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Urban Landscape Design and Biodiversity

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1. Introduction

Nowadays, cities are focal points of interaction between urbanization and nature. During the recent years, the density of buildings and other hard surfaces have dramatically increased by population growth in urban area and urbanization becomes the phenomena in our century both in developed and developing countries.

Today, more than half of the of the world's population lives in cities which is increasing by time (Tratalos et al., 2007). Research indicates that by 2030, 1.75 billion new urban residents are expected in urban area (Mcdonald et al., 2008). Also, by 2050, more than two-third of the significantly larger world will be living in urban area (Muller et al., 2010).

Although, cities cover 2% of the world's surface (Muller et al., 2010), they have an enormous impact on the earth environment. Urban areas consume 75% of global natural resources and cause 80% of 'greenhouse' gas emission. Also, urbanization modifies the ecology and features of urban landscape. There are some of the ecological impacts of the urbanization on environment such as fragmentation of open and natural areas, degradation of water resources, loss of free natural services (Benedict & Macmahon 2002), alteration of habitat, loss and dismemberment of natural vegetation and the creation of novel habitat types (Tratalos et al. 2007). These rapid changes cause concerns about the future of life in cities. Therefore, sustainable approach towards use of the earth's natural resources and biodiversity in urban area become vital to ensure the next generations life.

Alberti et al. (2003) claimed that cities are both complex ecological entities which have their own unique internal rules of behavior, growth and evaluation and important global ecological forcing functions.

During the last few decades, the topic of urban biodiversity as a component of urban ecology has been discussed in many researches. These researches indicate that urbanization, land use and land cover (Muller et al. 2010) are the main factors threat of biodiversity by direct habitat conversion or indirect effects of human population growth on local, regional

and global scales (Clergeau et al. 1998, Blair 1999, McKinney 2002; Ricketts and Imhoff 2003). Over the years, an approximately species decline by 10-15% caused just by habitat lost. These figures will increase by pollution, climate change and other environmental problems caused by urbanization (Zitkovic 2008).

The distribution of people across the Earth's surface is not an equal one. Therefore the pressure of population growth on balancing the conservation and the use of natural resources varies in different parts of the world (Kohsaka 2010).

Generally, the levels of urbanization are high in developing countries which most of the protected areas are located in. In addition, the distance between protected areas and cities is reducing that brings with it, significant conservation challenges (Mcdonald et al. 2008; Oliveira et al. 2011).

This situation is not better in developed countries. According to Muller & Warner (2010), the number of vascular plant species decreases from more than 400 species per km² at urban fringe to less than 50 species per km² in city center, in central European cities. That's why urbanization and its impacts on environment are global issue for human future. However, there is still a glimmer of hope for preserving the urban biodiversity because there is a growing awareness that the health of the planet's biological diversity is essential for determination of human own destiny. Therefore, more protection is required for biodiversity than what has occurred to date (Millennium Ecosystem Assessment 2005; Connery 2010). In Addition, nature in the city and studies of urban biodiversity become more vital because of rapid urbanization growth in the world.

In this case, landscape architects have significant role in designing the cities as a healthy and aesthetically pleasing living environments while conserving biodiversity. Preserving and improving the natural areas in parallel with biodiversity is an important concept in urban landscape planning and design.

Towards these objectives, this chapter focuses on the urban biodiversity and the opportunities and conflict of improving urban biodiversity. First section of chapter as a conceptual framework starts by reviewing some important concepts related with urban biodiversity. Consequently, the opportunities for improving urban biodiversity are identified. Also, the planning, management and design of urban landscape have been discussed as a tool of development, protection and creation of biodiversity. In addition, planting and constructional urban landscape design has been explained in order to creation and protection of biodiversity in urban areas. Finally, some of the conflicts in preserving and improving urban biodiversity are discussed.

2. Conceptual framework

2.1. Definitions of urban biodiversity

The concept of biodiversity is general term that can occur at any levels of life. Savard et al. (2000) explained that life is structured in a hierarchical manner which start by cells that

constitute individuals, then form the populations, which regroup into species and as a result end as communities.

Biodiversity is usually defined as living diversity of nature and as a component of environment. It involved all form of life, the structural and functional aspects together. Biodiversity is not only the quantity. Therefore, as assessment criteria; richness and its spatial distribution, significant and rare characteristics, homogenization and hybridization factors will be considered.

The concept of urban biodiversity is specific part of living diversity of nature. Zitkovic (2008) describes it as plants and animals that are living in the built environment. It also consists of patches of land that have survived during city expansion and represent the area before dense human settlement. In another definition by Muller et al. (2010), the urban biodiversity is explained as “the variety and richness of living organisms (including genetic variation and habitat diversity found in and on the edge of human settlements”.

Through the history of human life, a lot of factors affected biodiversity. Permanent settlement, agriculture revolution, cultivates plants and domesticates animals influenced the urban biodiversity. In addition the manner that land is used and built up, economic, social and cultural dynamics affected urban biodiversity. Beside that the cities’ development impacts directly urban biodiversity. It also influence how biodiversity is distributed among the different groups of the population (Oliveira et al.2011).Therefore, in the urban areas with less dense of population and shorter history of human impact original natural areas and species can be found. However, in mega-cities or more densely populated areas urban biodiversity includes only the species that can survive or adapted to the character and quality of urban ecosystems.

Today, urban biodiversity is not only the important part of urban ecosystem but also, it is a substantial ecological and cultural integrating element. Furthermore the native flora and fauna are important tools for urban ecological and cultural identity.

There is variety of biodiversity from rural borders to urban core according to the different types of habitats. Muller et al. (2010) categorized urban landscape and habitat levels as follows;

- Remnants of pristine natural landscape (e.g. leftovers of primeval forests rock faces);
- Agricultural landscapes (e.g. meadows, areas of arable land);
- Urban-industrial landscape (e.g. city canters, residential areas, industrial parks, railways areas, formal parks and gardens, brownfields).

It must be highlighted that the concept of urban biodiversity is not include just native species. Urban biodiversity may not accommodate the native biodiversity of the surroundings as this may not be compatible with the urban environment or the connivance of urban residents. For example, Manaus in Brazil is surrounded by the Amazon jungle, but its citizens do not expect to share their daily life environment with local fauna including boas or piranhas. Some native trees may not be suitable for urban environment due to the natural limitations (e.g., the need for space, clean air, water or certain species to survive) or management constraints (e.g., the frequent need for trimming or cleaning beyond local

capacity). Indeed, removal of some species from cities, like mosquitoes, can add to the quality of life in those cities. As for desert cities, citizens may want to have trees and other non-native species. Therefore, the role of cities to foster biodiversity will vary according to its individual context. For one city, the urban biodiversity may comport with the surrounding biodiversity and the city can leave a corridor for this biodiversity thus intertwining the urban fabric with local habitats. For another city (like Manaus), this may not be possible, or at least for some species (Oliveira et al. 2011).

The modern concepts of biodiversity and ecosystems have the potential to remedy this misconception. Ecosystems show that components within any geographical unit are connected, including nature, human beings and cities. Biodiversity reflects the interconnectivity of all life on Earth.

2.2. The importance of urban biodiversity

The urban environment is ecologically highly dynamic (Gilbert, 1989; Adams, 1994; Savard et al. 2000) and can provide opportunities for improving the biodiversity and ensure beneficial insights into the management of biodiversity in other ecosystems. The existence of urban biodiversity can have positive impacts on quality of life as well as environmental improvement. Green areas such as parks can provide interactions between human and nature (Figure 1). It can also influence the form of the city and its inhabitants. Furthermore, the conservation of urban biodiversity is an important issue in managing urban landscape especially in mega-cities (Qureshi & Breuste 2010).



Figure 1. Green areas such as parks can provide interactions between human and nature as well as improving biodiversity (Photo from Ankara-Turkey taken by Aysel Uslu)

Also, urban ecosystem can make favorable condition for improving biodiversity. Many researches indicate that there is a variety of species living in urban area that are well-adapted to the urban life (Oliveira et al. 2011). Also, some research has produced substantial evidence indicating that biodiversity in urban area can be more than rural areas surrounding (Qureshi & Breuste 2010). The reason is that, there are unique physical and ecological conditions in urban area. These are mixed and small-scale habitat mosaic, different from of landscapes and land uses, the various influences of people that result in habitat types and plant and animal associations or communities (Muller & Werner 2010). Muller (2007) justified the reasons for high biodiversity in cities as follows:

- Cities often include relics of natural habitats- forests, rivers...
- Cities often include relics of semi-natural habitats - meadows, arable fields...
- The variety and distinctness of urban habitats - residential areas, gardens, parks, industrial areas, railway areas, brownfields
- Cities are centers of immigration
- Cities are centers of importation, naturalization and spread of exotic species.

Therefore, the urban ecosystem is valuable for biodiversity including population structure, genetic diversity. Savard et al. (2000) explained an excellent example for these advantages. Planting rare vegetable or rare form of plants in backyards can sustain a source for genetic variability. Additionally creation of pools and wetland can reproduce variety of aquatic organisms. Cultivation of flowering plants in cities parks and even private lots can attract butterfly and birds and consequently increase the diversity of these species. For example, in 2010 as part of the Landscape Urbanism biennale, an area was planted up to reintroduce butterflies back into the city Bat Yam Israel.

2.3. Urban ecosystem and biodiversity

Urban ecosystems are similar from different perspectives such as structure, function and constraints. The geographical location, size and the type of landscape they modify are the factors of their difference. One of the important element influences plant and wildlife species which can be found in urban built environment is the landscape surrounding the city. Therefore it has a significant role in the management of urban biodiversity (Savard et al. 2000).

There are lots of examples indicate immigration of animals and plants to urban areas from their natural habitats. The reason of this immigration in most cases is food supply and lack of predators (Muller & Werner 2010).

There is a general agreement that cities are characterized by high species richness in terms of vascular plants and most animal groups. This is the result of the high beta-diversity that means the large variety of habitats present and variation in vertical and habitat structure, the considerable variation in the type and intensities of land use, the range of material used and the huge array of micro-habitants, and the most varied habitat mosaic configurations (Muller & Werner 2010).

According to Muller & Werner (2010), during the 19th and 20th centuries, the number of naturalized species (tree, shrubs and herbaceous plants) increased significantly. The urbanization is shown as basic reason of this *biotic homogenization*. During these years, planting small number of nonnative species and cultivars in gardens caused biotic homogenization of these species. By the time, these species spread as invasive species into their surroundings (Muller & Werner 2010). Beside these plant species, some of the animal species also become naturalized in urban area. As a result of biotic homogenization process, the biodiversity increase in urban areas.

Urban biodiversity have positive impact on human wellbeing. Expanding the urban green areas and contributing the natural areas development in cities not only promotes species richness, but also bring better quality of life for the residents. Curitiba Declaration on Cities and Biodiversity (2007; Connery 2009) emphasized the importance of urban biodiversity signaling the need “to integrate biodiversity concerns into urban planning and development, with a view to improving the lives of urban residents ...”

Urban biodiversity provide recreational areas in artificial urban environment, so, it is essential for resident’s health (Niemela 1999).The biological diversity also helps people, shape their “sense of place.”(Connery 2009). Existance of varaiety of plants or animals as characteristics of places can present a memorable picture from different sites and led to the identification of places.

Additionally, urban biodiversity as a key component of ecosystems have positive effect on ecological service function. Several ecological services having significant role and human wellbeing are the direct products of urban biodiversity. On the other hand, biodiversity loss can influence almost all services provided by ecosystems (MA, 2005; Oliveira et al. 2011). These ecological services range from provisioning services (e.g. food, fuel, water) to regulating (e.g. climate/air pollution regulation, waste assimilation, flood and fire regulation) and cultural services (Oliveira et al. 2011). Using the local diverse vegetation can be more effective improving ecological services.

Furthermore, urban biodiversity can play a significant role in improving the green infrastructure that influences the human health and climate changes and heat islands positively (Vergnes et al. 2012).

Conservation of urban biodiversity is an important global issue because urban environment have a significant role in preserving the local species and maintaina platform for urban citizens to understand the natural process. For a long time, urban planning effort was to establish protected area and corridors in cities (Hostetler et al. 2011). However today, most of the biologists and ecologists believed that creating the connection between parks, preserves and other important ecological areas and establishing green infrastructure is the key concept for pereserving biological diversity and ecological process (Benedict ve Macmahon 2002).

Benedict & Macmahon (2002) describes green infrastructure as an ecological framework needed for environmental, social and economic sustainability. It can also be defined as

protected natural open space and corridors (adjoining residential yards or sections) (Hostetler et al. 2011).

Green infrastructures consist of a system of *hubs* and *link*. Hubs are “destinations for the wildlife and ecological processes moving to or through them” and links are a “connections tying the system together and enabling green infrastructure networks to work”.

The corridors have significant role supporting biodiversity because they allowing some species, especially the less mobile ones, to disperse to distant locations and limit the negative impacts of fragmentation (Vergnes et al. 2012).

Vergnes et al. (2012) analyzed the effect of corridors on the variety of species, the number of individuals, the means by which species disperse (in the air or on the ground) and the main habitats in which the species are typically found. The results of this research indicate that, not only do corridors affect the dispersal of individual species; they also allow species to maintain community structure. Furthermore, corridors can connect urban areas with new city regions locating in rural areas surround the main city.

During the history of life, cities often occur in unique and valuable natural ecosystems such as the River side and delta. Urbanization in these areas fragments the natural and original habitats (Schaefer 2003). Over the time, continued urbanization isolates these areas. However, in some cases these areas are protected as natural parks, but their biodiversity decreasing as a result of isolation. Planning green infrastructure and green links enables these areas to act as more viable larger units, thereby helping to protect their biodiversity.

Most of the time the growth of population in cities cause spreading to rural areas surrounding where original vegetation is exist. These areas have an opportunity for its use as parts of the urban infrastructure in the new city regions (Breuste, 2004; Florgard 2010). Planning the green infrastructure will connect these areas to urban areas and can improve the biological diversity indirectly.

One of the challenges in urban planning and design is the habitat fragmentation caused by urbanization. Connectivity is the product of green infrastructure in urban environment that ties the island biogeography and conservation biology and unable them to function as larger units containing larger breeding populations and more complex food webs (Schaefer 2003).

Habitat fragments are the nodes of this web and corridors are the connection between them. Linehan et al. (1995; Schaefer 2003) determined the strength and impact of network connectivity by the number of network in region, the dimensions of the links within the networks and the number and sizes of the nodes.

Many researchers accepted the value of connectivity in forestry conservation and founding the movement of wildlife between habitat patches (Harris 1984; Noss 1987; Schaefer 2003).

Wildlife movement through the corridors can range small to large mammals (e.g Wegner and Merriam 1979) and birds (e.g. Dmowski and Kozakiewicz 1990; Schaefer 2003). Some criteria can examine the quality of corridors in green infrastructure such as vegetation

layering, diversity of plant life and a minimum of invasive alien species (Thorne 1993; Schaefer 2003).

Today, there are a lot of examples of corridors and ecological connection in European cities that bringing nature into city centers and developing physical and ecological connection between built-up areas and natural and greens paces (Beatley 2000).

In many of the urban areas, there is generally one or more open and green spaces with large size that presenting as a mother habitat patch for preserving biodiversity. But, preserving and protecting these habitat patches is not enough for improving urban biodiversity. The reason is that without the connection between them, isolation and loss of genetic diversity is unavoidable. Corridors of urban green infrastructure connect different size of habitat patches such as backyards, hedgerows, green roofs to parks.

Population increasingly grows in urban area and human life still depends on the nature and the ecosystem that they live in. An ecosystem generally can be defined as “a set of interacting species and their local, non-biological environment functioning together to sustain life” (Moll and Petit, 1994; Bolund and Hunhammar 1999). Cities are depending on the ecosystems beyond the city limits. In the study of 29 largest cities by Bolund & Hunhammar (1999), in Baltic Sea region, it was estimated that the cities claimed ecosystem support areas at least 500–1000 times larger than the area of the cities themselves. But, in this chapter the concept of urban ecosystem is focused and the effects of ecosystem inside the borders of cities.

Ecosystems usually differ in size, borders and location. In the case of urban environment, it can be defined as a single large ecosystem including all the individual ecosystems like parks, lakes and etc. or can investigate as several individual ecosystems (Rebele, 1994; Bolund and Hunhammar 1999). In this chapter the concept of urban ecosystem consist of all ecosystems located in urban area.

The concept of ‘ecosystem services’ refers to benefits human populations derive from ecosystems. Bolund and Hunhammar (1999) identified seven urban ecosystems including;

Street trees; lawns; parks; urban forests; cultivated land; wetlands; lakes; sea; and streams.

Then, they range the ecosystem services generated by these systems as: air filtration, micro climate regulation, noise reduction, rain water drainage, sewage treatment, and recreational and cultural values. Finally, they emphasized the locally generated ecosystem services have a substantial impact on the quality-of-life in urban areas and should be addressed in land-use planning. Now, what the relations of urban biodiversity and the urban ecosystem services is.

Urban biodiversity can provide series of benefits in urban ecosystem by improving the ecosystem services ranging from the more directly perceived, such as water supplies and recreation facilities (parks) to less tangible effects of large bio diverse areas, such as hosting species which may help cure diseases or contribute to long term climate stability.

Nowadays one of the important challenges in urban area is the problems caused by the climate change. The increasing growth of structural areas and fragmentation of natural and open spaces is the main reason of the urban heat islands and climate changes (Baris et al. 2010). Today, it becomes vital to create micro climatically comfortable spaces within the artificial urban environment both for human thermal comfort and for enabling the conservation of biodiversity that can still be called the native flora of the region (Hagen & Stiles 2010).

In a variety of studies, the significant impact of vegetation in urban climate, its ecological balance and effects on citizen's comfort is documented (e.g. Bolund & Hunhammar, 1999; Dimoudi & Nikolopoulou, 2003; Gill et al. 2007; Hagen & Stiles, 2010). Also as Ong (2003; Hagen & Stiles, 2010) emphasized sustainability of city depends on the urban vegetation.

There is lots of evidence that vegetation can reduce the air pollution in urban area (Svensson and Eliasson, 1997; Bolund and Hunhammar 1999). Also, research represents the effective role of the vegetation on air filtering than water or open spaces (Bolund and Hunhammar 1999). Different component are affective on the level of pollution reduction provided by vegetation. Plants can filter the pollution and particulates in the air using their leaf. Therefore, filtering capacity increases with more leaf area and using the trees in urban design. Using trees can be more effective in air pollution reduction than the bushes and grassland.

Complex species assemblages also can improve the soil health. They can decrease the capacity of soil for absorbing the flood water. Also they can have positive impact on water filtering. Using the various species of plants specially trees can filter air and reduce the amount of carbon in the air causing the greenhouse effect in urban area. It must be noted that using local vegetation has advantages of cutting costs in many cases. The reason is that these species live several years without requiring little human attendance or input of water.

Green space in the urban landscape helps in overcoming fundamental environmental problem, further enabling and easing conservation efforts from local and regional authorities and others.

Biodiversity and healthy ecosystems within city limits support the quality of life of citizens, facilitate municipal services and aid in restoring a positive and integrated perception of the environment to citizen.

3. Preserving and restoring urban biodiversity

For decades, preservation of biological diversity restricted just for protected areas where biodiversity is guarded from human threats. Today, protected areas cover approximately 15% of earth whole land surfaces (Mcdonal et al. 2008). Although having such a small rate, the protected areas still have significant role on preserving biodiversity. In addition, the protected area, the concept of preserving biodiversity in urban area gets importance in last years. There are a few causes for the importance of this issue.

The reason is that the urban areas consist of different habitats and ecosystems allowing many species to grow and expand as we mentioned before. Therefore, the richness of the

species proliferates in these areas. On the other hand, cities consume a large amount of natural resources of places, far away from cities and indirectly affect the bio diversities' of these areas. In addition, most of the cities' activities generate air pollution, solid waste and so on that directly has negative impact on cities biodiversity.

That's why; it is essential to develop methods for identifying where the human threats and biodiversity coincide (Ricketts et al. 1999; Ricketts & Imhoff 2006) to decrease the negative impacts of urbanization on urban biodiversity and preserve the existing species while restoring the damaged areas.

According to these objectives in this section, the opportunities for preserving biodiversity in urban areas are firstly evaluated. Because preserving a functional biotope and ecosystem are a basic step in sustainable development in cities and towns. Also, it can provide aesthetical and functional advantages that can ensure many social and economic benefits in cities.

In second part, the relation between urban landscape design and biodiversity is discussed. Also, the methods of planning and design of urban landscape that can improve urban biodiversity are defined. Furthermore, the effective method for improving urban biodiversity is recommended.

Finally, the conflicts and challenges in preserving and improving urban biodiversity are investigated. The problems related to preserving urban biodiversity are emphasized in this part because if the obstructions identified, better solutions will emerged and elimination of problems will accelerate the improvement of urban biodiversity.

3.1. Opportunities to promoting urban biodiversity

Cities are the parts of larger ecosystems and don't exist isolated. Therefore, investigating opportunities to promote urban biodiversity can impress the richness of species not only inside the urban borders but also in areas surrounding the cities. However, while perusing these opportunities, it must be highlighted that all of the species are not equal in urban area.

Most of the species existing in urban area are different in many features such as size, shape, abundance, distribution, trophic position, ecological function, feeding habits and desirability. It is substantial to identify which species have more important role in the community and their absence will affect other species while evaluating the opportunities for promoting species life.

Urban structure consists of different natural corridors such as waterways and green ways. These natural habitats inside the urban borders accommodate many species and generally are connected to the areas out of the urban boundaries. So, they are important features for biodiversity both as stable and as transient habitats (McIntyre, 2000; McIntyre et al., 2001; Angold et al. 2006).

Therefore, evaluating the opportunities in preserving biodiversity in these areas can increase the urban biodiversity richness as well as near rural and natural areas species diversity. Any

vegetated corridors linking urban green areas to each other or connecting these areas with rural habitats are important to maintain and enhance urban biodiversity (Flink and Searns, 1993; Savard et al. 2000). The reason is that, they facilitate the movements of species between the different habitats. Consequently, they insure the colonization of natural areas.

Streams and other waterways as natural corridors in urban areas are another opportunities for promoting biodiversity. If these corridors are well managed, they can improve biodiversity not only in the habitats beside the land but also can have positive effects on the proliferation of aquatic species (Figure 2).



Figure 2. Waterways in urban areas as opportunity for promoting biodiversity (photo from Brussels-Belgium taken by Aysel Uslu)

In addition to urban corridors, urban landscape consists of natural areas covered by local species of plants. These plants constitute habitats for many other animal species. Therefore, protecting these natural areas inside the cities, results many benefits especially those influencing biodiversity. They also help preservation of local habitats and species that are in peril of extinction (Figure 3).

Beyond supporting a variety of species and habitats, other advantages of protecting natural areas in cities are contributing the essential services including water filtration and absorption, nutrient cycling, air filtration that can improve biodiversity indirectly. In addition, they can bring nature closer to city dwellers. As a result, the native species will recognized and be familiar for inhabitants. Therefore, urban residents will protect these species by rising awareness of environmental issues and importance of urban biodiversity.



Figure 3. Natural green spaces can support the life cycle of local species (photo from Luxembourg taken by Aysel Uslu).

Also there are series of open public areas inside the cities that have potential for improving biodiversity. If these areas including; parks and public gardens, outdoor sports activity areas, playground, squares, hobby gardens and urban farms are well-designed and managed, then they will provide life habitats for many plant and animal species.

Apart from preserving and linking of existing green spaces, creating new green spaces inside the cities is essential to complete green network and sustainable urban development (Hagen & Stiles, 2010). New green spaces can increase the potential of species to move through urban areas and colonize the surrounding habitats. Residential areas gardens can have a significant role in this concept. According to Savard (1978), well vegetated residential areas can establish aerial corridors through their tree canopy. These areas are beneficial for migrating birds which use them extensively as they provide food and protection against aerial predators.

Besides the gardens and greening the courtyard, any other green strategies such as green roof are essential for improving urban biodiversity. Rapid urbanization caused most of the natural green spaces inside the cities to be destroyed and fragmented. Consequently of these modifications, the natural habitats of many species are damaged. Therefore, creating new green areas can improve these habitats supporting urban biodiversity.

Unused land within cities and brownfield sites are the other parts of urban landscape structure that can have significant role on rehabilitating the urban natural biodiversity. One example for unused land within cities is railways. Railway sidings with vegetation can connect different green spaces within cities and play as a network enhancing habitat for

biodiversity as well as improving its capacity to provide ecosystem services. They also can connect cities to the surroundings area and facilitate the movement of different species of insects and animals depending to the plant species.

An example for brownfield is unused industrial areas inside the cities. If these areas were abandoned for a long time, natural plants begin to grow without any intervention. As a result of this vegetation, several species of insects and other animals will attract to the area and if this habitat modification managed properly, it will be transformed into new habitat for many species. In some cases these areas turned to man-made parks that have positive impact on urban biodiversity as well as natural vegetation. The research of Strauss and Biedermann (2006; Haase & Schetke 2010) indicate the positive response of different species to large area of inner-city grassy brownfields and negative reaction to the absence of them. In addition to brownfield, some researchers reported considerable potential of shrinking cities for biodiversity and the improvement of urban green system. The residential and commercial properties and their subsequent demolition area provide opportunities enlargement of urban green space as well as the ecological restoration of cities. Therefore, identifying these areas and investigating their potential for improving urban green space will have significant role in increasing urban biodiversity (Haas & Schetke 2010).

Beside the opportunities related to land use, constructional elements in cities can provide opportunities for promoting urban biodiversity. Walls are one of these noticeable constructional elements in cities that can support biodiversity and provide other environmental benefits as well. As a result of population growth and decrease in land area available for urbanization, the vertical dimension in urban areas expanded. Utilizing these elements as a habitat for different species can improve urban biodiversity.

In general three types of walls in urban area can be observed; free standing (boundary) walls, buildings walls and retaining walls. Different vascular plant species have the ability to grow on these types of walls. Most of the studies on walls vegetation have focused on old walls maintaining an interesting flora, sufficient to attract some initial botanical attention. As a result, some walls are identified as worthy of conservation because they have some biodiversity value as well as historical and cultural value (Darlington, 1981; Gilbert, 1992; Jim and Chen, 2010; Francis 2010).

However, establishment of more plants on walls depends on the physical and ecological features of walls allowing the trapping and germination of seeds (Darlington, 1981; Francis and Hoggart, 2009; Segal, 1969; Francis 2010). Other factors such as physical substrate, moisture, nutrients, micro climate are also decisive factors on walls biodiversity. Free-standing walls are often the common location for vegetation in urban areas. But maintaining the other vegetation species on the buildings wall still require new technologies and constructional materials development (Figure 4).

Finally, it must be highlighted that urbanization provided appropriate environments for many exotic species to grow inside the city's boundaries. If these advantages are well-managed, the biological diversity of urban areas will improve with native species as well as exotic species. Thus, urban government must plan, design urban environment in such way

that outcomes of urbanization influences on the biodiversity can have positive impact on quality and quantity of urban biodiversity.



Figure 4. New technologies for maintaining vegetation species on the buildings walls (photo from Brussels-Belgium taken by Aysel Uslu).

3.2. Urban landscape design and biodiversity

Through the history of civilization, most of the attempts to increase the urban biodiversity restricted just to managing the particular green areas or conserving and restoring certain habitats inside the cities. Also, it must be highlighted that the main goal of these activities was providing recreation areas for urban residents like urban parks and green belts rather than improving urban biodiversity. As a result, most of planning process and managing urban land use policies were based on the immediate issues and ignore the wider ecological patterns in urban area.

Recently, emphasizing the importance of urban biodiversity in many research and increasing environmental awareness caused urban biological diversity to be slightly considered in urban planning and designing process to have sustainable and more resilience environment. However, for the implementation of this concept in comprehensive manner, more effective urban planning and design policies are required. Therefore, for shedding light to this issue, in this part some of the planning and design methods for improving urban biodiversity will be identified and recommended.

According to Angold et al. (2006), better understanding of the interplay between landscape and local factors that affect urban biological diversity is first step for managing urban environment. Therefore, identifying the existing biological diversity potential and protecting these areas is essential for improving biodiversity. Accordingly, local planning and design practices yields better results in the term of urban biological preservation. Also, local planners having more information about biodiversity potential of specific area can make better decision for improving biodiversity and react better facing to particular challenges.

Urban planners must determine the inventory resources within cities and organize them by unique structure, corridors. Therefore the landscape characteristics of the area must be considered in land-use decision. For example, valley or streams can be considered as natural corridors. Also, during the urban growth process it must be considered that these areas must remain as natural as possible (Figure 5).

For example a simple meadow containing wildflowers is valuable from the biological preserving point of view. However, shearing these flowers before their blooming can cause the loss of biological diversity values. Therefore, these potential zones, must integrate social and ecological considerations to avoid conflicts.

Today, there are many examples of strategies for bringing cities and nature more closely all over the world. The use of native species for ornamental purposes, establishment of conservation areas, revitalization of the nearby water river basin, planning for tree lined streets and linear parks are some of these strategies. European cities offer many examples of these kinds of efforts to incorporate green features and nature into the design of the built environment in urban areas.



Figure 5. An area with wildflower inside the city borders is valuable for urban biodiversity (photo from Ankara-Turkey taken by Aysel Uslu).

Also, it is important that urban planners act on large scales including entire city or smaller scale including neighborhoods. Local action and regional action are equally important in the concept of improving biodiversity. It is critically important that urban planners and other related professionals such as landscape designers or urban designers consider the protection and conservation areas inside the cities in their urban planning and design strategies. In addition, continuous network of these protected zones together with other

urban greenery must be determined. For this purpose as Niemela (1999), emphasized, 'green belts' surrounding cities and 'green corridors' running through cities are the effective strategies. Because these areas, prevent urban sprawl and ensure the connection between green and natural patches (Oliveira et al. 2011). The surrounding areas of different cities in world include lawns, grove and forest areas. These areas contain large amount of biological diversity. Creating network between these areas and inner cities green and open areas is one of the most effective instruments to preserve and enhance urban biodiversity in large scale.

Also, large scale green spaces inside the city has significant role on improving biodiversity. The reason is that small parks or green areas are scattered inside the cities without connectivity to other green spaces. So, they can have slight contributions to preserving biodiversity in urban area (Figure 6).



(photo from Brussels taken by Oguz Yilmaz).

Figure 6. Low-maintenance green area design to promote urban biodiversity in small scale designed by Christine Guerard & Almuth Bennett

Beside the green spaces, in large scale, planning and design strategies for aquatic urban habitats are so important for improving urban biodiversity. Therefore, the sustainable design, planning and management of urban streams, canals, rivers, ponds, reservoirs, lakes and other water bodies, constitutes can have significant role on aquatic biodiversity inside the cities. One of the examples for sustainable management of urban aquatic habitats is Urban Biosphere Reserve (UBR) approach in Istanbul (Tezer, 2005; Oliveira et al. 2011).

Another important point that must be noted for preserving biological diversity in large scale is housing programs in urban areas. Designing more natural built environment to have minimal impact on surrounding landscape and existing biodiversity is a key concept in urban design according to the goals of preserving urban biodiversity. For these purpose, during the construction phase and the process following that, the cooperation of ecologist with urban planners and designers is very important to protect existing local biodiversity and improving flora and fauna diversity in future. One of the positive initiative according to these objectives is Eco-housing a program developed jointly by UNEP and UN-HABITAT, a concept of sustainable principle for entire lifecycle of a housing project. Eco-housing in urban area will have positive impacts on biodiversity conservation by reducing footprint and the environmental pollution caused by urbanization (Oliveira et al. 2011).

The concerted efforts at various scales on improving urban biodiversity can produce best results. Designing with biodiversity in mind must be an important part of sustainable design strategies at a neighbourhood level such as micro district, subdivision, housing complexes. In small scale, home-owners can take various actions for improving urban biodiversity. It is important that home owners realize that their individual effort can contribute to a larger collective effort that would culminate in the creation of a real biological corridor. Such a corridor can facilitate the movements of several species throughout the city and improve urban biodiversity (Laurence and Palmaerts, 1991; Savard et al. 2000). Plantings on balconies, in window boxes and on roofs beside promote residential gardens including decorative or vegetable gardens can have positive impact on improving urban biological diversity (Figure 7).

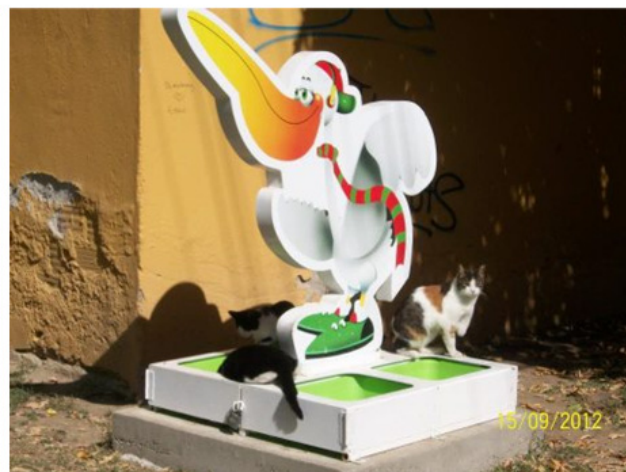


Figure 7. Flowerboxes containing various flowers diverse (photo from Brussels-Belgium taken by Aysel Uslu).

In all large and small scale cases, the qualities of plants species used in green spaces are determinant factor for the habitat that these species provide. The reason is that these habitats encourage the particular species of animals. Generally, vegetation with a diversity of native plant species especially in areas, where land development is intensive, is recommended for increasing animal biodiversity (McKinney, 2002; Oliveir et al. 2011). For example planting trees in private gardens or cities' street provide the opportunities for improving bird biodiversity in urban area. The main problem in this case is that, after the urbanization development, most of the animals and plants do not ensure compliance with city life. But, widely use of native plants can have positive impact on improving the original habitats. Beside that, many other human efforts can help animals to adapt themselves to these new conditions. For example, by provision of artificial nesting or feeding structure inside private gardens or public green spaces in the cities, most of the birds and other animals are encouraged to live inside the city (Figure 8).



(a)



(b)

Figure 8. Artificial nesting or feeding structure for improving urban biodiversity (a) Photo from Pol Ghekiere 's house garden in Belgium taken by Aysel Uslu (b) Watering cup for street animals in Izmir

Tree planting issue is an important to promote biodiversity. Also, the maintenance of green area should promote some specific animals. For example birds use the branches of trees in their nesting season. So, cutting of these branches may disturb the life cycle of the bird and decrease the urban biodiversity. Therefore municipality or the owners of private gardens must manage their green area maintenance programs according to the biodiversity management.

One of the important opportunities for improving biodiversity in urban area is that, urban environment has potential for naturalization of non-native species. Generally the term alien species are used for these types of plants and animals coming from outside a set area. When these species adapted to their new environment, they can be able to spread and improve biological diversity of the area. Therefore particular strategies in planting design of the green areas inside the cities can help new species to be adapted and existing of these species beside the local one can help to increase the biological diversity in cities.

Most of the time in planting design of urban areas the designers utilize particular species of trees, flowers and other plants. But, diversifying plant design can support many animal species life inside the cities. For example, using different species wildflowers encourage more insects depending on the nectar feeding these insects. As a result, instead of using a small number of plants, using large number of plant species increase the opportunities for improving urban biodiversity.

Also, bringing together different types of habitats can provide shelter and feeding opportunities for wildlife, therefore can have positive impact on urban biodiversity. Combination of forest trees, shrubs and meadow can create nesting opportunities for different animals. Also, diversity in the combination of trees, shrubs, wild flowers, dead trees inside the public open areas creates more habitats for wildlife in urban areas. These rich mosaics of different habitats are attractive for urban residents too. The reason is that diversity of habitat creates different views inside the cities pleasuring the urban residents.

In addition, biological diversity usually increases in the junction point of the habitats borders. Therefore, these areas constitute habitats with different environmental characteristics. Thus, it is necessary in urban landscape design to bring different types of habitats beside each other (Figure 9). For example, Using shrubs beside the meadow area provide opportunities for life of diverse plants and animal's species.

As described above, with various methods of planting design in urban area, the biological diversity can be improved. On the other hand, there are some incorrect assumptions in urban landscape design and management that must be modified for getting better result in biodiversity improvement. One of them is that utilizing plants and vegetation having attracting fruit or seed for birds and butterfly or any other insects is not applicable in planting design of urban public open areas and parks. The reason is that, these plants and animals may cause environmental pollution that can disturb urban residents. But, the fact is that, these plants can provide habitats for birds and other animals improving urban biodiversity. Therefore, any kind of plants ensuring the life of animals and birds species

must be identified and the methods of utilizing these plants in the urban area should be developed.



Figure 9. Bringing different type of habitats inside the urban park- Ankara(photo from Ankara-Turkey taken by Nasim Shakouri).

Besides the visible impacts of biological diversity in urban areas, after the death of animals and plants, they provide many habitats for fungus, micro-organism and degrading organisms as well. The reason is that, these corpses are nutrient for many organisms. Therefore, supporting urban biodiversity improve natural life cycle inside the cities too.

It must be noted that it is essential in urban landscape planning and design to make biodiversity more viable, more visible and sensible for urban residents (Figure 10). By engaging with those who design the places where people live and work, human habitats can be modified to places providing life requirements for wild species, a form of conservation biology that calls 'reconciliation ecology'(Rosenzweig, 2001, Rosenzweig, 2003; Miller 2005). These efforts can restore the human connections with the natural world by closing the places where people live and work to the places having the potential for improving urban biological diversity, increase public environment awareness and facilitate participation of urban residents in preserving urban biodiversity.

Another way for reproducing urban biodiversity as well as restoring human connection with nature is urban agriculture program in public lands. According to these programs, urban open areas are used for production of organic food while contributing to environmental education of local residents. These methods can improve biological diversity by creating spaces for growth of various species of plants inside the city. Also, it contributes urban residents to participate in agriculture activities that increasing plant cultivation and preservation knowledge. For better result, urban government, planners and designers must identify appreciate open places inside the cities and analyzed their potential for vegetation growth, then utilize these areas by applicable design for agriculture purposes.



Figure 10. Biodiversity management should create benefits for poor communities and more visible and sensible for urban residents. A sample of edible landscape design in urban area Belgium.

Finally, it must be noted that, creation and improvement of urban biological diversity processes require time. Therefore, the programs and design methods should be based on characteristics of the local ecology considering the time required for each stage. Also, it must be highlighted that, to be successful in conserving biodiversity, the value of nature in public mind must be made clear. Also, by using different levels of environmental education, government raises environmental awareness of urban residents to ensure the next generation life in cities. The reason is that most of the biological diversity restoration and improvement work would not have been possible without the participation of volunteers and urban residents (Figure 11).



Figure 11. Promoting awareness of biodiversity to local communities (photo from Brussels in Belgium taken by Oguz Yilmaz)

In addition, the establishment of networks for city governments, scientific and researchers is essential for cooperation, knowledge sharing, critical debate, monitoring and evaluation of the factors effecting urban biodiversity. Integration of biodiversity into urban plan should be considered.

3.3. The conflicts in order to improvement of biodiversity in the cities

While investigating methods and opportunities for preserving the urban biodiversity has gained importance, the challenges and conflicts of achieving these goals are more emerged. That's why, in this part, the conflicts of improving urban biodiversity is determined and discussed.

As described before, urban ecosystem is highly dynamic and beside human beings involves wildlife communities too. While the proportion of urban residents increasing, the nature and properties of urban ecosystem gain importance. The reason is that, urban ecosystem is the determining factor in quality of human life as well as other living creatures. Also, the scale and speed of urban growth is the main reason of urbanization and transformation of the spatial configuration and ecological process in urban area (Alberti 2005, Dale et al. 2000, McDonnell et al. 1997, Dramstad et al. 1996, McDonnell and Pickett 1990; Connery 2009). Therefore, planning the urban growth and applying the principles used for managing or enhancing biodiversity not only can be effective in increasing the quality of human life but also can have positive impact on natural life diversity in urban ecosystem. This section investigates the difficulties and challenges in enhancing the urban biodiversity from different points of view.

Nowadays, the words 'nature' and 'biodiversity' remained images of areas that are located far from the cities. For many people these areas are places that are unaffected by human impact. Therefore, when the concept of biodiversity is discussed in urban area, the idea of preserving and improving urban biodiversity is not familiar for them. The reason is that over the years as the urbanization expands, human being grows more and more distinct from the natural world. So, the wedge between people and nature is driven deeper. Miller research (2005) indicates that people spend most of their daily life for indoor activities. It is not applied just for adults but also it is a tendency for children to spend fewer hours outdoors as well.

The fact is that, the environment encountered during childhood becomes the baseline against which environmental degradation is measured later in life. Therefore, one of the fundamental solutions for preserving urban biodiversity is to bring people closer to the nature beginning from their childhood and give the opportunities for recognizing the natural values to preserve them in future (Figure 12).

In addition to these, there is still lack of environmental awareness. People do not understand the importance of the natural biodiversity of their region. For example, trees that are established in natural areas and buffers may be cut down by adjoining residents because of facing conflicted values such as the trees interfering with their "view" (Hostetler et al. 2011).

Raising the awareness of biodiversity is an important part of maximizing urban biodiversity conservation.



Figure 12. Creating natural areas inside the cities can be effective for bringing together urban residents and nature (photo from Brussels-Belgium taken by Aysel Uslu).

Furthermore, most of the time the urban residents don't perceive the attempts by planners and scientists to protect nature in urban environments (Breuste, 2004; Oliveira et al. 2011). Therefore, they don't participate in the implementation of the strategies for improving biodiversity. The major problems especially appear when the government and urban planning neglect the principle of urban biodiversity preservation and improvement in their urban planning and design strategies.

The other problem relating to preserving urban biodiversity is misperception the concept of natural areas that are protected inside the cities borders. Most of the people believe that these areas are squalid and unsafe regions for residents (Figure 13). Therefore they prefer these areas have particular design and form such as urban park. It is not a problem for residents but also most of the urban planners and municipalities officials have the same idea. Therefore, environmental education and defining the value of natural biodiversity is vital for straighten of this incorrect opinion.

Another problem related to human behavior, is that people do not know about the native species and they unconsciously influence the spread of non-native species. Urban ecosystem makes opportunities for growth and the replacement of native species with alien (non-native) species (McKinney 2002; Oliveira et al. 2011). Heightened air and surface temperature in urban areas comparing to surrounding areas create new habitat in urban ecosystem. Consequently, this modification in habitat type can make opportunities for non-native species to growth and disperse. Also it has a homogenizing effect on biodiversity as native habitats (McKinney and Lockwood 1999, McKinney 2002; Miller 2005). Urban-rural

gradient research in many cities emphasized that the number of native species decreases in central parts of cities, where the ratio of built spaces to green spaces and the proportion of impervious surfaces are high (Zerbe et al., 2003, McKinney, 2002; Oliveira et al. 2011). Also, most of the native species that remain in cities have tendency to be segregated from the neighborhoods where most of the human residential areas are located (Turner 2004; Miller 2005). In a research on the conservation value of clustered subdivisions, the result indicate that plant community within the open space was dominated by exotics because these areas did not have proper land stewardship to maintain native plant communities (Lenth et al. 2006; Hostetler et al. 2011).



(a)



(b)

Figure 13. Residents prefer the condition of photo (a) inside the cities. However, preserving the local biodiversity on (b) is more sustainable (photos taken by Aysel Uslu from Ankara-Turkey).

As a result, the increase in the number of non-native species in cities causes recognition of these species as native species by many people and shapes the people's view about native biodiversity incorrectly. Therefore, when the concept of preserving urban biodiversity is discussed, most of the people misunderstand this concept. For figure out such problems, considering the dynamic of urban ecosystem, the native species of every urban region must be identify and document, to prevent the unexpected result of non-native species distribution.

The other challenge relating to distribution of non-native species is hazards of invasion of aggressive species. In recent years, several Scientifics have discovered that increasing urbanization results in large proportion of existing plant species in urban areas being replaced by small number of wide spread and aggressive species. In some regions of the world, most of the invasive spices are non-native, which were first introduced into cities where they got established and naturalized, and spread. Thus, cities were the principle starting points from where many of these aggressive species spread (Muller et. al 2010).

Also it should be noted that many other factors can have unfavorable impact on native species. For example, storm water runoff can contain an excessive amount of nutrients, causing algal blooms in water bodies, fish kills, and the growth of invasive exotic plants. Therefore, urban planners must consider these hazards and manage them in such a way that the native species gets least vulnerability.

The other perception by urban resident related to biological diversity is the hazards of the illnesses causing by birds for human. Therefore most of the urban residents do not want to share their daily life environment with the birds or other animals. In these cases, urban inhabitant's behavior may influence the life of animals and birds adversely.

In addition to human behavior, biodiversity loss can be linked to the urban planning or lack of it. The fact is that, there is still a lack of proper instruments to deal with biodiversity at the city level.

Cities originally include natural areas with native flora and fauna. From the biological point of view these natural areas contain greater biodiversity than plantations (Mcdonnell, 1988; Gilbert, 1989; Florgard 2010). A critical problem relating these areas is that if the native vegetation lost, it can't be replaced by planting replacement species (Florgard 2010). However in most of the city planning strategies in developing countries this issue is ignored. As a result, fragmentation of the natural areas has occurred and causes the loss of native species.

Also, in most of the developing countries the need for housing put stress on surrounding ecology and cause unplanned and informal city plans. These plans have negative impacts on highly biodiversity ecosystems such as forests and mangroves. Rio de Janeiro is one of the top examples for this type of urban biodiversity loss. Research shows that the city lost a large part of its forests and mangroves due to the expansion of favelas (slums). Approximately 9% of the sandbank mangroves were lost during the last 3 years alone (Rocha et al., 2010; Oliveira et al.2011).

This situation in developed countries is not better than developing country. Suburban lifestyles by middle- and high-income groups in developed and developing countries caused the urban sprawl and suburbanization. Due to the increasing spread of suburban housing the rate of structural areas to the lands preserved as parks or conservation areas is accrued (Oliveira et al. 2011).

The reports of the Secretariat of the CBD (Convention on biological diversity) indicate that many of the fundamental threats to biodiversity loss in cities associated with public services and infrastructure planning and design policy that local government are responsible for these loss (SCBD, 2007; Savard et al 2000). Therefore, making the right decision in urban planning and design polices can preserve urban biodiversity as well as restoring the losses. Establishing extensive biotope and habitat mapping and protection programs will have positive impact on identifying important areas of wildlife habitat in and around cities and protecting and enhancing these areas. Also, coordination among different levels of government and among local governments for joint action is vital for getting better result. Furthermore, addressing the residential issues is vital for controlling the cities' ecological footprints. Also, polices of urban development must focus on compact urban forms and strong housing management to avoid the urban biodiversity losses.

Another issue must be underlined is that the process of urbanization influences habitats of species typical of open landscape adversely. Also, few local governments establish planning frameworks and implementation strategies through preserving urban biodiversity. For example, in central Europe, change in land use caused decrease in calcareous grassland belongs to the habitat types with the highest species richness (Joas et al. 2010). Therefore, maintaining high-quality natural areas in urbanizing regions or preserving natural areas containing high levels of biodiversity will require many municipal governments to change their perspectives and improve their urban planning according to the goals of urban biodiversity preservation and improvement.

Also, it must be highlighted that, planning open spaces and greenways are not luxury. However, they are the essential for preserving urban biodiversity and making connection between habitats with different species. Fortunately, in North America some local governments have begun to preserve and improve the urban biodiversity in their planning framework based in large part on Landscape Ecology's patch-corridor-matrix principles (Forman 1995; Connery 2009).

Finally, it must be emphasized that the researches and studies about urban biodiversity are still inadequate and limited. Generally, most of the studies analyses focus on only one or a few groups of species (e.g., Scott et al. 1993, Sisk et al. 1994; Ricketts and Imhoff 2003). Therefore, the authors evaluate data without considering the role of other species and the features of their habitat on the growth and distribution of the sample species. As a result the methods of preserving and improvement of the species community is not comprehensive and applicable. Also, many assessments include subjective information to measure threats to

biodiversity (Olson and Dinerstein 1998, Ricketts et al. 1999, Myers et al. 2000; Ricketts and Imhoff 2003). Thus, the results cannot be applied in the actual conditions.

However, urbanized areas function within a hierarchical decision system, managing is key concept for extending biodiversity. It must be highlighted that every nation is responsible for its own characteristic biotopes and species. Thus, the development plans of cities definitely affect biodiversity conservation and improvement. Therefore, for getting best result in conserving biological diversity; all issues related to urban biodiversity should be considered. Also, the importance of local biodiversity must be emphasized until then, with the cooperation of residents, scientific and governments, sustainable solution and plans will be emerged.

Biodiversity is not only an issue of the quantity of species and their habitats, but of the quality of areas and processes. This relates very much to the local scale because much of biodiversity's quality exists in its locality, referred to as in situ biodiversity. Biodiversity existing in its natural setting is considered most valuable, as opposed to specimens in zoos and botanical gardens. For instance, an assemblage of plants and animals that has occurred in an area for millennia may not have a comparatively high number of species, but may have special characteristics as an integrated system together. Targeting single species is nonetheless often an easier task for cities (Zitkovic 2008).

Finally, urban landscape design issues must have been considered ecological objective; protecting environment and our planet in contemporary world. It must be noted that the quality of landscape design must depend on the quality of green areas as a habitat. Urban green areas and landscape design should contain the subjects of landscape ecology knowledge which have been successfully implemented in reality.

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4. References

- Alberti, M., Marzluff, J. M., Shulenberger, E., Bradley, G., Ryan, C., Zumbrunnen, C., 2003. Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystems. *BioScience*, Vol. 53, No. 12 (Dec., 2003), pp. 1169-1179.
- Angold, P.G., Sadler, J.P, Hill, M.O., Pullin, A., Rushton, S., Austin, K., Small, E., Wood, B., Wadsworth, R., Sanderson, R., Thampson, K. 2006. Biodiversity in urban habitat patches. *Science of the Total Environment* 360 (2006) 196– 204.
- Barış, M.E. Shakouri, N. Zolnoun, S. (2012). Green roof: the suggestion project of Ankamall commercial building. *Journal of Tekirdag Agricultural Faculty* 2012 9(1) - 33-44.

- Beatley, T. 2000. Green urbanism learning from European cities. Island Press, 2000 - Business & Economics - 491 pages.
- Benedict, M. A. & Macmahon, E.T.2002. Green Infrastructure: Smart Conservation for the 21st Century, Renewable Resources Journal, Volume 20, Number3, Autumn 2002, Pages 12-17. Maryland, USA.
- Bolund, P. Hunhammar, S. 1999. Analysis Ecosystem services in urban areas. Ecological Economics 29 (1999) 293–301.
- Colding, J. 2007. Ecological land-use complementation' for building resilience in urban ecosystems. Landscape and Urban Planning 81 (2007) 46–55.
- Connery, K. (2009) Biodiversity and Urban Design: Seeking an Integrated Solution. Journal of Green Building: Spring 2009, Vol. 4, No. 2, pp. 23-38.
- Cook, E. D. 2002. Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning 58 (2002) 269–280. doi: <http://dx.doi.org/10.3992/jgb.4.2.23>.
- Dunnett, N. Swanwick, C. and Wooley, H.2002 Improving Urban Parks, Play Areas and Open Spaces, Urban Research Report, DTLR,, May 2002.
- European Communities, 2008. The European Union's Biodiversity Action Plan. "Halting The Loss of Biodiversity by 2010 and Beyond" <http://www.europea.eu>.
- Florgard, C. 2010. Integration of natural vegetation in urban design- information, personal determination and commitment. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd.
- Flores, A. Pickett, A. Zipperer, S. Pouyat, W. Pirani, R. 1998. Adopting a modern ecological view of the metropolitan landscape: the case of a greenspace system for the New York City region. Landscape and Urban Planning 39-1998. 295–308.
- Francis R. A. 2010. Wall ecology: A frontier for urban biodiversity and ecological engineering, *Progress in Physical Geography* 2011 35: 43 originally published online 18 November 2010. <http://ppg.sagepub.com/content/35/1/43>.
- Goddard, M.A. Dougill A.J. Benton, T.G. 2009. Scaling up from gardens: biodiversity conservation in urban environments. Trends in Ecology and Evolution Vol.25 No.2
- Haase, D. & Schetke S. 2010. Potential of biodiversity and recreation in shrinking cities: contextualization and operationalization. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd.
- Hagen, K. Stiles, R. 2010. Contribution of landscape design to changing urban climate conditions. . *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd.
- Hostetler, M., Allen, W., Meurk, C. 2011. Conserving urban biodiversity Creating green infrastructure is only the first step. Landscape and Urban Planning (2011), doi:10.1016/j.landurbplan.2011.01.011.
- ICLEI. 2008. Partnerships & networks for urban biodiversity. Local and regional Authorities for biodiversity 2010.

- Ignatieva, M. Design and Future of Urban Biodiversity. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd. 118-144.
- Joas, Ch. Gnadinger, J. Wiesinger, K. Haase, R. Kiehl, K. 2010. Restoration and design of calcareous grasslands in urban and suburban area: examples from the Munich plain. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd.
- Kendle, T . 1997. Urban Nature Conservation: Landscape Management in the Urban Countryside, E and F Spon.
- Kohsaka, R. 2010. Economics and the convention on biodiversity: financial incentives for encouraging biodiversity in Nagoya. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd.
- Mcdonald, R. Kareiva, P. Forman, R.T.T. 2008. The implications of current and future urbanization for global protected areas and biodiversity conservation, *Biological conservation* 141.
- Miller, J. R. 2005. Biodiversity conservation and the extinction of experience, *TRENDS in Ecology and Evolution* Vol.20 No.8 August 2005.
- Muller N., Werner p., Kelcey J.G. 2010. *Urban Biodiversity and Design*. John Wiley & Sons, Mar 5, 2010 - 648 pages.
- Muller. N. 2007. Distinctive characteristics of urban biodiversity. *Cities and Biodiversity: Achieving the 2010 Biodiversity Target* . Curitiba, 26. – 28. March 2007.
- Müller, N. Most Frequently Occurring Vascular Plants and the Role of Non-native Species in Urban Areas – a Comparison of Selected Cities in the Old and the New World. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd. 227-242.
- Niemela, J.1999. Ecology and urban planning. *Biodiversity and Conservation* 8: 119±131, Kluwer Academic Publishers. Printed in the Netherlands. 1999.
- Oliveira, J.A., Balaban, O., Doll, C.N.H., Peñaranda, R. M., Gasparatos, A., Iossifova, D., Suwa, A. 2011. Cities and biodiversity: Perspectives and governance challenges for implementing the convention on biological diversity (CBD) at the city level. *Biological Conservation* 144 (2011) 1302–1313.
- Opdam, P. 2002. Assessing the Conservation Potential of Habitat Networks, in gutzwiller, K.J., (ed). *Applying Landscape Ecology in Biological Conservation*, Springer(2002), p.381.
- Qureshi, S. & Breuste, Jurgen H. 2010. Prospects of biodiversity in mega city of Karachi, Pakistan: potentials, Constraints and implications. *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd.
- Ricketts, T. and M. Imhoff. 2003. Biodiversity, urban areas, and agriculture: locating priority ecoregions for conservation. *Conservation Ecology* 8(2): 1. [online] URL: <http://www.consecol.org/vol8/iss2/art1>.

- Savard, L. Clergeaub, Ph., Mennechez, G., 2000. Biodiversity concepts and urban ecosystems. *Landscape and Urban Planning* 48 (2000) 131±142.
- Schaefer, V. 2003. Green Links and Urban Biodiversity – an Experiment in Connectivity 2003 Georgia Basin/Puget Sound Research Conference.
http://planet.botany.uwc.ac.za/nisl/Conservation%20Biology/Conservation_CCT/2c_schae.pdf.
- Town and Country Planning Association, 2004. Biodiversity by Design: A guide for sustainable communities. http://www.tcpa.org.uk/data/files/bd_biodiversity.pdf
- Tratalos, J., Fuller, R.A., Warren, Ph. H., Davies R.G., Gaston, K.J. 2007. Urban form, biodiversity potential and ecosystem services. *Landscape and Urban Planning* 83 (2007)
- Vergnes, A., Le Viol, I., Clergeau, P. (2012) Green corridors in urban landscapes affect the arthropod communities of domestic gardens. *Biological Conservation*. 145: 171–178. Doi:10.1016/j.biocon.2011.11.002.
- Yang, F. S., Freedman, B., Cote, R. 2004. Principles and practice of ecological design. *Environ. Rev.* Vol. 12, 2004. NRC Canada.
- Werner, P. Zahner, R. Urban Patterns and Biological Diversity: A Review, *Urban biodiversity and design* 1st edition. Edited by N. Muller, P. Warner and John G. Kelcey. ©2010 Blackwell Publishing Ltd. 37-55 145-176.
- Zitkovic, M. 2008. Managing green spaces for urban biodiversity. Local and regional Authorities for biodiversity 2010.
http://www.countdown2010.net/2010/wp-content/uploads/FS7Greenspace_small.PDF.