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TOWARDS URBAN BIODIVERSITY: SIMULATING DESIGN PARAMETERS FOR WILDLIFE-INCLUSIVE GREEN INFRASTRCUTURE

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Urban Biodiversity, Wildlife-inclusive, Green Infrastructure, Shouf Biosphere Reserve

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TOWARDS URBAN BIODIVERSITY: SIMULATING DESIGN PARAMETERS FOR WILDLIFE-INCLUSIVE GREEN INFRASTRCUTURE

Abstract

As of 2021, more than half of the global population resides in urban areas. This resulted in an overwhelming footprint affecting species habitat areas leading to biodiversity loss. By definition, urban biodiversity is the diversity of living things within the urban realm. By providing chances for habitat as part of new developments, preserving on-site habitats, and attempting to connect with the local ecosystems, we can help promote biodiversity. Green infrastructure (GI), which includes all semi-natural areas in the urban context, can serve as a vessel for biodiversity. Therefore, the problem can be defined by the urban footprint that expands on the expense of native habitats, leading directly to biodiversity loss and impacts on human health, and indirectly affecting livelihoods. Moreover, often times the approaches are sometimes limited to 'green' in more aesthetic ways than operational. It is also important to seek socio-ecological frameworks to promote adequate interaction of urban communities with wildlife. Therefore, this research aims to simulate design parameters for wildlife-inclusive green infrastructure to contribute to the creation of built environments that support urban biodiversity. If equipped with a socio-ecological framework, beyond 'green' results can be yielded. Using a case study method, the author will provide an application of the extracted parameters from the literature on a chosen geography with reference of ecological data provided of the 'Shouf Biosphere Reserve' of Lebanon to provide supported insight into wildlife-inclusive green infrastructure examples. In the context of this literature, we need to examine the manifestation of those concepts mainly on an operative level with respect to ecology. Also, it is required to examine the socio-cultural aspects of this interaction through architecture. In conclusion, as presented in the case study of SBR, the additional ecological and socio-cultural layers in planning of green infrastructure, can yield beyond 'green' results as a whole system designed with both the local ecosystems and urban inhabitants in mind within the landscape. Each geography will display its endemic version of 'green' as well. Variations of wildlife species can become parameters that also help shape our built environments. 'Our' built environment exists in the larger scope of the natural setting. Nature-based solutions can be implemented for our urban problems. A geographically specific GI network can provide alternative infrastructure for local ecosystems. Therefore, with increasing repercussions of urban expansion on habitat areas, immediate action plans must be formulated to stop species loss.

Keywords

Urban Biodiversity, Wildlife-inclusive, Green Infrastructure, Shouf Biosphere Reserve

1. INTRODUCTION

For its intrinsic natural worth and advantages to human health and well-being, biodiversity should be preserved. A greater awareness of these health advantages might increase public support for conservation. We keep learning more about how much humans depend on the natural environment and biodiversity for their well-being (Buttke,2018).Evidence-based ecological planning is crucial in creating and reconstructing healthy, thriving cities for the future due to the continued threat of new diseases and the growth of urban-wildlife interactions (WBG, 2021). As of 2021, more than half of the global population resides in urban areas (UN,2021). Urbanization activities have resulted in an overwhelming footprint that is often on the expense of the natural world. However, if a proper ecological planning framework is applied, biodiversity loss can be mitigated through creating alternative habitat opppurtunities within green infrastructure networks.

For the purpose of extracting parameters for wildlife-inclusive green infrastructure, an investigation into framework that operate on a scoio-ecological level is required. Using a case study method, the author will provide an application of the extracted wildlife-inclusive design parameters on a chosen geography with reference of ecological data provided of the Shouf Biosphere Reserve of Lebanon to provide an evidence based and ecologically supported insight into wildlife-inclusive green infrastructure.

1.1 Research Approach

As cities have entered lockdown during the COVID pandemic, many wild creatures have ventured to explore the urban realms (as shown in Fig.1). This occurrence has shed light on the various wildlife that resides near urban areas. By definition, urban biodiversity is the diversity of living things within the urban realm. By providing chances for habitat as part of new developments, preserving on-site habitats, and attempting to connect with the local ecosystems, we can help promote biodiversity.

Green infrastructure(GI), which includes all semi-natural areas in urban cities, can serve as a vessel for biodiversity. By creating wildlife-inclusive GI networks, alternative infrastructure for local ecosystems can be provided. However, the design of green infrastructure must not be limited to the 'green' aspect only. It is important to investigate approaches that include both whole natural ecosystems and the urban inhabitants.

Fig.1: Wildlife roaming streets amid lockdown in Wales. Source: The Guardian.com, Apr 2020

1.2 Problem Definition

It is anticipated that biodiversity will decline dramatically over the coming decades for the first time since the last extinction event. One of the main causes of this decline is the quick increase in urban human populations and their intensive use of resources often on areas with a lot of biodiversity (Elmqvist et al. 2013). Ecological variations such as climate change and habitat loss are caused by inadequate human activity (IPBES,2020). The rapid loss of natural habitats is linked to significant zoonotic disease outbreaks (UNDP,2020). As host populations for (disease) populations lose their habitats, hosts for those populations become less readily available, which encourages illnesses to spread to other species (As shown in Fig.2).

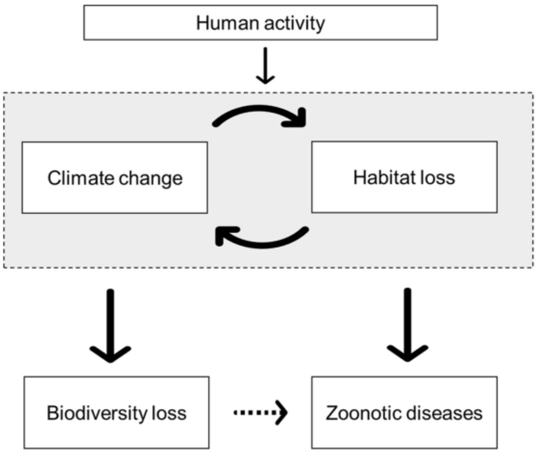

Fig.2: Risks associated with biodiversity loss Source: cambridge.org, May 2022

From findings published in Nature Communications in 2020, it is stated that this imbalance is expected to drive to an expected loss up to 23% of all natural habitat ranges (As shown in Fig.3). Habitat loss could accelerate the extinction of already vulnerable species. According to WHO, biodiversity loss can have a significant direct human health impacts if ecosystems services are no longer balanced. Indirectly, those changes can affect livelihoods, income, local migration, and on occasion cause political conflict (WHO,2015). *Therefore, the problem can be defined by the urban footprint that expands on the expense of native natural ecosystems and habitats, leading directly to biodiversity loss and impacts on human health, and indirectly affecting livelihoods.* Moreover, even in attempts of sustainability, often times the approaches are sometimes limited to 'green' in more aesthetic ways than operational. Green infrastructure such as green walls and green roofs in many cases are not planned in accordance with the local ecosystems, and as a result don't often contribute to the promotion of biodiversity or alternative habitat. Moreover, the limit of proper interactions of urban communities with wildlife and awareness to it stunts any efforts aimed at creating green infrastructure that includes local species in its design.

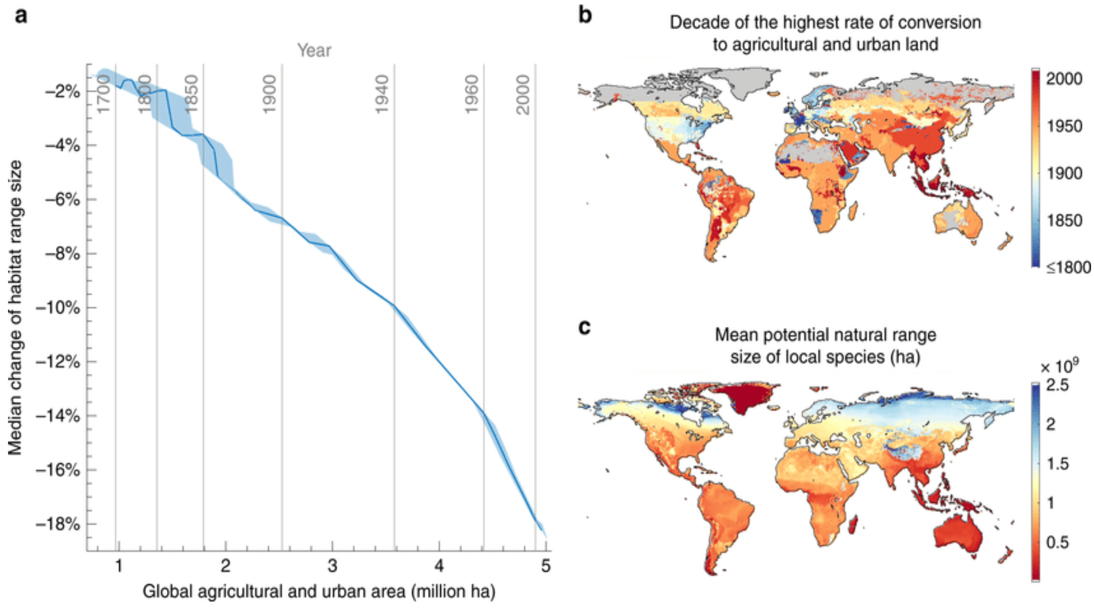

Fig.3: Acceleration of the Marginal Impact of Land use on Species' Range Sizes.
Source: Historical and projected future range sizes of the world's mammals, birds, and amphibians, Research Gate.net, Nov 2020

1.3 Aim of Research

If a proper socio-ecological framework is applied, green infrastructure can allow urban cities to become integral with the surrounding natural environment. Finding non-anthropocentric approaches that are beyond the concept of 'green' is required. It is also important to seek parallels between nature and culture to promote adequate interaction of urban communities with wildlife. *Therefore, this research aims to simulate design parameters for wildlife-inclusive green infrastructure to contribute to the creation of ecosystem based built environments that support urban biodiversity.*

1.4 Objectives

This research aims to contribute to urban biodiversity principles and the objectives for the study are as following:

a. To contribute to non-anthropocentric and multispecies design approaches.
b. To contribute to both socio-ecological sustainability in the built environment.

1.5 Hypothesis

This research aims to extract design parameters that promote biodiversity in urban areas. *If equipped with an evidence-based ecological and socio-cultural framework, beyond 'green' results can be yielded.* By using the case study method, the author will perform an application of the concluded parameters on a specific geography with reference to ecological reports on biodiversity indicators of the area of Shouf Biosphere Reserve, Lebanon.

2. LITERATURE REVIEW

The detrimental effects of urbanization on biodiversity can be mitigated through wildlife-inclusive approaches for urban growth, management of protected areas nearby urban settings, integration of habitat for biodiversity, and adoption of nature-based solutions to urban problems (The Nature Conservancy, 2018).

2.1 Urban Biodiversity: Definitions

Different types and concentrations of biodiversity can reside in various urban natural areas. *Urban biodiversity* is the diversity of living things, including their genetic variants, and the range of ecosystems found in and around densely populated areas (MAMROT, 2013). *Urban nature* includes all forms of life found in a city, such as gardens, green roofs, street trees, birds, and butterflies, as well as large, sometimes untamed green and blue spaces (Turini et al., 2015).

Referencing the World Bank Group Policy brief (Urban Nature and Biodiversity for Cities), here are some general definitions of the spectrum urban biodiversity.

a. **Ecological Planning:** An approach to design that considers biodiversity and the natural world. Such Planning in urban settings considers people, nature, and biodiversity. It involves nature-based approaches to urban issues, the merging of "gray" and "green" approaches to build sustainable cities. (Steiner et al. 1988).
b. **Green Spaces:** Comparatively large areas covered in vegetation; in urban areas, such as parks, botanical gardens, or zoos cemeteries, community gardens, allotment sites and golf facilities.
c. **Blue Spaces:** Spaces that have surface water such as marshes, lakes, rivers, or seaside beaches or cliffs (Nutsford et al. 2016).
d. **Green Infrastructure:** Semi-natural elements incorporated into urban planning that meet practical needs of cities and the natural environment, such as cooling, noise reduction, and flood protection (Fairbrass et al. 2017).

2.2 Green Infrastructure

According to the European Environment Agency (EEA), green infrastructure (GI) can be defined by a network of (semi-)natural places that are conserved and improved to provide ecological services, as well as benefiting biodiversity and society at large. *GI is made up of a variety of environmental elements that function at various scales and are connected by an ecological network. These characteristics need to serve multiple purposes; they can't just be "green spaces".* Moreover, it includes both green and blue spaces. It can also be a part of a hybrid strategy that combines grey and green infrastructure to produce resilient solutions. Such interventions can be implemented at micro and macro of the built environment, from the smallest scale (e.g., green building facades or roofs, green sidewalks, streets, or green courtyards), to city-scale (parks, urban woods), or macro scale (e.g. green hubs and corridors). The EU 2020 Biodiversity Strategy focuses on the primary causes of biodiversity loss. Particularly, it emphasizes implementing *green infrastructure into spatial design to preserve and improve ecosystem services and restore degraded ecosystems*.

GI elements as shown in Fig.4 are as following:

1. *Protected Areas:* Core locations with a high significance for biodiversity, notably protected areas of habitat like Natura 2000 sites.

2. *Ecosystems Areas:* Large, functional ecosystems are present in core areas outside of protected zones.
3. *Wildlife Corridors:* Watercourses, ponds, hedgerows, and woodland strips are examples of natural features that serve as wildlife corridors or stepping stones.
4. *Restored habitats:* such as a reed beds or wildflower meadows, can assist in reuniting or enhancing existing natural regions.
5. *Artificial elements* (Grey and Green Elements): including eco-ducts, eco-bridges, fish ladders, and green roofs and walls that improve ecosystem services or facilitate wildlife mobility.
6. *Buffer zones:* Spaces that are properly maintained and green, for example through wildlife-friendly farming, contribute to enhance the overall ecological quality and permeability of the terrain to biodiversity.
7. *Multifunctional Agriculture:* Which includes agricultural production and environment with services to society.
8. *Multifunctional zones:* Zones with multiple uses that can work together to manage several land uses in the same space, such as areas where agriculture and social activities can coexist to create nature and culture parallels.

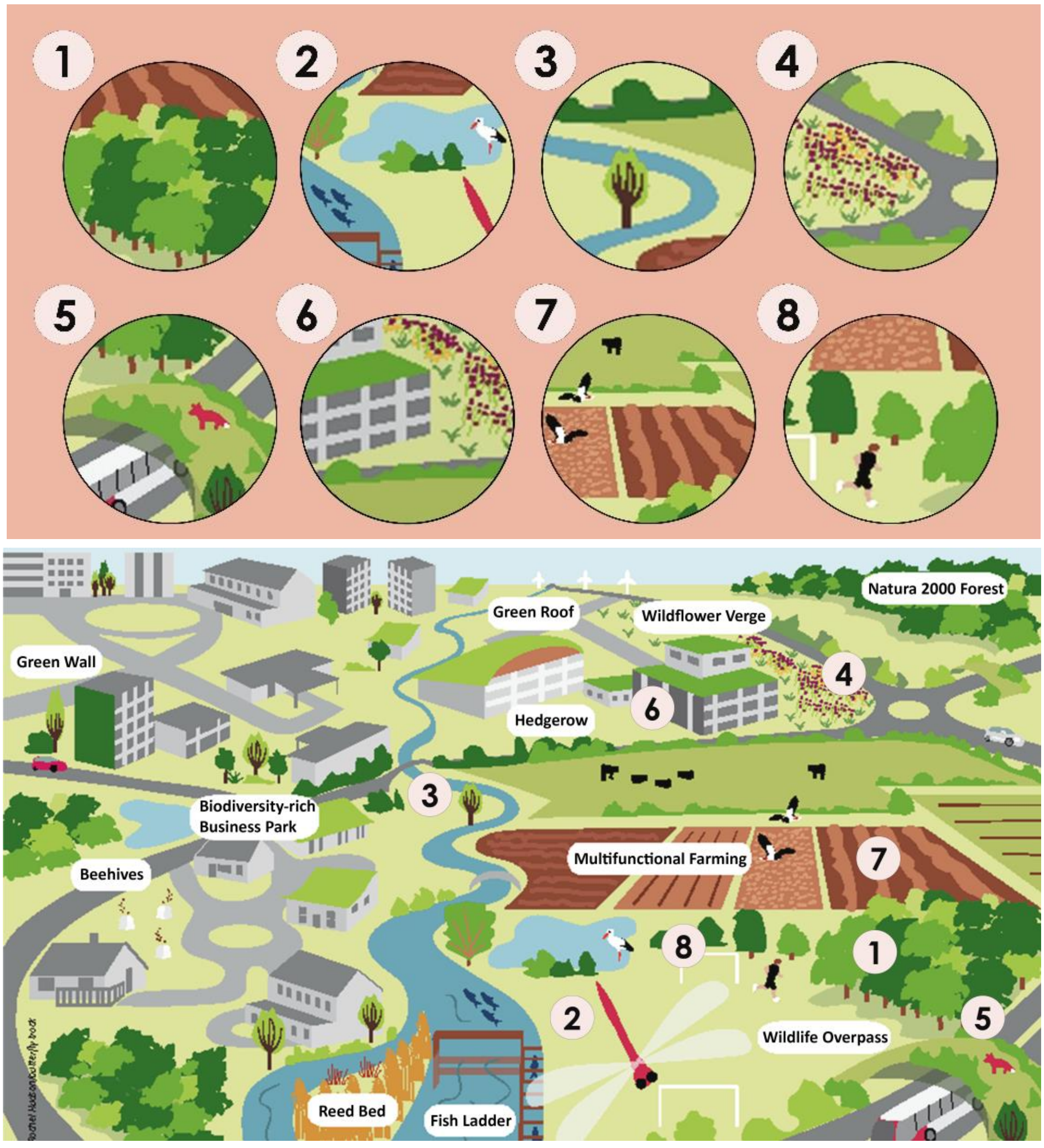

Fig.4: Examples of green infrastructure across an urban-rural landscape
Source: European Environmental Agency (EEA) (Edited by Author), 2013

2.3 Ecosystem Services and Socio-Ecological Systems:

Ecosystem services (ES) are the advantages that come from nature, and their worth reflects how much an ecosystem contributes to the objectives of a community. In other words, ES relates to advantages to human well-being brought about by a combination of social and natural capital (As shown in Fig. 5). In order to not stunt the efforts aimed at creating green infrastructure that includes wildlife in its design, it is essential to also follow a socio-ecological framework as well (E. Honeck et al.,2020). Moreover, if not managed properly urban features could negatively affect wildlife (As shown in Fig. 6).

a. **Ecosystem Advantages:** The advantages that humans derive from nature, such as food production, flood protection, climate stability, soil fertility etc. (Guerry et al. 2017).
b. **Ecosystem Disadvantages:** the adverse effects of nature on humans, including allergic reactions to pollen, poorer air quality caused by plant emissions, and disease transmission by some species. (von Döhren Et al.,2015).

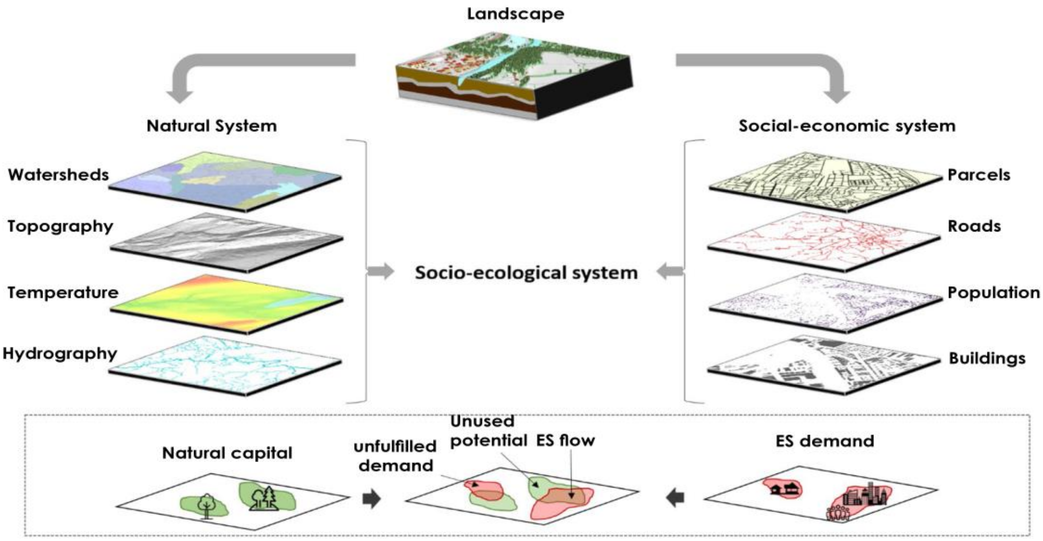

Fig.5: Illustration of socio-ecological systems
Source: Methods for Identifying Green Infrastructure, 2020

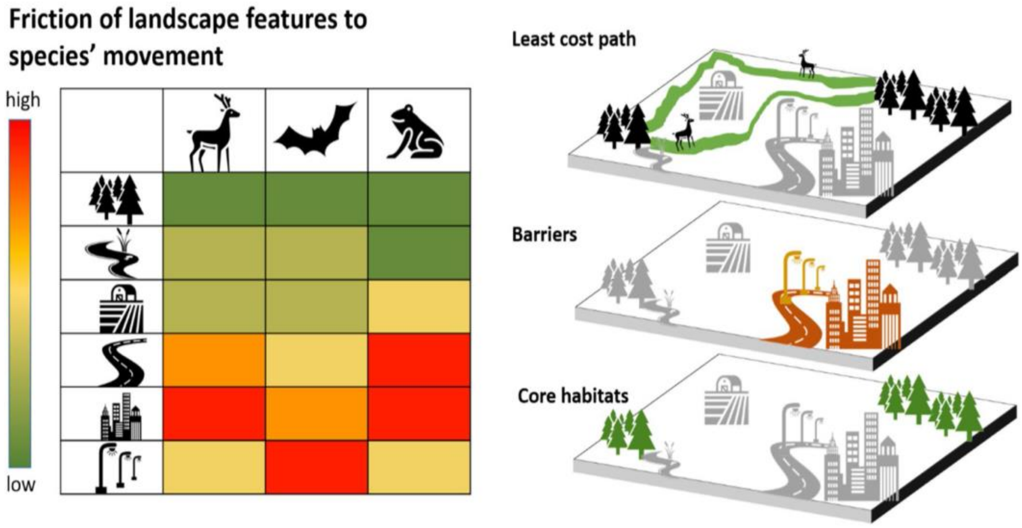

Fig.6: Friction of Landscape features to species' movement.
Source: Methods for Identifying Green Infrastructure, 2020

Even the smallest areas such as sidewalks, landscape features, and back and front yards could become an integral part of a larger whole system. An example given by *Designing Ecologically Sensitive Green Infrastructure that Serves People and Nature* includes lanes that were changed into a linear bioswale (Storm water runoff), with trees and a diverse perennial meadow. Given the area's frequent use, a variety of native, non-native, and decorative plants were used in the plantings to ensure a lengthy flowering time for people, insects, and birds (As shown in Fig.7).

Fig.7: Examples of green infrastructure across an urban-rural landscape
Source: TNOC, 2018

a. Urban-Wildlife Interactions in the Urban Environment

Throughout all of the existence of the human species, interactions with other species has been an occurrence. Many of these contacts fall under the category of "poor" interactions. For instance, few individuals enjoy rats or cockroaches. On the other hand, other contacts are "excellent" in the sense that people at the very least appreciate them. Also the way an interaction is perceived can change in particular circumstances. Urban cats, which are prized as pets but are also frequently regarded as pests when wild (Perry et al,2020). If not managed properly, urban wildlife can be problematic in the following forms:

- Damage to property, food supplies, waste, litter.
- Animal-automobile collisions.
- Noise or odour nuisances.
- Physical threats presented by carnivores.
- Disease Transmission.

However, as habitat areas are lost to urbanization activities species populations are affected. Some decrease in the given area, and others develop unhealthy urban adaptations. Moreover, these adaptions lead to a dominant monoculture. In many cases, the dominant species becomes a pest in an urban environment. The issue lies in the increasing populations that as consequence of lack of space, take refuge in areas that provide unsanitary conditions such as sewage, encouraging spread of disease. Habitat areas should be protected or repaired whenever possible to provide habitat for specific species. This would stop urban monoculture from engulfing the environment (McCurley, 2001). On the other hand, some cities such as Istanbul in Turkey, have one of the lowest levels of rodent pest populations in the world. This is a result of the incorporation of the feline species into the built environment by providing suitable habitat conditions and policies as well as encouraging a socio-cultural advocacy. The city hosts up to hundreds of thousands of cats. If a proper framework is followed, we can equip nature-based solutions to urban problems. However, it is vital to formulate a framework that functions on an eco-system level to prevent urban wildlife monoculture in any case.

2.4 Similar Examples

For the simulation of a wildlife-inclusive design parameters for green infrastructure in the context of this literature, we need to examine the manifestation of those concepts mainly on an operative level with respect to ecology (First similar example). Also, it is required to examine parallels between nature and culture to address the socio-cultural aspects of this interaction through architecture (Second similar example). For the scope of this paper, the nature-culture parallels are limited to serving preservation needs and awareness to urban biodiversity.

A. First Similar Example: Animal Aided Design in the Living Environment (Ecological Framework)

In Germany, there are 59 different species of mammals, 180 different breeding bird species, and more than 17,000 different insect species in Berlin. This richness of wildlife is due to a variety of factors. Animal Aided Design (AAD) focuses on the requirements of certain species and seeks to incorporate these requirements into landscape architecture and urban design planning to make it possible for fresh perspectives on and encounters with urban nature.

a. Target Species Selection and Life Cycle

Therefore, to prevent subsequent rejection, it is important to take into account and balance both biological and behavioural aspects (As shown in Fig. 9) when choosing target species for AAD. Therefore, the following factors should be considered when choosing species:

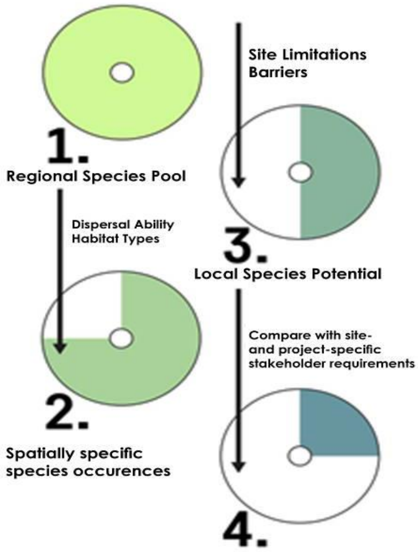

Fig.8: The AAD Process Diagram
Source: The Animal Aided Design Method (AAD), 2018

- The ecological traits of the species, which reveal the essential conditions that must be met in order for it to survive at the project site.
- Species occurrences in the city as well as potential impediments to dispersal; socio-cultural factors that reflect preferences for or aversions toward particular species or groups of species.

The target species lifecycle is summarized as following:

Breeding and raising of young: The innermost circle depicts the stage of the life cycle during which the individual species' animals give birth or lay their eggs, and, if relevant, when the young are nurtured. The approximate start of this initial stage in the species' life cycle is shown by the hand of the "clock" as shown in Fig 9.

Adults: The period during which the species goes through its adult life cycle is depicted by the second circle. This loop is complete for organisms that go through multiple life cycles.

Overwintering: The third circle depicts the phase of a species' life cycle during which it adapts its behaviour to survive the winter. This may occur, for instance, through migration to warmer places or dormancy or hibernation.

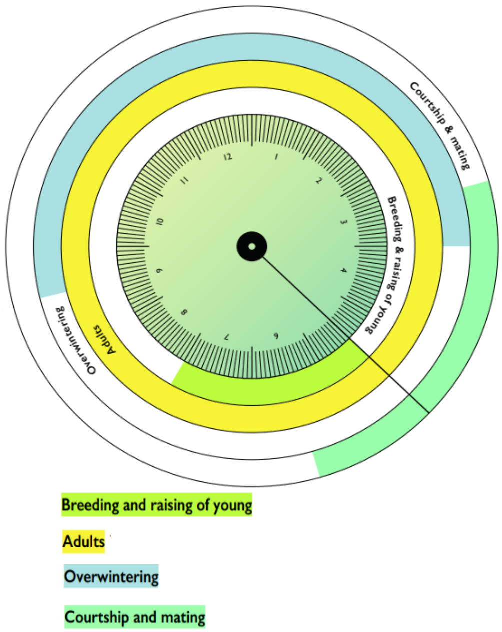

Fig.9: Species Life cycle clock
Source: The Animal Aided Design Method (AAD), 2018

Courtship and Mating: The outermost circle depicts the time frame during which the species locates a mate and reproduces.

b. Species specific design for European Hedgehog (Application)

The installation of hedgehog units (As shown in Fig.14,15,16) was supposed to coincide with the refurbishment of the façade, which has now been done, however it was finished while the study was still being conducted. House sparrow nesting supports could be fixed to balconies or already-installed climbing aids (cable systems). To make the large green roofs of the bicycle shelters more beneficial to house sparrows and red admirals, grasses and herbs might be grown on them (As shown in Fig.10).

Fig.10: Case Study Application 3d View
Source: The Animal Aided Design Method (AAD), 2018

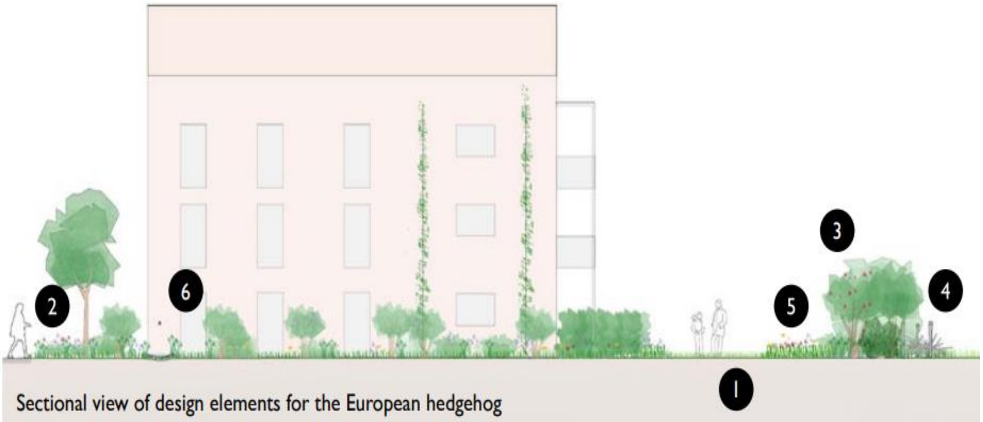

Fig.11: Wild Life Considerations and Zoning-Sectional View
Source: The Animal Aided Design Method (AAD), 2018

Another choice would be to plant wildflower strips at the margins of the open spaces and less often mowed meadow regions to attract insects, which are the main component of the hedgehog's diet. It is also important to consider circulation pathways as shown in Fig.12.

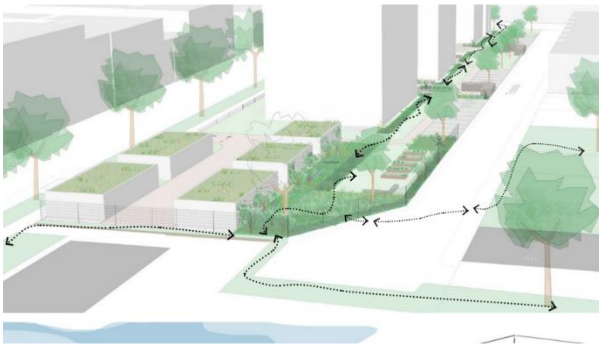

Fig.12: Wild Life Considerations and Zoning-Pathways
Source: The Animal Aided Design Method (AAD), 2018

Challenges: The open spaces were previously managed in an environmentally responsible manner. The open regions previously featured many hurdles for the hedgehog, as rabbit wire was employed to keep rabbits out of many cultivated areas. The project could serve as an example because the open areas and structures are close to other housing complexes. By implementing ecological land cover and land management strategies, habitat areas could be ensured (As shown in Fig. 13)

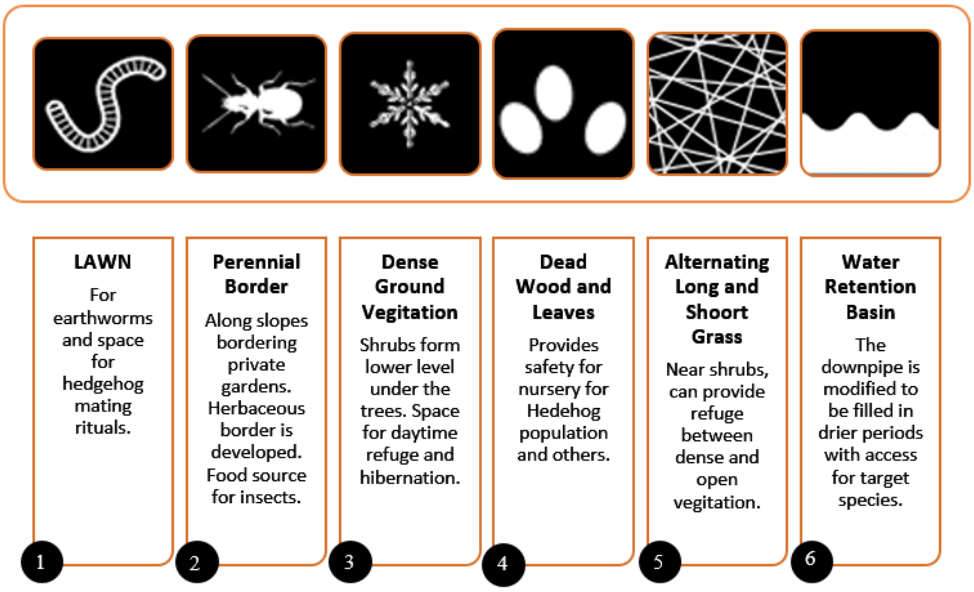

Fig.13: Wildlife-inclusive Vegetation and Landcover
Source: The Animal Aided Design Method (AAD), 2018

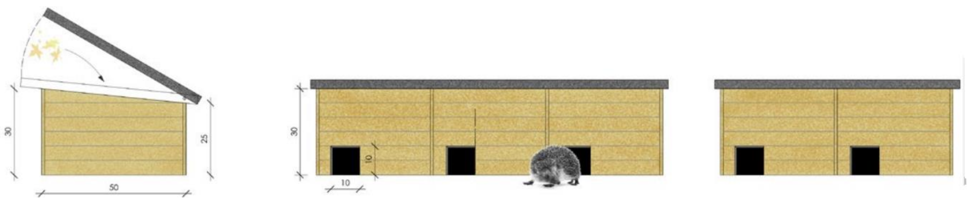

Fig.14: Artificial Hedge Hog Hole Units
Source: The Animal Aided Design Method (AAD), 2018

Fig.15: Artificial Winter Nesting Areas for Hedgehog
Source: The Animal Aided Design Method (AAD),2018

Fig.16: Artificial Summer Nesting Areas for Hedgehog
Source: The Animal Aided Design Method (AAD),2018

B. Second Similar Example: Alusta Pavilion and Insect Hotel (Nature and Culture Parallels)

From June 2022 to October 2023, the Alusta pavilion, which is housed in the courtyard of the Design museum and the Museum of Finnish Architecture in Helsinki, will serve as a *venue for interspecies interactions and insect hotel*. Previously a parking lot, the research pavilion looks into how nature and culture are connected and looks into solutions to preserve biodiversity in urban settings. On the level of its materiality and multisensory experience as well as the various activities that take place there, *the pavilion serves as a forum for environmental conversation.*

Together with ecologists, the needs of the many pollinating insects, including bees, bumble bees, and butterflies, were determined. Perennial plants that are good for pollinators and rotting wood provide food and shelter for insects (As shown in Fig. 17).

In addition to providing outdoor spaces for humans, the porous clay constructions also provide non-human users habitat. The biochar components and clay plaster that has been combined represent novel material research possibilities and add to the aesthetic texture of the space. The plants will relocate in their planting containers to another location post relocation for continued replanting. The burnt components will be utilised in another structure, while the raw clay will be returned to the earth. The pavilion is seen as a process that is constantly evolving rather than as a physical thing with distinct boundaries in space and time. *Borders blur and become porous, and architecture tends to bind rather than divide.* Via courses on constructing with clay, planting, and bokashi composting, the pavilion's human users have been allowed to participate in its construction. There will be 23 different types of programs offered there in the summer of 2022, including nest-building clay workshops for families with young children, summer schools for high school students on sustainable architecture, lectures and roundtable discussions for design professionals, and free cultural events like media-art screenings and poetry workshops.

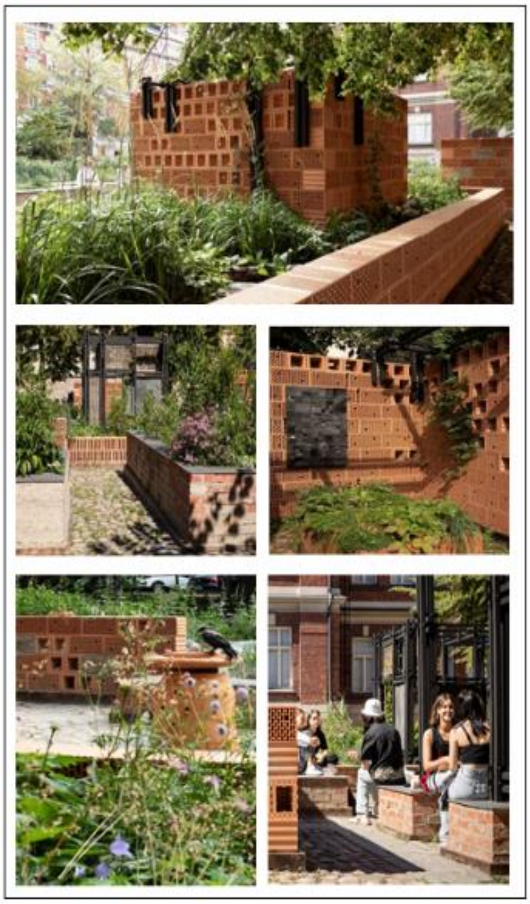

Fig.17: Gallery of Photographs from the Pavilion from Top to Bottom: Pavilion Structure, wildlife hardscape
Source: Archdaily.com, 2022

2.5 Design Parameters for Wildlife-inclusive Green Infrastructure:

According to all the previous literature review, the design parameters are as follows:

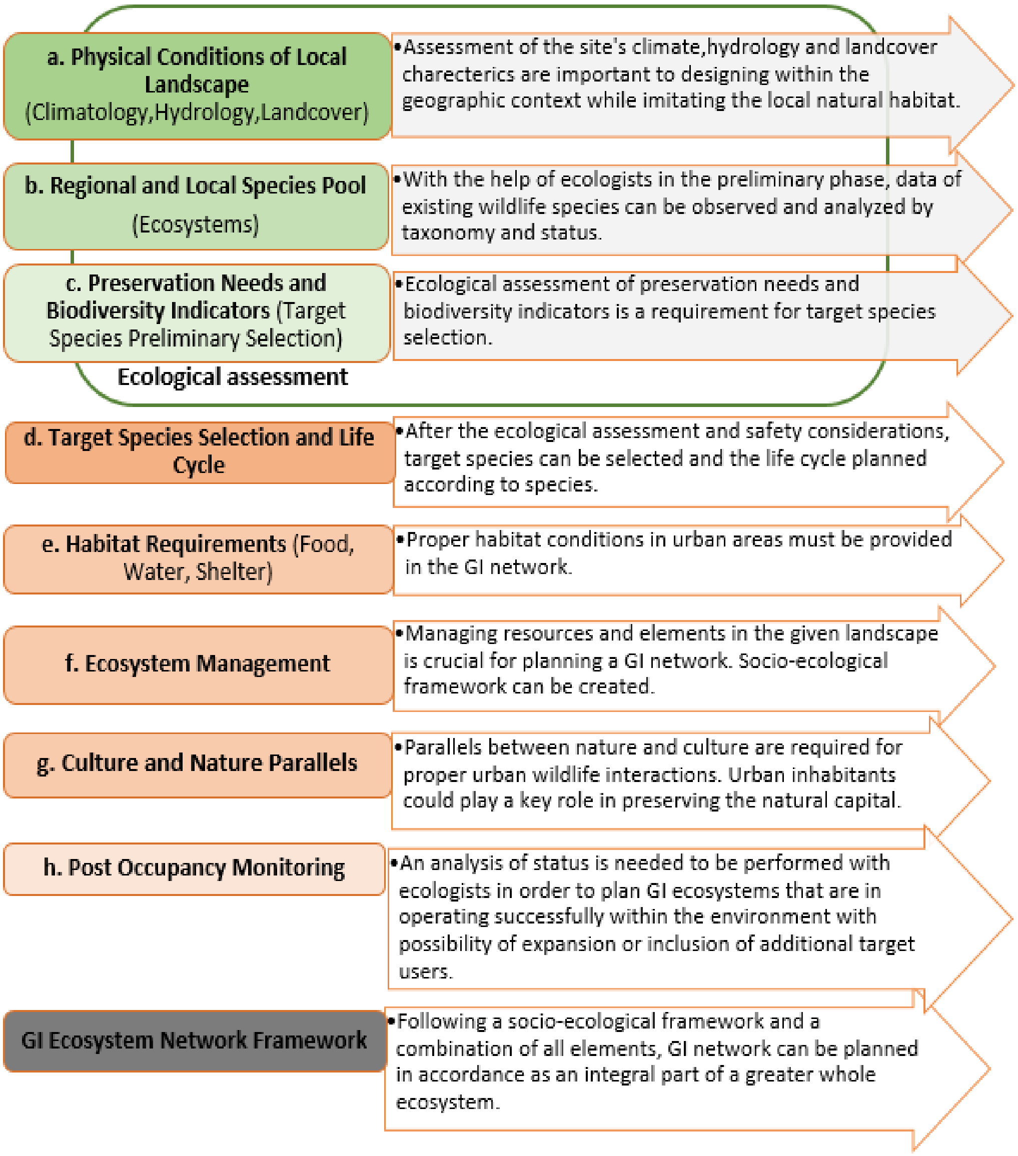

Fig.17: Proposed Design Parameters for Wildlife-inclusive Green Infrastructure
Source: Edited by author, 2023

3. METHODOLOGY

In this paper, three types of research methodology were used. The first method is the *inductive method*, which consists of a gathering and presenting of the ecological data of the chosen case study of 'Shouf Biosphere Reserve' in Lebanon. The second method, *analytical method* will include an application and analysis of the extracted parameters, with reference to given ecological data in order to link the theoretical aspect to specific geographies. Finally, in the *deductive method*, as a combination of all methods and extracting conclusions for a GI network framework for landscapes similar to SBR. Those three mentioned methods are presented in the paper as follows.

3.1 Introduction of the Case Study of 'Shouf Biosphere Reserve' in Lebanon.

The SBR landscape is a 550 km2 mountainous area is distinguished by a gradient of ecological, geomorphological, and climatic qualities that support a variety of rural inhabitants, wildlife species, and ecosystems that have coexisted for millennia. It is proposed to apply the extracted wildlife-inclusive design parameters to an area surrounding the SBR. The application will give insight into a green infrastructure network that is an integral part of a bigger natural ecosystem.

Fig.18: Shouf Biosphere
Source: The Mountains Magazine

UNESCO designated the Shouf Cedar Nature Reserve, which covers over 50,000 hectares, or 5% of Lebanon's total land area, as a "Biosphere Reserve" in July 2005 (UNESCO,2015). The region offers a full range of *ecological services*, including a wild genes pool, freshwater storage, climate mitigation, hydro-geologic balance, and aesthetic/leisure value. It also has some of the tallest mountains in the Middle East. It is home to the largest stands of Lebanese Cedars, one of the most iconic trees in the world, as well as a diverse array of medicinal plants with significant economic potential. There are 520 types of plants there, including 48 indigenous to Lebanon and 25 species that are threatened both domestically and globally. Various wildlife has a good potential for restoration. It is ideally situated at a crossroads for bird migration, with access to Europe, Africa, and West Asia. There are over 250 bird species listed in the Biosphere Reserve, and the Ammiq wetland is home to many of them.

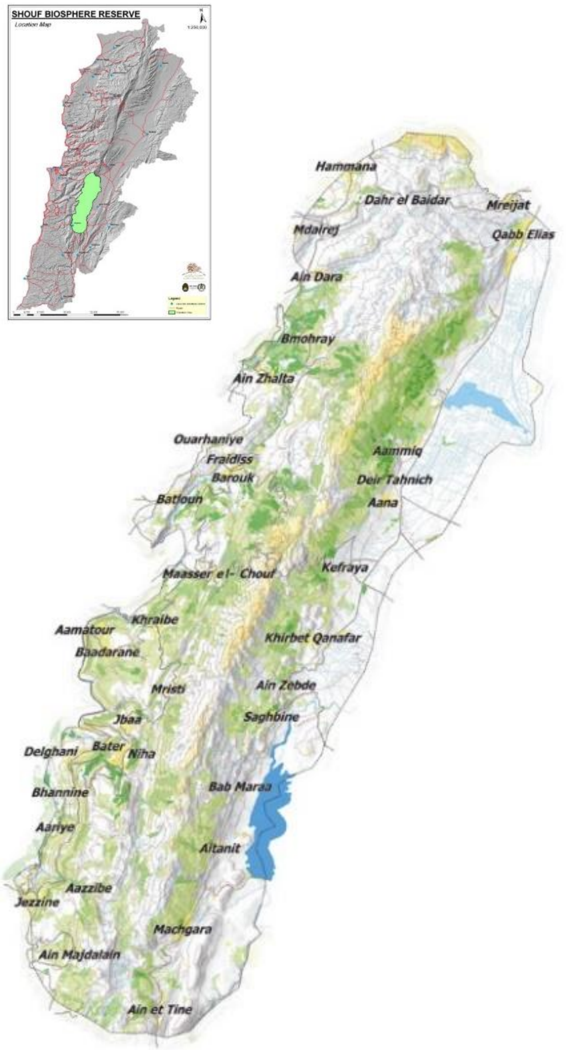

Fig.19: Shouf Biosphere Location Map
Source: shoufcedar.org, 2019

Unfortunately, the Shouf region is not exempt from the repercussions of urban expansion. With the lack of building regulations in Lebanon, many of the local eco-systems could suffer and as a result the loss of biodiversity. There is a need to create design parameters that regard the characteristics of the geographical context.

3.2 Analysis: Application of the Extracted Parameters with Reference to SBR:

With the increase of unmanaged urbanization activities and habitat loss, it is important to envision a GI network that provides an alternative infrastructure for local ecosystems. Therefore, the proposed application of the parameters for SBR are as follows:

a. Physical Conditions:

- *Land Management:* In 1996 the Lebanese government declared government owned land areas as natural reserves and this yielded some positive results in preventing forest damage. However, this declaration has also caused an increase in number of visitors. As a result, housing and commercial projects also increased in proximity to the protected areas. The natural reserve is surrounded by transitional areas that are undergoing rapid urbanization. (CEPF, 2020). In order to facilitate management, the SBR is divided into (SBR,2019):

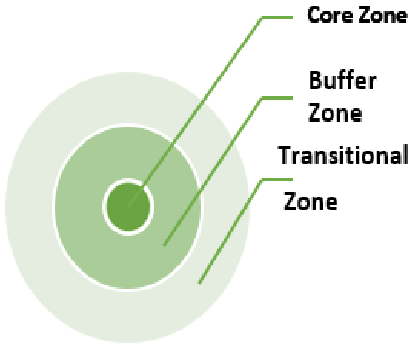

Fig.20: Shouf Biosphere
Source: SBR, Edited by author, 2023

Core zone: An area of around 115.5 km2, includes the natural reserve of the SBR. This zone is rich in species as well as natural and cultural heritage values.

Buffer Zone: The buffer zone surrounds the core zone and extends for around 64.5 km. It allows for activities that are compatible with conservation goals (such as ecotourism or agriculture).

Transition zone: The transition zone, which encompasses all the urban settlements near the SBR where sustainable resource management methods are advocated, spans a region of about 359 km.

- *Site and Location:* The terrain runs along a north-south axis, with the western slopes in the Shouf district facing the Mediterranean Sea and the eastern slopes in the West Beqaa district facing the Anti-Lebanon range and connecting to the Beqaa valley. The SBR contains:

1. The 1996-founded Shouf Cedar Nature Reserve, which is situated in the Shouf mountains.
2. The Ammiq Wetland in the Beqaa Valley, to the east of the Shouf area.

- *Climatology: A typical Mediterranean climate with four distinct seasons; the warmest month (August) and the coldest month (Jan) have average temperatures of 20 °C and 4 °C, respectively. Winters are chilly and damp, whereas summers are hot and dry.*
- *Hydrology: Two hydrological systems are thought to split at the range's peak. The western slope is less steep and supports ground water aquifers, whereas the eastern slope is significantly steeper and favours surface stream flows. In addition to the Ammiq swamp which is a major ecological node.*
- *Land-cover/Land-use: A vast variety of habitats, wildlife, and rural inhabitants coexist in the mountainous landscape. 30% of the land in the SBR environment is used for agriculture, while 19.4% of that area is currently uncultivated. 16.1% of the area is covered by forests, while 14% of the SBR* is pastureland, of which 38.5% are low mountain pastures that permit cattle grazing and 61.5% are high mountain grasslands in the core zone (SBR,2020).

The core zone must be protected and preserved without urban interference. With sites in close proximity to core zone, natural corridors and buffers must be provided in conjunction with urban areas in buffer zones. Transitional zones require green infrastructure that provides habitat near urban settlements. To provide habitat conditions, the geographic and natural features of a selected area of study are in need of imitation and preservation.

Also, it is crucial to preserve the water bodies available on site, as they are a primal habitat requirement for amphibian and fish species, as well as a source for water. It is also important to control the impact of our built environments on the macro and micro climates such as heat islands. From the given data, SBR is a Mediterranean mountainous area with many of its wildlife inhabiting forests. However, up to 30% of the land is also used for agriculture. Multifunctional agricultural based activities could serve as an additional vessel for biodiversity. Also, given the site's location in the Mediterranean, allows the human users to spend majority of time outdoors thus indicating the importance of human-wildlife interaction opportunities.

b. Regional and Local Species Pool

- *Ecosystems:*

Two main bioclimatic zones exist in the region with a diversity of species spread around.

The reserve is classified as a reserve under the Corine Classification (1999):

1) The "Supra-Mediterranean Level" which is adjacent to the rural settlements. It consists of forest land, with oak trees predominating, covers the lower portions of the eastern and western slopes up to 1500 meters in altitude. On the western slopes, however, cedar trees predominate between 1050 and 1925 meters (LRI,2019).

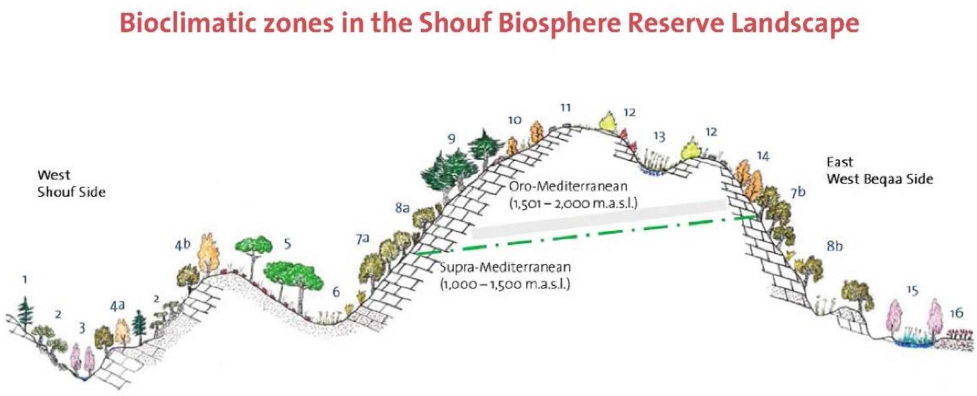

Fig.21: Bioclimatic Zones in SBR
Source: Shouf Reserve Biosphere

2) The "Montane Mediterranean Level," which spans both sides between 1500 and 1900 meters and is characterized by cedar trees predominating on the western mountain slopes and their absence on the eastern slopes, where oak and hawthorn trees prevail.

3) The the "Oro-Mediterranean level," which rises above 1900 meters. Due to the harsh environment little human activity takes place. The dominating species is cedar.

The SBR database provides valuable data concerning other living beings inhabiting the region and their behavioural patterns. For example, the database provides us a review of the Jackal animal in the region. By knowing the animal features well as its habitat areas and behavioural patterns, we can truly include the wildlife in the planning process (As shown in Fig.22).

Fig.22: Fauna Description
Source: Shouf Biosphere Reserve

The SBR terrain hosts a large variety of wildlife. There are two categories of species once the regional species pool map has been created. First, there are those species that have been found nearby the location able to reach the site premises without limitation. Second, some species have only been discovered farther away from the project location, where they are unable to access the site. Which of these categories a specific species falls under depends on both its ability to disperse and the location in which it has been found (Apfelbeck et al.2019).

The main priority of ecological interventions is to protect those species from extinction. Conservation needs of red listed species and their habitat areas must be incorporated in the operating policy in all phases.

c. Preservation Needs and Biodiversity Indicators

In Lebanon, many threats in addition to habitat loss face wildlife. One of the most major causes for animal death is uncontrolled hunting activities and road kill on highways. Hunting activities however have been decreasing with the recent applied prohibition laws. Road kill however, can be mitigated by creating Eco bridges.

According to SPNL (Society for Protection of Natural Land), an essential tool for informing management about the status of biodiversity as well as the integrity of ecosystems is the concept of biodiversity indicators. Indicators of biodiversity also provide information on how effectively species can be conserved.

- Landscape-wide Interventions (Lebanese Reforestation Initiative LRF Program) (FLORA)

  The "Mediterranean Mosaics (MM)" project, aimed to increase the resilience of the Mediterranean landscape to socioeconomic and climatic change. In close cooperation with local people and other socio-economic actors, innovative and climate-adaptive knowledge and landscape-wide actions for the restoration of ecosystem services, biodiversity conservation, and sustainable rural development. The programme also aims to increase Lebanon’s forest land from 13% to 20%. The Lebanese government views forest restoration as a crucial step in meeting the country's commitments to fighting desertification, combating climate change, and conserving biodiversity.

- Important Bird Areas (IBA) (FAUNA)

  SBR is ideally situated at a crossroads for bird migration, with access to Europe, Africa, and West Asia. There are over 250 bird species listed in the Biosphere Reserve, and the Ammiq wetland is home to many of them. The SBR is considered as an IBA zone. IBA zones are important bird areas in which many important endemic species of birds reside as well as the importance of the bird migratory activities that take place.

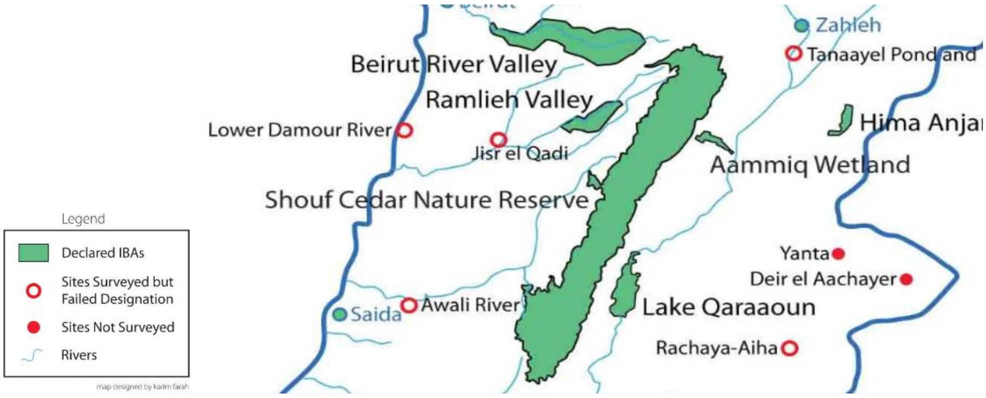

Fig.23: IBA Areas
Source: spnl.org, 2007

As in the case of SBR, the focus shifts towards the avian species and their preservation. If future built environments can provide habitat and sanctuary for such birds, biodiversity can be promoted further. However, a mixed approach can also be adopted depending on site limitations.

Based on the reports on ecological actions and constrains, in addition to endemic species preservation, two major axis of priorities appear. The first, the IBR zone and the pathway of avian migratory species. While the second being the forestation interventions. If future built environments can provide habitat and sanctuary, biodiversity can be promoted further. However, a mixed approach can also be adopted depending on site limitations (SBR,2019).

Fig. 24: Migratory Birds in Lebanon
Source: PAP, 2019

d. Target Species Selection and Life Cycle

For a small scale specific approach, singular or plural species can be selected for a reinforced conservation. According to ‘A Conceptual Framework for Choosing Target Species for Wildlife-Inclusive Urban Design’, target species selection for conservation has generally been entrusted to qualified specialists, such as biologists employed by government agencies or non-governmental conservation organizations (NGOs). Therefore, if not entirely, species selection is driven by *conservation needs*. (Apfelbeck et al.2019). For example, according to the ecological reports of the study of the biodiversity indicators of West Beqaa area which is a node in the larger SBR ecosystem ‘MONITORING OF BIODIVERSITY INDICATORS IN THE WEST BEQAA LANDSCAPE’, the chosen species in need for preservation and can aid in promoting biodiversity are:

1. Syrian Serin Serinus syriacus:

The species nests in an evergreen tree (ideally a cypress tree) in March or April after the males perform a song show to attract the females. Four pale blue, glossy eggs are laid in April and May, and the female incubates these for 12-14 days. After barely 14 to 16 days, the young fledge, and the parents travel up to about 1,800 meters in July and August to give birth to a second clutch. The pair can raise three broods if the circumstances are right. Due to the lack of suitable breeding habitat at higher elevations, it appears that most pairs in southwest Jordan only breed once a year. They can have up to three broods at Anjar without ascending to a higher height (R. Jaradi et al., 2018.).

Fig.25: Syrian Serin
Source: OSME, 2022

2. Turtle Dove Streptopelia turtur (Threatened Species)

It prefers open woodlands over thick ones and frequently forages on the ground. Although it will occasionally nest in expansive gardens, it is typically quite reticent, likely as a result of the intense hunting pressure it experiences. Turtle doves need tall, overgrown bushes for nesting and short, weed-filled spaces for foraging, but the availability and suitability of these habitats have been drastically reduced by agricultural expansion. Turtle Doves now exclusively consume seeds from domesticated plants after moving from foraging in "natural environments" over the past 40 years to ones made by people.

Fig. 26: Turtle Dove
Source: SPNL, 2018

The selection of the target species, will first and foremost depend on conservation priorities set by ecologists. However, it is also important to consider all risks and safety measurements required for a successful interaction between wildlife and the urban zones. Moreover, given the example provided by the West Beqaa area, the given data can provide insight into elements of the creation of the suitable alternative habitat. Such species can provide ecosystem services as pest control as well as promoting biodiversity. Therefore, for the scope of application, the chosen target species is the avian species. Initially, the framework can be tailored for the Syrian Serin and Turtle Dove in attempts to create adjacent efforts between evidence based ecology and urban planning.

e. Habitat Requirements:

Now that target species has been selected, species specific initiatives can take place for concentrated effort. According to Avian Report, ornithologists indicate that “a bird’s habitat is often a signature of its identity.” Each habitat type has a specific composition and structure to which a species is well-adapted. The following are crucial components of avian habitat:

Food: There are many different types of food that birds can find in their environment. A bird needs certain physical characteristics and behaviours in order to efficiently collect food, whether it be fruit, nectar, or invertebrates. Food can be provided by certain local flora selection with insect population or artificial feeding spots.

Water: Just like other creatures, birds depend on it for survival. Water can be abundant or scarce depending on the situation. Water bodies are a core element of many bird's lifecycle, thus blue spaces must be preserved. Moreover, artificial drinking spots can be added.

For nesting and reproduction, a place to stay and partners: Birds have specialized needs for refuge and nesting; some species build their nests in trees, bushes, rock walls, cavities, and even on the ground. The shelter is essential for predator safety. Some birds can be adjusted in artificial shelter units fixated to buildings or urban features.

Therefore, in addition to suitable natural habitat areas, artificial elements such as shelter units, feeding and drinking spots for example, can be added to the design considerations.

f. Ecosystem Management (Operating Natural and Cultural Capital)

According to the FLR program, a highly diverse and functional landscape is envisioned that is internationally recognized for cultural heritage linked to its natural resources and species that sustains healthy ecosystems and viable populations resilient to environmental risks. The restored ecosystem services support the economic, cultural, and spiritual needs of local communities. According to the forest landscape restoration guidelines for the SBR area the vision for a resilient landscape consists of (SBR,2020):

1. The SBR mountain ecosystems' connectivity, functioning, and diversity restoration goals, increasing capacity to withstand the effects of climate change and assisting species in meeting their adaption requirements.
2. A balanced predator-prey (wolf, caracal, hyena)-prey (Nubian ibex, wild boar) food web is created as a result of the large herbivore population (Nubian ibex) of the SBR landscape being restored. This has a profoundly positive impact on the nearby plant, bird, and mammal communities throughout the landscape.
3. With a harmonious relationship between humans and wildlife, increased pastureland and water availability, and efficient rotation-resting livestock management, the governance of short-distance transhumance system is restored and adjusted to the contemporary socio-political situation.
4. Oak and pine forests are maintained adaptively by converting excess biomass into bioenergy (briquettes), enhancing growth and carbon storage, and lowering the danger of fire and tree deaths from water stress and diseases.
5. Restoration of traditional agricultural terrace systems and associated semi-natural habitats supports vital ecosystem functions such as hydrologic regulation, soil fertility, microclimate, pest control, and fire break, while also producing high-value, diversified crops of wild culinary plants and local fruit varieties using a crop-livestock integrated management approach.
6. Based on green value chains of forest, agriculture, livestock, and tourism-related products produced as a result of FLR interventions, the local economy is strengthened and diversified—local businesses and employment creation with a gender and youth focus—targeting the local, national, and international markets.

g. Culture and Nature Parallels:

The area is a crossroads of numerous cultures, faiths, and historical occurrences, all of which have left their mark and contributed to the region's cultural history, which is as diverse as its ecosystems. A committed group of people who live at the SBR work hard to preserve the area. For example, many locals who have worked as environmental guides for more than ten years are familiar with every inch of their and the surrounding green spaces (IUCN, 2018). 70,000 people reside close to the SBR, which is surrounded by 24 distinct communities that are part of 3 distinct Districts (SBR, 2020).

Fig. 27: Educational Activities
Source: SPNL, 2018

For implementation to be sustained over the long term, education and young engagement are crucial. *A great method to find common ground for the preservation and sustainable use of natural resources is through environmental education*. Children's participation in environmental education activities piques the attention of their parents, who subsequently get involved and take pride in their offspring's accomplishments. This has a catalytic impact, increasing adult awareness of the need to better utilize natural resources through their children. Teachers and students from numerous public and private schools in the SBR communities have participated in a multitude of environmental education events that the ACS team has conducted. In addition to supporting them in the planning of lessons and field trips to the SBR to learn about various environmental challenges, the education activities offered training to school teachers on important environmental issues related to the SBR and the FLR-related programs.

Given the safety and risk measurements have been met. Human and wildlife interaction is strongly encouraged because natural values, if incorporated culturally can produce far bigger results. In the urban setting, human users operate urban spaces that are constantly changing to meet their needs. It is important to establish neutral areas for both human and non-human users to interact within the urban setting to increase awareness and cooperation.

h. Post-occupancy monitoring:

Since this process is constantly changing and affected by various factors, the approach is experimental. Depending on the target species life cycle, the wildlife inclusivity will be set by the beginning and end of this cycle. Post occupancy assessment allows designers and users to foresee future scenarios as well as assess current situations for decision making. It is important to follow through with ecologists even after the completion of the project’s construction to assess the status of the target species as well as habitat conditions. If site limitations or species limitation occur, they can be reconsidered. Also, if the target species incorporation was successful, further additional species can be added in accordance for the planning of a wider landscape scale framework.

3.3 Discussion: The GI Network Framework Plan

Following a socio-ecological framework, the GI network can be planned in accordance to the extracted parameters as an integral part of a greater whole ecosystem. In a radial order, the core zone is the inner circle that is preserved and unaltered. Operating on both the ecological and cultural level this network could provide both alternative habitat and resilience for the landscape and its human inhabitants. Many spaces in the urban realm have capacity to withhold ecosystems of many scales. Those spaces are often polluted and disregarded. On the other side, if restored habitats and buffer zones replace those spaces, biodiversity could be achieved in the built environment on a level that doesn't require additional input of capital. Artificial elements such as green walls and green roofs if **tailored for the local geography, can become an extension of an existing landscape. Connectivity is** essential in the operation of such frameworks. The local natural capital is a key resource for urban revitalization in Lebanon. In a country that lacks capital and is rich with natural resources, such framework can yield nation wise benefits.

Moreover, in response to the latter concern of forestation efforts, birds can be very beneficial in spreading seeds and controlling of pests harmful to trees. In this case, we can mitigate the loss of forest land from urbanization by encouraging bird species habitat areas. Therefore, allowing us to create nature-based solutions for urban based problems.

The following diagram provides summary into the main aspects to be looked into when planning a GI network for landscapes such as SBR:

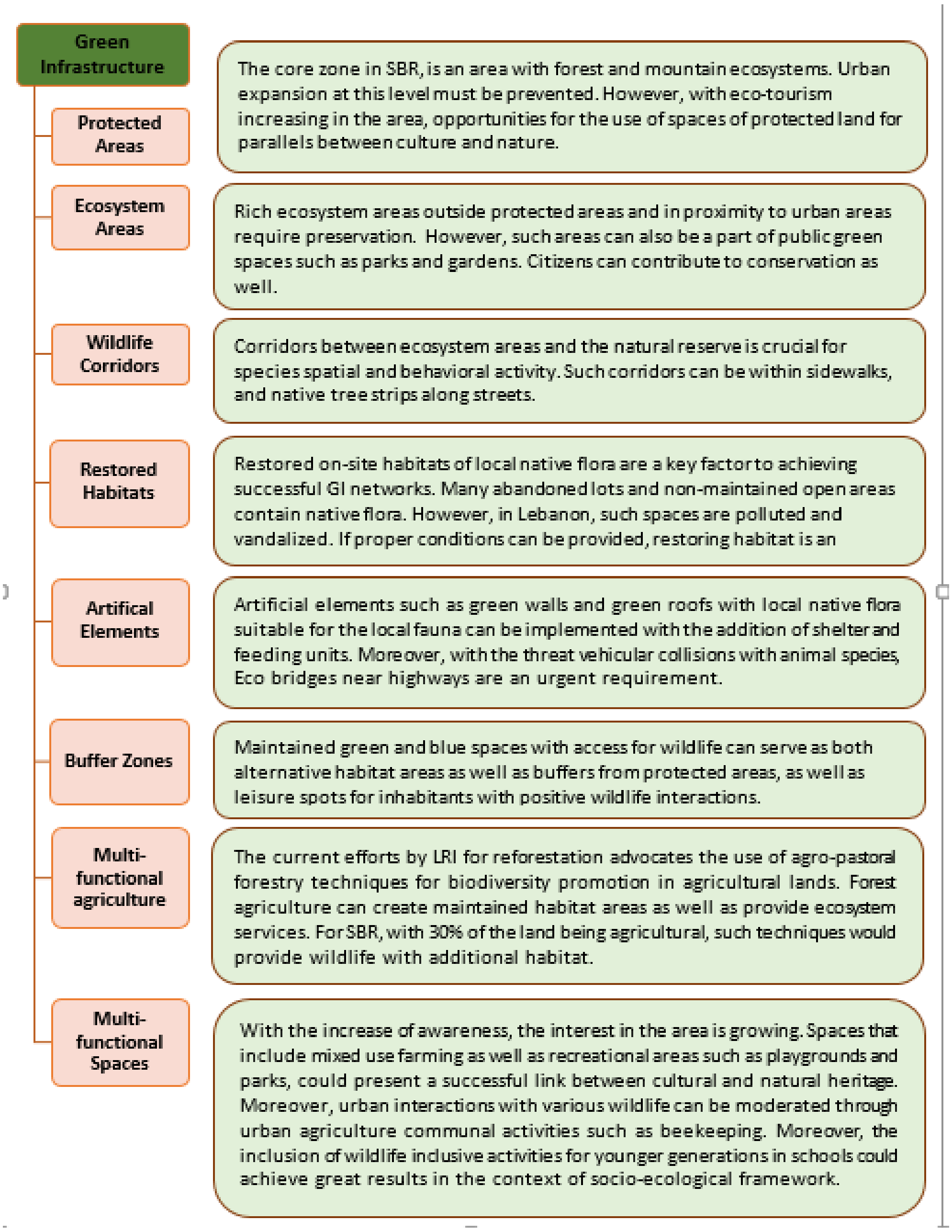

Fig.28: GI Network Formulation for Landscapes Similar to SBR
Source: Edited by author, 2023

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3.4 Conclusion

The following paper focuses on finding wildlife-inclusive design parameters for green infrastructure that provides alternative habitat chances in the face of urbanization expansion. The hypothesis emphasized on achieving beyond 'green' results from seeking a multidisciplinary approach be investigating socio-ecological frameworks to envision a holistic and resilient landscape. Multispecies built environments can mitigate biodiversity loss. By spatially planning land cover and physical conditions tailored for specific species, reinforced conservation can be achieved. The additional ecological and socio-cultural layer in planning of green infrastructure, allows the 'green' to be identified as a whole system designed with both the local ecosystems and urban inhabitants in mind within the landscape. Each geography will display its endemic version of 'green' as well. Variations of wildlife species can become parameters that also help shape our built environments. 'Our' built environment exists in the larger scope of the natural setting. Therefore, with increasing repercussions of urban expansion on habitat areas, immediate action plans must be formulated to stop species loss. A geographically specific GI network can provide alternative infrastructure for local ecosystems.

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