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Public Green Corridors in Cochabamba

- A Conceptual Model Proposal for Green Infrastructure in Cochabamba, Bolivia

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A Conceptual Model Proposal for Green Infrastructure in Cochabamba, Bolivia

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Sammandrag

(1) Urbaniseringen världen över har bidragit till fragmentering av växter och djurs naturliga habitat och städerna bildar växande matrix som hindrar spridningen av arter. Detta skadar biodiversiteten och leder i förlängningen till att arter utrotas. (2) Vi gjorde en inledande litteraturanalys för att samla information om urbanisering, gröna korridorer, biodiversitet och pollinering. Vi inventerade parken Parque Fidel Anze och de kortaste spridningsvägarna till närliggande gröna ytor. Vi gjorde en pilotstudie där vi inventerade de största avenyerna i närheten för att skapa en utgångspunkt. Vi inventerade även en yta i närheten av denna park för att undersöka hur grönytorna är fördelade på den privata marken. (3) Vi sammanställde inventeringsresultaten och kom fram till att gatan Calle Potosí hade bra förutsättningar att bli en god spridningsväg mellan Parque Fidel Anze och den närliggande parken Centro Simon I. Patiño. (4) Vi designade ett förslag att göra Calle Potosí till en grön korridor där delar av gatan bör stängas av för fossildrivna fordon och där fler skikt av grönstrukturen kompletterar de två gräs- och trädskikt som idag dominerar Cochabamba. Förbättringsförslag för Parque Fidel Anze för att förbättra biodiversiteten och funktionerna i parken gestaltades också, där vikt lades på en kontinuitet gällande grönytor samt nyplantering. (5) Den bristande planeringen av grönstruktur uttrycks framförallt i den södra delen av Cochabamba där de offentliga parkerna är både för få och för små. I övriga staden behöver perenner och buskar användas i större utsträckning för att skapa gynnsamma miljöer för insekter som lever och rör sig i staden. Dessutom bör gator utan biltrafik införas för att skapa en tryggare miljö för såväl människor som djur.

Abstract

(1) The urbanization around the world has led a fragmentation of the natural habitats of plant and animal species. The urban structure is generating a growing matrix that is preventing the dispersal of species. This is damaging the biodiversity and is leading to mass extinction. (2) We made a literature review to gather information about urbanization, green corridors, biodiversity and pollination. We inventoried the park Parque Fidel Anze and the shortest dispersal pathways to the surrounding green areas. A pilot study was made to study the largest avenues to compare our streets with. We also inventoried the surrounding property in an area near the park to get view of the green area distribution of private plots. (3) We compiled the results of our inventories and decided that the street Calle Potosí prerequisites to become a good green corridor between Parque Fidel Anze and the semiprivate park Centro Simon I. Patiño. (4) We designed a proposal that would make Calle Potosí into a well-functioning dispersal pathway, where parts of the street were closed off from fossil fuelled vehicles and more greenery layers were introduced to supplement the existing two layers consisting of grass and trees that is dominating the green infrastructure of Cochabamba today. (5) The absence of proper planning of green infrastructure is especially noticeable in the southern parts of the city where the official parks are too few and too small. The rest of the city need more perennials and bushes to create profitable environments for animals that live and move through the city. Streets without fossil fuelled vehicles should be introduced to create a safer environment for both animals and men.

Contents

1. Introduction

This study is carried out within the model of the Minor Field Studies Scholarship Programme, MFS, which is founded by the Swedish International Development Cooperation, Sida/Asdi.

Below is an introductory section with the aim and research questions that are illuminated in this thesis followed with a glossary to help the reader understand the definitions used in this thesis.

Fragmentation, habitat loss and poor living conditions affects many species in the urban areas due to the urban expansion and densification, and Cochabamba is no exception. Huge buildings are replacing family houses to make place for the growing population (McGranahan 2015). The way humans exploit the earth has alarming effects on biodiversity with mass extinction in a rate that are 100-1000 times higher than pre-human rates (De Vos 2014).

As cities densifies the street infrastructure will be the main network connecting the parks of the city, as the private gardens of one-family houses get replaced with large tower blocks. There are many benefits associated with a healthy green infrastructure and to affirm this in urban planning is essential for the development of cities all over the world (Tzoulas et al. 2007).

It is important to look at the possibilities of green infrastructure on different scales. Parks and green spaces contribute to many benefits beyond the social and recreational ones used by humans. The cooling effect of transpiration in trees and vegetation that provide habitats for of many animal species are just a few of many examples of why green areas are important in the city (Susca et al. 2011; Hernández et al. 2015).

The many alarming reports about pollinators decrease around the world (Brown & Paxton 2009; Goulson, Lye & Darvill 2008; Williams & Osborne 2009) made us interested in how this problem is dealt with in cities with large ongoing urbanization. The parks in Cochabamba areas are still as small as they were when they only were surrounded by villas with green gardens (Wright, Wendel & Heather 2012).

1.1. Aim and purpose

The purposes of this project are to combine literature on the concepts of green infrastructure and ecosystem services and to formulate a conceptual model for the green corridors surrounding Parque Fidel Anze. Our aim was to collaborate with students and professionals at the University of San Simon and to increase their understanding of ecology and ecosystem services. The results in this thesis are therefore not a final solution, but rather an argument in an ongoing debate of sustainable urban development.

1.2. Research questions

The main questions we want to investigate is (1) “Do green corridors exist for pollinators and how are they designed in the public area in and between parks in Queru Queru, Cochabamba?”, (2) “How can conditions for biodiversity in green

corridors for pollinators to Parque Fidel Anze be improved?" and (3) "How can the green infrastructure in Cochabamba be improved?".

1.3. Delimitation

We chose to investigate one park and the connections to other green areas located within a 300-meter radius from the edges of Parque Fidel Anze to keep this project within the ten-week limit. The 300 m limit is based on the number of surrounding larger green areas since the distance to the closest green area outside this area was 600 meters. To study the connections between all green areas within a 600-meter radius from the park would be too extensive for a bachelor thesis.

Because of the limited time we did not focus a lot on the social or aesthetic functions of the park. Some social functions are inventoried at the site to provide a detailed picture of the situation. Humans, animals and plants intervein with each other and the human usages of areas have some impact on the biodiversity and vice versa. It is important to also investigate the social activities at the sites as some functions, for example playgrounds and bee nests, should not be located near each other.

Due to our limited insect knowledge we will be focusing on a plant diversity, knowing that a good biodiversity among plants facilitate a biodiversity among insects as well.

1.4. Thesis structure

The thesis is structured by six main sections. After this introductory section follows two sections that are meant to build understanding and fundamental knowledge about the subjects discussed in this thesis. The third section is about method and materials, and helps the reader understand how we conducted the problems and how to recreate our studies. In the result section we have gathered the results of our inventories as well as the knowledge learned through meetings and from our design process. These results are discussed in the last section as well as the discussion about how this thesis was conducted and what could be learned from it.

1.5. Acronyms & definitions

- **Biodiversity** can describe many things, such as the diversity of genes within a species or the diversity of ecosystem types but in this thesis we will use the term as a synonym with species richness (Townsend 2008).
- **CEPLAG** - Centro del Planificación y Gestión. The department of planning and managing at University of San Simon.
- **Climate change** "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (IPCC 2001).
- **Cochabamba** - in this thesis we will be discussing the area of the municipality Cochabamba, not the department Cochabamba, in Bolivia.
- **Connectivity** is a description of how well habitats are connected through green corridors and provides the potential to enhance population viability (Beier & Noss 1998).

- **Ecological traps** are habitats that are like natural habitats but contain hidden dangers that the natural habitat does not have (Keilsohnet et al. 2018).
- **Ecosystems** are demarcated land- or water surfaces were living plants, animals, insects and microorganisms' lives in a cycle where they are dependent on and affect each other. Ecosystems could be a forest, city park and the whole planet (Berg 2019).
- **Floral abundance** A wealth of flowers where pollinators and insects can feed on a big variety of nectar and pollen (Fowler et al. 2016).
- **Floral species richness** Species of flowers that has a strong reward of nectar for insects (Fowler et al. 2016).
- **Fragmentation** means the increased isolation between different habitats (Inostroza et al. 2013).
- **Green areas** are in this thesis used as a term for areas larger than 200 m^2 in urban spaces that contains a variety of vegetation.
- **Green corridors** are narrow, linear habitats in an inhospitable matrix between two larger, non-linear habitats that promotes dispersal movement between the larger habitats. This definition does not include linear habitats that does not connect larger habitat patches (Beier & Noss 1998).
- **Green infrastructure** can be defined as a coherent system of greenery areas that links the inner city with the countryside. It is a structure that upgrades the urban green space systems into a coherent planning entity (Tzoulas et al. 2007).
- **Habitat** is an environment where a certain plant or animal species can live.
- **Matrix** is an inhospitable environment that could be mortal or less good for different species to live in.
- **Microzone** is a small climate zone that create growth for plant or animal species (Wilkinson & Dixon 2016).
- **SLU** – Sveriges Lantbruksuniversitet. Swedish University of Agricultural Science.
- **Stepping stones** are smaller habitat spots that are isolated from each other by different biotopes.
- **UHI,** Urban Heat Islands, a phenomenon caused by impervious surfaces that accumulates and reradiate heat from primarily the sun, causing a much warmer temperature in the urban area than in the surrounding rural area (Wilkinson & Dixon 2016).
- **Urbanization** is the movement of a population from rural to municipal areas (McGranahan 2015).

2. Site description - Cochabamba

2.1. Location and context

Cochabamba is a municipality in the Cochabamba department, located at an elevation of 2558m in the centre of Bolivia in South America (Acebey et al. 2017). Bolivia is a country in the western inland of South America were two thirds of the inhabitants belongs to indigenous people. The country has a lot of natural resources such as natural gas, oil and minerals. Despite this Bolivia suffers from high foreign debts and is classified as one of the poorest countries in South America. One important reason to this poverty problem is that the economy unilaterally relies on raw material exports. When the market prices decrease in value the export incomes will not be enough to cover the costs for the import, which contributes to big social and economic differences in the country (Landguiden 2016).

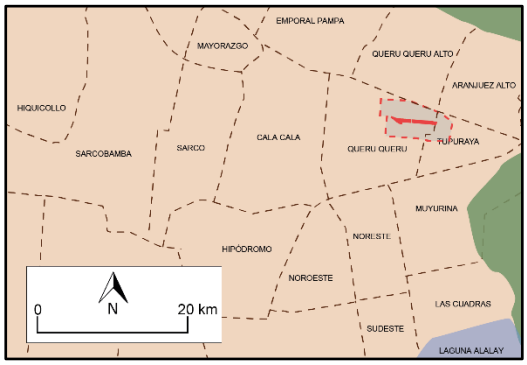


Figure 1: Map of Bolivia.

Figure 2: Map of the central zonas of Cochabamba. The area investigated in this thesis is marked red.

Approximately 2,58% of the total area of 13.854,44 ha. in Cochabamba consist of forest. The river Río Rocha and many small canals run through the city and a small lake Laguna Alalay is located southeast of the city centre (Acebey et al. 2017). Estimated population of the department of Cochabamba is approximately 2 million, and the municipality has 630 000 inhabitants (INE 2012; INE 2016).

Cochabamba is divided in 6 comunas that each has a headquarter and is deciding about licenses and architectural plans within the cumuna. Each comuna is divided into a total of 37 zonas (Cochabamba, Bolivia 2018).

In this thesis we will be examining an area surrounding the park Parque Fidel Anze that is located between the Queru Queru and Tupuraya zonas (see figure 2). This is the largest park in Cochabamba and is well known within the city. It is surrounded by many smaller parks which is ideal for studying green corridors. Since it is a well-known park, it improves the possibility of stakeholders at the municipality to understand our conceptual model and design.

2.2. Climate & nature

The climate and nature levels in the Cochabamba region can be divided in four different divisions that are categorised with different biodiversity and site preference. Piso Montano is the biodiversity area that surrounds the city of Cochabamba and constitutes the largest division in the Cochabamba area. Because of the interweaving of nature and urban landscapes the plants and flowers in the urban parts of Cochabamba must adapt to a mosaic pattern that are fragmented all over the city. The Andes surrounds the green areas and creates a variating weather climate in the city were the air temperature can change rapidly from high to low degrees during the day. The plants and flowers in the Cochabamba region need to adapt the extreme weather of rain and drought seasons combined with the varying air temperature. Because of the steep mountain ridges and fine-grained soil, landslides are very common in the Andes. Therefore, the plants in the Cochabamba region needs to have a deep root system that can manage the landslides and other natural phenomena (Aguirre et al. 2015).

2.3. The urban and green infrastructure

The urban expansion in Cochabamba is stochastic, with no system regulating the urban development. The last couple of years the expansion and densification has been spreading horizontally, affecting the neighbouring municipalities. Large buildings are built on land that should be used for agricultural purposes because of the good soil quality. The rapid urban development is causing gaps between families with different income since low income families are forces to move from developing blocks. These families have to move into peripheral areas of the city where basic water services, basic sanitation, education and health services are bad (Ledo 2013). The water quality is poor as the lakes Alalay, Quenamari and Coña Coña are polluted (Acebey et al. 2017; MMAyA 2015) and the city experiences periods of flood and drought events throughout the year (Callejo et al. 2018).

Cochabamba is called “Valle de la eterna Primavera”, the city of eternal spring and is known in Bolivia as the City of Gardens. To keep this name the municipality has to have a certain level of maintained parks which acquire a lot of water which is damaging the water supplies (Acebey et al. 2017). Since the aquifers in the area are very vulnerable it is extremely important to economize with the water to protect the water supply from contamination and destruction (MMAyA 2015).

2.3.1. Biodiversity

The current trend in Cochabamba, as in other cities of Bolivia, is that a tree located within the city is considered a distinctly landscape element and vegetation is incorporated as a final decorating element (Acebey et al. 2017). The xeric bioclimate is characterized by 8-9 months of drought every year. The city is surrounded by the Tunari mountains which is a part of the Andes mountain range. The city is placed at the bottom of the valley and is spreading up on the mountain slopes. This creates a dam for cold air during nights and cold mornings, leading to polluting gases, smoke and dust being detained in the valley until the sun warms the air. During cold days with no wind, this creates a polluted environment, especially in the southern regions of the city (Aguirre et al. 2015).

The municipality of Cochabamba has determined that public sidewalks and avenues in need to have at least 3 trees per 100m, which is the reason why almost every street has trees in the sidewalk. Most parks are in the northern parts of the city, and only 1% of the southern area are covered by trees. Parks and other official green areas account for 6% of the total urban area (Acebey et al. 2017).

2.3.2. Ciclovía

The Ciclovía is a 27 km long bikeway starting southwest of the city, at Circuito Bolivia, and ends at Wiracocha park, in the northern parts of the city (Montes 2017). The municipality has plans of extending the bikeways throughout the city (Cochabamba 2016; Montes 2017), adding almost 100 km throughout laps during the next 10 years (Montes 2017).

Figure 3: A map over the area we have investigated. The area is limited by Avenida Circunvalacion in North, Calle P. Dalense in West, Avenida Portales and Zenon Salinas in South and by Calle A. Villalobos in the East. There is only a small part of the Ciclovía shown in the map. It continues in both directions.

Ciclovía is crossing through our area of study and since it connects three green areas, we found it to be an interesting object to investigate.

3. Theoretical background

A working green infrastructure is the foundation to a healthy biodiversity in the city (Tzoulas et al. 2007). In this thesis we have focused a lot on pollinators since they are a key for providing biodiversity amongst plants which in return are providing good environments for both animals and humans (Fowler et al. 2016). By focusing on providing great environment for pollinators we believe that working ecosystems would develop in the interim. We have gathered some elementary information about the connections between urban planning and biodiversity in this section called “theoretical background”. This segment is made

to support the comprehension of the complexity in planning and developing green corridors.

3.1. Urban environments

Urbanization is a global phenomenon that has been going on for centuries and more than half of the world's population live in cities (Pickett et al. 2001). The number of additional people in urban areas accounts for most part of the world's population increase, which forces the urban areas to expand. Since the automobile was introduced in the early nineteenth century a suburbanization was set in motion (McGranahan 2015). This is one of the reasons why large city structures often densifies near the city centre and sprawl into the rural and wild lands, making up web-like configurations. The urban sprawl has led to an inefficient use of land and has many negative effects on the environment like air pollution and loss of fertile soil. It is important to evaluate what impact the urban structure has on these issues, as well as the approaching climate change (Chakraborty & Wilson 2013). In modern city planning it is more common to densify the existing urban areas instead of expanding into the surrounding rural area. As the cities become denser, green infrastructure often get disintegrated into smaller pieces, a process called fragmentation (Inostroza et al. 2013; McGranahan 2015). Private family houses with flowering gardens that provide habitats for many pollinator and bird species are being replaced by large buildings with, if any, a very small garden everywhere in Cochabamba. The lack of large-scale planning and knowledge about ecology is causing a reduction of biodiversity in the city (Acebey et al. 2017).

3.2. Ecosystem services

Services gained through healthy biodiversity in urban areas are called ecosystem services. These are usages that benefit humans, for example vegetation that provide cleaner air, better microclimates and increase human health. The importance of functioning ecosystem services in urban landscapes increases with the urban expansion (Naturvårdsverket 2019). World Health Organization (2016) recommend that all cities should be structured in a way that provides a small green area (at least 2 ha) for all inhabitants no more than 300 meters from their home as the green infrastructure is essential for the overall health of the city. Functioning ecosystem services in the city also improves the health of ecosystems surrounding ecosystems outside of the city (C/O City, 2014). A healthy ecosystem creates a good soil structure that is needed to supply nutrients, absorb and store water and provide a growth medium for plants to grown in. These structures are easily destructed through fertilization and irrigation and contaminated by pesticides and other toxins used by humans (Pickett et al. 2001).

3.3. Pollinators

Pollination is the transfer of pollen from one flower to another and the movement is conducted through wind, water, birds and bats, but most pollinators are insects such as bees, bumblebees, butterflies and ants (Goulson 2009). Some flowers reproduce by pollination predominantly or exclusively by bumble bees, but most

flowers use multiple pollinators. Flower diversity is highly linked to pollinator abundance and many crops such as watermelon, pumpkin and cranberries (Goulson, Lye & Darvill 2008) and approximately 90% of the vitamin C available for human consumption comes from crops dependant on pollinators (Berg 2019). Studies has shown that pollinators find flowers suitable for their attributes if the flowers are planted in large clusters instead of heterogeneous mixtures (Fowler et al. 2016).

All bees and bumblebees are phytophagous which means that they primarily feed on nectar or pollen (Michener 1974). The bumblebee species *Bombus opifex* and *Bombus funebris* (Abrahamovich & Díaz 2002) and the bee species *Brachyglossula communis* & *Brachyglossula schlumpbergeri* are a few of many pollinating insect species found in Cochabamba (Alsina & Compagnucci 2012). Bumblebees prefer to live in holes in trees and often prefer old deserted bird nests. The previous owner often leaves moss, grass and feathers which the bumblebee uses to build a little ball which it lives in (Taylor & Cameron 2003). Various bee species prefer to nest in different places, in burrows of soil or wood (Michener 2007).

Pollinators uses their sight to find food as different bee species prefer different flowers. Bumblebees prefer larger flowers than honeybees since their size make it difficult to reach into narrow flowers. Pollinators also use their sight to judge the age of the flower, since older flowers tend to have less nectar. Bees and especially honeybees have a large foraging range, with up to several kilometres when local resources are scarce. Solitary bees are generally thought to only travel a couple hundred meters in their search for food (Goulson 2009).

Three hummingbird species has been sighted in the municipality of Cochabamba; *Colibri coruscans,* sparkling violet-ear hummingbird, *Chlorostilbon mellisugus,* blue-tailed emerald hummingbird, and *Amazilia chionogaster,* the white-bellied hummingbird. Their habitats include forest edges, open woodland, flowering gardens and bushes. They feed on nectar of various plants of different families as lantana, centropogon and mallows. 16 more hummingbird species can be found in the department of Cochabamba (HBW 2018).

Histiotus montanus, the small big-eared brown bat, *Myotis oxyotus,* the montane myotis, *Eumops perotis,* greater mastiff bat, *Promops nasutus,* brown mastiff bat and *Tadarida brasiliensis,* the Brazilian free tail bat are all bat species found within the department of Cochabamba (Aguirre et al. 2015). These bat species feed mostly on insects like flies, beetles and moths, but also nectar and flower parts. Their natural habitats are caves and hollow trees but can be found living in buildings that provide similar conditions (Brock Fenton 1983).

3.4. Green infrastructure

A part of the solution to end the pollinator decline is to reduce barriers and build multi floral passages between habitat patches, in other words developing a green infrastructure network (Goulson et al. 2008; Su et al. 2015). Patch areas, connectivity, distance to nearest patch, diversity for patch types and patch shape are important factors for the abundance of pollinating insects (Mattesson et al. 2008) and when developing green infrastructures in cities it is important to compound the greenery through layers of grass, annuals, perennials, trees and

bushes in order to provide shelter and food resources for all kinds of animals that need to travel through or live in the cities (Tzoulas et al. 2007). Urban parks often provide good habitats for many species since they can contain a large amount floral abundance and nesting sites (Mattesson et al. 2008).

Studies from different parts of the world show that habitats that were frequently mowed and contained short non-native grass without nectar resources had a much higher pollinator mortality than habitats containing trees and shrubs as their dominant vegetation (Keilsohnet et al. 2018; Söderström & Hedblom 2007). Neither should a green corridor provide qualities that is too similar to the habitats of territorial species, such as butterflies, since it can lead to blockage in a narrow habitat. There are also many dangers, such as nearby trafficked roads and predators that makes a green corridor a bad long-term accommodation (Söderström & Hedblom 2007).

Developed green infrastructures does not only benefit the ecological state of the city, but also the economical one. Green areas boost the value of the surrounding real estates and reduces the consequences of floods and droughts which can save a community a lot of money. Green areas also attract business which bring economic growth (C/O City, 2014). WHO (2016) recommend that each inhabitant should have 300 meters or less to a green area of at least 20 000 m^2.

3.5. Threats to biodiversity

Following section is not a comprehensive description of the threats against biodiversity but a sample for explaining the complexity of threats in the urban city.

The way humans exploit the earth today has alarming effects of the comprehensive biodiversity with mass extinction rates between 100-1000 times higher than natural rates (De Vos 2014). Populations of bees and bumblebees are decreasing all over the world (Brown & Paxton 2009; Goulson, Lye & Darvill 2008; Williams & Osborne 2009) which is very alarming since our world is very dependent on the existence of pollinating insects.

3.5.1. Fragmentation

Fragmentation and habitat degradation through agricultural intensification are big problems since the farmland must grow bigger to provide resources for the growing urban population. Natural ecosystems are being converted to crop fields (Townsend 2008) and with the many coca leaf plantations in Bolivia this country is no exception (Sweden Abroad 2019). The decrease of floral abundance and diversity of flowers in the urban landscape is leading to habitat loss for pollinators. The growing matrix makes it harder for insects to move between habitat patches which makes populations vulnerable to stochastic extinction events and inbreeding (Goulson et al. 2008). It is important to have a range of flower species as various pollinators prefer different flower shapes and sizes (Fowler et al. 2016; Mattesson et al. 2008; Goulson et al. 2008). Bees for example has various tongue sizes, making them favour out certain flowers through their shapes and sizes suitable for the attribute of the bees. (Fowler et al. 2016).

3.5.2. UHI

Urban heat island is a phenomenon that is a big threat to biodiversity in cities since many species, both animal and plants, are not built to endure the high

temperatures that is the consequence of UHI (Wilkinson & Dixon 2016). The effect of UHI on bees were studied in North Carolina, United States and the study showed that bee abundance declined with 41% per 1°C increase in average site temperature (Frank et al. 2018). A study conducted in New York showed that vegetation can mitigate the UHI effect and reduce the temperature with 2°C (Susca et al. 2011). The high pollution levels, the altered light and moisture regimes affects the pollinators too (Goulson et al. 2008; Su et al 2015).

3.5.3. Traffic

Traffic affects many parts of the urban landscape and high-speed vehicles area exposing both animals and humans for dangers (Johansson & Küller 2005). A study conducted in Brazil shows a negative correlation between traffic speed and pollination. As traffic speed increased, the pollination decreased, and the researchers believed that the most likely reason was that pollinators were being killed at a higher rate as the traffic speed increased. Emphasis is put on the quality of diverse habitat types surrounding traffic (Chaves et al. 2016), which is also discussed in the research article by Keilsohnet et al. (2018).

3.5.4. Artificial light

To enhance the quality of human life, altered lighting was a natural side effect of the urbanization. This is affecting many animal species in form of changed metabolism, migration and reproduction caused by changed day-night cycle (Hölker et al. 2010).

4. Methods and materials

In order to answer our research questions, we used both qualitative methods (literature studies and dialogue) and quantitative methods (inventories). This was achieved through addressing three objectives:

- (A) Undertaking a critical review of the literature on associations between green infrastructure components and the ecosystem services. This is an important step in defining what a green corridor and green infrastructure in order to know if green corridors exist and how they can be improved which are important foundations for answering our research questions (1) “Do green corridors exist and how are they designed in the public area in and between parks in Queru Queru, Cochabamba?” and (2) “How can conditions for biodiversity in green corridors to Parque Fidel Anze be improved?”.
- (B) Preform site inventories and study visits, which are necessary steps to increasing our understanding of the green structure in our area. This is the most important step in order to connect our selected area to the information we have learned through literature studies. These methods help us answer questions (2) and (3) “How can the green infrastructure in Cochabamba be improved?”.
- (C) Constructing a conceptual model for the interface between the result gained from objective A & B combined with information collected from our

dialogues. This design process is an essential step in answering questions (2) & (3).

Through CEPLAG we got information concerning Cochabamba and we were able to take part of their plans. Our goal was an investigative and open process where our final report is not a final solution, but rather tools to use as arguments when planning urban environments.

4.1. Literature review

We did a literature review of biodiversity, green structures and ecosystem services to ensure we had enough knowledge when inventorying the green structure. We used peer reviewed scientific articles and books on the subject.

4.1.1. Scientific articles and books

We used SLU Primo as our search engine, limiting the search results to only Swedish and English articles. Our study concerns a global issue which and we used articles from many parts of the world. We received a book from the biodiversity department of the San Simón University with information about the green structure of Cochabamba. We used following keywords “green infrastructure”, “green corridors”, “habitat corridors”, “pollinators”, “pollinator habitat”, “mortality pollinators”, “bee habitat”, “bumble bees”, “urban heat island”, “biodiversity”, “Cochabamba”, “urbanization”, “flowers Bolivia”, “ecosystem”. Some documents were handed to us by employees from the both universities and by municipalities of Sweden.

4.1.2. Study sites

We made an introductory literature combined with studying maps in Google Earth to find a suitable area to investigate that was typical for all of Cochabamba to make our findings most likely to be applicable in other areas of the city. We studied documents with information and statistics of urban planning provided by CEPLAG.

4.2. Inventories

We made inventories to investigate the specific green structure and usage of Parque Fidel Andze and the streets connecting the park to nearby green areas. We investigated Calle Antonio Quijarro, Calle Potosi, Avenida Melchor Urquidi, Avenida Julio Rodriguez Morales and Calle M.M. Marquez. We also investigated a part of the bicycle lane Ciclovía that passes along the side of Parque Fidel Anze.

Because of the limited amount of time we had in Cochabamba we decided to inventory a part of the streets that could be representative for the whole street. We inventoried one or two blocks depending on the street size. We walked through all the selected streets from where they started to where they ended. After a general overview was done, we started to look for significant blocks that could be representative for the street in total.

We created templates so that the inventories would be conducted in the same way regardless of who is inventorying. Since there is no tradition of administering inventories focused on biodiversity in Cochabamba and no similar study has been

performed here, we had to perform a pilot study to create measures to compare with.

Founded on the theoretical background in this thesis we founded our templates mainly from a biodiversity point of view. We also inventoried some social aspects to see if we would find a connection to biodiversity.

4.2.1. Implementation

The inventories were made during the approximate same time every day and not during rainy days to ensure that pedestrian or vehicle traffic would not differ because of weather or time. We estimated rough numbers of vegetation coverage since we did not have access to geographic information systems. This was calculated through measuring the size of tree crowns from satellite photos and compared with the size of the street the trees were sited at. We were able to measure the size of the tree pits with measuring tapes.

The results are displayed in diagrams to illustrate how the vegetation were structured, how the surrounding buildings were composed and how traffic flows.

We designed a template to classify the quality of transport routes for pollinators between this park and nearby parks. This template was based on inventory guides used by the municipality of Alvesta, Sweden, and NILS by Sjödin et al. (2016). The streets between nearby parks and Parque Fidel Anze was graded by biodiversity, size and traffic.

4.2.2. The templates

Our pilot study took place at Avenida America and Avenida Gral Galindo since they are streets that we were well acquainted within our area of study and therefore good objects to compare other streets with. With the heavy traffic and large paved surface, we found these streets to have low biodiversity in plants. These streets were highly trafficked and had an average of 80 cars, trucks and motorcycles passing in both directions during two minutes. The number of pedestrians passing during the same time was 32. We did not measure bicyclists since they are so few in Cochabamba. We set 41 vehicles and above as *highly trafficked,* between 16-40 vehicles per 2 minutes were categorized as *moderately trafficked* and below 15 were *lightly trafficked* streets. The pedestrian measures were above 31 as *highly trafficked,* between 11 - 30 as *moderately trafficked* and 10 and below as *lightly trafficked* sidewalks.

We used Google Earth to measure vegetation percentage of the streets by dividing the total tree canopy area with the street and sidewalk area. This estimation was combined with counting trees and measuring tree pit sizes to get as accurate results as possible.

By measuring different sidewalks and exploring how many people that can walk beside each other or encounter other pedestrians we could adjust the sizes for the template. We decided that the sizes would be: small (S) 100-149 cm, medium (M) 150-249 cm and large (L) from 250- cm.

A category described the surroundings around the streets, where the sizes of the buildings were inventoried. Bigger buildings create longer shadows which affects the micro climate and small family houses are important for creating stepping stones in the city because of the plant diversity in the private gardens. We counted the floor levels to categorize the buildings. A house with more than 12 floor levels were classified as a big tower building. 7-12 floor levels houses were medium size

of the tower buildings and the smallest towers had 3-6 floor levels. Houses with less than 3 levels were categorized as one-family houses. We realized that this categorization was vague, and we therefore supplemented it with another inventory that showed the link between number of building levels and garden size.

The green areas were divided into three different categories; trees, bushes and perennials. After comparing different streets during our pilot study, we resolved that one or more trees in five meters is classified as *many trees* in a street division. One tree in a ten meters distance is classified as *some trees* and less than one tree per 15 meters is *few trees*. For the bushes we had the same distance as the trees. Many bushes were one or more than one bush in 5 meters and some bushes had one per 10 meters. For a street with few bushes it was classified as lesser than one bush per 15 meters. We counted the total amount of perennials per street because it was easier to measure the whole perennial border then count individual perennials in a certain distance. Many perennials in a street were set to be in a border that were six to ten meters long and some perennials would be in border that were three to six meters. For a street to have few perennials it needed to be a border that were one to three meters. But it was so few bushes and trees in the streets, so this structure was mostly applied for trees.

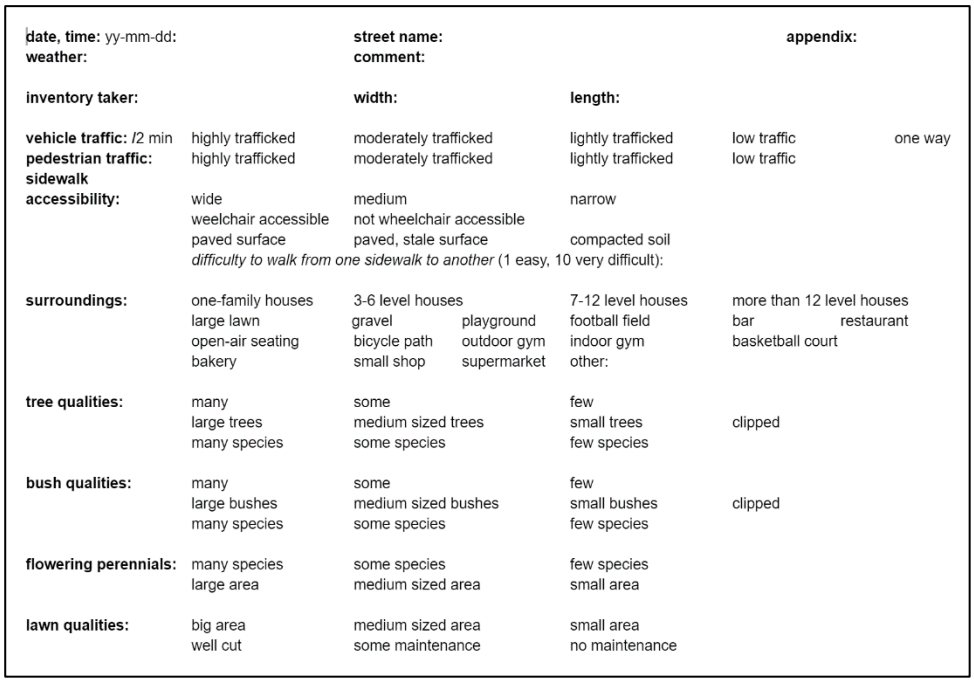
We decided to categorize trees over ten meters high as *big trees*. The *medium sized trees* measures between four to ten meters and trees shorter than four meters are categorized as *small trees*. Bushes larger than 100 cm high were categorized as a *large bush*, a *medium sized bush* were between 50–100 cm and *small sized bushes* were lower than 50 cm high. Perennial areas larger than 5m^2 were categorized as *big area*, areas between 1–5 5m^2 were categorized as *medium sized area* and an area smaller than 1 square meter were a *small area.*

We did not use any equipment to measure the exact inclination, but simply walked up and down the streets to see and feel the gradient. With us having some education about inclination this technique was sufficient for this inventory. An inclination of approximately 3° or less was categorized as flat and above 3° were steep. If a street had variating inclination it was categorized as such.

We did our main inventory during daytime because of security precautions. We walked through the streets and counted how many lampposts we could see and the distance between them. We later drove by car during night-time to appreciate the quality of the artificial lighting.

The area of use was measured by analysing movement pattern of pedestrians and motorists to see how they moved. We asked 10 people at each site what they were doing at each site. For example, there is a high school near Avenida Julio Rodriguez Morales and the people mostly used the street for transportation to their institution.

An extra inventory was made to investigate the surrounding properties and how much of the private areas are a part of the green infrastructure today. We used eye measurement and the measurements were therefore approximate. Gardens with a green area consisting of more than 100 m^2 were categorized as a *Large garden*, a garden between 10 m^2 and 99 m^2 were *Medium garden* and vegetational areas below 9 m^2 was categorized as *Small or no garden.*



date, time: yy-mm-dd: **street name:** **appendix:**
weather: **comment:**

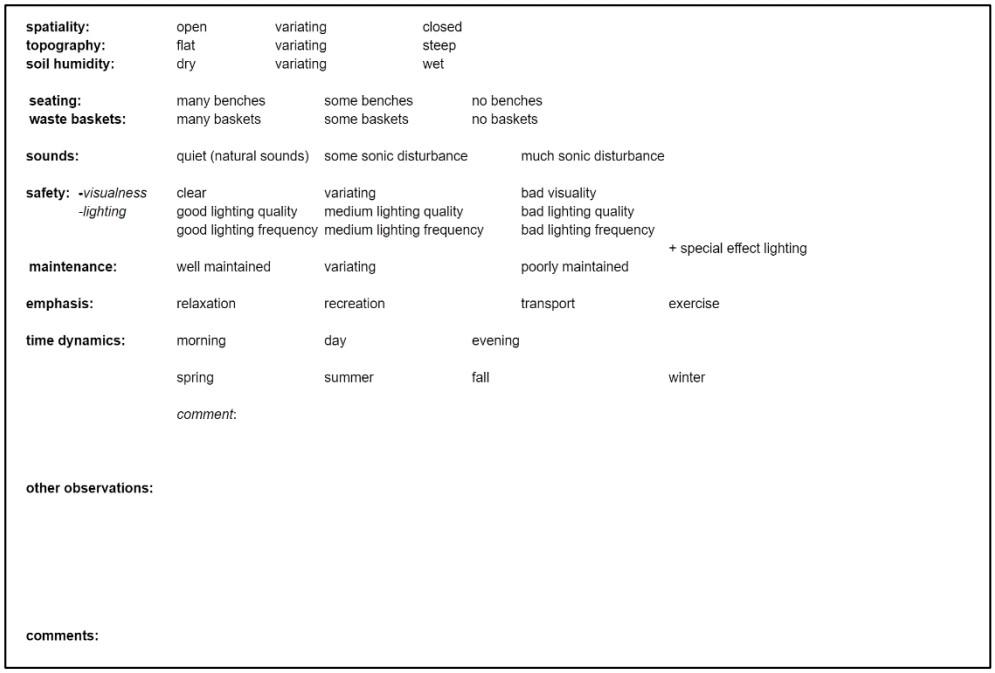
inventory taker: **width:** **length:**

vehicle traffic: /2 min	highly trafficked	moderately trafficked	lightly trafficked	low traffic	one way
pedestrian traffic:	highly trafficked	moderately trafficked	lightly trafficked	low traffic	
sidewalk accessibility:	wide	medium	narrow		
	weelchair accessible	not wheelchair accessible			
	paved surface	paved, stale surface	compacted soil		

difficulty to walk from one sidewalk to another (1 easy, 10 very difficult):

surroundings:	one-family houses	3-6 level houses	7-12 level houses	more than 12 level houses	
	large lawn	gravel playground	football field	bar restaurant	
	open-air seating	bicycle path outdoor gym	indoor gym	basketball court	
	bakery	small shop supermarket	other:		
tree qualities:	many	some	few		
	large trees	medium sized trees	small trees	clipped	
	many species	some species	few species		
bush qualities:	many	some	few		
	large bushes	medium sized bushes	small bushes	clipped	
	many species	some species	few species		
flowering perennials:	many species	some species	few species		
	large area	medium sized area	small area		
lawn qualities:	big area	medium sized area	small area		
	well cut	some maintenance	no maintenance		

Figure 4: Page 1 of the template we used for each street we studied.



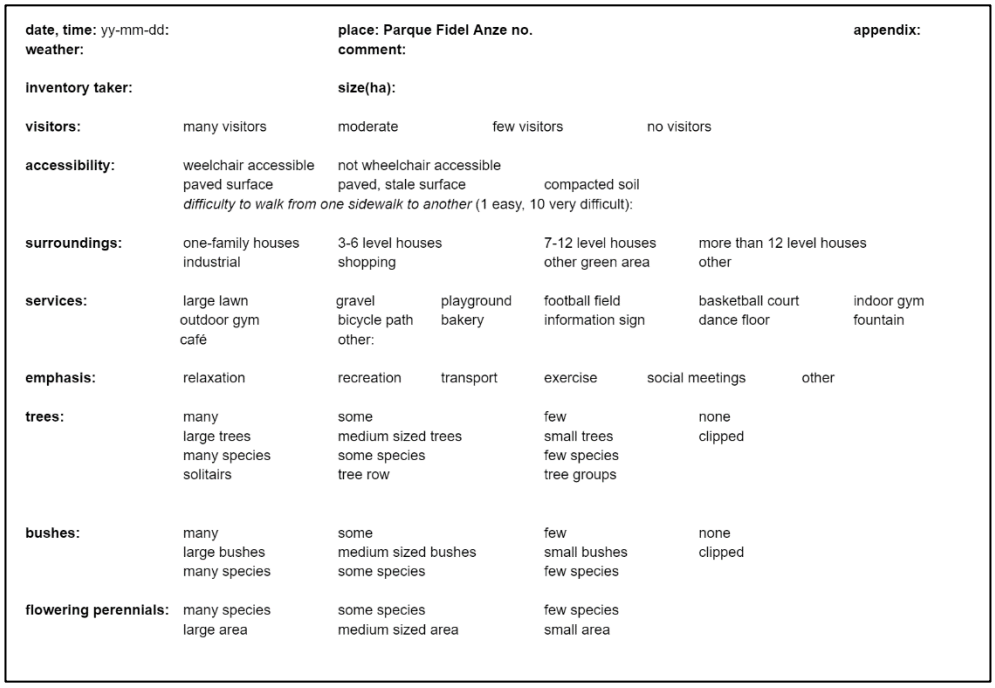
spatiality:	open	variating	closed	
topography:	flat	variating	steep	
soil humidity:	dry	variating	wet	
seating:	many benches	some benches	no benches	
waste baskets:	many baskets	some baskets	no baskets	
sounds:	quiet (natural sounds)	some sonic disturbance	much sonic disturbance	
safety: -*visualness*	clear	variating	bad visuality	
-*lighting*	good lighting quality	medium lighting quality	bad lighting quality	
	good lighting frequency	medium lighting frequency	bad lighting frequency	
				+ special effect lighting
maintenance:	well maintained	variating	poorly maintained	
emphasis:	relaxation	recreation	transport	exercise
time dynamics:	morning	day	evening	
	spring	summer	fall	winter
	comment:			

other observations:

comments:

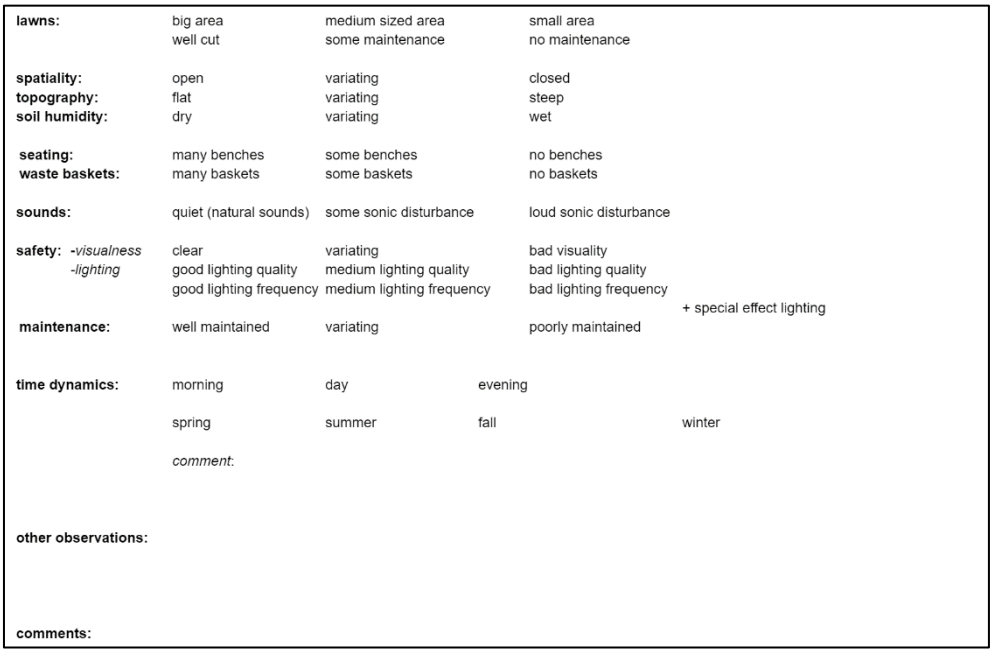
Figure 5: Page 2 of the template we used for each street we studied.

We designed a similar template to classify the biodiversity in Parque Fidel Anze. Since the composition of vegetation and traffic looks different in parks than in street environments. The park was divided into smaller sections to make the results more precise. The primary inventory took place on 24th of April in sunny weather. We conducted two extra inventories to see if the park was used differently from weekdays and to inventory the artificial lighting in the park.



date, time: yy-mm-dd:		**place: Parque Fidel Anze no.**				**appendix:**
weather:		**comment:**				
inventory taker:		**size(ha):**				
visitors:	many visitors	moderate	few visitors	no visitors		
accessibility:	weelchair accessible	not wheelchair accessible				
	paved surface	paved, stale surface	compacted soil			
	difficulty to walk from one sidewalk to another (1 easy, 10 very difficult):					
surroundings:	one-family houses	3-6 level houses	7-12 level houses	more than 12 level houses		
	industrial	shopping	other green area	other		
services:	large lawn	gravel	playground	football field	basketball court	indoor gym
	outdoor gym	bicycle path	bakery	information sign	dance floor	fountain
	café	other:				
emphasis:	relaxation	recreation	transport	exercise	social meetings	other
trees:	many	some	few	none		
	large trees	medium sized trees	small trees	clipped		
	many species	some species	few species			
	solitairs	tree row	tree groups			
bushes:	many	some	few	none		
	large bushes	medium sized bushes	small bushes	clipped		
	many species	some species	few species			
flowering perennials:	many species	some species	few species			
	large area	medium sized area	small area			

Figure 6: Page 1 of the template we used for each segment of the park.



lawns:	big area	medium sized area	small area	
	well cut	some maintenance	no maintenance	
spatiality:	open	variating	closed	
topography:	flat	variating	steep	
soil humidity:	dry	variating	wet	
seating:	many benches	some benches	no benches	
waste baskets:	many baskets	some baskets	no baskets	
sounds:	quiet (natural sounds)	some sonic disturbance	loud sonic disturbance	
safety: -*visualness*	clear	variating	bad visuality	
-*lighting*	good lighting quality	medium lighting quality	bad lighting quality	
	good lighting frequency	medium lighting frequency	bad lighting frequency	
				+ special effect lighting
maintenance:	well maintained	variating	poorly maintained	
time dynamics:	morning	day	evening	
	spring	summer	fall	winter
	comment:			
other observations:				
comments:				

Figure 7: Page 2 of the template we used for each segment of the park.

4.3. Study visits

We conducted study visits around the Tunari Peak and Lake Corani to find native plants and we went to the botanical garden of Cochabamba and four private gardens in different parts of Cochabamba to find both native and exotic plants that can endure and thrive in the dry and harsh Cochabamba climate. Since we found that the perennial and shrub layer was missing in the green corridors around Parque Fidel Anze, we focused most on investigating these because they are so important

for the pollinators and biodiversity. The knowledge about plants we gained through study visits was combined with plant details from the Royal Horticultural Society (Royal Horticultural Society 2019), National parks flora and fauna web from the Singapore Government (National parks, Singapore Government 2019) and a handbook from the municipality of Cochabamba (Acebey et al. 2017). The results of our study visits were displayed in a template (see section 5.7.2. Plant lists).

4.4. Design process

We have taken inspiration from how Pickett et al. (2001) developed the human ecosystem model by combining facts from literature studies to form a model that can be used by municipalities in the Cochabamba department. We combined literature studies with inventories and our meetings to further adjust our results to the Cochabamba area that would contribute to profitable fallout for the ecology of pollinators. By sorting out our ideas by different topics we could form an idea of what we believe a good green corridor should consist which we merged into a conceptual model.

By applying our conceptual model to Calle Potosí, we could visualise what a public green corridor could look like in a Cochabamba street.

5. Results

Through combining the theoretical background information with results from Parque Fidel Anze, five streets and the bikeway we found that ecosystem services, ecosystem health as well as human health parameters were especially important in order to look at when developing the large network of green infrastructure. These parameters indicate where a green area is most needed, and which functions it should contain. We constructed a conceptual model for green infrastructure that can be used when investigating areas for urban planning which tells which aspects must be taken into consideration when planning green areas in urban environments. We also constructed a conceptual model for green corridors that shows us the importance of combining a well-planned green area with smart traffic solution and education of the people that is working with green environments, both gardeners and planners. Our inventory results and conceptual models are presented in this segment, as well as lists with perennials and bushes that are especially suited for the Cochabamba region.

5.1. Results of inventories

We investigated the park Parque Fidel Anze and five streets that are connected to the park. We also investigated a part of the bicycle lane, Ciclovía, that passes along the side of the park. We found that the streets had a large quantity of trees, but the tree pits consisted often of compacted soil or short cut grass. None of the streets had any perennials planted in the public area and the few bushes we found were

very small and clipped. We wanted to further investigate one street to see if any specific changes could do to enhance biodiversity. We chose Calle Potosí because of its poor biodiversity conditions that makes it a barrier between two parks with high biodiversity. Of the streets we inventoried Calle Antonio Quijarro could in a similar way be modified into a better green corridor, but with another park being located only one block away we felt that Calle Potosí is in greater need of a reconstruction.

Figure 8: The five streets we inventoried are marked with red dots, the two streets we used in the pilot study are marked with brown dots.

5.2. Parque Fidel Anze

Parque Fidel Anze is located between Queru Queru and Tupuraya, north of the city centre. It is one of the biggest parks in Cochabamba with an area of 5,6 hectare. The surrounding buildings are variating between 1 and 10 storeys with some cafés and restaurants. The park has high maintenance with gardeners working there almost every day, cutting grass, weeding and take away any fallen leaf and the grass cut.

The park is divided by five streets which divides the park into smaller segments that has different areas of use, and these parts have different design and functions.

The two western parts have a large playground, water facilities, football and basketball fields and an outdoor gym. The vegetation variates with many medium sized areas of perennials and small bushes and different compositions of trees, which creates an open space. These areas are mainly used for activity, with many families and kindergartens visiting the playground and young people using the sport facilities. There are many benches to sit on.

The third fragment is closed for public use with high fences. This was for a short time a football field, but after some lobbyism from the neighbours of the park the area was replanted with a mixture of different trees, all with a maximum age of two years. There is no perennials or bushes planted.

The middle segments have a different design than the western parts, with fewer perennial and bush patches which contained fewer plant species. The main function of this part is social meetings and recreation, with many visitors relaxing on the

grass in the shade of the large trees. There are some benches, many integrated with the brick perennial plantings. Some trees were dead.

The eastern segments solely consist of short cut grass and trees. No perennials or bushes, nor benches to sit on. These parts of the park are mostly used as a transport routes for pedestrians and runners, and they are also used by dog owners taking their dogs on a walk. Not as many people stay in here to relax on the grass as in the other segments of the park.

During our two extra inventories during the weekend we found that the western and middle segments were used even more frequently compared to the eastern parts.

5.3. Surrounding properties

42 plots were inventoried and there were no buildings with 4, 5, or 7 levels in the investigated area and are therefore not put in the chart below. The large and medium gardens are only connected to buildings with 1,2 and 3 floor levels. Buildings that have 6 floor levels or more constitutes the only amount of small or none gardens in the specific plot area.

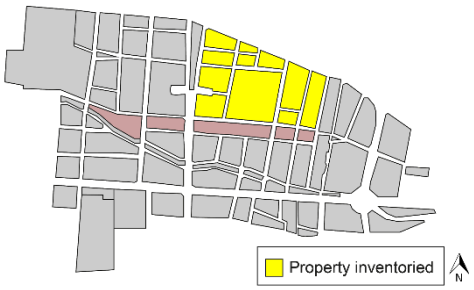
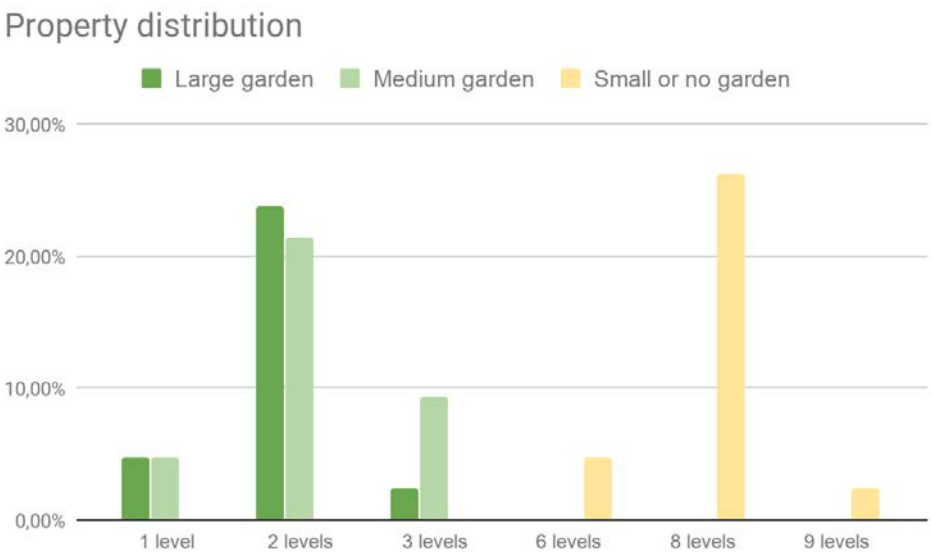


Figure 9: The area investigated during our surrounding property inventory.

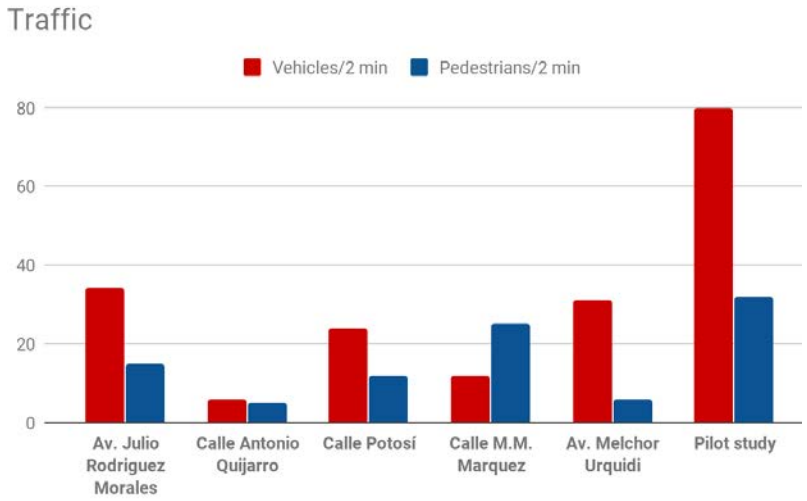


Graph 1: The distribution of land property in a neighbourhood north of Parque Fidel Anze.

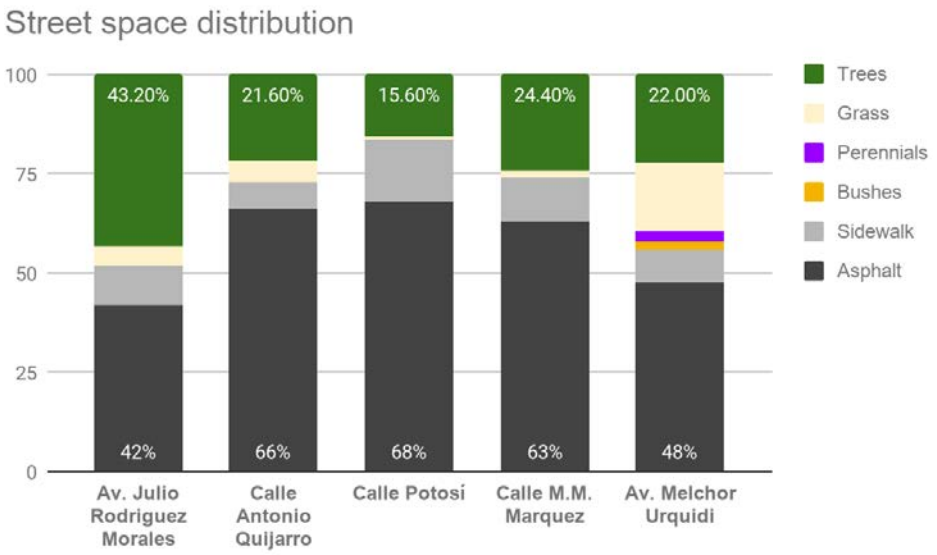
5.4. Streets

The inventory that were made of the selected streets to Parque Fidel Anze shows a small variety in results. The first diagram that is listed below display the traffic of vehicles (red staples) and pedestrians (blue staples) with in a duration of 2 minutes per transport. The size of the streets does not tend to have any specific influence of the number of vehicles and pedestrians. For example, Calle Potosi which is a small street with a section of one-way traffic had more vehicles per 2 minutes than Calle M.M. Marquez which is a bigger street and with nearby city parks and a big university. All the streets were inventoried around 10-11 PM.

The second diagram show the street space distribution of every specific street that has been inventoried. Asphalt and paved surfaces obtain nearly or more than 50% of all the street space distribution. Avenida Julio Rodriguez Morales has the most equal percentage of green and hard surfaces where the asphalt and trees obtains nearly the same percent of the street. The green space in nearly all streets had an imbalance of vegetation levels. As the diagram shows, trees dominate the green spaces in every street and that there is a big lack of bushes and perennials. There is one exception which is Avenida Melchor Urquidi where there was a variation of vegetation levels, but this outcome had to do with an old and dry water channel which had no maintenance and was overgrown.



Graph 2: The diagram above shows the traffic abundance of the streets we have inventoried, and Avenida America



Graph 3: The space distribution of the streets shows that only one of the streets we inventoried had any perennials. The asphalt and paved surface make up more than half of the street surface.

5.4.1. Calle Potosí

Calle Potosí is a 1400 meters long street located between the big avenues Avenida Uyuni and Avenida Circunvalación and crosses Avenida America, another big avenue. It passes along one of the ends of Parque Fidel Anze and a big semiprivate park, Centro Simon I. Patiño. The surroundings are variating, with a mixture of one-family houses and up to 12 storey buildings. The street level contains many different businesses as cafés, restaurants and shops.

The vegetation variates with a coverage between 8% and 25% between blocks, consisting mostly of small and some medium-sized trees.

5.4.2. Ciclovía

The bicycle lane has many great assets, but the installation around the city centre and not through it keeps people from using bicycles as primal means of transportation. It is a detour for anyone wanting to travel downtown by bike. During our two-minute traffic inventory we were passed by 8 pedestrians and 0 cyclists. Out of a biodiversity view this has two perspectives; (1) that the bicycle lane could provide a sanctuary for the insects and hummingbirds to travel around the city undisturbed since there is only few people using the Ciclovía and (2) that if this few people are travelling by bike they must be travelling by another mean of transportation. Many people are travelling by vehicles that uses fossil fuel which is polluting the environment which is not providing a profitable situation for the pollinators.

5.5. Design Process

5.5.1. Conceptual models

Through combining the literature studies with the information gained at our meetings we could construct tentative conceptual models of green infrastructure and green corridors. These models have many more dimensions than presented in

this thesis and should therefore not be looked upon as a comprehensive description, but merely a first attempt towards describing of the complexity of planning green infrastructure Cochabamba.

In Figure 10 we have gathered a selection of parameters to look at to know where a green network needs to be developed. The urban planners need to be aware of ecosystem health and ecosystem services parameters since because the animals who live here cannot speak for themselves. Human health parameters are often overlooked when developing green infrastructure, but they are important guidelines to show where parks and good traffic is needed. Parks should not only be a place to keep the property prices up, but to be looked on as an investment in inhabitant health and as a home for many animal species.

Conceptual model of Green Infrastructure

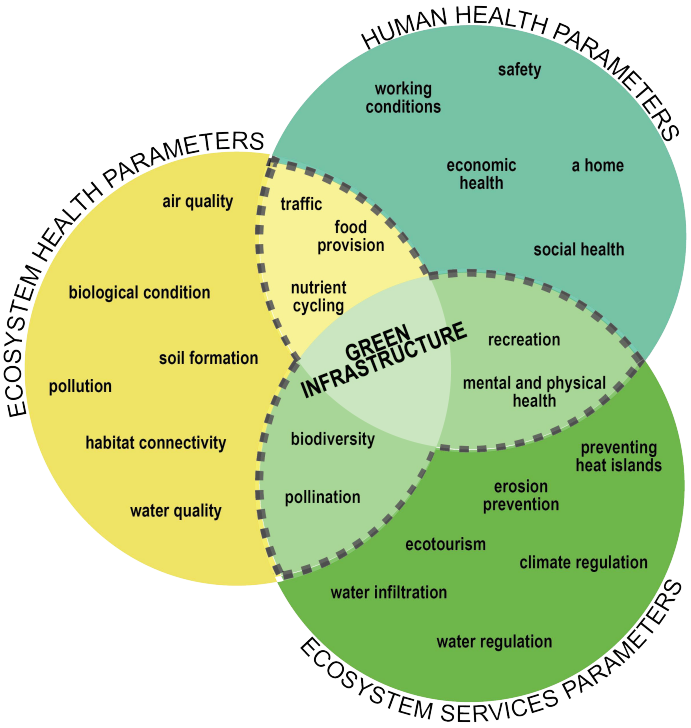


Figure 10: A model constructed by us to illustrate the complexity aspects to keep in mind when developing a green infrastructure. This is a tentative model that only illuminate aspects that are essential in the planning of creating a working green infrastructure: ecosystem services, ecosystem health as well as human health parameters. Everything within the dotted lines are a part of the green infrastructure.

The conceptual model of green corridors (Figure 11) are the parameters to look at once the specific areas for development are defined from using the green infrastructure model. It is important to look at the distinguishing characteristics at each site and we could pinpoint three aspects that are especially necessary to take into consideration. The green corridors at the site need to connect larger green areas. Preferably it should join a larger network of green corridors connecting the rural areas surrounding the city. The traffic should be carefully planned to develop

streets that promotes other transportation means than fossil fuelled ones. This would lead to less pollution, better health in human and animal species and promote pollination. The third and perhaps the most important aspect of developing a good green infrastructure is educating the people that work with green areas, both planning and maintenance to ensure that both plant, animal and abiotic species has good living conditions.

Once the basics of a green corridors and infrastructure are portrayed the design process can start. Base the design on the conditions of the site, using knowledge about plants to increase or reduce these conditions to create a civilised environment.

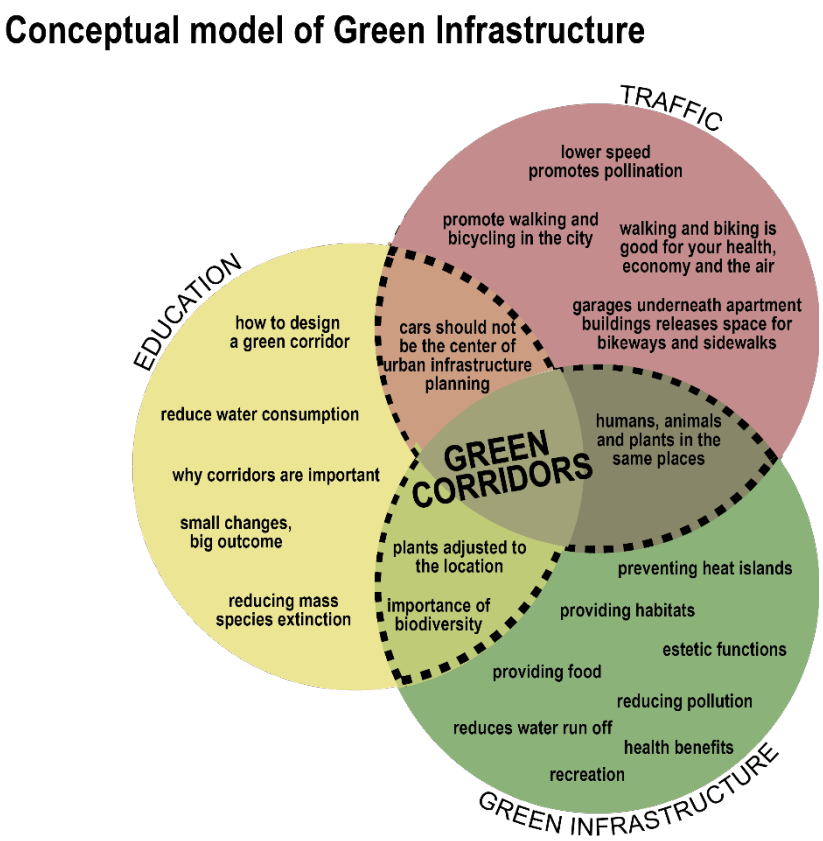


Figure 11: Green corridors are one part of the green infrastructure that is presented in the conceptual model in Figure 10. The overlapping areas within the dotted lines display what encompasses green corridors in Cochabamba.

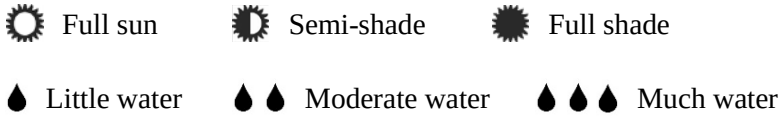
5.5.2. Plant lists

Through study visits we constructed two templates with plants suited for the Cochabamba climate. These lists are a collection of base plants that can be used by municipalities and companies when planning green areas in the Cochabamba region.

These tables contain plants, all suited for plantings in Cochabamba, with variating attributes. The first column contains the Latin name which is the universal plant name. The second column contains the English name. The third

column contain the plant details which explains what soil conditions the plant prefer and how tall it will become when full grown.

The icons below describe preferred sun and water conditions:



The first table is a list of shrubs.

The second table contain many perennials, but also some bulbs and cactuses to provide a variety of flowers and to keep the flowering seasons spread out over the year. Native plants are marked with * and should be primarily used because these plants are specifically adapted to and thrives in the Cochabamba climate.

Latin name	English name	Plant details
Adesmia miraflorensis*	adesmia miraflorensis	Dry soils. 0.3-0.7 m tall.
Baccharis salicifolia*	seep willow	Dry soils. 0.8-2 m tall.
Bougainvillea spectabilis*	bougainvillea	Well drained soils. 4-8 m tall.
Brunfelsia pauciflora	yesterday-today-and tomorrow	Well drained soils. 0.6-3 m tall.
Buddleja davidii	butterfly bush	Well drained soils-moist soils. 3 m tall.
Buddleja tucumanensis*	buddleja tucumanensis	Well drained-sandy loam soils. 3 m tall.
Callistemon speciosus	bottle brush	Well drained-sandy loam soils. Up to 8 m tall.
Cestrum parqui*	willow-leaved jessamine	Well drained soils-fertile loamy soils. 0.9-3 m tall.
Duranta erecta*	golden dewdrop	Well drained soils. Up to 5 m tall.
Hippophae rhamnoides	sea buckthorn	Dry soils-sandy and saline soils, 3-5 m tall.
Nerium oleander	oleander	Well drained soils. Up to 6 m tall.
Pyracantha coccinea	firethorn	Well drained soils. 1-1.5 m tall.
Spartium junceum	spanish broom	Sandy loam soils - well drained soils. 1.5-2.5 m tall.
Spiraea japonica	japanese spirea	Well drained soils. Up to 1.5 m tall.

*=Native plants

Table 1: Suitable shrubs for the Cochabamba region

Latin name	English name	Plant details
Agapanthus africanus (B)	african lily	Sandy loam soils - well drained soils. 0.5-1 m tall.
Aloe vera* (C)	aloe vera	Sandy-well drained soils. 0.5-1 m tall.
Aloysia citrodora* (P)	lemon verbena	Well drained soils. 1.5-2.5 m tall.
Bergenia crassifolia (P)	elephant ears	Well drained soils. 0.1-0.5 m tall.
Bryophyllum fedtschenkoi (C)	lavender scallops	Dry soils. 0.1-0.3 m tall.
Centropogon nigricans* (P)	centropogon nigricans	Well drained-moist soils. 0.3-0.7 m tall.
Cortaderia rudiuscula* (P)	pampas grass	Sandy loam soils-well drained soils. 1.5-2.5 m tall.
Dennstaedtia bipinnata* (P)	cuplet fern	Well drained-moist soils. 0.5-1 m tall.
Echinacea purpurea (P)	purple coneflower	Well drained soils. 0.5-1 m tall.
Echinopsis huottii* (C)	echinopsis huottii	Dry soils. 0.1-0.2 m tall.
Hemerocallis fulva (P)	common orange daylily	Moist well drained soils. 0.5-1 m tall.
Hippeastrum pardinum* (B)	hippeastrum pardinum	Well drained soils. 0.1-0.5 m tall
Iris germanica (B)	bearded iris	Sandy-well drained soils. 0.5-1 m tall.
Lantana balansae* (P)	lantana balansae	Well drained soils. 1-1.5 m tall.
Lantana camara* (P)	yellow sage	Well drained soils. 1-1.5 m tall.
Lavandula angustifolia (P)	lavender	Dry-well drained soils. 0.1-0.5 m tall.
Malva alcea (P)	greater musk mallow	Well drained soils. 1-1.5 m tall.
Opuntia cochabambensis* (C)	opuntia	Dry soils, 0.5-1.5 m tall.
Pisoniella arborescens* (P)	pisoniella arborescens	Well drained soils. 0.1-0.3 m tall.
Salvia leucantha (P)	mexican bush sage	Well drained loam soils. 1-1.5 m tall.

Stachys byzantina (P)	lambs' ear	Sandy dry soils. 0.1-0.5 m tall.
Thunbergia grandiflora (P)	bengal clock vine	Well drained loam soils. 4-8 m tall.
Verbena bonariensis* (P)	purpletop vervain	Well drained soils. 1.5-2.5 m tall.
Zinnia elegans* (P)	zinnia	Well drained soils. 0.1-0.5 m tall.

*=Native plants (P)=Perennials (B)=Bulbs (C)=Cactus/Succulents

Table 2: Suitable perennials, bulbs and succulents for the Cochabamba region



Figure 12: Hummingbird and Aloe Flower (Grayson 2017).
Figure 13: Monarch on Verbena Bonariensis (Dwight Sipler 2007).
Figure 14: Diggin' (Christoph Zurnieden 2015).

Different flowers attract different kinds of pollinators. All pictures have been cropped.

The plantings get more resistant towards weeds when using perennials like *Stachys byzantina* that cover the soil and block out sunlight. This way of planting reduces encroachment of weeds which could reduce the need of maintenance in the park.

5.5.3. The case of Calle Potosí

We applied all the knowledge we have gained through dialogues and literature studies to the street Calle Potosí to visualise how a good green corridor could look like in Cochabamba.

Calle Potosí is a long street and therefore we only focused on a small segment to connect Parque Fidel Anze with park Centro Simon I. Patiño. A small adjustment would be helpful for the pollinators. This small change could be enough during the time the municipality needs to plan how to redirect traffic in turn to create an even greater green infrastructure combining Centro Simon I. Patiño with Parque de Educación Vial that is in the south end of Calle Potosí.

In our visualisation we lowered the speed by placing tree pits in the street to make it difficult for vehicles to drive fast through the street. We also changed the paved surface from asphalt to tiles to make drivers aware that they are on

pedestrians' territory. It is possible to keep some of the paved surface as a bikeway to promote the usage of alternate vehicles.

We wanted to create an environment that promotes pollination and created a layered greenery with a mix of perennials, bushes and trees with rich flower abundance.

Figure 15. Calle Potosí today, May 2019.
Figure 16. Our visualisation of Calle Potosí. A calm street environment with flower abundance that promotes pollination.

6. Discussion

In the following segment we are discussing the methods and materials used in this thesis. Furthermore, a reflection of the results gained from different parts of this study and our thought on future possibilities and issues. The research questions of this thesis are answered in the last section of this segment.

6.1. Methodology

6.1.1. The Site

In this thesis we discussed the area of the municipality and not the department Cochabamba, even though our model could be applied in other parts of the department of Cochabamba as in other regions of Bolivia with similar conditions. We believe that we would get similar results if we would have inventoried a similar park of Cochabamba. Since we chose the biggest park of the city and it was surrounded by many smaller parks and plazas, we believed that this site would have the best prerequisites to have good conditions. Since the conditions could

have been better in terms of biodiversity, our results indicate that the green infrastructure could be even worse in other areas of the city.

6.1.2. Literature Study

We are aware that we only had time to read a handful of articles about pollinators, green infrastructure and the other topics mentioned in this thesis and it is possible that articles with different results than ours may exist. Through our gathered experiences, our education and with articles from unconnected sources from all around, we believe to have grounded this thesis on true evidence.

We could only rely on literature to provide information of which pollinators exists in Cochabamba. We can therefore not be totally sure that we have thought of all pollinators in the city, since our literature may be poor and leave out essential species. Our education in ecology and the many articles we have read during the literature study all point in the same direction; that a good green infrastructure provides greater possibility for pollinators to survive and thrive in the city than a poorly planned one. Even though one pollinator species may prefer one flower shape over another, the facts show that floral abundance is necessary for all pollinators and that a variety of flowers benefit most pollinators.

Our approach has been a landscape architectural one and we have therefore been not been focusing on the economical aspect of green infrastructure. We can see financial gains as a result of improved planning of the green structures, but we leave the exact numbers for the economists to calculate.

There are some topics that we are aware of that affects the ecosystems in the city, but that are not discussed in this thesis. Such topics are the impact of wind, altered light, usage of pesticides and other chemicals. There are plenty of research from other parts of the world that refer to these problems and we therefore found no need to further investigate those issues in this thesis.

Using Google Earth may not have given us the best geographic information, but it is that program that is used at CEPLAG and the only geographic program with information about Cochabamba we could get hold of. We estimated rough numbers of vegetation coverage since we did not have access to geographic information systems which made our numbers imprecise. Even with roughly estimated numbers of vegetational distribution the numbers indicate that the impervious surfaces are dominant in street environment.

6.1.3. The inventories

We could not use an existing method for inventorying because of the limited usage of these kinds of investigations in our area of investigation. We had therefore no other option than to construct our own method with distances and measures that we found fit. This led to many discoveries that are important in the eyes of Europeans, but we may have overlooked some aspects that are essential in Bolivia.

Our inventories did not only involve the biodiversity of the green areas but also social aspects and usages, which can seem to be irrelevant. We believe that all places should be available for both humans and animals which introduces the risk of pollinators, for example bees, nesting nearby areas with a lot of human activities as playgrounds and we therefore found reason to investigate the usages too.

We could have done a more thorough selection of which blocks to investigate, but the limited time made us preform a fast selection. We do not believe that we would get a much different result by inventorying other blocks on the same streets.

6.2. Parque Fidel Anze

We found that the trees in the eastern parts of Parque Fidel Anze were not as big nor did they provide as much shadows as the trees in the central parts of the park. This could be one of the reasons why the visitors were so few in these segments. We do not know if this is a consequence of bad planning or due to a tree sickness, but we believe that if the municipality would start planning ahead and plant trees continuously the new trees could grow big before the old ones had to be cut down.

The newly planted trees in the restricted area were very small, none more than two years which is causing a risk that they might never grow and become large trees since there is no large trees in the area providing shading protection. This might be because of a restricted budget that a larger tree is more expensive to purchase and plant. We do not know if a potential diminish of trees was in the calculations when planting these trees so that the number of adult trees is going to be enough for this segment, or if this is a result of poor knowledge. We suggest that a variety of age and size among the trees, and preferably at least 2 years old in future new large scale plantings to restrict the amount of time that the segment have to be closed off from public use and secure that fewer of the newly planted trees will die.

The eastern segments did not have any bushes or perennials, which can be one of the reasons fewer visitors stayed in these parts. The low disturbance in this area indicates that these segments could provide better habitats for pollinators than the western segments that had sport facilities and a large playground. More plantings with large floral abundance would increase the quality for pollinator nesting spots and in the same time enhance the beauty of the site. This could lead to more people visiting these segments and to avoid disturbance some elements as benches that indicate slow activities should be added to the spot. This could enhance the possibility of harmony between visitor and pollinator.

6.3. The streets

The streets we inventoried between Parque Fidel Anze and nearby parks all had some trees in the sidewalk, only one of them had any perennials, annuals and bushes. The many trees are providing shade and the cooling effect on the street environment is tangible which is good for all creatures existing in that environment. The lack of low vegetation is creating a dangerous zone for pollinators that cannot hide in short cut grass or on pavement. They are in large danger of predators, and there is a greater risk that the pollinators will exhaust themselves running out of water and energy supply before they reach a destination with these assets (Söderström & Hedblom 2007). A larger tree pit would enhance the prosperity of the trees as more storm water would run down the pit and at the same time enhance the biodiversity at ground level.

Another big problem with the street structure is that no streets are free from cars which is creating a polluted atmosphere with high speed dangers everywhere, so that the pollinators have to seek private gardens for refuge (Chaves et al. 2016). These results suggest that something must be done not only with the green infrastructure, but that the traffic that surround it needs to be restructured too. The many cars parked in the streets would be better off parked in garage levels below the large buildings. We believe that a law requiring every new building to provide

one indoor parking for every apartment built would disembarrass a lot of space that can be used for wider sidewalks and larger plantings.

6.4. Calle Potosí

We believe that parts of Calle Potosí could be made into pedestrians' priority spaces. With a safe traffic environment, parents could let their children walk alone to school at a younger age which is beneficial for the child's development. This could lead to fewer having to drive their car in order to drop off all their kids, which would have many positive effects such as better air quality which is especially important in Cochabamba. Car traffic would be diverted onto other streets which influences the movement in the surrounding area which could have other effects. With a reduce of speed intensity, it would be easier to insert larger plantings along the street without the risk of developing ecological traps.

6.5. Ciclovía

The development of Ciclovía has large potential of becoming a great green network corridor if the municipality focuses on the many large coherent plantings that surround Ciclovía today. Even better would be if perennials and bushes were planted in the plantings rather than grass. Perhaps more people would be motivated to travel by bike if the municipality replaced the grass with different perennials, annuals and bushes, making the Ciclovía into a beautiful experience.

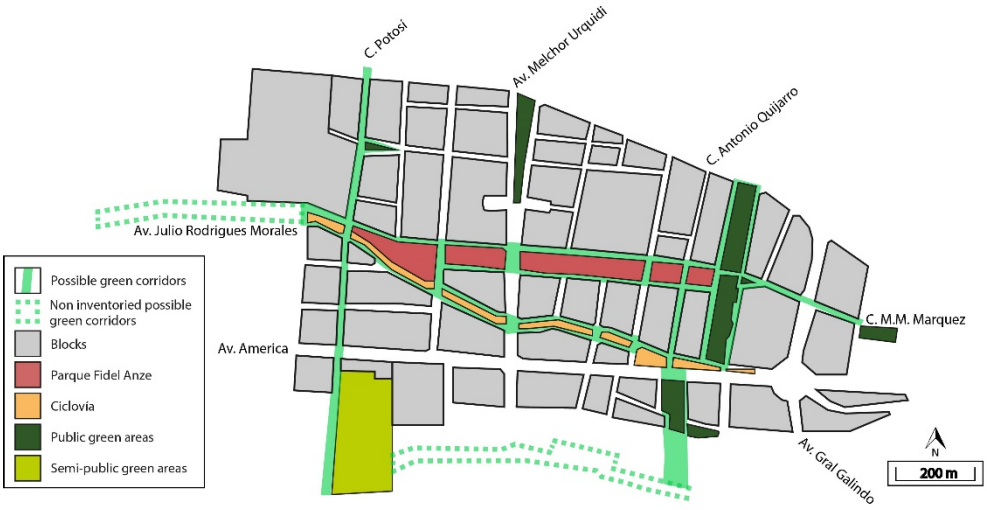
During the development of Ciclovía, some links between outer zonas and downtown should be cut off from motor driven vehicles. This would force cars to take detours to get into the centre of the city creating an environment where people prefer walking or taking bicycle because it would be faster. If more people would choose these means of transportation it would bring many positive effects, such as better air quality and improved health and in the same time provide a safer environment for pollinators.

6.6. The Green Infrastructure

The most critical issue of the public green corridors was the lack of a layered greenery. None of the streets in our area had deliberately planted perennials and scarcely any bushes. As Söderström & Hedblom (2007) described in their article that a variating greenery is essential for a functioning green infrastructure. Ecological hotspots need to be combined through a network with variations of landscape and floral compositions (Goulson et al. 2008; Su et al. 2015). The private gardens near Parque Fidel Anze are today providing such network. We found a relation between large and medium sized gardens and buildings with 1, 2 or 3 floor levels. These houses had a big variety in plant species and flower diversity and the maintenance are not as strictly done as in the small gardens at the front of the big apartment buildings, which only had a small, if any, green patch in front of the building. When the small houses disappear as the city densifies, the large gardens surrounding these houses will disappear too and the large network of layered greenery will go with it. The medium and large sized gardens are creating a green mosaic pattern of stepping stones throughout most parts of Cochabamba and they

are a great asset for the wildlife. Either something must be done to prevent these plots from being converted into larger apartment buildings or the network of gardens must exist somewhere else, for example in the streets.

Söderström & Hedblom (2007) writes that a linear, narrow green area between two biodiversity hotspots should not be too similar to the natural habitat of pollinators since it is not good for animals to make the corridor into their territory and it is therefore it is not wise to provide too good environments in the green corridors. Even though focus should be on large floral diversity inside the parks, some floral diversity is required in the corridors too, especially in a city like Cochabamba where the parks are small and with low diversity of flowering plants. With more floral shapes and sizes to entice different kinds of pollinators the chances for successful transportation between parks would be iThe parks of Cochabamba have many aesthetic details, but we believe that the high maintenance may be creating an environment where many pollinators have a hard time finding



flowers and places to build nests here too since all grass cut, sticks and fallen leaves are raked away. Our suggestion is more plantings with seasonal dynamics in every park, and every part of the parks to generate a lively environment where different flower species take turns of dominating the planting throughout the year. Since perennialughout the year. Since perennials are not much used in Cochabamba, only few people have any knowledge about these plants. The knowledge about the many benefits for pollinators they bring is even more limited. The details in the list of perennials from this thesis should provide knowledge about where to place plants in order to minimise maintenance.

Figure 17: A map over the streets that we have inventoried and that we believe could become a part of a green infrastructure net in Cochabamba. The dotted lines are streets that we have not inventoried but visited and believe could become converted into green corridors too.

Many surrounding streets in the area had similar conditions to the streets we inventoried, and we believe that some of these had possibilities for increasing the biodiversity and becoming green corridors. Avenida Portales and Zenon Salinas in south as well as the continuation of Ciclovía are marked with green dots in figure

17 could become green corridors which could be the start of the larger green infrastructure network.

The only street we inventoried that had some layered greenery, Avenida Melchor Urquidi, was not equipped for transformation into a green corridor because of the heavy traffic. As described in Figure 11, the traffic is a large part of making the green infrastructure functioning.

Interesting enough we found that bee abundance did not increase with increased floral abundance if the temperature was too high (above 27°C) according to the studies made by Frank et al. (2018). This indicates that the many trees that are counteracting the urban heat islands in Cochabamba today should be highly valued and well preserved.

6.7. Study visits

The different urban structure in the many zonas of the city makes it hard to immediately apply our concept of green corridors in all zonas. The fact that the green areas are fewer in the southern and the northern parts compared to the central parts makes it especially difficult to connect these in a continuous public green infrastructure. One neighbourhood can provide many different micro zones and when planning green corridors, you need to look at the attributes at each site. It is important to develop a functioning green infrastructure in the northern and southern parts as we can imagine a future as these areas will get densified too.

There is always a risk of creating ecological traps when designing green corridors. One of our biggest concerns when developing green infrastructures in Cochabamba is the risk of luring pollinators into the traffic and as Chaves et al. (2016) found there is a lower pollination near high speed streets, probably because many pollinators die. We therefore think that creating green corridors and to evolve a different street network than the one existing in Cochabamba today are closely linked together and should be planned at the same time. It is important to explore the possibilities of limiting traffic along important dispersal pathways between biodiversity hotspots in the city.

FOur suggestions consist of using plants that require maintenance. This is a cost for the municipality, but the cost of n municipality, but the cost of not having pollinators in the future will be much higher. The increased the levels of health in inhabitants could give more people the chance to work a few more years when they are old, thus creating more income to the municipality through taxes.

If nothing is done with the green infrastructure and the densification proceeds there is a high risk of inbreeding of the animals in the city because they can only move in certain areas. Questions that would be interesting to study are “How is the traffic in Cochabamba affecting pollinators?” and “Which applicability do our conceptual model of green corridors have in other areas of Cochabamba and other cities in Bolivia?” to further investigate how the green infrastructure can be developed.

6.8. Conclusion

Do green corridors exist and how are they designed in the public area in and between parks in Queru Queru, Cochabamba?
Through our research of what good green corridors and infrastructures should contain and by comparing these facts with inventories we found that this area in Cochabamba did not have a well-functioning green infrastructure from the view of pollinators. The streets were mainly paved with trees in small tree pits that contained grass or no vegetation in the lower greenery layer. The regions Queru Queru and Tupuraya are today very dependent of the private gardens as transportation routes for pollinators. These gardens are being replaced with large apartment buildings with a small or no garden through the ongoing densification of the city.

How can conditions for biodiversity in green corridors to Parque Fidel Anze be improved?
Our literature study showed that a layered greenery is necessary for the biodiversity in the city, our inventories showed that this was missing in Queru Queru and Tupuraya in Cochabamba. We need to change the tradition of not using perennials in street environments and that the gardeners need to learn which plants to use at different sites. The lists on page 28 and 29 in this thesis present safe plants to use in Cochabamba. They should be used as a starting foundation and should be expanded by the gardeners and planners of Cochabamba as new knowledge emerges by trial and error. Some streets should be pedestrians' and bicycles priority space so that fewer pollinator species get killed in traffic.

How can the green infrastructure in Cochabamba be improved?
To secure the dispersal of pollinators in and through the city of Cochabamba in the future, a network of low speed traffic with layered greenery that connects all parks must be developed. Education in both urban city planners and gardeners is a huge part of enabling this change. With the ongoing climate change we believe that urban areas all over the world need to rethink their way of planning green infrastructure and realize all the possibilities that healthy ecosystems in the cities has. The municipality should recognize the connection between urban development and ecology, and that the government need to create a green infrastructure in order to be prepared for the ongoing densification of the cities.

Reference list

Acebey, J., Arzabe, R., Ávila J.E., Cabrera, M.E., Claros, S.T., Lacunza, M.P., Pinto, L., Saavedra, D., Stroobandt, K.L., Villarpando, S. (2017). Plan Maestro de Forestación y Reforestación Municipal (PMFOR). *Manejo integral del arbolado municipal en Cochabamba.* Cochabamba: Gobierno de la Ciudad.

Aguirre, L.F., Navarro, G., Maldonado, M., (2015). Biodiversidad, Ecología y Conservación del Valle Central de Cochabamba. *Centro de Biodiversidad y Genética (CBG)* Cochabamba: Universidad Mayor de San Simón.

Alberto H. Abrahamovich & Norma B. Díaz (2002). Bumble bees of the Neotropical region (Hymenoptera: Apidae). *Biota Colombiana*. [Online] 3 (2). Available at: https://doaj.org/article/ed77309700db441db2a1fc27eb68fbfc. [2019-05-01]

Beier, P. & Noss, R.F. (1998). Do Habitat Corridors Provide Connectivity? *Conservation Biology 12* (6) p.1241–1252. DOI: 10.1111/j.1523-1739.1998.98036.x

Brown, M.J.F. & Paxton, R.J. (2009). The conservation of bees: a global perspective. *Apidologie*, 40, 410–416.

C/O City (2014). *Ekosystemtjänster i stadsplaneringen - en vägledning*. [Pamphlet] Stockholm: C/O City. Available at: https://hallbarstad.se/cocity/wp-content/uploads/sites/121/2018/02/Ekosystemtj%C3%A4nster-i-stadsplaneringen.pdf [2019-05-06]

Callejo, I.D., Cerruto, N., Chila, G., Encinas, S., Jonsson, A.C., Kumar, A., Rani, A., Rydhagen, B., Wilk, J., (2018). Assessing vulnerability in Cochabamba, Bolivia and Kota, India: how do stakeholder processes affect suggested climate adaptation interventions? International Journal of Urban Sustainable Development. [Online] 10 (1), 32–48. DOI:10.1080/19463138.2018.1436061

Chakraborty, A. & Wilson, B. (2013). The Environmental Impacts of Sprawl: Emergent Themes from the Past Decade of Planning Research. *Sustainability 2013*. 5 (8), 3302–3327. [Online]. DOI: 10.3390/su5083302

Chaves, R.S., Dargas, J. H. F., Fischer, E., (2016) Pollination of lark daisy on roadsides declines as traffic speed increases along an Amazonian highway. Plant Biology. [Online] 18 (3), 542–544.

Cochabamba, Bolivia (2018) *Comunas, distritos y zonas de Cochabamba*. http://cochabambabolivia.net/comunas-distritos-y-zonas-de-cochabamba [2019-05-05]

Cochabamba, Gobierno de la Ciudad (2016). *PROYECCIÓN DE OBRAS*. Available at: https://www.cochabamba.bo/application/municipio/proyectos [2019-05-02]

Compagnucci, L. A. & Roig Alsina, A. (2012). A new species of Brachyglossula Hedicke with a remarkable morphology of the first metasomal tergum (Hymenoptera, Colletidae). *Revista del Museo Argentino de Ciencias Naturales, Nueva Serie* 14(2):357-362. DOI: 10.22179/REVMACN.14.205

De Vos, J.M., Joppa, L.N., Gittleman, J.L., Stephens, P.R., Pimm, S.L. (2014). Estimating the normal background rate of species extinction. *Conservation Biology 29* (2) 452-462 DOI: 10.1111/cobi.12380

Eco, U. (2015). How to write a thesis. 1. ed. Cambridge, Massachusetts: MIT Press

Fenton, M. Brock (1983). *Just Bats [Elektronisk resurs]*Fowler, R.E., Rotheray, E.L., Goulson, D., (2016). Floral abundance and resource quality influence pollinator choice. *Insect Conservation and Diversity*. [Online] 9 (6), 481–494. DOI: 10.1111/e] 9 (6), 481–494. DOI: 10.1111/icad.12197

Frank, S.D., Hamblin, A.L., Youngsteadt, E., (2018) Wild bee abundance declines with urban warming, regardless of floral density. *Urban Ecosystems*. [Online] 21 (3), 419–428.
Goulson, D. (2009). Bumblebees: Behaviour, Ecology, and Conservation, Oxford University Press. Available at: http://ebookcentral.proquest.com/lib/slub-ebooks/detail.action?docID=472276 [2019-05-01]
Goulson, D., Lepais, O., O'Connor S., Osborne, J.L., Sanderson, R.A., Cussans, J., Goffe, L. & Darvill, B. (2010). Effects of land use at a landscape scale on bumblebee nest density and survival. *Journal of Applied Ecology 2010.* DOI:10.1111/j.1365-2664.2010.01872.x
Goulson, D., Lye, G.C. & Darvill, B. (2008). Decline and conservation of bumblebees. Annual Review of Entomology, 53, 191–208. [2019-04-10]
Handbook of the Birds of the World (2018). Species with materials recorded in Cochabamba. Available at: https://www.hbw.com/ibc/geo/29993/species [2019-04-30]
Hernandez, J., Pérez-Hernández, C.G., Saura, S., Vergara, P.M., (2015). Do corridors promote connectivity for bird-dispersed trees? The case of Persea lingue in Chilean fragmented landscapes. *Landscape Ecology*. 30 (1), 77–90.
Hölker, F., Wolter, C., Perkin, E.K., Tockner, K. (2010) Light pollution as a biodiversity threat. Trends in Ecology & Evolution. [Online] 25 (12), 681–682. DOI:10.1016/j.tree.2010.09.007
Inostroza, L., Baur, R., Csaplovics, E., (2013). Urban sprawl and fragmentation in Latin America: a dynamic quantification and characterization of spatial patterns. *J. Environ. Manag. 115*, 87–97. DOI: 10.1016/j.jenvman.2012.11.007
Instituto National de Estadística (2012). FICHAS ESTADÍSTICAS MUNICIPALES DE INFORMACIÓN COCHABAMBA. *Censo Nacional de Población y Vivienda 2012 - Instituto Nacional de Estadística.* Available at: http://www.conexion.org.bo/uploads/COCHABAMBA.pdf [2019-04-18]
Instituto National de Estadística (2016). Población de Cochabamba llega a 1.916.000 habitantes al 2016. Available at: https://www.ine.gob.bo/index.php/component/k2/item/416-poblacion-de-cochabamba-llega-a-1-916-000-habitantes-al-2016?highlight=WyJjb2NoYWJhbWJhIl0= [2019-04-18]
IPCC. (2001). Definition of Climate Change 2001: Synthesis Report Available at: http://www.ipcc.ch/ipccreports/tar/vol4/index. php?idp=204 [2019-05-09]
Johansson, M. & Küller, M. (red.) (2005). Svensk miljöpsykologi. Lund: Studentlitteratur, 142-154.
Keilsohn, W., Narango, D., Tallamy, D.W., (2018) Roadside habitat impacts insect traffic mortality. Journal of Insect Conservation. [Online] 22 (2), 183–188.
Landguiden (2016). *Bolivia, ekonomisk översikt*. Available at: https://www.ui.se/landguiden/lander-och-omraden/sydamerika/bolivia/oversikt/ [2019-05-15]
Matteson, K.C., Ascher, J.S., Langellotto, G.A., (2008). Bee Richness and Abundance in New York City Urban Gardens. *Annals of the Entomological Society of America. 101140–150.*
McGranahan, G. (2015). Urbanization. *International Encyclopedia of the Social & Behavioral Sciences*. [Online]. pp. 958–964. DOI: 10.1016/B978-0-08-097086-8.72120-9
Michener, C.D. (1974). The Social Behavior of the Bees: A Comparative Study. 2nd ed. Harvard University Press (Belknap Press), Cambridge, 404 pp.
Michener, C.D. (2007). The bees of the world. 2. ed. Baltimore:MMAyA, Ministerio de Medio Ambiente y Agua (2015). *VICEMINISTERIO DE RECURSOS HÍDRICOS Y RIEGO*. Coch *RECURSOS HÍDRICOS Y RIEGO*. Cochabamba: Ministerio de Medio Ambiente y Agua. Available at:

https://www.mmaya.gob.bo/uploads/PRESENTACI%C3%93N_VRHR_2016.pdf [2019-04-30]
Montes, L. (2017). Alcaldía decide construir ciclovías al norte y sur. *Los Tiempos*, April 2017.
National parks, Singapore Government (2019). *Flora&Fauna Web*. Available at: https://florafaunaweb.nparks.gov.sg/Special-Pages/plant-detail.aspx?id=2473 [2019-05-09]
Naturvårdsverket (2019). *Vad är ekosystemtjänster?* Available at: https://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Uppdelat-efter-omrade/Ekosystemtjanster/Vad-ar-ekosystemtjanster/ [2019-04-09]
Pickett, S.T.A., Cadenasso, M.L., Grove, J.M., Boone, C.G., Groffman, P.M, Irwin, E., Kaushal, S.S., Marshall, V., McGrath, B.P., Nilon, C.H., Pouyatj, R.V., Szlavecz, K., Troy A., Warren, P. (2001). Urban ecological systems: Scientific foundations and a decade of progress. *Journal of Environmental Management.* [Online] 92 (3), 331–362. DOI: 10.1016/j.jenvman.2010.08.022
Royal Horticultural Society (2019). *Find a plant*. Available at: https://www.rhs.org.uk/plants/search-form [2019-05-09]
Sjödin, M. (Red.). (2016). Fältinstruktion för Nationell Inventering av Landskapet i Sverige NILS år 2016. *Institutionen för skoglig resurshushållning, SLU*.
Söderström, B. & Hedblom, M. (2007). Comparing movement of four butterfly species in experimental grassland strips. *Journal of Insect Conservation*.
Su, Z., Li, X., Zhou, W., Ouyang, Z., (2015). Effect of landscape pattern on insect species density within urban green spaces in Beijing, China. PLoS ONE 10 (3)
Susca, T., Gaffin, S.R., Dell'osso, G.R. (2011). Positive effects of vegetation: Urban heat island and green roofs. Environmental Pollution. [Online] 159 (8), 2119–2126. [2019-03-31]
Sweden Abroad (2019). *Bolivia*. Available at: https://www.swedenabroad.se/sv/om-utlandet-f%C3%B6r-svenska-medborgare/bolivia/reseinformation/ambassadens-reseinformation/ [2019-05-15]
Taylor, O.M. and Cameron, S.A. (2003). Nest construction and architecture of the Amazonian bumble bee (Hymenoptera: Apidae). *Apidologie* 34: 321– 331.
Townsend, C.R. (2008). *Ecological applications: toward a sustainable world.* Malden, M.: Blackwell. pp. 7-34.
Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kazmierczak, A., Niemela, J. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: a literature review *Landscape and Urban Planning, 81*, pp. 167-178. DOI: 10.1016/j.landurbplan.2007.02.001
Wilkinson, S.J. & Dixon T. (2016) 'Green Roof Retrofit and the Urban Heat Island', *Green Roof Retrofit.* [Online]. Chichester, UK: John Wiley & Sons, Ltd. pp. 37–61.
Williams, P.H. & Osborne, J.L. (2009). Bumblebee vulnerability and conservation world-wide. *Apidologie*, 40, 367–387.
World Health Organization (2016). *Urban green spaces and health, a review of evidence*. Copenhagen: WHO Regional Office for Europe, 2016. Available at: http://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf [2019-04-25]
Wright, W. & Heather E. (2012). Accessibility and usability: Green space preferences, perceptions, and barriers in a rapidly urbanizing city in Latin America. *Landscape and Urban Plannng*. [Online] 107 (3), 272–282.

Images references

Grayson, R. (2017). Hummingbird and Aloe Flower [photography]. Available at: https://flic.kr/p/TFfbzH [2019-05-16]

Sipler, D. (2007) Monarch on Verbena Bonariensis [photography]. Available at: https://flic.kr/p/3a4VXw [2019-05-28]

Zurnieden, C. (2015) Diggin' [photography]. Available at: https://flic.kr/p/vQnFWh [2019-05-28]