscape Architecture, Department of Urban and Rural Development, Swedish University of Agricultural Sciences, P.O Box 7012, Se-75007 Uppsala, Sweden. E-mail: maria.ignatieva@slu.se.
Research interests: sustainable landscape design, ecological design, landscape history, restoration and conservation of historical parks and gardens.

CECIL KONIJNENDIJK VAN DEN BOSCH

Doctor of Science in forest policy and economics, professor in Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, P.O. Box 58, Se-23053 Alnarp, Sweden. E-mail: cecil.konijnendijk@slu.se
The head of Department of Landscape Architecture, Planning and Management.
Research interests: urban forestry, urban greening, green infrastructure planning, green space governance, urban ecosystem services.