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# Mapocho river as a Sustainable Urban Drainage Device in the City of Santiago

## A Methodological Design Proposal

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## TABLE OF CONTENTS

PART 00:

## FOREWORD

My name is Emilia Zuniga. I was born and raised in Chile. A very long and narrow country in the southernmost part of the American continent. More specifically, I am from the capital city: ”The Great Santiago”.
I live in a house with both of my parents and my dog in the northeastern part of Santiago (far from the downtown). I take my dog on daily walks through my neighborhood which encompasses a stretch along Mapocho River. Which led me to experience the river from a closer perspective.
However, I’ve always seen this river from afar, but never entered its basin. From the outside it looks like a pretty disgusting, abandoned and dirty place. Very dry, which sounds contradictory when you are talking about a river, but yes, it is a dry basin.
This river crosses the city from east to west, and it has accompanied the development of Santiago since its foundation. In fact, it was the source of fertility of the valley in its beginnings, and the reason why the founder of Santiago, Pedro de Valdivia, decided to found the city in this location back in 1541. But sadly, today it is totally abandoned and degraded because his beloved city turned its back on him.
Anyway, I've grown to love the river, and that is why I’ve decided to work with it for my thesis.

I have been to the river hundreds of times in the last 4 years.
I’ve experienced how beautiful it is in spring; green and flowery.
How hot it is in summer.
How dry it is in autumn.
How angry it is in winter.
This is the essence of the Mapocho for me: a changing river with a very special character, and a beauty that few manage to grasp and admire.

"*The territory is not a datum, but the result of diverse processes*".

(Corboz, 1980)

I see it as a wild horse that the citizens have been trying to tame for hundreds of years, and still cannot succeed. Because they fail to understand its true nature.

Urban planners have changed the role and morphology of the river dozens of times trying to respond to the city's necessities. The truth is that today its appearance does not live up to its importance. It is humble in the way it flows through the city without showing off. But, in reality, it's a constant water course in a city that is going through an extreme water crisis. IT IS GOLD.

*"All that is gold does not glitter,*

*Not all those who wander are lost;*

*The old that is strong does not wither,*

*Deep roots are not reached by the frost.*

*From the ashes a fire shall be woken,*

*A light from the shadows shall spring;*

*Renewed shall be blade that was broken,*

*The crownless again shall be king."*

(Tolkien, 1991)

I dedicate it to you, forsaken river.

PART 00:

# INTRODUCTION

I invite you to look at the world as one, where everything is related. Where all living beings, from the most simple, fungi or bacteria, to the most complex, us human beings, are vital. As Emanuele Coccia said,

"*(...) the world is a perpetual contagion.*" (Coccia, 2018, p. 68)

And it is in our hands to create the right relationships that will guide us towards a joint evolution.

A continuity- in- transformation (metamorphoses) creates inventive connections that allow us to alter existing patterns of life and address our changing environment. Achieving a fluid flow of life matter and energy involves the unity of the living, creating a chain of multispecies players that will manage to re-cycle the existing reality and build one that can transform itself for adaptation.

The world was globalized long before we knew it, and it has always been that way. The Amazon rainforest in South America depends on the Sahara desert in Africa , and the Tropics depend on the Poles. Natural cycles and ecosystems act at all existing scales, and involve all existing matter.

"*(...) the world is by definition the life of others: the ensemble of other living beings. The mystery that needs explaining is therefore the inclusion of all in the same world, and not the exclusion of other beings - which is always unstable, illusory, and ephemeral.*" (Coccia, 2018, p. 43)

Our structure of nature is extremely complex and involves an infinite range of characters. As architects, we must consider the ensemble of other living beings as a fundamental pre-existence to achieve balance in our habitat. Aim for an object shaping that is capable of integrating the diagrams of process, in order to evolve with our territory.

PART 00:

# RESEARCH FORMULATION

EXISTING DEFICIENCIES

I. Degradation of the natural landscape in the city of Santiago and its limits. Specifically of the Mapocho Torrent.
II. Incapability of the city to adapt to the variations in the climatic conditions due to Global Warming.
III. Constant overflows during the peak flow season, compared to insufficient water to supply the city in the minimum flow season.

RESEARCH QUESTIONS

I. How can I transform the degraded river basin into green areas without increasing the water consumption?
II. How can I use the territory (Santiago valley)and its specific conditions to my advantage?
III. How can I protect the city against natural disasters provoked by extreme weather?

HYPOTHESIS

I. Climate risk reduction: Making the torrent capable of reducing the city's vulnerability to variable climate scenarios.
II. Water purification: The Mapocho river as the main filter and infiltrator of the city's water.
III. Habitat and ecological connectivity: Recovery of the torrent ecosystem and creation of a green corridor that crosses the center of Santiago.
IV. Provision of recreational spaces: Integrating the river to the city, giving it the character of an open-air natural green space.

GENERAL OBJECTIVE AND SPECIFIC OBJECTIVES

The aim is to build a symbiotic connection between the Mapocho river and the city, where both will be able to exploit their full potential.

I. Understand the characteristics of this torrent and its dynamics.
II. Get a glimpse of the role that the river has had in the past, and has now in the city.
III. Introduce the climatic conditions of the Santiago valley and their relationship with the native and existing

vegetation.

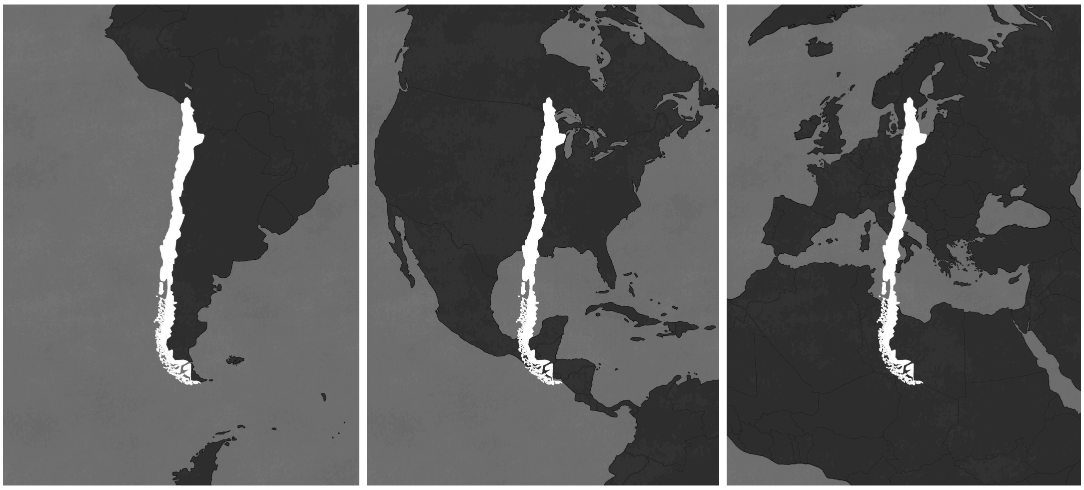
IV. Use nature based solutions to restore the natural landscape of the Mapocho River. Position it as the main water draining device of the city.

METHODOLOGY

I. Historical Research: Understand the current shape of the river as a result of its history.
II. Site Characteristics Research: Understand the climatic, geographic, and botanical characteristics of the degraded landscape.
III. Field study: Gather physical evidence in different sections.

PART 01:

## LET'S BEGIN WITH CHILE...



*" Primarily the map is traced in order to understand and then to perform. It has the same status as the territory of being a process, a product, a project, and since it is also form and meaning, we even run the risk of taking it for a subject."*

(Corboz, 1980, p.31)

Chile has an area of 756,950 km2, a length of approximately 4,300 km. and an average width of only 180 km. (Gob.cl) Being so long and narrow, it runs from 17º 30' to 56º 30' south latitude. To the north it borders Peru and Bolivia, to the west the Pacific Ocean, and to the east Argentina. Along the east side of our country we have the Andes mountain range, which plays a very important role in our geography. And along the west side, we have more than 6,435 km of coastline on the Pacific Ocean. (Gob.cl)

In addition, the varied climatic conditions give rise to varied landscape typologies, ranging from the Atacama Desert in the north, to Patagonian glaciers in the south. According to the Köppen climate classification, Chile includes within its boundaries the 5 major climatic groups that exist in the world (Tropical, Desert, Temperate, Continental, Polar) which give place to a variety of 46 different ecosystems throughout the country.

## **INTRODUCING SANTIAGO**

The Santiago basin is located more or less in the middle of the country, in the Hoya Hidrográfica of the Maipo River. This hydrographic basin originates in the Andes Mountains and runs approximately 250 km until it flows into the Pacific Ocean. It is composed of other smaller ones, among which is the Mapocho hydrographic basin, that holds the river that now flows through sixteen communes of the city.
Its major axis is north-south oriented and has an area of about 2,440km2. It is delimited by the Andes and the Coastal Range to the east and west, and by transversal cords (Chacabuco and Angostura de Paine mountain ranges) to the north and south. Expressions of these mountain ranges in the valley have created island hills in the city, and occupy an area of approximately 110 km2. The average slope of the valley is 1%, with a height in the center (where the main square is located today) of 520 meters above sea level.

To truly comprehend the morphology of the great city of Santiago today, we must first approach the territory, and the cultural heritage it embodies. We can only formulate an accurate idea of the landscape and its present conditions, if we analyze the process, in terms of its relationships with time and extent.
Space is in a continuous process of development, or of dissolution and replacement. True appreciation of historical values has led geomorphologists to link the physical landscape of the present with its geological origins, and to derive it from there step by step. (p.13, The Morphology of Landscape)

*"Territory is not a given, but the result of various processes. (...) In other words, the territory is the object of a construction. It is a kind of artifact. Thus, it is also a product."* (Corboz, 1980, p.27)

HISTORICAL CHRONICLE:
When it comes to the Santiago valley, its first interactions with humans were around 13.000 bC, when small groups of hunter gatherers sporadically converged along the waters of the Mapocho river. In the year 500 bC agro-pottery societies (Aconcagua, Llolleo and Bato) settled semi-permanently on the valley and used the watercourse for agriculture. Later, in 1400 the Mapocho River was incorporated into the Tahuantinsuyo (Inca empire). The Incas settled peacefully in the basin for almost 100 years and generated strong changes in the conformation of the landscape. Being a hydraulic culture, they created 26 main ditches and canals 25 km long for the development of agriculture in

very dry areas of the valley. They managed to occupy the valley effectively, organized the population and created a productive agricultural system and achieved significant economic development. (Nunez, 2022)

Thanks to the waterworks of the Incas, the valley became incredibly fertile. So much so, that the news made its way to Spain, and on February 12, 1541, Pedro de Valdivia reached the continent to found the city of "Santiago de Nueva Extremadura" in the Mapocho valley, at the foot of the Huelén hill, over the ancient Inca settlement, destroying it. (Museo Histórico Nacional, 2013)

"*The cultural landscape is created by a cultural group out of a natural landscape. The culture is the agent, the natural area is the medium, the cultural landscape is the result. Under the influence of a given culture, itself changing over time, the landscape is subject to development, goes through phases, and probably reaches the end of its development cycle. With the introduction of a different culture - that is, from outside - a rejuvenation of the cultural landscape is established, or a new cultural landscape is superimposed on the remnants of a previous one. The natural landscape, of course, is of fundamental importance, for it provides the materials from which the cultural landscape is formed. The shaping force, however, lies in the culture itself.*" (Sauer, 1925, p. 20)

Thus it was that outsiders, unaware of the territory, its geography and its dynamism, began to develop a "civilization" according to European standards. They gave a rigid form to a wild terrain, and extrapolated ideas of urbanization that came from distant dissimilar territories. They founded the city along the Mapocho River, and did not pay attention to the dynamism of its flow. It is a torrent that remains silent for most of the year, but during the rainy season, it transforms itself into a powerful and aggressive waterflow. This situation led to an intensified channeling process and interventions to its basin conducted by Spanish urban planners. The objective was to confine its course and build the city of Santiago around it, but, as the modifications to the flow increased, the river rises intensified.

1544 river overflow. (Ministerio de Salud, 2021)

1574 river overflow. (Ministerio de Salud, 2021)

1581 river overflow.

1597 river overflow. (Ministerio de Salud, 2021)

1609 river overflow.

1610 the Mapocho river begins to be walled.

1620 river overflow.

1621 river overflow. (Imagina Santiago, 2013)

1647 river overflow.

1650 river overflow.

From 1650 onwards protections of the river began to be built. Wood and stone winches.

1657 river overflow.

1660 river overflow.

In 1717 the Cabildo de Santiago establishes rationing the water of the Mapocho river for agricultural use, due to the drought. (Ministerio de Salud, 2021)

1749 river overflow. The Cutwaters were completely destroyed.

1783 river overflow.

1802 construction of the San Carlos canal.

1808 the definitive construction of the embankments of Santiago, which covered a total of 33 blocks, was completed.

1965 river overflow.

1982 river overflow. (Monasterio de Carmelitas, 1862)

1986 river overflow. (Rocha, 1986)

1987 river overflow.

2016 river overflow. (Redacción, 2021)

The river has overflowed its banks 25 times.

In the present, Santiago is the capital of the country, and concentrates 30% of the national population, which is around six million people. It is also a city of great territorial expansion, with an area of about 650 km2 (five times the size of the city of Turin). The density of the city is 393 inhab/km2, more than 15 times the national average, 26 inhab/km2. (Angel, 2016)

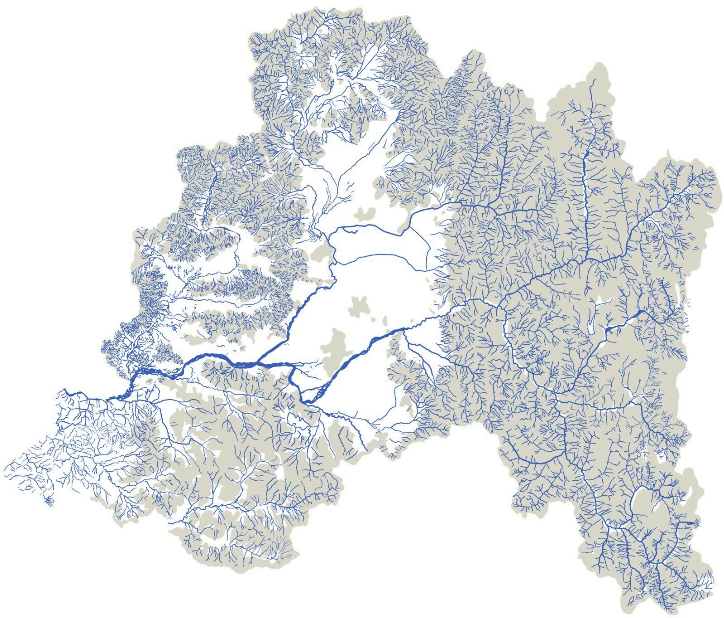
Santiago's climate is Mediterranean, which means that we have a long dry season and a rainy winter with average temperatures between 22.1°C (January) and 7.7°C (July). It is a climate similar to Madrid (Spain) and Los Angeles (United States). (Weatherspark)

It does not rain much, the average annual rainfall is 356.2 mm, and unfortunately, due to climate change this number is decreasing every year. In the period 2012-2021 annual precipitation averaged only 188.4 mm, and since 2010 there has been a sustained decrease of 30%. In addition, an increase in aridity is projected, which implies fewer rainfall events with greater violence. In fact, if we analyze the data since 2009, Santiago today would belong to a warm semi-arid climate zone (BSh). There is an increase in the extremes of the average temperature of the Andes in 2.6°C and 3.0°C, and also in the whole country’s temperatures. (Llacza, 2021)

As a consequence of the sustained increase in temperatures, the amount of snow in the Andes Mountains has decreased considerably, and with it, the reserves of freshwater. This directly affects the reservoirs that supply the city of Santiago with drinking water, El Yeso and Laguna Negra, which have decreased up to 25% of their capacity. (Baier, 2017)

Another important fact is that not only surface water is decreasing, but also groundwater. The Metropolitan Region lost 3.8 billion cubic meters of groundwater between 2010 and 2020. This volume is equivalent to the amount of water flowing down the Po River in front of Valentino Park for more than 2 years. (Caracciolo, 2022)

In addition, it should be added that the constant increase in Santiago's population demands more and more drinking water. Surface and underground sources are in danger, as they are diminishing and are not being renewed. With the sustained increase in temperatures, glacial ice thousands of years old is melting irreversibly, and the impermeability of the city prevents the infiltration of water to renew groundwater.



## THE WATER DILEMA

There’s a popular phrase that says:

"*Water warms the soul more than wine*" p.35 (Fenoglio, 2023)

And in Santiago, we are running out of it.

Today, Chile leads the water crisis in Latin America, classified as a country with "extremely high water stress". 2019 and 2021 were years of hyper drought, and experts say this is an unprecedented water crisis with no clear horizon for improvement. (Soto, 2023)

“*Like it or not, we are in the string figure game of caring for and with precarious worldings made terribly more precarious by fossil-burning man making new fossils as rapidly as possible in orgies of the Anthropocene and Capitalocene. Diverse human and nonhuman players are necessary in every fiber of the tissues of the urgently needed Chthulucene story*”

(Haraway, p.55)

The inhabitants of Santiago consume an average of 600 liters of drinking water per person per day, and according to the World Health Organization, only between 50-100 liters of water per person per day are needed to guarantee the coverage of basic needs. (Aquae Fundación, 2021)

This means that we are using from six to twelve times more water than necessary. Rounding up the numbers, let's say that Santiago has 6,000,000 inhabitants, and that each one consumes 600 liters of drinking water per day. That's 3.6 billion liters of drinking water consumed in the city per day, that's a lot of water. In Europe an average of 128 liters of water is consumed per inhabitant per day, and if we consumed the same amount in Santiago, we wouldn’t even reach one billion liters (0.77) of water per day.

Additionally, it is important to note that water consumption in the city of Santiago is three times higher than water consumption in the rest of the Metropolitan Region, which demonstrates the high water requirement of the city itself. With the growth of the population and the expansion of the urban area of Santiago, this problem becomes more and more evident. The strategic intentions of the Europeans planners when founding the city did not contemplate the challenges of an American landscape pattern. Today this model cannot handle the climate and hydrological crisis that the city faces. (Migues, 2023)

It is not only the responsibility of the inhabitants, but also of the municipalities and urban planners that have created a city with an unhandleable hydric demand that does not meet the available resources. A changing reality requires re-membering the landscape's character that defines the natural cycles and rhythm, in order to create a framework for design that is sustainable over time.

## DISTRIBUTION AND GREEN SPACES


(Censo, 2017)

The objects that exist together in the landscape exist in interrelationship. Santiago is a city with a complex geography and a significant territorial expansion that results in a multiplicity of elements. It is divided into 32 municipalities with very diverse characteristics, each of them fundamental to conceive the city as it is. We state that they constitute a whole reality that is not expressed by a consideration of its constituent parts separately. The territory, the society, and the culture are indivisible. The city possesses form, structure and function, and therefore position in a system, and is subject to development, change and culmination. (Sauer, 1925)

"*We have made fetishes of movement and transformation. And yet we do everything possible to make movement impossible. We aspire to move, to change our position in society, to move to a new home, to pass from one state to another. But all of these changes are illusory: we merely move the same life into a new setting -a pleasant trompe-l'oeil that diverts attention from the cobwebs that remain intact on the old furniture of our souls.*" (Coccia, 2021)

The wide social gap that exists in the city gives each commune very clear specific characteristics that distinguish the income and economic capacities of each municipality. These differences are also manifested in the complexity of the city and the amount of green areas and water consumption per inhabitant.

The WHO establishes that the minimum recommended amount of urban parks, gardens and squares in cities should be 10 m2 per inhabitant. In the commune of Torino it is 55.43 m2 (Città di Torino). In Santiago it is 3.7 m2 , a significantly lower number, and also distributed very irregularly in the different districts of the city. (Depolo, 2020)

The four communes with the highest amount of public green areas per inhabitant in Santiago are:

- Vitacura 18.67 m2/inhab.
- Recoleta 18.6 m2/inhab.
- Providencia 14.94 m2/inhab.
- Lo Barnechea 15.21 m2/inhab.

In addition, three of these communes in the northeastern part of the city (Vitacura, Providencia and Lo Barnechea) are the communes with the highest permanent own income per capita (IPPP). And they are among the municipalities with the highest average residential potable water consumption per capita (L/inhab/day), accompanied by Las Condes and La Reina. (SINIM, 2018)

On the other hand, the communes with the lowest amount of public green areas per inhabitant in Santiago are:

- Puente Alto 1.5 m2/inhab.
- El Bosque 1.9 m2/inhab.

And these communes are also among the five communes with the lowest permanent own income per capita (IPPP) (Senado de la República de Chile, 2017). This demonstrates that access to and consumption of water resources and the amount of m2 of public and private green areas are another expression of the territorial and social inequality in Santiago. The water consumption of these four communes is significantly higher than the rest of the city and the national average, Las Condes consumes almost twice what Maipú consumes, Vitacura almost three times what Lo Espejo consumes, and Lo Barnechea almost four times what La Pintana consumes. (Emol, 2017)

The biggest problem today lies in the water supply of these three municipalities with a very high water demand. The Maipo river basin, that's the main tributary in the valley, supplies 80% of Santiago's population, , and the remaining 20% is supplied by the smaller basin of the Mapocho and Arrayán rivers. The latter has considerably decreased its flow, delivering much less water than it did historically and today is not able to meet the quantities demanded by the municipalities of Lo Barnechea, Vitacura and Las Condes. (Alvarez, 2022)

> *"The river, from being a cherished mentor and friend, strong and worthy of respect, has turned into a servant to be squeezed without measure, whose congenital restlessness procures nuisance and discomfort."* (Fenoglio, 2023, p.17)

In the city of Santiago, the margin between water availability and drinking water requirements is narrow, and minimum ecological flows are being compromised. Projections show that this margin will only narrow further and consequently water security levels will decrease even more. In addition, water rationing plans are projected in the coming years because the system is collapsing and the average water consumption is still too high. (Alvarez-Garreton, 2022)

Fortunately, we are living beings capable of modifying our behaviors and adapting to our environment. All transformation responds to changes in the living space that force appropriation. Managing running waters and controlling access to rivers is becoming a factor of extreme importance. We must treat freshwater as the valuable resource that it is, discover different methods to multiply it, take care of it, and reintegrate it into the cycle, as it should naturally be.

Every event is both cause and consequence, the world is made by object-shaping entanglements. We have been ignoring the capabilities of our ecosystem for years, and today the hydrological crisis is expressed as a consequence. This water scarcity and extreme weather, in turn, can be seen as the cause of upcoming positive transformations and sustainable exploitation of natural resources.

"*A common livable world must be composed, bit by bit, or not at all. What used to be called nature has erupted into ordinary human affairs, and vice versa, in such a way and with such permanence as to fundamentally change means and prospects for going on, including going on at all.*" (Haraway, p.40)

## FLORA CONFORMATION OF THE VALLEY

As I mentioned earlier, the Santiago basin is historically defined as a Mediterranean climate zone. This climate comprises only 5% of the planet's surface, but fortunately it has a very high biological diversity [9], which offers us a wide variety of species. Both the Mapocho River and the Santiago basin are located in a biodiversity hotspot of great global conservation importance. Central Chile stands out for its unique high level of endemism, that is, for its flora and fauna species which are found exclusively in Chile and nowhere else on the planet. (Diaz, 2021)

It is important to consider these facts because every organic compound in the ecosystem is, directly or indirectly, the result of the influence of solar energy captured by plants and transformed into organic mass and living matter. (Coccia, 2018)

As we can see in the figure, the Metropolitan Region and Santiago have a wide ecosystemic variety. There are fourteen types of vegetational formations present in the region, varying in relation to different zones and geographic conditions . In Santiago, the main ones are:

- "Andean Mediterranean sclerophyllous forest of Quillaja saponaria and Lithrea caustica".
- "Andean Mediterranean thorny forest of Acacia Caven and Baccharis paniculata".
- "Inner Mediterranean thorny forest of Acacia Caven and Prosopis chilensis".
- "Coastal Mediterranean sclerophyllous forest of Cryptocarya alba and Peumus boldus".
- "Low Andean Mediterranean scrubland of Chuquiraga oppositifolia and Nardophyllum lanatum".

(Arriaga, 2017)

The species present in these vegetational formations grow slower and are less imposing in height than the temperate or rainy climate species seen in cities. This is because they have evolved over millions of years to adapt themselves to the specific conditions of the unfavorable mediterranean soil and climate. Their structure is a direct consequence of defense methods that have allowed them to survive prolonged dry seasons and very high temperatures. They have also been able to establish communication between different beings to generate ecosystems in which the circulation of life matter and energy creates a resilient vegetative structure. (Fernández, 2022)

For this reason, we must conceive landscape as a process and an example. The structure of these native ecosystems and their behavior responds one hundred percent effectively to their environment. Millions of years of evolution and interaction with a fluid medium have led to a conformation that results in a perfect example of nature adaptation.

*"(...) the landscape is going through multiple transformations. This contact of man with his changing home, as expressed through the cultural landscape, is our field of work."* (Sauer, 1925, p. 24)

We should imitate the architecture of organisms when building green spaces in cities. Start from the same basis that nature does, respect, growth, movement and transformation. It is impressive to think that, having resilient species that have developed amazing features that increase water uptake, decrease water loss, increase water storage capacity and buffer excess energy to control temperature, 86% of the species present in the city of Santiago are exotic. (Fernández, 2022)

It all began with the "Quinta Normal de Agricultura", the first large-scale space designed for the cultivation and acclimatization of agricultural and forestry species in Santiago. It was founded in 1841, and in 1849 Luis Sada di Carlo, an Italian agronomist engineer, carried out an important import of foreign species [2], [3]. According to a study conducted in 2015 by Guevara and Fernandez [2], of the total number of species in Quinta Normal in the second half of the nineteenth century, almost one hundred percent corresponded to exotic species, 50.2% from Europe and North America, 10.8% from South America, and the rest from Asia, Oceania and Africa. (Hecht, 2017)

The tree matrix of the city of Santiago today is mostly composed of exotic species from Quinta Normal, plus some species introduced later with criteria similar to those used in the nineteenth century. Unfortunately, only 21.2% of these exotic species come from a Mediterranean climate similar to the one that we have in Santiago, and have the attributes to thrive in our climate. The remaining large percentage (78.8%) come from temperate rainy, tropical, tropical savanna and cold continental climates [2] that do not have similarities to our climate. (Guevara, 2015)

*"In general, a large number of exotic species is perceived as negative, because it would diminish the ecological integrity of the place and its environment. (...) exotic species can invade environments close to the urban area, displacing native species"*

Nelida Villasenor, researcher at the Laboratory of Geomatics and Landscape Ecology, U. de Chile.

After creating this artificial incubator for the planting and "adaptation" of exotic species, there was an attack against the cultural heritage of the territory's landscape and total destruction of its DNA. The native species were removed, replaced with extremely damaging trees. When implementing an arboreal pattern in an unequal context, it is not about imitating particular forms or style, but about understanding the relevance of what the native method privileges and engenders and how it can be rethought in the context of current environmental frameworks". (M'Closkey, 2013)

*"These are stories in which multi-species actors, entangled in partial and flawed transpositions across difference, remake ways of living and dying in tune with a finite flourishing still possible, a recuperation yet possible"* (Haraway, p. 10)

A Fondecyt-funded study suggests that the number of trees in the urban areas of Santiago has remained stable over the last 12 years. This is not encouraging, as it means that tree planting programs have failed to increase the number of trees in the city. The distribution is also another factor of concern, since the number of trees has increased by 6% in the communes with higher incomes, decreased by 4% in communes of the middle stratum, and decreased by 7% in the poorest communes. (Gonzalez, 2018)

The wealthiest communes have about 26 trees per hectare more than the communes with lower incomes, and much more diversity, nine to nineteen species more (Gonzalez, 2018). A study done in ten communes with a sample of 334,000 trees and more than 300 species (Fernandez, 2021), indicates that the most planted species in the city, which make up 54% of the tree mass of the communes considered, are:

- Liquidámbar - "*Liquidambar styraciflua*" (United States)
- Robinia - "*Robinia pseudoacacia*" (United States)
- Ciruelo de flor - "*Prunus cerasifera*" (Turkey)
- Acer negundo - "*Acer negundo*" (United States)
- Plátano acerifolia o hispánica - "*Platanus x acerifolia*"
- Melia - "*Melia azedarach*" (India)
- Tulipero - "*Liriodendron tulipifera*" (United States)

Liquidambar, Robinia, Acer negundo and Tulipero come from areas of the United States with rainfall of 1,100- 1,400 mm per year, and with a more even distribution of rainfall throughout the year. Melia comes from India and grows in areas with an average annual temperature of 27°C and rainfall of 1,100 mm per year. Plum blossoms come from Turkey and have a climate similar to the Metropolitan region.(Fernández, 2022)

We need, therefore, to recognize not only the presence or absence of a vegetative cover, but also the type of cover that interposes itself between the exogenous forces of climate and earth materials, and that acts on the sub-surface matter. (Sauer, 1925, p. 16). Today we are witnessing the urgency of considering a matrix of vegetative species adapted to rather arid and warm climates in Santiago, since sustaining this large mass of climatically maladapted trees is proving to be almost impossible and makes no contribution to the ecosystem. With the current limitations, Santiago's watershed is not capable of sustaining this model, and we face a highly challenging scenario. We must harmonize the needs of urban space and the requirements of ecosystem services by urban vegetation.

"*Cities are growing, the urban population is increasing, and space is becoming scarcer—all at an exponential rate. Given this context, what is the role of nature within the city? How can infrastructure be integrated into public open spaces? How can engineering progressively adapt itself to facilitate such an integration?*" (Baur, 2012)

Plant life is life as complete exposure, in absolute continuity and total communion with the environment (Coccia, 2018, p.5) Every individual comes from a particular ecosystem on the planet, where over millions of years it has evolved and adapted to certain site-specific conditions. And, when they are transferred to an urban context with very different conditions from those of their origin, species can present problems of adaptation and growth. These problems are often not so evident, since the plasticity of the species allows them to live in circumstances that limit their physiological capabilities, but are ultimately manifested in inferior growth performance, greater susceptibility to pests and diseases, problems in the development of flowers and fruits, excessive desiccation, etc.

In order to create a sustainable development in terms of urban trees, we must prioritize native species, since they present an optimal climatic compatibility in their place of origin and require little (or no) external support. We must also include other species, such as mosses, lichens, creeping plants, and shrubs that are essential for the absorbency and retention capacity of the soil. Consequently, the permanence and good performance of these specimens over time will depend mainly on the adequate coupling of the species with the place of establishment, and not on an excessive use of resources (Fernandez, 2022).

## NATIVE SPECIES

*"The natural landscape: climatic basis."* p.15.

Natural landscape forms include, in first instance, all crustal matter that defines the surface forms and their relationship with the understory to some significant extent (Sauer, 1925, p.14). In addition to trees, every ecosystem considers a wide range of living beings. These creatures have a great influence on the resilience and proper development of the whole system. If we want to create urban green areas with a greater capacity to adapt to the existing extreme climatic conditions, we must use a varied palette of native plant species that have optimal climatic compatibility, and maintain symbiotic relationships.

*"It has been found that the greater the structural complexity and diversity of the vegetation, the greater the resilience of the whole."*
(Estades, 1997)

NATIVE TREES (Alvarado, 2013) (Garcia, 2008)

1. Quillaja saponaria
2. Drimys winteri
3. Peumus boldus
4. Prosopis chilensis
5. Cryptocarya alba
6. Aristotelia chilensis
7. Lithrea caustica
8. Acacia caven
9. Maytenus boaria

NATIVE SHRUBS

1. Escallonia pulverulenta
2. Buddleja globosa
3. Haplopappus foliosus
4. Lobelia Excelsa
5. Alternaria porrigens
6. Baccharis concava
7. Baccharis paniculata
8. Aristeguietia salvia
9. Eryngium paniculatum
10. Chuquiraga oppositifolia
11. Sisyrinchium striatum
12. Libertia chilensis
13. Stipa caudata
14. Nardophyllum lanatum

NATIVE CACTACEAE (Señoret, 2013)

1. Puya Venusta
2. Agave Atenuata
3. Puya chilensis
4. Cistanthe grandiflora
5. Austrocactus spiniflorus
6. Copiapoa coquimbana
7. Cumulopuntia sphaerica
8. Echinopsis bolligeriana
9. Echinopsis coquimbana
10. Echinopsis chiloensis
11. Eriosyce aspillagae
12. Eriosyce aurata

13. Eriosyce curvispina
14. Eriosyce chilensis
15. Eriosyce subgibbosa

NATIVE CREEPING PLANTS (Belov)

1. Arenaria serpens kunth
2. Gayophytum micranthum
3. Quinchamalium chilense
4. Convolvulus Demissus
5. Phyla canescens
6. Verbena ribifolia
7. Verbena bonariensis
8. Buddleja globosa
9. Haplopappus foliosus
10. Lobelia excelsa
11. Alternaria porrigens
12. Baccharis concava

NATIVE GEOPHYTES (Nunez, 2021)

1. Alstroemeria ligtu ssp. simsii
2. Phycella cyrtanthoides
3. Pasithea caerulea
4. Leucocoryne ixioides
5. Trichopetalum plumosum
6. Moscharia pinnatifida
7. Stellaria chilensis
8. Solenomelus pedunculatus
9. Loasa placei
10. Phacelia secunda
11. Stachys grandidentata
12. Clarkia tenella

13. Chloraea chrysantha
14. Erythranthe lutea
15. Oenothera acaulis
16. Oxalis megalorrhiza
17. Anemone decapetala
18. Quinchamalium chilense
19. Schizanthus porrigens
20. Conanthera campanulata
21. Alonsoa meridionalis
22. Conanthera bifolia
23. Tropaeolum tricolor
24. Amsinckia calycina
25. Calceolaria corymbosa

NATIVE FUNGI

Ramas y troncos:

1. Cyclocybe aegerita
2. Anthracopnyllum discolor
3. Chondrostereum purpureum
4. Clavaria acuta sowerby
5. Calocera cornea
6. Grifola gargal singer
7. Cyttaria berteroi
8. Cyttaria espinosae
9. Gymnopilus junonius
10. Ganoderma australe
11. Hericium clathroides
12. Pholiota subflammans
13. Mycena haematopus
14. Hypholoma brunneum
15. Mycena pura

Pastizales:

16. Agaricus campestris

17. Agaricus xanthodermus
18. Bovistella utriformis
19. Coprinellus disseminatus
20. Coprinus comatus
21. Morchella conica
22. Morchella esculenta
23. Mycenastrum corium

Bosques y plantaciones:

24. Amanita muscaria
25. Amanita phalloides
26. Butyriboletus loyo
27. Geastrum saccatum
28. Geastrum fornicatum
29. Lycoperdon perlatum
30. Suillus granulatus
31. Russula nothofaginea
32. Russula sardonia
33. Ramaria flava
34. Leratiomyces ceres
35. Geoglossum umbratile

NATIVE LICHENS (Quilhot, 1998)

1. Acarospora schleicheri
2. Caloplaca cerina
3. Candelariella vitellina
4. Dictyonema glabratum
5. Graphis scripta
6. Haematomma fenzl ianum
7. Lecanora dispersa
8. Pertusaria velata
9. Physcia adscendens
10. Physcia caesia
11. Pseudocyphellaria bartlettii

12. Pseudocyphellaria neglecta
13. Rhizoplaca chrysoleuca
14. Roccella portentosa
15. Roccellina cerebriforme
16. Teloschistes chrysophthalmus
17. Teloschistes flavicans
18. Xanthopastis rupicola

NATIVE WATER PLANTS (Rodriguez, 2020)

1. Azolla filiculoides
2. Eleocharis macrostachya
3. Lemna valdiviana
4. Isoetes chubutiana
5. Lemna minuta
6. Sagittaria montevidensis chilensis
7. Schoenoplectus californicus
8. Stuckenia striata
9. Sporobolus densiflorus
10. Wolffiella oblonga
11. Callitriche lechleri
12. Hydrocotyle ranunculoides
13. Ludwigia peploides montevidensis
14. Ludwigia grandiflora hexapetala
15. Myriophyllum quitense
16. Myriophyllum aquaticum
17. Senecio fistulosus

## MAPOCHO AS A TORRENT

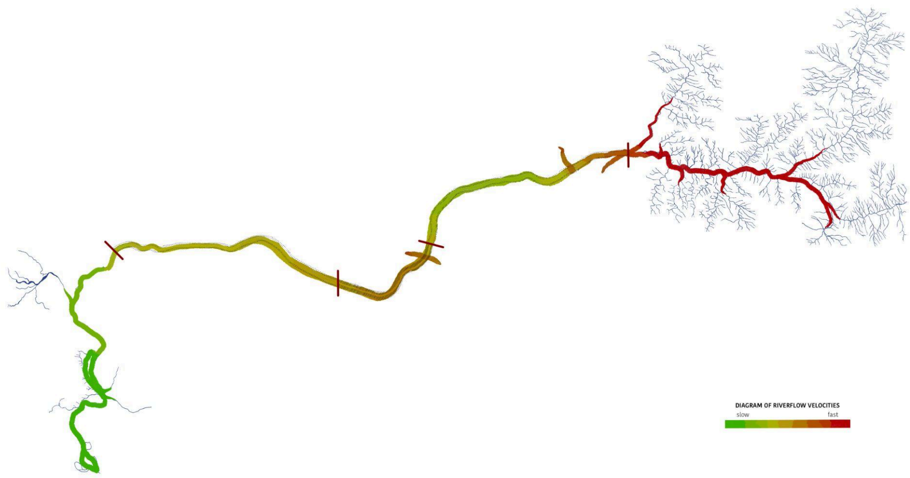
*"(...) the awareness of the multi-millennial link between river, agriculture and civilization has now almost completely disappeared in common thinking."* (Fenoglio, 2023, p.43)

To begin to describe the Mapocho River, we must start with the first thing, this river is not really a river, but a “torrent”. Perhaps that is why we have not been able to understand it in urban terms, nor adapt the city to its characteristics. From now on we will call it by its real name, the "Mapocho Torrent".

Torrent (masculine noun)

1. *Sudden and violent influx of a current of water that is only formed by abundant rainfall or during the thawing season and does not usually last for long.*
   (Oxford Languages)

The Mapocho torrent of nivo-pluvial regime has an approximate length of 120 km, a hydrographic basin of 4,230 km2, and an average width of 35 km. It rises in the Andes mountain range, crosses the city from east to west, passing through sixteen municipalities, Lo Barnechea, Vitacura, Las Condes, Providencia, Recoleta, Independencia, Santiago, Quinta Normal, Renca, Cerro Navia, Pudahuel and Maipú, in that order respectively, and then empties its waters into the Maipo riverbed to the south of the city.



*"(...) the natural state of the Mapocho does not flourish in the same way throughout its sixteen municipalities. That is why it is inevitable to speak of the torrent in " sections". For many, the different faces of the Mapocho reflect the inequality in the city*." (Nunez, 2022)

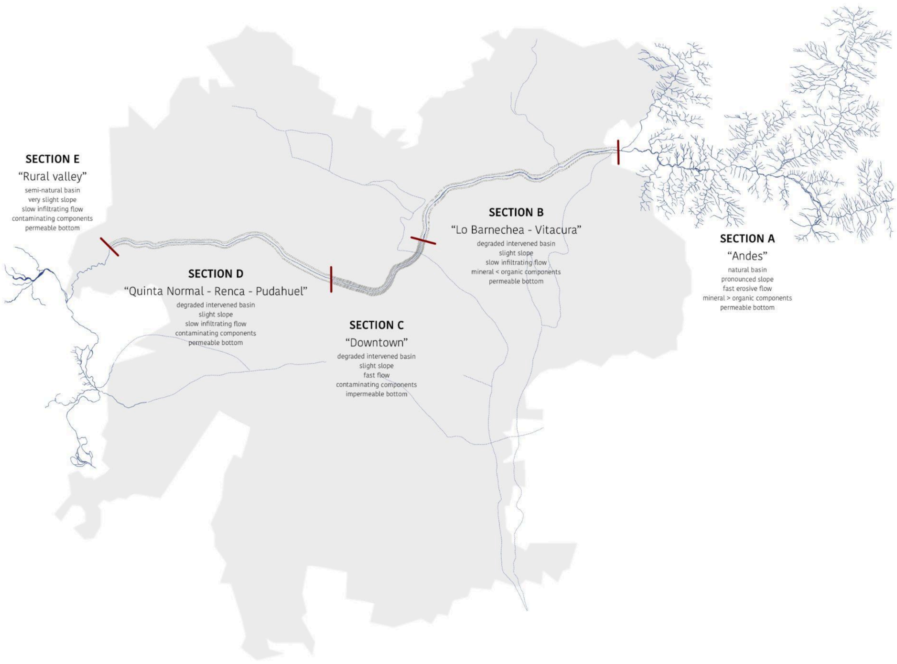
The first section of this body of water is snow-fed and emerges at the foot of El Plomo hill, in the town of Lo Ermita, in Lo Barnechea, east of the city of Santiago. There, in the foothills, the San Francisco estuary and the Molina estuary join to give rise to the Mapocho torrent. This body of water rises at an altitude of approximately 1.159 meters above sea level and has a basin of 620 km2 between the confluence and the valley of Santiago. (Ferrando, 2008)

Upon entering the valley, the second section of the torrent begins, where the river is incorporated into the city and flows through an extensive plain formed by alluvial material. This segment is approximately 30 km long, and its flow is increased by the contributions of the intermediate tributaries and the pluvionival regime. Its main tributaries are the Arrayán stream, the San Carlos canal in the Providencia district, the Lampa stream in the Pudahuel sector, and the Zanjón de la Aguada in the Loma Blanca sector. (Araneda, 2019)

As it is a torrent, its flow varies greatly throughout the year, with the greatest volume occurring during the rainy season, and its average flow is 6.1 m3/s. In the spring (November) its maximum average flow is 13.6 m3/s, and in the fall (April) its minimum average flow is 2.3 m3/s. The transmissibility of the aquifers is quite low, especially in the center of the city, where there is intense channeling of the river. In the eastern urban zone, when the Mapocho is incorporated into the city, the subway water table flows are about 120 lts/s. In contrast, to the southwest of the city, outside the urban zone (Peñaflor), this value rises to 1,500 lts/s.

The third and last section of the Mapocho is after the incorporation of the Zanjón de la Aguada into its course. After crossing the city of Santiago, it continues its course to the southwest, until it joins the Maipo River as its main tributary, and flows into the Pacific Ocean. (Araneda, 2019)

(Memoria Chilena)




Due to the changing contextual conditions, and the length of the torrent, Mapocho presents many variations along its course. Therefore, for this research, the waterflow has been divided into five different sections which consider similar characteristics.

- SECTION A "Andes"

  "*In El Arrayán* (section A), *where it is originated, the amount of water is impressive, it is very abundant at times,* and *in fact it is difficult to cross on foot. It brings a lot of water from the mountain range, it has a light blue and white color that reminds one of glaciers, but before reaching the city, the greatest amount of water is available for human use."* (Diaz, 2021)

- SECTION B "Lo Barnechea - Vitacura"

  *"* (section B) *Here is the first dramatic change, because it is no longer this river with a large flow, and it becomes the small trickle of water that we usually see downstream*", Joaquín Moure. (Diaz, 2021)

- SECTION C "Downtown" - SECTION D "Quinta Normal - Renca - Pudahuel"

  "*The Mapocho watercourse (and its services) is tremendously different depending on the commune it crosses. While in Las Condes, Vitacura or lo Barnechea* (section B) *the river bank provides some biodiversity, the urban pressure of Providencia, Santiago and Recoleta* (section C) *has transformed it into a boxed channel, and the poor waste management is a serious threat to Cerro Navia and Pudahuel* (section D)", Dr. Mauricio J. Carter. (Diaz, 2021)

- SECTION E "Rural Valley

  Moving away from the most populated areas, Mapocho is regaining its biodiversity. In fact, according to a diagnosis elaborated by the GEF Mountain project, the "*Mapocho River in the section of the communes* *of Peñaflor, Talagante, El Monte and its confluence with the Maipo River in the commune of Isla de Maipo, is a strip of high relevance to preserve and restore the connectivity of the surrounding landscape, corresponding to a biological corridor, in the most populated region of our country, which fulfills important environmental functions and provides diverse ecosystemic services"*, Marianne Katunaric. (Diaz, 2021)

## WHERE DOES THE WATER GO?

The waters of the Mapocho do not interfere or interact with the city, and are only hermetically connected to their context. This is due to the long-standing canalization works, which have progressively transformed the waters of the torrent into an unwelcome element in the city.

It's an intention that is highly aligned with the principles of conventional urban drainage systems, which seek to evacuate water as quickly as possible from the city. Drainage systems are needed in developed urban areas because of the interaction between human activity and the natural water cycle. In nature, when rainwater falls on a natural surface, some water returns to the atmosphere through evaporation, or transpiration by plants; some infiltrates the surface and becomes groundwater; and some runs off the surface. The relative proportions vary with time and depend on the nature of the surface, but both groundwater and surface runoff are likely to find their way to a river. (Waring, 2007)

In urban areas, not only the ground is mostly covered by artificial impermeable surfaces, but also the drainage systems are made up by artificial networks of sewers (pipes and structures that collect and dispose of water). This artificial impermeabilization of the water pathways interferes with the natural process of water, and has a significant effect on the draining process and ecosystem (Pokorný, 2008). It increases the amount of surface runoff in relation to infiltration, and therefore increases the total volume of water reaching the drainage system and river in a shorter period of time, provoking high peak flows that can collapse the system faster. Unfortunately, this doesn't give time to draw off pollutants, and reduced infiltration means poorer recharge of groundwater reserves. (Butler, 2018)

This approach, called "gray infrastructure" (drains, subway collectors, among others) is the predominant one in Santiago, and its objective is to evacuate rainwater from the city as quickly as possible. As we can see with the Mapocho torrent, such an approach contributes to the protection of people and infrastructure, but to the detriment of the surrounding ecosystem, as it increases runoff velocities, enlarging the contamination of receiving water bodies and intensifying the urbanization pattern. (Teutsch, 2021)

There is a completely different approach that aims to protect the ecosystems and decrease contamination using green infrastructure and nature based solutions, the “Sustainable Urban Drainage Systems”.

*"Green infrastructure are nature-based solutions, which help mitigate the effects of climate change and increase the efficiency and sustainability of cities, as they provide multiple ecosystem services, such as reducing carbon dioxide (CO2) emissions, flood mitigation and temperature reduction, as well as being an opportunity to provide and restore biodiversity, this in direct benefit of people's health and quality of life"*

(Muñoz, 2019)

Effectiveness varies depending on its quality, quantity and distribution, but it is estimated that on an urban scale, a well-designed green infrastructure system is capable of reducing runoff by 85% to 100%, avoiding significant damage to communities (United States Environmental Protection Agency [EPA], 2008). The main benefits of an urban drainage system involving green and blue infrastructure are:

1. Reducing climate risks, reducing vulnerability and thus risk. One of the most imminent climatic threats to urban drainage is flooding and mass removals (Davis & Naumann, 2017), especially in the current context of Santiago and climate change. Sustainable drainage networks are able to improve soil infiltration, purify rainwater and stabilize slopes. Therefore, they reduce the vulnerability of urban centers, increasing their resilience and reducing disaster risk (EPA, n.d.).

2. Water purification, filtering and treating pollutants in rainwater. Sustainable urban drainage designs consider key strategies to favor infiltration, thus recharging aquifers and increasing soil moisture, improving water availability and quantity (Gonzalez-Meler, 2013). This also safeguards the city's hydrological cycle.

3. Provision of habitat and ecological connectivity, promoting biodiversity and connecting habitats. Integrating green areas into the urban drainage network provides important benefits, since, with the right choice of plant species, it is a strategy for adapting to global change. It avoids the unnecessary use of water as irrigation (Ministerio de Medio Ambiente, 2017), and also recovers and protects biodiversity in urban areas.

4. Provision of recreational spaces, spaces for leisure and cultural development. According to the Cities

Roundtable for Climate Change Adaptation (Muñoz, 2019), public space implemented from the green infrastructure approach is a support for the resilience of cities, also allowing to increase the happiness of its inhabitants, decrease the stress of people and increase the sense of security in urban spaces (Navarrete-Hernández & Laffan, 2019).

Against this background, the Mapocho torrent is a key component of the urban drainage system of the city of Santiago. Due to its scale, it has to be the main character when talking about the transformation of the city and implementation of sustainable urban drainage. It has the potential to be a device that is designed to provide recreational spaces while purifying its waters, reducing climate risks, and providing ecological connectivity.

## DOWN TO EARTH




*"The territory, overloaded as it is with numerous traces and past readings, is more like a palimpsest. In order to install new equipment, to exploit certain lands in a more rational way, it is often indispensable to modify its substance irreversibly. But the territory is not a lost package or a commodity that can be replaced. Each territory is unique, hence the need to "recycle", to scrape once again (but with the greatest care if possible) the old text that men have inscribed on the irreplaceable material of soils, in order to deposit a new one that responds to today's needs, before being revoked in its turn."* p. 34.

(Corboz, 1980)

Matters of fact, matters of concern, and matters of care are knotted in string figures ( Haraway, p.41). We can not talk about ecosystems, societies and vegetation without talking about "soil", one of the most complex living structures on which many others depend. The unity of the living is the mark of divinity (Coccia, 2018, p. 33), and strengthening this unity leads to a maximization of the potential of diversity. Everything is connected, even the most unexpected bodies, and soil is the corpus in which life is transformed and multiplicated. Where the most exciting exchanges and reactions are carried out.

Due to its vast scale, and its ability to sequester immense quantities of greenhouse gasses, it could just be the one thing that can balance our climate, replenish our freshwater supplies, and feed the world. Our health and the health of the earth are together, and today about 2/3 of the world are decertifying, the soil is dying and turning into dust (desert).

This phenomenon is evident in the Mapocho river basin, where continuous interventions have progressively exhausted the ecosystem. So much so, that at present, one could say that it is nearly lifeless. When we create too much bare ground water evaporates very quickly, and humidity decreases. This results in a reduction in precipitations, and 40% of rainfall comes from small water cycles (transpiration from plants and trees) (Tickell, 2020). Therefore, it could be said that, if designed in favor of regenerating ecosystems, it might be possible to increase rainfall.

A common livable world must be composed, bit by bit, or not at all. (Haraway, p.40) Soil is the most basic of all resources, the essence of all terrestrial life and the provider of numerous ecosystem services (e.g., food, feed, fiber, climate moderation through C cycling, waste disposal, water filtration and purification, elemental cycling) (Graber, 1995; Robinson, 2012). It is alive, and its quality must be protected because it is not an infinite resource, and some estimates indicate that degradation has decreased soil ecosystem services by 60% between 1950 and 2010 (Leon, 2014).

We have to protect our soils because in this world, everything is in everything.(Coccia, 2018, p.32), and soil quality has strong implications to human health (Abrahams, 202; Lal, 2009), society and the environment. In the design of urban spaces, importance should be given to the work of soils, since it is an architectural element that has been, and continues to be mistreated. In terms of sustainability, it should be handled as a living element and its regeneration should be prioritized.

The Mapocho river bed comprises a sizable area within the city of Santiago, and restoration of its soils is still achievable throughout most of its course. Action must be taken to address its deterioration, because once the process of soil degradation is set-in-motion, it feeds on itself in an ever- increasing downward spiral. It can be seen that it results in a reduction in structural attributes including pore geometry and continuity, thus aggravating a soil's susceptibility to crusting, compaction, reduced water infiltration, increased surface runoff, wind and water erosion, greater soil temperature fluctuations, and an increased propensity for desertification. (Lal, 2015)

"*(...) species of all kinds are consequent upon worldly subject- and object-shaping entanglements.*" (Haraway, p.13)

One of the most severe consequences of soil biological degradation is that soil becomes a net source of GreenHouse GAS emissions (i.e., $CO_2$ and $CH_4$) rather than a sink. Ecological degradation leads to disruption in ecosystem functions, and the overall decline in soil quality, both by natural and anthropogenic factors, leads to a decline in ecosystem services and reduction in nature conservancy. (Lal, 2015)

Making reference to the Mapocho Torrent,

"*The depletion of its biodiversity, the excessive exploitation of its waters, the direct discharge of sewage and the deposit of garbage, are some of the culprits that have mercilessly degraded this wild river (...)*" (Diaz, 2021)

High soil quality or a healthy soil provides the foundation for a healthy economy, environment, and terrestrial biosphere. Restoring soil quality within managed ecosystems is critical to improving and sustaining water quality. To accomplish this goal, it is essential to develop strategies for integrated management of soil and water resources because of their strong inter-connectivity or the soil-water-waste nexus.

The finite nature of soil resources must never be taken for granted—they must be used, improved, and restored.

PART 02:

## DECANTING IDEAS

The passage of various civilizations and the exercise of living beings produces culture, making the impression of man's work on the territory strongly influence on the natural course of events. Human beings must assume this condition of active agents in their ambience, "gardeners", and act with awareness. The watercourse of the Mapocho has been the focus of a succession of events which have had an impact on its course, and have given it the characteristics that it holds in the present. It is very likely that we will never get to admire the biodiversity of the Mapocho torrent as it once was, due to historical and profound human intervention. But we know that non-human life is still present in the basin despite the difficulties, and continuously evolving to adapt in transformation. (Diaz, 2021)

After describing in depth the area under dispute, its history, morphology, and role in the city, it is time to focus on the future and, as an architect, design a new framework that favors all the participating actors. Architecture for organisms is sought to develop a layout aligned with the past, present, and future, the torrential nature and the dysfunctional city. Re-member (create connection) in a non-ecosystemic river inserted in a city that for years has been undergoing an extreme hydrological deficit.
The river was lonely, natural, exploited, displaced, polluted, and today it is not. (Iturriaga, 2018)

"*Landscape reveals the tensions and contradictions of societies. The landscapes we create are a reflection of the value we place on the different components of our contexts*" (Brunet, 1992).

The river has morphed from being a lifesource to a neglected deposit of urban waste. For the first indigenous settlements, it was a sacred body of water. For the Incas, the head of the irrigation system that converted and provided fruitfulness to the whole valley. And for the Spaniards, the fundamental motive for establishing the city of Santiago in that location. Thus it was that outsiders, unaware of the territory, gave a rigid form to a wild terrain, and extrapolated ideas of urbanization that didn't take into consideration the existing geography and dynamism.

So it was that the torrent has overflowed again and again, has been exploited, and for many years misused as a dumpsite and as a sewer. The basis of its reputation that continues to exist to these days, of being unsightly and disgusting. Likewise, the city has also had this dislocated pattern of development, and today has an unsustainable, almost totally exotic body of vegetation that is not aligned with the climatic conditions of the region. We are still creating ambiguous and poor landscapes , as a result of a disability to create from the cultural, physical, social and economic environment that we are entitled to. Most of the time we want to impose a conception of landscape imported from other realities, regardless of all the contradictions that this generates in a foreign environment. (Katz, 2009)

"*The unfinished Chthulucene must collect up the trash of the Anthropocene, the exterminism of the Capitalocene, and chipping and shredding and layering like a mad gardener, make a much hotter compost pile for still possible pasts, presents, and futures.*" (Haraway, p.57)

The Mapocho has been forever misunderstood by Santiago's urban planners, but in reality, it is a cultural landscape with great architectural potential. Its long course silently crosses sixteen districts with extremely diverse socio-economic backgrounds. This watercourse has the possibility of becoming a social buffer if it were to be an active infrastructure, and of providing resilience in the future extreme hydrological events. Through nature based solutions we can overcome the abandoned, dirty and worn river, and exploit the changing condition of this watercourse to our advantage. Create a repertory of action which allows us to transform the Mapocho into a landscape for living, inviting people to diversify the activities and existing uses of the waterfront, in order to give it back the life it once had before the city was built.

" *We have lost along the way the pleasure of invention, creative transgression, the ability to hold together art and science, strategy and courage, and above all that necessary irony that should never be lacking.*" (Placemaker)

The task of an architect is to make kin in lines of inventive connections as a practice of learning to live and die well with each other in a thick present. Reinventing oneself and the space to make trouble, to stir up potent responses to unexpected events, as well as to settle troubled waters and rebuild quiet places out of unpredicted natures. (Haraway, p.1)

"*The landscape becomes the heritage of those who perceive and inhabit it, acknowledging its various scales from the macro-territorial level to the singular and tangible one, and its totality through the vision, the journey and the historical and physical experience of each individual or space (...) of the eye and of the foot*" (Gosselin, 2007).

Let's put all the ideas together and create Oddkin.

Oddkin (noun):

1. "We require each other in unexpected collaborations and combinations."
2. "An unlikely collection of intimacy."
3. "brings the odd ones together into kinship."

   (Haraway)

## PROJECT FUNDAMENTALS

Through the addition and subtraction of elements in the Mapocho waterfront, a new symbiotic dialog is established between the river and the city. The inflexibility of the boundary is altered to provide a space for people, other forms of life, and water. Certain articulations are able to create a unity of the living that gives way to a landscape with response-ability.

LEARNING FROM NATURE

This transforming living space will present unexpected and logical solutions to integrate adaptation into the complexity of the environment. Native vegetation in the Mediterranean climate is able to increase water uptake with the development of pivot or deepening roots and with partnerships with mycorrhizal fungi. Also, they've developed techniques to decrease water loss, improve water storage, and control temperature.

"*Plant life is life as complete exposure, in absolute continuity and total communion with the environment.*" (Coccia, 2018, p. 5)

This customized vegetation native to the valley, is struggling to survive in the exotic and contaminated jungle that Santiago presents today. the nature of the city is completely perverted. There is a method, developed by the Japanese botanist Akira Miyawaki, which is capable of accelerating the growth of native forests up to ten times, using sophisticated planting techniques of native plants and through a previous study of soil conditions. It has been successfully applied in areas with Mediterranean soil, and is already being used in Chile, in ecological restoration projects and creation of new green areas of rapid growth and low maintenance cost. (Yajure, 2021)
Certain techniques can be extrapolated from this method to be applied in the regeneration and renaturation of the Mapocho torrent, earthworks and biodiversity. This area with a cyclical pattern needs fast-growing flora that is capable of acting as a sponge in the face of the river's growth. It must also have the capacity to absorb and retain water, in order to withstand the long periods of drought which are common in this climate.

In relation to the latter, an interesting breakthrough comes to light from the scientist Monica Decker, she calls it “Stealth Gardening”. She created the hydrogel seed bombs, made up of compost, hydrogel granules, fertilizer, and seeds inside a water-permeable clay shell. When these bombs are launched and absorb water, the hydrogel begins swelling with it, and pushes the seeds out into a wider radius. This makes it a good planting method for large areas that don’t need to be planted with any precision, like Decker says, “a good tool to reclaim urban surfaces that have been barren” (like the Mapocho basin). Moisture is released slowly over time, and is less able to evaporate, especially if the gel makes its way underground. This hydrogel can absorb and release water over many cycles, lasting for several years.
These seed bombs are portable, covert, and require only a decent throwing arm to use. (Mortice, 2017)

In addition to the seed bombs, the field of organic materials with the capacity to flourish and degrade with the passage of time and interaction with the environment has been explored extensively as part of the project itself. There are also papers, yarns and fabrics that include seeds in their production process, in order to sprout in the presence of moisture.

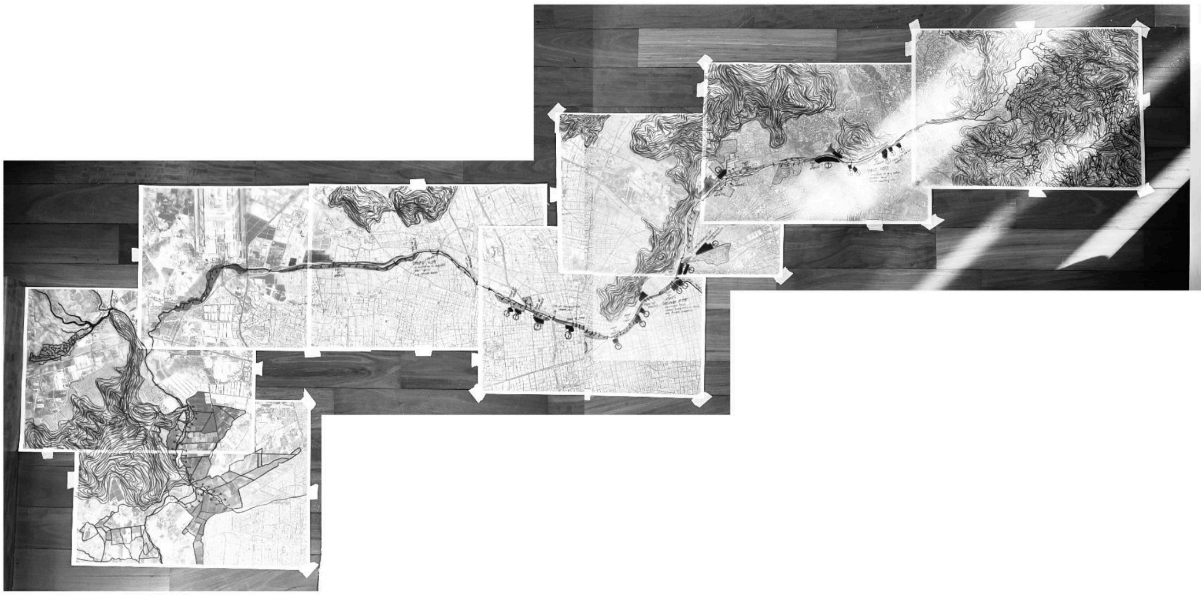
LEARNING FROM CULTURE

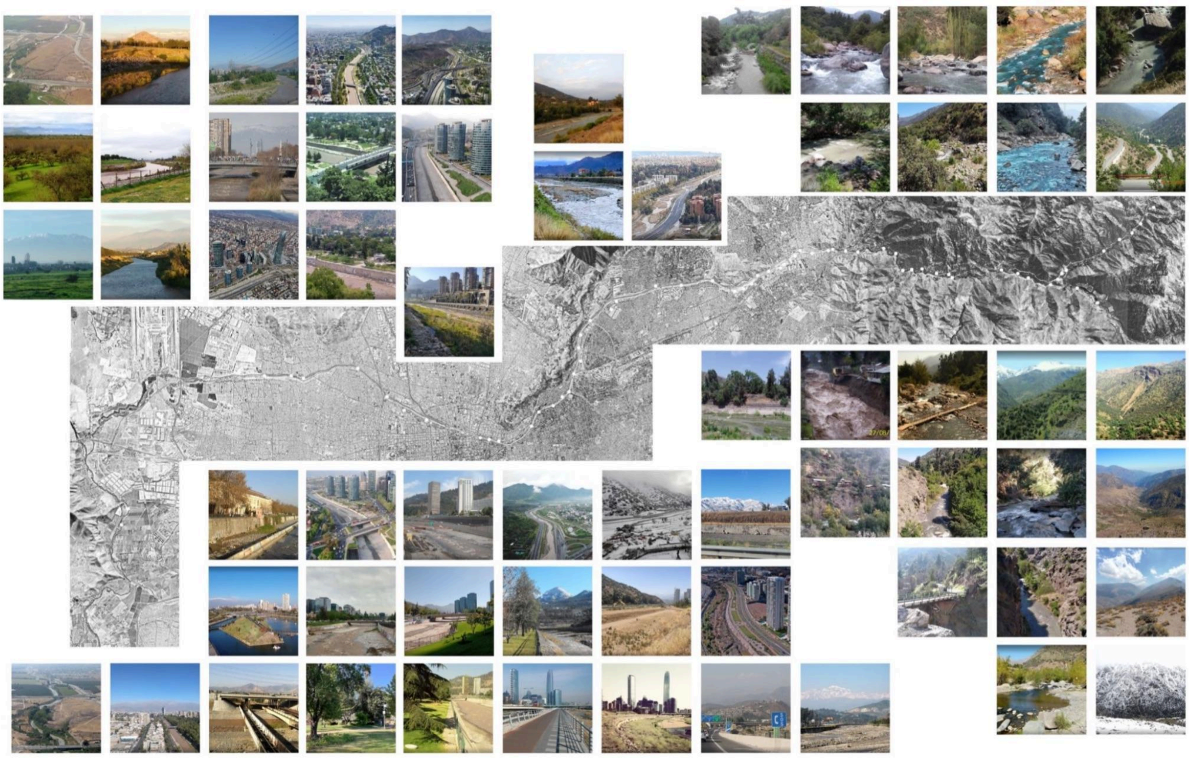
As one delves into the world of vegetative materials, the will to explore the historical and territorial inclusion of available resources increases in strength. The ancestors of creativeness that were capable of converting the existing wild landscape into a liveable scenery.

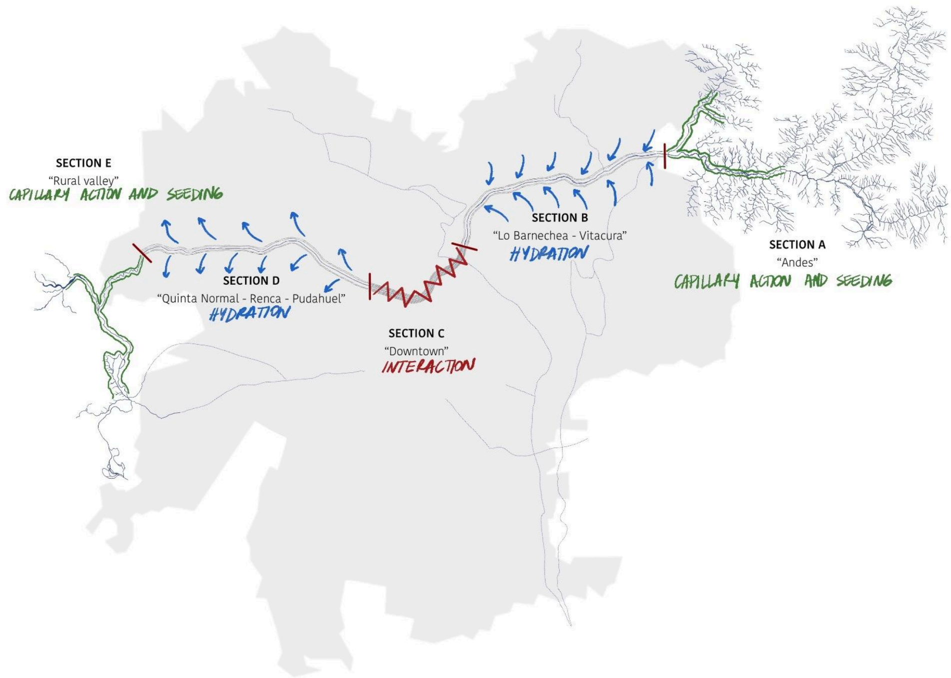
The weaving of natural fibers is a popular craft along the Chilean territory, and in the heart of the central valley, the weaving of "mimbre" is of great importance. Skilled artisans of a mestizo tradition have been cultivating, harvesting and processing these fibers for more than two centuries. This versatile raw material is used to weave all kinds of utilitarian objects, from baskets to dining room furniture. Its quality and durability has given this traditional handicraft international recognition (Castro, 2020). “Mimbre”, the raw material used, comes from a specimen of the Salix genus, a tree that has a strong rooting capacity and an extensive root system, which gives it a high tolerance to flooding and sedimentation (Kuzovkina and Quigley, 2005). In addition, they are excellent natural filters that improve water quality and favor the fixation of slopes, reduce erosion and decrease the risk of floods in water courses. For this reason, they have been implemented in the ecological restoration of wetlands and wildlife preservation, as well as in the reclamation of land with high air and soil pollutants.

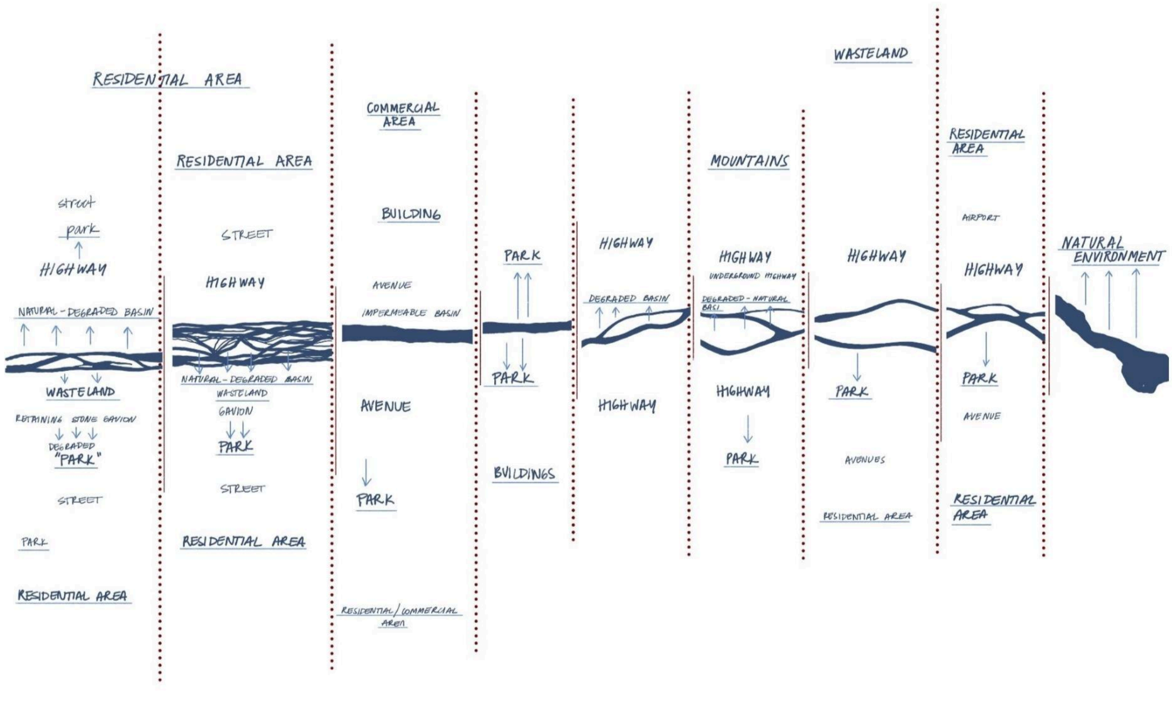
## REPERTORY OF ACTION

*WORK IN PROGRESS

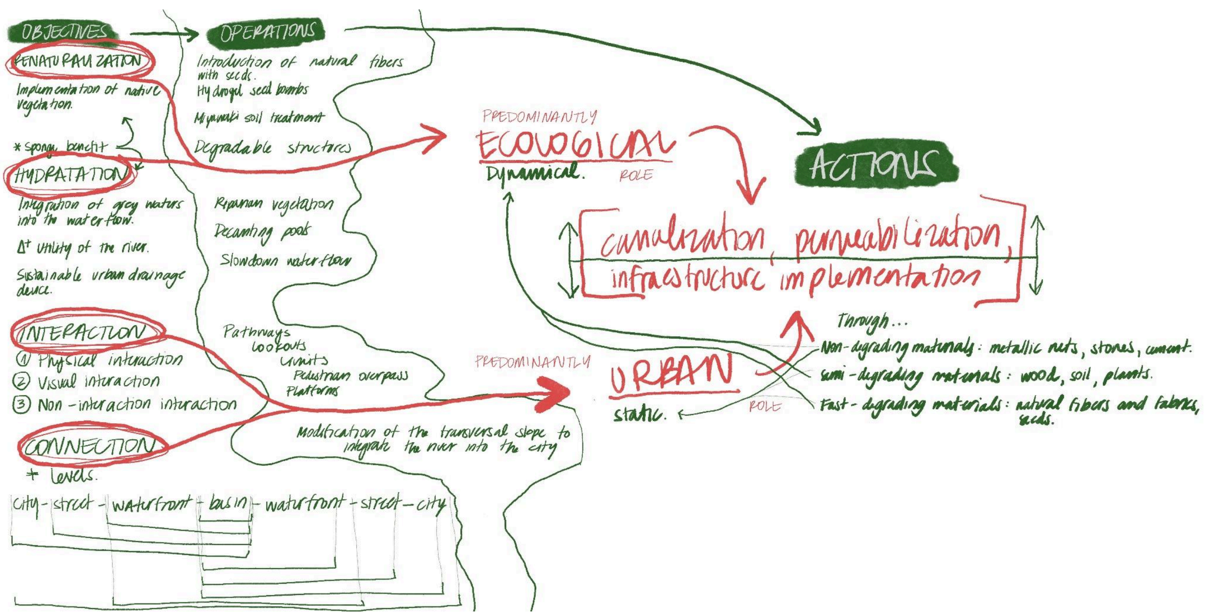


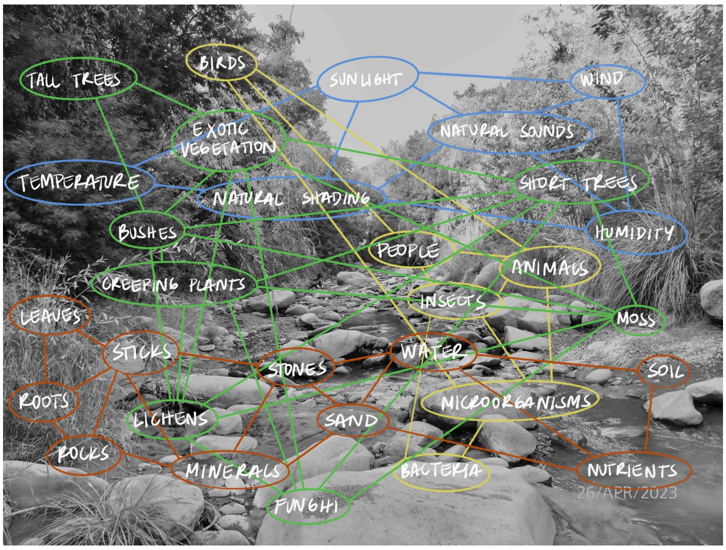


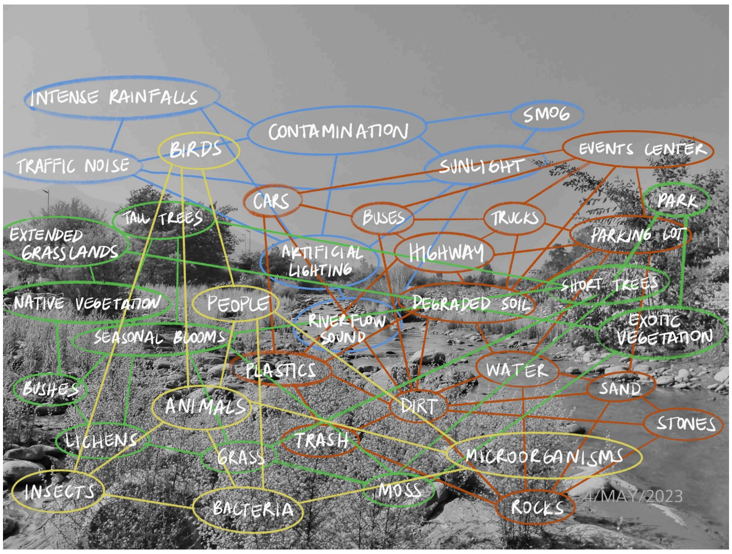

SECTION E
"Rural valley"
CAPILLARY ACTION AND SEEDING
SECTION D
"Quinta Normal - Renca - Pudahuel"
HYDRATION
SECTION C
"Downtown"
INTERACTION
SECTION B
"Lo Barnechea - Vitacura"
HYDRATION
SECTION A
"Andes"
CAPILLARY ACTION AND SEEDING

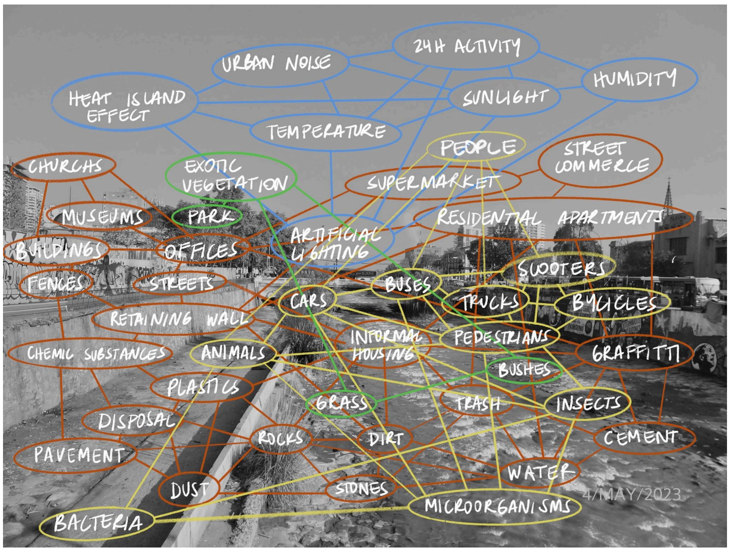

RESIDENTIAL AREA
street
park
HIGHWAY
NATURAL - DEGRADED BASIN
WASTELAND
RETAINING STONE GAVION
DEGRADED "PARK"
STREET
PARK
RESIDENTIAL AREA
RESIDENTIAL AREA
STREET
HIGHWAY
NATURAL - DEGRADED BASIN
WASTELAND
GAVION
PARK
STREET
RESIDENTIAL AREA
COMMERCIAL AREA
BUILDING
AVENUE
IMPERMEABLE BASIN
AVENUE
PARK
RESIDENTIAL / COMMERCIAL AREA
PARK
PARK
BUILDINGS
HIGHWAY
DEGRADED BASIN
HIGHWAY
MOUNTAINS
HIGHWAY
UNDERGROUND HIGHWAY
DEGRADED - NATURAL BASI
HIGHWAY
PARK
WASTELAND
HIGHWAY
PARK
AVENUES
RESIDENTIAL AREA
RESIDENTIAL AREA
AIRPORT
HIGHWAY
PARK
AVENUE
RESIDENTIAL AREA
NATURAL ENVIRONMENT

| | | SECTION E<br>*"Rural valley"* | SECTION D<br>*"Quinta normal - Renca - Pudahuel"* | SECTION C<br>*"Downtown"* | SECTION B<br>*"Lo Barnechea - Vitacura"* | SECTION A<br>*"Andes"* |
|---|---|---|---|---|---|---|
| **TERRITORIAL EXPLORATION** | HYDRIC | slow infiltrating flow with contaminating components | slow infiltrating flow with contaminating components | fast flow with contaminating components | slow infiltrating flow with organic (andes erosion) components | fast erosive flow with mineral components |
| | ECOSISTEMICAL | slight slope, semi natural basin, permeable bottom, degraded vegetation | slight slope, artificially shaped basin, permeable bottom, degraded vegetation | slight slope, artificial, straight and impermeable basin, no vegetation | slight slope, semi natural basin, permeable bottom, degraded vegetation | pronounced slope, natural basin with permeable bottom |
| | URBAN | low density agricultural land use | mostly residential, also industrial and services, medium density | very high human flow (including traffic), offices, services, high density | mostly residential, medium density, high amount of green areas | mostly natural environment |
| **EXISTING RIPARIAN DEFFICIENCIES** | HYDRIC | decontamination, infiltration | decontamination, infiltration, basin use | decantation, decontamination, infiltration | decontamination, infiltration, basin use | flow control, decantation, infiltration |
| | ECOSISTEMICAL | native, diverse and riparian vegetation | native, diverse and riparian vegetation | native, diverse and riparian vegetation | native, diverse and riparian vegetation | native, diverse and riparian vegetation |
| | URBAN | - | appropiation and connection, attractiveness, hydratation of sorroundings | appropiation and connection, attractiveness and integration | appropiation and connection, attractiveness, exploitation of sorroundings | - |
| **PROPOSITIVE TACTICS** | HYDRIC | - | HYDRATION (river water extraction) | - | HYDRATION (grey water introduction) | - |
| | ECOSISTEMICAL | CAPILLARY ACTION AND SEEDING | - | - | - | CAPILLARY ACTION AND SEEDING |
| | URBAN | - | - | INTERACTION | - | - |



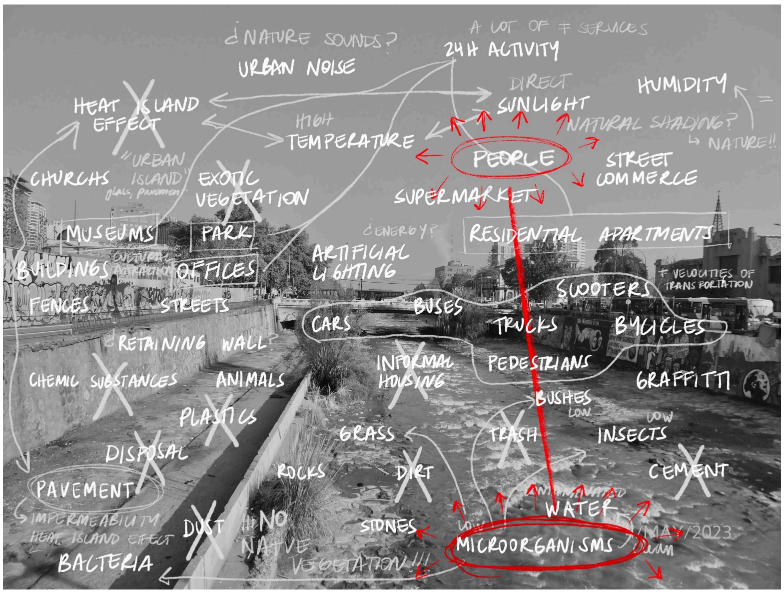

TALL TREES
BIRDS
SUNLIGHT
WIND
EXOTIC VEGETATION
NATURAL SOUNDS
TEMPERATURE
NATURAL SHADING
SHORT TREES
BUSHES
HUMIDITY
PEOPLE
ANIMALS
CREEPING PLANTS
INSECTS
LEAVES
MOSS
STICKS
STONES
WATER
SOIL
ROOTS
MICROORGANISMS
LICHENS
SAND
ROCKS
MINERALS
BACTERIA
NUTRIENTS
FUNGHI
26/APR/2023

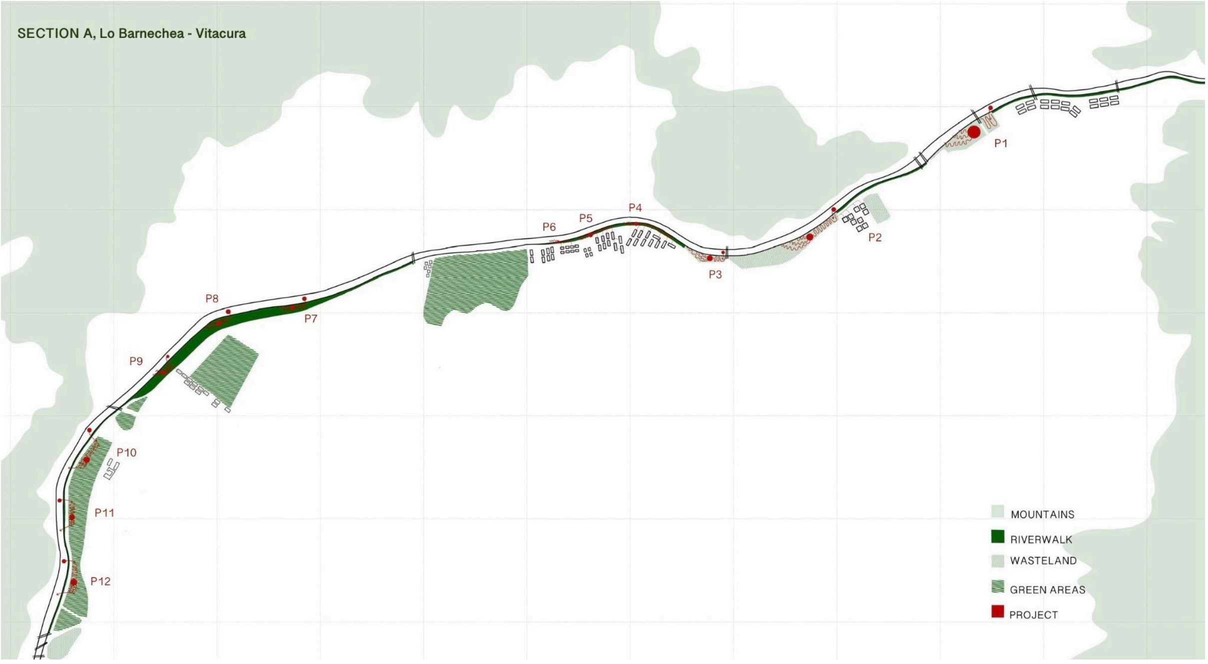

INTENSE RAINFALLS
CONTAMINATION
SMOG
TRAFFIC NOISE
BIRDS
SUNLIGHT
EVENTS CENTER
CARS
PARK
TALL TREES
BUSES
TRUCKS
EXTENDED GRASSLANDS
PARKING LOT
ARTIFICIAL LIGHTING
HIGHWAY
NATIVE VEGETATION
PEOPLE
DEGRADED SOIL
SHORT TREES
RIVERFLOW SOUND
EXOTIC VEGETATION
SEASONAL BLOOMS
PLASTICS
WATER
BUSHES
SAND
ANIMALS
DIRT
STONES
LICHENS
TRASH
GRASS
MICROORGANISMS
INSECTS
MOSS
BACTERIA
ROCKS
4/MAY/2023

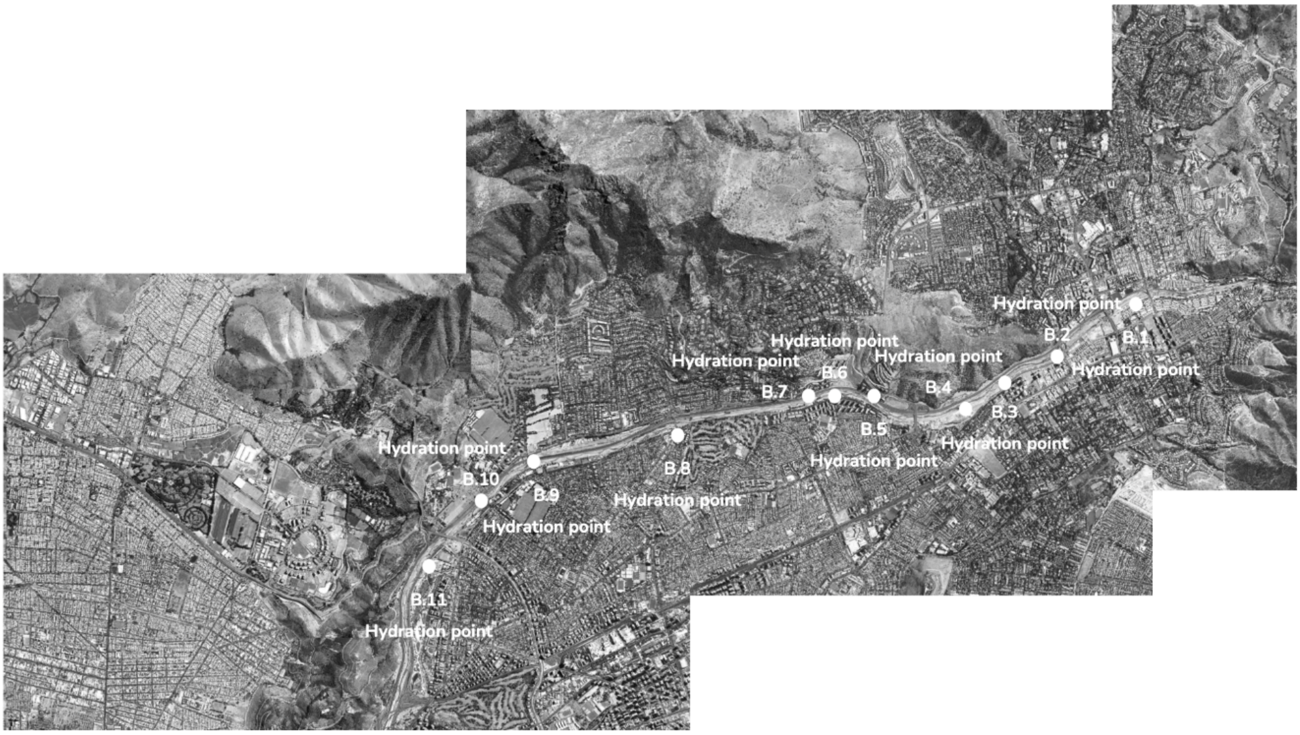

24H ACTIVITY
URBAN NOISE
HUMIDITY
HEAT ISLAND EFFECT
SUNLIGHT
TEMPERATURE
PEOPLE
STREET COMMERCE
CHURCHS
EXOTIC VEGETATION
SUPERMARKET
MUSEUMS
PARK
RESIDENTIAL APARTMENTS
BUILDINGS
OFFICES
ARTIFICIAL LIGHTING
SCOOTERS
FENCES
STREETS
BUSES
CARS
TRUCKS
BYCICLES
RETAINING WALL
INFORMAL HOUSING
PEDESTRIANS
CHEMIC SUBSTANCES
ANIMALS
GRAFFITTI
BUSHES
PLASTICS
GRASS
TRASH
INSECTS
DISPOSAL
ROCKS
DIRT
CEMENT
PAVEMENT
WATER
DUST
STONES
MICROORGANISMS
BACTERIA
4/MAY/2023

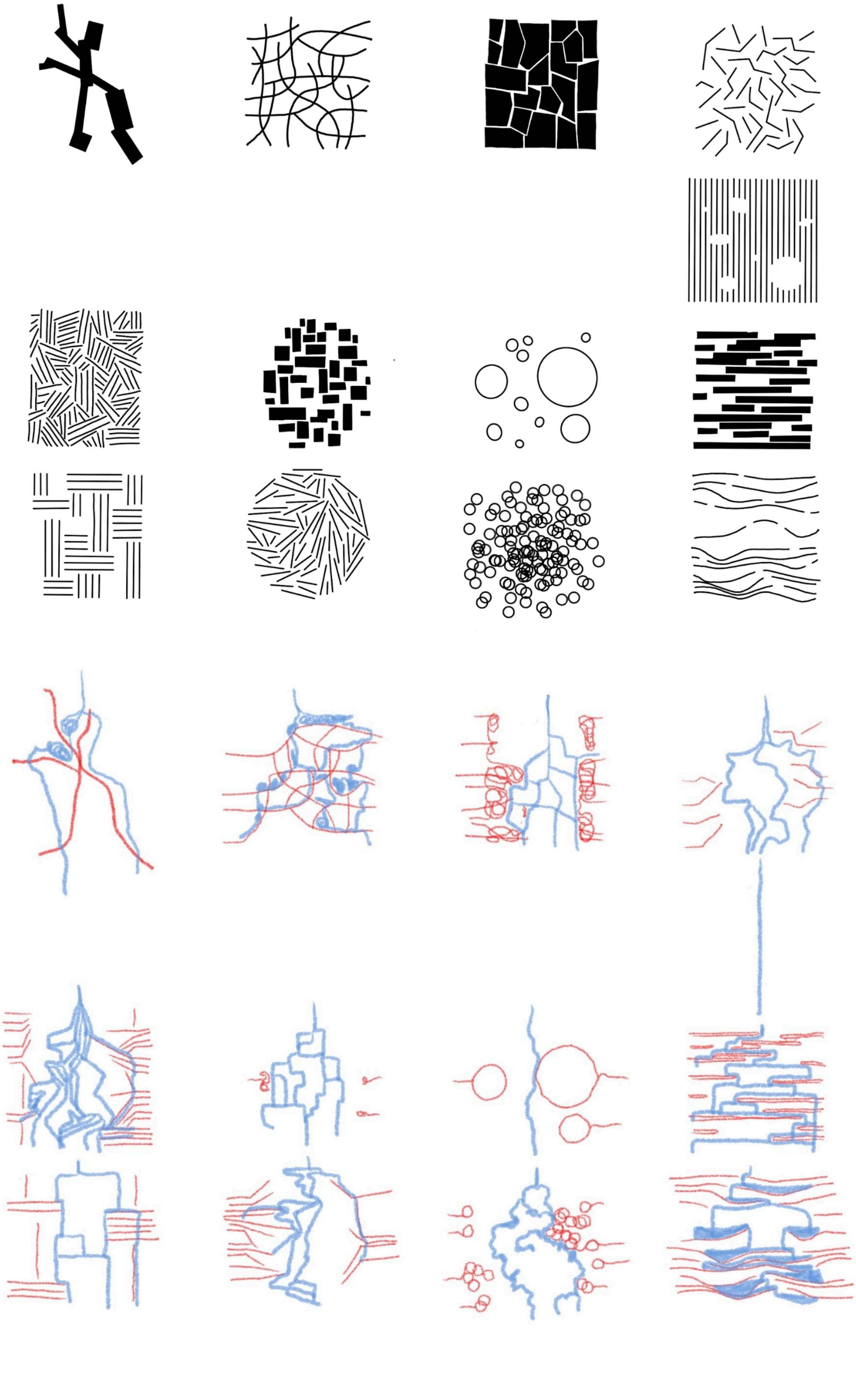

TALL TREES
relationship between ≠ levels
BIRDS
SUNLIGHT
WIND
EXOTIC VEGETATION
NATURAL SOUNDS
TEMPERATURE
regulated by vegetation
NATURAL SHADING
SHORT TREES
BUSHES
HUMIDITY
from vegetation
PEOPLE
ANIMALS
CREEPING PLANTS
CONTAMINANTS
INSECTS
LEAVES
MOSS
STICKS
WATER
STONES
SOIL
ROOTS
MICROORGANISMS
balance
LICHENS
SAND
ROCKS
MINERALS
BACTERIA
NUTRIENTS
FUNGHI
=LIFE
26/APR/2023


INTENSE RAINFALLS
SMOG
CONTAMINATION
BIRDS
DIRECT SUNLIGHT
[PEOPLE]
EVENTS CENTER
TRAFFIC NOISE
CARS
PARK
TALL TREES
BUSES
TRUCKS
EXTENDED GRASSLANDS
DRAUGHT!!!
ARTIFICIAL LIGHTING
HIGHWAY
PARKING LOT
NATIVE VEGETATION
PEOPLE
DEGRADED SOIL
SHORT TREES
SEASONAL BLOOMS
RIVERFLOW SOUND
EXOTIC VEGETATION
PLASTICS
WATER
BUSHES
DIRT
SAND
ANIMALS
STONES
LICHENS
TRASH
MICROORGANISMS
FOUNDERS OF THE ECOSYSTEM
GRASS
INSECTS
MOSS
BACTERIA
ROCKS

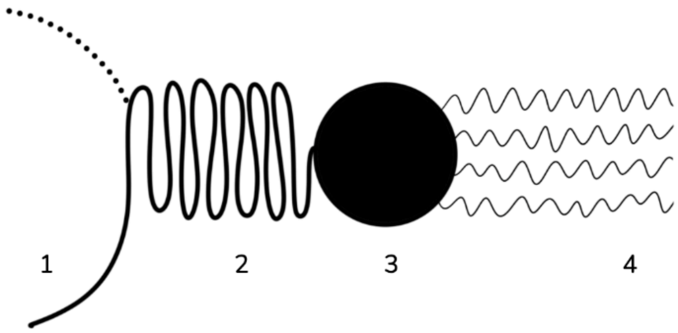

¿NATURE SOUNDS?
A LOT OF ≠ SERVICES
24H ACTIVITY
URBAN NOISE
HEAT ISLAND EFFECT
DIRECT SUNLIGHT
HUMIDITY
HIGH TEMPERATURE
NATURAL SHADING?
NATURE!!
PEOPLE
STREET COMMERCE
CHURCHS
EXOTIC VEGETATION
SUPERMARKET
MUSEUMS
PARK
RESIDENTIAL APARTMENTS
BUILDINGS
OFFICES
ARTIFICIAL LIGHTING
SCOOTERS
FENCES
STREETS
BUSES
CARS
TRUCKS
BICYCLES
RETAINING WALL
CHEMIC SUBSTANCES
ANIMALS
INFORMAL HOUSING
PEDESTRIANS
GRAFFITTI
BUSHES
PLASTICS
GRASS
TRASH
INSECTS
DISPOSAL
ROCKS
DIRT
CEMENT
PAVEMENT
IMPERMEABILITY
WATER
DUST
NO NATIVE VEGETATION!!!
STONES
MICROORGANISMS
BACTERIA


SECTION A, Lo Barnechea - Vitacura
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
MOUNTAINS
RIVERWALK
WASTELAND
GREEN AREAS
PROJECT


Hydration point
B.1
Hydration point
B.2
Hydration point
B.3
Hydration point
B.4
Hydration point
B.5
Hydration point
B.6
Hydration point
B.7
Hydration point
B.8
Hydration point
B.9
Hydration point
B.10
Hydration point
B.11
Hydration point



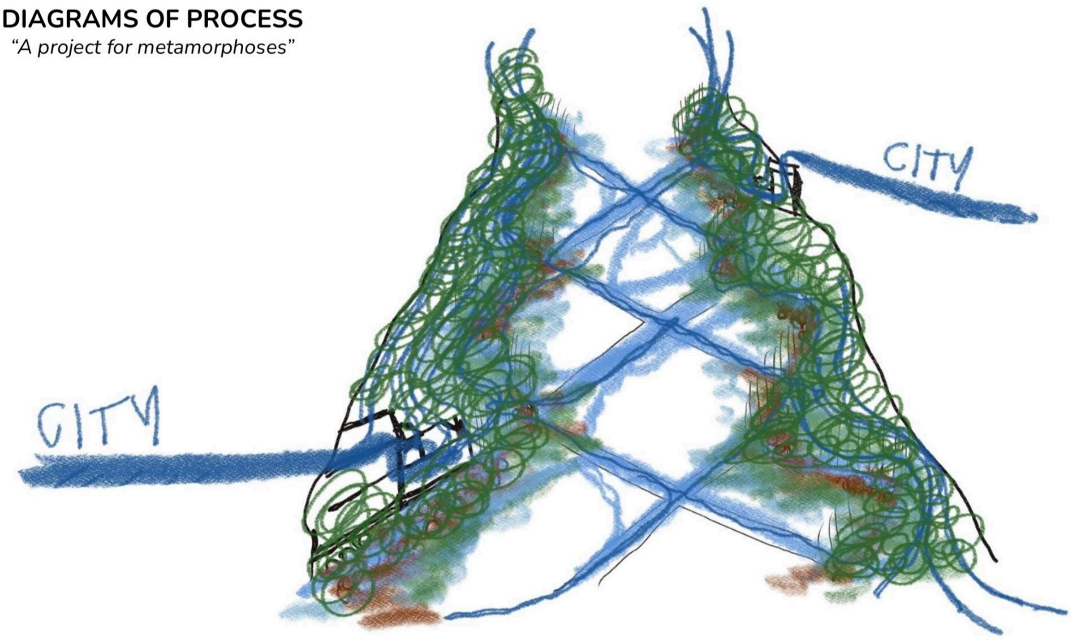
**HYDRATION PROJECT**

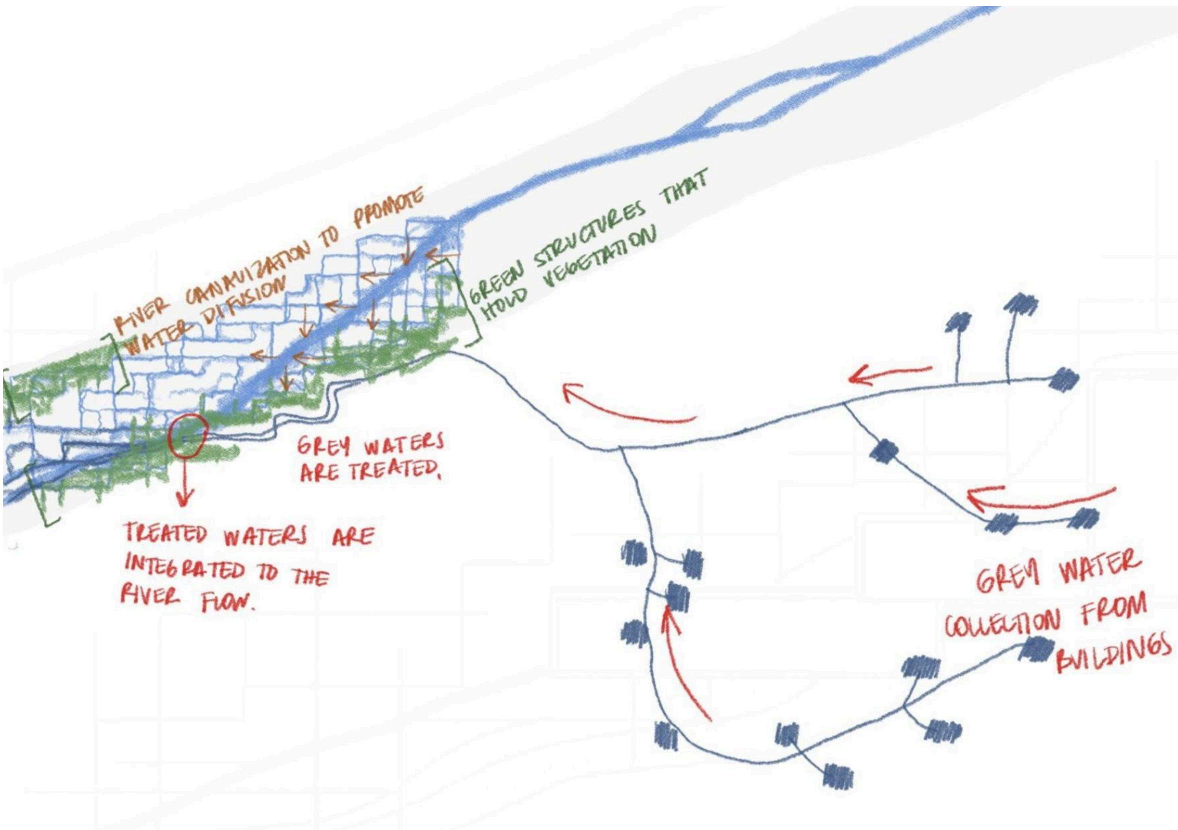


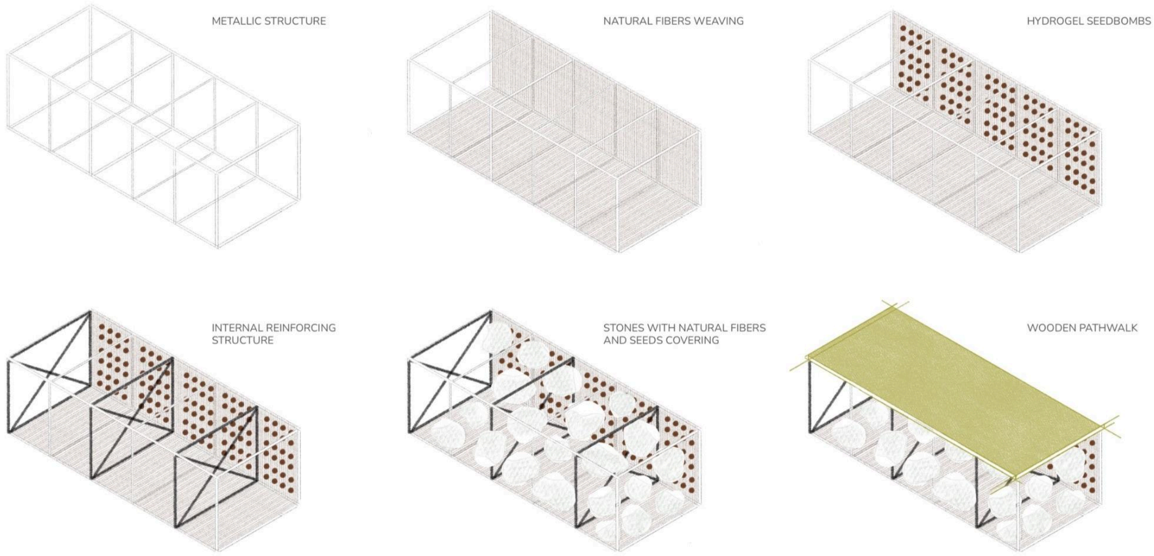

1. Integration of water (grey water or contaminated from the river flow).
2. Slow infiltrating section. Renaturation of the basin.
3. Accumulation of water for extraction, recreation and decantation.
4. Overflow and integration back to the river. Basin hydration.

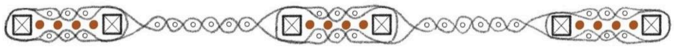
## DIAGRAMS OF PROCESS

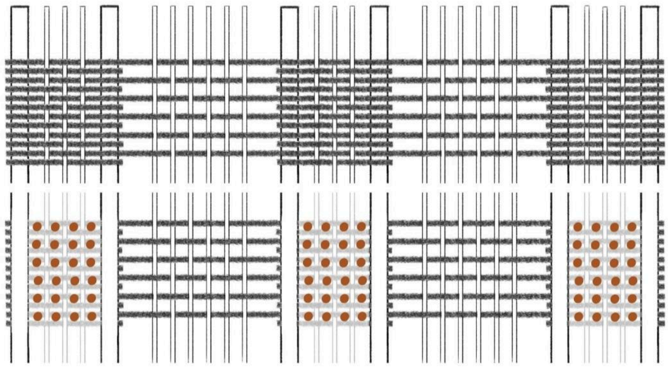
*"A project for metamorphoses"*

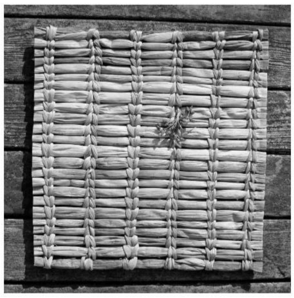


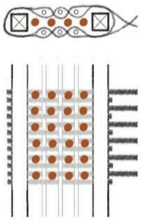

RIVER CANALIZATION TO PROMOTE WATER DIFFUSION
GREEN STRUCTURES THAT HOLD VEGETATION
GREY WATERS ARE TREATED.
TREATED WATERS ARE INTEGRATED TO THE RIVER FLOW.
GREY WATER COLLECTION FROM BUILDINGS


METALLIC STRUCTURE
NATURAL FIBERS WEAVING
HYDROGEL SEEDBOMBS
INTERNAL REINFORCING STRUCTURE
STONES WITH NATURAL FIBERS AND SEEDS COVERING
WOODEN PATHWALK



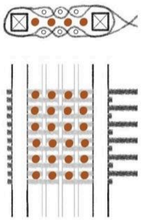






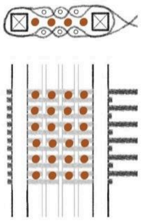
LOW HYDRIC DEMAND

- Mediterranean native vegetation.
- Native Cactaceae.
- Native Geophytes.
- Native fungi.



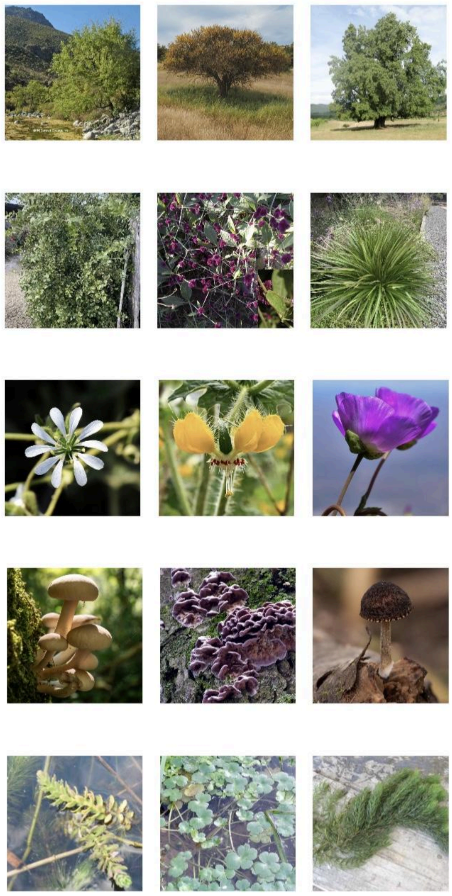
MEDIUM HYDRIC DEMAND

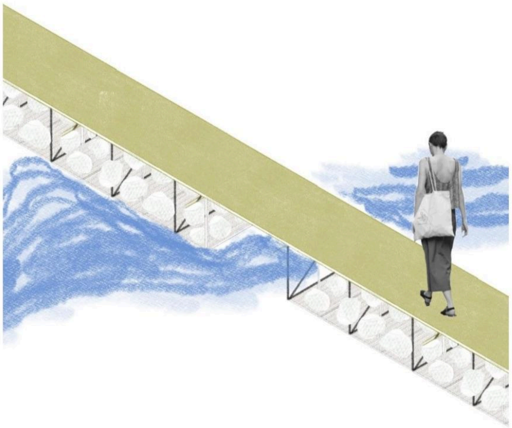
- Native trees and shrubs.
- Native creeping plants.
- Native fungi.

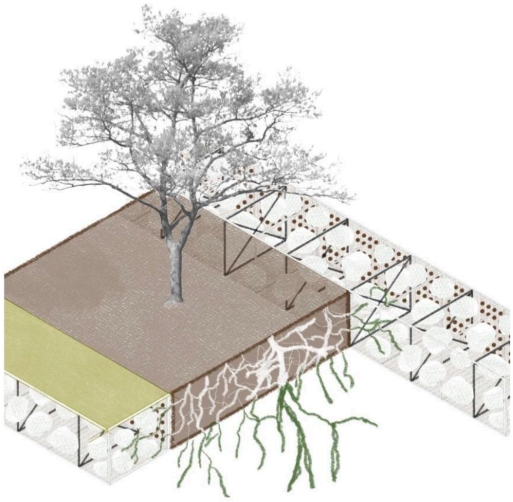


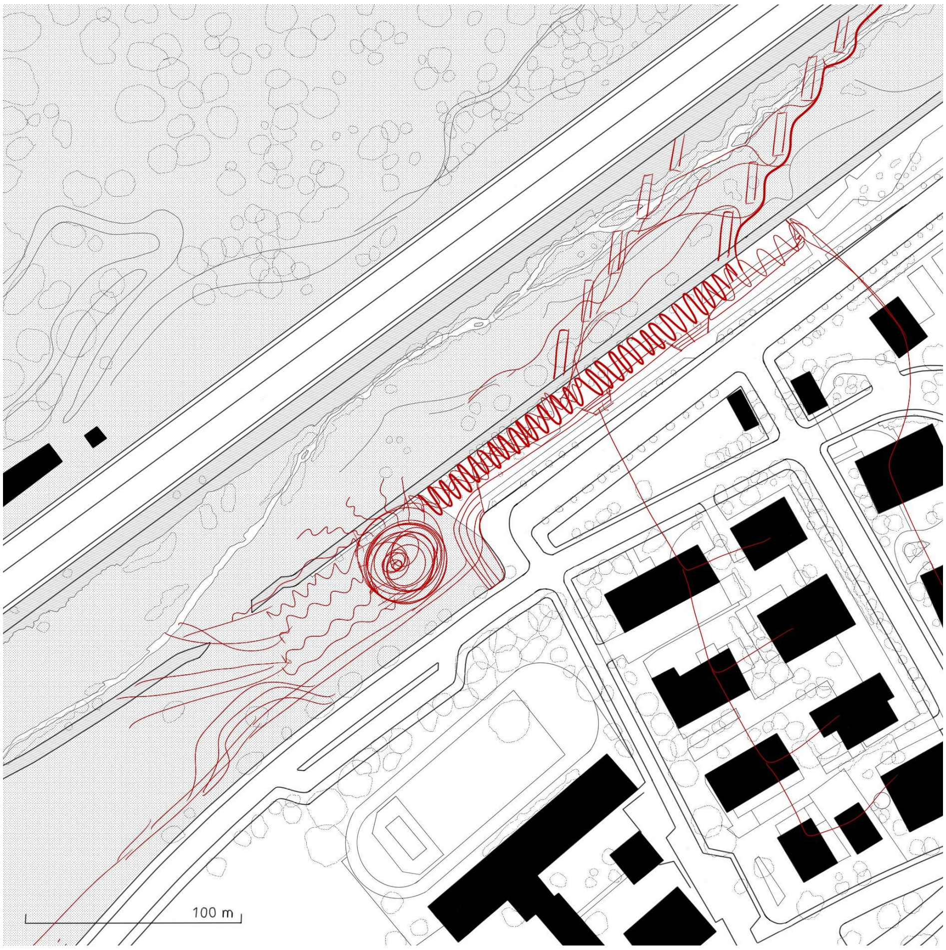
HIGH HYDRIC DEMAND

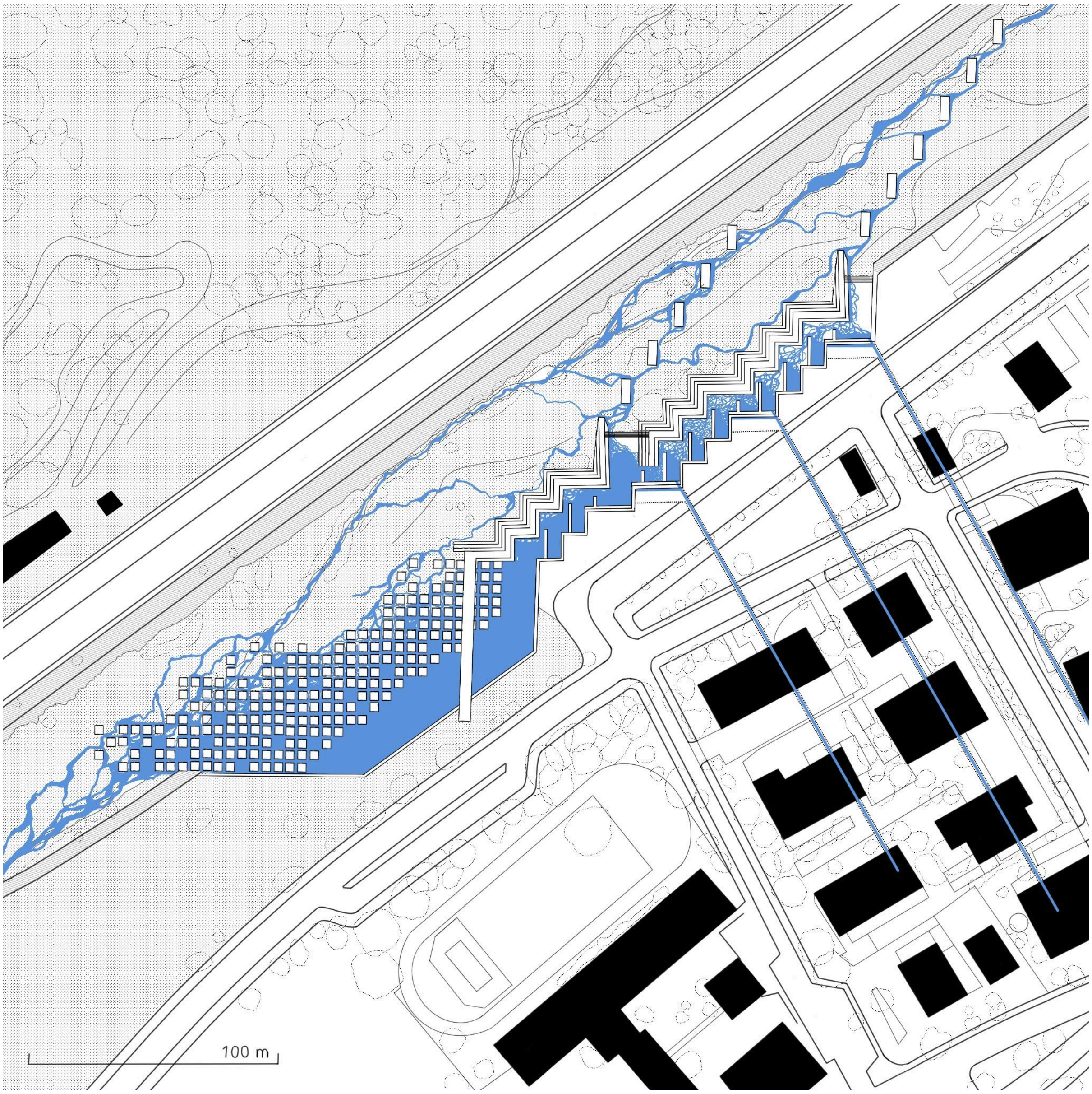
- Native mosses.
- Native fungi.
- Riparian native flora.
- Aquatic native flora.

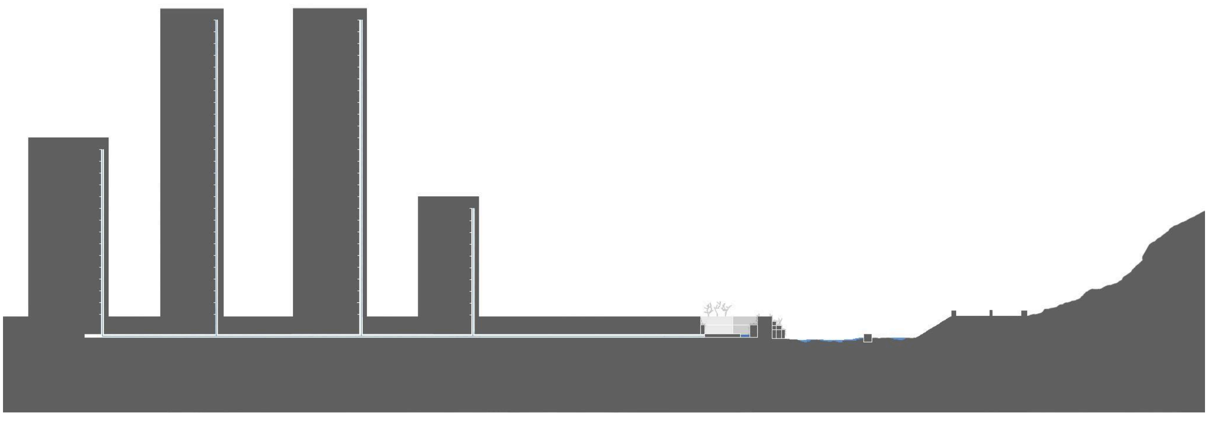







100 m


100 m



**BIBLIOGRAPHY**


1. Waring, R. H., & Running, S. W. (2007). "*Water Cycle*". Forest Ecosystems (Third Edition), ScienceDirect. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hydrologic-cycle
2. Pokorný, J., & Rejšková, A (2008). "Water Cycle Management". Encyclopedia of Ecology, ScienceDirect. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hydrologic-cycle
3. Abrahams, P. (2002). "*Soils: Their implications to human health*". Sci. Total Environ. 2002, 291, 1–32. https://www.sciencedirect.com/science/article/abs/pii/S0048969701011020
4. Alvarado, A., & et al. (2013, June). "*Árboles Urbanos de Chile: Programa de arborización un chileno, un árbol*". Corporación Nacional Forestal, Chile.
5. Alvarez, C. (2022, March 28). "*Comunas del sector oriente tienen el mayor consumo per cápita de agua potable en la RM (CNN Chile)*". Center for Climate and Resilience Research. Santiago, Chile. https://www.cr2.cl/comunas-del-sector-oriente-tienen-el-mayor-consumo-percapita-de-agua-potable-en-la-rm-cnn-chile/
6. Alvarez-Garreton, C., et al. (2022, June 24). "*Análisis (CR)2 | La crítica situación del agua potable en la Región Metropolitana*". Center for Climate and Resilience Research, Santiago, Chile. https://www.cr2.cl/analisis-cr2-la-critica-situacion-del-agua-potable-en-la-region-metropolitana/
7. Aquae Fundación (2021, August 23) "*¿Cuánto es el consumo de agua por persona en Europa?*". Madrid, Spain. https://www.fundacionaquae.org/wiki/europa-consumimos-una-media-128-litros-agua-persona-dia/#:~:text=Seg%C3%BAn%20la%20Organizaci%C3%B3n%20Mundial%20de,cobertura%20de%20las%20necesidades%20b%C3%A1sicas.
8. Araneda, M., et al. (2019, October 7). "*Modelo estructural de la cuenca de Santiago, Chile y su relación con la hidrogeología*". Revista Geofísica, Chile. https://www.revistasipgh.org/index.php/regeofi/article/view/541
9. Arriaga, R. (2017, November). "*Cerros Isla de Santiago: Construyendo un nuevo imaginario de la ciudad a partir de su geografía*". Ediciones ARQ, Santiago, Chile. https://issuu.com/fundacioncerrosisla/docs/cerros_isla_gore
10. Angel, S., et al. (2016). "*ATLAS OF URBAN EXPANSION*". UN Habitat, NYU University, Lincoln Institute, USA. http://atlasofurbanexpansion.org/acknowledgements
11. Baier, S., (2017, September). "*Aguas Andinas Corporate Presentation*". Aguas Andinas, Chile. https://www.aguasandinasinversionistas.cl/~/media/Files/A/Aguas-IR-v2/presentations/en/aguas-andinas-corporate-presentation-september-2017.pdf
12. Baur, T., et al. (2012). "*Kallang River @ Bishan-Ang Mo Kio Park: Integrating River and Park in an Urban World.*" CITYGREEN 01, no. 5 (2012): 98. http://dx.doi.org/10.3850/s2010098115000717.
13. Belov, M. "*Chileflora*". Chile. https://www.chileflora.com/Florachilena/FloraSpanish/SPlantdbase.htm
14. Biblioteca del Congreso Nacional de Chile. "*Clima y Vegetación Región Metropolitana de Santiago: Chile Nuestro País*". Chile.
15. Memoria Chilena. "*Santiago (1930-2006): Fisonomía de la ciudad*". Biblioteca Nacional de Chile https://www.memoriachilena.gob.cl/602/w3-article-93814.html

16. https://www.bcn.cl/siit/nuestropais/region13/clima.htm#:~:text=La%20principales%20caracter%C3%ADsticas%20clim%C3%A1ticas%20que,y%20con%20un%20invierno%20lluvioso.
17. Biswas, S., et al. (2019) *"The Sponge Handbook: Chennai - Using the Landscape Approach to transform the South Buckingham Canal Area"*. Team Sponge, India.
18. Brito, R. (2019) *"Río Mapocho Aguas abajo: Paisaje [Alterado] en Proceso"*. Pontificia Universidad Católica de Chile, Chile.
19. Butler, D. (2018). " *Urban Drainage*". CRC Press, Fourth Edition, USA. https://books.google.es/books?hl=es&lr=&id=PGpQDwAAQBAJ&oi=fnd&pg=PP1&dq=urban+drainage&ots=Rq35nCbCZq&sig=DM3hbCt3yL6Pidvj_XjW6LxA_ks#v=onepage&q=urban%20drainage&f=false
20. Campos, D., Moya, A. (2023, January 12). "*Resumen climático del año 2022*". NextGEN Chile, Chile. https://climatologia.meteochile.gob.cl/publicaciones/boletinTendenciasClimaticas/boletinTendenciasClimaticas-202212.pdf
21. Caracciolo, F., (2022, January 31). "*Il Po a Torino si sta svuotando: isole davanti ai Murazzi*". La Stampa, Italy. https://www.lastampa.it/torino/2022/01/31/news/il_po_a_torino_si_sta_svuotando_isole_davanti_ai_murazzi-2844586/#:~:text=Non%20%C3%A8%20un%20record%20assoluto,si%20vedevano%20dalla%20scorsa%20estate.
22. Castro, A., et al. (2020). "*Origen y evolución del mimbre de Chimbarongo (1762 - 2017)*". San Pedro de Atacama, Chile. http://dx.doi.org/10.22199/issn.0718-1043-2020-0010
23. Censo 2017 (2020). "*Datos Geográficos*". Gobierno de Santiago, Chile. https://www.gobiernosantiago.cl/datos-geograficos/
24. Città di Torino (2020). "*Torino Green Print*". https://www.torinovivibile.it/aree-tematiche/torino-green-print/#:~:text=I%20dati%20raccolti%20rivelano%20che,m%C2%B2%20di%20verde%20per%20abitante
25. Coccia, E. (2018). *"The Life of Plants: A Metaphysics of Mixture"*
26. Coccia, E. (2021). *"Metamorphoses"*
27. Corboz, A. (1980). "*The Territory as Palimpsest*".
28. Davis, M., & Naumann, S. (2017). "*Making the Case for Sustainable Urban Drainage Systems as Nature-Based Solution to Urban Flooding*". N. Kabisch, H. Korn, J. Stadler, & A. Bonn (Eds.), Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice (pp. 123–137). https://doi.org/10.1007/978-3-319-56091-5_8
29. Depolo, S. & Dibán, A. (2020, November 5). "*Áreas verdes en la ciudad: ¿cómo avanzar hacia territorios más justos?*". Diario UChile, Chile. https://radio.uchile.cl/2020/11/05/areas-verdes-en-la-ciudad-como-avanzar-hacia-territorios-mas-justos/#:~:text=En%20el%20caso%20de%20las,zonas%20perif%C3%A9ricas%20del%20%C3%81rea%20Metropolitana.
30. De Ovalle, A. (1776) *"Histórica Relación del Reyno de Chile y de las Misiones y Ministerios que ejercita en la Compania de Jesus"*. Compañía de Jesús y su procurador en Roma, Chile.

31. Del Pozo, B. (2022, January). "*CONDICIONES HIGROTÉRMICAS CONFORTABLES PARA EL CUERPO HUMANO EN ESPACIOS FLUVIALES URBANOS: Las distintas tipologías y ecologías en el río Mapocho*" (thesis). Escuela de arquitectura de la Pontificia Universidad Católica de Chile. Santiago, Chile.
32. Diaz, F. (2017, April) *"Masa crítica: El nuevo paisaje de la arquitectura en Chile".* Rita Magazine 07 "Chile", pp. 34-41, Chile.
33. Diaz, P. (2021, June 14). "*La resiliente biodiversidad del río Mapocho: varias caras de una naturaleza que resiste el impacto de la ciudad".* Ladera Sur. https://laderasur.com/articulo/la-resiliente-biodiversidad-del-rio-mapocho-varias-caras-de-una-naturaleza-que-resiste-el-impacto-de-la-ciudad/
34. Emol (2017, May 29). "*Estudio revela cuáles son las comunas con peor acceso a áreas verdes: Puente Alto y El Bosque lideran en Santiago*". Santiago, Chile. https://www.emol.com/noticias/Nacional/2017/05/29/860451/Estudio-revela-cuales-son-las-comunas-con-peor-acceso-a-areas-verdes-Puente-Alto-y-El-Bosque-lideran-en-Santiago.html#
35. Fenoglio, S. (2023). "*Uomini e fiumi*". Rizzoli, Italy.
36. Fernández, M. P. (2021) "*Proyecto 'Adecuación climática de especies de arbolado urbano para Chile'*" Santiago, Chile.
37. Fernández, M. P., et. al. (2022). "*ARBOLADO URBANO DESAFÍOS Y PROPUESTAS PARA LA REGIÓN METROPOLITANA*". Facultad de Agronomía e Ingeniería Forestal Pontificia Universidad Católica de Chile, Santiago, Chile. https://www.enel.cl/content/dam/enel-cl/sostenibilidad/medio-ambiente/biodiversidad/proyectos/Arbolado-Urbano-desafios-y-propuestas-rm.pdf
38. Fernandez, T., & Courard, P. (2018). "*Parque Kaukari del río Copiapó".* https://www.scielo.cl/pdf/arq/n99/0717-6996-arq-99-00070.pdf
39. Ferrando, F. (2008, June). "*Santiago de Chile: antecedentes demográficos, expansión urbana y conflictos*". Revista de urbanismo, N. 18, Chile. https://revistaurbanismo.uchile.cl/index.php/RU/article/view/249
40. Garcia, N., & Ormazabal, C. (2008, December). "*Árboles Nativos de Chile*". Enersis, Chile.
41. Geitner, C., et al. *"Soil Ecosystem Services in the Alps"* 20-66 (2019). Agricultural Institute of Slovenia. Interreg: Alpine Space (EU), Slovenia. https://alpinesoils.eu/wp-content/uploads/2019/11/2019-1025_SoilEcosystemServicesInTheAlps-WEB.pdf
42. Gobierno de Chile, *"Nuestro País".* Gob.cl https://www.gob.cl/nuestro-pais/#:~:text=Su%20forma%20es%20%C3%BAnica%3A%20es,promedio%20de%20solo%20180%20km.
43. González, C. (2018, March 20). "*El 86% de los árboles de Santiago corresponde a especies exóticas*". La Tercera, Santiago, Chile.
44. Gonzalez-Meler, M. A., et. al. (2013). "*The Environmental and Ecological Benefits of Green Infrastructure for*

*Stormwater Runoff in Urban Areas*". JSM Environ Sci Ecol, 1(2): 1007.
https://www.latercera.com/tendencias/noticia/86-los-arboles-santiago-corresponde-especies-exoticas/105361/

45. Graber, D.R., et al. (1995). "*Human and ecosystem health*". J. Agromedicine 1995, 2, 47–64. https://www.tandfonline.com/doi/abs/10.1300/J096v02n03_06
46. Guevara, C., & Fernández, M. P. (2015). "*El patrimonio vegetal de la Quinta Normal de Agricultura: 1852 vs. 2015. Adaptación climática de las especies arbóreas propuestas por Lui Sada di Carlo*" Pontificia Universidad Católica de Chile, Chile.
47. Gutierrez, R. (2023, May). "*Reporte Anual de la Evolución del Clima en Chile*". Oficina Cambio Climático, Dirección Meteorológica de Chile, Chile.
48. Hans-O, P., Roberts, D., (2022) *"Summary for Policymakers"*. Cambridge University Press, USA and UK.
49. Haraway, D. J. (). "*Staying With the Trouble: Making kin in the Chthulucene (Experimental Futures)*"· Duke University Press Books, USA.
50. Hecht, R. (2017). "*Dissecting the origins of Chile's Quinta Normal de Agricultura as a colonial garden, 1838–1856*" Stud. Hist. Gard. Des. Landscapes, vol. 37, no. 4, pp. 273–293, 2017, doi: 10.1080/14601176.2016.1231504.
51. Herrera, R., Skarmetta, M., Gennero, R. (1971) "*Las Aguas Servidas de Santiago: Estudio de Factibilidad del Tratamiento*". Ingenieria y Proyectos INPRO Ltda., Chile.
52. Hidalgo, G., et al. "*Santiago 1872- 1875: Un Plano para el Plan de Vicuña Mackenna*". Pontificia Universidad Católica de Chile, Chile.
53. Hidalgo, G., Vila, W. (2015, June) "*Calles- que fueron- Caminos. Intensificación de la Trama de Calles al Sur de la Alameda en Santiago de Chile hasta fines del Siglo XIX*". Historia No 48, vol. I, enero junio 2015: 195244, Chile.
54. Hou-Jones, X., et al. (2021, July) "*Nature-based Solutions in Action: Lessons from the Frontline*". Climate Action Network UK, UK.
55. Huber, J. "*LID: Low Impact Development*". University of Arkansas Community Design Center, USA and UK.
56. Imagina Santiago (2013). "*Historia de Santiago de Chile*"
57. Iturriaga, S. (2013) "*Obras y Proyectos*". Equipo Mapocho 42k, Chile.
58. Iturriaga, S. (2017). "*MAPOCHO 42K*" (1st ed.). Ediciones ARQ.
59. Katz, C., et al. (2009, August). "*Tres visiones sobre el río Mapocho*". ARQ (Santiago) n.72, Santiago, Chile. http://dx.doi.org/10.4067/S0717-69962009000200011
60. Laborde, M. (2007). "*Parques de Santiago: historia y patrimonio urbano Santiago, Chile*". Ed. Midia Comunicación, Chile.Ledermann, W. (2021) "*About how the sewerage was gestated in Santiago de Chile*". Chilean Infectol Magazine, 38 (1), pp. 102-105, Chile.

61. Lal, R. (2015, May 15). “Restoring Soil Quality to Mitigate Soil Degradation”. Sustainability 2015, 7(5), 5875-5895. The Ohio State University, Columbus, OH 43210, USA. https://doi.org/10.3390/su7055875

62. Leon, J., & Osorio, N. (2014). “Role of Litter Turnover in Soil Quality in Tropical Degraded Lands of Colombia”. Sci. World J. 2014, 13. https://www.hindawi.com/journals/tswj/2014/693981/

63. Leveratto, M. (2018, May) "*Permeabilidad del Suelo Urbano como Estrategia de Mitigación*". 3 Congreso Interamericano de Cambio Climático, Argentina.

64. Lira, L. (2022, January 28). “*La desigualdad en el acceso a las áreas verdes públicas: Un problema global*”. Ciudades Verdes, Chile.
https://ciudadesverdes.com/la-desigualdad-en-el-acceso-a-las-areas-verdes-publicas-un-problema-global/

65. Llacza, A., et al. (2021, November). “*Escenarios climáticos al 2050 en el Perú: Cambios en el clima promedio*”. Servicio Nacional de Meteorología e Hidrología del Perú SENAMHI, Ministerio del Ambiente, Perú.

66. Lubelli, M. (2017, 2018) "*Nuovo Scenario per il Quartiere du Champ a Lione*". Politecnico di Torino, Italy.

67. M’Closkey, K. (2013, May 24). “*Synthetic Patterns: Fabricating landscapes in the age of ‘green’*”. Journal of Landscape Architecture, 8:1, 16-27, DOI: 10.1080/18626033.2013.798919.
http://dx.doi.org/10.1080/18626033.2013.798919

68. Madrid, C. (2019, January) "*La línea del agua*". Pontificia Universidad Católica de Chile, Chile.

69. Martinez, R. (2007) "*Santiago, los planos de transformación, 1984- 1929*". Revista Electrónica DU & P. Diseño Urbano y Paisaje Volumen IV N°10, Chile.

70. Martinez, V. (1843, 1934) "*Canalización del Río Mapocho: Proyecto Presentado a la Municipalidad de Santiago*". Cámara Chilena de la Construcción, Chile.

71. Maureira, H., et al. (2018, June) ”*Radiografía del agua: Brecha y Riesgo Hídrico en Chile*". Escenarios hídricos 2030 Chile, Chile.
https://cambioclimatico.mma.gob.cl/wp-content/uploads/2023/05/reporteEvolucionClima2022.pdf

72. Migues, G. (2023, March 22). “*Water Resilience for Santiago de Chile*”. Alliance for Global Water Adaptation. https://www.alliance4water.org/wr4er-cases/water-resilience-for-santiago-de-chile

73. Ministerio de Medio Ambiente (2017). “*Plan de Acción Nacional de Cambio Climático 2017-2022*”. Santiago, Chile. www.mma.gob.cl/wp-content/uploads/2017/07/plan_nacional_climatico_2017_2.pdf

74. Ministerio de Salud (2021, August 30). “*Registro histórico de emergencias y desastres ocurridos en agosto…*”. Departamento de gestión de Riesgos en Emergencias y Desastres.
https://degreyd.minsal.cl/registro-historico-de-emergencias-y-desastres-ocurridos-en-agosto/

75. Ministerio de Salud (2021, July 30). “*Registro histórico de emergencias y desastres ocurridos en julio…*”. Departamento de gestión de Riesgos en Emergencias y Desastres.
https://degreyd.minsal.cl/registro-historico-de-emergencias-y-desastres-ocurridos-en-julio/

76. Ministerio de Salud (2021, June 30). “*Registro histórico de emergencias y desastres ocurridos en junio…*”. Departamento de gestión de Riesgos en Emergencias y Desastres.
https://degreyd.minsal.cl/registro-historico-de-emergencias-y-desastres-ocurridos-en-junio/

77. Monasterio de Carmelitas (1862). "*Relación de la inundación, que hizo el río Mapocho de la Ciudad de Santiago de Chile, en el Monasterio de Carmelitas, Titular de San Rafael, el día 16 de julio de 1783*". Imprenta del Ferrocarril. Santiago, Chile.

78. Monnet, J. (2012). "*La interpretación del mundo, de la representación a la acción: Una mirada desde la geografía francesa*". C.Capron, C.Icazuriaga Montes, S.Levi, E.Ribera Carbo, V.Thiébaut. La geografía contemporánea y Elisée Reclus, Publicaciones de la Casa Chata, pp.135-159, 2011. https://shs.hal.science/halshs-00714003/document

79. Moreno, O. (2021, November) "*Del jardín a la infraestructura verde. La arquitectura del paisaje como soporte para la sustentabilidad y resiliencia del territorio*". Anales del IAA, 52(2), pp. 1-17, Chile.http://www.iaa.fadu.uba.ar/ojs/index.php/anales/article/ view/449/729 Nicolì, A. (2020, July) "Green garden e sistemi di drenaggio urbano sostenibile per la gestione dei cambiamenti climatici". Politecnico di Torino, Italy.

80. Mortice, Z. (2017, April 18). "*Seed Bomb Away*". Landscape Architecture Magazine, USA. https://landscapearchitecturemagazine.org/2017/04/18/seed-bombs-away/

81. Munoz, J. C., et al. (2019). "*Ciudades y cambio climático en Chile: Recomendaciones desde la evidencia científica*". Comité Científico COP 25; Ministerio de Ciencia, Tecnología, Conocimiento e Innovación, Santiago, Chile. https://www.cedeus.cl/wp-content/uploads/2019/12/Ciudades_ Munoz_04.pdf

82. Museo Histórico Nacional (2013, February). "*Fundación de Santiago*". Gob.cl, Santiago, Chile. https://www.mhn.gob.cl/cartelera/fundacion-de-santiago

83. Navarrete-Hernández, P., & Laffan, K. (2019). "*A greener urban environment: Designing green infrastructure interventions to promote citizens' subjective wellbeing*". Landscape and Urban Planning, 191, 103618. https://doi.org/10.1016/j.landurbplan.2019.103618

84. Nunez, T. (2022, August) "*Conociendo la historia ambiental del Río Mapocho, el habitante más antiguo de la ciudad de Santiago*". Ladera Sur, Chile.

85. Núñez, T. (2021, September 27). "*¡Bienvenida primavera! Les compartimos esta guía práctica para identificar flores silvestres de la región Metropolitana*". Ladera Sur, Chile

86.

87. Oficina Cambio Climático, Gutiérrez, R., "*REPORTE ANUAL DE LA EVOLUCIÓN DEL CLIMA EN CHILE*" 1–52 (2023). Santiago, RM; DGAC Chile.

88. Ojeda, A. "*Tipos de Suelos, Geología y Sismos en Santiago de Chile*". Geotecnia Facil, Chile.https://geotecniafacil.com/tipos-suelos-santiago-de-chile/

89. Pavez, A. (2017, October) "*Arquitectura para el fin del mundo: Un proyecto de existencia mínima sobre los fiordos Patagónicos*". Pontificia Universidad Católica de Chile, Chile.

90. Piwonka, G. (1999) "*Las Aguas de Santiago de Chile 1541- 1999*". Editorial Universitaria, EMOS, Centro de Investigaciones Diego Barros Arana, Chile.

91. Quilhot, W., et al. (1998, August 28). "*CATEGORÍAS DE CONSERVACIÓN DE LÍQUENES NATIVOS DE CHILE*". Boletín del Museo Nacional de Historia Natural 47: 9-22, Chile.

https://publicaciones.mnhn.gob.cl/668/articles-65021_archivo_01.pdf

92. Redacción (2021, April 14). "*Chile: Desborde Del Mapocho, Origen De Arbitraje Entre Costanera Norte Y Aseguradora*". CIAR Global, Chile. https://ciarglobal.com/chile-desborde-del-mapocho-origen-de-arbitraje-entre-costanera-norte-y-aseguradora/
93. Reyes, S., Figueroa, I. (2010, December). "*Distribución, superficie y accesibilidad de las áreas verdes en Santiago de Chile*". Scielo Magazine, Chile.
94. Rizzo, F. (2018, July). "*Drenaggio urbano sostenibile: il caso del Politecnico di Torino*". Politecnico di Torino, Italy.
95. Robinson, D., et al. (2012). "Soil Natural Capital and Ecosystem Service Delivery in a World of Global Soil Change". Soils Food Secur, 35, 41–68. https://books.google.cl/books?hl=es&lr=&id=bHMoDwAAQBAJ&oi=fnd&pg=PA41&ots=1hLFozlQpR&sig=GAqGTfW5EXS2mPdpVttGJIzf-uw&redir_esc=y#v=onepage&q&f=false
96. Rocha, E (1986). "*Desborde del río Mapocho*". Memorias del Siglo XX, Chile. https://www.memoriasdelsigloxx.cl/601/w3-propertyvalue-132868.html
97. Rodriguez, R., & Fica, B. (2020). "*Guia de Campo: Plantas Vasculares Acuáticas en Chile*". Corma, Chile.
98. "*Salix Viminalis*". https://www.arbolapp.es/especies/ficha/salix-viminalis/
99. Sauer, C. (1925, October 12). "*The Morphology of the Landscape*". University of California Publications in Geography. Vol. 2, No. 2, pp. 19-53. USA.
100. Senado de la República de Chile (2017). "*Ingreso Municipal per Cápita 2015*". Unidad de Asesoría Presupuestaria, Chile. https://www.senado.cl/site/presupuesto/2017/cumplimiento/tematicos/Ingresos%20Municipales%20per%20C%C3%A1pita.pdf
101. Señoret, F., & Acosta, J. P. (2013). "*Guía de Campo: Cactáceas Nativas De Chile*". CORMA, Chile. https://fundacionphilippi.cl/wp-content/uploads/2018/10/guia_de_cactaceas_corma.pdf
102. Sistema Nacional de Información Municipal (2018). *"Infraestructura Verde Urbana".* Sexto Reporte del Estado del Medioambiente, Chile. https://sinia.mma.gob.cl/wp-content/uploads/2022/01/C9-infraestructura-verde-urbana-rema-2021.pdf
103. Soto, J. (2023, June 5). "*Estudio revela ciudadanos de Santiago consumen tres veces más agua que la media de Latinoamérica*". Corporación del Acueducto y Alcantarillado de Santiago, Chile. https://www.coraasan.gob.do/index.php/noticias/item/710-estudio-revela-ciudadanos-de-santiago-consumen-tres-veces-mas-agua-que-la-media-de-latinoamerica#:~:text=El%20informe%2C%20el%20primero%20que,a%20200%20litros%20por%20persona.
104. Subdere. "*Gobierno Regional Metropolitano de Santiago*". Subsecretaría de Desarrollo Regional y Administrativo, Santiago, Chile. https://www.subdere.gov.cl/divisi%C3%B3n-administrativa-de-chile/gobierno-regional-metropolitano-de-santiago
105. Technical Sector Board for Building and Civil Engineering (2001, September) "*Code of Practice for Earth*

*Retaining Structures*". British Standard, UK.

*106.* Teutsch, C., et al. (2021) "*Ciudades Sensibles al Agua: Guía de Drenaje Urbano Sostenible para la Macrozona Sur de Chile, VI*". Patagua, Fundación Legado Chile y Pontificia Universidad Católica de Chile, Chile.

*107.* Teutsch, C., et al. (2021) "*Ciudades Sensibles al Agua: Guía de Drenaje Urbano Sostenible para la Macrozona Sur de Chile, VII*". Patagua, Fundación Legado Chile y Pontificia Universidad Católica de Chile, Chile.

108. Tickell, J. (2020, September). "*Kiss The Ground*" [Film]. Benenson Productions.

*109.* Tolkien, J.R.R. (1991). "*The Fellowship of the Ri*ng". HarperCollins, UK.

110. United States Environmental Protection Agency (2008). "*Managing Wet Weather with Green Infrastructure*". Action Strategy 2008, Chicago, USA. https://nepis.epa.gov/Exe/ZyPDF.cgi/P1008SI8.PDF?Dockey=P1008SI8.PDF

*111.* Valdivia, S. (2019, January) "*Revelando la Traza del Agua: Canales Periféricos en la Trama Urbana como Infraestructura de Paisaje Multifuncional*". Pontificia Universidad Católica de Chile, Chile.

*112.* Villaseñor, N., Truffello, R., Reyes-Paecke, S.(2021, December) "*Greening at multiple scales promotes biodiverse cities: A multi-scale assessment of drivers of Neotropical birds*". ScienceDirect: Urban Forestry & Urban Greening, Vol. 66. https://www.sciencedirect.com/science/article/abs/pii/S1618866721004210

113. "*Water Cycle*". Forest Ecosystems (Third Edition), ScienceDirect. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hydrologic-cycle

114. Weatherspark. "*Compare el clima y el tiempo en Santiago de Chile y en otra ciudad*". https://es.weatherspark.com/compare/y/26525/Comparaci%C3%B3n-del-tiempo-promedio-en-Santiago-de-Chile#google_vignette

*115.* Woods Ballard, B. (2015) "*The SuDs Manual*". CIRIA, UK.

116. Yajure, J. (2021, April 16). "*El sorprendente método Miyawaki de restauración ecológica y creación de bosques de rápido crecimiento que ya está en Chile*". LaderaSur, Chile. https://laderasur.com/articulo/el-sorprendente-metodo-miyawaki-de-restauracion-ecologica-y-creacion-de-bosques-de-rapido-crecimiento-que-ya-esta-en-chile/

*117.* Yuan, J., et al. (2021) "*Experiment using semi-natural meadow vegetation for restoration of river revetments: A case study in the upper reaches of the Yangtze River*". Elsevier, China.

118. https://openjicareport.jica.go.jp/pdf/10301505_02.pdf

119. http://mapas.centrogeo.org.mx/atlaslatinoamerica/chile/riomapocho.htm