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Loving and Healing a Hurt City: Planning a Green Monterrey Metropolitan Area

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Abstract: In many conurbations, the pressure on the quality of living increases and affects the most vulnerable, human, and non-human populations the most. In this article we describe a mapping and designing investigation how a green metropolis can be developed. The approach used is to make a distinction between the landscape pain, the ways of healing and the opportunities to create environments that people can love. We found that this approach reveals concrete and widespread pain in the metropolis, such as interventions in natural landscapes (rivers and mountains), air pollution, ecological degradation, and hydrological disconnections. The strategy to heal this pain is to uncover the currently hidden and invisible creeks and rivers, then create an abundant zone of ecological space around it before integrating human activities and urban uses. In addition to this, specific design principles have been developed for hydro-ecological corridors, water retention, green islands, and greenways. These places can be replicated to support the healing strategy. These places create an environment that the urban residents love. The analysis of landscape pain, the healing strategies, and the local places to love, can be applied to enhance the quality of life for many urban residents and non-human ecologies in metropolitan areas around the globe.

Keywords: metropolis; Monterrey; landscape pain; regional scale; urban planning; green; pain-heal-love

1. Introduction

With more people living in cities than ever before, since 2014 more than half [1], and rising to 68% by 2050 [2], it is paramount to create healthy, clean, and livable living conditions for the urban residents. Many cities experiment with green infrastructure [3–8], urban ecology [9–11], and climate adaptive policies and plans [12–15], but even so many have trouble finding the right and impactful solutions to transform cities from its industrial variants into a symbiotic urban future [16–19].

In this article we aim to overcome the fragmentation of widespread sole and separated solutions in silos such as biodiversity, water sensitivity, green infrastructure, or urban forestry. Many of the related initiatives operate often on a too small scale to have an profound impact, and should be interconnected and planned at the large scale of the metropolis itself. We propose an analytical, and strategic approach, supported by greener spaces at the local scale.

2. Background

In 2020 there are 1934 metropolises with more than 300,000 inhabitants representing approximately 60% of the world's urban population [20]. According to the Oxford dictionary and Collins English dictionary a metropolis is "a large city or conurbation which is a significant economic, political, and cultural area for a country or region, and an important hub for regional or international connections, commerce, and communications" [21,22].

For many years the largest conurbations were the metropolises, however in recent years megacities, or megalopolises emerged throughout the world. A megalopolis, following the work of Gottmann, refers to two or more roughly adjacent metropolitan areas that, through a commonality of systems—e.g., of transport, economy, resources, and ecologies—experience a blurring of the

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boundaries between the population centers [23], such that while some degree of separation may remain, their perception as a continuous urban area is of value, e.g., "to coordinate policy at this expanded scale" [24]. Simply put, a megalopolis is a clustered network of big cities. Gottmann defined its population as 25 million [25], while Doxiadis defined a small megalopolis a similar cluster with a population of about 10 million [26,27]. Although some claim that more condensed and large metropolises are greener [28], opposing urban sprawl, it is a limited scope to oil-dependent mobility mainly. The argument it creates may support sustainability (e.g. reduced carbon emissions), it does not necessarily create a greener, natural, or more biophilic city, offering residents to connect with nature in a meaningful way [29]. Despite the fact there are significant efforts to green cities and metropolises [30–34], larger cities tend to be less green, in terms of GHG emissions, in comparison with smaller cities and towns [35]. The number and area of green spaces is more related to climate, demography, and social-economic conditions than the size per se with large cities in high income countries have more adequate green provision than those in less privileged circumstances [36].

We live in perilous times [37], as changes in climate move ever faster and become more unpredictable and potentially more impactful. Cities are seen both as the cause and the possible solution to reducing the harmful greenhouses gases that are causing global temperatures to rise [38].

Generally, biodiversity is impacted by human (urban) activities. This is happening in a direct way through habitat loss, fragmentation, and the introduction of new species, but also in an indirect way as humans tend to change climate, the hydrological networks, the soil, and chemical conditions of the environment [39]. Apart from the number of people living in urban centers [2], approximately 50% of the global GDP depends on biodiversity [40]. Therefore, cities deserve to be reimagined as enhancing biodiversity and all its attached benefits, instead of accepting that urban areas are destructive to it. Metropolises can reduce its vulnerability for climate change, improve human health and well-being, and enhance a sustainable, regenerative development [41,42].

Apart from the pressure on biodiversity and natural habitats, cities and metropolises also use considerably more resources [43,44]. Urban areas, despite covering only around 3% of the Earth's land surface, are responsible for approximately 75% of the world's natural resource usage [45]. The concentration of industrial production and population in cities leads to a significant demand for resources like water, food, and energy [45]. Studies reveal that cities exhibit high tendencies of consumer-like behavior due to the concentration of tertiary sectors within urban areas, leading to high resource utilization but low output [46].

Furthermore, metropolises and urbanized areas have a significant impact on human health [47]. For example, the emissions of all kinds of particles and gases into the air leads to higher levels of air pollution [48–51], but it also causes high levels of heavy metals in road dust [52–54], which end up in the human body via the intake of leafy vegetables and other food [55,56] or via ground and drinking water [57–59]. The urban fabric also has impact on the physical health of people [60–63], for instance through the options for exercise in green spaces [64,65], accessibility of parks and green spaces [66–68] or the lack of abundance of infrastructure that stimulates active transport [69–71]. The mental health implications of living in an urban context are also clear [72–75]. As an example, the risk at ADHD is increasing for people living in urban contested environments as opposed to people living in a natural environment [76]. At the same time, children with ADHD function better in nature than in built environments [77], while pollution and a lack of green spaces are risk factors for ADHD, as children living in greener and less polluted areas have a 50% lower risk of developing the disorder [78]. In short, more trees mean less ADHD [79].

Reduced biodiversity, the use of more than reasonable amounts of resources and the degradation of human health which all take place or are caused by our urban lifestyles, the construction of vast areas of built-up areas and an ever-increasing consumption pattern, directly or indirectly exacerbate problems in large conurbations. Some of the most pressing are related to environmental threats such as climate change, scarcity of resources, social inequality and slums, exclusion of disadvantages people from technology, and ill-working governance models [80].

In this sense, the human activities, of which most occur in cities, increase emissions of Greenhouse Gases (GHG) in the atmosphere, the main cause of climate change. Roughly half of these

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are caused by combustion of fossil fuels to generate electricity and heat (or cooling), industrial activities and transport. This affects urban environments and the humans living there, the most [81]. As a result of the fast-growing populations in cities, metropolises, and megalopolises these areas are the most vulnerable for climate change impacts, and at the same time are a major factor in causing it. Rising temperatures and the increase of hard surfaces in cities leads to accelerated amounts of areas that suffer from urban heat island effects, which are responsible for 4% of summer related deaths [82]. In Europe alone providing 30% of green cover could prevent up to 2,664 premature deaths [82].

People that suffer most from these heating conditions and the occasional climate disasters, such as floods or hurricanes, are often the most vulnerable and not the ones that are mostly responsible for causing climate change [83]. And with more than 50% of its residents in some cities live without regular income in disadvantaged communities, problems such as security and social disparity exaggerate [84] as is their vulnerability for unprecedented climate impacts. And analyses show that this is not easy to alter: the number of homeless people (in 2017 roughly 2% of global population and 20% without adequate housing) is said to proportionally increase with progressing urbanization, and this is mainly caused by social injustice in cities [85]. The poor are relegated to neighborhoods with poor infrastructure and limited access to services, mentally far away from the enclaves for the rich and wealthy. This unequal use (and production) of urban space causes socio-economic and health disparities, including mental illnesses, political exclusion, and territorial stigmatization [86]. This exacerbates their vulnerability for climate impacts caused by others.

With more people living in metropolises and megalopolises, the conclusion can be drawn that in a time of accelerating climate change [87], biodiversity is under pressure, too many resources are used, and human health is at stake, and these problems have the highest impact on the most vulnerable inhabitants. Cities have become places where the privileged are closest to nature, can use the resources they want, have the easiest access to health care and can escape from floods and heat islands as they wish. As urban residents experience their environment in an integrated way [88–90], a holistic effort is needed to reduce the impacts of biodiversity loss, climate change and resource depletion, while improving human health and social equity. In this article we offer a methodological approach, which is illustrated using the Monterrey Metropolitan Area in the northern part of Mexico.

After the literature review (Section 2), Section 3 starts with describing the mix of methods used in the research, after which Section 4 presents the findings. The article finishes with discussion and conclusion in Section 5.

3. Materials and Methods

3.1. Monterrey Metropolitan Area (MMA)

The area of study is the region of Monterrey (Figure 1), the second largest city of Mexico, located in the northeast of the country. The metropolis marks the transition of the Sierra Madre Oriental in the west-southwest to the northeastern arid plain of Tamaulipas. The region is the southernmost part of the watershed of the Rio Grande (or Rio Bravo), eventually flowing in the Gulf of Mexico. The city is built in a valley surrounded by the mountains and isolated mountainous hills. This topographical condition causes high temperatures in summer, easily above 40ºC, and many days with one of the worst air qualities on earth. In 2020, the metropolis was inhabited by a little more than 5.3 million people, divided over 15 municipalities [91]. The total area considered is roughly 70x70km.

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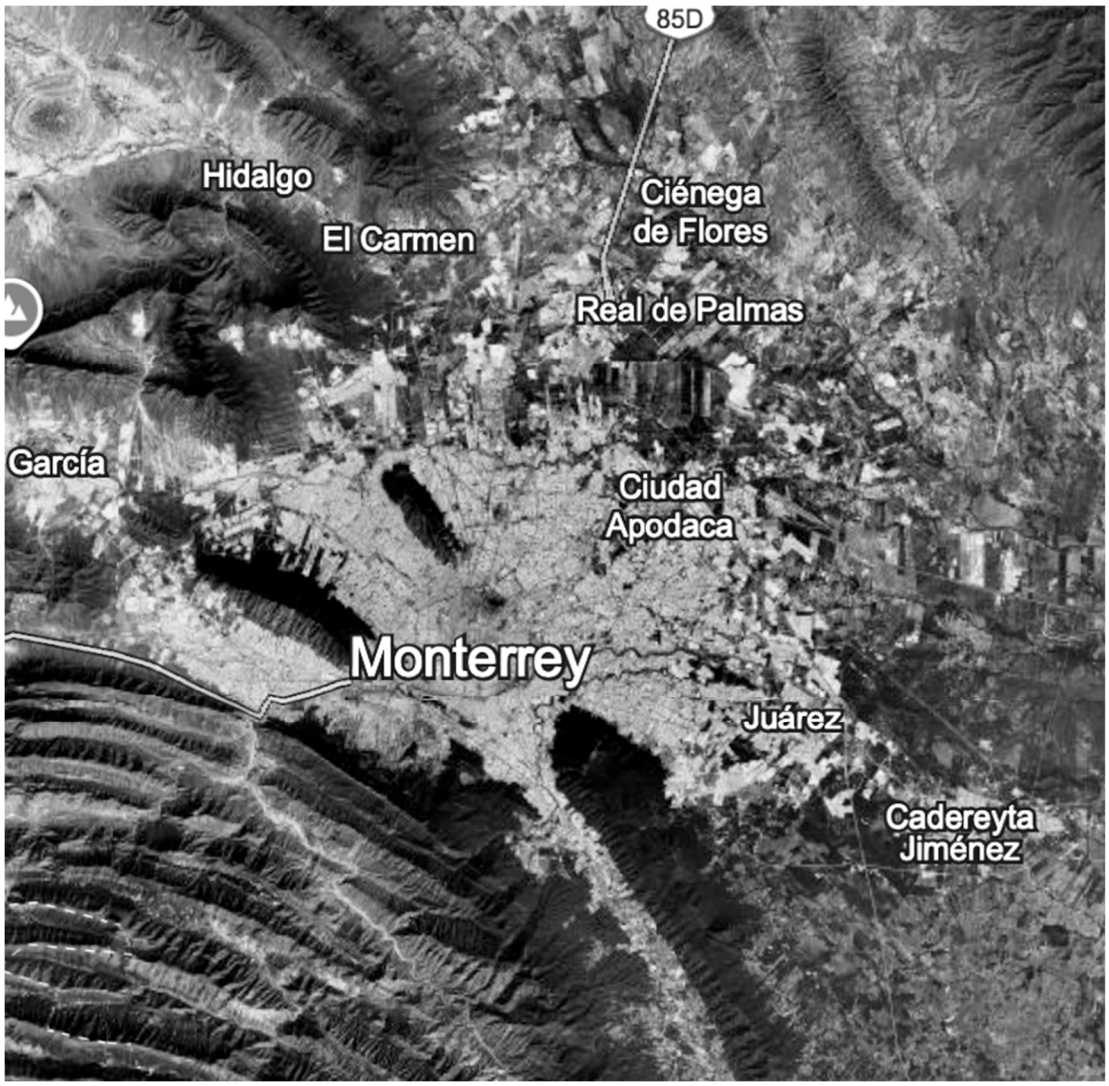

Figure 1. Monterrey Metropolitan Area (source: Google Earth).

3.2. Methods

For this research we have used a mixed methods approach. The different parts and steps are reflected in Figure 2.

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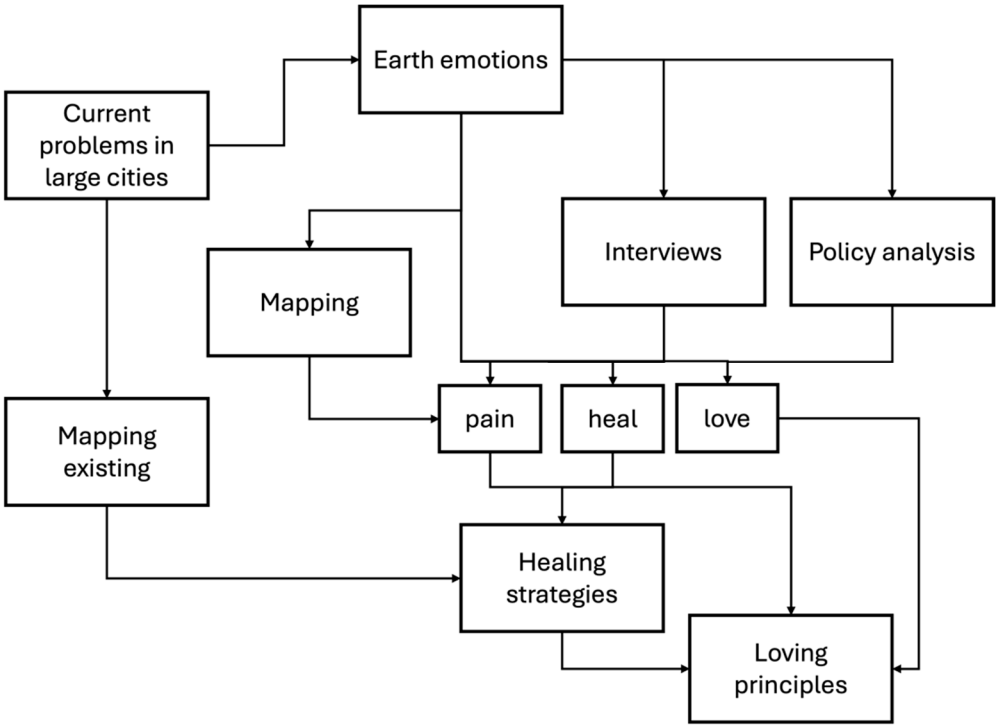

Figure 2. Overview over the steps and parts of the research.

Firstly, for the identification of the main current problems in the region an extensive internet search has been undertaken, using a range of sites such as google scholar, science direct, JSTOR, and web of science. In total over 400 articles have been scanned and of these a selection of the most relevant (their spatial scale, typical problems) articles have been used to the analysis (in Section 2).

Secondly, the existing conditions in the region have been mapped using a range of available sources (Table 1). The following themes and topics were part of this spatial investigation: water systems, elevation, ecology, landscape, soil and geology, amount of green space, urban growth, densities, climate impacts.

Table 1. Maps current conditions and sources used [92–106].

Map	Data source
Rio Bravo basin	Lehner et al., 2008
Monterrey´s subbasins	INEGI 2020
Ecoregions	Secretaría de Medio Ambiente de Nuevo León 2023
Land cover	NALCMS
Green cover, city comparison	INEGI (2020), BC Stats (2023), Instituto Nacional d'Estadística I Institut d'Estadística de Catalunya (2022), GHS Settlement Characteristics (2018).
Percentage natural area	NALCMS 2020, GHSL 2018
Proximity to green spaces and accessibility by vulnerable groups	LANDSAT 2019, Population and Housing Census, INEGI, 2020 Open Street Maps, CONEVAL 2020
Heat index	URSA, BID
Rainfall	CONAGUA, Servicio Meteorologico Nacional, 2023
Urban growth	Secretaria de Desarrollo Sustentable de Nuevo Leon, Carpio et al., 2021, GHSL and Consejo Nuevo Leon
Urban density	Secretaría de Desarrollo Sustentable de Nuevo León (2018), Carpio et.al (2021), GHSL and Consejo Nuevo León (2023).
Urban heat islands and wildfires	Copernicus Agencia Espacial Europea (2024); Global land análisis and discovery (2022)
Air quality	OCCAMM 2024

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Thirdly, to not only depend on technical mapped information of the region, but we also sought more emotional-psychological ways to describe the current problems as experienced by the population living in the Anthropocene [107,108]. Therefore, we used the work of Glenn Albrecht, who developed a new vocabulary to give words to these feelings [109–113]. Based on these the main vocabulary has been ordered according to their role in describing the experience; whether they describe current pain, ways to heal that pain, or regenerate love and affection for a future environment.

Fourthly, a second mapping exercise was undertaken to identify the elements of pain in the region. The elements that people experience as painful, such as infrastructural barriers, extra-large buildings, impaired mountains and natural reserves, air pollution and disrupted waterways. The maps and the used sources are summarized in Table 2.

Table 2. Mapping landscape pain and used sources [114–118].

Map	Data sources
Quarries and constructions in natural reserves	NPA, Open buildings dataset (Google Earth Engine), Sirko et al., 2021
Large roads (more than 6 lanes each way)	INEGI
XL and L buildings	Open buildings dataset (Google Earth Engine, https://sites.research.google/gr/open-buildings/#open-buildings-download). Sirko et al., 2021
Heat islands	Debbage and Marshall Shepherd, 2015
Railways and above metro system	INEGI, PRIMUS 2019
Energy infrastructure/air quality	Secretaria de Desarrollo Sustentable de Nuevo Leon, 2018.
Hydrological obstructions	INEGI 2010, Open buildings dataset
Landscape transformation	Balon et al., 2023; Cao et al., 2020

Fifthly, we inquired the municipal policies and ambitions. 15 municipal and State policy plans have been analyzed, and all written policy objectives and spatial strategies were assessed and categorized to belong to pain, heal or love. Additionally, 11 in-depth interviews were conducted with strategic employees in these organizations (directors, heads of planning department, chairmen)[1]. After explaining the findings of the landscape pain mapping exercise, the interviewees were asked which spatial strategies for healing and loving they would emphasize and asked them to draw these on a regional map.

Sixth, the design phase of the research consisted of two parts. In the first part several design workshops have been held with the research team and client to develop a range of future scenarios for the metropolitan development. These were focused on the development of healing strategies. In the end four of these were selected as being distinct enough to discuss the desired green metropolis. The development of a regional spatial strategy how to grow into a greener metropolis was also part of these workshops and had the objective to identify the process of green urban development. The second part focused on creating design principles that visualize urban environments which residents could embrace, affectionate and love. These design principles have been created in different ways and for several typical spaces in the metropolis. Several design principles were subject of design workshops with the research team, others have emerged out of the work of four Master theses by students Landscape Architecture in Delft University of Technology, and some have been created by

[1] Secretariat of Territorial and Economic Competitiveness and the Directorate of Environment of Guadalupe, Institute of Urban Planning and Management of San Pedro Garza García (IMPLANG), San Pedro Parques, Chipinque Ecological Park Association, Clab North Region of Tecnológico de Monterrey, Directorate of Green Development of the Municipality of Monterrey, Subsecretariat of Territorial Planning and Public Space Nuevo León Council for Strategic Planning, Monterrey Region Urbanism Society, Citizen Observatory for Air Quality of the Monterrey Metropolitan Area, and the Water Center of Tecnológico de Monterrey.

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students of the Master of Architecture and Urban Design at Tecnológico de Monterrey. Some of the typical spaces are hydrological corridors, green streets, urban forests, urban gardens, rivers and creeks, retention basins, sub-metro greenways, avenues, green islands (transformation of large parking areas), and green roofs on industrial sites. For each of these one or more visualizations have been designed.

4. Results

4.1. Urban Problems Hit Disadvantaged Human and Natural Communities the Most

The literature review (Section 2) revealed our current conurbations, in which a growing number of people is living causes or exaggerates problems that are crucial for our survival. The resource depletion, biodiversity loss, and being a motor of climate change and its impacts, has severe consequences for human health, physically and mentally. In these conurbations the most disadvantaged people, who have, in majority, not caused these problems suffer the most from it.

4.2. Discrepancy Between the Natural Qualities and Urban Impacts

The existing conditions of the Monterrey Metropolis are formed by its natural landscape of mountains, forests, creeks, and rivers, and rapidly degenerating due to urban growth, industrial and human impacts, and climate change. This led to a city that is stuck in its economic paradigm, of growth and inevitably more pollution and pressure on the natural landscape. The maps of the ecology, water system, forestry, geology, and soil illustrate the natural interdependencies of ecology, water, air, and soil. On the other hand, the maps of urban and human induced aspects show a darker side: urban heat islands, air pollution, social inequal accessibility of green, and deficit of green space dominate the existing city [119].

4.3. Need for Making a Distinction Between the Pain, Its Healing, and the Desired Love

To systematically create regenerative urban futures, understanding of causes and possible solutions is not enough. This research revealed that emotional attachment to certain activities, images and uses of the urban realm represent a deeper, more confronting and exciting impression of the city than simple land-use and mobility patterns can. Earth emotions [112] (Table 3) can be subdivided in three categories.

- Pain - The emotions that are painful (visual, emotional, physical, health) highlight all elements that people might experience as unpleasant, hurting.
- Heal – These emotions can help to compensate for the pain, solving the painful elements to a healthy, neutral state. For instance, by building with nature, the negative impact of painful activities and urban uses can be healed.
- Love – actions that not only solve the painful elements (heal) but transform them in a way that people can embrace them, develop affection, and love their environments again.

Every emotion is caused by concrete urban spaces, uses or activities. By categorizing them, each set of urban actions is mapped for the Monterrey Metropolitan area.

Table 3. Identification of pain, heal and love based on Earth emotions' vocabulary (after [112]).

Verb	Translation	Etymology	Explanation
PAIN			
T**erraphthora**	Earth-destroyer	terra = earth; phthora = to destroy, destroy, ruin	In the Anthropocene they were still given the title 'polluter'. 'Earth's lawyer' Polly Higgins didn't use the word 'ecocide' for nothing. In the Netherlands, multinationals such as Shell and Tata Steel and previously DSM are considered the biggest destroyers of the earth. But you can also think of traffic and transport, or bio-industry and large-scale livestock farming. Earth destroyers will be increasingly held accountable, both by the public and politicians.
T**ierratrauma**	Earth trauma	tierra = region/zone;	What has been happening to the Earth in recent decades is increasingly affecting people as a trauma. We could say that 'those

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		trauma = wound	who are sensitive to it' increasingly suffer from a traumatic stress syndrome, which is not 'post-', but 'present-'. An 'acute Earth-based existential trauma in the present'
Solastalgia	Consolation	solari = to comfort; nostalgia = longing for past times	The more nature and the environment around us are compromised, the less comfort we will experience from that immediate environment. We are more likely to long for a time and a state when nature still offered us comfort, and the planet was not in such hopeless trouble. A 'pain or distress caused by the loss -or lack of- solace and the sense of desolation connected to the present state of one's home and territory.'
Terrafuria	Climate rage	terra = earth; furia = anger, rage	Recently, 'terrafuria' has been regularly expressed by activists. For example, when they glue themselves to paintings or to talk show tables. Also consider the book How to blow up a pipeline by the Swedish professor Andreas Malm. The anger about what Greta Thunberg now calls 'climate collapse' is becoming increasingly manifest. It seems as if we are moving from the stage of protest and demonstration to action and use of force. 'The extreme anger unleashed within those who can clearly see the self-destructive tendencies in the current forms of industrial-technological society and feel they must protest and act to change its direction'
HEAL			
Sumbiofact	Built-with-nature	sumbio = from the close cooperation between two or more different biological entities; factum = operation, creation, result of action/deed	It is becoming a hip subgenre in architecture and design: buildings that are almost completely 'natural', but are somewhat 'controlled' or 'nudged' by humans. For example, a bridge made of trees and lianas over a river. The bridge was created because humans sent something natural, but without causing damage to nature (such as mining or clothing dyeing, which uses water that must then be disposed of polluted). It is therefore about 'built with nature' and not obtained through exploitation or extraction. 'Fabricated by human/nature interaction. As distinct from 'artefact', an object made by a human being, artificially'
Symbiocene		symbiosis = living together; kainos = new	History can be divided into geological periods, this is also called geo-chronology. The duration and characteristics of the older eras are based on stratigraphy, the sequence of rock layers found worldwide. Since the Holocene (that era started 11,700 years ago), humans have been a more important 'determiner' of the era than the rock layers. 'The era in Earth history that comes after the Anthropocene. The Symbiocene will be in evidence when there is no discernible impact of human activity on the planet other than the temporary remains of their teeth and bones. Everything that humans do will be integrated within the support systems of all life and will leave no trace'
LOVE			
Endomophilia	Own-place-love	endemos = native, at home, born and raised in, among us; philia = love for	If nature and the environment are threatened, we will love that (immediate) environment more. And as the environment and nature face a less certain - and more worrying - future, our love for the beauty of our own immediate natural environment will increase. How much love can you have for nature, the environment and the climate (and therefore also biodiversity)? If our 'own place love' increases, the Symbiocene will approach more quickly, you would say. 'The particular love of that which is locally and regionally distinctive as felt by the people of that place'.

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Eutierria	Planet connection	eu = good; terra = earth; tierra = region/zone	When and how do you feel one with the earth, and when do you feel it most? This is different for every person: do you live in the countryside or in a busy city? Are you someone who often seeks out nature? Do you have an eye and feeling for it or do you view nature as 'the space between two cities'? Are you only looking for a connection with the earth on holiday or when traveling? It might be nice to think back about how that applies to you personally: has your bond with nature and the environment and the earth changed, how has it developed 'over the years'? 'A positive and good feeling of oneness with the Earth and its life forces where the boundaries between self and the rest of nature are obliterated and a deep sense of peace and connectedness pervades consciousness'
Psychoterratic	Earth soul movements	psyche = the human soul or spirit; terratic = relating to the earth	Our existence seems to be increasingly influenced by the question: 'what are we doing to the earth?'. Or: 'how can I minimize the pain of the earth with my actions or by denying myself things or making sacrifices myself?' Those who feel strongly connected to nature and the earth also experience its pain and joy. Such earth-related emotions are likely to increase as we humans become increasingly concerned about the fate of the earth. 'Emotions related to (positively and negatively) perceived and felt states of the Earth'.
Terranascia	Soil enricher	terra = earth; nascia = to be born	'Green Gold', re-greening of parched deserts and fallow regions. It seem like magic. For example, the food forests that are springing up like mushrooms in the east of the country, or the plans to green the Sahara again. 'Earth creator'

4.4. Landscape Pain Is Widespread

The analysis of all pain in the metropolitan region is represented on a series of maps. The following topics have been identified as being painful:

- Quarries and housing in nature reserves. In the Metropolitan Area of Monterrey (MMA), 1289 ha. of excavations (quarries) are found in mountainous slopes. In addition, 29,928 constructions (houses, buildings) are in or on the slopes of mountains and hills. Of these, 3497 are in Natural Protected Areas [119].
- Green spaces. There is a lack of access to green spaces and limited amount of green space per person. In the entire Metropolitan Area, including the urban fringes and agricultural land, there is 22.2 m^2 of green space per inhabitant [119]. However, these green spaces are not equitably accessible to all inhabitants, and the indicator is not representative of a green city compared to the 51 m^2 per capita in Barcelona [96]. At the same time, it is advised to have a minimum of 9.5 m^2 of green space per inhabitant [120]. Although this indicator is outdated and is an average while urban areas are composed of very different densities, functionalities, and activities, it still gives an indication how well cities do. When parks and green spaces in the urban precincts of the Monterrey Metropolitan Area are calculated, there is only a mere 4 m^2 of green space per capita.

  Furthermore, applying the 3-30-300 rule [121], the advised 30% of tree cover is only met in 50% of the Monterrey Metropolitan Area [119], and only 43% of the population has access to a green public space within 300m [119], or within a five-minute walk [122]. For vulnerable groups such as children (25%) and elderly (40%), this accessibility is even lower [119]. This unbalanced distribution of green spaces over the different neighborhoods in the city leads to the most vulnerable urban population to live in the hottest conditions, suffering from urban heat [123]. In Monterrey, approximately 40% of the population that faces a medium or high social gap [98] has access to a public green space [119].
- Main roads (over six lanes) and surface parking. In the MMA 670 km of highways over six lanes are found and over 996 ha. for parking, which is two thirds of the space allocated for public parks. The emissions caused by the cars using this infrastructure is estimated at 7,764,568 tons of CO_2/year. This car-infrastructure has profound impacts on human health through air pollution, soil degradation and a general decline of quality of life [124–126].

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- Large or extra-large sized buildings. In the MMA a total of 972 buildings over 10,000m2 (XL) and another 7628 between 2500 and 10,000m2 (L) are found [119]. These buildings, mainly logistics and industrial, have no or a large deficit of green spaces on and around them. It causes large, uncovered surfaces, which are a main cause of the urban heat island effect [127,128].
- Abandoned rail tracks and public transport elevated above ground (metro system). The 411 kms of rail tracks provide a noise problem, as many of these lines generate levels of 80-100dB [129] and 19.3 kms of elevated metro lines signify spatial problems in the form of exaggerating barriers between neighborhoods and rivers and green spaces, creating problematic underpasses and reduce the views on the surrounding mountainous landscape.
- Polluting industries such as the Pemex-refinery emit the majority of PM10 and PM2.5 particles, causing adverse effects on human health including life-threatening diseases [130]. It is estimated that, in 2021, 1684 deaths were directly related to air pollution.

Apart from the visual effects, landscape pain (Figure 3) shows a strong correlation between places where large concentrations of oversized buildings are found, the lack of green cover, the urban heat islands, and air pollution. Its serious impact on air quality and urban heat has severe negative effects for human and ecological health.

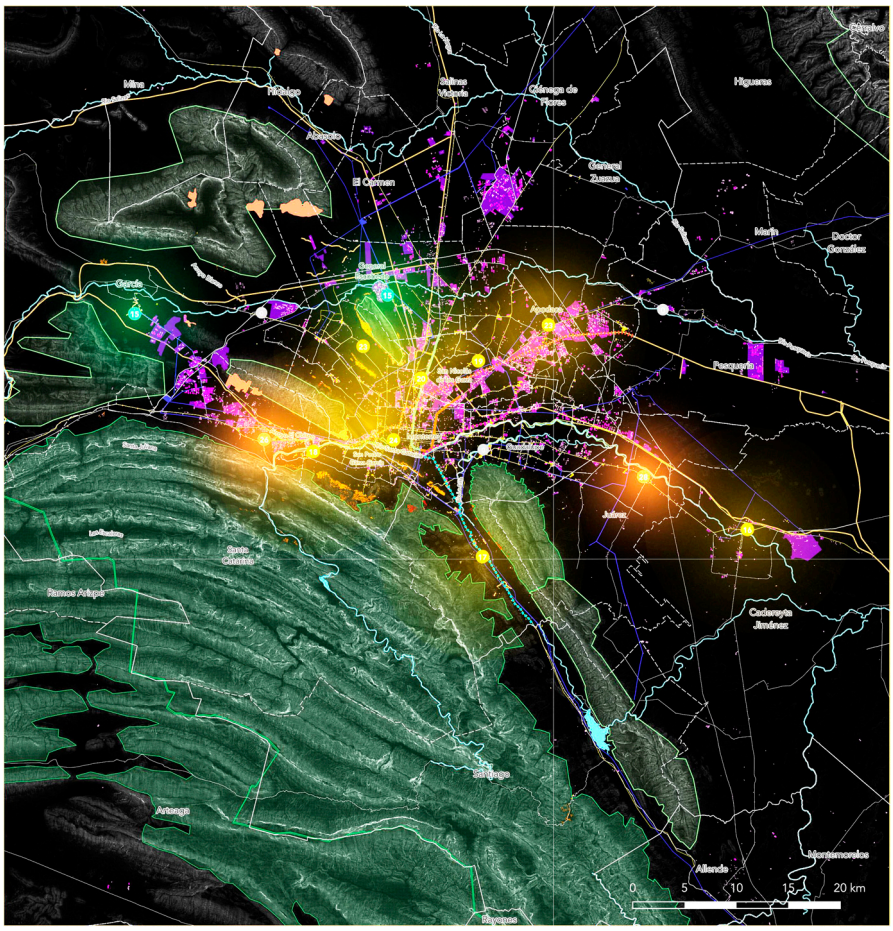

Figure 3. Map with integrated aspects of landscape pain [119].

Additionally, hydrological pain has been identified. Sprawl and uncontrolled urban growth have led to natural waterways that have been obstructed by 17,003 constructions (Figure 4). These are houses, other buildings, streets and roads, or simply unknown obstacles, through which the water disappears or cannot flow naturally. Not coincidentally, this causes local urban floods, and is also related to the concentrations of urban heat in the MMA. Because of this, water quality and regulation of the hydrological cycle is disturbed, negatively impacting natural ecosystems [131].

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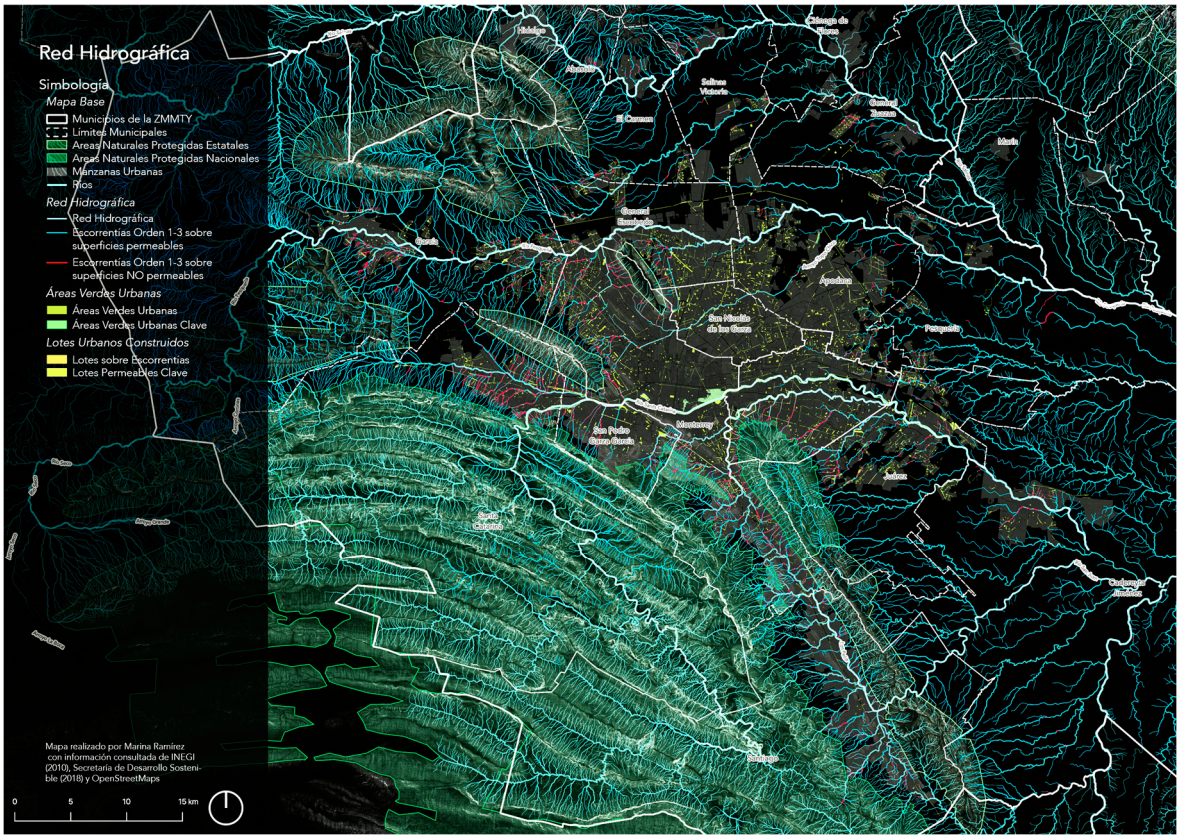

Figure 4. Map of hydrological pain [119].

4.5. Governmental Policies Focus on Pain and Heal

The analysis of governmental policies show that most measures, objectives, and plans focus on identifying the current pain (35 policies) or objectives related to healing (25 policies). The attention for creating a future environment that people will be able to embrace, or love is represented by only two policies [119].

During the interviews undertaken with strategic planners, directors and advisors in municipal planning agencies or community organizations revealed that there is a strong preference for strategies that enhance the health, beauty, and ecological quality of the city. On the map that the interviewees sketched a range of proposals were suggested. The main aspects that were mentioned is the continuation of green and blue systems (rivers and creeks, green spaces, ecological networks), reforestation and large-scale green projects, such as planning a greenbelt, and integrating green, ecological networks, and waterways in the different neighborhoods, streets, and squares.

4.6. Ways to Heal

Once the landscape and hydrological pains are distinguished, strategies can be developed to heal these conditions. Two different strategies are found to be helpful, a process approach (Figure 5) and a scenario-based regional design (Figure 6).

The first strategy aims to highlight the spatial priorities, or, in other words, which elements of the planning process are considered first, and which ones later. This approach is based in the so-called landscape first theory [132–138], which emphasizes to use the understanding of the natural landscape conditions first, before implementing other, non-human or urban entities. For the Monterrey Metropolitan Area this means uncovering and reconnecting the waterways, creeks, and rivers throughout the region, providing each of them with an abundant zone for green, ecology and water retention, after which the spaces remain where urban activities can find a place (Figure 5). This way the network is reestablished

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which serves the mitigation of urban heat, improves humidity and the air quality, and provides an environment in which both humans and non-humans thrive and are healthy.

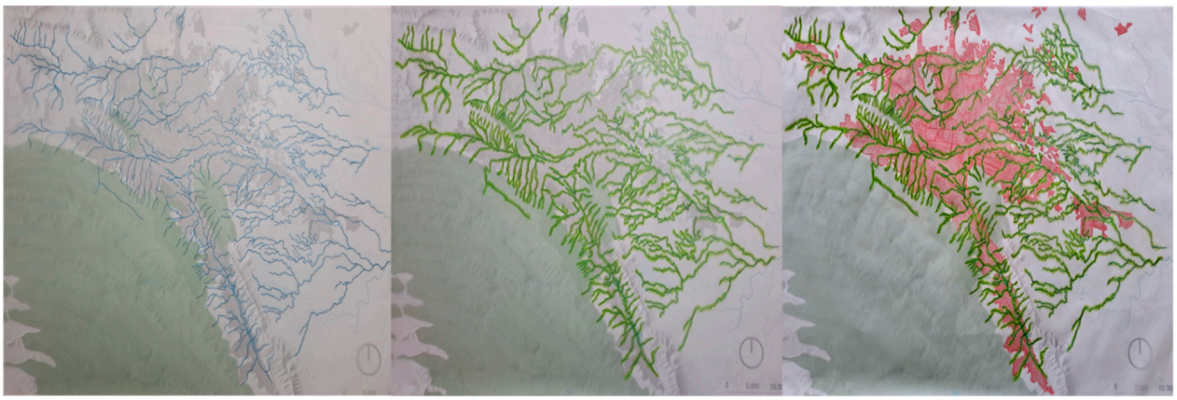

Figure 5. Strategy to uncover creeks and waterways, greening the regional network, and find spaces for urbanity within [139].

The second strategy is explorative through design. For this scenario planning [140–143] is used to design four explorative possible visions for the regional future. This way distinct and coherent storylines are explored. We mention here only two of these: The BAU-scneario and the ReConquer the City-scenario (Figure 6). In the first scenario the city grows uncontrolled and reaches a population of up to 10 million, meanwhile occupying large parts of the natural landscape. Within this sprawl, small batches of green spaces are incorporated as parks, and sports facilities. The second scenario limits the boundaries of the Metropolitan Area by creating a wide green belt [144], at the same time green cover takes back space from the urban by covering roofs, roads, and the abundant bio-ecological network. The basis for this scenario lies in the natural landscape with its waterways, hills, and mountains.

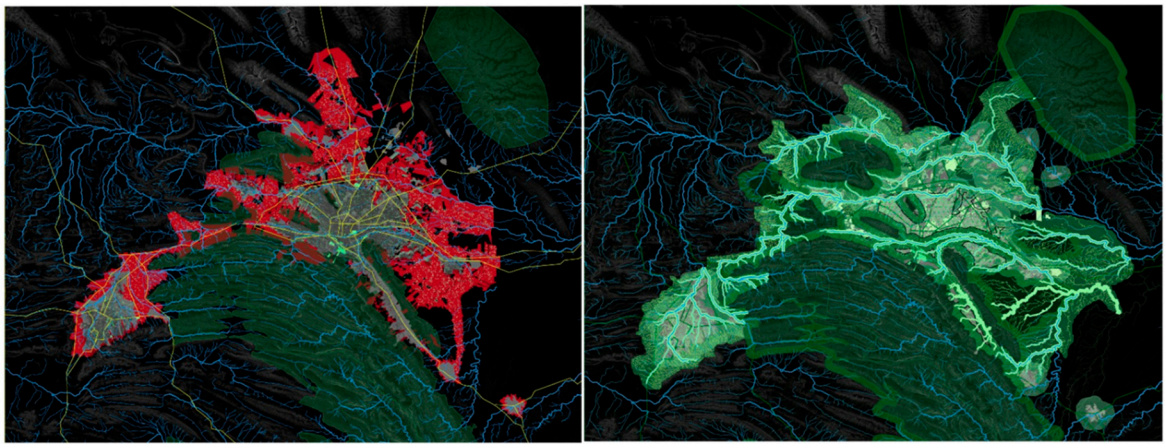

Figure 6. Strategy to uncover creeks and waterways, greening the regional network, and find spaces for urbanity within [119].

The scenarios are explicitly not meant to make choices or decisions but illustrate the potential futures under certain conditions.

It may be concluded that the combination of the process approach and the explorative scenarios, lead to a future for the region that is based in the landscape, and celebrates the green-blue corridors and networks.

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4.7. Ways to Love

Once the strategies to heal the landscape pain are discovered, concrete interventions can be designed that support this regional strategy. These are design principles for hydro-ecological corridors, water retention, green islands, and green ways. Each of these can be replicated in many similar conditions and are designed to present residents an environment they can embrace and love, but foremost that brings a healthy and pleasant environment close.

The hydro-ecological corridors (Figure 7) integrate nature into the city, renaturalizing the watersheds [126], and reducing temperatures in the MMA.

Figure 7. transforming a street into a hydro-ecological corridor [145].

Water retention spaces (Figure 8) are designed to recharge the aquifer by infiltration and absorption in the soil meanwhile reducing flood risk and improving the natural habitats. These are crucial to keep the runoff water, store it and release slowly.

Figure 8. Water retention design principle [145].

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Green islands (Figure 9) are integrated in neighborhoods through green roofs and facades. The use of these novel green spaces can be very functional, such as for the growth of food. Additionally, these green spaces reduce the impermeable surface, regulates temperature hence minimizing urban heat, and captures excess rainwater.

Figure 9. Transformation of impermeable surfaces into green productive oases [119].

Finally, greenways (Figure 10) can reform current rail tracks, elevated metro lines and six lane-roads. The greening of these spaces allows pedestrian a safe crossing, regulates the local water system, preventing droughts and floods, and enhances biodiversity.

Figure 10. Design principle of a greenway [119].

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These four design principles can be used to implement in similar situations throughout the MMA. It provides attractive environments for the residents and creates a better living condition for humans and non-humans alike.

5. Discussion

In many cities, national policies, and overarching organizations such as UN Habitat [146] and the WEF [147], a pledge is made for naturalizing the urban environment, in the form of tree-planting programs [148], sponge cities [149], urban rewilding [150] and many more. Most of these emphasize the need to counteract an economic driven urban development, industrially and commercially created precincts, without a lot of attention to the quality of life, lives, and nature. In many ways, we might not have a good answer to tan ever progressing urbanity. And the question is in which direction we need to search for answers?

- Is it philosophical, seeing human and nature as one cosmology [151] or from a religious perspective, acknowledging the role of nature as the source of all life on earth [152]?
- Is it embedded in traditional knowledge of indigenous people, to discover the strong connections to the land, and making use of traditional technologies and approaches [153,154]?
- Is it a form of strategic planning at the national level, creating national spatial visions for entire countries, such as for the Netherlands [155,156], or to create a national ecological network [157]?
- Is it spatially precise in determining a nature-beneficial land-use [158]?
- Is it a design at the urban regional scale, such as the administrative collaboration between large cities in the North [159] and South [160] Wing of the Randstad in the Netherlands?
- Is it driven from a political ideology, based on the influence of one mayor, such as in Curitiba, Brazil [161], or Medellin in Colombia [162]?
- Or does it emphasize a policy from a specific sector, such as nature [163], (urban) agriculture [164] or water [165,166]?

Undoubtedly, each of these perspectives have their own merit and most likely deserve to be investigated separately. However, designing a true green metropolis needs to go beyond one or a couple of these perspectives. It needs to connect spatial scales and recognize the relevant socio-ecological views.

6. Conclusions

The ways landscape pain is felt differs for each viewpoint, and healing will be adequate at different scales. An inherent deeply felt love for the environment can only be embraced when philosophical, religious, indigenous, and political are aligned and concretized at the (hyper)local scale.

This requires a staggered strategy, in which the landscape pain is understood at the regional, watershed scale, identifying healing opportunities by designing spatial strategies that are based in the natural landscape. This implies the natural systems in the region are prioritized over human made systems. Current spatial planning and urban design is often too fragmented by the development of individual projects on a plot-by-plot basis, to halt urbanization and reconnect water- and ecological systems throughout urban metropolises. To achieve this, structural programs for upscaling the design principles throughout the region need to be implemented, which need to be executed at the above-municipal scale.

Mapping and understanding the regional landscape pain first, after which healing strategies at regional level can be created and translated in concrete design principles which make the urban environment be loved by its residents is a novel approach that can shine a light on a green metropolitan future.

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