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Territories in Time: Mapping Palimpsest Horizons

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Table of Contents

Table of Contents

COGITATIO

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Editorial

Territories in Time: Mapping Palimpsest Horizons

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Abstract
In the early 80s André Corboz, in describing the territory as being the result of slow and long-term processes involving multiple transformations, implicitly declares the onset of a new paradigm for understanding cities and territories: a new gaze attentive to the chronological dimension of spaces, aware of the long history of places, interested in that ensemble of signs, traces and voids so tangible, and yet ignored by the paradigm of tabula rasa. To describe this complexity, Corboz proposes the metaphor of territory as palimpsest: A palimpsest is a two-dimensional writing board bearing a three-dimensional matrix of signs, which, as a metaphor, allows for a contextual, four-dimensional apprehension of territory, portraying space in its chronological evolution. This text re-contextualizes the notion of palimpsest—both as a methodological and a theoretical question—in the light of two main conceptual 'shifts': the 'territorial turn,' which increased interest among different disciplines, projects, and policies for the dimension of cities as territory, and the 'digital turn,' namely the rapid evolution of data recording, archiving, and mapping technologies.

Keywords
city-territory; digital transition; mapping; mapping time; palimpsest; territorial turn

Issue
This editorial is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

1. A 'Territorial Turn'

The essay "Le Territoire Comme Palimpseste," published by the Swiss historian of architecture and urbanism André Corboz (1983), marks a decisive step in what can be called a 'territorial turn.' The text begins by recording an increasing enthusiasm for the theme of territory among a broad cohort of disciplines including, political science, geology, topography, planning, zoology, and cultural history. At the same time, the incredible success of exhibitions such as "Cartes et Figures de la Terre" (organised in Paris, Centre Pompidou, in 1980, no less successful than an exhibition of Impressionist paintings), and the broadening territorial scale of public policies, allow Corboz to conclude that a new "horizon of reference" (Corboz, 1983, p. 15)—a new paradigm—is emerging. A horizon that Corboz sees as an opportunity to definitively overcome the city-countryside opposition inherited from the industrial revolution—an expression of the political and cultural power of the city—in favour of an apprehension of the urban as a larger territorial condition. This leads to a shift in perspective, whereby, with the territory as the unit of measurement of human phenomena, it is now the city-territory that must be referred to when designating the geography of the urban. Now, in Corboz's 1983 essay, the notion of palimpsest enters the scene after a long and dense premise, in order to describe the territory as the outcome of a slow and long-term process involving multiple transformations, to deal with the evolutionary history of

places, and to stress space as a conglomerate of signs, traces, and voids—so real, and yet altogether ignored in the field of planning, dominated by the paradigm of tabula rasa. In addition, by choosing the metaphor of the palimpsest over the more classical, that of archaeological sedimentation, Corboz not only aligns himself with but goes beyond that 'reclamation of the past' as pursued by the post-modern designers and modern critical theoreticians (Huet, 1986; Rossi, 1966; Rowe & Koetter, 1978). Only one year after the publication of Gerard Genette's (1982) *Palimpsestes: La Littérature au Second Degré*, that theorized the palimpsest as a metaphor for the thickness of literature texts, the same metaphor allows Corboz to theorize the territory as a thick blackboard upon which society can write—trace, erase, and ultimately re-trace—new chapters of its urban transformation. The quantity of writing finds its own echo in the sheer number of possible readings. A palimpsest is indeed a two-dimensional writing board carrying a three-dimensional matrix of signs, inscriptions, and texts; as a metaphor, it allows a contextual, four-dimensional apprehension of territory, portraying space in its chronological evolution (Marot, 2013). Finally, such a contextual, four-dimensional apprehension of territory, conceived in its chronological evolution, does not imply that space needs to be read as an incremental accumulation of traces, but rather, and most importantly, as a selective process, through multiple erasures. The metaphor of the palimpsest has disclosed an enormous potential for architectural, urban, and cultural studies, design, and planning (either theory and practice); the infinite quotations of André Corboz's seminal essay in scientific papers and in educational activities are the most visible demonstration. Nevertheless, a precise understanding of Corboz's theoretical proposal cannot help but considering its first, original mapping prototype, that is to say, the *Atlas du Territoire Genevois*, published by the Canton of Geneva in 1993 (Léveillé, Cassani, & Mayor, 1993). Realised under the coordination of Léveillé (formerly Corboz's teaching assistant at the University of Montréal, where he taught from 1967 to 1980) the atlas performs a corpus of mapping comparisons between two types of cadastre (the Napoleonic and the federal) through three historical thresholds (about 170 years far): the Napoleonic cadastre (1806–1818), the *Plan d'Ensemble du Territoire Genevois* (1935–1959), and the contemporary *Plan d'Ensemble* (1991).

Based on an extremely simple mapping legend (parcel, building, road, vegetation, hydrography, and topography) the comparisons between the three historical thresholds identify single-elements transformations over time—what has been added, what has been transformed, and what has been erased. The transformations are then classified according to three main categories: permanence, persistence, and disappearance (Figure 1). The shift from the complexity of the metaphor of the territory as a palimpsest to an elementary, descriptive mapping strategy is absolutely meaningful: dealing with space and form of territory (Gregotti, 1965), the atlas demonstrates the possibility of a mapping strategy which pertains to a very specific disciplinary field, that is to say, that morphological approach mainly cultivated by Italian scholars (Caniggia, 1976; Muratori, 1960). The atlas describes the morphological evolution as both material (a canal becoming a street, a building which is expanded, etc.) and immaterial transformations (changes in the property boundaries). This emerging double dimension of palimpsest—as both a space and a cartography—is the topic of Corboz's contribution to the atlas, "Le Dessous des Cartes" (Corboz 1993, 4-7), while the one by Léveillé accurately explains the whole methodology of the atlas (Léveillé 1993, pp. 9–11).

While the prototype of the Geneva Atlas plays an important role in translating the notion of palimpsest as a new paradigm for an operational mapping, its impact serves as evidence that cartography is not only a tool for analysis or description but also for planning and governance. Indeed, the 'palimpsest atlas' has not only been definitively integrated into design and planning practices, but it has also become the prime authoritative tool of Canton Geneva in the field of architectural and landscape heritage policy. Regarding the latter, it is important to point out that the same atlas authors have critically distanced themselves from this application as a normative tool, as the original, historical, and critical objective of the atlas was certainly not to 'celebrate' permanent and persistent structures by labelling them as heritage, nor to consider 'erasure' as destruction. According to Corboz, erasing is a legitimate 'writing action.'

2. The Territorial Palimpsest: An Evolving Concept

After the 'territorial turn,' nowadays, both territories and their representation have come to face new challenges: while territory is going through multiple transitions—environmental, social, and economic—, a new 'digital turn' has come to the fore as the main subject for territorial visualisation. More particularly, it is precisely the convergence of these two conditions that makes us believe that a critical and methodological update of Corboz's palimpsest could prove it still to be an operant and powerful theoretical frame.

On the one hand, emerging global issues—such as climate change, sources shortages, economic, and health crisis—are increasingly confronting territory with complex dynamics that are progressively replacing static and immanent structures. In this sense, the three categories of permanence, persistence, and disappearance can be seen as clues of today's discourses about material cycles, in dialogue with preservation, recycling, and demolition processes. Furthermore, it emerges an extended notion of time, that of dynamic, temporary, and cyclic, one that relates to both extremely short and *longue durée* processes. Within this framework, we can observe that current mapping productions call for the exploration of the interactions between spatial, social, and environmental processes through the prism of the temporal dimen-

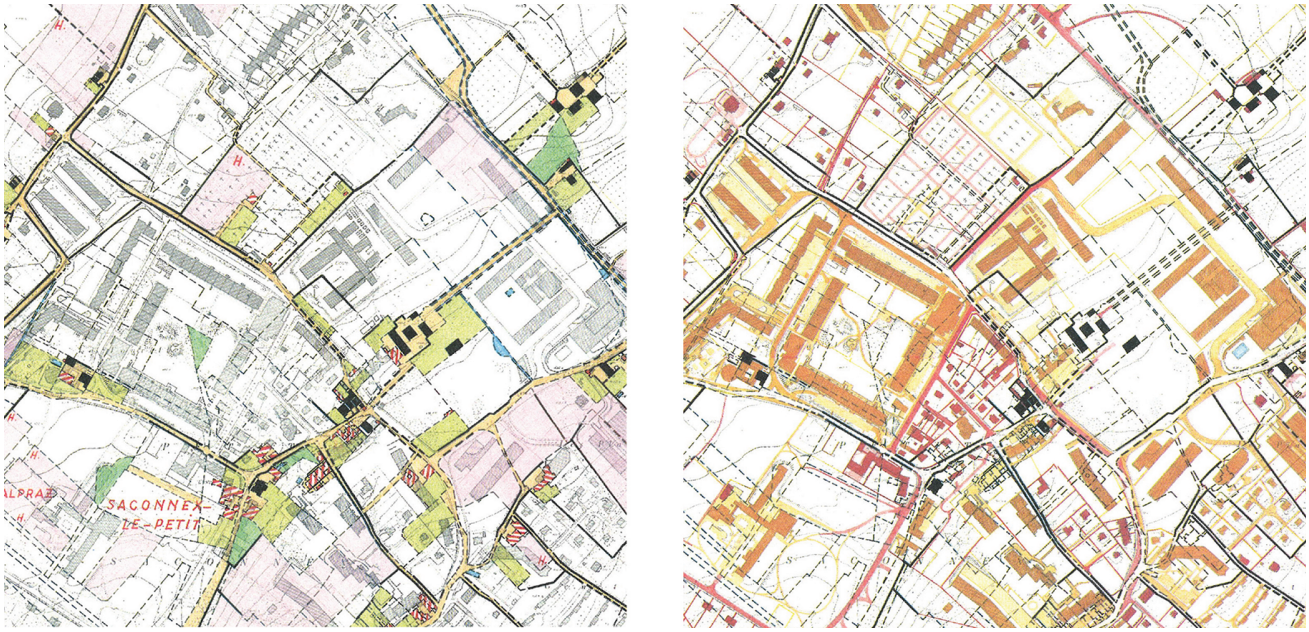

Figure 1. *Atlas du Territoire Genevois.* Left: Transcription of the Napoleonic cadastre to the 1991 plan. Synchronous reading of two states of the territory 170 years apart. Right: Comparison among the Napoleonic cadastre, the 1935–59 plan, and the 1991 plan. Formation/transformation of the territory 19th and 20th century; diachronic reading by attributing historical coordinates to each element of the built morphology (roads, parcel, building). Source: Service des Monuments et sites de la République et Canton de Genève (Léveillé et al., 1993).

sion, without necessarily considering the palimpsest theory and benefiting from its epistemological implications. After the deliberately 'reductive' approach of the Geneva atlas—dealing with complexity through a strong reduction of categories and elements—we think that the concept of 'territory as palimpsest' deserves to pass through a new process of extension and hybridization, so as not to exclude the possibility of being able to make new relevant reductions.

On the other hand, if since the 90s the multiple powers—internal and external—of maps were acutely unveiled (Harley, 1989; Wood, 1992), meanwhile, both the production of cartographies and the theoretical reflection on the same have been reinforced by the rapid evolution of new technologies of data sensing, collecting, sharing, and visualising. If we think that every two days more data is being produced than in all of history before 2003 (Kitchin, 2014), it becomes clear that such a large amount of information is imposing a further and unforeseen dimension on time: the so-called 'real-time,' a continuous and relentless flow of information that critically questions the agency of mapping as a necessary step of design operations. Moreover, new technologies such as 4D platforms coupled with point cloud modelling have introduced qualitatively different proceedings of understanding territorial and urban changes: They produce complex and incredibly precise images whose logics are only perceivable if the fourth dimension of time is added to those of space.

If referring to the main scope of this issue, these emerging technologies become key and meaningful in broadening and intensifying the potential of interpreting, shaping, and mapping our territories as constantly evolving processes, as transformative dynamics, and ultimately as both metamorphic and metabolic palimpsests. In other words, these emerging and rapidly evolving tools offer the conditions to update the palimpsest territorial analysis beyond its original morphological approach and towards one that reconstructs evolutionary processes on both the macroscopic and microscopic scale; one that operates an interdisciplinary investigation of hybrid processes intertwining geomorphological, social, mechanical, biological, climatic, and ecological dimensions with the multiple dimension of time. At the same time, if the act of considering space and forms as evolutionary processes through time allowed Corboz to criticize the conventional opposition between city and countryside, and to claim for the city-territory (Cavalieri & Viganò, 2019; Tafuri, Piccinato, & Quilici, 1962), nowadays the kaleidoscopic variety of temporalities that digital mapping deals with—the linear, the cyclic, and the instant time—creates extraordinary premises for a wide, interdisciplinary and democratic arena to debate categories and concepts of urban habitat.

Following this line of thinking, this thematic issue aims to first re-explore the metaphor of palimpsest as a methodological question in the light of a cartographical 'digital turn,' and then to reframe urban transformation within the renewed categories of both time and urban. Categories whose intertwining exemplifies the occasion for this thematic issue, that is rooted in the collaboration between the Habitat Research Centre and the Digital

Humanities Laboratory, EPFL Lausanne. The former is a trans-disciplinary research platform that aims to explore the city-territory as a renewable resource and to produce visions, strategies, and projects on this primary and crucial topic; the latter, which initiated the Europe Time Machine network and shaped the Venice Time Machine as the first prototype, develops new computational approaches for rediscovering the past and anticipating the future. The fundamental hypothesis behind the need to digitalise materials such as historical archives, literature, cartographies, and ultimately cultures is that of putting forward a 'large' quantity of 'data' that, besides not being digital, has shaped the space we live in today (Kaplan, 2015). This twofold trajectory, also emphasized by the three commentaries in this thematic issue, reflects the main perspectives through which we intend to discuss the notion of the palimpsest: as an operant tool for renewed urban and historical analysis (Denny & Waldheim, 2020), as a means for experimental design operations (Viganò, 2020), and as a 'horizon of reference' for re-orienting big data-based analysis (Kaplan & di Lenardo, 2020).

Within such a binomial contextualisation, this issue attempts to reveal the multiple and possible applications of the palimpsest as a tool of both representation and historical interpretation that allows one to codify the present and thus to frame the future out of the restrictions of a prescriptive approach. A tool that goes beyond mainstream tendencies and that rather seeks to track down the weak signs, that sort of underneath spatial and cultural geographies that become the starting point for a specific type of project.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Mapping the Palimpsest of *Milieus*: Towards a Shared Project on the Open Spaces of the Plaine Lyon-Saint-Exupéry

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Abstract
This article examines the tools and methods that contribute towards the development of open-space projects in urban countrysides as part of land-use planning processes. It focuses on the creation of a support to encourage dialogue between ecology and landscape architecture professionals, in relation to their common interest in the history of the territories they are analysing. Based on the notion of palimpsest, we propose an original methodology for the cartographic representation of *milieus*, designed as a tool for interprofessional work. We conducted an experiment within the operational context of the Plaine Lyon-Saint-Exupéry so as to set out this method of data and map production on GIS software, reinterpreting the historical atlas of the Canton of Geneva (Corboz, 1983; Léveillé et al., 1993). We will see that these cartographic representations allow for unique readings of planned territory in order to imagine its future. For ecology and landscape professionals working on the open spaces in question, they contribute to develop complementary project intents and new modes of exchange with local actors with regard to its co-construction. The palimpsest mapping tool may therefore be defined as an 'intermediary object' for a shared multifunctional project on open spaces.

Keywords
cartography; interprofessionality; landscape architecture; landscape ecology; open space; periurban; regional planning; territorial planning; urban countryside

Issue
This article is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato (EPFL, Switzerland).

1. Introduction

For urbanists, open spaces are study objects. When planning urban countrysides marked by the development of built-up areas and infrastructures that fragment these spaces, their valorization is deemed essential to territorial restructuring (Donadieu, 1998; Magnaghi, 2014; Sieverts, 2003). For this purpose, different types of spaces are taken into consideration, ranging from unbuilt spaces within urban envelopes to agri-natural spaces.

The multifunctionality of open spaces, including ecosystemic services, are among a territory's main resources for a living environment, biodiversity, agricultural production, safe water adduction, among others. Nowadays, projects relating to these spaces call upon different types of knowledge and challenge the implementation of inter-professional work. Our argumentation looks more specifically at the fields of landscape ecology and landscape architecture, respectively defining them as a scientific approach to ecological networks and as a project approach linked to socio-cultural processes (Décamps & Décamps, 2004; Nassauer, 1992). We consider the transversality between these areas of knowledge to be essential to the development of a multifunctional project and to commitment from territorial actors.

Our reflection will focus on the development of tools and methods that will create favourable conditions for this interprofessional work. More specifically, it will be a case of developing representation supports, an area of interest in urbanism and landscape architecture (Loubière et al., 2007; Pousin, Marco, Bertaudière-Montès, Barthélémy, & Tixier, 2016). We will look at

these in relation to the sociology of innovation which studies modes of dialogical exchange between different actors (Callon, Burchell, Lascoumes, & Barthe, 2011). These representations are designed as 'intermediary objects' characterized by their ability to link heterogeneous social and professional worlds (Vinck, 2009; Vinck & Jeantet, 1995).

The palimpsest refers to the historical depth of the constitution of a territory (Corboz, 1983) and we identify it for its capacity to interest different types of knowledge. Inter-professional work might be federated around this territorial heritage, between nature and culture (Poli, 2018).

Regarding these aspects, our article proposes a methodology for mapping the palimpsest of *milieus*, in order to produce 'intermediary objects' that contribute towards interprofessional work on the open spaces of urban countrysides. To this end, we will reinterpret the historical atlas of the canton of Geneva (Léveillé et al., 1993) as it relates to our objectives.

To develop this method, we will rely on a test conducted within the operational context of the Plaine Saint-Exupéry located in the Lyon metropolitan zone in France. We will see that it allows for unique readings of planned territory in order to imagine its future. For ecology and landscape professionals working on the open spaces being studied, these cartographic representations contribute to develop complementary project intents and new modes of exchange with local actors with regard to its co-construction. A retrospective reading of the history of open spaces opens the way for a prospective narrative (Sgard, 2008).

We will develop our argument in three stages. First of all, we will explain how the question of time can make it possible to link ecological and landscaping approaches in the context of planning open spaces in France. We will then explain the methodology used to create these maps of the palimpsest using GIS software and the production of the corresponding temporal data. Finally, we will look at how they can be a tool with which to read open spaces and define hypotheses as to their future as part of an inter-professional and multi-actor process.

2. The Temporal Dimension for the Development of Interprofessional Work on Open Spaces

2.1. The Landscape Ecology Approach

The landscape ecology approaches were developed in professional practice alongside planning policies on ecological networks. The latter began with the Convention on Biological Diversity adopted on an international scale in Rio de Janeiro in 1992. Various ways of including them in territorial planning have been developed in European countries (Jongman, Külvik, & Kristiansen, 2004). In France, it was to a large extent the Grenelle laws of 2009–2010 that introduced themed regional planning: the regional scheme for ecological coherency (SRCE). This was included in lower-level general planning documents such as the territorial coherency schemes (SCOT). A certain number of financial assistance contracts were implemented to support local ecological restoration projects.

This policy focuses on conceptions and methods borrowed from landscape ecology and considers open spaces as structures with which to tackle biodiversity loss (Ahern, 1991; Burel & Baudry, 1999; Forman & Godron, 1986). Indeed, one of its founding texts talks about the identification of "ecological corridors" to allow a given species to move between favourable *milieus* known as "reservoirs of biodiversity" (MEEDDM, 2010, p. 10). This mobility allows fauna and flora to maintain a sufficient living space when faced with the fragmentation of their natural habitats as a result of anthropic activities (urban sprawl, infrastructures, intensive farming, etc.). Ecology professionals define reservoirs by essentially basing themselves on pre-existing protection and naturalist inventory perimeters. For the corridors, different methods exist, mainly using GIS mapping, which can be applied on a regional (1/100000) or local (1/10000) scale. Environmental permeability analyses are common (Amsallem, Sordello, Billon, & Vanpeene, 2018). To achieve this, maps of current land occupation are created, generally using GIS data produced by National Geographic Institute (IGN), along with some additional pre-existing naturalist data. These maps thus define the main categories of the mosaic of ecological *milieus*, each being allocated a permeability coefficient per species guild, i.e., per wildlife group presenting relatively similar habitats and modes of displacement. After modelling and simulating fauna displacements, this makes it possible to determine existing corridors linking biodiversity reserves, and then to guide the restoration operations that need to be undertaken to improve the situation. These GIS maps serve as a basis for discussions with local actors.

At the launch of the Grenelle laws, thought was given to the term 'landscape' in these socio-cultural and economic dimensions, in relation to the elements that constitute the ecological network, such as hedges, riverine forests, ponds, etc (MEEDDM, 2010, pp. 27–28). Yet no project methodology was mentioned in relation to this notion, which disappeared from the implementing decrees and circulars. The guides published under these laws refer to landscape ecology methods, without creating any tranversality with those relating to landscape (APCE, 2016, pp. 10, 13).

2.2. The Landscape Architecture Approach

Throughout the history of regional planning, landscape architects have developed different methods for dealing with landscape quality, a goal that was indeed been confirmed by the European Landscape Convention in 2000. Open space is seen as a structure for organising urbanisation and contributing to the well-being of inhabitants.

In France, we can place the beginning of such landscaping approaches at the start of the 1900s with J. C. N. Forestier's (1906) "park system" conceptions, inspired by F. L. Olmstead. However, the methods currently used were developed in the 1960s–1970s in the regional organisations for metropolitan study and planning (OREAM) that were tasked with creating the metropolitan area scheme (SDAM). This organisation brought together professionals from different backgrounds, and young landscape architects such as Jacques Sgard and Pierre Dauvergne conducted studies on large landscapes. In particular they described the project to be undertaken with regard to the 'green corridor,' 'green separations' or 'green belt' announced in the metropolitan area scheme and in lower-level planning documents, as town planning and development schemes (SDAU). One of the methods defined was the identification of landscape units working on socio-cultural processes related to spatial landscape structures (agricultural spaces, transitions with urban spaces, reliefs, afforestations, watercourses, etc.). Geographers, agronomists, ecologists, sociologists and other experts took part in order to integrate the different functions of these green continuities (OREALM & PAYSA, 1975; Zarmati, 1980).

These inaugural approaches were developed alongside landscaping policies, driven in particular by the 1993 landscape law. This can be seen in the landscape atlases, plans and charts which are becoming more and more widespread, contributing to projects for territorial enhancement. Guides provide details of the methodologies used (Pernet, 2014, pp. 57–89; Raymond, Luginbühl, Seguin, & Cedelle, 2015). Maps, block diagrams, sketches, photos, etc. are used as representation supports for discussions with local actors. Hand drawing is the preferred technique for expressing landscape ambiances, cartographies included. However, current reflections relate to representations from GIS techniques (APCE, 2018).

Current general regional planning documents such as territorial planning schemes and regional schemes for territorial planning, sustainable development and equality (SRADDET, which integrate and replace the SRCE) refer to these landscape approaches. They are clearly defined in such a way as to distinguish them from landscape ecology approaches (Raymond et al., 2015, p. 64).

2.3. The Potential of Time to Link Ecology and Landscape

Landscape ecology and landscape architecture approaches focus respectively on natural dynamics and socio-cultural processes. Methods were developed independently. However, a transversal and multifunctional approach is a major challenge when attempting to act effectively on open spaces (Décamps & Décamps, 2004; Nassauer, 1992). With this objective in mind, and in addition to these specific methods, we propose to develop a palimpsest mapping project as a support for inter-professional dialogue.

We were interested in the temporal dimension because it is something of interest to both ecologists and landscape architects. Indeed, in order to develop a project, landscape architects need to understand the past and the socio-cultural depth (Pernet, 2014, pp. 76–83; Raymond et al., 2015, pp. 27–28, 41–45). Ecologists, for their part, are interested in historical approaches to existing *milieus* in order to better characterise them and better envisage modes of ecological restauration (Girel, 2006; Lefeuvre, 1999).

We understand this temporal and heritage-related dimension through the analogy of the palimpsest as presented by Corboz (1983). The territory is seen as an accumulation of traces resulting from processes of addition and deletion. It conveys a meaning and a collective imaginary that are a combination of multiple factors, natural and human, material and immaterial. For Corboz, an attentive and nostalgia-free understanding of the dynamics of transformation allows one to intervene intelligently in the space. This approach considers the 'territorial heritage,' including places that are run down, in order to project a valorisation of the territory (Poli, 2018, pp. 102–104).

Our approach to the past will be restricted to the long period of metropolitan regional planning and its adaptations at lower scales, i.e., between 1960 and today. This was a significant period of open-space planning, also accompanied by major environmental deterioration. We therefore feel that it is important to provide new knowledge of this past planning in order to raise questions concerning the desired effects of current planning and ongoing projects. The notion of palimpsest, characterized by the joint presence of accumulations and deletions, guides the development of this knowledge. The lengthy duration of the constitution of the territory is approached through the heritage that existed in the 1960s and through the way it has been considered until today. An extension of our work, which we will not discuss here, might be to place the lengthy planning within a longer temporality.

We chose to represent the palimpsest using GIS cartographic software. This is a standard technique in the field of urban planning, which makes it a relevant interprofessional project work tool. We will focus on the possibilities of visual representation afforded by GIS in order to interest both ecologists and landscape architects. As we will see, we will include components of the territory that are of interest to them. Moreover, we will use a graphic interpretation to relate the complexity of the territorial palimpsest. Ecologists will be able to see a representation created through familiar technology, while landscape architects will be able to see the expression of landscape patterns through a digital drawing, supplementary to the image drawn by hand (Tiberghien, 2013). This cartographic work is therefore of a 'descriptive' nature in the sense proposed by Corboz (2001). It proceeds from a selective reading of the territory in order to be coherent with the professional cultures concerned and is project-oriented.

3. Method for Mapping the Palimpsest of *Milieus*

3.1. Zone of Experimentation: The Plaine Lyon-Saint-Exupery

The Plaine Lyon-Saint-Exupéry is the study zone for which we will develop and test the palimpsest mapping method, in line with our research orientations. This urban countryside was chosen because it is the object of an open-space project process involving landscape and ecology professionals, and because it is a space planned over a long period of time.

Since the 1960s and the development of its planning, this area has been identified as strategic for the development of the Lyon airport platform (Dugua, 2015, pp. 541–571). It is located on the border between three departments (Ain, Rhône and Isère). There are currently four planning documents related to it on a territorial scale (SCOT), themselves framed by a regional territorial planning scheme (DTA) modified in 2015 following several studies (Dugua, 2015, pp. 610–649, 687–753). The challenge is to structure the development of this strategic area—including, in particular, the extension of the airport, the creation of railway infrastructures and business zones, etc.—around agri-natural open spaces with ecological and landscape functions (Figure 1). These orientations are consistent with other regional planning documents (SRCE and SRADDET). More specifically, landscape and ecology professionals are interested in this area. In the region, within government departments, the Plaine Saint-Exupéry is a pilot site for a landscape approach that takes ecological networks into consideration (APCE, 2016, p. 36). Moreover, as an extension to the Rhône-Alpes SRCE, this territory was the object of two pre-operational studies on ecological networks, each of which was driven by a river syndicate (or equivalent) in order to specify ecological restoration actions with a view to obtaining a financial assistance contract (ECOVIA, 2016; TEREO, 2016).

However, actions on open spaces show a lack of joint work between ecology and landscape professionals. Indeed, ecological methods are the only ones to be developed in the pre-opérational studies. Actors involved in environmental protection, territorial planning and farming have discussed modelled ecological networks in order to jointly define the work that each profession can carry out: the construction of wildlife passageways at infrastructure level, differentiated green space management, hedge planting, creation of open habitats or ponds, reconfiguration of watercourse banks, etc. No landscape professionals took part in these studies. Yet, during an interview in 2017, the two technicians in charge of studies on the Bourbre Basin and the east-Lyon region pointed out that once the action contract

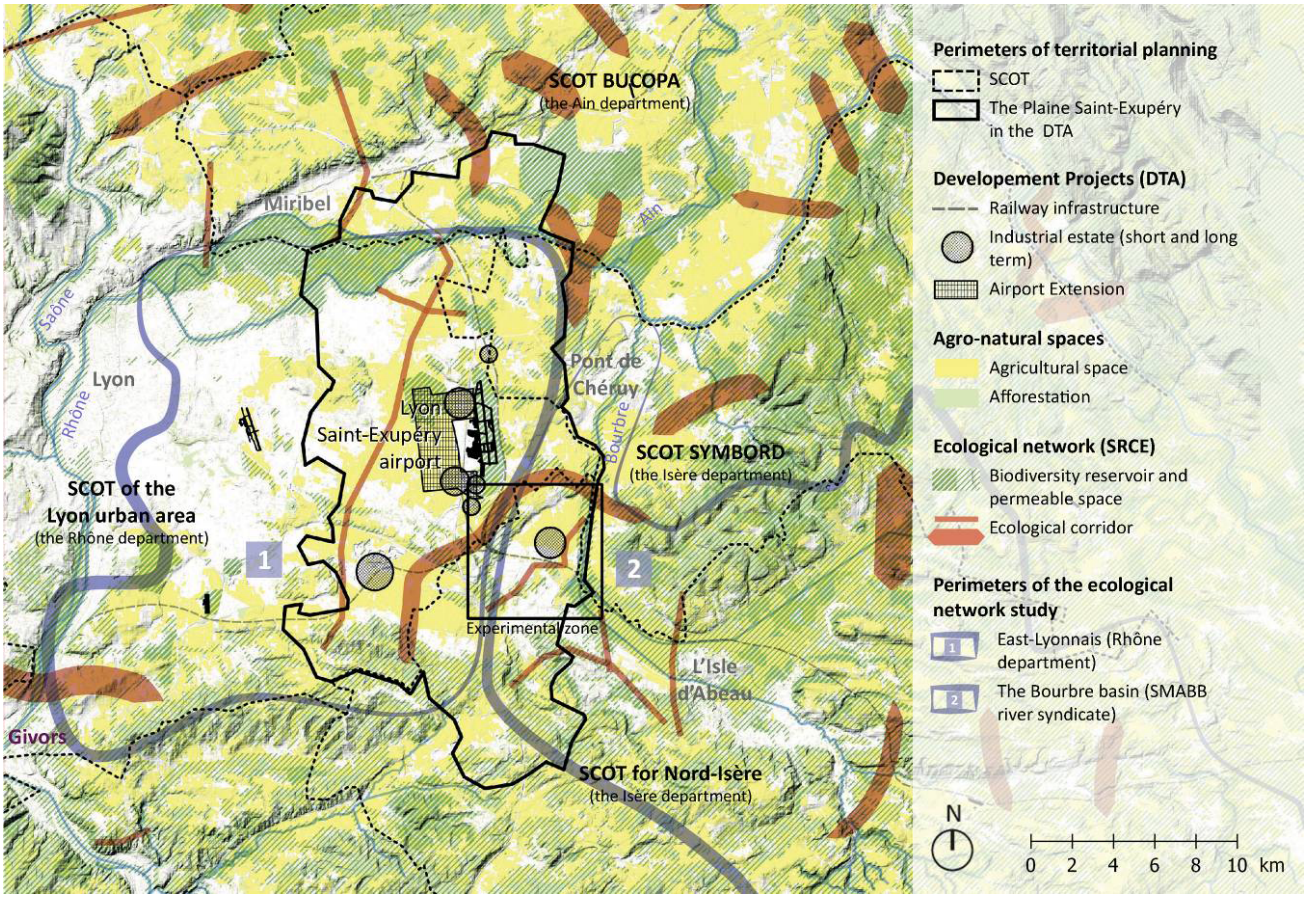


Figure 1. Plaine Saint-Exupéry: Perimeters for planning, ongoing projects and environmental challenges. Source: Author.

has been set in motion for a five-year period, lengthy discussions with the various municipalities, operators, land owners and/or administrators will be required in order to specify possible actions. Generally speaking, the ecological theme is not enough to mobilise local actors. Landscape is a useful entry point. It is for this reason that the Bourbre river syndicate (SMABB) will seek landscape expertise from CAUE Isère (consultancy, architecture, urbanism and environment) in addition to ecological consultancy with CEN Isère (natural space conservatory). While the partnership with the CEN is commonplace in contracts resulting from the SRCE, the CAUE partnership is the first of its kind in Isère and their role is still being defined. No method or tools have been prefigured to link the ecological and landscape aspects. This is therefore a useful context for testing our approach.

With our cartographic work, we wish to take a step back from the open spaces of the Plaine Saint-Exupéry regarding ecological and landscape changes over the long period of planning, on the hypothesis that this will contribute towards an inter-professional dialogue. To this end, we began by analysing the territory's planning documents, of which there are many and which have different approval dates due to the territory's administrative fragmentation. To give ourselves an overview, we set reference years at 15-year intervals to distinguish between the different generations of these documents (Figure 2). For each one, we identified the main ideas relating to open spaces (Autran, 2004). Around 1975, the Plaine Saint-Exupéry was identified as a strategic part of the 'green belt' that separated Lyon's urban area from two new towns. It was a case of restricting the growth of the urban area, of protecting and modernising periurban agricultural zones (irrigation, land consolidation, etc.) and of inserting metropolitan infrastructures such as the airport. These orientations were set out at a territorial scale and prefigure the future limits of planning documents (Figures 1 and 2). A reflection on landscape and the environment was discretely presented during this period, via the notion of 'living environment' and was reaffirmed in the 1990s with a focus on landscape approaches. A proposition was made to reveal the territorial geography (waterways, watercourses, reliefs, etc.) for the Lyon urban area (Gras, 1995). A landscape map was created for the Isle d'Abeau territory so as to link the planning projects to the relief and vegetation of agri-natural areas (Bédarida, 2002). In addition, the Rhône-Alpes landscape observatory relayed these approaches on a regional scale as from 2005. The ecological dimension was to be highlighted with the regional planning in the mid-noughties as part of the multifunctional design of a "green mesh network" (Préfecture de région Rhône-Alpes, 2006). The Plaine Saint-Exupéry, which was currently under development, became part of the urban

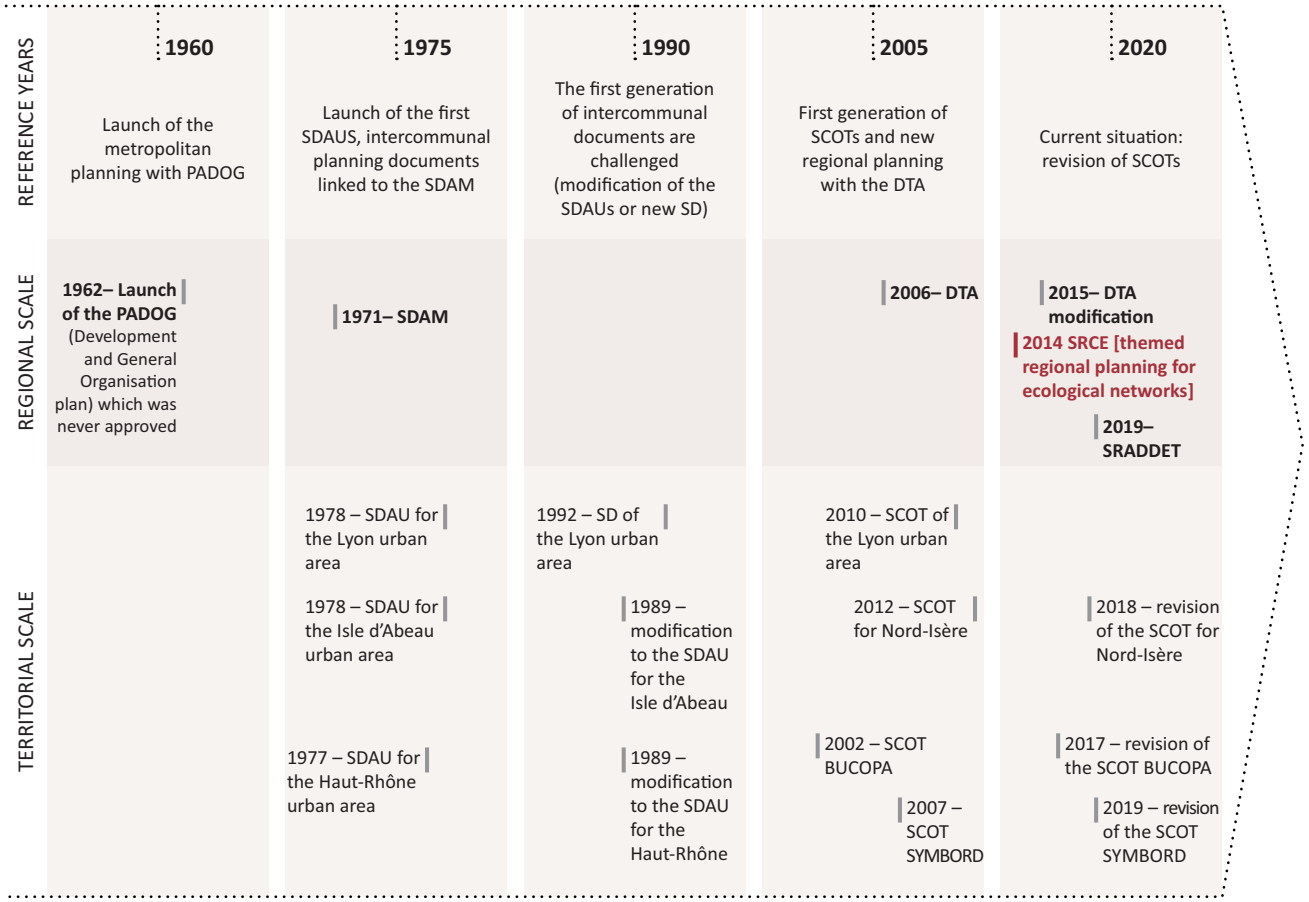


Figure 2. Planning documents for the Plaine Saint-Exupéry territory. Source: Author.

area 'green belt,' concerned with the challenges of landscape requalification, ecological functionality, the development of environmental farming practices and the protection of water resources. These orientations were set out on a territorial scale, i.e., between the commune and the region. These issues were updated in accordance with recent revisions or modifications to the planning documents, bringing us to the current problems with open spaces, as seen above.

3.2. Reinterpreting the Historical Atlas of the Geneva Canton

Our cartographic construction draws on the historical atlas of the Geneva canton (Léveillé et al., 1993). Part of the latter can be accessed online at SITG-Le Territoire Genevois à la carte (Cartes professionnelles/patrimoine: 'Territoire 1800' and 'Territoire XIX–XX'). It superimposes the 1991 cadastral plan onto that of the beginning of the 19th century, thus defining the 'permanencies,' 'persistences' and 'disappearances.' This hand-drawn representation, which includes urban countrysides, offers a simultaneous visualization of the past and present of the different components of the territory (parcels of land, watercourses, roads, buildings, vegetation, etc.). We feel these characteristics to be of interest regarding innovation in current research on the historical GIS mapping of open spaces. The latter tend either to separate the visualization of elements that have appeared and disappeared (Franchomme & Dubois, 2010) or to give a quantitative representation per pixel (Bellec, Gauthiez, Fenet, & Kaufmann, 2019), without expressing complex spatial patterns. Moreover, such research generally focuses more on areas of dense urban agglomeration (Khirfan, 2010), or on specific agri-natural spaces (Franchomme & Dubois, 2010), than on urban countrysides with the specific relationhips between open spaces and the built environment.

We therefore propose to reinterpret the cartographic work carried out in Geneva in the 1990s. To achieve this, we adapted many aspects relating to the context on which we are working. First and foremost, we represent the elements that are significant for landscape ecology, i.e., those that contribute towards the fragmentation of natural habitats (urbanised spaces, infrastructures, etc.) and those that make up the mosaic of the ecological network's *milieus* (grasslands, hedges, afforestation, waterways, bodies of water, etc.). As constituent parts of territorial morphology, these components also have meaning for the landscape. Secondly, although we are inspired by permanencies, persistences and disappearances, we do not make the distinction between 'permanence' and 'persistence,' which we group with the term 'continuance.' We also add the term 'appearance' (Figure 5). Finally, this mapping was performed at the same 1/10000 scale which is also commonplace for modelling landscape ecology when defining local actions.

The reference area is that of the Plaine Saint-Exupéry, but this article will focus on an open space that links a

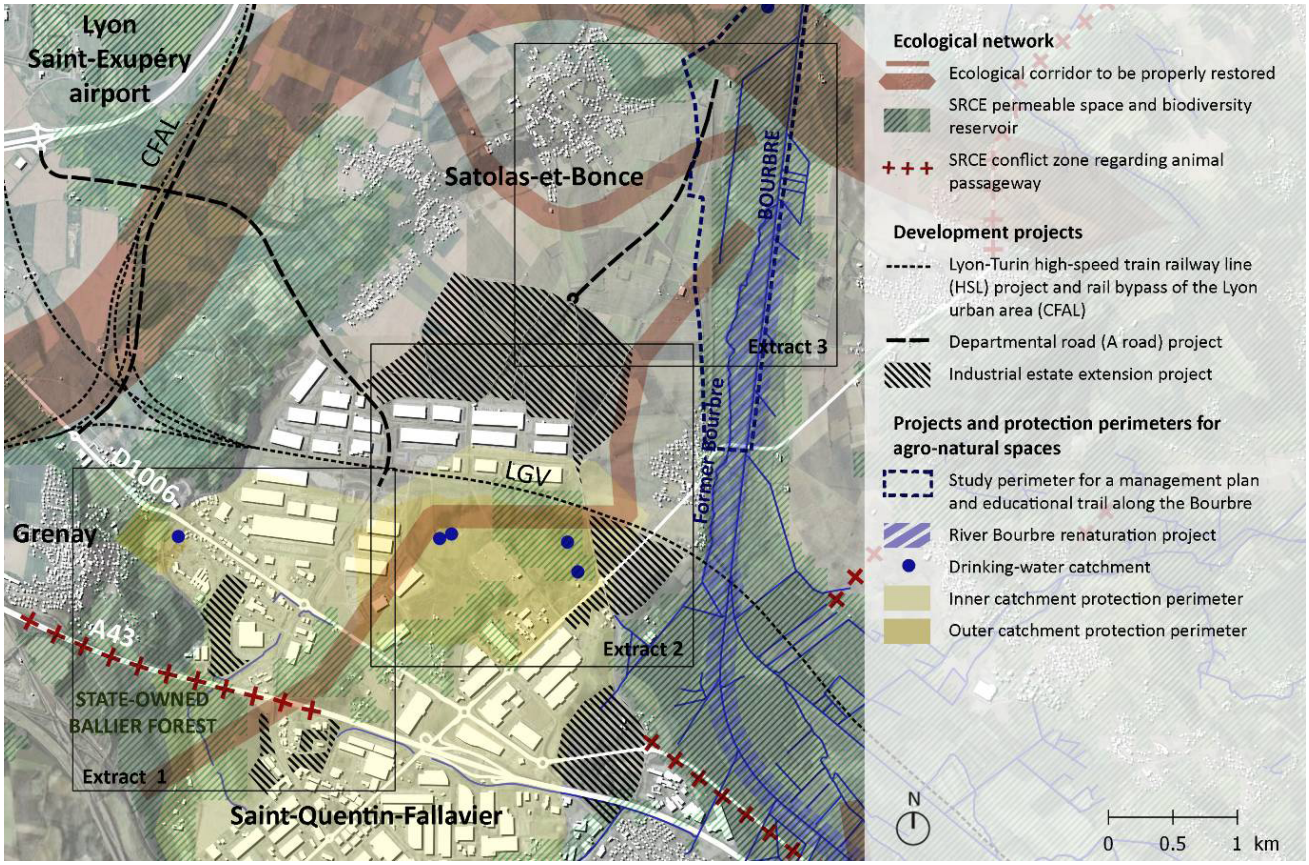


Figure 3. Experimental zone, ongoing planning projects and environmental challenges. Source: Author.

reservoir of biodiversity in the Bourbre marsh to a state-owned forest (Figure 3). This particular space is representative of the broader challenges that the territory in question poses, as it combines issues of ecological functionality, landscape quality, planning, agricultural protection and conservation of water catchments.

3.3. Data and Map Production Method

GIS mapping involves the manipulation and production of digital data. The first stage of our GIS work consisted of collecting the materials needed.

First of all, based on the years of reference for the different generations of planning documents and, depending on their availability, we chose old maps and aerial views from the National Geographic Institute (Figure 4). They are either georeferenced on GIS after digitalisation, or else loaded via National Geographic Institute's web map service flow.

We then collected three types of GIS Shapefile and Raster data relating to the current situation:

- The 2016 land registers containing information from the directorate general for finance.
- The 2016 graphic parcel register (*registre parcellaire graphique*, RPG) produced by the service and payments agency listing the agricultural land parcels being farmed.
- The National Geographic Institute's 2016 large-scale repository (*référentiel à grande echelle*, RGE) containing the BD Topo, which describes the elements of which the territory is comprised and its infrastructures (roads and railway lines, buildings, hydrographics, etc.), and the large-scale repository Alti made up of a digital terrain model.

One final source concerns georeferenced documents and GIS files from various ongoing actions and projects (urban planning, zones protecting water catchments, renaturation project, etc.). These were supplied either by local actors, or else downloaded from the operators' websites.

In addition, we carried out field work, walking the land, taking photos, surveying and talking to inhabitants, farmers, elected officials and technicians from local communities. This work was useful in gaining an understanding of the process involved in transforming the territory, and also helped us to interpret the aerial views by referring to existing studies and to the collective memory of spatial transformations.

The second stage consisted of producing new shapefile mapping data for the selected territorial elements, by giving them temporal information. For each of these elements, we identified the most pertinent sources to use, the idea being to achieve an equivalent level of accuracy for each period, with the objective of creating a 1/10.000 map.

We generally use BD Topo shapefiles, to which we add a time-dedicated field with QGIS. This gave us a working base that contained all of the territory's existing components (roads, railway lines, airports, electric lines, waterways, surface water, hedges and woods). We then dated their appearance by using photographs and historical maps to go back in time. We redrew certain inaccurate aspects of the BD Topo, such as hedges and woods. Finally, we did the reverse, working from

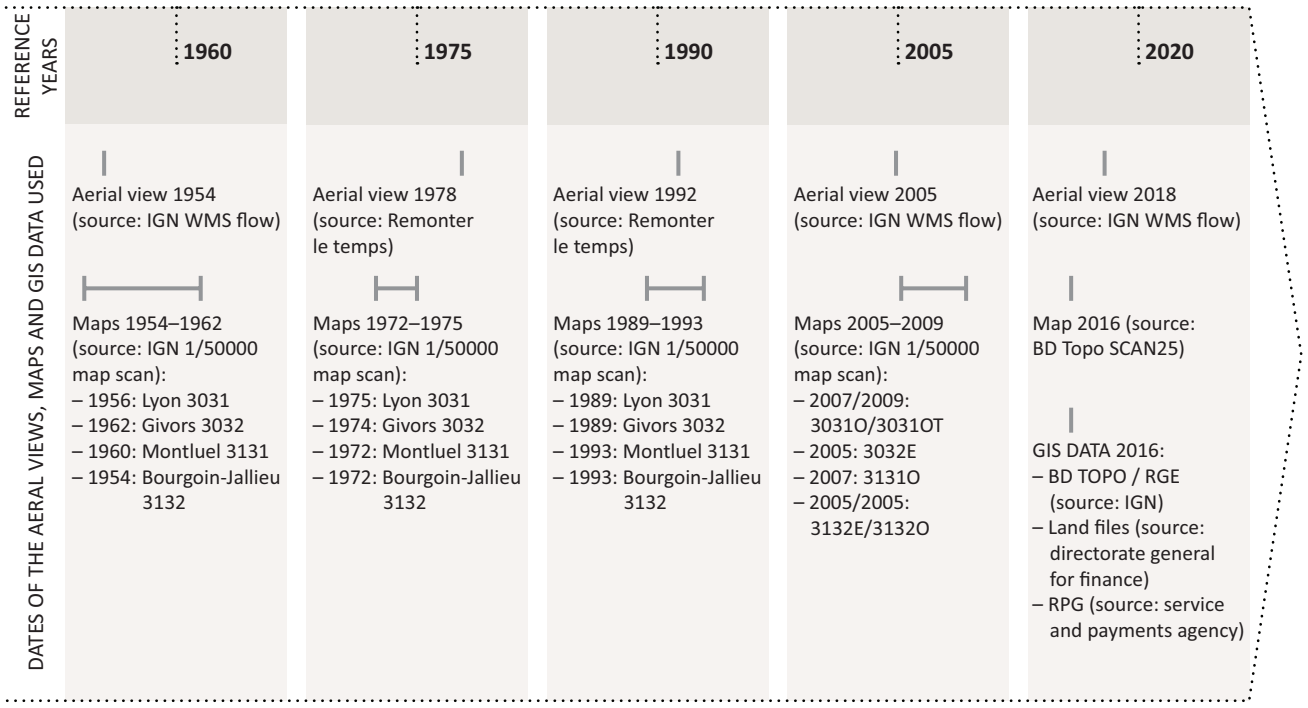


Figure 4. Reference dates for Plaine Saint-Exupéry planning and the sources used for mapping. Source: Author.

1960 to the present day, drawing and dating the components that had disappeared, or which had appeared and then disappeared.

We also used other sources. Regarding the urbanised spaces, the land registry files containing the building permit applications allowed us to date the urbanization of agri-natural open spaces. For the open spaces, the RPGs provide precise information on cultivated zones (crops, grasslands, etc.), but do not make it possible to go back in time, with the exception of grass filter strips, as they only came into being recently, with the Grenelle II law. So, in order to have the same level of information for all of the reference dates, we mainly used aerial photographs. These views were also used to identify the different types of sub-surface exploitation.

While certain elements were relatively easy to identify with the abovementioned sources—roads and railway lines, infrastructures, etc.—others required interpretation, and were subject to a possible margin of error. In terms of the agri-natural components, this essentially meant the hedges and open habitats. This is due to the fact that in poor-quality aerial photos, crops and certain grasslands can look very similar, and the shadows from hedges can be confused with those caused by herbaceous formations of embankments or ditches. In terms of urbanised zones, this mainly related to built-up parcels, due to the incomplete nature of the land register, the absence of information on the constructed parcels whose buildings had been destroyed and the poor definition of old aerial photographs with which to complete it.

We then produced a final data type, relating to the ongoing projects. As the materials gathered so far were mainly JPEGs and PDFs that had then been georeferenced on GIS software, we created a shapefile layer in order to redraw the footprints of the projects (urbanisation perimeter, infrastructure layout and perimeter of action on the agri-natural spaces).

The final stage consisted of using the resulting shapefile database to create two palimpsest mapping panes. These mappings echoed those in Geneva's historical atlas, highlighting on the one hand "the superimposition of the Napoleonic cadastral map onto the current overall map" and "the territorial formations-transformations of the 19th and 20th centuries" on the other (Léveillé et al., 1993, pp. 18–21). In our case and as the legend explains (Figure 5), they will explore:

- The differential between 1960 and the present day and the forthcoming projects, underlining the continuances that are essentially shown in dark shades. This pane consists of one map.
- The differential that we identified by planning period (1960–1975, 1975–1990, 1990–2005, 2005–2020), underlining the changes (appearances, disappearances) by showing them in a dark shade. This pane is composed of four maps.

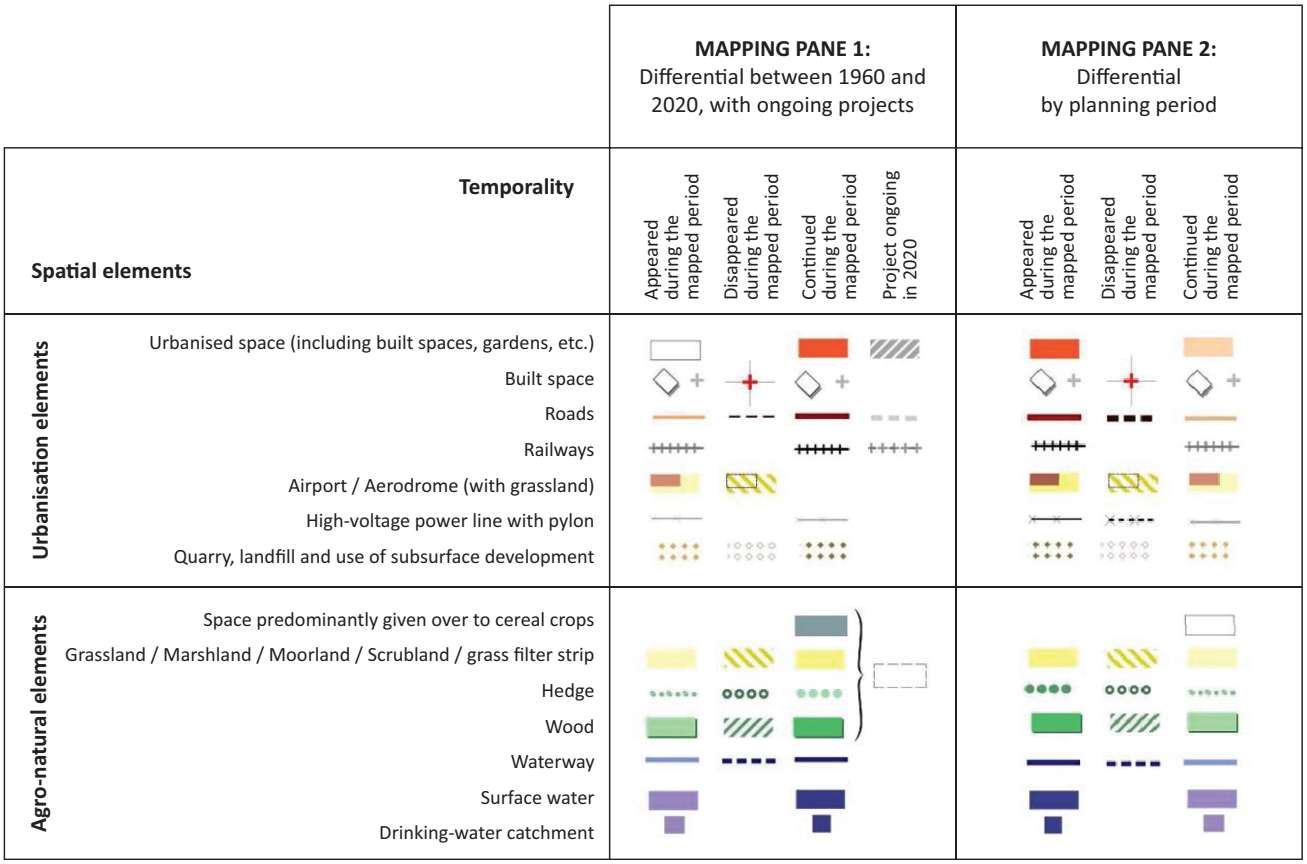


Figure 5. Legend for the mapping of the palimpsest of *milieus*. Source: Author.

The first mapping pane allows us to see the territory's transformations and continuances in a succinct manner, and the second pane lets us view the details of these changes, over shorter periods of time of the territory (Figures 6, 7 and 8).

4. A Visual Tool with Which to Develop a Shared Multifunctional Project

4.1. A Visual Support for Reading the Evolution of Planned Open Spaces

This mapping tool allows one to read and assess the planning of open spaces and of land. To achieve this, the ecological habitat and landscape transformations revealed by the mapping panes are compared with the different orientations of the successive planning documents. This is what we propose to do by describing the evolution of an open space on the linear of an ecological corridor also concerned by landscape quality issues. Three extracts from the palimpsest mappings (Figures 6, 7 and 8) allow us to identify spatial transformations that are potentially significant for landscape and ecology professionals. Characteristic aspects of urban countrysides are observed in detail: infrastructure transition, urban sprawl, intensive agriculture, relics of remarkable natural areas, etc.

The first extract (Figure 6) allows us to see the permanent nature of the wooded hillside in Grenay (Figure 6, no. 1) and the resulting transformations relative to the appearance of a roadway infrastructure followed by the industrial estate. The motorway, construction of which began before the 1970s planning documents were approved, takes the place of an old country road, thus removing the pre-existing local links between hamlets and villages (Figure 6, no. 2). Open habitats are structured here and there, including along the route through the wood (Figure 6, no. 3). Flowing from the hillside and prior to its infiltration by a gravel soil, a stream was culverted to cross the motorway and a retention basin was created nearby (Figure 6, no. 4). The industrial estate, one of the largest in Europe, began to develop in the 1970s in line with the Isle-d'Abeau's 1970s planning document. In an annex, the latter presents a 'green SDAU' recommending that it be created outside the hillsides and morainal knolls. It was developed on flat land. The existing roads and tracks disappeared (Figure 6, no. 5). A new main road served this urbanisation and ungrassed retention basins were organised on either side, as an extension of the stream (Figure 6, no. 6). In addition, we can see that a railway line, relatively unused nowadays, was laid at the foot of the hillside and crossed over the motorway in the 1970s–1980s (Figure 6, no. 7). The landscape and ecological orientations found in the planning documents of the 1990s–2000s translated into the roads and retention basins being landscaped with lines of plants and vegetation (Figure 6, no. 8).

The second extract (Figure 7) extends the observations concerning the deletion of previous territorial structures, made beforehand with regard to the industrial estate, and completes it with a description of the forest park. As from the 1990s, new roads, independent of their predecessors, were built to serve recent industrial buildings and logistics. This either led to ruptures in the side-street network—with the dead-end roads on the outskirts of these developments (Figure 7, no. 1)—or to the creation of roundabouts at strategic crossroads (Figure 7, no. 2). Before and during the construction of the industrial estate, the old hedge structures were removed (Figure 7, no. 3) and then replaced as from the 1990s by plantations that landscaped the main roads and the new roads servicing this urbanized space (Figure 7, no. 4). The landscape and ecological orientations (fauna, flora, groundwater protection) that had begun to assert themselves in the 1990s–2000s with the Isle-d'Abeau landscape plan in particular, came to fruition with the forest park. This is located level with the catchment protection perimeters and underneath the high-voltage lines (Figure 7, no. 5), while remaining within the operational boundaries of the industrial estate. The 'green SDAU' had prefigured the park in the mid 1970s, defining an agricultural corridor linked to the wooded hillside and making the most of the fact that no construction was authorised underneath energy transport infrastructures. This space now remains virtually uncultivated, with the majority of the land being left fallow (Figure 7, no. 6). Recent wooded areas (Figure 7, no. 7), designed as carbon sinks, reconfigure the site. We can nevertheless see a certain number of rare permanencies of former landscape structures such as the bodies of water close to existing catchments (Figure 7, no. 8) and the roads, built spaces and grasslands further south (Figure 7, no. 9). Other previous structures can be found on the agricultural plain and in the urbanisation of a hamlet, the main characteristics of which are similar to those described in the following extract.

The third extract (Figure 8) relating to the Bourbre marsh and Chesnes agricultural plain, is characterised by gradual yet major changes due to the modernisation of cultivated spaces and to the development of residential urbanisation. The 1970s planning documents provide a framework for these dynamics, which had begun much earlier. The restructuring of agricultural spaces to create field crops began in the 1960s, as evidenced by the crops that replaced the marsh grasslands between the 1960s and 1980s (Figure 8, no. 1), by the drying up of a branch of the river (Figure 8, no. 2) and by the razing of the hedges (Figure 8, no. 3). We can also see that the hillside grasslands have disappeared due to the decrease in livestock farming (Figure 8, no. 4). Nowadays however, we can see a certain number of permanencies such as hedge structures (Figure 8, no. 5) road structure (Figure 8, no. 6) and various remnants of grasslands on the hillsides (Figure 8, no. 7) and next to an old peat mining operation (Figure 8, no. 8). Environmental orientation can be identified here with the creation of grass filter strips as from 2005. Some of these were required, along the Bourbre, the former Bourbre and some marsh

drainage ditches, in order to preserve the quality of their water (Figure 8, no. 9). Others were placed from time to time by the farmer on the agricultural plain, in order to have a sufficient area of ecological interest creating the right to certain subsidies (Figure 8, no. 10). In addition, there was a significant decrease in hedge clearance as from 2005. Urbanisation processes were marked by the uninterrupted construction of housing from the 1960s onwards (Figure 8, no. 11). The old roads were preserved and deadend service roads were built. This dynamic led to the disappearance of farmland, including grasslands and hedges (Figure 8, no. 12). We can also see that retention basins were built, including one that is entirely grasped, perhaps suggesting environmental sensitivity (Figure 8, no. 13).

The evolution of the spaces presented in these extracts continues today. Several major ongoing agri-natural and planning management projects are underway (Figure 3), the main ones relating to the extension of the industrial estate (Figures 6, 7 and 8, area A), the construction of infrastructures for the Lyon-Turin high-speed train (Figure 7, area B) and a new road (Figure 8, area C), a plan for managing the marsh and part of the hillsides with an educational trail (Figure 8, area D) and the renaturation of the Bourbre river (Figure 8, area E). An analytical reading of the effects of the planning, made possible by the palimpsest mappings, gives pause for thought regarding future projects. How will they be embedded in the territorial heritage, in the context of current planning? What would be the benefits of an approach that effectively links the fields of ecology and landscape?

4.2. A Visual Support for Outlining a Multifunctional Project

This brings us to how these cartographic representations are used for interprofessional work, approached here through their appropriation by the CEN Isère and the CAUE Isère. We focus on these para-public structures that involved in our area of study, as they exist on a national scale to advise local actors in their respective fields of ecology and landscape architecture. The approach used in our particular case could therefore be adapted to suit other contexts.

In order to understand the operational benefits of this mapping tool in terms of the future of the territory, in 2018 and 2019 there were several meetings with CEN and CAUE personnel. In February and September 2019, two semi-directive interviews enabled us to clarify their respective visions. We therefore showed them the maps, their development and certain relevant aspects of analysis, and asked them how they thought it might help us to think about the development of future projects on open spaces. Of the two mapping panes, the pane 1 map (upper part of Figures 6, 7 and 8), which is more succinct, was the main one used for our discussions.

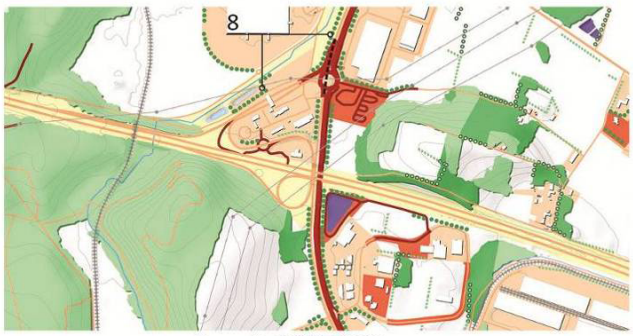
The experts made observations relating to the statement of project intent. This was based on their complementary readings of the territory's history, suggested by the mappings of the palimpsest. The CEN has been concentrating on the development of field crops that has been taking place since the 1960s, leading to the disappearance of numerous grasslands, both dry and wet. What remains of these *milieus* could be conserved and redeveloped, so as to preserve the flora and fauna that depend on them—such as amphibians in the marshlands. Above and beyond these spaces considered to be reservoirs of biodiversity, the CEN points out that there is a group of elements that are part of the ecological network, for example hedges, grassy strips, retention basins linked to urbanisation, along with abandoned spaces and animal passageways near infrastructures. Current thinking focuses on ways to intensify them and to establish ecological management. The CAUE approaches these ordinary spaces via the history of urban expansion around former villages and hamlets, leading to the disappearance of a border of big gardens, vegetable gardens and grasslands around the built spaces. This border had previously ensured the relationship between the structure of the built and agricultural landscape with a diversity of vegetal structures and uses. These transitions now need to be reinterpreted, particularly in the context of ongoing urban extensions and infrastructures. The elements mentioned by the CEN might help with this if they are considered in relation to the uses and perceptions of the territory. Multifunctionality is one key to the development of a projet on open spaces and the CAUE also highlights its importance in recognised spaces of biodiversity, such as wet zones. The practice of hiking and the sensitive aspect of things such as the views over a waterway, a pond or grassland could be combined with ecology.

The aims of the CEN and CAUE lead us to take an interpretive look at the history of the territory in order to formulate orientations concerning it future that go beyond merely conserving small areas of biodiversity or simply landscaping a given development. If we base ourselves on elements of the local palimpsest to be intensified and reinterpreted, we will be able to sketch hypotheses for a multifunctional project on the ecological network. We propose to give an account of this for each of the three extracts. The wet grasslands of the former peat mining operation and of the grassy hillsides of extract 3 (Figure 8, no. 7 and no. 8) could be maintained or even redeveloped alongside the projects around the Bourbre river (Figure 8, areas D and E), whilst taking different uses and local memory into consideration. The borders of the new infrastructures and of the future urbanisation of extracts 2 and 3 (Figures 7 and 8, areas A, B and C) could be worked with pathways and with plant-covered and hydraulic structures intersecting with the existing network of roads, hedges, grassy strips, fallow lands and woods (Figure 7, no. 6 and no. 7, Figure 8, no. 5, no. 6 and no. 10). Incentives to strengthen these pre-existing semi-natural elements could be offered during this process. Such a project would develop ecological functionality, especially as it would combine with animal passage-

Pane 1: 1960-2020 and ongoing projects

Pane 2: 1960-1975

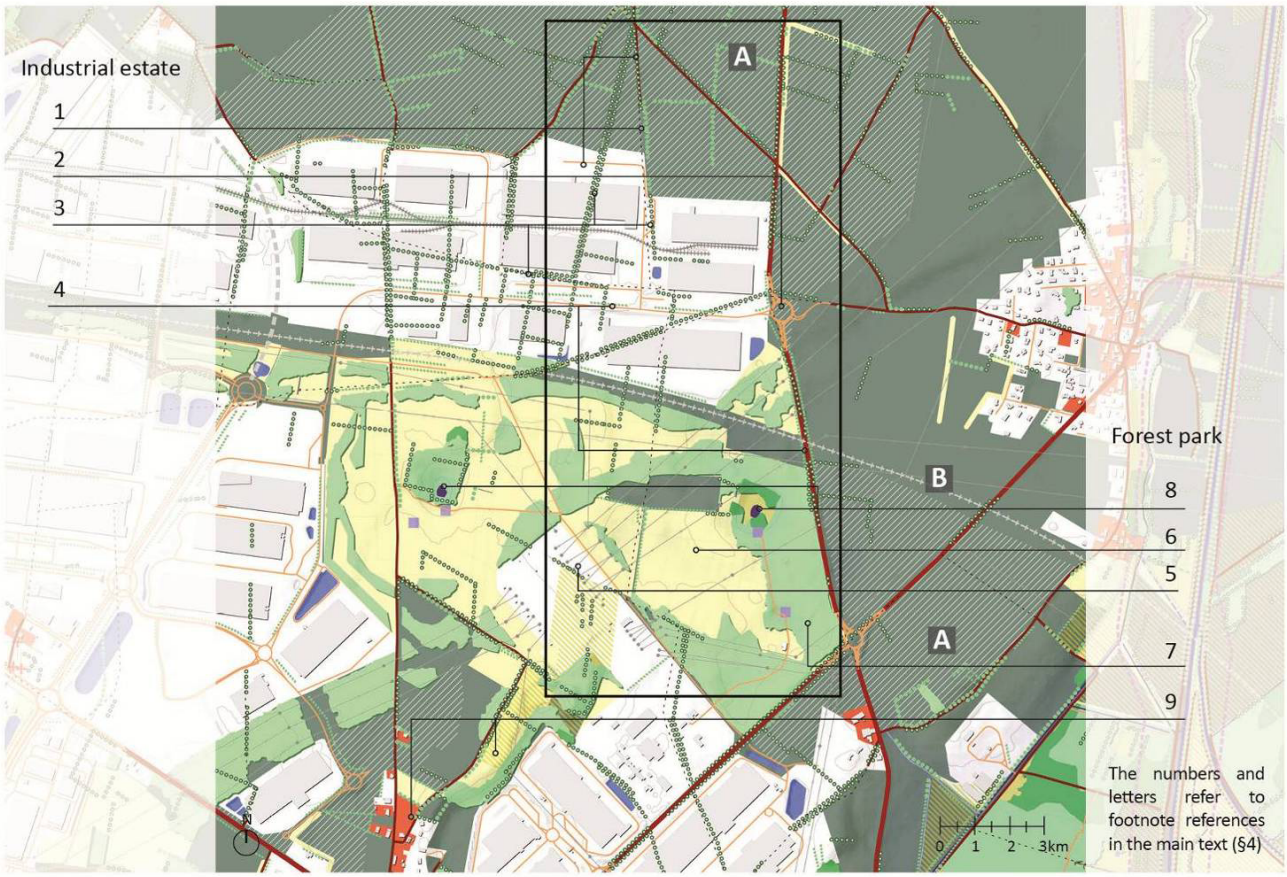
Pane 2: 1975-1990



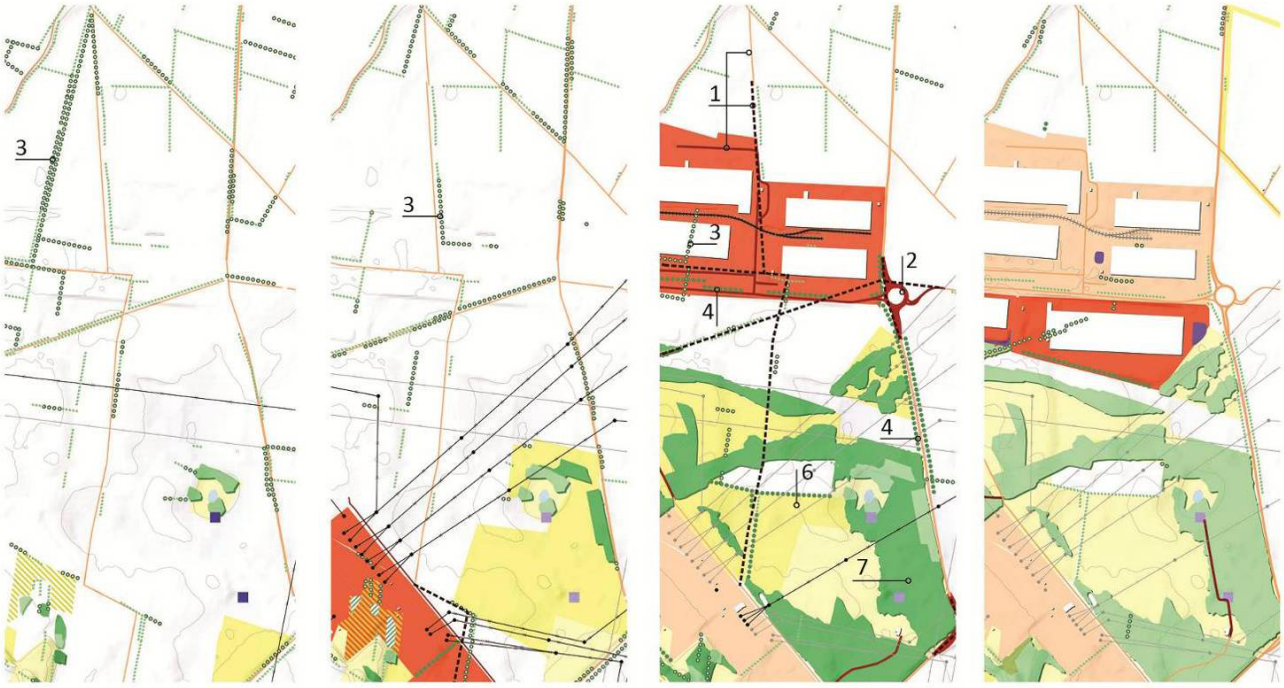
Pane 2: 1990-2005

Pane 2: 2005-2020

Figure 6. Extract 1 from the palimpsest mapping: The wooded hillside Grenay (east of the industrial estate). Source: Author.

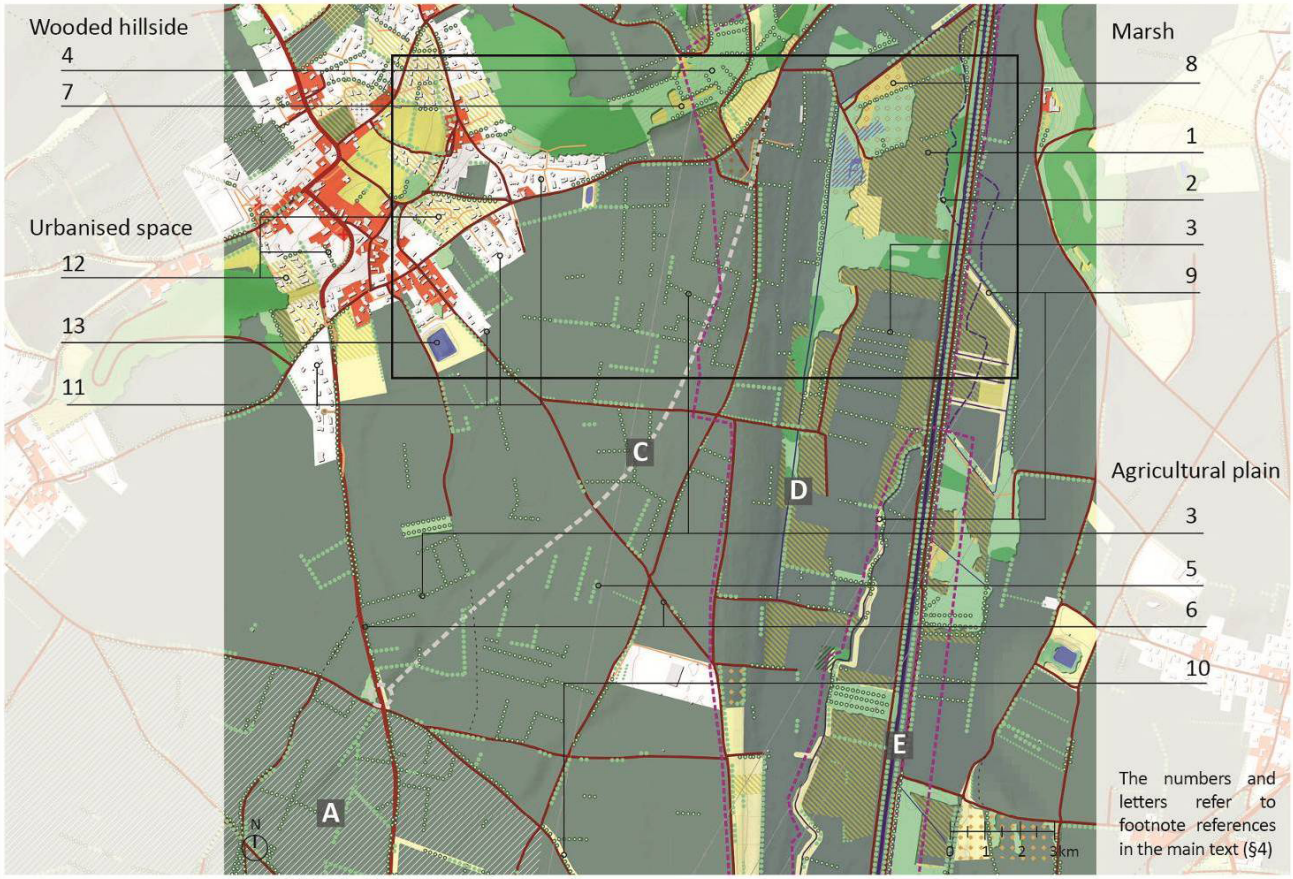


Pane 1: 1960-2020 and ongoing projects

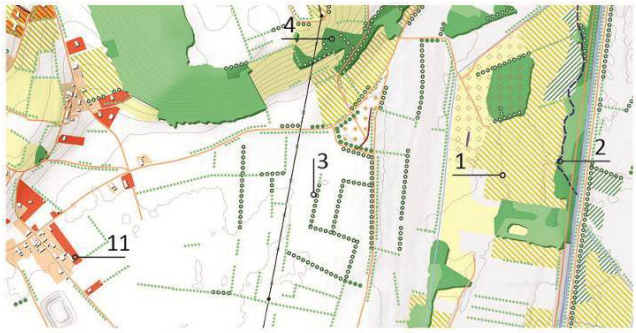


Pane 2: 1960-1975 Pane 2: 1975-1990 Pane 2: 1990-2005 Pane 2: 2005-2020

Figure 7. Extract 2 from the palimpsest mapping: The industrial estate forest park. Source: Author.



Pane 1: 1960-2020 and ongoing projects



Pane 2: 1960-1975

Pane 2: 1975-1990

Pane 2: 1990-2005

Pane 2: 2005-2020

Figure 8. Extract 3 from the palimpsest mapping—The Chesnes agricultural plain (north of the industrial estate). Source: Author.

ways with which to cross the main roads, and with suitable choices regarding plant species and management. It would also lead to a qualitative perception of developments through the transitions made with the agricultural space and the forest park—reinterpreting the former agri-urban borders—and to new practices (agricultural, leisure, etc.). Regarding extract 1, the under-used railway line at the foot of the hillside (Figure 6, no. 7) and the retention basins of the planted road that follows the channelled stream (Figure 6, no. 4, no. 6 and no. 8) constitute a potential that could be explored so as to create ecological and landscape connections with the forest park. Such a link would follow the geography of the site and would provide a motorway crossing for both fauna and human beings. The end of the urbanisation east of the industrial park (Figure 6, area A) might benefit from this type of reflection.

4.3. A Visual Support for the Co-Construction of a Project with Local Actors

The CEN and CAUE highlight another aspect concerning the potential of the palimpsest maps, that of opening up a dialogue with a broad public (elected officials, inhabitants, etc.) on the matter of the territory's history and future. This is an interesting dimension with regard to the co-construction of a multifunctional project, including the appropriation of the notion of ecological networks by local actors. There is feedback to support this idea. The CEN ecologist explains how he frequently uses old aerial photographs from different periods (1940s, 1960s, 1980s, 2000s) with a brief photo-interpretation of the evolution of wooded areas and grasslands. This makes it possible to talk to elected officials about the types of space that they would like to see in the future, and indirectly about the species that might prosper there. These actors prefer this type of approach to a lecture on the conservation of species of animals and plants. Local inhabitants generally prove to be just as receptive to a temporal reading of the space. On this matter the CAUE landscape architect refers to a portrait of the history of a municipality that she helped the inhabitants to draw. There was a simultaneous dialogue with local officials, to reflect upon territorial developments. The mapping tool that was developed thus offered a potential to engage in a multi-actor dialogue. With this objective in mind, the CAUE has set out paths for development. It would be useful to create complementary supports relating to cartographies, such as photographs, to enhance exchanges with local actors. Quantitative figures available from GIS could also be used.

The CAUE also mentioned possible follow-ups to this work. This raises the issue of both collaborations between academic research and operational development, and between the structures that can support this type of cartographic approach associated with mediation between actors. Would it be possible to develop a partnership between the CEN and the CAUE? In our inter-territorial context, which is characteristic of rural-urban metropolitan areas, might our proposal contribute to co-operation mechanisms of an 'Inter-SCOT' type (Dugua, 2015)? Could urban planning agencies developing cartographic observatories (Loubière et al., 2007), including historical ones, pilot such work?

5. Conclusion: Palimpsest Mappings as 'Intermediary Objects'

Our article proposes a methodology for mapping the palimpsest of *milieus* as an 'intermediary object' in order to develop a shared multifunctional project on open spaces. These maps are collective visualisation tools that can be used to reflect upon the geography and the temporal depth of space, in terms of both environment and landscape in response to the challenges of contemporary projects (Delbaere & Pousin, 2011). The palimpsest mapping experiment highlights the benefit of this tool to encourage discussions about the possible futures of the territory, by calling upon territorial heritage. It is a potential common support between professionals when defining the intent of a multifunctional project, and to generate interest and collaboration between actors, using retro-prospective narrative (Sgard, 2008).

Elements of the method used for the Plaine Saint-Exupéry could be adapted to other contexts. In conclusion, one of the processes that we wish to highlight is the 'work of equipment' carried out to link heterogeneous social worlds (Vinck, 2009; Vinck & Jeantet, 1995). It stems from the wish to combine the approach of ecological experts with that of landscape experts so as to define a multifonctional projet on open spaces that can involve different partners. After analysing the two professional practices we had targeted, we put forward the hypothesis of the utility of a cartographic representation of time. We focused on the planned evolutions, since 1960, of certain territorial components likely to be of interest to them. The resulting legends and temporal frame thus 'equip' the maps to make the required dialogue possible. The alignment of the CEN's and CAUE's views then specifies how the mapping tool might be used to co-construct a shared multifunctional project. When the CAUE suggests completing the maps with photographs or quantitative data, in order to facilitate discussions with the different actors (elected officials, local inhabitants, farmers, etc.), we can see the desire for an additional 'equipment' with which to strengthen the dialogical interactions made possible by this 'intermediary object.'

In order to refine the proposed methods and tools, along with their benefits and limits, it would be necessary to first develop the perspectives that emerge in the context of the Plaine Saint-Exupéry. We are currently working on a paper which will discuss some of these aspects (Callens, 2020). Secondly, this type of approach would benefit from being used in other territories. The capacity of this 'intermediary object' to connect different local actors could thus be tested. Moreover, we would be

able to verify its utility with regard to interprofessionality. Such work would also benefit from being extended to deal with the diverse problems that arise, in relation to agronomics, hydrology, ethno-ecology and infrastructure engineering. Where necessary, these situations would allow the mapping of palimpsests to evolve, using layers relating to new themes (pedology, water tables, vegetation in urbanised spaces, parcel boundaries, etc.), from other data production techniques (remote sensing, participatory maps, etc.), with new methods for making maps and possible combinations with other representations (photography, etc.). Developments like these would expand the horizons of palimpsest mapping highlighted in this article.

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Conflict of Interests

The author declares no conflict of interests.

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Article

Large Landholdings in Brabant: Unravelling Urbanization Processes in the City-Territory

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Abstract
Through the observation of land property (*le foncier*) and, specifically, large landholdings, this research aims to take a fresh look at urbanization and urban planning in the Belgian Walloon Brabant Province. In contrast with most Belgian urban studies that tackle the issue of sprawling urbanization through small-scale parcels, fragmentation processes and individual initiatives, this investigation complements recent research on estate urbanization by examining large-scale properties and how they played a role in the city-territory's urbanization during the second half of the 20th century. Large landholdings in Walloon Brabant are remnants of 18th century territorial dominions inherited from nobility and clergy, progressively dismantled, reorganized or maintained as result of the urbanization dynamics integral to the reproduction of modern and contemporary society. The village of Rixensart is the subject of a series of these transformations. By mapping the de Merode family's large landholdings in the south of the commune and analyzing the allotments permit, we retrace urban transformations and the reordering of social and ecological relations through changing land structure. The palimpsest notion is used as a tool to unravel the set of actors involved in urbanization dynamics and to highlight the socio-spatial transformations and construction of recent urbanization. The profound transformations taking place in Walloon Brabant today present an opportunity to reflect on its future, and questions regarding landed estates suggest potential for tackling the city-territory's greater systemic challenges.

Keywords
Brabant; de Merode; dispersion; *foncier*; land; land ownership; landholdings; metropolization; property

Issue
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1. Introduction

Since the 1980s, the specific urban realm coined as the diffuse city (Indovina, 1990) has been the subject of many urban studies. Our research is rooted in the Belgian urbanism research field, in which a series of concepts have been developed such as the Radiant Suburb (Smets, 1986), urbanization without urbanism (Grosjean, 2010), and the horizontal metropolis (Secchi & Viganò, 2012). The last was addressed by many researchers focusing on contemporary urbanization and urbanism in a descriptive manner; they investigated the production of the built environment as being a result of multiple processes of urbanization (Dehaene, 2018), itself the product of fragmentation, individual initiatives (De Meulder, Schreurs, Cock, & Notteboom, 2009; Dehaene, 2013; Grosjean, 2010; Uyttenhove, 2011), and specific infrastructure and networks (De Block, 2011; De Block & Polasky, 2011; Peleman, 2013; Ryckewaert, 2011). Although our topic is part of this epistemological movement, it corresponds to a collective interest that has emerged more recently and that lies at the interface between urban history through the analysis of changes in land structures (Corboz, 1983, 1993) and the analysis of a social geography (Babar, 2015; Zitouni, 2010). More recent research shows a converging interest in other forms related to the urbanization of large estates and noble and aristocratic domains. This work on land transforma-

tions processes linked to the large estate was initiated for Brussels or Antwerp (Babar, 2015; May, 2018; Wambecq, 2019; Zitouni, 2010). The specific contribution of our research concerns the urbanization processes of estate urbanization in the territory of Walloon Brabant.

In continuity with this corpus, we investigate Walloon Brabant territory as historically comprised of large domains and landholdings that belonged to the nobility and aristocracy, the clerical order, and the Church or industrial and bourgeois landlords. Large landholdings or estate operations are examined to determine which constitutive role they played in metropolization processes in the production of the spatial and material conditions of urbanization. Building on cases of these estates' transformation, we aim to explore the production of urbanization in Walloon Brabant for a specific spatial configuration. Among the cases, we encounter a variety of situations: allotment, businesses, industrial areas, and preserved green elements such as forest, golf courses, etc. (see Figure 1 and Table 1). This article highlights one of those situations and explores the type of urbanization produced after some large noble land holdings in Rixensart were dismantled. While leaving the unbuilt domains for further development, we will focus on built estates and their progressive urbanization.

From this overview, we formulate hypotheses and preliminary questions. Does the size of these landholdings generate a different form of urbanization? If urbanization has not been underpinned by an emancipatory political will to grant ownership access to middle-class households but is rather the result of reproduction processes driven by a social group or economic force, can we identify the intermediate actors and their role? If urbanization occurred by dividing an area via one consistent operation, as opposed to a parcel by parcel fragmentation, what were the necessary elements of negotiation between actors of urbanization (landlords, buyers, municipalities, provinces) and did they define the material conditions of such urbanization? Then, within the specific spatial condition of dispersion mentioned above, to

Figure 1. Selection of former noble large land holdings in Walloon Brabant, square of 20 × 20 km. Drawing by the author based on Popp [ca. 1854], Meuwissen (1994), the lotissements dataset (SPW-DG04, 2020) and the orthophotoplan (SPW-DG04, 2018).

Table 1. Selection of former noble large land holdings in Walloon Brabant and their urbanization.

Large estate localization	Urbanization	Continuous or fragmented
Wavre Nord/Bawette domain	Urbanized: economic activities and tertiary area, golf course	Continuous: golf Fragmented: activities
Rixensart/de Merode ownership	Urbanized: residential allotments Not urbanized: Bois de Rixensart	Continuous: wood Fragmented: residential allotments
Louvain-La-Neuve/D'Hoogvorst ownership	Urbanized: new town	Fragmented: mixed functions
Waterloo/Battlefield Waterloo	Not urbanized: Battlefield of Waterloo	Continuous: tenant farming
Villers/Abbey	Urbanized: abbey Not urbanized: agricultural fields	Continuous: agricultural lands
La Hulpe/Domaine Solvay	Urbanized: La Hulpe Park and pharmaceutical industries	Continuous: park Fragmented: industries

what extent do these large landownership urbanizations articulate themselves either to a metropolitan figure or to the one of a city territory?

2. Land Ownership and Its Influence on Urbanization

Land ownership and its parcel division is taken as the vantage point to describe the urbanization of this part of the Brabant. Why ownership? The history of urbanism and urbanization in Belgium is strongly linked to private ownership policies and the development of specific imaginaries around the ideal figure of the owner. Already during the Industrial Revolution, the 1889 owner-worker's law proposed an incentive system for workers to become owners in rural areas (Grosjean, 2010; Mougenot, 1999; Smets, 1977). After World War II, new policies for home ownership were supported by De Taeye Law of 1948, illustrated in Smets (1986), which describes the consumptive context of the Golden Sixties (*les trentes glorieuses*). Meanwhile, land or home ownership and the liberal construction of society based on non-selective private and individual initiatives supported by selective national infrastructure policies are the core of the Belgian narrative of urbanization (Dehaene, 2013).

The study of property is particularly rich owing to the latter's complex and polysemous aspects (Bernard, 2017; Vanuxem, 2018). Property, as a bundle of rights, combines several understandings linked to the plural realm of its definition: as land (relation to soil, its use and value), as a social item (relation to owners, social groups and their regulation by law), as a morphological element (plot, matrix and forms, their permanence and transformation), and as a territorial system (territorial domination of social groups, possession and accumulation). This polysemous meaning led us to read ownership and its transformation in an urban manner. Alongside the history of properties, one can read the history of ownership, unveiling societal relations and the balance of power between social groups. The territory is then investigated as a societal product (Corboz, 1983), a construction resulting from the actions of its inhabitants and their power relations. Large estates were most often owned by dominant groups such as the nobility, *ancien régime* clergy, followed by bourgeoisie and capitalist forces. Their construction or dismantling are the signs of social changes through economic mechanisms and negotiations between various actors in a society. Within the urban development of the metropolis, these signs also highlight conservation, speculation or migration between the so-called center and periphery.

We investigate estate urbanization on a regional scale within the frame of a city-territory (Piccinato, Quilici, & Tafuri, 1962). The village of Rixensart is the context of a large series of these land ownership transformations. As for a dense city such as Brussels, the landholdings' reconfigurations occur through incremental processes (Babar, 2015) and lead to negotiated planning (Zitouni, 2010). The description of the social geography helps to qualify the material condition resulting from this urbanization process. In Rixensart, the de Merode family's landholdings will serve to describe a palimpsest of urbanization through relations between actors and land processes.

3. Building the Unbuilt Patrimonial Estates: The Case of Rixensart

Rixensart, a former village and now a municipality in Walloon Brabant, is located on the southern outskirts of the Brussels metropolitan region, in a continually urbanizing area serviced by the trains of the Brussels Regional Express Network. The Walloon Brabant is often described as a peripheral region of Brussels, home to a wealthy population who wanted to escape the metropolis. Originally constructed upon the rural and light industrial structures belonging to a fiefdom of several noble, aristocratic, and bourgeois landowner families (Hanin, 2004; Meuwissen, 1994), the Walloon Brabant is currently experiencing intensifying processes of metropolization and their direct and collateral effects: rising real estate values, construction of new mobility

infrastructure and congestion of existing ones, pressure on and disappearance of farmland, and spatial inequity (Halleux, 2013; Hanin, 2012).

3.1. Area South of Brussels

The Walloon municipalities to the south of the Brussels Region have long been a typical example (Grosjean, 2010; Hanin, 2012; Puissant, 1997; Seebohm Rowntree, 1910; Vandervelde, 1900). Indeed, processes of urbanization in Rixensart were described when Emile Vandervelde (1900) selected it as a study case of the growing influence of Brussels on the Brabant Region (see Figure 2). While covering thoroughly land ownership in Belgium and Brabant with sharp datasets, Vandervelde showed two parallel trends driven by capitalistic forces: the fragmentation of property and the reinforcement of large landholdings. Indeed, the development of railway infrastructure caused speculation on the land for the growing metropolis of Brussels. Furthermore, southeast Brussels is historically linked to the territories of owners who inhabited villages and properties near the Sonian Forest and its former lumber yards, comprised mainly of nobles and clerical groups (Génicot, 1973; Hasquin, 1976).

3.2. Land Ownership and Governance

In the 18th century, Rixensart was the fief of a branch of de Merode's family (the Felix de Merode branch), a historic family of Belgian nobility. After the *ancien régime* during the 19th and 20th centuries, the municipality remained under the strong influence of the de Merode family, who owned much of the village and governed it via a mainly Catholic dynasty of *Bourgmestre-Régisseurs* (mayor/estate-stewards). Instituting a concordance of private land ownership and public governance in the municipality, they strictly controlled land use and therefore society. Thus, Rixensart's case reveals strong links between nobility, industrialization, municipalism, and land ownership structure modifications.

As a consequence of inheritance, de Merode lands were divided among several family members. After Félix de Merode's death in 1943, each of nine heirs inherited part of the whole. It was the first time the family's land was clearly divided and, while some holdings had already been sold in the early 20th century, they now began selling more of it, especially in the 1960s. All in all, de Merode property, a combined 537 hectares that represented two-thirds of the municipality in 1834, were reduced to 128 hectares by the 2000s (Meuwissen, 2016). In Section 5, we will investigate relations between sellers and buyers and the property's rearrangement.

3.3. Production of Urbanization

De Merode's land division occurs after the De Taeye Law of 1948, one of the most important post-war rebuilding and housing policies. At individual and private level, it provided incentives and subsidies to encourage private construction among the low-income population. Mortgage loans were made mostly through loan companies such as Caisse Générale d'Épargne et de Retraite and the Société Nationale des Habitations à Bon Marché. The law is regarded as a Catholic government effort to

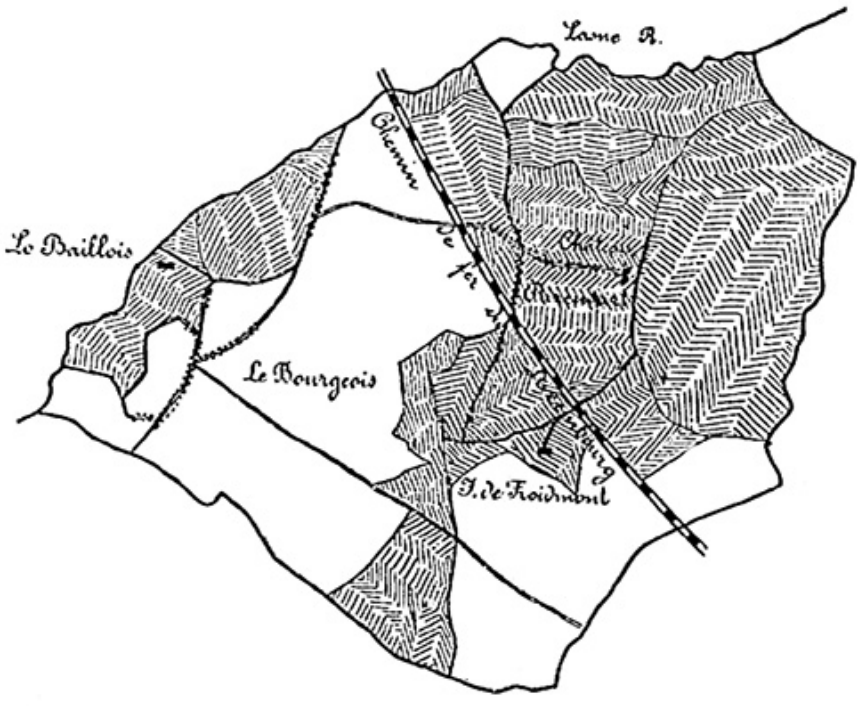

Figure 2. De Merode's properties in Rixensart municipality (gray areas). Source: Vandervelde (1900).

keep village populations close to churches (Smets, 1985; Theunis, 2007).

The period coincides with the socio-economic context of the Golden Sixties and the implementation of the modern planning policy in the law of 29 May 1962, which is the founding basis of institutionalized urban planning as we mostly still know it, dedicating areas to specific land use under a strong functionalist assumption (Grulois, 2011). This resulted in a crucial moment in Rixensart's urbanization: the building of most of its current urban structure and material condition. Indeed, a large amount of the buildable parcels were then subdivided through allotment permit, a procedure defined in the 1962 law, creating large residential areas available for upper and middle-class populations. Various allotments south of the municipality are paradigmatic of this process, congruent with de Merode landholdings close to the train station and not far from the highway, in close relation with the growing Brussel metropolis. Whether Rixensart is a combination and specific result of both conjectural laws remains to be verified, since De Taeye's operational scale acts at an individual level. We rather insist here on larger allotment operations and more liberal so-called uncontrolled estate operations. Nevertheless, we will see that municipal and regional administrations proceeded quite consciously to produce urbanization.

3.4. Urbanistic Regulations

One hypothesis is that urbanistic policies were very permissive during the first years of their implementation (Laconte, 2012). Furthermore, some of the sales and trading operations occurred before urban planning and planning tools emerged and became institutionalized in Belgium—land use plans that were announced in the 1962 law were only operational in the 1980s. In the meantime, allotment and building permits (see Figure 3) fulfilled almost by default the role of more systemic plans or urban policies that were not yet elaborated. Most decisions were municipal, supervised by provincial or regional authorities, since permit authorizations were delivered, except in specific cases, under the municipality's responsibility after considering the advice of a regional delegated agent known as *le fonctionnaire délégué* (prefiguring the balance of power between municipality and region in Belgian urban planning). Administrative permit documents help us to deepen the analysis and set up a grid, although allotment plans control some limited parameters: plot dimensions, setback distances, alignments, façade cladding and roof coverings, trees, and plantations, and in some cases density. Regarding the quantitative output the permits dealt with, we find few limitations or constraints driven by more collective, ecological or political rationalities.

4. Mapping the Estates: A Descriptive Analysis

Among the domains that were sold, we limited our examination to seven allotments on former noble landholdings in Rixensart, chosen for their large size and period of development: Léopold and Blanc Champ Avenues, Clos de la Mare au Loup, Albertine and Churchill Avenues, the Froidmont Farm neighborhood (Winterberg Avenue), Hauts-Taillis Avenue, and Fond Marie Monseu (Figure 4). Popp's [ca. 1854] map and cadastral matrix, the first covering systematically the Belgian territory (in 1861 for Rixensart; see Vrielinck, 2018), were used to identify de Merode properties. Today, allotment permits are collected in a GIS layer by the Service Public de Wallonie. Original plans, allotment permits, and legal prescriptions are accessible for each perimeter. More than a century separates the two maps, but the unaltered structure of ownership until the first half of the 20th century (Meuwissen, 2016) allows us to proceed with this

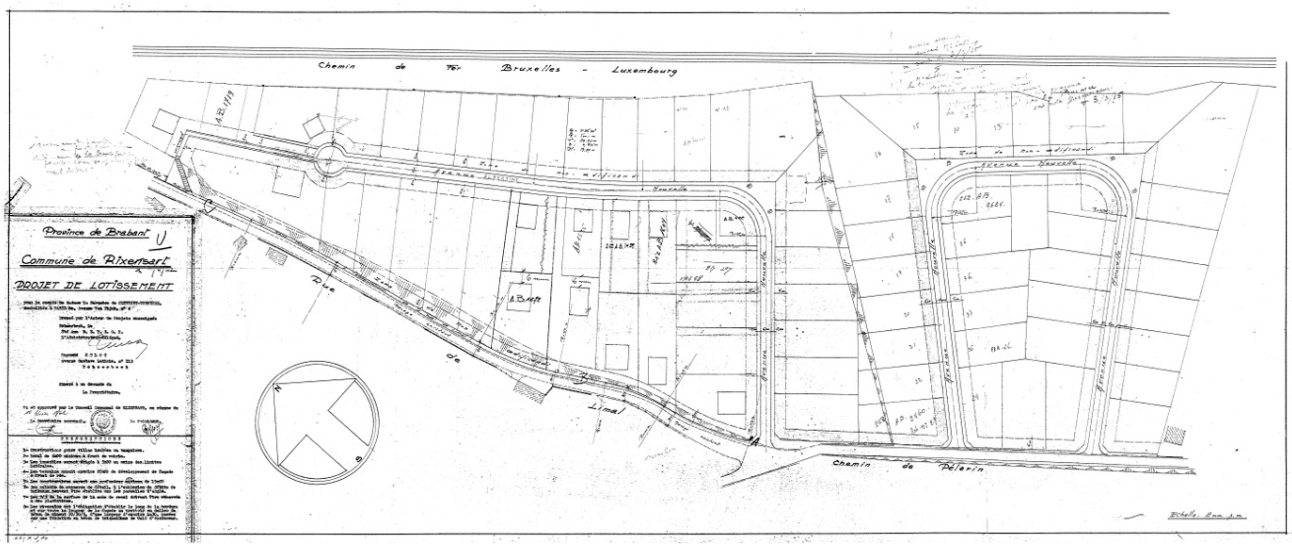

Figure 3. Example of a Rixensart allotment plan, Albertine, 1962. Source: Service Public de Wallonie, Lotissements (SPW-DG04, 2020).

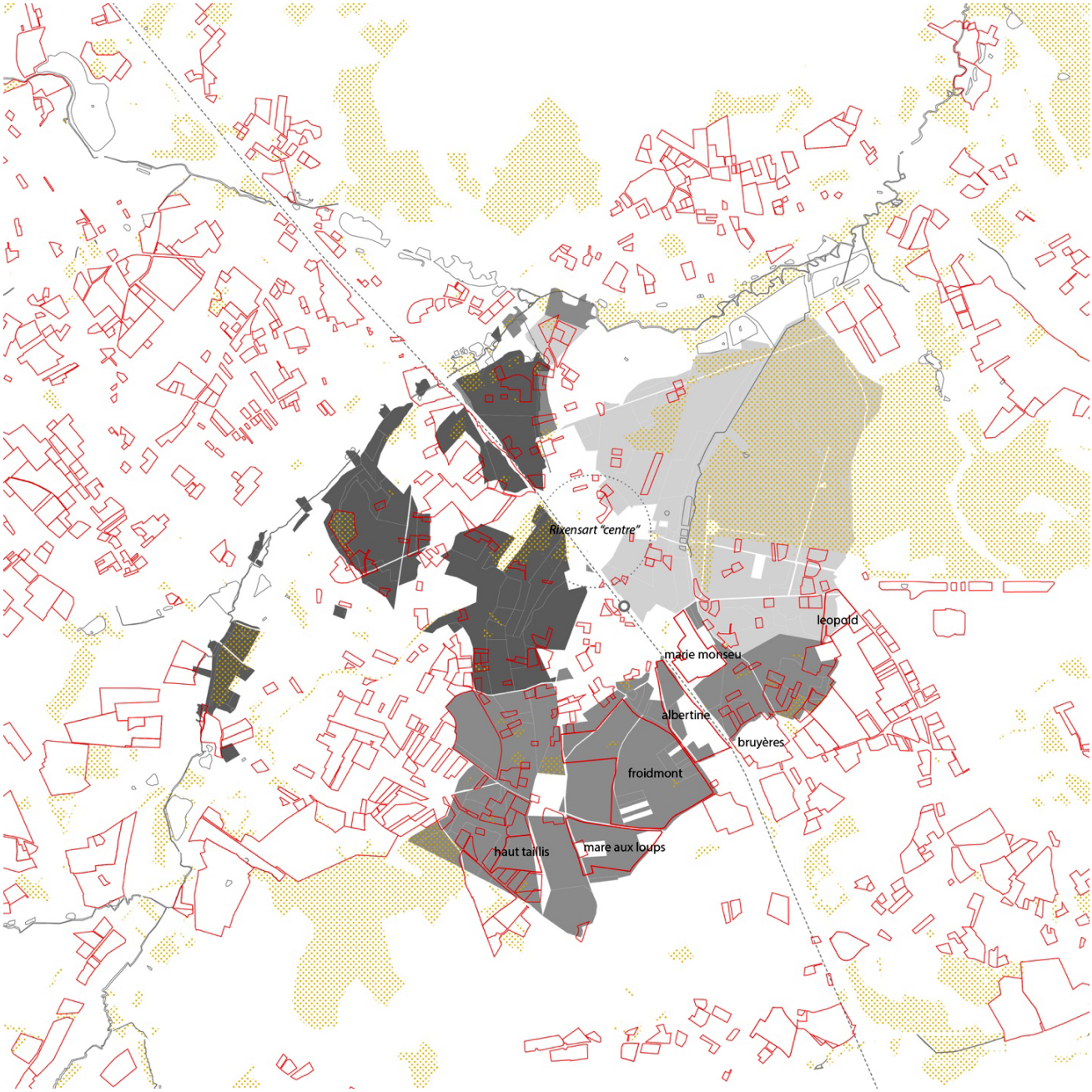

Figure 4. Cadastral map of Rixensart in 1854 with overlapping of allotments permit in 2019, de Merode properties. Dark gray areas represent the property of de Montalembert; gray areas, the property of Albertine de Merode; light grays, the property of Frédéric de Merode; red perimeters represent subdivision permits; yellow dots, the forest areas. Drawing by the author based on Popp [ca. 1854] and the lotissements dataset (SPW-DG04, 2020).

comparison. Table 2 lists the characteristics of the seven allotments. Allotment reference, date of authorization, owner, estate company (if any), parcel size, location, and main prescriptions are indicated. Altogether, they represent 67.2 hectares. This superimposition of land structure and the evolution of the cadaster following the subdivision permit allow a first level of reading of the palimpsest (Corboz, 1993).

Almost exclusively residential, the allotments are comprised of villas and detached houses; most are single-story and with occupied attic. Furthermore, if we look at the typo-morphological map of this area (Figure 5), more neighborhoods seem to be made up of separate villas, even though they are not included within allotment perimeters. An allotment permit is only needed when the owner wants to divide the land to subsequently sell it or build on it. Simple building permits are then not included in the allotments' dataset. Nevertheless, they could still be the result of a sale of de Merode's land, parcel per parcel, resulting from earlier subdivision.

Building these large landed properties in the 1960s greatly impacted the construction of an urban realm in

Table 2. Selection of allotments in Rixensart.

Name	Location	Owner(s)	Date	#	Ha.	Estate cie.	Geom./Arch.	Delivering Authority	Prescriptions
Léopold	Avenue Léopold Avenue du Blanc Champ	SA Matexi, Van Coppenolle	27–3–59	30	3.2	Matexi	Ernest Crickx	Delegated official (J. Wurth)	Villas, bungalows, cottages. Petrol pump or shop allowed on an angle 15 m or 20 m wide plots (depending on situation) Setback = 6 m, 3 m lateral Limitation of felling trees
Fond Marie Monseu	Avenue Marie-Christine, rue Froidmont	SA Matexi	16–7–62	55	5.3	Matexi	Ernest Crickx	Delegated official (L. Vanneste)	Villas, cottages, bungalows. H_cornice = 6 m, pitched roof Setback = 6 m of which 2/3 are planted and 5 m lateral 20 m wide plot Road 6 m + 2 × 2 m sidewalk Building materials limited
Albertine	Avenue Albertine, Avenue Winston Churchill Rue de Limal	Marquise de Clermont-Tonnerre	16–04–62	77	9	Beteor SA	Achille Dupuis Georges de Halloy André Gallée	Delegated official (J. Wurth)	Detached villas or bungalows. H_cornice = 5 m Setback = 6 m minimum of which 2/3 planted minimum plot 20 × 15 m Shop allowed on the angles 1.3 m mandatory sidewalk in 30 × 30 cm tiles

Table 2. (Cont.) Selection of allotments in Rixensart.

Name	Location	Owner(s)	Date	#	Ha.	Estate cie.	Geom./Arch.	Delivering Authority	Prescriptions
Froidmont	Avenue de Winterberg (Ferme de Froidmont)	Chevalier J. Demeure, et indivision Baron Dubost Christian Delacroix Christian Demeure Edouard Demeure	24–5–68	273	30	/	Achille Dupuis Georges de Halloy André Gallée	Permit refused by the municipality to preserve agricultural land, based on the opinion of the delegated official 252/FL/27. Legal recourse and permit issuance by the permanent deputation of the province which defines the area without agricultural quality (supported by agronomist report) and of little economic importance. It is nevertheless asked to preserve the rural character	Villa or bungalow, single family house, max 200 m^2 1 lot (266) reserved for a shop. Setback = 6 m of which 2/3 are planted H_Cornice = 5.5 m (manuscript crossed out and replaced by 3.5 m) mandatory sidewalk 30 × 30 cm tile Utilities networks at the expense of the purchasers, + maintenance of the roads during the works
Plateau des Bruyères	Avenue des Aubébines, Paola, Fond Marie Monseu	D. de Lannoy, M. de Lannoy, P. Gillet (c/o Cte Delannoy)	19–6–64	74	6.4	/	Henri Souka	permit delivered by the municipality + opinion of delegated official (L. Vanneste)	Single family house with De Taeye Law requirement (min 60 m^2) Setback = 6m of which 1/2 are planted and 5m lateral Limitation of felling of trees

Table 2. (Cont.) Selection of allotments in Rixensart.

Name	Location	Owner(s)	Date	#	Ha.	Estate cie.	Geom./Arch.	Delivering Authority	Prescriptions
Mare au Loup	Clos de la Mare au Loup, Avenue Boulogne, Rue du Monastère	Demeure André Foncière de développement SA.	16–5–89	38	9.7	Foncière de développement SA.	Georges de Halloy Leleux, C.	permit delivered by the municipality, asking to change some road configurations	Single family house Pitched roof Setback = 6 m, 3 m lateral Building materials limited Area covered by a *schema directeur* PPA, indicating density and contiguity requirements and road/path network
Haut taillis	Avenue de Villefranche, Avenue des Hauts Taillis	Dumont de Chassart	7–7–69	19	3.6	B.C.I. sprl	BCI (?)	permit delivered by the municipality + opinion of delegated official (R. Beckers)	Single family house (max 250 m^2) Setback = 6 m of which 1/2 are planted and 5 m lateral Limitation of felling of trees Building materials limited

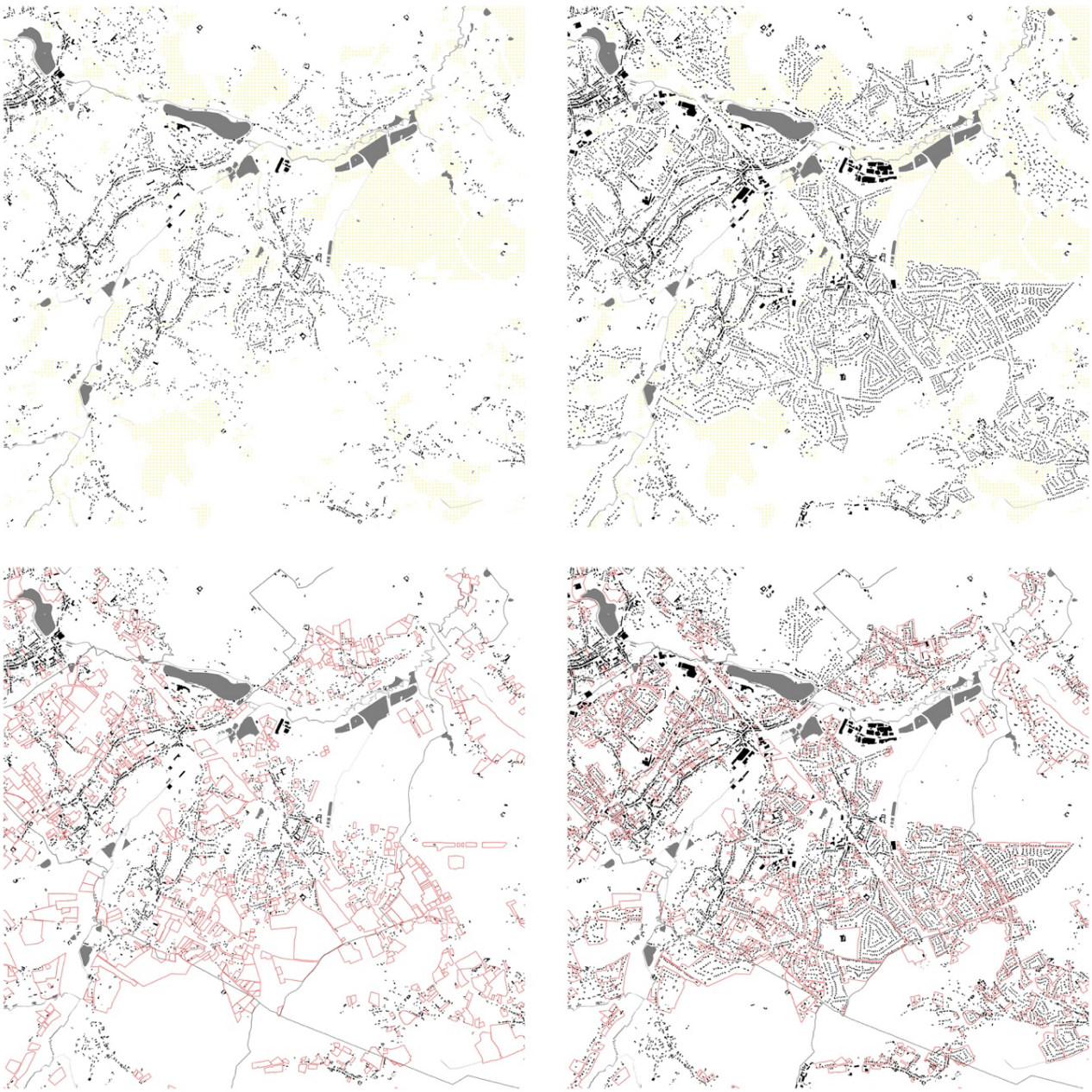

Figure 5. Map of Rixensart 1960 (left) and 2010 (right). Built elements (black), forest (yellow dots), water (grey), and allotments perimeter (red), municipal perimeter (dotted line). Elaborated by the author based on SPW-DG04 (2020).

Rixensart. The resulting urbanized patterns are mostly residential, erasing almost any other type of use or function (permits authorized some shops that were never built), offering quite a different environment than the one usually described for the nebulous Belgian city, resembling rather a typical periurban urbanization (Figure 6).

Nevertheless, under the apparent holistic process of transformation of land inherent to the allotment process, some territorial structures persist as traces in the patterns of the new development, remaining untouched as remnants (of a farm or monastery), fragments or a geometrical feature in the landscape (path, rural pattern, tree alignment). If division was part of the allotment act, the selling of and building on each parcel may have been a longer process, as shown by the variety of house styles, some of which are very recent.

In contrast, we should consider the preservation of some parcels that were neither sold nor built on and may have been a form, intentionally or not, of ecological protective measures. Mostly grouped around the de Merode Castle, some of the unbuilt plots are recognized as valuable natural areas such as Bois de Rixensart or Bois de Merode. Behind the land use and land ownership structure, several patrimonial, inheritance or economic decisions led to the current spatial configuration and the preserved areas today continue to be pressured.


Figure 6. Urbanization in the Winterberg Avenue in Rixensart. Photographs by the author.

5. Building the Material Condition of The City-Territory Urban Landscape

5.1. A Palimpsest of Actors

To observe the urbanization produced on these large landholdings, we use the concept of the palimpsest mentioned above. In between the lines of the parcels, spaces of negotiation are recognizable and should be analyzed as part of rethinking our territorialities (Corboz, 1983, 1993). The concept of a palimpsest would not be of particular interest if it did not highlight the transformation of urban society through changing land structures (Vanneste, 2018). Through the multiple reading levels of the property concept (owner/ownership/property) and the land structure, we emphasize the relationships between land situation, uses, and value, which allow us to look at the production of space as intertwined with the agency of social and professional groups. Underneath this space of negotiation, we describe the urbanization produced in the specific socio-economic and urban context of Walloon Brabant.

Emphasizing the overlapping of actors involved is an additional approach to the idea of a palimpsest, enabling a territorialized vision of an urban society. In these processes of transfer of property, we scrutinize the actors' constellation behind elements of negotiation to envision the material conditions that supported the production of the urban landscape. Actors involved are witnesses of territorial changes in the ownership structure abruptly shifting from one long established situation with large dimensions' family estates with patrimonial value to one at the scale of middle-class owners marking the emergence of large-scale land commodification. In the middle is the real estate company, trading on the economic value of this ownership transfer. In this sense, this urbanization represents a discretized capital accumulation typical of post-war growth and the possibility for the housing market to absorb this surplus. This last palimpsest layer largely overwrites the former ones but is also largely conditioned by them.

In the case of Rixensart, this sequence of modification implying multiple actors occurred in the 1960s and 1970s and created the material and spatial conditions of urbanization. In the following step, we highlight the link between these actors and the material conditions of urbanization. Doing so, we relate the characteristics of the urbanization to the actors who took part in its construction voluntarily or not. Investigating these groups through a socio-spatial palimpsest clarifies what part of the urbanization belongs to the specific and successive transformation of large landholdings.

Let us browse these different groups. Letters and legal prescriptions attached to the subdivision permit listed previously make it possible to draw a portrait of the negotiation or opposition within the transfer of property and to what extent the delivering authority allows, refrains from or negotiates elements of the urbanization project. Which actors favored maintaining agricultural land? Which private or public actors pushed for more development and why? Who defined the dimension of the plot, streets, the proportion of built and open space? Ultimately, by whom and how were the material conditions of urbanization defined?

5.2. Noble Estates

Nobility owned land that remained mostly unbuilt. Estates were wooded and agricultural land. The successive division through inheritance processes reduced the size of de Merode land holdings but resulting plot size remained of large dimension. When sales started in the second half of the 20th century, the land structure inherited from the 19th century and their owners conditioned the dimension of the operation, enabling estate companies to buy, divide and sell quickly and consistently important pieces of land.

Recalling de Merode's strong influence on local governance and land ownership (through the estate steward and mayor), this fragmentation of nobility ownership could denote a loss or shift of influence domain. Nevertheless, some parcels still belonged to the fam-

ily during the 1960s and most owner names still reflected those of noble family members, who were probably the heirs and inheritors belonging to different de Merode branches. In 2019 a more distant branch of the original de Merode family reinvested in the Rixensart Castle and its domain for patrimonial and touristic reasons by buying the castle of Rixensart (de Vogelaere, 2019). Therefore, large areas remain unbuilt, such as the Rixensart woods.

5.3. Sales Operations, Administration, and Urban Grammar

Sales operations involved a set of professional and private actors. Geometers, architects, resellers, and estate companies were to draw and conceive allotment plans for the municipal and provincial administration to analyze and authorize. Real estate companies were often present as operating actors in the process of dividing, selling, and building on the land. In two cases, the company itself was already the owner of the parcel in the permit document, implying that the parcel was sold in an earlier transaction, maybe not directly by the de Merode family.

What were the benefits of or the need for creating such companies? Couldn't the noble's family have sold themselves the land? Estate companies probably eased the management of repetitive and massive operations and outsourced a technical service. Incidentally, members of the nobility were still involved in the real estate companies, as reflected in allotment permit forms. Furthermore, they could help in inheritance procedures or just personify an economical tool to multiply subdivision operation, given we found companies involved on different allotment sites.

It was, however, not an innocuous operation. Resellers' financial interest and modern land use policy defined not only the plot's dimensions and repeatability and setback distances, but also the grammar of roads and house size and volume. Within the urbanization processes of these domains, decision-makers were indeed crucial actors in the precise definition of an urban grammar. Municipality, Walloon Region, and Walloon Brabant Province authorities and representatives had great decision-making responsibilities concerning parcel urbanization, or at least the type of product and urban fabric. When allotments were distributed, one of the representatives was Léopold Gilson, mayor from 1952 to 1970 and the last estate steward of the de Merode family, meaning the person in charge of managing the family's assets and estates.

5.4. Territorial Base and Natural Features

Unbuilt properties were mostly wooded or agricultural areas. One can see in analyzing the permit document that the neighborhood's character was discussed in an attempt to maintain a rural look and existing vegetation. Among the allotment dossiers, the agricultural value of the Winterberg Avenue allotments around the Froidmont Farm was a defense against the act of building (Figure 7). In 1962, the permit was refused by the municipality on the advice of the regional functionary, on the ground of defending valuable agricultural land and the landscape's rural character. To oppose the decision, the owner went to a higher court, at the provincial level. The province delivered the permit against the municipal decision, lessening the value of the agricultural land based on an agronomist's report, but, ironically, still asked the owner to maintain a rural character in the project's development. The case anticipates the problem of agricultural land consumption by urbanization, which today is a fundamental element of the European debate over 'no net land take,' aiming to reduce oversized residential areas of zoning plans.

Figure 7. Neighborhoods of the Froidmont Farm in Rixensart. First houses under construction on Avenir Avenue, picture of H. Pilmeyer around 1954. Source: de Séjournet (2020a).

Another key element in the prescriptions accompanying the building permit is the conservation of trees or limiting of tree felling. Indeed, in all the other cases, some previous natural or landscaped features, such as trees and onsite vegetation, are the subject of preservation requests as well, in whole or in part. Most of the sold land was wooded, part of former de Merode domains and remnants of the Sonian Forest. All legal prescriptions included preservation of wooded areas. If the documents provide no reason for it, one can assume the reasons are the trees' ecological value but also their symbolic value as being linked to the area's noble roots, conferring on certain parts of the neighborhood aspects of inhabited forest (Figure 8).

The defense of agrarian and natural characteristics, even in a sterile or picturesque manner, emphasizes a certain idea of living in an open landscape and foreshadows more ecological topics. The opposition between the institutional actors such as the province, the commune, and the regional functionary should be explored to understand each party's interests and if specific themes were defended or opposed regularly.

5.5. Middle Class and Suburban Imaginaries

Middle class families inhabited these new allotments, buying or building mainly single-family houses from the developer, being the end of line in the selling process we are describing. This generation embodied a way of life based on individual social and economic achievement embodied in the image of suburban villas. Through their purchase, they anchored Golden Sixties capital values in periurban landscapes. Some nuance is required to understand the operation's time span. While the transfer of properties and allotments of land ownership took place over a few decades, house construction reveals that the progressive development of the plots spans from the division of the land until today; some houses were still under construction in the 2000s. This prolonged period of construction gives the urbanization a heteroclite appearance: each house represents the aesthetics or building standards of its time.

Another recurrent regulatory requirement of the subdivision permits is plot dimensions, including setback distances. Surprisingly, setback distance is very consistent, six meters from the street, five to three meters from neighbors. Inner roads of the allotment are the developer's responsibility, then retroceded to the municipality. Quite often, the plot's buyer and future owner are responsible for the sidewalk, therefore taking part in responsibility for road infrastructure. Some basic compensation mechanisms force the developer to dedicate a small part of the area to green spaces or playgrounds. While setback distance allowed in latter phases for house additions or a backyard for each inhabitant, it is also a space of ambiguity, without real contiguity between neighbors kept at a distance and behind a green curtain of plants. The ambivalent permit requirement of urbanistic responsibility for the sidewalk constitutes equally a collective effort in the construction of the infrastructure as well as an absence of collectiveness, each inhabitant taking care of his or her own front space.

Ultimately, this in-between space creates an open and low-density fabric associated with garden cities,

Figure 8. Wooded land built on through an allotment process. Avenue Joséphine-Charlotte, picture from the J.-L. Lebrun collection. Source: de Séjournet, E. (2020b).

which were preeminent in a primary phase of modern development in Belgium; even though it ceased after a few experiments, the movement left an important imprint on housing imaginaries in Belgium (Smets, 1977, 1986). All in all, the urban fabric is characterized by a 'setback urbanization,' either physically by distancing the building, or conceptually by placing elements of infrastructure such as sidewalks or green areas under the responsibility of the individual rather than the collectivity.

6. Conclusion

Mapping the transformation of large domains and landed properties in Rixensart reveals dynamics of urbanization produced in a coherent socio-economic period of growth, on a territorial scale, in strong relation with the metropolization of Brussels. Timewise, the study case unfolded during a specific moment of post-war urbanization. Through the case of Rixensart we arrived at several findings addressing four main issues: metropolization on preexisting conditions, forms of urbanization (large dimensions with little collective arrangements), the relationships between actors (entrepreneurship and administration machine), and the regional condition of land ownership.

First, we argued that de Merode land subdivision processes—and, by generalization, large domains inherited from former feudal noble structures—had generated another type of urbanization when entering the buildable land market: not incremental, fragmented and mixed as predominantly observed in the industrial phases of urbanization that usually defines Belgium's dispersed urbanization, but rather large, functionalist, and homogeneous, which is typical of periurban metropolitan dynamics. The production of urbanization occurs on a larger scale than it did previously, although it still relies on dispersed features of the rural and pre-industrial territorial structure. In our case, the spatial configuration of the land ownership structure, embodied in the municipality's noble estates—relics of a fiefdom—and family relationships with municipal decision-makers allowed urbanization to occur.

Second, the large amount of available land made possible the settlement of a middle-class generation and the construction of its suburban imaginary. It resulted in the production of a quite consistent urban fabric, drawn up by 'setback urbanization' where individual freedom is embodied by each individual's plot but where, paradoxical to the plot's unifying morphology, no collective spatial dimension is fundamentally incorporated. It is striking to note the few but nevertheless existing nods to landscape or ecology in the urbanization process. Except from the case mentioned above, where the emergence of a conflict between buildable land value and natural or geographical land value, opposing economic and ecological value, is evident, the valorization of landscape or natural features only occurs at the level of the parcel, in each discretize and individual form. In another way, the absence of preservation or strong defense of natural or ecological land is also a lack of a collective dimension.

The case of Rixensart reflects strong links between nobility, industry, municipalism, and land ownership structures. The original approach to reading these relationships through a geography of actors offers a new perspective on recent forms of Walloon Brabant urbanization in a Belgian city-territory context. Indeed, the case reveals a period of strong municipal governance during which planning tools were very recent, permissive, and only in some cases opposed by higher authorities. We find the involvement of private entrepreneurship, as described in dispersed city conditions, but here on the broader scale of the allotments, with the involvement of developers and estate companies. Thus, not only the planning tools and administrative machine but also the private sales of powerful territorial actors form a web of relationships. In this sense, large domains are the receptacles of post-war socio-economic dynamics and national growth, which find an easy outlet in quickly accumulated land capital and lead to an urban morphological pattern of greater urbanization.

Furthermore, under the socio-spatial palimpsest of the Rixensart case, we uncovered a territorial condition of Walloon Brabant urbanization that proved to be related to large land ownership. This landed structure and availability of buildable land is strongly linked to the former power structure of *ancien régime* noble families—and later of the industrial bourgeoisie. Several Walloon Brabant municipalities present a configuration similar to Rixensart's, where the permanence of land ownership and a genealogy of political management of the municipality coincide (Goblet d'Alviella and Boël in Court-Saint-Etienne, Vanderlinden d'Hoogvoorst in Ottignies, Solvay in la Hulpe, Cornet in Braine, etc.). As shown in the introduction, not all of these lands resulted in periurban urbanization, but most were transformed during the 20th century whether they became golf courses, business parks, or residential areas.

Revealing the actors and their interrelation with the urbanization of former estates brings a descriptive knowledge about the production of this specific space. Noble families, by owning large landholdings and selling them in large tracts, intervene in the size of the estate operation; discussion between estate companies and administrations about land use, landscape, and plot size defines the layout of the space; the middle-class population inhabiting these urbanizations generate architectural styles and picturesque gardens. After the fine descriptive period of the 80s that described the horizontal and nebulous city, palimpsestic description today should testify to the complexity of city territory and spur thought regarding the future processes between metropolization and dispersion.

Conflict of Interests

The author declares no conflict of interests.

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Article

Territories of Extraction: Mapping Palimpsests of Appropriation

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Abstract
This article—framed as a methodological contribution and at the intersection between the critical urban, urban political ecology and world-ecology disciplines—builds on Corboz's metaphor of 'territory as a palimpsest' to explore the representation of the socio-economic and ecological processes underpinning uneven development under extractive capitalist urbanization. While the palimpsest approach has typically been used to map transformations of more traditional urban morphologies, this work focuses instead on remote extraction territories appropriated by the global economy and integral to planetary urbanization. The article suggests the central notion of 'palimpsests of appropriation' as a lens to map the extraction processes. It does so in its multi-scalar and temporal dimensions and on the basis of the three intertwined frames—i.e., the productive, distribution and mediation palimpsest—shortly exemplifying its use on the ground for the iron ore extraction territory in the Swedish-Norwegian Arctic. With this, the article contributes to the development of an expanded representational methodology and conception of territories of extraction—where social and natural production are brought together—illustrating how appropriation has been (re)shaping each of the frames throughout historical thresholds, but also how socio-natures are being (re)made in its image.

Keywords
appropriation; extraction; palimpsest; planetary urbanization; territory

Issue
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1. Introduction

The journalist and writer Po Tidholm opened his recent book *Norrland* with a poem from Albert Viksten written at the beginning of the 20th century, already reflecting on how the lands of northernmost Sweden had historically been robbed and its value been lost—i.e., as its riches have continuously been expropriated (forestry, hydropower, mining, railways and so forth) for the wealth and benefits of mainly state powers and capitalists (Tidholm, 2014). Tidholm's book, among other works, critically revises historical processes of uneven development within northern Sweden and Scandinavia (Figure 1). A process-like view very much akin to the lenses Henri Lefevre began developing from the very crucial moment when, in one of the many times in which he returned to his hometown in the Pyrenees, sulphur deposits had been discovered nearby—immediately leading to extraction, the building of a new town and the transformation of the landscape. Seeing such a process of how a predominantly rural landscape was being rapidly transformed into a predominant industrial urban landscape would then drive Lefebvre to start working on the transition of the rural to the urban—or what he called the process of urbanization (Elden, 2015), a work that would later lead him to the formulation of the radical hypothesis of the complete urbanization of society (Lefebvre, 1970).

Figure 1. Scandinavia. Malm territory iron ore appropriated by global economy, railway, shipping flows, concentrated urbanization, mining production sites, processing and commercial services. Source: Elaborated by Berta Morata based on Geonorge, LKAB, Natural Earth, NOAA, SLU, SSAB.

This line of research has more recently been developed by the scholars of planetary urbanization (Brenner, 2019; Brenner & Schmid, 2015), ever pushing forward—epistemologically and conceptually, but also methodologically and representationally—to critically explore the historical processes of urbanization from the most remote zones. These remote zones form territories of so-called 'extended urbanization,' that is, territories mostly of primary commodity production, circulation and waste disposal, commonly thought to lie outside the urban condition and critical to the material basis of planetary urbanization. One of these remote territories strongly linked to the extraction of iron ore is the 'Malm territory,' which has been forming since the mid-1500s across the sparsely populated and relatively isolated Swedish-Norwegian Arctic and sub-Arctic region (located around the 66.5° latitude), radically transformed over time into industrial-urban landscapes. Today, approximately 90% of Europe's iron ore is extracted from the mines in northern Sweden, where only the 0,0002% of its population live (LKAB, 2013). However, overall extraction in the region is not confined to mining alone, but historically deeply intertwined to forestry or energy: 97% of the forest under the alpine line—where no more trees can grow—is industrial in Norrbotten (Länsstyrelsen Norrbotten, 2018); also, 30% of Sweden's hydroelectric power is generated in Lule river alone, equal to 13% of Sweden's electricity (IVA Electricity Crossroads project, 2017).

Following this line of thinking and in the current conjuncture of climate change and environmental attention, territories of extraction such as the Malm territory need to be understood not only as occurring in the mines and remote regions far away from the main agglomerations; but as appropriation processes by the urbanization of society—and perhaps also (and in dialectic relation to) the urbanization of nature. Appropriation processes that are actually continuing across scales while simultaneously reproducing uneven spatial development patterns—and socio-nature inequalities. In this regard, there is an urgency to rethink territories of extraction and accordingly, this article proposes to tackle cartographic exploration via the proposing notion of 'palimpsest of appropriation.'

The article engages first with critical urban theory and expands it with literature from urban political ecology (UPE) and world-ecology, discussing around a specific set of analytical concepts and arguments. This positioning and building-up on key analytical dimensions then lead to a specific definition of 'appropriation.' Next

in section three, the article explores the most relevant literature to the planetary urbanization framework on the representation of territories of extraction and discusses them conceptually and methodologically, to then revisit the palimpsest mapping methodology and the actual inherent possibilities that could be challenged from territories of extraction. In the fourth section, the notion of 'palimpsests of appropriation' is advanced and defined, and its methodology process deployed step by step, then using the Malm territory to shortly test the palimpsest of appropriation on the ground and discuss it analytically.

2. Challenges From Territories of Extraction

The planetary urbanization theoretical framework offers an important alternative lens to urbanization as a process-oriented approach—implicit in the Lefebvrian worldview—and one deeply embedded within the broader dynamics of capitalist development. Such processual understanding is central in this work and arguably helps to characterize the historical formation of territories of extraction in the age of capital, or 'Captialocene' (Brenner & Katsikis, 2020; Moore, 2017, 2018). Yet it will be argued that, if moving beyond urbanization as mere geographical distribution, planetary urbanization could mobilise its framework to further challenge production. This would entail additionally complementing with UPE's and world-ecology, to then relate to the mode of production with a radically different approach—that is, making the shift of raising nature (the production of nature) to the level of space (the production of space) of Lefebvre (Smith, 2010).

2.1. From Critical Urban Theory

So far, and because planetary urbanization remains highly abstract, its conceptualization as the outcome of mutually constitutive processes of (1) concentrated urbanization, (2) extended urbanization and (3) differential urbanization, cannot be used directly as sole analytical dimensions for the analysis of contextual specificities. The latter appear as key if used linked to the changes unfolding on the ground through the use of other mediating concepts beyond planetary urbanization (Brenner & Schmid, 2015; Khan & Karak, 2018). Concentrated urbanization (1) is broadly conceived concerning "the density of population and its asymmetric distribution," or to "the distribution of built space in the form of structures and infrastructures" (Brenner & Schmid, 2015). Though, concerning territories of extraction, it refers to landscapes with high levels of primary production, in the form of for example, extraction of minerals. Therefore, mining operations—due to the high concentration of activity in certain geologically dense composition areas—can be both very punctual (like most drilling operations), or very land extensive (like open pits; Katsikis, 2016). Extended urbanization (2) refers to the outward expansion of the urban form from the city centres or 'agglomeration landscapes,' encompassing both infrastructures and landscapes of primary commodity production or 'operational landscapes.' More significantly, and to constantly overcome sociospatial barriers for capital accumulation, the forms of extended urbanization often lead to the expropriation, privatization, and profit-oriented modes of appropriation of land and water—i.e., as by large-scale infrastructures (mines, dams, industrial corridors) in remote regions which end up displacing populations, indigenous peoples and everyday social spaces—while disrupting established forms of livelihood. In this line, the theoretical framing of operational landscapes of extended urbanization as merely a mode of geographical organization can be troubling—framed as they are as deriving from a direct relation to 'agglomeration economies' (from economic geography). The latter has been distinguishing between three categories—localization, industrialization and urbanization economies—and translated in the form of so-called 'landscapes of possible externalities.' Yet, if moving beyond the externalities form—which is limiting and characterizing operational landscapes by some sort of 'machinic' behaviour to the elements of natural geography—planetary urbanization could challenge production beyond its socio-spatial understanding, or say, as mere configurations of particular geographically-distributed elements.

To this extent, and in line with the processual understanding of the urban, the third intertwined moment of differential urbanization (3)—between the forms of extended and concentrated urbanization—implies a creative destruction process of socio-spatial configurations concerning the broader dynamics and crisis-tendencies of capitalism. This moment highlights the perpetual dynamism of capitalist forms of urbanization—both concentrated and extended—in which socio-spatial configurations are tendentially established, only to be rendered obsolete and superseded through the relentless forward motion of the accumulation process and industrial development (Brenner & Schmid, 2015). Yet, in each urbanization cycle differentiated geographies carry transformative potentials in the social, economic and cultural spheres (and perhaps also the natural). In this regard, differential urbanization could be key to the purpose of bridging the advancements of planetary urbanization in its socio-spatial configurations on the reproduction of the social relations of production, and other disciplines' complementing insights.

2.2. From UPE and World Ecology

Considerably, planetary urbanization could expand its framework by engaging with the latest UPE advancements on moving beyond the urbanization of nature. Acknowledging socio-natures as being increasingly enrolled in the circuits of capital beyond city/no city, and so, further challenge the mode of production from territories of extraction (i.e., the ways of organizing socio-

natures under capitalism). That is to say, considering the post-cityist UPE of linking the tracing of metabolic exchanges of matter, energy and capital not only as unidirectional processes concerning cities, but to the extended forms of urbanization key to uneven geographical development (Angelo & Wachsmuth, 2015; Arboleda, 2016; Katsikis & Ibañez, 2014; Tzaninis, Mandler, Kaika, & Keil, 2020). Thereby the heart of the matter may lie not in the mere quantification of flows (as not all are valued within capital's dynamism); but more in line to the world-ecology optic, into the articulation of social and natural forms—moving beyond the 'Cartesian' binary and dualisms. In this light, the operational landscapes of extended urbanisation could be characterized not merely by a machinic behaviour whereby capitalism is developing and acting on nature; but as active landscapes continuously transformed by the articulation of a whole set of relations—of capital (accumulation), (pursuit of) power and what is more (the production of) nature—that are not fully under the control of economic and political actors, and where capitalism develops through the web of life (Moore, 2015b, 2016).

This set of relations has been reflected in depth by Jason Moore with the concept of 'ecological surplus' and its tendency to fall between 'capitalization' and 'appropriation.' Where capitalism not only extracts value through the exploitation of paid work but also, and crucially, from unpaid work by both human nature and nature alike (i.e., like geological processes that produce minerals or the water cycle for hydropower energy generation). It is precisely on this appropriation of unpaid work or the so-called "free gifts of nature" by Marx (Marx & Mandel, 1976), that the production-process relation is to be critically questioned. Briefly, the ecological surplus can be defined as "the ratio between the actual capital investment paid work (wage-labour), fixed capital and raw materials; and the unpaid work that is mobilized with it" (Moore, 2015a). In its tendency to decline, the ecological surplus is offering a core additional layer for the historical analysis here intended: for exploring the relations of power and re/production whilst bundled with the specific historical natures in territories of extraction, for exploring its particular ways of organising the society-nature relations and more notably in the creative-destruction moments of crisis throughout the successive eras of accumulation. Across these moments, the ecological surplus can be: in underproduction, very high, eroding, contracting and in conjuncture (Moore, 2015b). Historically, in its tendency to decline, the ecological surplus is linked on the ground with new (not just sociospatial but) socio-nature forms of differential urbanization—a dialectic that is importantly including the production of nature relation.

For example, within a previously 'untouched' mining deposit or uncommodified 'first nature,' minimal investment in labour and machinery might be needed to exploit high amounts of work that have been produced by nature in the deep time of its geological formation. As accumulation proceeds, the initial high ratio of ecological surplus tends to fall, the exhaustion of the resource and closing of frontiers bring about expansion, intensification, technological innovation and processes of creative destruction—a commodification of socio-nature relations. A 'second nature' is then produced, which in turn depends upon maximized throughput or say, upon further appropriation of raw material outputs to be generated by smaller inputs of capital and capitalist power (i.e., as unpaid rights for mining into a colonized territory). And yet with time, a new frontier opens up: the 'financialization of nature,' involving a new vertical integration of nature that moves beyond appropriating available nature to rather produce an inherent social nature as a basis of new sectors of production and accumulation (Smith, 2007). The production of nature is thus an important aspect historically characterizing extended urbanization, deeply intertwined with the notion of differential urbanization and successive expropriations, violence and dispossession practices. This process involves economic forces, yet is strongly dependent on the state—to seize portions of the earth through extra-economic force—and ruled by science—to objectify the social and natural world as a means to exert direct control in service to commodity exchange.

Thus, the key notion of appropriation in this work is to be understood as within the mentioned logics of separation located at the core of 'primitive accumulation,' allowing for unpaid work/energy to be mobilised for capital accumulation. At its root, according to Marx, the capital relation presupposes the separation of the workers from the means—land and water—that would allow them to be self-sufficient (Marx & Mandel, 1976); it is a process of expropriation premised on violence and created by the same capital relation—highly visible in territories of extraction and extremely on indigenous lands and waters. However, primitive accumulation here is to be understood not just as part of an original past but more in line with what new readings propose, as a historically ongoing dynamic where appropriation goes far beyond the geographical expansion of capital. This is particularly true with the shift of finance and the real subsumption of nature to capital, historically enabling capital to transcend geological and temporal limits towards accumulation. What is more, technological change is allowing for the continuous production of 'an outside' but within the same physical boundaries, advancing not merely by appropriating socio-natures but by (re)making them for capital to work harder and faster (Arboleda, 2020). As such, the limits to this relational process of appropriation are not reduced to biophysical realities alone but located between the capitalization of nature and the ecological surplus at its highest point (Moore, 2015b). Indeed, the limits have a particular way of organizing (articulating) humanity's relation to nature, in short, of changing co-produced socio-nature relations between the agglomerated and operational landscapes.

Under this framework and linking back with the processual approach to the urban, territory is also

to be thought of as a process and not as an outcome. Continuously made and remade by states, science and corporations, territory becomes a form of political technology (Elden, 2019; Mezzadra & Neilson, 2013). Extraction is also to be understood as processes, going far beyond the merely forced removal of raw materials to supply significant cities and zones of the world, and becoming historically intermingled with finance, logistics and urbanization (Arboleda, 2020; Gago & Mezzadra, 2017; Mezzadra & Neilson, 2017). Furthermore, to be able to expropriate large and varied geographies, states require forceful financial penetration on the land to be mapped—in the first moment of surface expansion—and mobilized—for its steady intensification in volume. It is in this sense that the map becomes not only the territory but the technology (Bélanger & Lister, 2018). The critical representation through time and scales of these extraction processes can thus provide important analytical insights for elucidating the uneven role of appropriation—both in the surface and in volume—across the successive historical ecological crisis under the capitalist mode of production.

3. Images of Extractive Territories

The next paragraphs review the literature on the representation of extraction territories by exploring the two basic interpretations of the concept of territory as signalled of more importance to the analytical framework of planetary urbanization: (1) the operational landscape approach, prevailing mainly in the English-speaking world and more recently developed as from the 2010s, and (2) the morphology approach, emerging from the French and Italian-speaking worlds, antecedent from the 1980s (Schmid, 2015).

In line with the (1) operational landscape approach, the research in the fields of urbanism and landscape has lately gained interest for territories of extraction, and the latter has been the object of plural descriptions and representations (Bhatia & Casper, 2013; Brenner et al., 2013; Correa, 2016; Ponte & Kowal, 2017; Sordi, Valenzuela, & Vera, 2017). As a result, these spaces have progressively been defined as regions located far beyond the city centres but paradoxically providing resources and goods for cities so they can develop and operate (Brenner & Katsikis, 2020). For that, several layers of connectivity infrastructures have been continuously deployed and driven resource extraction to ever faster and more remote areas. Settlements have in turn been put in place and are often referred to as 'camps' or temporary living hubs, that is, as part of the overall extraction industry and infrastructure (Correa, 2016; Sordi et al., 2017). Operational landscapes thus often reflect a particular layout and socio-economic plan of extended—but also a certain degree of concentrated—urbanization of extraction, a form of urbanization in dialectic relation to the elsewhere agglomerated landscapes it supplies. More critically, in the book *Empire Extraction* (Bélanger & Lister, 2018), the notion of territory is used to signal the power dimension and political control of the State on the land—the geographical surfaces that the State maps as its political territory—while exercising cultural domination, indigenous dispossession, settlement imposition, resource acquisition, environmental engineering or international disposition. In this sense, the 'state' map is here not only the territory but also the technology through which the power of the State is continuously upheld. Together, through both power and mapping, the State is severely considered the preeminent extractive technology (Bélanger & Lister, 2018). Therefore, within these English-speaking world interpretations, territory is regarded as a political entity, a demarcated abstract space or as a large area equating to the extent of an authority. Extraction and the enabled appropriation are dematerialized: territory, when defined as a bounded portion of the earth's surface, with a conceptualization of land as a passive container, is giving a troubling—and it will be argued uneven—role of nature in urbanization processes.

A fundamentally different position is prevailing in the (2) approach as morphology, where both morphology and territorial materiality are taken as a starting point. What emerges here is that territory is produced by human activity, be it either material or mental. In this line, Claude Raffestin, geographer in Geneva, referred to territory as the outcome of social conditions, relations and power structures (Raffestin, 1980). Similarly, Corboz (1983) would regard territory as a product of historical processes of transformation, putting forward the metaphor of the 'palimpsest' and understanding the land as constantly reworked through the variety of social and economic processes (Corboz, 1983a). For both authors, it is clear that territory is a socially appropriated space. However, conceptualizing the land as remote, bounded and being merely and constantly socially reworked is perhaps further enabling the dualist visions between society and nature, between the city and the landscapes of extraction, or say, between production and distribution infrastructures. This work takes on this critique and uses the aforementioned analytical dimension of the ecological surplus to explore the representation of the asymmetrical processes, between the hidden appropriation (of unpaid work) and the concerning capitalization (the exploitation of labour productivity). Thus understanding how socio-natures are co-producing each other, and how production and distribution are just different 'moments' of the same historical process (Marx & Nicolaus, 1993).

4. Mapping Palimpsests of Appropriation

The palimpsest metaphor applied to territory is still a very productive methodological tool which can be further mobilised and challenged when brought to territories of extraction. Beyond Corboz's recognition of the land as being formed by separated and yet mutually influenced layers of natural and human-induced pro-

cesses, recent revisitings on the palimpsest focusing on ecocritical discourses have moved forward to consider them as merged via time (Layne, 2014). In effect, by allowing the multiple layers to acquire the same importance, the palimpsest can transcend dualisms and render visible the hidden intertwined historical transformations. However, approaching the territory as a palimpsest has some limitations, it can project visions (past and future) but cannot add that which never was (Layne, 2014). Also, it's very representation depends on subjective operations done with a certain "margin of interpretation" by the researcher (Genève République et Canton, 1993). And, as Corboz worried, landscapes cannot be reduced to maps—which have the potential to filter out cultural aspects such as seasons, experiences or memories (Corboz, 1983).

The idea of 'palimpsest of appropriation' is proposed here as the metaphor through which to render visible the hidden historical processes of appropriation of unpaid work (from both human-nature and nature alike) fundamental to the dynamics of accumulation in territories of extraction and intrinsic to capitalist urbanization. For that purpose, this article engages with the theorization of the circulation of capital—as laid out by Marx in the second volume of Capital, extensively interpreted by Harvey and recently more specifically into extraction by Arboleda (2019; see also Harvey, 1989; Marx & Mandel, 1992)—and uses it to spatialize and map appropriation processes through time and scales. On this basis, it proposes to deploy the mapping operations into the three intertwined frames (different moments of the same process) where capitalist appropriation takes distinct intricate spatial configurations: (1) production, which comprises both the built and non-built environment, directly or indirectly involved in the iron ore production—pits, shafts, tales, processing facilities, industrial buildings, plots, housing for the workers, public facilities; (2) distribution, formed by all the network infrastructures that enable the transportation of iron ore from sites of extraction to their exchange in the market—ports, railway, roads, paths, cableways, fiber cable, energy grid; and (3) mediation, which encloses the financial actors and institutional systems investing in science and technology (harnessing science to production to contribute to the processes that continuously revolutionize the productive forces in society), and in social expenditures (for the necessary reproduction of labour power, their qualitative improvement and integration and even repression of the labour force)—constantly mediating and transforming extraction at multiple spatial scales.

The combination of the three frames forms a matrix (Table 1), providing a framework of interpretation that sheds light on the modes in which extraction territories have been continuously appropriated and reshaped into different uneven spatial socio-nature configurations. Yet, the process for mapping the three frames can be described according to three—sometimes overlapping—mapping operations or gazes that mainly correspond to (1) the elementary, (2) the inter-scalar and (3) the chronological.

The elementary gaze (1) is recognising the elements that produced such processes and proceeds to break down their mapping complexity into clear individual parts, that is to say, a process of description (Cavalieri

Table 1. Table matrix palimpsest of appropriation.

	Production	Distribution	Mediation
	layers	layers	texts
elementary	(water, herding routes, roads, harbours, geology, orography, vegetation, housing buildings, other public facilities, production buildings, plots and land use)	(water, sameby, railway, paths, electricity network, shipping routes, cableways)	(key historical facts, financial actors, institutions, policy frameworks)
	plot 1:2,500 settlement 1:5,000 regional 1:500,000 national 1:10,000,000 global 1:20,000,000	plot 1:2,500 settlement 1:5,000 regional 1:500,000 national 1:10,000,000 global 1:20,000,000	plot settlement regional national global
inter-scalar + chronological	synchronic (a) 1550–1888 | in underproduction (b) 1889–1939 | very high (c) 1940–1969 | in erosion (d) 1970–2020 | contracting & (e) diachronic | in conjuncture	synchronic (a) 1550–1888 | in underproduction (b) 1889–1939 | very high (c) 1940–1969 | in erosion (d) 1970–2020 | contracting & (e) diachronic | in conjuncture	synchronic (a) 1550–1888 | in underproduction (b) 1889–1939 | very high (c) 1940–1969 | in erosion (d) 1970–2020 | contracting & (e) diachronic | in conjuncture

& Viganò, 2018): water, railway, roads, paths, electricity network, herding areas and routes, harbours and shipping routes; geology, orography, vegetation, housing buildings, other public facilities, production buildings, plots and land use. Later, these layers are studied in their multitude of existing and potential connections both geographically, at the multi-scalar (i.e., varying between the settlement and region, and in relation to the national, and global) and historically, along multiple timeframes (identifying historical time thresholds, past and present dynamics and flows, as well as including the future short and long-term visions).

The second gaze, the inter-scalar (2), crosses scales. Extremely sparsely populated regions require with an even greater need to be understood multi-scalarly, to simultaneously grasp the complexity of spatial forces. This analysis is performed at different scales: (1) plot, scale 1:2,500 with attention to the form of the plot, the materiality of the architectural artefact, and its land-use variations; (2) settlement, scale 1:5,000 looking at the socio-nature morphologies (plot, housing, production facilities, pits, shafts, tailings, underground galleries, paths, roads, railway and water); (3) region, scale 1:500,000 (the river, railway, reindeer herding areas, herding paths, mines, settlements, harbours, seaways, military zones, plots, paths, hydropower plants, electricity lines, wind parks, data centres, cableways, fibre cable); and (4) national and (5) global interconnectedness, scales 1:10,000,000 and 1:20,000,000 (tracing the circulation of iron ore export flows, from the sites of appropriation and linked harbours to the global markets).

The chronological gaze (3) looks through time by selecting different 'time thresholds.' The periods are identified by each of the creative-destruction historical moments when the ecological surplus tendency changed and the major re-inscriptions and transformations occurred: (a) 1550–1888, in underproduction, when the structures preceding the appropriation of unpaid work/energy for capitalist accumulation were being put in place; (b) 1888–1939, very high, marking the beginning of the rapid transformation and growth until the irruption of WWII; (c) 1940–1970, eroding, during the turning post-war period of rapid expansion, spurred by added technological advancement; (d) 1971–2020, contracting, in the stagnation and shifting of the financialization of the economy; and (e) the future in conjuncture, when the tendency towards underproduction reasserts itself.

These time thresholds build up a synchronical visualisation—comparing two periods at a time—distinguishing the elements that can be qualified as permanent, persistent, transitioning or disappeared. Permanent, for when the element stays invariable in the same position, shape and dimension. Persistent, for elements that have slightly changed while keeping the same position on the ground. Transitioning, for those elements that have been moved to a new position but are keeping their shape and dimension, accepting that minor changes can be encountered. Disappeared elements, for those no longer there. At the end of the successive comparisons, a final interpretation of each scale provides a diachronic image that directly reveals the historical traces still in place as well as those that are hidden from view.

4.1. The Malm Territory Palimpsest of Appropriation

The Malm territory provides a unique site for discussions on mapping the 'territory as a palimpsest of appropriation.' It has long been the object of historical investigations and subject of critical analysis (Forsgren, 1995; Forsström, 1973a, 1973b; Hansson, 1994, 1998, 2015; Luciani & Sjöholm, 2018; Müller & Engström, 2018; Öhman, 2016, 2020; Rizzo & Sordi, 2020; Tidholm, 2014; Viklund, 2015) while the cartographic representation of spatial transformations has largely been ignored. It stretches from the iron ore production in the mining towns of Kiruna, Svappavaara and Malmberget, its distribution with the Malmbanan railway to the shipping harbours—Luleå by the Baltic Sea in Sweden and Narvik in Norway to the Arctic Sea—the military town of Boden to protect from foreign threats, and the hydropower plants and associated temporary towns along the Lule River.

However, the railway and mines period is merely one of several periods in which the Malm territory palimpsest was re-inscribed by stratified socio-nature appropriations. To critically understand its formation, it is necessary to trace the historical transformations and creative-destruction moments since the mid-1500s—a period where the structures for capitalist accumulation started to emerge and landscape changes occurred in a radical shift of scale, speed and scope (Moore, 2017), coinciding with the appearance of the first mappings of the northern areas, the charting of its resources by southern powers (ruling kingdoms and expanding states) and the following expropriation of the lands from Sami indigenous peoples (Elenius, Tjelmeland, Lähteenmäki, & Golubev, 2015). To make it very clear, although the article critically focuses on the appropriation processes inherent to the unevenness of capitalist' urbanization and its ecological crisis, it is critical to stress its roots.

For 11,000 thousand years Sami indigenous peoples have lived across all of Fennoscandia—today's Sweden, Norway, Finland and eastern Russia—and its history has been violently overridden by colonial narratives, even if forming a far more advanced civilisation than what has previously been understood. New research has revealed that Sami had been producing iron and steel on an advanced large scale, 2,000 years before the Swedish colonial state and LKAB began operating (Bennerhag, 2017). This is certainly no terra nullius, and there is no frontier (Belanger, 2016). The Malm territory palimpsest of appropriation as here discussed has only been possible by the expropriation process created by the capital relation, in essence, what primitive accumulation is about. Separating indigenous peoples and settlers from the means that allow them to be self-sufficient and

submitting them to being governed, or otherwise—if not giving up to this control—condemned to disappear (Arboleda, 2020; Öhman, 2020). Since Gustav Vasa ascended to the throne in the 1520s—when the nation of Sweden was established—and coinciding with the Protestant Reformation of the 16th century, the efforts and structures to colonise the Sami territories started to emerge. From then onwards a dialectic between capitalization and appropriation of unpaid work and energy started to form, shaped as a combination of production and distribution, and mediated by the church, the state, and its financial and institutional systems.

4.1.1. Production Palimpsest

The mapping operations of the production palimpsest, for the region and settlement (hereby exemplified in the mining town of Malmberget) scales, begin by synchronically comparing two periods at a time (see Figure 2a, b, c, d, and Figure 3a, b, c, d). Using two colour (socio-nature) gradients—blue for the social production and red for the natural production—and moving from the darker degree for the 1550s to the lighter ones for the 2020 threshold. Appropriation takes thus different forms for each ecological crisis—or say moments of creative-destruction of differential urbanization—along with the tendency of the ecological surplus to decline.

From underproduction, Figures 2a and 3a relate to the production patterns whereby the first mines in the middle valley areas linked to few paths but many dispersed small settings and smelters along the river and towards the Baltic coast, distributed strategies yet also related to the agricultural fields cultivated by settlers and farmers near church locations, or spontaneous built-up structures—close to the scattered iron ore deposits—in relation to small-scale extraction.

Very high (Figures 2b and 3b); with a rapid first expansion (many new settlements appeared) and especially on the social production side (i.e., for the major need of labour power, represented in blue gradient colours, built-up areas corresponding to the municipal towns). Growth, in turn, was made possible by the secured access to cheap energy production from hydropower (the construction of which required first permanent settlements to be built). The mining operational landscapes were created in the shape between concentrated urbanization—of first informal uncontrolled shanty towns (mapped in red) and later under the added commissioned town plans (mapped in blue); and extended urbanization—the production of nature mapped in red, taking the shape of several punctual and extensive areas of mine pits and tailings (even if known these would eventually stretch towards the underground of the planned municipal towns). The pattern logics differ in the company area (with free access to the land and the means of production), and the municipal towns (controlled and planned)—both separated by a well-defined boundary, inherent to the dynamics of primitive accumulation.

In erosion; with an overall state-driven expansion mapped in the multiplication of traces that either appear both (Figure 2c) regionally—as roads to serve the forestry industry, nature reserves, airports, hydropower; and at the (Figure 3c) settlement scale—mining pits multiplied and extended, centralized and newly created and separated company towns, reinvestments in densified forms with new facilities and housing buildings in municipal towns and above the known location of ore deposits (establishing and structuring relatively equitable and socially homogeneous company towns, mainly to keep the needed labour in place). Shaped under an overall increasing separation logics: between company town and municipal town areas (clearly constituted by the railway infrastructure enclosing the mine); by disappearances (the river water along the now temporary towns to build the hydropower plants, or old railways and company areas overwritten by the new municipal town centres); by transitions (as the moving buildings of the temporary river towns); or by the maximized energy production which, after the technological outbreak innovation by which electricity could travel long distances, would be distributed and consumed far away nationally and internationally). In sum, an overall up-scaled appropriation of the unpaid work/energy produced by a second nature that would in turn fuel the development of the Swedish welfare state.

In the approach of a turning point whereby the ecological surplus relation is contracting (Figures 2d and 3d), capitalization is exceeding appropriation, meaning a rising labour productivity and implying an even greater increase in raw materials and energy volume per labour-time (Moore, 2015a)—clearly represented in the unprecedented dimensions that the operational landscapes take at the settlement scale, in surface and in volume. And importantly in the forced disappearance of built housing structures and public buildings—representing the internalization of spaces necessary for capital accumulation to proceed, although under increased costs caused by the land subsidence of mining operations beneath (Figure 4). The latter links with the appearance of new built-up middle areas (between municipal towns), inherent to the logics of separation but also to the simultaneous financialization—where settlements move towards a reorienting into the 'tertiary circuit' (i.e., commercial services, scientific and technological innovation; Harvey, 1985). More noticeable, at the regional scale, new enclosures related to the construction of wind parks appear underway—between the middle valley and coastal areas—and concerning the last shift towards the electrification of large-scale industries, and crucially to the more electricity-intensive data centres industry (i.e., the new regional vision strategy for a 'sustainable future'). The latter represent thus just the last step into the historically layered conflicts, unceasingly deepening, between reindeer herders or indigenous modes of life and capitalist appropriations of indigenous lands and waters with unprecedented expansions in surface and intensifications in volume, the vertical shift of the production of nature.

Diachronically, the mapping of (Figures 2e and 3e) relate to a future ecological crisis in conjuncture. They reveal the cumulative appropriations through time whereby socio-nature transformations become ever more polarized, progressively advancing from the coast to the mid-valley areas and then in between—better represented in the section tool (Figure 8). In this line, appropriation repeatedly draws socio-nature urbanization into the expanding logics of separation inherent to primitive accumulation—represented between the two colour gradients and significantly between concentrated and extended urbanization processes. This is shown in its ex-

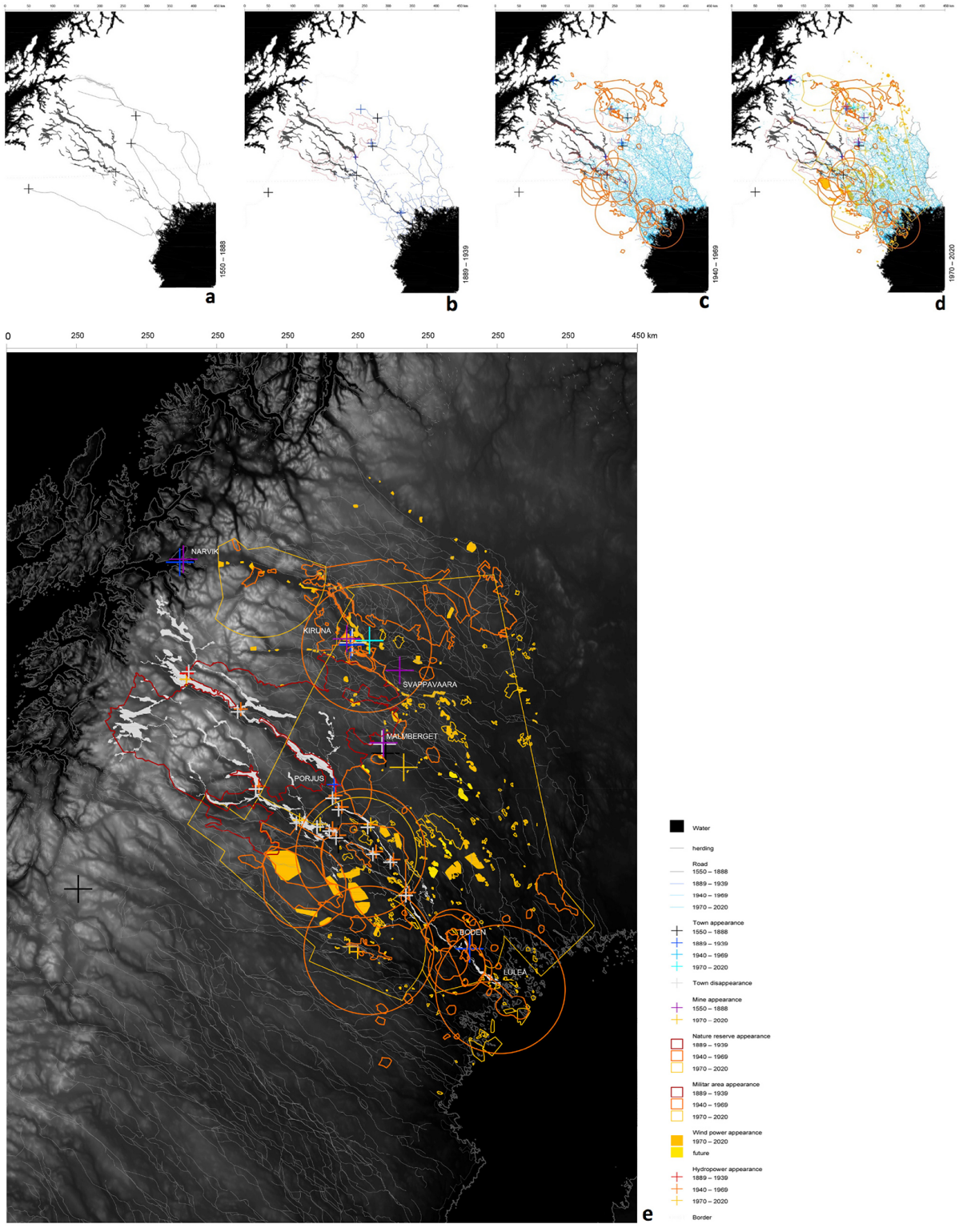

Figure 2. From images A through D: Region, synchronic comparison, production palimpsest. Image E: Region diachronic production palimpsest. Source: Elaborated by Berta Morata based on Geonorge, LKAB, Natural Earth, SLU, historical maps.

treme in the comparison as mapped in (Figures 3e, 4 and 9), with grey color for the disappeared or transient built-up areas (mainly moved buildings to the company area), and in dialectics to the expansion between pits and ore deposits. Hence, accumulation by appropriation becomes increasingly costly over time due to financialization, physical depletion, and other uncertainties such as climate change or the irruption of new contesting anti-systemic movements (i.e., as by the resistance and revindications of indigenous ways of life). However, intrinsic to this are also the possibilities for the remaining and hidden traces—as internalized by capitalist production—to

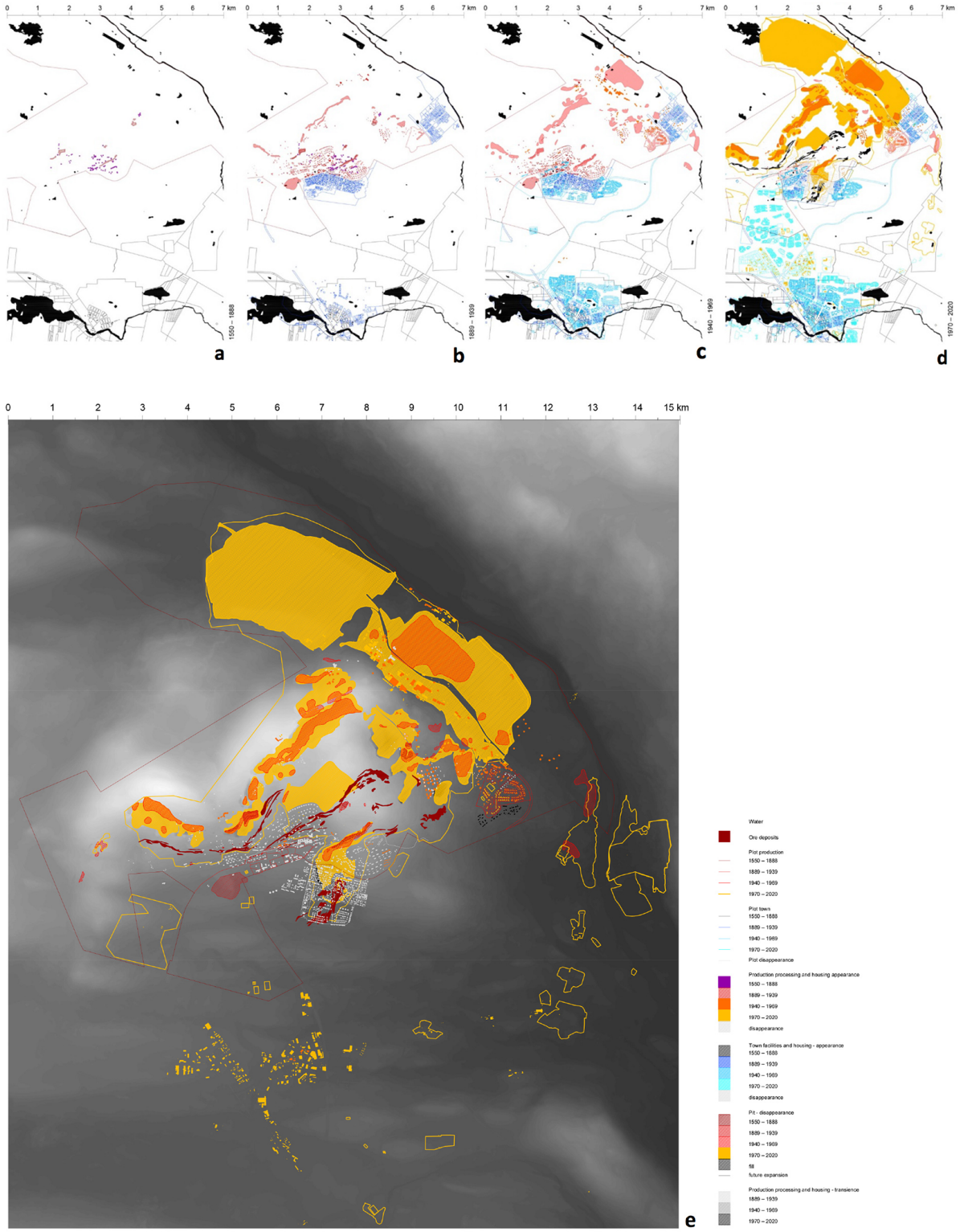

Figure 3. Images A through D: Settlement synchronic comparison, production palimpsest. Image E: Region diachronic, production palimpsest. Source: Elaborated by Berta Morata based on Geonorge, LKAB, Natural Earth, SLU, historical maps.

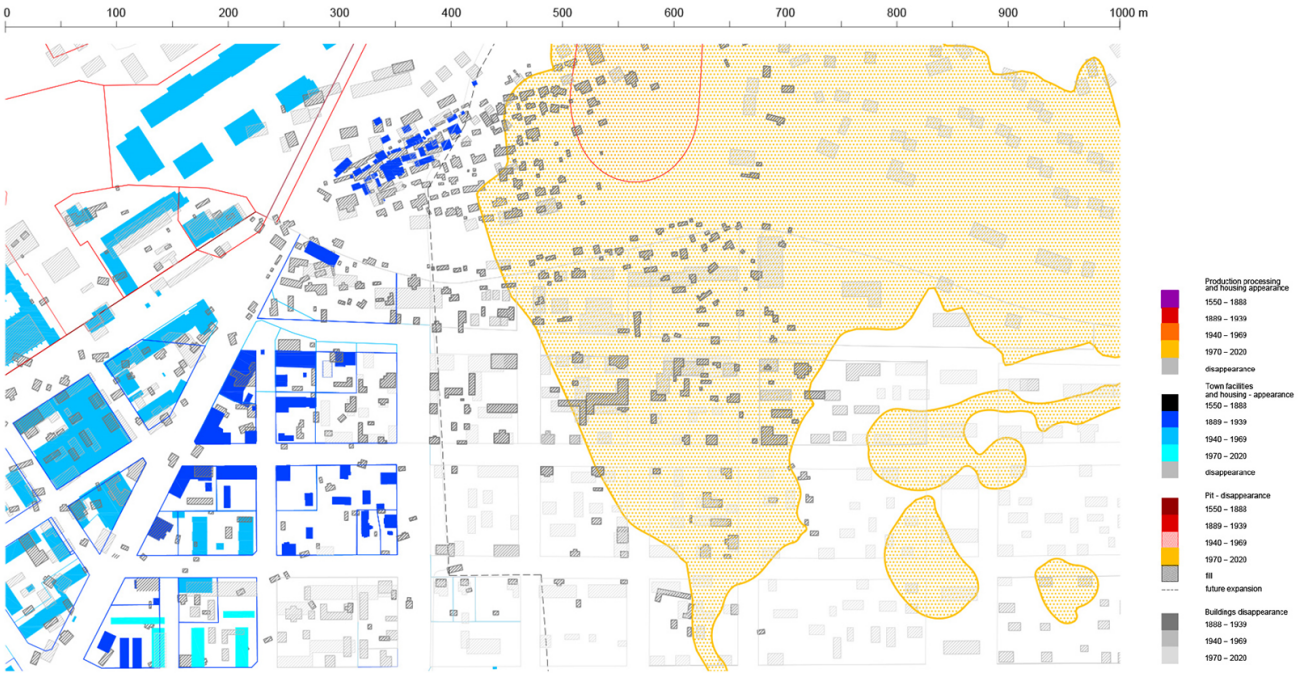

Figure 4. Plot, diachronic production palimpsest (Malmberget). Source: Elaborated by Berta Morata based on LKAB, SLU, historical maps.

be reconfigured in new ways of organizing socio-natures. These internalized spaces, through the notion of differential urbanization and commodity flows, relate to appropriation processes beyond the region and settlement scales (Figures 1 and 5).

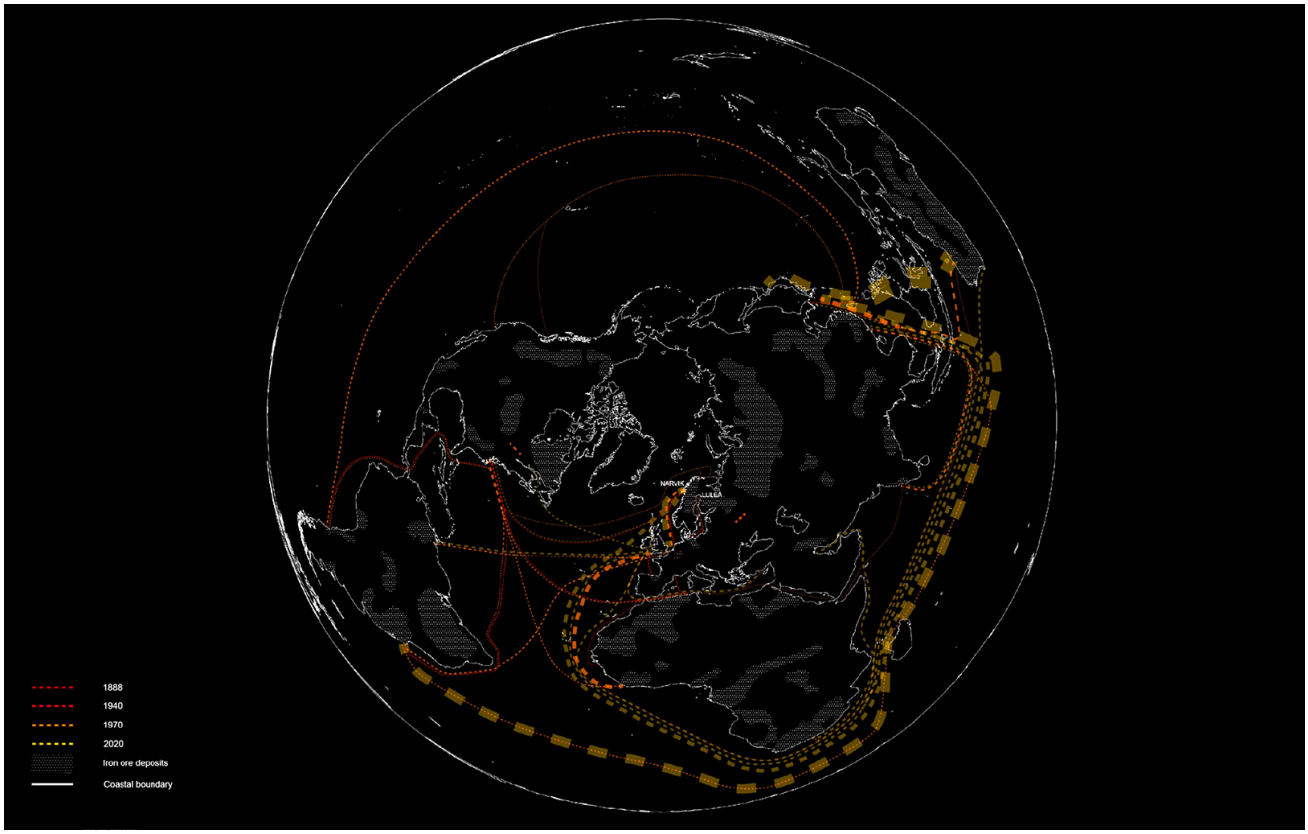

Figure 5. Global production of iron ore appropriated by the global economy. Source: Elaborated by Berta Morata, based on Natural Earth, USGS, historical maps.

4.1.2. Distribution Palimpsest

The mapping of the distribution palimpsest, exemplified in (Figures 6 and 7) for the region and settlement scales, follows a similar process yet using mainly the red gradient pallet—since its traces mostly relate to the production of nature—encompassing the physical and social infrastructures that facilitate the distribution of iron ore. Hereby, capital is constantly searching to reduce the turnover time, the time that it takes to transition from the commodity form (production palimpsest) to the money form (mediation palimpsest) and returns to the capitalists as profits to be reinvested. This, in its tendency to modernize is more visibly scaling up and constantly reshaping, while rendering functioning connectivity infrastructures periodically obsolete. Yet, the constant transformations are interdependent to previous traces and to production, following different patterns and in relation to the ecological surplus tendency to fall.

From underproduction, although almost no traces appear inscribed in the map (Figures 6a and 7a), it is in this period that the most colossal attempts for distribution had been either imagined or partly built. Yet the decisive moment came with the arrival of the railway, deeply transforming the spatial and temporal logics of circulation (transporting the iron ore at higher rates). Contributing to increasing the output (from 0.02 to the 10% of the nation's total in only one year) by transporting the iron from the mining deposits of Malmberget (in the mid-valley areas) to Luleå (the coastal town by the Baltic sea), and shipped to the European markets. From that decisive moment onwards, the repeating pattern was that of first laying the path to the 'natural' site of production and then re-inscribing new traces of distribution.

Key to the next scaling-up of appropriation would be the access to more, cheaper, secured and continuous energy: hydropower; but no less important were the (thicker-mapped) electricity lines linking to the railway and mining operational landscapes. And next, the laborious and strategic extension of the railway arriving to Kiruna and Narvik (by the all-year-round ice-free Arctic sea). A period comparison (Figures 6b and 7b) with a very high ecological surplus relation, where the pattern was first to link the cheap energy source to the extraction sites, and later—and only to balance overproduction—electrify the coastal settlements (mapped with thinner lines) where the majority of the population lived. This construction pattern would start to change with the irruption of air transport (and the first inner regular flight in Sweden), to build the main water reservoir in the upper-valley and remote mountainous areas. Later, and only after the Malmbanan was built, the railway link to southern Sweden (Norrastambanan) was materialized (1894), and after (1937) the next railway line crossing the mid-valley areas (Innlandsbanan). Importantly, the railway shaped the settlements in the operational landscapes beyond the mere distribution, through a pattern of enclosing mining areas in a cut-like scheme—separating the company towns from the municipal towns.

In erosion, the huge connectivity expansion drew many new inscriptions to the map (Figures 6c and 7c). Technological breakthroughs are key to understanding the patterns of this post-war period, blurring boundaries in the interest of speed and connectivity. More importantly, this technological advancement meant that the expanded electricity production from hydropower in Lule River could travel great distances (linking to southern Sweden and internationally); yet also, and via its commodification, it meant the erasing of the Lule River as such (mapped in grey for disappearance). Part of the scaling-up is also the creation of airports, but so is the destruction of other infrastructures such as the Innlandsbannan railway (rapidly disappearing and never proving profitable, persisting only for summer tourism). Similar creative destruction processes occurred in the mining settlements and other hydropower sites of production, where railway trams were centralized along single trams or erased (i.e., as the mines were planning to move underground, or as some trams had only been needed for short-term construction works).

Contracting, not many new traces appear as in the previous comparison (Figures 6d and 7d). Yet there is a transformation in distribution becoming faster, capitalized or perhaps more socio-intensive. With financialization, the vertical integration of nature and the irruption of new economic sectors, people, and not only the iron ore (while there are twenty iron ore trains moving between Kiruna and Narvik every day, four trains and only one a day in winter are for passengers) are moving with increased frequency by air transport—a new pattern tendency directly linked to the technological upgrading in the mining industry, requiring more and more the overspecialization of intellectual fly-in fly-out workers. On the other hand, this leads to deskilling and labour uncertainty among industrial and manual operators living in the region—for which infrastructure building is not—and has never been—prioritized. Also, on the side of appropriation of unpaid energy, the capacity of the electricity grid has been upgraded (concerning more efficient hydropower plants and maximizing production). A more interesting shift is that nowadays the energy transition is pushing toward a new—uneven—overproduction cycle in the north, in both Sweden and Norway's renewables production and distribution (IVA Electricity Crossroads project, 2017). On the one hand, this links to the push for electrifying the mining sector (i.e., mines and SSAB's smelter in Luleå); on the other, to the possibility to appropriate new lands and even sea waters for resource extraction (i.e., especially the new 420 kV power lines linking the Lule River from Norway and arriving at the northernmost east coast and even later linking to Svalbard).

Diachronically—also represented for the national and global scales—Figures 1, 5, 6e and 7e relate to a future ecological crisis in conjuncture, of accumulated creative-destructions mapped in each of the successive

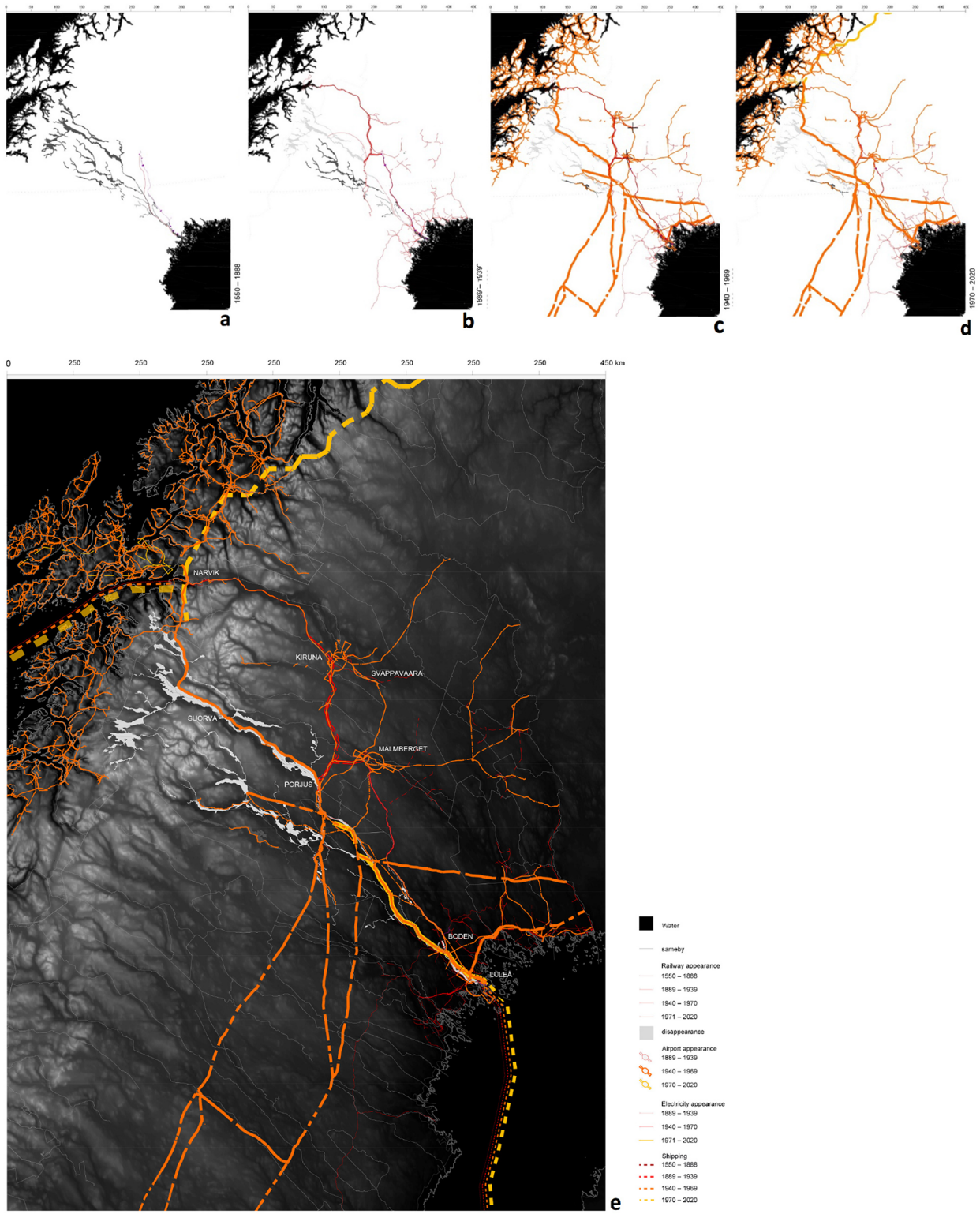

Figure 6. Images A through D: Region synchronic comparison, distribution palimpsest. Image E: Region diachronic, distribution palimpsest. Source: elaborated by Berta Morata based on Geonorge, LKAB, Natural Earth, SLU, historical maps.

appearances and disappearances. Waste and obsolete infrastructures, but also functioning or reusable ones that are internalized as left-over spaces. Hence, as the turnover times of capital continuously seek renewed up-scaling on the national and global levels (i.e., as for Sweden's next construction of the coastal railway 'Norrbotniabanan'), struggles continue to reassert at the regional and settlements scales, becoming ever more costly to overcome—beginning in turn to fetter the accumulation process.

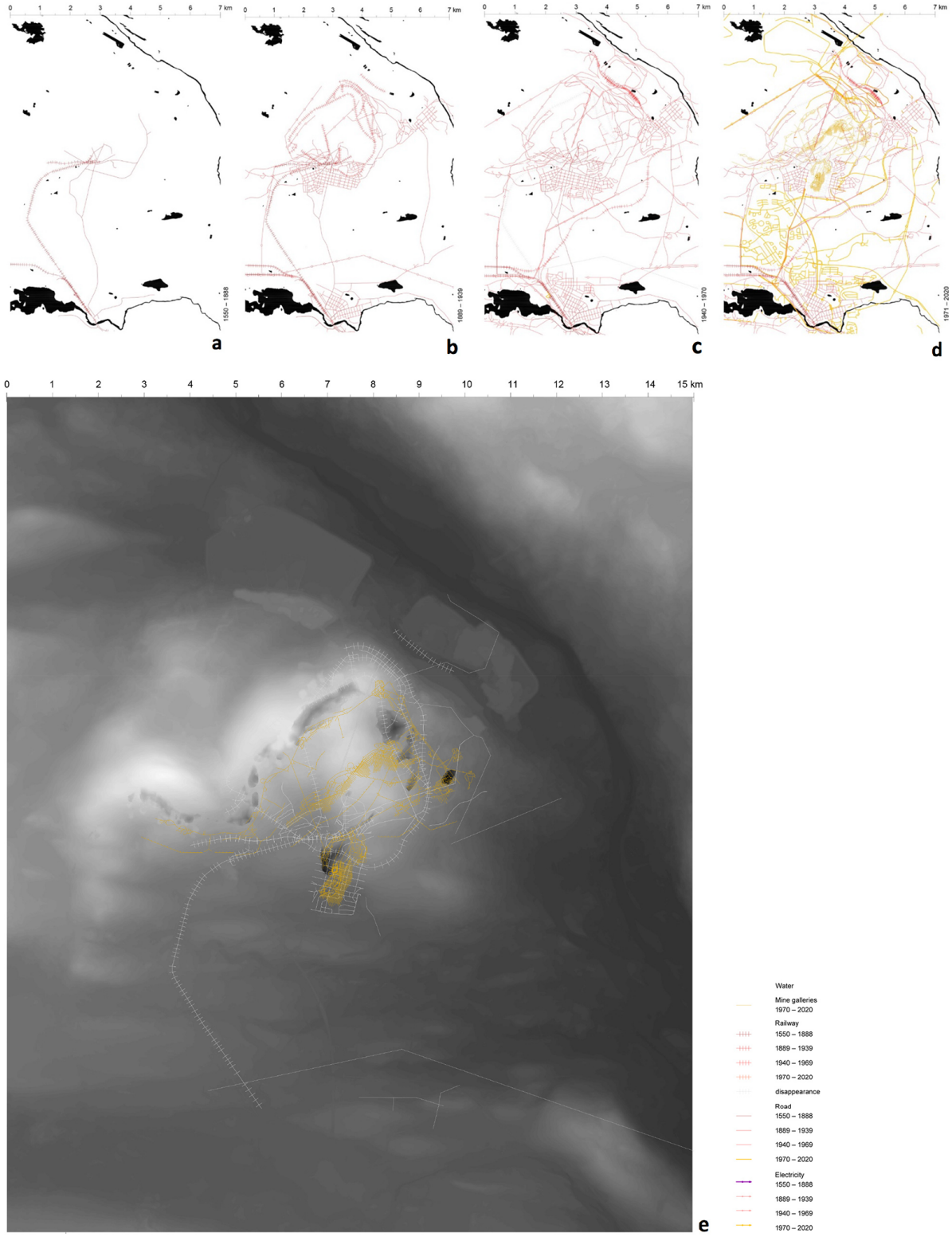

Figure 7. Images A through D: Settlement synchronic comparison, infrastructure palimpsest. Image E: Settlement diachronic, distribution palimpsest. Source: elaborated by author 1 from LKAB, SLU, historical maps.

4.1.3. Mediation Palimpsest

This last frame mediates the combined movement between the production and distribution frames. It manages the contradictions through the extension of credit, providing the required conditions—not spatially in a direct manner but influencing in its configurations—to the necessary appropriation in advance of real accumulation. As such, its representation does not materialize in a new set of drawings, but in an operation of interpreta-

tion (or abstract overlapping) that consists in combining the diachronic production and distribution palimpsest—conceptually and using the section tool (Figures 8 and 9). It aims to disentangle a few of the key historical facts and conditions (from texts concerning the mapping)—put in place by financial actors and institutions, policy frameworks, etc.—that produced the moments of creative-destruction which successively (re)shaped differential urbanization in each ecological crises.

Key to the formation of the Malm territory are all processes of expropriation from 1550–1888. In line with a view seeking to reveal the revolutionary shifts of environment-making—and the creation of appropriation structures—that occurred in early capitalism, and refusing the commonly accepted assumption that capitalism begins around the 1800s (Moore, 2015b). The first expropriation and colonization attempts of Sami territories could be traced back to as early as the late 13th century by the nobility and the Catholic church, yet progressively becoming more real and especially from the Protestant Reformation of the 16th century. In the 17th century, mining prospects and specific rules for settlements began shaping the Malm territory project, along with several policy frameworks such as the Lappmark Proclamation of 1673, the 1751 ratification of the Swedish-Norwegian border (whereby the reindeer feeding areas became regulated through taxes), the Avvttringen campaigns (parcelling land stolen from the Sami for the crown and settlers), the 19th century Reindeer Husbandry Acts, the development limits set by the parliament in 1867 and then breached by the government, the Nomad Schools in the 20th century (with learning restrictions for Sami children)—all contributing to the formation of the Malm territory and future successive waves of accumulation by appropriation (Öhman, 2020). Later on, the Swedish Companies Act of 1848 opened up a new way of finding domestic and foreign investors. Between 1860 and 1889 came the speculation and pouring of English capital and, in 1882, the government granted permission for the construction of the railway between Luleå and Malmberget. Throughout this colonization process, it has to be explicitly acknowledged that the Sami People owned the lands and waters, and the Swedish state expropriated or stole them under colonial and scientific racism (Lundmark, 2008)—conflicts to be framed as intrinsic to early capitalism's crisis tendency towards underproduction.

The ecological surplus relation changed to very-high once the first tram of the railway had been built, and in connection with its construction several national-developmental growth strategies came underway. In 1898, the decision was made to build the Ofotenbanan railway, the tram to Kiruna and Narvik. In 1889, the State took over the ore fields (including the railway, Luleå's harbour and surrounding infrastructure), and the mining rights were transferred to Swedish hands. Soon after, the decision to build the fortress in Boden was made to strengthen the defence of the railways and mines. In 1907 the state became half-owner in LKAB—with the agreement for a significant increase in ore mining and transport. Such an expansion put pressure on the energy component and in 1910 the Swedish state commissioned Porjus, with the vision that electricity could grow a major development block in the north—in line with the industrial policy aiming at promoting Swedish industrial development and thereby increasing the use of domestic natural resources. A cumulus of policies that had led to an ever-increasing government involvement in different areas, designed with no cooperation and by actors without anchoring in the county (Hansson, 1998).

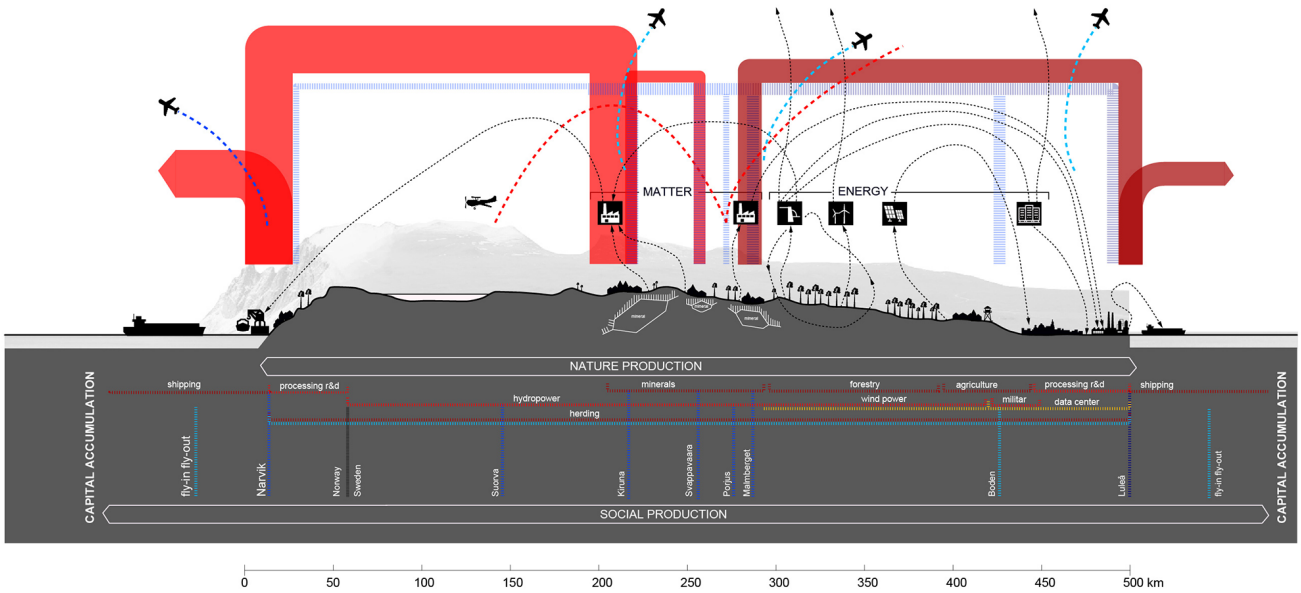

Figure 8. Region, valley section of appropriation. Source: Elaborated by Berta Morata based on Geonorge, LKAB, Natural Earth, SLU, historical maps.

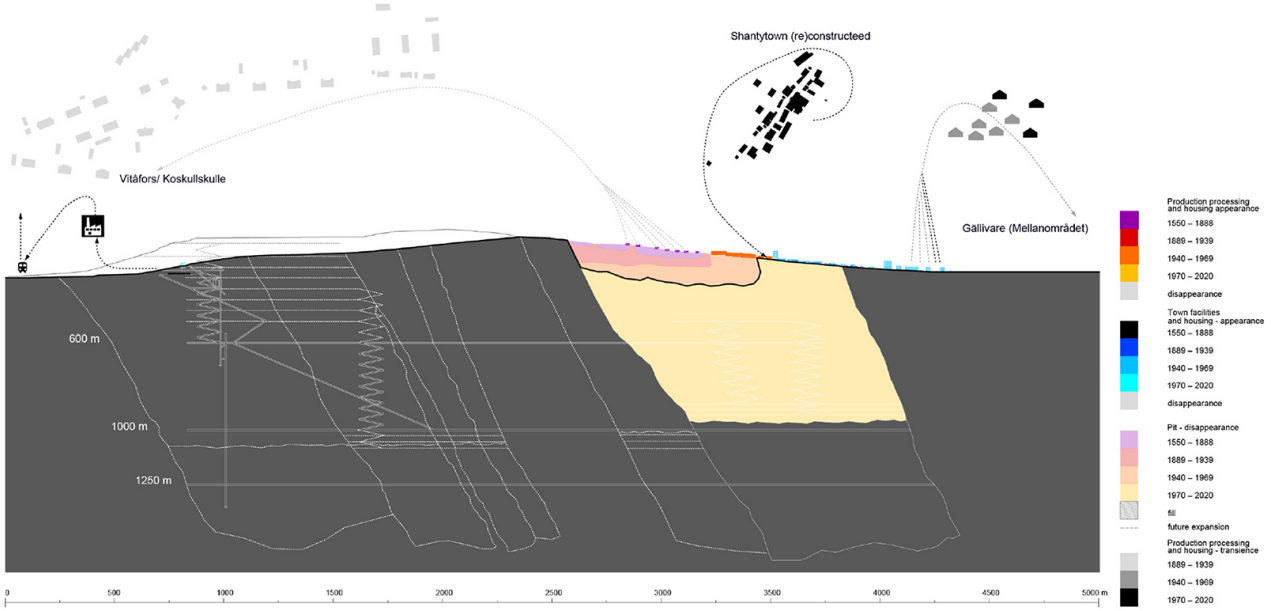

Figure 9. Settlement section (Gällivare—Malmberget—Koskullskulle). Source: Elaborated by Berta Morata based on SLU, historical maps.

The post-war period comparison, in erosion, saw a steady increase in state intervention coinciding with the growing need for labour and investment in society. It is in this line that the utopic modern projects for the mining towns are to be understood (i.e., Erskine's projects in Kiruna and Svappavaara), equally signalling the dependence of the salaried workers upon state investments and control. More extreme and ephemeral was the case for the temporary towns moving along the hydropower plant constructions in the Lule River, where housing rights were only given to employees (mostly male, discouraged to have a family or settle there). Nevertheless, such movable communities were provided with the most modern housing comforts (electricity, heating, water, plumbing, public facilities or sports fields). Even further, other creative-destruction processes were already popping up, such as from the side of the public energy company Vattenfall, which although once allied with manifold cooperatives in the process of electrification of the country, it had started absorbing the majority of them.

Contracting, the 1971–2020 comparison has more recently seen the conversion of both LKAB and Vattenfall AB into privately-owned-by-the-state-companies. Along these lines, the mining industry is becoming more capital-intensive, technologically advanced and autonomous. The research and development—with a clear focus on technological innovation—conducted since 1971 in Luleå University of Technology responded to that shift. In parallel, there is a decisive reorientation of the extractive industries towards corporate and speculative behaviours. In a time of growing environmental concern, mines in Sweden are still considered so important that protection agencies allow large emissions beyond what would be tolerated in other industries (Malmberg & Buckland, 2015). Swedish law is benefiting mining corporations and attracting foreign companies to the Swedish mining market. The legislation even allows mining companies to prospect and begin excavation on private land without the landowner's consent. The mining industry's so-called national interest trumps other socio-nature processes, but especially Sami reindeer herding and culture. Exemplification of this is that the mining industry is exempt from the landfill tax, has a lower energy tax, and only pays the mineral charge on 0,2% of the excavated value of its minerals (Tidholm, 2013). Furthermore, with China's growth decisively influencing the rise of global iron ore prices in the early 2000s LKAB decided to continue mining, even bearing with the growing costs associated with the 'move' (or building anew) of the sinking mining settlements of Kiruna and Malmberget. However, more public policies continue to be tailored to serve the next wave of accumulation underway, the establishment of data centres (i.e., Facebook from 2011), lowering taxes (by 97% in only one year) or providing for tailored urban planning even occupying former nature reserve lands (Sweco, 2017).

Still, beyond and stemming from the diachronic mapping of the mediation palimpsest, it is (among other dynamics) the underlying anti-systemic movement and resistance of Sami that is more recently revealing—behind appropriation processes and amidst the turning tendency towards underproduction. In January 2020, the Swedish Supreme Court ruled in favour of Girjas Sameby. The Sami—and not the Swedish State—will be entitled to manage the hunting and fishing rights (lost in 1993), in the continuing struggle to control their land. A historical decision completely altering the Sami's relation towards the colonising Swedish state, whereby perhaps Sami per-

spectives could start to become guiding principles (Allard & Brännström, 2020; Öhman, 2020).

5. Conclusion

This article addresses the mapping of palimpsests as a mapping of appropriation dynamics in extraction territories. More specifically, by framing the palimpsest of appropriation as a process of extraction in terms of the three intertwined frames—production, distribution, mediation—we intended to contribute to the exploration of new modes of representation of historical socio-natures within the analytical framework of planetary urbanization, UPE and world-ecology.

In this sense, via the 'Malm territory,' this work discloses an expanded notion of palimpsest, one that goes beyond the mere morphological analysis of sites, beyond the traditional scalar understanding of the urban and beyond the national notion of city and territory production. More particularly, this article clarifies (1) how uneven spatial developments developed over time; (2) how synchronic maps highlight those processes of appropriation that have constantly (re)made socio-natures throughout historical creative-destruction thresholds—that is to say throughout waves of imperialist capital accumulation—and, as a consequence; (3) how diachronic maps highlights how the disappearing—but yet accumulated—socio-natures can be either (re)appropriated or otherwise be left fallow as signs of precedent overaccumulation; we also looked into (4) how chronological analyses can break down those contradictions of scale, economy and processes that are embedded in the regions of extended urbanisation and, ultimately; (5) how space, within these processes, unprecedentedly extended both in surface and in volume.

The power of the visualization of the proposed palimpsest of appropriation may thus lie in the possibility and capacities to resist and destabilise the map as mere political technology—especially with its focus on the plot, settlement and regional scales—yet simultaneously morphologically relating to the intertwined production of socio-natures. By relating between the different forms extraction takes in each of the frames, this methodology has allowed to better understand the link and relevance of the production of nature as a very important part of urbanization and concerning the main agglomerated landscapes. As displayed here but, the historical and multi-scalar (beyond the more in focus discussed region and settlement scales) differential urbanization of extraction remains unexplored—and so, the appropriation process that continue beyond the actual sites of extraction.

Thus, and beyond the aim and space of this article, as production is not only natural but also social (socio-natures), the appropriation in remote territories of extraction should indeed be the object for the project of radically reorganizing urbanization as 'socio-natures production'—and not merely of distribution of, say 'death' or 'passive nature' from 'elsewhere.' Questioning the articulation between socio-nature processes of separation (or appropriation relations) would be at its centre.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Mapping as Gap-Finder: Geddes, Tyrwhitt, and the Comparative Spatial Analysis of Port City Regions

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Abstract
Politicians, planners, and mapmakers have long used mapping to depict selected spaces, to document natural and human-made changes within them, and to identify spaces where planning intervention is needed or can be helpful. Recent innovations involving big data, GIS-based research and digital datasets offer opportunities for maps and mapping that can lead to a better understanding of the interrelation of spatial, social, and cultural elements over time and to facilitate planning. A close analysis of the historic transformation of the built environment (such as land use, land ownership, infrastructures), the development of institutional structures (municipal boundaries) and the narrative that accompanies them (as embedded in maps and plans) through historical geo-spatial mapping can facilitate the identification of 'gaps,' where spatial, institutional, or cultural opportunities and challenges exist and where planning can be useful. Such an understanding can provide novel insights into the conditions and complexity of multiple transitions (energy, digital, technological) and provide a better foundation for future design. Our use of geo-spatial mapping to identify 'gaps' builds upon the work of Patrick Geddes and Jacqueline Tyrwhitt, who promoted the concept of survey-before-plan. As Tyrwhitt argued in 1950, the consistent overlaying of information can help us see patterns and outliers and derive meaning from huge, complex territories and large amounts of data (Tyrwhitt, 1950b). We can then better identify planning opportunities. Following an analysis of mapping as an analytical tool, we explore questions of sources, time, representation, and scale in the use of mapping at a time of increased availability of data. This article represents an initial effort to analyze the role of mapping as a tool of understanding, communicating, and ultimately planning through the lens of port city regions and their development over time. As a first step, it proposes conducting observations of historical geospatial mapping in port city regions in Europe: the Nieuwe Waterweg in the Netherlands, the Thames in the UK, and the Elbe in Germany. Probing the challenges and opportunities presented by historical sources, questions of representation and scale and data layers, the article concludes by proposing historical geo-spatial maps and mapping as a tool of display and comparative research and as a 'gap finder.'

Keywords
comparative spatial analyses; gap-finder; GIS; historical geo-spatial mapping; port city regions; survey-before-plan

Issue
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1. Introduction

Maps and mapping allow public and private stakeholders to understand spatial contexts, environmental changes, institutional settings, and cultural implications and to make informed decisions about future planning. Recent innovations involving big data, GIS-based research, and digital datasets offer new opportunities to use maps and mapping to gain a better understanding of spatial and cultural elements. They can facilitate interventions at a time of multiple transitions (energy, digital, technological) and provide a better foundation for future design.

Taking into account the new opportunities provided by GIS and digital datasets, this article proposes first steps towards a methodology that connects spatial and social mapping to gain a better understanding of economic, political, social, and cultural processes in port city regions at times of transition and to provide a foundation for contemporary planning. We posit that mapping can be used as a 'gap-finder' to provide insights into technological as well as socio-cultural development spurred by new technology and to identify opportunities and challenges for future (planning) interventions.

Few geo-spatial tools or research methods are designed to analyze and represent the palimpsest of spaces, social interactions, and cultural practices of cities and the evolution of particular processes over time. It is possible to access a great variety of maps and plans, written documents, and diverse visuals that document aspects of particular spaces and the social patterns of cities. A methodology is needed that complements quantitative assessments of economic and logistic aspects of a particular area and enables the analysis of spatial and cultural patterns (Hein & van Mil, 2019). Geo-spatial mapping can produce a better understanding of the historic transformations of urban settlements and their spatial, social, and cultural entanglements. Historical geo-spatial mapping can help us understand how people have changed cities and institutions over time and in conjunction with complex economic, political, social, and cultural transformations. It can serve as a methodology for transdisciplinary research helping spatial, social, and humanities scholars to consider both quantitative and qualitative aspects of life and work in a spatial context and it can serve planners and policy makers.

Although many planners have used mapping as a research method and have taken regional approaches, the proposed methodology is still in an early stage of development. This article first examines the power of maps and the shifting application of mapping as a tool for communication and understanding spaces. It argues that there is a long tradition that we can build upon. The use of mapping as a means to overlay different research approaches and to create a palimpsest of knowledge refers notably to the concept of survey-before-plan, an idea that was expounded a century ago by Patrick Geddes (Batey, 2018). This concept was further refined by Jacqueline Tyrwhitt in the 1950s and ever since it has continued to influence how plans are made. Following Geddes and Tyrwhitt, we raise questions about the appropriate scale of surveys and mapping and propose a scale that encompasses all relevant phenomena and that is not limited by administrative boundaries. With the increasing amount of digital data and the use of digital mapping techniques, survey-before-plan has taken on new meaning and promise. GIS, digital archives and datasets, Google Earth, Google Street View, and similar technologies provide many new possibilities to study and map large amounts of (spatial) data, at zoomable scales.

Historical socio-spatial mapping can be used to study any type of human settlement. We focus here on port city regions, which are paradigms of territories where complex global flows intersect. Many coastal cities worldwide still need to develop adaptation policies (Olazabal, Ruiz de Gopegui, Tompkins, Venner, & Smith, 2019) that are aligned with local conditions. Such planning requires coordination among stakeholders, including port authorities, city and regional governments, private and public actors, as well as NGOs and citizens. Effective plans will require a solid foundation and the identification of common values or a shared port city culture. International port city institutions, such as the AIVP (www.aivp.org/en) and RETE (http://retedigital.com/en), have long pleaded for the consideration of spatial and cultural factors in the analysis of port cities. To understand the challenges facing ports and cities today, we have to look beyond the physical and institutional borders of a port or a city or the challenges that occur on the border between them (often called the port-city interface; see also Hein & van Mil, 2019).

The economic development of ports and cities has always depended on their ability to reach into the foreland and hinterland. To understand processes of port and city growth and the interaction between ports and cities through the ages, we have to examine ports and cities at the scale in which they operate, here loosely called the region. For our pilot study, we have chosen three port city regions on which we have already worked and for which we have sufficient data. The port city region of the Western Netherlands, around the port of Rotterdam, serves as an example of the challenges and opportunities that large port city regions face world-wide. In our current area of investigation, Hamburg and London provide examples of other planning challenges for port city regions of past, present, and future. Each of these three case studies shows different historical interactions between port and city in the larger region. In our conclusion, we argue that historical geo-spatial mapping on different scales can facilitate transdisciplinary research and help bring lessons from the past to the attention of planners.

2. Mapping as a Historical Tool for Understanding, Communicating, and Designing

Knowledge is power, and mapping is a powerful tool for understanding landscapes and territories, spatial objects, and social relationships. Maps are select two-dimensional representations, defined in the *Encyclopedia Britannica* as "a graphic representation, drawn to scale and usually on a flat surface, of features—for example, geographical, geological, or geopolitical—of an area of the Earth or of any other celestial body" (Fuechsel, n.d.). Politicians, policy makers, and planners have used maps (and mapmakers) to extract and refine knowledge, to understand the physicality of the surface of the earth and man-made spaces and to prepare for military interventions. They have employed maps as pro-

paganda and they have used them to find routes over land and sea. Maps have served as foundations for new plans, urban designs, and other interventions. Cities in the Greek, Roman, and Chinese empires were built according to plans. Some landscapes, like those in the Netherlands, are largely man-made. Historic maps provide us with important insights on how decision makers of the past have conceptualized space. Digitized private and public map collections and geo-spatial tools have therefore gained importance for research and planning.

Mapping requires definitions of scale, time, and perspective. While this may be obvious, it is important to carefully conceptualize these elements as they can result in different planning approaches. Select types of mapping make it possible to explore neighborhoods, cities, land parts, or the course of rivers with different degrees of precision. The scale of mapping has usually been related directly to the realm of the commissioner of the map: Municipal leaders focused on their city and immediate territories, kings and nation-states would focus on their national realm. The interest of the commissioner also determined the availability of data and the scale of intervention. Just as the choice of a specific scale relates to the theme and narrative that the map-maker chooses, so does the selection of time or the choice of a theme.

To serve a multitude of stakeholders and to facilitate exchange, it is important to make careful decisions regarding scale, time, and detail of representation. These decisions must acknowledge a more mundane challenge that impacts mapping decisions: The usually rectangular proportions of the paper (or other material) on which the organic forms of natural and human-made spaces have been mapped impact the way in which maps transmit information (see Figure 1). Even in digital format, when zooming is possible, rectangular screens shape the perspective of the viewer. These decisions also have to acknowledge the variable reliability of maps. As Mark Monmonier (1996/2014) claims, maps lie because the choices that cartographers make—consciously or unconsciously—mean that a map is far from objective. To estimate the reliability of a map, it is important to know the function: Who is the cartographer or client and what was the purpose of the map? A map is first and foremost a tool of communication, and to understand a map we need to know both the supply side (the maker and client) and the demand side. We can only understand maps if we know what the cartographer wanted to show, to whom, and why. The purpose of the map determines the scale, the reliability, implementation, and content (Renes, 2016).

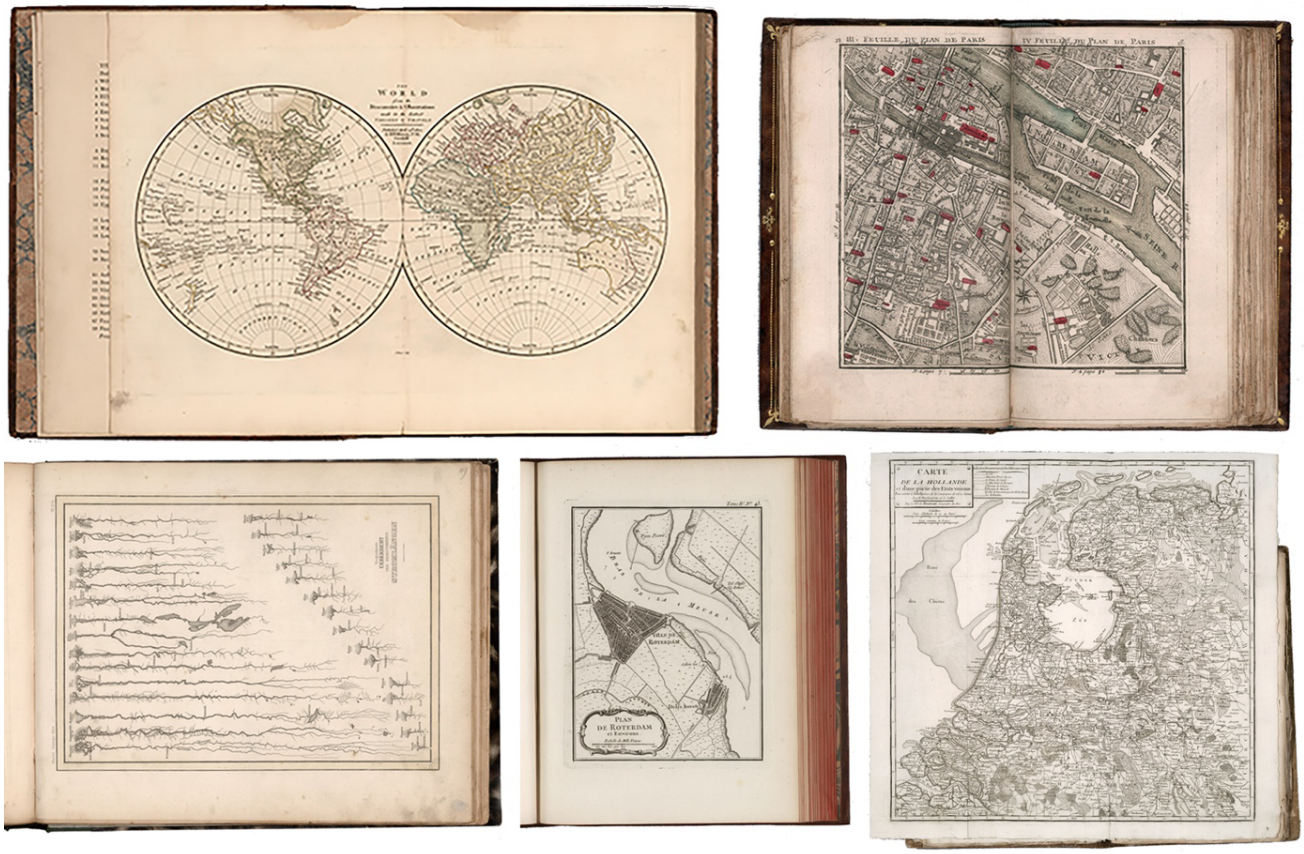

Figure 1. Examples of old maps. Top, from left to right: *The World from the Discoveries & Observations Made in the Latest Voyages & Travels* (Wilkinson, 1809); *IIIe. Feuille du Plan de Paris. IVe. Feuille du Plan de Paris* (Denis & Pasquier, 1765). Bottom, from left to right: *Vergleichende Uebersicht der bedeutendsten Stromlängen* (Meyer, 1852); *Plan de Rotterdam et Environs* (Bellin, 1764); *Carte de la Hollande et d'une Partie des Etats Voisins: Volume 2* (Grimoard & de Beaurain, 1672).

To facilitate discussions among different stakeholders and to bring together different perspectives, we propose mapping at a scale that helps identify challenges and opportunities in the fuzzy territories of overlapping spaces and institutions (Hein, 2019). Historical geospatial mapping can thus be used as what we call a 'gap-finder'—that is, as a tool to better understand transitional territories that often cross institutional boundaries without strong, mutually supportive governance frameworks, legal systems, and planning guidelines. The need for finding gaps has been recognized by other fields, such as traders and transit institutions as well as the Gapminder Foundation (www.gapminder.org); we apply it here to the fields of mapping and planning. We argue that the concept can enable the user to conceptualize spatial, institutional, or other boundaries imposed at a time when maps were only available as paper documents stored at local or national institutions. To understand and overcome choices made in the past in terms of scale, time, and perspective, it is important to think carefully about the continuities of conceptualization from historical maps to mapping using digitized historic data and interpretative geospatial analysis.

Opportunities for creating thematic, analytical maps of historic conditions have increased with digitization. Before the 19th century, map-makers mainly produced topographic and geographical maps. They tended to visualize forms on the surface of the earth as clearly and faithfully as possible. Only occasionally did they produce thematic maps, such as a map of yellow fever in New York published in 1790, one of the earliest experiments of social cartography (Vaughan, 2018). According to geographer and cartographer Arthur H. Robinson, in contrast to a general map, a thematic map concentrates:

> On showing the geographical occurrence and variation of a single phenomenon, or at most a very few. Instead of having as its primary function the display of the relative locations of a variety of different features, the pure thematic map focusses on the differences from place to place of one class of feature. The number of possible themes is nearly unlimited and ranges over the whole gamut of man's interest in the present and past physical, social, and economical world, from geology to religion, and from population to disease. (Robinson, 1982, p. 15)

Throughout the 19th century, cartographers used thematic maps to convey complex population statistics such as birth and death rates and on the spread of diseases and poverty within urban areas. Port cities were of particular interest because they were places where diseases were carried by ships and sites of rapid population growth, as exemplified by maps of London, New York, and Amsterdam, such as the *Map Showing the Spread of Cholera and the Number of Deaths from this Disease in Each of the 50 Neighborhoods of Amsterdam*, by Isaac Teixeira de Mattos (1866), and *Sanitary & Topographical Map of the City and Island of New York*, prepared for the Council of Hygiene and Public Health of the Citizens Association, under the direction of topographical engineer Egbert L. Viele (1865). In the Great Britain of the 19th century, the negative urban impacts of industrialization led to the emergence of social reformers who based their work on urban research. The social reformer Charles Booth produced street maps that revealed extreme contrasts of wealth and poverty in London (Figure 2). Fast-growing cities became the focus of attention for planning, with maps and statistical data for surveying and tabulating the 'uncharted' territories within urban settlements serving as evidence for the need for improvement and the starting point for urban planning (Vaughan, 2018).

As urban planning became a profession in the late 19th and early 20th century, mapping as a way of studying urban regions emerged as a scientific discipline. It became a way to systematically combine spatial and social data and to uncover health issues, social problems, or land use challenges. These uses of mapping developed hand in hand with the professionalization of urban and spatial planning (Hein, 2018). The added value of mapping for planning was aptly described by architect Jack Whittle:

> An important characteristic of a map is the facility it offers for locating, defining and describing some features of an area. By means of a map, fact (i.e., survey data) and ideas (or proposal for future use) can immediately related to the site they cover. Information, which in tabular form is not visually attached to any one piece of land, can be added to the map by using colors or symbols drawn on the appropriate part of the map, thus intergrading the information with the area involved. Map making, therefore, has become an indispensable part of planning technique. (Whittle, 1950, p. 540)

3. Geospatial Mapping Based on Geddes and Tyrwhitt

One of the most important developments for the application of mapping in urban planning was the introduction of survey-before-plan by Scottish biologist and pioneer of urban planning Patrick Geddes (1854–1932). Planners steadily improved their mapping methods and used maps for analysis and presentations. The 1950s saw the emergence of scientific principles of collecting and mapping data. In 1950, Tyrwhitt published her research and mapping method—based on Geddes' survey-before-plan—in the Association for Planning and Regional Reconstruction's (APRR) *Town and Country Planning Textbook* (see Tyrwhitt, 1950b). Here she introduced her overlaying technique, which became the foundation for the integrating and analytical capacities of geographical information systems (Nijhuis, 2015; Shoshkes, 2006, 2016).

Tyrwhitt was the first to describe the overlaying technique in an academic setting and two decades later

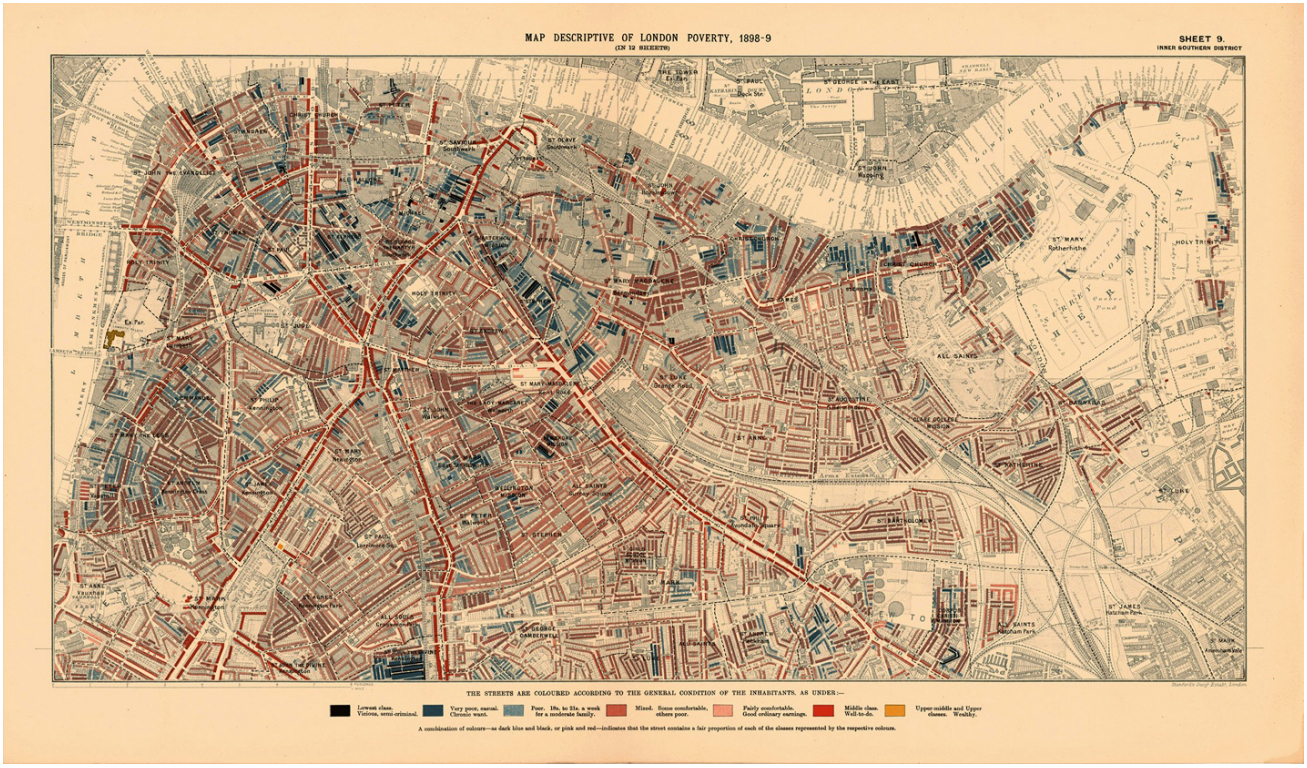

Figure 2. Example of a thematic map of poverty in south-east London: *Map Descriptive of London Poverty, 1898–1899. Sheet 9. Inner Southern District* (Booth, 1898). © 2016 London School of Economics and Political Science.

the technique became widely adopted in Britain and became a standard feature of the ecological planning method as taught and practiced in the Department of Landscape Architecture and Regional Planning at the University of Pennsylvania, in the United States, where Ian L. McHarg was Chairman (Nijhuis, 2015; Shoshkes, 2006). American landscape architects Philip H. Lewis and Ian McHarg applied it to a project in Delmarva in 1967. This was the first urban planning project which applied computer-generated maps, databases and digital overlaying techniques using a computer-based information system (Nijhuis, 2015). Tyrwhitt explained her method of conducting a planning survey based on Geddes' survey-before-plan in the APRR textbook. As starting point of the survey, Tyrwhitt called for an overall view of the physical setting of the community, mapping the important natural and man-made features. She described "what to look at" (the geography and the use of land), "what to analyze" (the people, where people are and how they move around) and how to get a general appraisal of how the community makes its living and the character and quality of life. In addition, she explained which resources to explore for planning, including documentary material like maps, plans, reports, statistics, and other sources of information needed for making the survey (Tyrwhitt, 1950b, pp. 150–153). Tyrwhitt relied mainly on national sources such as Ordnance Survey maps, geological survey sheets, land utilization surveys, census reports on country volumes, and parish tables.

Tyrwhitt made a number of key statements that have inspired our proposal for using mapping as a 'gap-finder.' She drew special attention to gaps in research data required for planning: "In some localities much of the preliminary planning will already have been done, and the problem will be to discover the gaps and achieve a balanced programme" (Tyrwhitt, 1950b, pp. 149, 177). We have built on this notion to create the term 'gap-finder.' She argued for a careful choice of the area of intervention, going beyond administrative borders. Tyrwhitt wrote:

> From the first preliminary survey and analysis it should be possible to decide tentatively the physical area to be planned for. The limits of this area are not to be confused with the corporate limits of a central city; surrounding urban areas that appear to be tied economically and socially should be included. (Tyrwhitt, 1950b, pp. 153–154)

She emphasized that "generally the survey should not be restricted to the local administrative boundaries, which seldom express geographical or social realities" (Tyrwhitt, 1950b, p. 161). Using predetermined, often historical, administrative boundaries does not help us understand urban regions. Tyrwhitt did not define the concept of the region herself but quoted the 1942 statement of Spanish architect Jose Luis Sert:

> Town and country merge into one another and are elements of what may be called a regional unit. Every city forms part of a geographical, economic, social, cultural and political region, upon which its development

> depends. Towns or cities cannot in consequence be studies apart from their region which constitute their natural limits and environment….The city should be examined in the economic ensemble of its region of influence. A plan of the economic unit, the 'city region' in its totality, must therefore replace the simple city plan of today. (Sert, 1944, pp. 246–249; Tyrwhitt, 1950a, p. 140)

Questions of scale and representation are addressed throughout the chapters in the textbook, each written by a specialist. In the district survey, Tyrwhitt introduces her method for making maps. She shows a series of twelve maps on a scale of 1:25.000 (Figure 3). Tyrwhitt uses a black and white presentation technique and transparent paper. She emphasizes that the whole series of maps must be drawn to the same scale, and on each map, she uses the river line as a general feature to act as guide, so that a viewer could readily relate places throughout the series (Tyrwhitt, 1950b, pp. 162–174). She writes:

> As far as possible maps should be drawn on transparent paper, so that when completed the maps to the same scale can be 'sieved'—i.e., placed one on top of another in turn so that correlations or their absence can be noted. (Tyrwhitt, 1950b, p. 157)

Tyrwhitt did not discuss the choice of scale. Instead, the architect Jack Whittle provided three main considerations for choosing the right scale in his contribution to the *Town and Country Planning Textbook*. He argued that planners should: 1) use the smallest scale at which it is possible to illustrate clearly the problem or proposals involved; 2) choose the detail of the base map so that it relates in scale to the detail of the information to be mapped; and 3) not confuse the scale used for analyzing with those for presenting (Whittle, 1950, p. 544).

The use of these transparent thematic maps anticipates the introduction of GIS. GIS based geo-spatial mapping allows us to provide a standardized basis for comparison and to adapt both representation and scale. We are also building on the work of Steffen Nijhuis and Han Meyer, from TU Delft, who produced a GIS based analysis of urbanized delta regions that can be considered a research method for studying deltas around the world (Meyer & Nijhuis, 2014), and we are building on existing comparative methodologies for analyzing port cities and port-city relationships (Andrade, Costa, & Blasco López, 2020; Guo, Qin, Du, & Han, 2020; Monios, Bergqvist, & Woxenius, 2018; Schipper, Vreugdenhil, & de Jong, 2017). To investigate and better understand the complex data of port city regions, we are proposing a research methodology based on historical geo-spatial mapping that brings Tyrwhitt's methods to the era of GIS and uses a shared method and shared definitions for scale, time, and perspective.

4. Digitization in Mapping and Design

Since the beginning of the 20th century, mapping has come to play an increasingly important role in the planning process, as evidenced by the APRR textbook where several chapters are dedicated to mapping and map-based survey methods. The introduction of GIS in the 1970s facilitated the use of overlaying techniques as a method for evaluating landscape change and the future impact of planning alternatives (Nijhuis, 2015). However, despite the benefits geospatial mapping offers for understanding and planning, urban and planning historians who study such inherently spatial topics as migration, segregation, gentrification, and suburbanization tend to rely on historical maps, rather than using interpretative geo-spatial mapping, to illustrate their findings. They only occasionally use GIS as a research method for analyz-

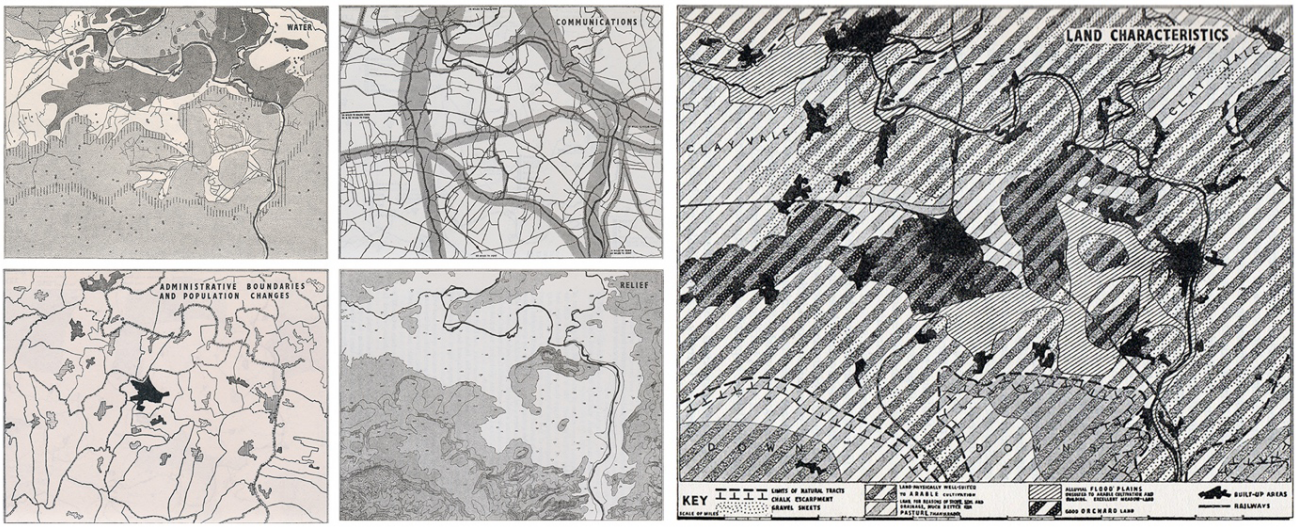

Figure 3. Example used by Tyrwhitt to explain the overlaying technique as a tool for research. Thematic maps on water, communications (infrastructure), administrative boundaries, population changes, etc., resulting in a synthesis map pointing out the characteristics of the landscape. Source: Tyrwhitt (1950b).

ing spatial patterns (Hillier, 2010). More explicit attention to the spatial nature of social and cultural topics and their interaction through the use of GIS based historical mapping can provide a better foundation for planners who need to understand the forces that have shaped cities and landscapes before they propose new interventions (Figure 4).

According to Professor of Digital Humanities Ian Gregory and human geographer Alistair Geddes, there are four main advantages to using GIS in historical research: 1) GIS structures data that allows them to be discovered and explored in ways that are explicitly spatial; 2) it allows data to be visualized using mapping and other approaches; 3) it allows the data to be analyzed in ways that are explicitly spatial; and 4) has the ability to integrate data from a wide range of apparently incompatible sources (Gregory & Geddes, 2014). In addition to the four benefits that Gregory and Geddes mention, GIS allows researchers to compare various data on multiple scale levels. Some prominent examples of the benefits of geospatial historic mapping exist, notably, the work of the American historian David Bodenhamer, who popularized the concept of deep maps as a way for humanists to take full advantage of the spatial dimension of the discipline (Bodenhamer, Harris, & Corrigan, 2015). Deep maps—a term coined by William Least Heat-Moon in 1991—are detailed representations of a place and the people, buildings, objects, flora, and fauna that are present there and part of the activities of daily life. To make such maps, we have to carefully reflect on issues of representation and scale.

The increased availability of digital data and the use of digital mapping techniques gives new meaning to Tyrwhitt's research method. Historic geo-spatial mapping facilitates the research method of survey-before-plan and allows us to make use of the time-intensive traditional methods of historians and planners, such as archival research, local observation or interviews. Tyrwhitt's research method—based on spatial mapping—can serve as foundation for setting up a research methodology for comparative spatial research. Digitization has increased the number of sources considerably and allows for combining historical data with new scalable maps. Historical maps are not necessarily accurate and interpretation is needed to link them to GIS coordinates. A major challenge for geo-spatial mapping is selecting reliable sources and interpreting them. Tyrwhitt built her research method on the more limited data available to her at the time: historical archives, (air)photos, physical maps, and her own observations. Gathering data from space remained a matter of hopeful thinking. She wrote in 1950: "To obtain a bird's eye view of the ex-

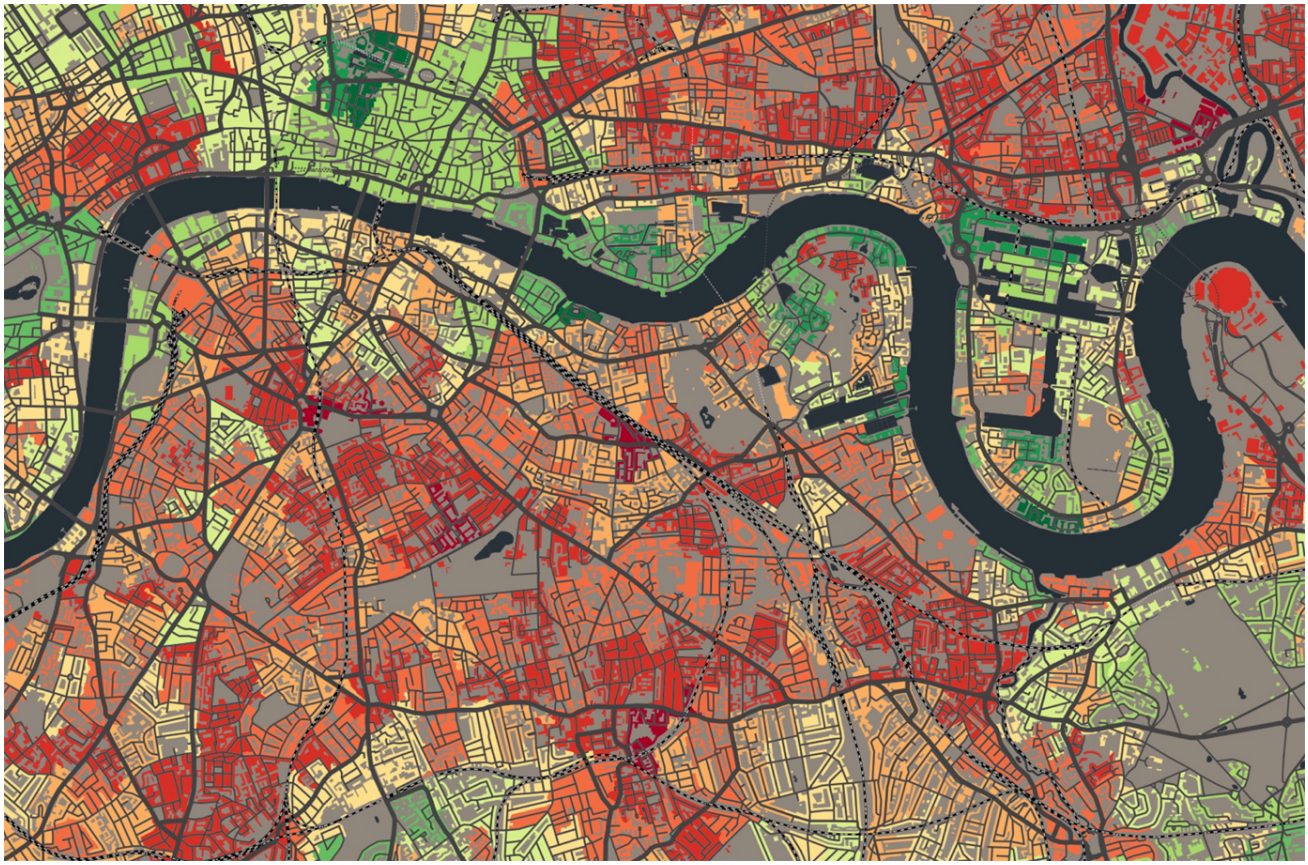

Figure 4. Example of a thematic map of south-east London showing the index of multiple deprivation from 2019 ratings in GIS. Most deprived decile in red, through orange and yellow through to light green and dark green for least deprived decile. Source: Oliver O'Brien & Consumer Data Research Centre (n.d). © Crown copyright right 2014–06.

isting pattern of physical conditions, an airplane flight could be made, or aerial photographs studied" (Tyrwhitt, 1950b, p. 149).

The use of GIS allows us to create a palimpsest from the diverse information embedded in historic maps of different provenance and to stitch these maps together using GIS. It also provides us with a unique opportunity to connect spatial maps with other quantitative and qualitative socio-spatial data. As a result, we can gain new insights into historical processes that have shaped the landscape. We can also visualize areas that have received more attention than others: For example, urban areas may have been depicted more often than rural ones. GIS based geo-spatial mapping can even serve as a foundation for the analysis and linkage of representations such as paintings, photographs, or postcards. The opportunities of GIS based geo-spatial mapping can help us overcome one key challenge of historical mapping—that of the choice of scale.

As Nijhuis stressed in his dissertation on GIS-based landscape design research:

> The computer and software cannot make sense of data without the expertise of the user. This implies that results of using GIS not only depend on the GIS-skills of the design researcher, but also depends on the research focus (what is researched) and the research methods used (how it is researched), and both in relation to the discipline involved. (Nijhuis, 2015, p. 59)

GIS as a tool makes spatial mapping and overlaying data more powerful. But using historical geo-spatial mapping as a way to study requires multiple steps of decision-making. These steps include identifying and mapping the most relevant data, defining the right scales and detail level for the maps and finding and interpreting reliable (historical) sources.

5. Setting Up a Methodology for Mapping Port City Regions

To gain an initial sense of how such mapping can function as a gap-finder, we have started to build on existing research and to develop a methodology for comparative historical geo-spatial investigation. We are specifically focusing on port cities because they exemplify complex spatial development, long-term investments, intersecting institutional realms, and overlapping flows of goods, people, and ideas. Port cities have experienced multiple transitions through time and they have historically demonstrated a special capacity for bouncing back after crises. Their traditional resilience can hold lessons for other urban areas (Hein, in press). Port city regions share many of these characteristics with other cities, but their location at the intersection of water and land and their dependence on shipping make them a particular type of space and one that is especially vulnerable. As trade centers, port city regions have long been spaces of human and technological innovation and urban development. As economic and transportation hubs, they are home to large infrastructures, energy storage and production, as well as industrial and trade clusters. For thousands of years and around the globe, people have adapted these spaces to accommodate shipping and to defend against major crises. Historically, such collaborations are a trademark of port cities around the world, their public and private stakeholders displaying great capacity for overcoming challenges.

The next section presents some preliminary ideas about decisions that need to be made concerning the use of historical geo-spatial mapping for port city regions. It identifies challenges and opportunities related to available historical data, choices of time, scale, and decisions regarding data layers. We focus on the long-term development of port regions, from urbanization to present, and include several nation-states. Through geo-spatial mapping we aim to better understand the multiple ways in which urban regions and their institutions operate. We also hope to develop a foundation for planning. To use historical geo-spatial mapping as a 'gap-finder' we need to identify the scale where challenges and opportunities become visible. This scale, however, is one that changes over time and through space. In the context of port cities, it is one that reflects the larger impact of port and city practices and their relation to the region. Each scale has its own reasons for investigation. Some scales have been used more extensively, notably ones that depend on specific institutions. The scales of ports and cities within their administrative territories are often represented. These scales do not show the full area where port activities leave their footprint.

To better demonstrate the potential role of mapping in re-conceptualizing the spatial and institutional dimension of port connections and to identify places of conflict and opportunity, we will focus here on the scale of the port city region. We define region here as a fuzzy territory of port-related flows of goods, people, and ideas that cross institutional boundaries without strong, mutually supportive governance frameworks, legal systems, and planning guidelines (Hein, 2019). Ultimately port networks are global, but to make their impact meaningful on a spatial scale, we have chosen a scale where port-related functions are concentrated and a scale at which borders between water and land, infrastructures, land use, and institutional borders are visible. Politicians, planners, and researchers often grapple with this particular space. Such a scale helps us better understand how multi-scalar markets and global value chains leave their imprint on the spaces of the port and on neighboring urban and rural territories, and it demonstrates that stakeholders in these areas are multiple and pursue different goals and functions.

Using ongoing research by the Chair of the History of Architecture and Urban Planning at TU Delft and the Leiden Delft Erasmus PortCityFutures program as a start-

ing point, we are proposing to focus on a shared body of water—the North Sea—as the foundation for a comparative research program (Figure 5). This focus allows us to establish and test the first steps towards a methodology for historical and spatial analysis through a comparative investigation of the interactions between port, city, and hinterland in three river-based port city regions around the North Sea: The Nieuwe Waterweg in the Netherlands, the Thames in the UK, and the Elbe in Germany. These port city regions are much larger than the cities situated near the ports of Rotterdam, London, and Hamburg. The area near the Nieuwe Waterweg covers the entire Randstad, including Amsterdam, Rotterdam, The Hague, Zoetermeer, and Utrecht. Together with Bremen and Bremerhaven, Hamburg forms the port city region of Elbe. The port of London has largely moved outside the historic city walls, but the decision-makers have remained in the city, creating a huge port city region. For a close analysis of the three case studies, we collected similar types of historical maps for each of the three cities. We geo-referenced this information and overlaid it with generic data on natural and man-made features and governance patterns.

5.1. Defining the Right Time and Scale Levels

Decisions on the selection of a specific scale, time, and perspective have to be made based on careful analysis. The scale of an object of study is important, because the choice of an area larger than the study area supposes the availability of additional data. But any smaller size than that of the smallest detail supposes additional knowledge and data as well (de Jong, 2007). GIS makes it possible to view data on various scale levels, but scale is not only related to the area of study, but also to time. The discussion of different temporalities between port and city is an important one that has been discussed elsewhere (Hein, 2016). Identifying the appropriate time period to represent in a map in relation to space allows us to capture key changes and path dependencies (Figures 6 and 7). We have chosen to start our case study in 1300, when the Hanseatic League helped sustain the urban development of cities around the North Sea. We then use steps of 200 years to capture major social, geo-political, or economic changes, such as the Golden Age, starting in Flanders in the 15th century, shifting to Holland in the 17th century, and to England in the 18th century. We add

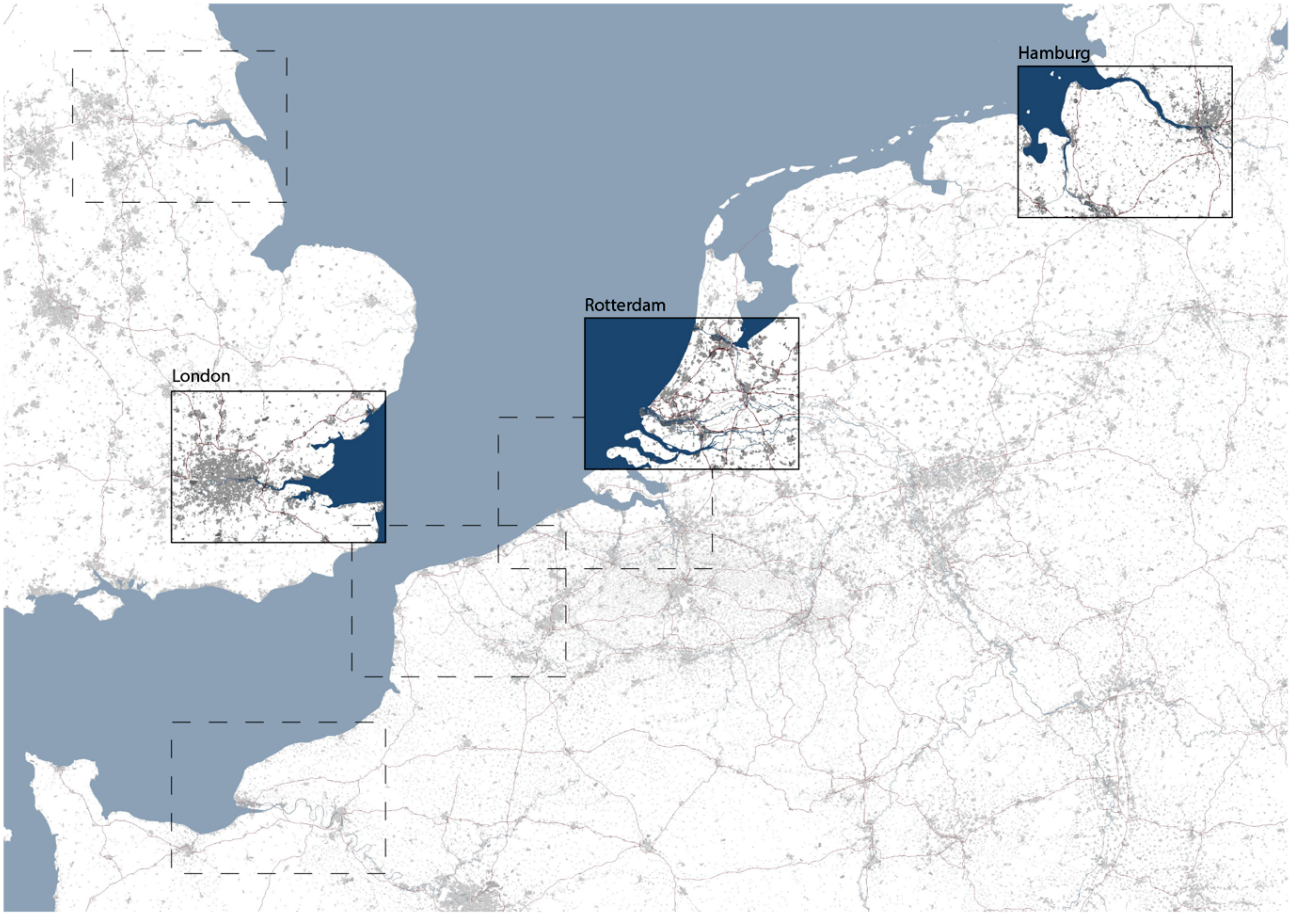

Figure 5. Research areas of the North Sea studied by the Chair of the History of Architecture and Urban Planning, with the case study of London, Hamburg, and Rotterdam highlighted and other potential case studies framed with a dashed line. Map by Yvonne van Mil based on Global Administrative Boundaries (2018), CORINE Land Cover (2016) and EuroGlobalMap (2017).

more detailed information through steps of 50 years starting with the industrial revolution, when the introduction of new technologies, political systems, new insights on health and legislation on housing and urban planning spurred numerous transitions in cities. These are represented through the years 1850, 1900, 1950, 1990, and 2020. When we consider a port city as part of a larger system—the region—we need to understand the economic, infrastructural, and social scale on which port cities operate.

At the onset of this process, we need to define the scales for maps that capture the relationship between port cities and their respective region. The relationship between the size of a port, the size of the metropolitan area, and its location in relation to the hinterland has changed over time. A scale of 1:10.000 captures the interaction of ports and cities in medieval cities, but by 1700 we need a scale of 1:25.000 to depict port and city and its immediate hinterland. As a result of urban growth and new defense infrastructure as well as bigger ships and increased shipping, the footprint of the port and the city has increased extensively. The individual locations' responses to these changes may be different, but their scalar impact is similar: all of them grow tremendously. To capture and compare the temporal and spatial dimension of the case studies in the years 1900 and 2020 a much smaller scale, showing a bigger area and less detail, is required. In the case of Rotterdam, Hamburg, and London, it is necessary to analyze them not only at the scale of the city at 1:10 thousand or 1:25 thousand, but also on a regional scale at 1:100 000 and 1:150 000. For a comparative study of the port city regions we need a scale of 1:500 000. Analyzing port, city, and region interaction at all of these scales is important, as it helps us identify relevant gaps.

5.2. Identifying Relevant Data Layers

The effectiveness of a map is a result of selectivity, but before selecting or determining data, it is important to acknowledge the purpose of the map in order to select the necessary information. Port city regions are the result of the combined action of both natural and human factors, the local geography, the water system, or the soil conditions on the one hand, and the investment in coastal protection, port and hinterland infrastructure, or in administrative centers on the other. In contrast to natural features, man-made features are more subject to change over time, as they are created and adapted to people's needs. For this reconnaissance we focus on man-made features and we have limited categories of land use to industrial areas, port areas, built-up areas, and densely built-up areas (city center). The density, spatial distribution, and physical characteristics of urban settlements are important drivers of social and environmental changes at multiple scales, and therefore crucial for our research. Infrastructure networks, such as transport networks over water, land, and rail, as well as bridges, dykes and defense systems are another important factor, creating conditions for settlements, economic activities, and mobility. We present the urban morphology in an abstract form, so that the level of detail matches the scale level and the available historical knowledge.

Showing administrative or political boundaries for several nation-states over time is a challenge because each country and each time period uses its own definitions and administrative units. Therefore, it is important to establish shared definitions. To avoid incompatibility issues across incomparable administrative definitions, we adopted hierarchies of categories. We distinguish three categories for political boundaries: Level 1, or the national level, is a recognized independent state (republic or kingdom); level 2, or the regional level, is the intermediate layer (province, region, or county); and level 3, or the local level, is the local government (municipalities or city). Consistent with Tyrwhitt's approach, our research first involves a general reconnaissance, mapping the important physical setting of the port city regions. The estuaries of the Nieuwe Waterweg, the Thames, and the Elbe are the most important element in the region and therefore the general feature or key element on all maps.

5.3. Finding and Interpreting (Historical) Sources

One of the biggest challenges in establishing a meaningful methodology for analyzing different geographical regions through time and space involves the availability and quality of (historical) data and sources. The scale of analysis for geo-historical mapping often does not align with the details that are documented. For example, even though information may exist at an urban scale, the same information may be absent at a regional scale or only available at a different time or in a different format, such as written sources. Since we study port regions around the North Sea, it is important to find datasets that cover several nation-states with sufficient spatial resolution to analyze and compare the regions in a consistent and systematic way. Global and continental datasets on transport networks, land use, soil, and elevation are suitable for beginning a systematic comparison. After selecting and preparing these datasets, to obtain the required maps, new data sets must be generated for the earlier periods. From the 19th century onwards, changes in the (urban) landscape can be mapped on the basis of regularly updated national topographic maps, such as Ordnance Survey maps. These topographic maps can serve as a starting point for research farther back in time.

For the period before 1850, finding reliable sources is much more difficult, especially for the region. Urban areas are often better documented than rural ones. Some historical empires, like Rome or China, produced reliable maps early on, but for most of the cities around the North Sea, reliable information is available only beginning in the 16th century. Early plans that exist are often reconstructions, that is, maps made centuries later, ac-

cording to ideas of what the city may have looked like. An example is the *Plan of London about 1300* by William R. Shepherd in 1926. In the absence of better sources, these reconstructions can be used to obtain an impression of the city around 1300. The first reliable maps of the area are available from 1500 onwards, such as the city maps of Braun and Hogenberg and Jacob van Deventer.

To get a better understanding of the appropriate time, scale, and perspective to study port city regions, we posit that there are three potential approaches exemplified in Figure 6. The horizontal approach shows different scales for one city in one time period. This scale can allow us, for example, to see how far the port network reached into the hinterland and to compare port city systems such as the Hanseatic League or the British Empire. The vertical approach shows the historical development of a select space at the same scale level. Such an approach shows how what used to be a major part of a multifunctional port city of 1300 has now developed into a revitalized waterfront. Both the horizontal 'scalar' and the vertical 'temporal' approach provide specific aspects to study port city regions over time. To study the interaction between port and city over time and to acknowledge the scalar change through time, we choose the diagonal approach, where scale levels change over time.

The diagonal approach, which we have chosen as a foundation for our research, allows us to make a comparative study of the spatial development of the three case studies to understand how port and city relationships have changed in terms of functionality, size, and location of the port in the city (Figure 7). The overview notably includes infrastructure, land use, and institutional borders. As a result, we can see that while port and city were always closely spatially and institutionally connected, the relationship between port and city did not always have the same balance in the three cities.

The port was the driver for the emergence of the city of Rotterdam in 1300. Port activities have led the development of the city and municipal expansion followed the expansion of port territories. The Port of Rotterdam continues to hold a leading role in the development of the region today. Many of the higher-level urban functions linked to the port, such as the location of headquarters, have been 'outsourced' to neighboring cities in the Randstad. Meanwhile, in the case of London, the economic functions of the city have taken the lead in the relation between port and city. After a period of port expansion based on private funding, evidenced first in the growth of the docklands and more recently in the move of port functions to Tilbury, the restraints of the urban context led private players to move first beyond the borders of the city and then those of the larger London region. The case of Hamburg shows a situation where port and city have remained intertwined and have been governed together. As the city grew, so did the port. In 1937, Hamburg incorporated the ports of Altona and Harburg to become a large urban port city region with shipping, port, and administrative capacities (Hein & Schubert, in press). Based on these maps, we can posit that a city in the vicinity of a port benefits from having control over the port's space and development for environmental, social, and safety reasons. A better understanding of the temporal and scalar development of port city regions from a comparative perspective and of the intersection

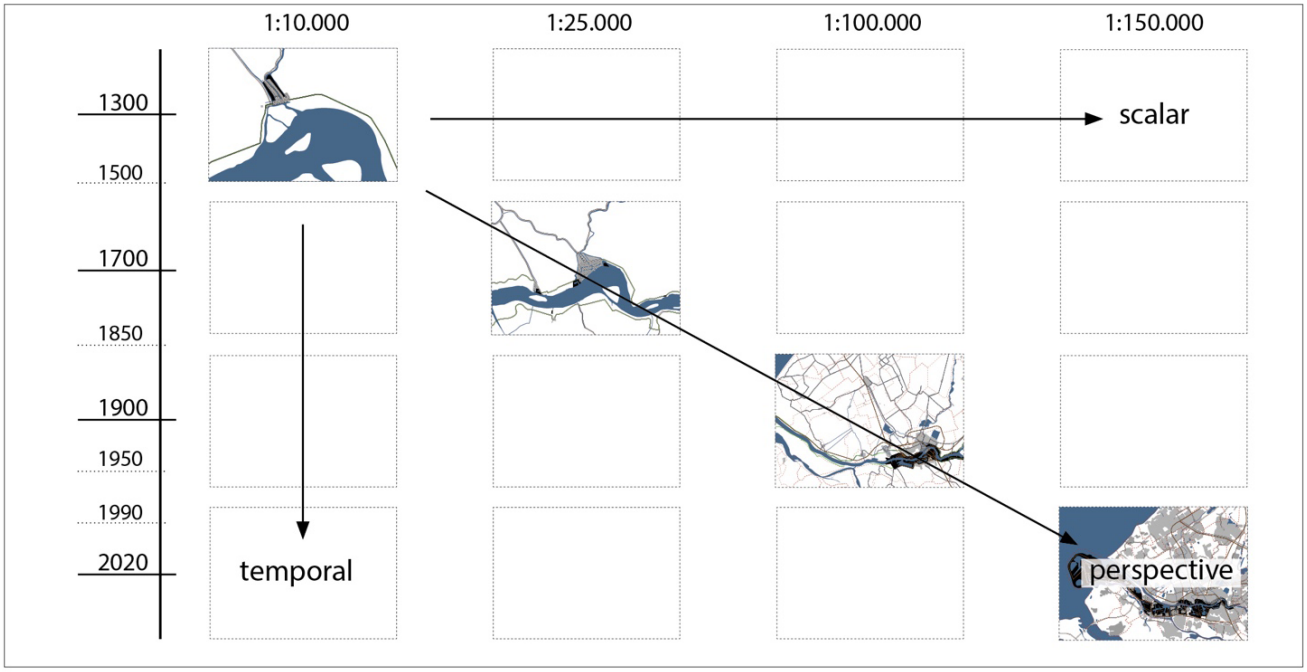

Figure 6. Conceptualization of different approaches to historical geo-spatial mapping and their usefulness for particular disciplinary approaches or questions. Figure by Carola Hein, Yvonne van Mil, Blanka Borbely, and Batuhan Özaltu based on Global Administrative Boundaries (2018) CORINE Land Cover (2016) and EuroGlobalMap (2017).

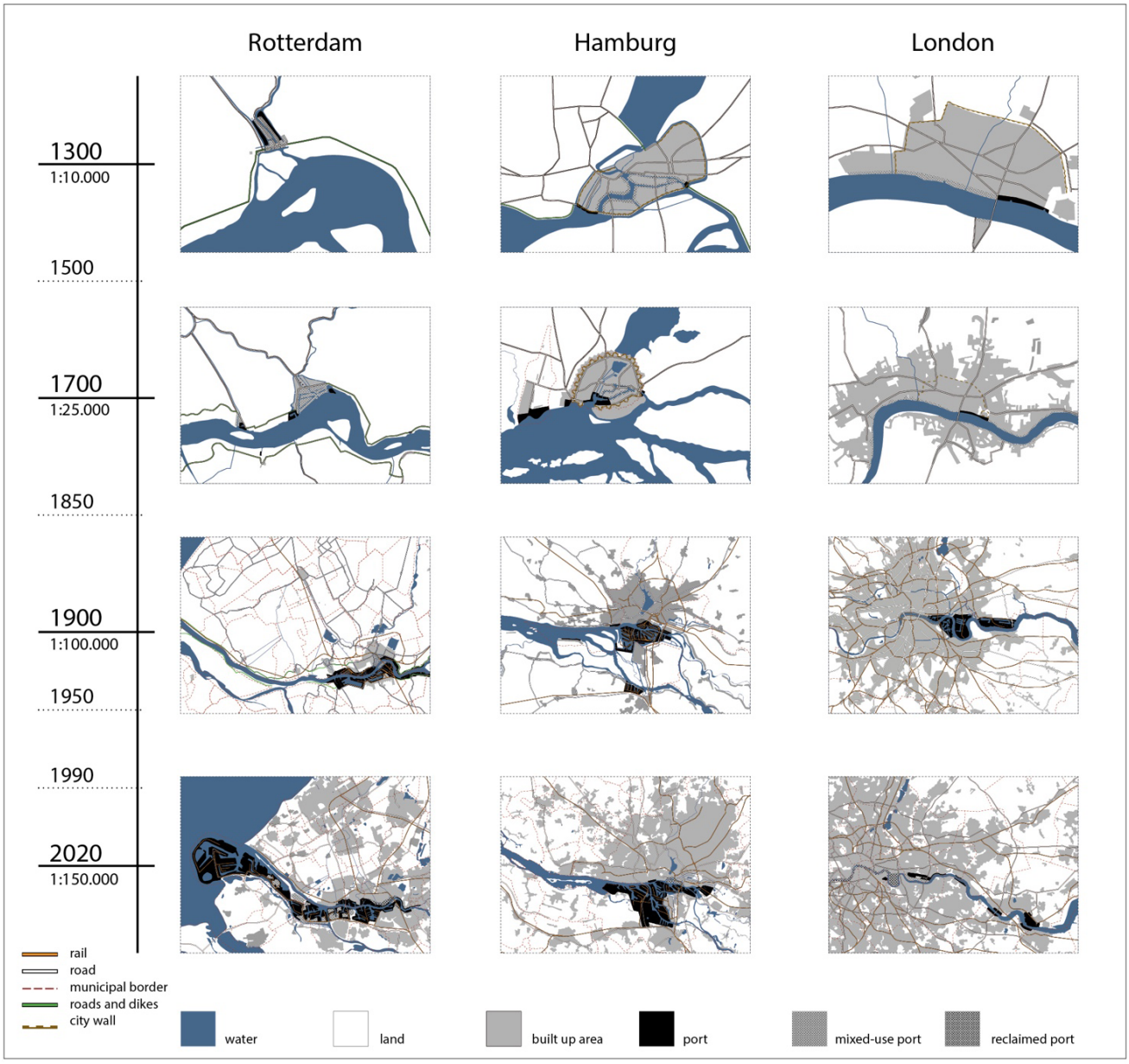

Figure 7. First draft for comparative geo-spatial mapping methodology, with case study of London, Hamburg, and Rotterdam. Figure by Carola Hein, Yvonne van Mil, Blanka Borbely, and Batuhan Özaltun based on Global Administrative Boundaries (2018) CORINE Land Cover (2016) and EuroGlobalMap (2017).

between spatial and social development can inspire better planning for port city regions. For example, one might argue that Rotterdam's striving to increase its standing in the ranking of Maritime Capitals (Späth, 2019) and to catch up with Hamburg would entail a closer collaboration among port and city stakeholders.

6. Conclusion: Mapping as Gap-Finder

The reflections on mapping and the role of scale, time, and perspectives presented here provide initial insights into the role of historical geo-spatial research on port city regions from a comparative perspective based on the analysis of complex patterns and multiple scales of spatial, social, and cultural transformations. A close analysis of three case study port city regions, the spaces of water and land, of port and city, of built environment and governance, allows us to reflect on the spatial and institutional impact due to the emergence of new technologies, new commodities, larger ships, building technologies, and mobilities. The time periods chosen give insight into the forerunners and followers in their response to these changes. Providing a standardized approach can provide a deeper understanding of how and why contemporary spaces, institutions and cultures emerged, it can also provide a thorough foundation for future-oriented planning. The different scales chosen for our mapping indicate the need to go beyond the scale of the city and to

study port city regions. Using a temporal or a scalar approach can be attractive to specific disciplines. Historians may benefit from a standardized approach for the thorough study of one place or for the comparative investigation of, for example, historic shipping patterns, ports, and regional development. Planners may benefit from a deep historical analysis of a small site, such as a waterfront, a warehouse district, or office area. The diagonal approach that we have followed allows us to explore the changing port-city relationship in a larger context over time.

Many steps still need to be taken to establish a thorough methodology for comparative longitudinal research on port-city-region relationships. We have started to reflect on the analytical foundation for using historical geo-spatial mapping as a 'gap-finder.' In the long term, such a methodology can help identify opportunities and challenges by exposing spatial and institutional developments that require increased attention from planners. A close analysis of the historic transformation of the built environment (land use, land ownership, infrastructures), the development of institutional structures (municipal boundaries) and the narrative that accompanies them (as embedded in maps and plans) through historical geo-spatial mapping can facilitate the identification of 'gaps,' where spatial, institutional, or cultural opportunities and challenges exist. Such an understanding can provide novel insights into the conditions and complexity of multiple transitions and provide a better foundation for future design.

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Conflict of Interests

The authors declare no conflict of interests.

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Commentary

Palimpsest Metaphor: Figures and Spaces of the Contemporary Project

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Abstract
What are the consequences of the use of the palimpsest metaphor on the construction of the contemporary project? The metaphor casts criticism on the modern project and opens to the long-term (*longue durée*). The investigation of territorial rationalities brings to the fore these temporal dimensions and the organizational structures of space. Understanding territorial rationalities is inescapable to define the basis of any exploration of the future of territorial, urban-rural configurations. The metaphor of the palimpsest alludes to the meeting/clash between different times, endless modifications and transformations. Until the use of the support is not so serious as to question its very existence, directions, dynamics and, at times, fortuitous encounters interweave on its shriveled skin; forms of power and violence are measured there, which, in turn, will generate new conflicts. "Unintentional monuments" are places where this intensity of pure overlapping disconnected intentions become monumental and the substance of a project, revealing, celebrating and exposing their landscapes, as episodes of collective human and environmental history. The palimpsest as a figure in the contemporary project is not only a criticism of the modern space, but the expression of a change of direction in the design activity, of its social role and of the theories intended to support it: Design space in the second degree.

Keywords
contemporary project; landscape design; *longue durée*; palimpsest; territorial rationality; urban and territorial design

Issue
This commentary is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

1. Introduction

There is great convergence on the figure of the palimpsest. Architects, urban planners, landscape designers, sociologists and naturally historians of the city all seem to agree on the usefulness of the metaphor of the territory as a palimpsest. But what are the consequences of the use of this metaphor on the construction of the contemporary project?

André Corboz's article "Le Territoire Comme Palimpseste" (Corboz, 1983) starts with a clear criticism of the *tabula rasa* of the modern project, in which the territory has no form or resistance; it does not need to be known or described, as the project will inevitably be strong enough to incorporate and rethink everything. Corboz belongs to that set of scholars and intellectuals who achieved detachment from the modernity of the *grands récits*, the death of which was celebrated by Francois Lyotard (1979) in *La Condition Postmoderne. Rapport sur le Savoir*, published just a few years before « Le Territoire Comme Palimpseste. » The Genevan scholar expressed there his crisis of confidence in an organizing, centralized and pervasive rationality. The metaphor of the palimpsest calls into question and radically denies the *tabula rasa* as an operating field on which the project unfolds.

2. Territorial Rationality

As stated by Corboz (1983, p. 16), 'le territoire n'est pas une donnée': The territory is the result of a construction. The palimpsest intercepts it as an accumulation of physical and mental objects, theories, value systems and rationality that are not always consistent with

each other. Together with the palimpsest, André Corboz took up the theme of the *longue durée* (long-term), introduced by Fernand Braudel who, from the 1920s, pondered the construction of a history of the Mediterranean (Braudel, 1949).

Taken prisoner on the Maginot line in 1941 and locked up in Mainz where he remained for five years, Braudel laid out and developed his positions on the *Annales* school and his long archive research within the hypothesis of a history placed outside of the events, a "repetitive" and "immobile" history. The *longue durée* represents the structure of history (Braudel, 1986). If there is a structure of signs reported in the territorial palimpsest, it is that defined by the *longue durée* which traces geometries of reference, horizons of meaning over the long-term, and reveals rationalities that do not perish—even if their material manifestations may appear incomplete or, in places, patchy. This structure sets the bounds for episodic, non-repetitive traces of the history of events that are set to disappear or become confused with others.

The metaphor of the palimpsest therefore casts criticism on the modern project and is open to the long-term and the *longue durée*, the idea of the territory as a place of slow and repetitive accumulation, a stratified space. It is interesting to note how this hypothesis formed in a scholar like André Corboz who did not believe in strong specializations. He was a hybrid researcher and self-professed historian who became an expert on each new theme he studied, acquiring an interdisciplinarity entirely unique to himself and omnivorous knowledge that, through his efforts, managed to highlight relationships invisible to most (Viganò, 1998), generating real transdisciplinary knowledge. Against specialization but not against vertical in-depth analysis, Corboz focused his research on the formulation of the hypothesis, an aspect that structures the entire path, without stiffening it, as the hypothesis is shaped by the research itself which, while it is being carried out, rewrites and updates it.

The long research on the territory of the Venetian "diffuse city" (Figure 1) we carried out in the last decades involved the development of exploratory moves around the idea of territorial rationality (Viganò, 2008), which brought to the fore the long-term (the long construction of water management infrastructure in relation to the topography and the nature of soil and subsoil over two thousand years) and the *longue durée* (the maintenance and revival of this system by the Benedictine monks in the Early Middle Ages, the Venetian Republic, and then and now by the reclamation consortia).

The two systems of "water and asphalt" and their logics of accessibility and water management emerge as organizational structures of space and society, inescapable elements of any interpretation of the widespread contemporary urban condition and at the basis of each exploration of the future of new urban-rural configurations. It is their slow transformation and, together, the destructive force of some events (for instance the route of a motorway that interrupts the flow of water from the slopes and the network of canals), or the evolution of techniques (from a surface irrigation network to its demise and burial) that become part of

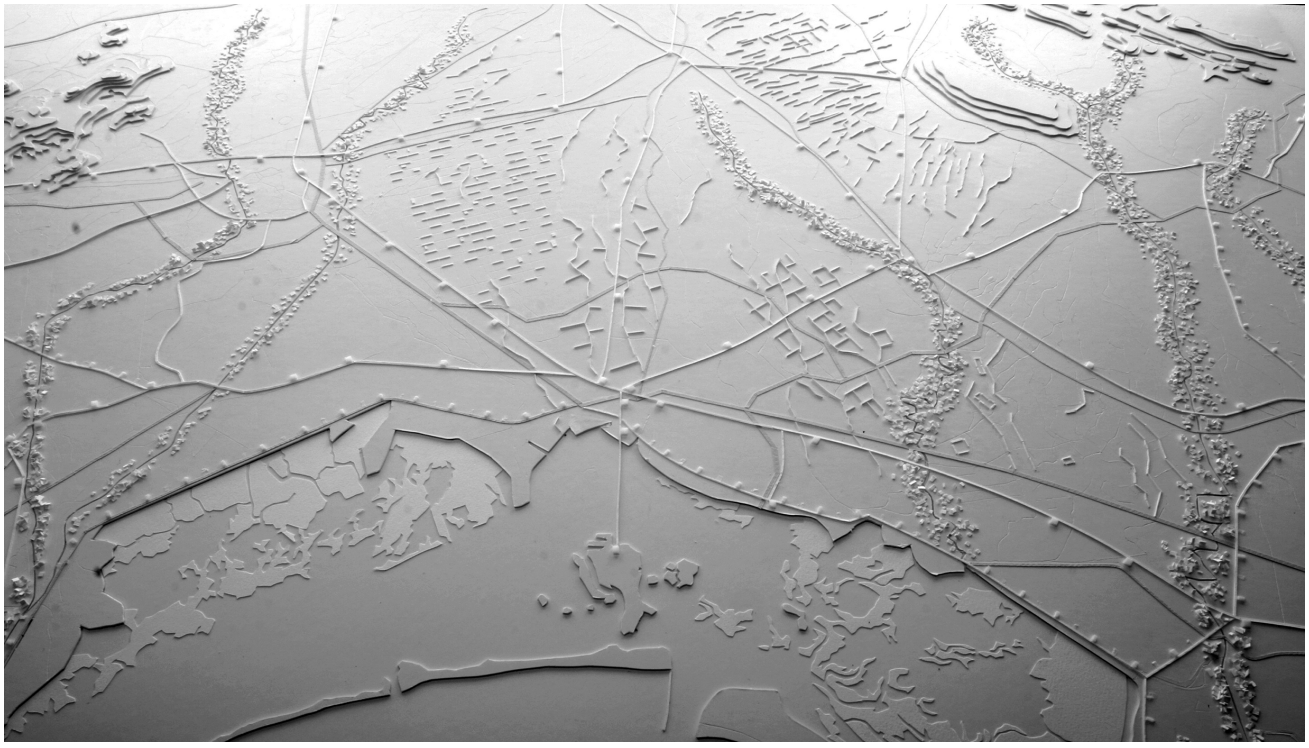

Figure 1. Isotropy as a figure of political rationality. Source: Viganò, Secchi, and Fabian (2016). Image credits due to B. Secchi, P. Viganò and IUAV PhD students at "Water and Asphalt," Venice Architecture Biennale, 2006.

the construction of future territorial scenarios: of mitigation and adaptation to climate, economic and social change (Viganò, Degli Uberti, Lambrechts, Lombardo, & Zaccariotto, 2009; Viganò et al., 2016).

Attention to infrastructural transformations (roads, drainage and irrigation networks, etc.), and the exploitation of resources (gravel extraction in the dry plain) provides an understanding of rationalities that are often invisible agents, gives hints about their material construction as imperfect territorial machines that are so rooted in our territories to become a second nature, as defined by Cicerone, new ecologies, capable of guiding, in this sense, the transformations over time. A transversal gaze is established by linking different temporal forms: the present-day context of the city territory and the thick territorial accumulation. The isotropic nature of these infrastructures, therefore, appears to be long-term, imbued with permanence, persistence and rationalities, rather than superficial chaos. Taking these considerations as a starting point, the vision is defined around the hypothesis that a project of isotropy can support climate change mitigation and adaptation strategies (from the "NoCar" to "more space for water"), reflecting the efficiency of a multitude of different and diffuse actions in opposition to the logic of large concentrated works.

3. The Unintentional Monument: A Space in Common

The palimpsest does not cease to undergo changes; the territory is a monument; it contains memories but it is not a tombstone. It does not cease to be transformed by confused and widespread alteration practices that urbanism assumes as its field of observation and design (Secchi, 2000). It is important to return to this point: The metaphor of the palimpsest alludes to the meeting/clash between different times, endless modifications and transformations, at least until use of the support is not so serious as to question the very existence of the palimpsest. Until that moment, directions, dynamics and at times fortuitous encounters will interweave on its shriveled skin, and forms of power and violence will be measured there, which, in turn, will generate new conflicts. They will come face-to-face on the palimpsest and will leave their traces mixed with the recursive practices of the *longue durée*. The territory is the result of countless projects and is, itself, the project subject: It raises, in this case, the question of responsibility for the interpretation/representation of the palimpsest, the burden of proof (Marquard, 1987) which accompanies any act of transformation (Jonas, 1979), and that is the inevitable counterpart of vision and hope (Bloch, 1959).

The palimpsest, metaphor of the stratified space in which relationships are crafted and reciprocal adaptation between the territory and population occur, gives rise to places where its intensity and depth become monumental. They were not designed with this purpose: They are unintentional monuments (Riegl, 1903). It is not the search for territorial rationality here that leads the design exploration and eventually the construction of a new interpretation, but rather the effort is to explore the apparent lack of meaning and relationships between one layer and another. The real point of interest is the pure overlapping of disconnected intentions that becomes the substance of a project, providing legibility, revealing, celebrating and exposing their landscapes, making them recognizable as episodes of a collective human and environmental history. Stories of distant relationships and random intersections, such as that between Belgium, the Manhattan Project and the abundance of uranium in the Congo; the establishment in the Flemish region of Limburg, after the Second World War, of a nuclear center where engineers and scientists worked in a "model atomic village" (*Atoomwijk*) isolated among fields and forests but supported by the OECD. The village designed by the architects Wybauw and Thiran is a monument of modern architecture in Belgium. Nowadays, after it was almost completely abandoned (a renovation has started in 2019), the decision to accumulate all the country's nuclear waste at this site invites the community to reflect on the new position this site will assume in the national collective imagery. A monument-space.

The new nuclear information center in Dessel and its adjoining large park (see Figure 2) raised new concerns about the transparency of the project to store nuclear waste and the need for disclosure to near and distant populations. Once built, the center and the park will dialogue with the vestiges of the nuclear village, the Bochelt-Herentals canal (built in 1843 and extended in 1928), the sand extraction lakes, the regional cycle paths, and the industrial areas requested by the local community as compensation. Nonsensical relations and stories surfacing on the palimpsest, but they can actually be understood one by one, traces of histories in proximity to each other, like theatrical characters without a common discourse. The monument keeps the memory alive: for instance, controversial decisions such as the one to establish a function that will characterize the future for centuries to come in a place marked by a long history of agricultural production, industrial exploitation. The "park" is the space where these different environmental and cultural stories can be given a contemporary sense.

Alongside "intentional monuments" that commemorate an event to be preserved in the memory and monuments that through their capacity to stay the course of time ("age-value monuments") demonstrate the succession of the life cycles of buildings, the unintentional monument, according to Riegl, marks an instant that can be recognized in the development of human activity. The extension to environmental history and the long-term is a must in the case of the Dessel nuclear park which, for a long time to come, will bear witness to the new territorial condition, taking the role of a problematic "space in common," where to share contradictions for which we currently have no solution.

Marked by deforestation from the 5th century onwards, and by overgrazing and depletion between the

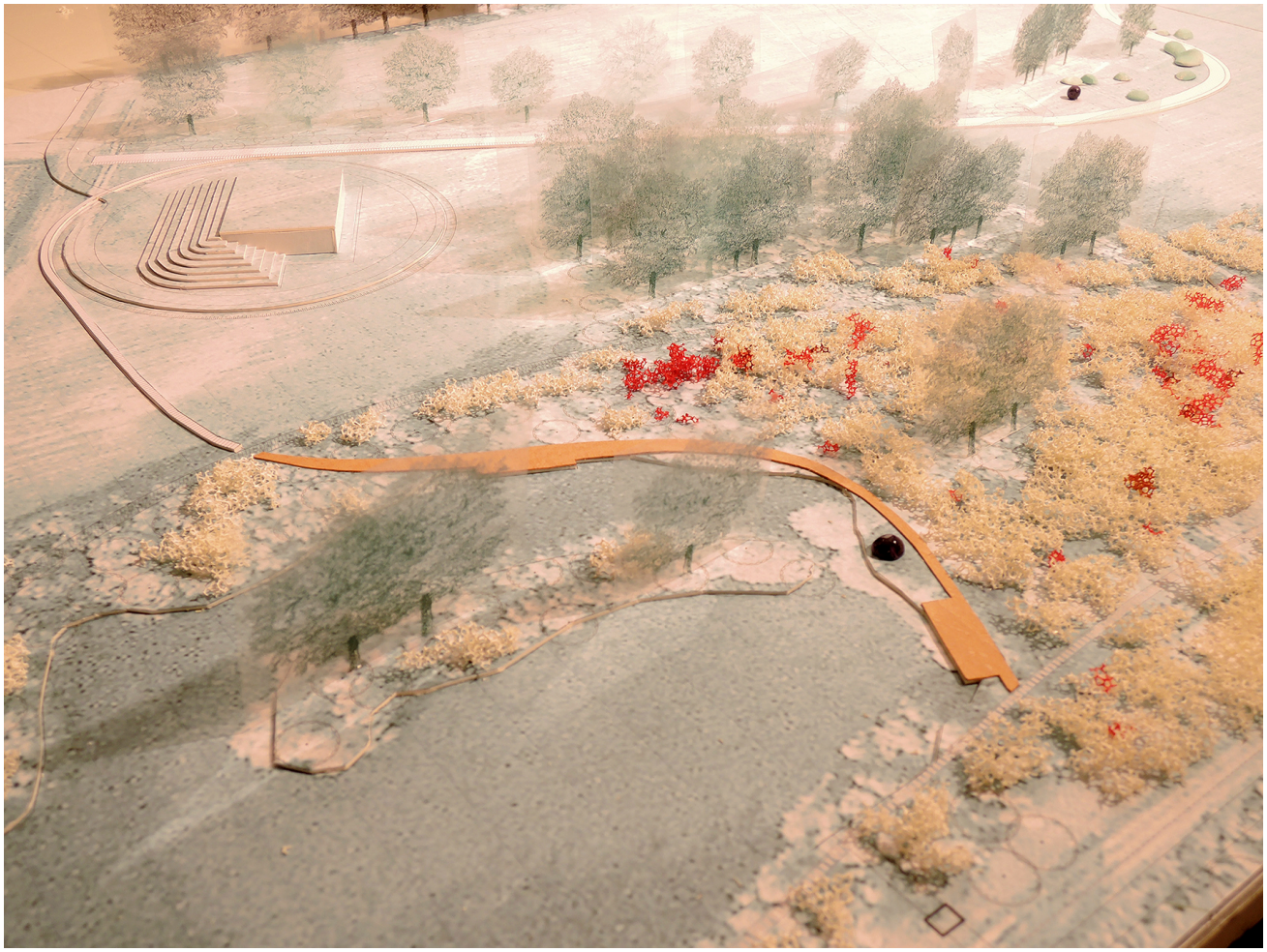

Figure 2. Dessel nuclear park. Sequences of landscapes: The wet heath. The new information center is being realized by Bovenbouw and ONO architectuur. Image credits due to the StudioPaolaViganò (P. Viganò, U. degli Uberti, V. Cox, J. de Vlam, A. Tamiazzo, C. van Maercke, K. Yoshida, Q. Zhang) and ARA (Dries Beys; 2017-ongoing project).

10th and 19th centuries (the Ferraris map of 1777 represents the sandy soils that were difficult to cultivate and the presence of heather), the large lawn in the center of the park will attest to centuries of fertilization, first natural and then chemical, which made a fairly infertile soil productive; it will be surrounded by pine reforestation, started in the 18th century for production purposes, and the extension of the spaces to reintroduce heather, added more recently. Fragments of landscapes close to low density and diffuse urban areas. The project does not envisage a return to an original and primal nature (as a form of compensation), represented in this context by the heather landscape, which would lead to the profound erasure (even at soil quality level) of the current situation, but the presentation of a multitude of histories (including that of the big rock music concerts held there thanks to maintenance of the large central lawn). This forms the basis for the new park narrative which work towards the maintaining of all memories, including that of the presence of nuclear waste. An unintended and unintentional monument. The park project, with the strip equipped with an area for playing and walks, adds a space that subliminally evokes images of the upturned soils of First World War battlefields, an image that settles on the palimpsest and redesigns it.

4. Design Space in the Second Degree

> As a project, the land is semanticized. It can be parsed. It bears a name. Projections of all kinds are attached to it, transforming it into a subject. (Corboz, 1983)

A metaphor, although operative, does not guarantee the quality of the transformation introduced by the transformation. The palimpsest organizes our gaze, its capacity and interest in reading what remains visible of the previous texts. This is why, before Corboz, Gérard Genette used the metaphor to represent the hyper textual relationships and the hypertext (another well-known Corboz' metaphor, elaborated in Corboz, 1994) as the text that relies on and derives from a previous text through simple or indirect transformation operations (transformation—imitation; see Genette, 1982). In Proust's *Recherche du Temps Perdu*, to which Genette dedicated an essay that

appeared in the mid-sixties, the vast literary materials and the whole context are reworked and manipulated. Proust "is" the palimpsest (Genette, 1966). Writing, like many other artistic forms, lives on in the signs, words and sentences that accumulate on the palimpsest, becoming a refined game of revival and abandonment, decontextualized representation and over-interpretation, the re-invention of the relationships between the texts. The transparency of the last writing (which does not totally hide the previous ones) and the visibility of the texts that preceded it are typical of the palimpsest and emerge in the new text that incorporates and integrates them: literature in the second degree (Genette, 1982).

The palimpsest as a figure in the contemporary project is not only a criticism of the modern space, but an expression of a change of direction in the design activity, of its social role and of the theories intended to support it. Design space in the second degree, to paraphrase Genette, the palimpsest project reuses the previous structures and traces, whatever they may be; it is an expression of common languages and techniques, as well as a refined language and sophisticated technique. Starting from this ambiguous support, which does not legitimize any new discourse, but is rather an integral part of it, the contemporary project attempts to define new reasons for being that it can take responsibility for.

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Conflict of Interests

The author declares no conflict of interests.

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Article

Cajamarca: Mapping (Post)Mining Palimpsests of the Peruvian Andes

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Abstract
Mining, in addition to other human activities and natural phenomena, has repeatedly reshaped the landscapes of the Peruvian Andes. Long-standing, significantly modified and new Andean landscapes have resulted in a complex reading of the 'land as palimpsest' (Corboz, 1983). In recent decades, large-scale modern mining has disturbed headwater landscapes and broader Andean ecologies, as exemplified in Cajamarca's gold mines. This article critically reads past and present spatial transformations induced by gold mining in the headwaters of the Cajamarca Basin. Through archival documentation, fieldwork and interpretative cartography, it analyses the large-scale surface mining operations in Cajamarca from 1993 to 2020, as well as their impact on downstream rural and urban ecologies. A cross-scalar mapping investigation discloses the spatial-ecological outcomes of twenty-seven years of mining (and closure) operational procedures. As a conclusion of the palimpsest reading, a design-research question is posed as to how Cajamarca's post-mining landscapes can be opportunely premeditated. It hypothesizes that, already during exploitation, the post-mining landscapes can be consciously constructed by an intelligent manipulation of mining procedures and create a layer of the territory that is more robust. Environmental reconstruction after mining closure recreates a pseudo-natural environment that supposedly erases the traces of mining and restores natural condition—literally back to nature, with no cultural trace. In this regard, reconstruction is merely theoretical since the repairing to a natural state would mean no palimpsests. However, despite the most imaginative and ecological repair, the territory remains a mega palimpsest, cruelly violated and disrupted. Therefore, at best, the proposition can be to build a cultural, consciously conceived and tailored post-mining landscape, merging mining and post-mining landscape construction into one movement, where the remaining (palimpsest) is part-and-parcel of the newly constructed.

Keywords
Andes; Cajamarca; palimpsest; (post)mining landscapes; reconstruction

Issue
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1. Introduction

In addition to other human activities and natural phenomenon, resource extraction has repeatedly reshaped the Peruvian Andes landscapes. Since early human occupation (20,000 BC), a steady process of landscape domestication and colonization has challenged the territory's inhospitable environmental conditions. Since the 16th century, processes of colonial resettlement and intensive resource extraction introduced new landscape configurations while ancient ones receded. Long-standing, significantly modified or abandoned and new Andean landscapes have resulted in a complex condition of the 'land as palimpsest' (Corboz, 1983). In recent decades, large-scale modern mining has continuously reshaped headwater landscapes and broader Andean ecologies, as exemplified in Cajamarca. In parallel to relentless surface gold extraction are ecological restoration activities. Although

they comply with international standards of post-mining rehabilitation, Cajamarca's mining closure procedures remain detached from its historical development. Indeed, it could be argued that generic reconstruction of landscapes and ecologies in the North Andean headwaters are yet another brutal landscape disturbance.

Sustainable post-mining development in Cajamarca —as in other Andean regions—requires a critical reading of its long-term history in order to inform the design of resilient landscapes and ecologies. A post-mining design project in Cajamarca necessitates looking beyond the timeframe and physical boundaries of mining activities. It entails the identification of resilient Andean ecologies.

2. Methods and Objectives

This article critically reads past and present spatial transformations induced by human activities and mining (and closure) in the Peruvian Andes (from 4°S to 18°S latitudes) and the headwaters of the Cajamarca Basin (7°S latitude). It is based on a literature review and interpretative cartography. The work is premised on fieldwork trips in 2015, 2017 and 2018, which included visits to the mining sites and the larger territory as well as informal interviews with key stakeholders. The research seeks to contextualize Cajamarca's landscape evolution within the broader history of the Andes. The Cajamarca Basin has been occupied by mining operations since 1993. The analysis focuses on the manipulation of topography and water as disturbance ecologies.

In order to address dynamics at different altitudes, parallel sections across scales were systematically overlaid. The mapping methods relate to those of Alexander von Humboldt (1805) and Paz Soldán (1865a), which incorporate empirical and interpretative components of the Andean environment. The interpretative mapping developed for Cajamarca's (post)mining landscapes allows for their problematization and discloses future potentials.

The first section of this article sheds light on the dynamic configuration of the Andean environment and the resilient ecologies of the Andes and Cajamarca until Spanish colonization (16th century). The next section illustrates successive waves of ecological disturbance and landscape transformation until the establishment of modern mining in Cajamarca and the Andean region (20th century). In the third section, there is a critical review of the mining (and mining closure) operations in Cajamarca's headwaters from 1993 to 2020, as well as their impact in the basin's downstream rural and urban ecologies. The cross-scalar mapping investigation discloses and contextualizes the spatial-ecological outcomes of twenty-seven years of mining (and closure) operational procedures.

The reading of the territory as a palimpsest led to a design-research question: How can Cajamarca's post-mining landscapes be premeditated and recontextualized within the landscape's *longue-durée*? There is the hypothesis that, during exploitation, postmining landscapes can be consciously constructed by an intelligent manipulation of mining operation procedures and create more robust territory. Despite the most imaginative processes of ecological repair, Cajamarca's cruelly manipulated territory remains disturbed. The proposition is to build a cultural, consciously conceived and tailored postmining landscape, which merges mining and postmining landscapes where the remaining (palimpsest) is part-and-parcel of a new constructed environment.

3. Andean and Cajamarca's Palimpsests

The Andes have their origins in the accelerated convergence and subduction of the Nazca Ocean Plate below the Continental Plate of South America, which occurred twenty-five million years ago (Montgomery, Balco, & Willett, 2017). From 5°N to 45°S latitudes, seven thousand kilometres of uplifted ocean sediments and 'trapped' mineralized areas were the result of its orogenesis. Multi-metallic deposits are disseminated across the Andes (Purser & Purser, 1971). Problematically, they are mostly concentrated in headwater areas, which are vital to the hydric balance of local, regional and continental ecologies. The Andean geography comprises an array of hypsometric conditions. Its abrupt altitudinal variations generate a direct proportional variation in microclimates and life zones (Tosi, 1960).

Indigenous populations of the Peruvian Andes (4°S to 18°S latitudes) identify eight 'ecological floors,' each which is comprised of specific climatic conditions in correspondence to variations in altitude (Pulgar Vidal, 1946, 1996; Troll, 1962). Each 'floor' contains specific climatic conditions, relief, (sub)soil, hydrology, flora and fauna (Pulgar Vidal, 1946). Of particular ecological importance are the higher ecological floors: *suni* (from 7°S to 18°S latitudes) or *jalca* (from 4°S to 7°S latitudes)—also denominated *páramo* above the 4°S latitude—which are positioned above 3,500 meters altitude and below the limits of permanent snow. Tropical, semi-tropical and semi-arid climates respectively differentiate the *paramo*, *jalca* and *suni*. In the *jalca*, seasonal rains allow for the growth of natural pastures across plains and hummocks. Within each 'floor' there are additional micro-climates which are determined by sun exposure, shadows and winds.

Cajamarca (7°S latitude) is semi-tropical, located in the area between the northern tropical and the southern semi-arid Andes. Its particular geography, with proximity to the warm Pacific equatorial current in the west, and the Amazonian Forest to the east, creates the necessary moistness for the existence of unique *jalca* ecosystems in the basin's headwater (Galán de Mera et al., 2015). The *jalca* is critical for headwater and regional hydric balances. Native pastures (*stipa ichu*) and thick topsoil absorb and store water, thereby nourishing headwater lakes, wetlands, aquifers and river tributaries and springs of the *quechua* ecological floor (2,500–3,500 meters altitude; Buytaert & De Bièvre, 2012). Below the *jalca* sur-

face, mineral deposits with high sulfidation were formed during the Upper Cretaceous (66 million years ago) and the Paleocene (56 million years ago; Instituto Geológico, Minero y Metalúrgico [INGEMMET], 2017). Gold and copper metals are disseminated in hydrothermal mineral deposits, at a depth of approximately two kilometres underneath the *jalca*'s surface (INGEMMET, 2017). Incipient mining in these areas dates back to pre-Hispanic and colonial periods.

The Andean hemisphere-scale conditions are affected by tectonic activities and natural 'disasters' which create dynamic conditions in watersheds and hydrological regimes. Periodic droughts, floods, landslides, hailstorms and frost have always been risks for the region's food-security. Through centuries of trial and error, technical improvement, innovation and remodelling, Andean peoples learned to thrive in the mountains. Because of environmental challenges, the primary goal of the different Andean techniques and civilizations has been to achieve sustainability in agropastoral endeavours (Valdivia, Reinoso, & Elías, 1999). Technological innovation not only involved 'terraforming' the Andean surface to "substitute natural biodiversity with agrodiversity" (Erickson, 2018, p. 29), but also implied establishing social mechanisms of solidarity, exchange and reciprocity, as John Murra documented in the Southern Andes (Murra, 1972; van Bruen, 1996).

Ancient populations adapted to a multitude of dispersed fertile pockets, all with particular flora and fauna, depending on specific ecologies and microclimates (Murra, 1972). Steady colonization of the *puna*, *suni* and *jalca* from 100 BC to 600 AC, was followed by the adoption of a general agro-pastoralism across the Andes (Lane, 2009). Economic specialization gave way to a symbiosis between full-time pastoralism in the *suni*, *jalca* and *puna* (from 3,500 meters altitude), and farmers in the *quechua* (2,500—3,500 meters altitude) and *yunga* (500—2,500 meters altitude) valleys.

From 2000 BC onwards, technological advances led to the establishment of permanent settlements. Civilizations diversified their economies, which implied settling in discontinuous hamlets next to productive areas. Field dispersal, food storage and preservation techniques, improved survival chances during bad years (Erickson, 2018). The 'vertical archipelago' settlement configuration across different ecological floors was established by autonomous groups of people with the same ancestors (*ayllus*; see Murra, 1972). While tapping into complementary resources across ecological floors, they established mechanisms of reciprocity within their same ethnic unit. Complementary exchange occurred between people from different *ayllus*. Regional interchange included goods, such as coca leaves from the *yunga*, tubers from the *quechua* as well as wool, salt and raw materials from the *suni*, *jalca* and *puna*. Particularly, during the Inca Empire (1440 to 1532 AC), there was large-scale redistribution of such goods amongst different populations (Alberti & Mayer, 1974). The footprint of these multi-scalar interrelations enlivened the territorial articulation of ecological floors.

Since 100 BC, communities of the Cajamarca Basin settled discontinuously in *llaqtas* (hamlets), on artificially terraced lands across *jalca* peaks and *quechua* hillsides (Reichlen & Reichlen, 1949). The ceremonial centres of the basin's valley complemented these *llaqtas* (Watanabe, 2010). As in other Andean regions, Cajamarca's communities practised a direct and complimentary use of resource niches, along with social mechanisms of reciprocity and redistribution (Espinoza, 2018). The *Qhapac Ñan* and *tambos* facilities, administrative infrastructures of the late Inca Empire (1438–1532), were superposed on the 'vertical archipelagos' (León Ascurra & Camargo Mareovich, 2014).

Across the region, Andean civilizations mastered various agro-pastoral and water management technologies to multiply and maintain production niches (see Figure 1). In Cajamarca, a region privileged by its semi-tropical humidity, such technologies implied the maintenance and management of headwater sources for the benefit of lower ecological floors. In the semi-arid Andes, techniques involved highland-terracing and managing water at altitudes between the *yunga* and *puna. Qochas* (artificial lakes), *waru-warus* (raised fields of the Altiplano), *andenes* (agricultural terraces) and *bofedales* (artificially irrigated pastures) were dominant landscape infrastructures (Kendall & Rodríguez, 2009). These techniques were complemented by infrastructures of production (industrial workshops), storage (*collcas*) and communication (*qhapaq ñan*, or Inca roads), mostly concentrated in *tambos* (administrative/resting sites) and larger urban centres which accommodated passing through armies and ritual celebrations (Mumford, 2012).

The Andean communities carefully managed headwater ecosystems—their primary water source (Guillet et al., 1987). The construction of *qochas* provided an answer to limited water sources. They stored water during rainy seasons by building dams in natural water catchments and lining them with impermeable sediments (Lane, 2014). A cascading series of *qochas* transferred water from one to another, as well as to grasslands and river tributaries.

In headwater areas, the *qochas* supported herding pastures and habitats for wildlife and seasonal settlements. The construction of *qochas* also induced the appearance of *bofedales*, a native denomination for artificial, high-altitude moorlands with a rich plant biota eaten by camelids. *Bofedales* retained organic silt for geologic water storage and embodied a natural water-cleansing system (Fairley, 2003). The systemic nourishing of headwater aquifers generated and improved downstream systems that depended on groundwater (springs and wells), while simultaneously extending the limits of viable cultivation of tubers, legumes and semi-cereals to liminal areas between the *quechua* and the *suni* (or *jalca*).

Massive pre-Hispanic plantations of *polylepis* in headwater areas of *suni* and *puna* regions increased water re-

tention (Pulgar Vidal, 1946). However, afforestation upstream went hand-in-hand with deforestation of mountainous woodlands on lower ecological floors to create agro-pastoral lands (Ellenberg, 1958). The present treeless condition of the Andes is the result of more than 10,000 years of prolonged human activities (Lynch, 1990) and their intensification during the last 500 years. Human settlement implied systematic erasure of the natural forest. As in so many contexts, the construction of new landscapes required the radical clearing of forests (Girot, 2013). The Andean settlement system persisted as dispersed, as a constellation of patches nested in particular spots, folds and other landscape pockets. Palimpsests are usually understood as traces of previous texts, while in urbanism they are understood as remaining traces of earlier constructions. They are distinct from the new text, new development that covers the page, or the landscape (Corboz, 1983). It appears that the Andean civilizations did not entirely rewrite the landscape, but instead grafted their 'vertical archipelago' system onto the relatively few and irregularly dispersed, yet fertile pockets that subsisted after deforestation. Perhaps the palimpsest is here not so much the ruin of constructs that have become purposeless, but rather the resistant patches of fertility. Pockets of nature that withstand total and catastrophic erasure.

Figure 1. A painting of production niches across ecological floors in Ayacucho. In addition to productive pockets were other niches of artisanry, hunting and fishing, as well as networks of communication. The system prevails today, with new niches and programs inserted since 1532. Source: Berrocal (1995).

4. Historical Ruptures

The Inca Empire restructured the territory, with infrastructure and other means, without abandoning the logics of the 'vertical archipelago'. Spanish colonization (1532–1821) enforced several waves of radical transformation as did the republic afterwards. More recent events include land reform (1969), the Shining Path's insurgency (1980–1992), and acceleration of mining activities in the wake of neo-liberal policies (1990 to today). They all are, in their own contradictory ways (reform, revolution and globalisation), reactions to the incredible social injustice that has, since Spanish colonisation, become part of the region's inescapable fate. The *longue durée* (Braudel, 1949) of the organic evolution of the Andean environment has been innumerably disrupted. Human dislocations, raids and retreats across different ecological floors, are amongst the direct consequences of these canonical ruptures. In parallel with the ruptures, has been the steady, yet explosive processes of urbanization and resources exploitation, in addition to the introduction of agricultural tissues in the wake of the land reform.

Between 1550 and 1580, indigenous people were relocated and concentrated in reductions, facilitating population control and labour management (Lohmann Villena, 1957). The Spanish relocation program was paralleled by the nearly total destruction of old *llaqtas*. Native productive niches and settlements were appropriated by Spanish lords. Colonial *haciendas* and cities were founded in privileged locations of the *quechua*, *yunga* and *chala*, thus replacing pre-Hispanic livelihoods. Most colonial Andean cities were superimposed on pre-existing urban blocks (Mumford, 2012). Their structures were literally enmeshed as palimpsests with underlying pre-Hispanic structures—in the physical as well as social and cultural sense. New regime rules (as forced labour) paralleled surviving dynamics of reciprocity. Cities, *haciendas*, reductions and mining enclaves defined new settlement constellations.

At the same time, Conquest wars, non-native epidemic diseases and human exploitation caused massive demise of indigenous peoples during the early Spanish regime. In the Peruvian Andes, the population fell from about 9 million in 1520 to 600,000 in 1620 (Newson, 1993). The population was moreover confined to living in reductions, Catholic missions or mining compounds. Violent processes of depopulation and dislocation produced a massive-scale abandonment of landscape infrastructures (Tello, 1921). The interruption of water-table nourishment caused a general water decline, which led to the retreat from multiple unsupplied *andenes*.

The occupation of *suni*, *jalca* and *puna*'s mineral niches by colonial enterprises expelled Andean peoples from headwater areas. Mines displaced seasonal agro-pastoral settlements, as well as headwater sources for mineral processing and human consumption (see Figure 2). Demands of fuel (for metallurgy) and wood (for mine girders and urban constructions) incited massive deforestation in headwater areas (Kessler, 1995), thereby reducing their water-retention capacity. Nonetheless, mining settlements developed and grew despite the inhospitable conditions of the *suni*, *jalca* and *puna* for permanent human occupation. They typically developed with neither sufficient planning nor structural investment. Colonial mining was all about extraction and export. The development of a qualitative environment was never on the agenda. Not surprisingly, it began as a predatory, ex- and appropriation of indigenous settlements and resources. After an interruption during the independence wars, mineral extraction in the headwaters resumed. A number of colonial mines were taken over by foreign and Peruvian mining companies (Aramayo Bazzetti & Sanchez Infantas, 2010), while artisanal mining activities reclaimed other old shafts.

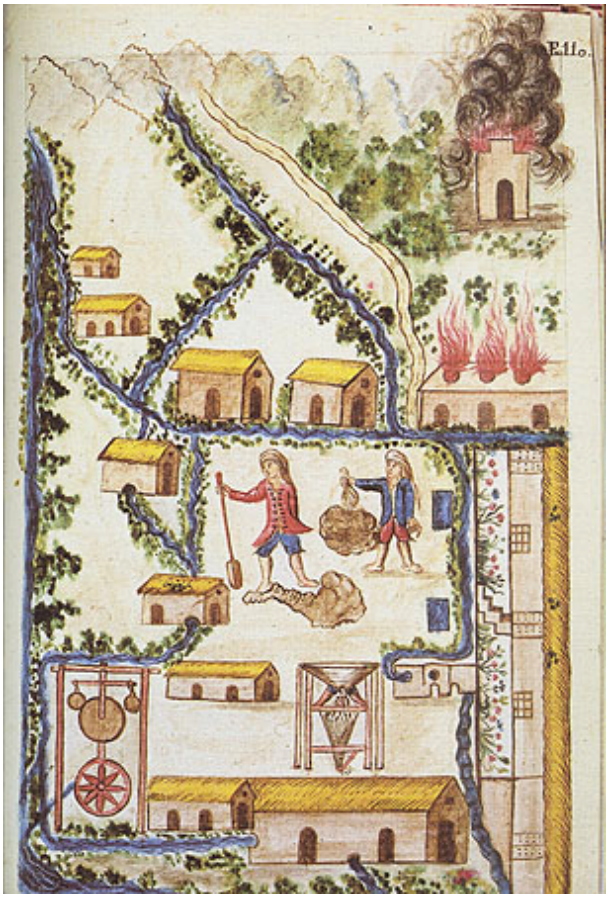

Figure 2. In 18th century Cajamarca, mining operations implied the canalisation of headwater sources for mineral processing and the burning of native vegetation for fuel. Source: Martínez Compañón (1936/2015).

After independence (1821), Spanish descendants intruded on community lands to expand their *haciendas*. This new wave of dispossession and reclusion to less fertile areas forced peasants to over-exploit fields, become *hacienda*'s servants or simply migrate to cities. By 1950, permanent confrontations between *hacendados*

and peasants, as well as rising urban and rural poverty, culminated in simultaneous waves of peasant insurgencies throughout the country. In 1969, reform sought to re-structure the nation's land tenure system. Coastal plantations and semi-feudal haciendas in the highlands were expropriated and redistributed. By 1979, more than nine million hectares were returned to 370,000 beneficiaries (Eguren, 2006).

With few exceptions, colonial settlements took over almost all pre-Hispanic sites of Cajamarca. After indigenous resettlements in the Chota, Cutervo and Santa Cruz reductions (1551 to 1578), vacant *llaqtas* and productive lands were converted into *haciendas* (Espinoza, 2018). Urban structures of Cajamarca's colonial city replaced Inca ceremonial facilities and squares located in the western foothills of the valley (Mumford, 2012), and in the floodplain believed to have once been an ancient lake (von Humboldt, 1850). Simultaneously, *caseríos* emerged around new colonial agglomerations, most of which prevail until today (see Figure 3). Indigenous reductions became towns, and dismantled *haciendas* (after the land reform) were subdivided into multiple (large) productive plots.

For centuries, Cajamarca's *jalca* was part of the region's agro-pastoral and water management (Young, 1988). In Cumbemayo (the southwest *jalca* of the basin), a 7,600 meters-long pre-Hispanic canal conveyed water from headwater pastures to downstream settlements. The abundance of headwater sources enabled the existence of a large-scale, but fine-mazed irrigation system, as well as a considerable amount of springs (in mountainous areas) and wetlands (in the lowlands; see Figure 4). However, during the colonial era, *haciendas* owners intensively herded ovine in the *jalca* and over-consumed headwater resources.

In the early 1900s, cattle and dairy production in *haciendas* became the foundation of Cajamarca's economy; herding occurred in irrigable lands. In 1947, Nestlé's dairy production was situated in the region and rapidly increased areas of herding grasslands. The increase of pastures continued despite implementation of the Peruvian Land Reform. However, given new plot subdivisions, the industry shifted towards a decentralised model of supply from small-land holders.

Seasonal herding also re-colonized the *jalca* and dispersed Andean settlements were re-established adjacent to headwater lakes. Between 1953 and 1989, local communities reproduced Cumbemayo's canalization model in the headwaters of the Grande River. A series of canals were constructed in the basin, tapping water from tributaries to irrigate valley pastures. As a sequence of development waves, the reoccupation of headwaters and mountainous areas by dispersed settlements reactivated traditional systems, erased the colonial impositions and undid appropriations of large landowners.

Yearly burning practices in the *jalca* allowed fresh *ichu* for grazing to grow while preventing other vegetal species from colonizing the highlands. Until 1993, dense *ichu* vegetation covered 77% and dispersed *ichu* vegetation accounted for 16% of the basin's *jalca* (Palacios & Lundberg, 2006). In the liminal areas between the *quechua* and *jalca* ecological floors, nests of wildlife around rocky areas coexisted with crops. Only limited extraction of raw materials occurred. Headwater communi-

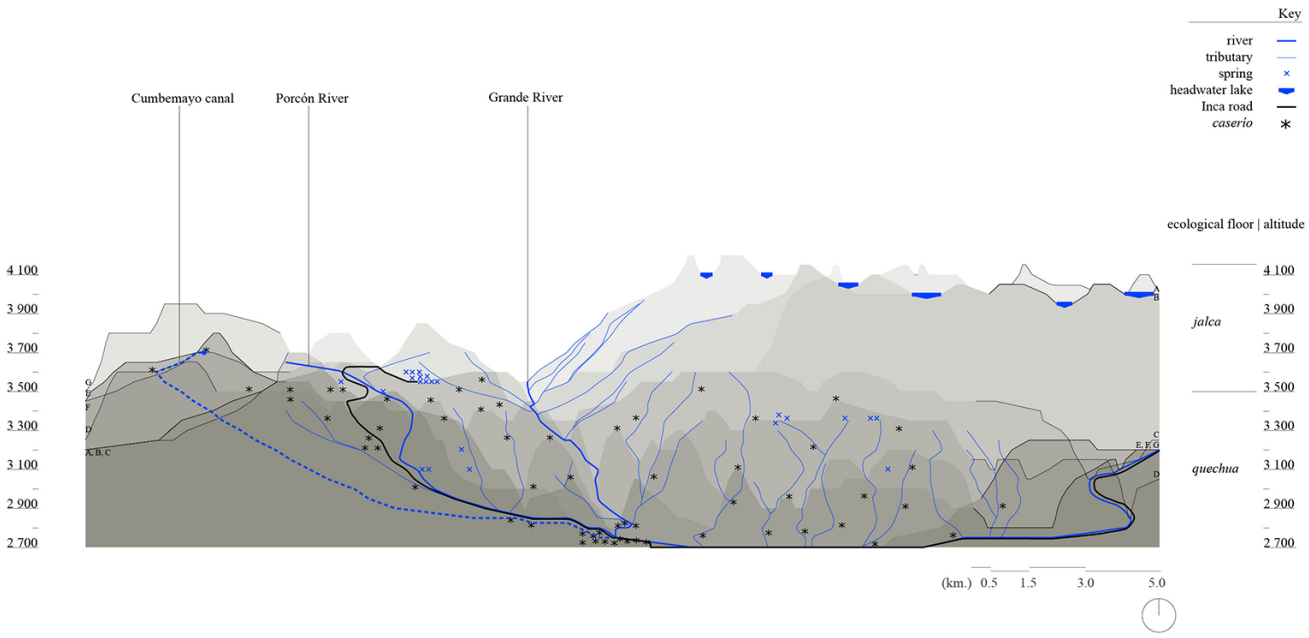

Figure 3. The self-subsistence economies of *caseríos* in the Cajamarca basin are articulated by a hydrological network of headwater lakes, springs and streams. Human agglomerations only began to occur in the basin's floodplains after the establishment of the colonial Villa of Cajamarca. Sources: Elaborated by Margarita Macera, based on database from Gobierno Regional de Cajamarca (2015) and CGIAR-CSI Consortium for Spatial Information (2015, Version 4).

Figure 4. Foraging and dispersed housing occurred in the basin's lowlands, once an ancient lake. Urbanisation and agro-pastoral activities in the area caused a progressive drying of the territory. Source: Paz Soldán (1865b).

ties retrieved mud for the construction of *adobes* (mud-bricks) and used pasture hatch for the construction of roofs and mattresses, as medicine and domestic fuel or, eventually, as a commercial supply for urban brick factories (Palacios & Lundberg, 2006).

The Andean peasants welcomed the redistribution of land brought by the land reform. At the same time, they heavily resisted reform's push for the commercial-based logics of the single-crop. Extensive agriculture is contrary to the nature of indigenous traditions. It targeted, some would say in the best colonial tradition, export markets rather than regional needs. Not surprisingly, the induced modernization processes increased rural poverty in the Peruvian Andes, as sadly illustrated by (infant) mortality rates (McClintock, 1984). For many peasant communities, the rise of the Shining Path (1980) was an inevitable act of rebellion against centuries of oppression (Ron, 2001). The violent iteration of action and reaction it catalysed induced massive retreat from rural livelihoods and an accelerated migration towards cities. During the early 1990s, the country's pacification resulted in a favourable investment climate.

Since 1992, new neoliberal policies stimulated investment of multinational large-scale mining companies in headwater areas (Bury, 2005). Modern mining in the Andes uses the latest available technologies for multi-metallic exploitation. A more substantial capacity of excavation, a hydro-metallurgy and automated processing technologies have allowed for 'world-class' resource extraction (Randolph, 2011). However, these newer techniques require more water usage and cause increased environmental damage—the costs of which are externalized. Since a substantial part of the country's tax income is obtained from mining, land concessions (through forced expropriation) and privileged access to headwater sources are easily granted to mining enterprises. It strikingly resonates with centuries of old colonial policy and its legitimization. The rural poor endure the brunt of this newest wave of expropriation and their livelihoods dwindle. After being expelled to the unhospitable mountains and headwaters during colonialism, local communities are now pushed out of the headwaters and into the informal urban realm.

Complicating matters further, water has become highly contested (Budds & Hinojosa-Valencia, 2012). Regional hydric stress is not only a consequence of the intensive use of water for metallurgy. Hydric pressures also stem from Peru's rapid urban growth and the tangible effects of climate change (Buytaert & De Bièvre, 2012). Unsustainable mining and urbanization combined with rapid deglaciation and uneven rainfall patterns in Andean headwaters have driven the region into a 21st century hydric emergency. Farming communities inhabiting the unhospitable foothills and mountain

slopes, where they have historically been both pushed to and driven out of, are squeezed between the water hungry mining sites in the headwaters and cities in the valleys.

The Cajamarca Basin circumscribes Cajamarca city and includes a series of dispersed mountainous settlements, and the goldmines of Yanacocha (see Figure 5). Yanacocha's surface mines overlap with the basin's northern *jalca* and the tributaries (and upstream canals) of the Grande River. New techniques to optimize ore extraction from dispersed ore-containing soils allow profitable mining in the *jalca*, previously considered a 'marginal' site. The first exploration in the *jalcas* was led by France's Bureau de Recherches Géologiques et Minières in 1970 (Palacios & Lundberg, 2006). In 1983, the multi-national mining companies, Newmont S.A and Buenaventura, in-

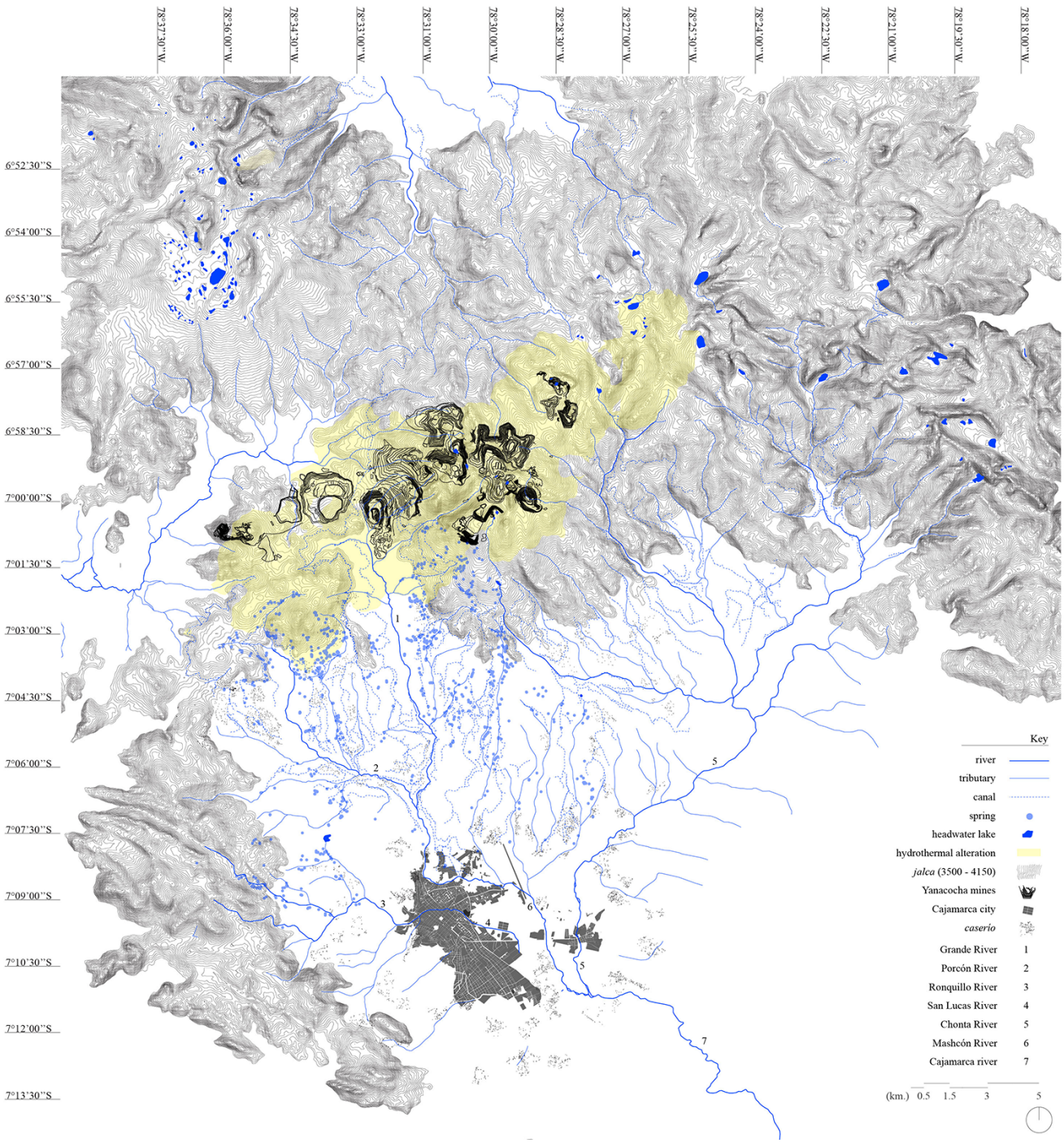

Figure 5. Water in the Cajamarca Basin is an element of contestation and articulation between mining, urban and rural ecologies. The mining compound's strategic location monopolises large-scale mechanisms of water management. Sources: Elaborated by Margarita Macera, based on database from Gobierno Regional de Cajamarca (2015), CGIAR-CSI Consortium for Spatial Information (2015, Version 4) and Google Earth.

tensified prospecting (see Figure 6). In 1993, Cajamarca became the first site of large-scale modern mining in the Peruvian Andes. The Yanacocha mines, 40 km north of the city, have had sequential phases of exploitation, expansion and temporary inactivity (see Figure 7). With mining plans being continuously updated, there is no precise date for the compound's final closure. Yanacocha went through a first productive cycle from 1994–2001. In 2001–2007, mining operations expanded towards the fluvial deposits of La Quinua, upstream of the Grande River. In 2008, the construction of a gold mill to process higher-grade ores facilitated the extension of mining operations until 2015, 2023 and then 2027. As well, already in 2006, mineral exploration indicated the pres-

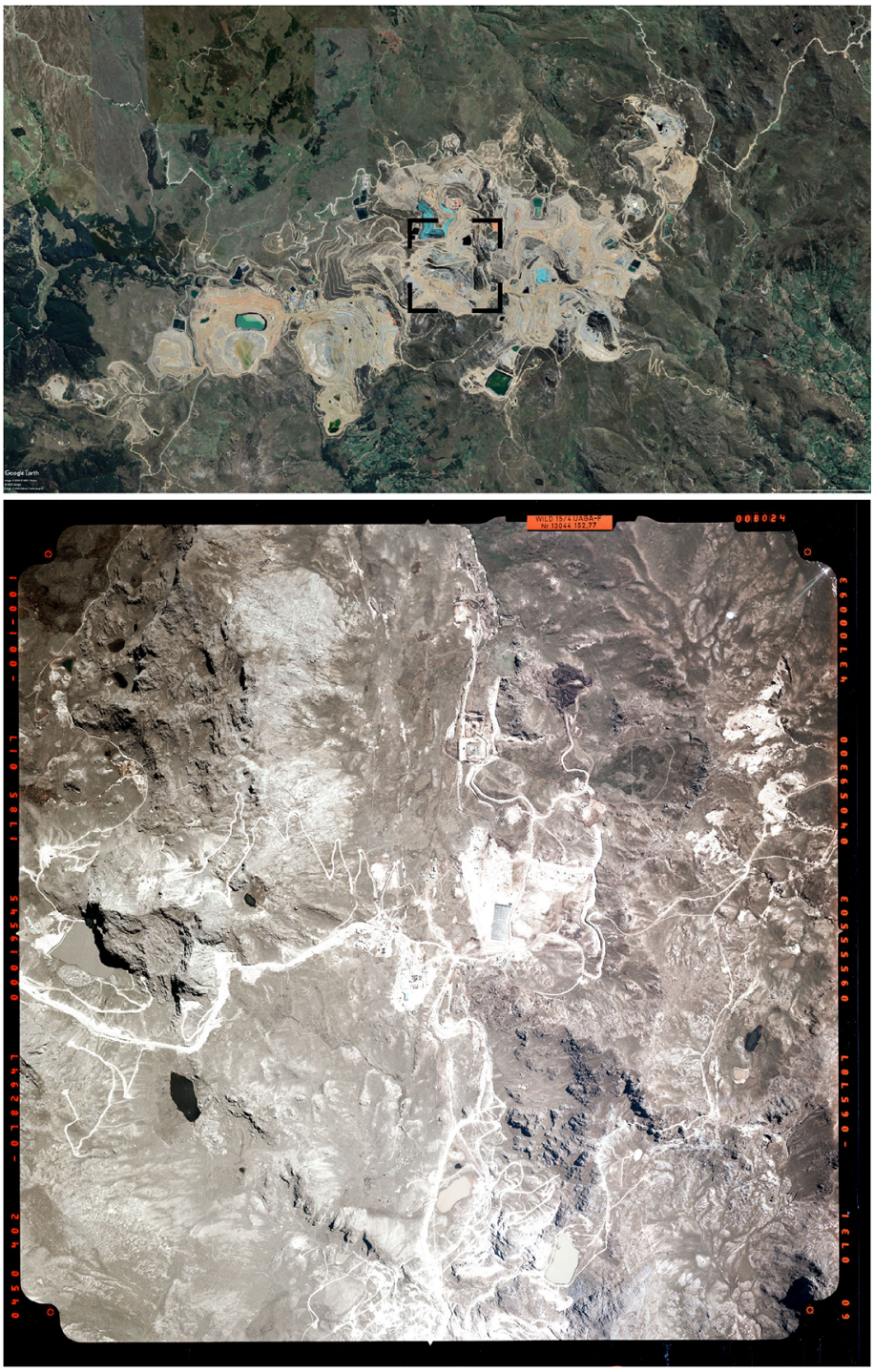

Figure 6. Mining prospections of 1983 took place next to Yanacocha Lake (upper aerial photograph). Pedestrian infrastructures intertwined with new roads for vehicles, headwater lakes, rocky surfaces and hummocks. The morphology of this landscape is unrecognisable after 37 years of mining activities (lower aerial photograph). Sources: Servicio Aerofotográfico Nacional (1983) and Google Earth.

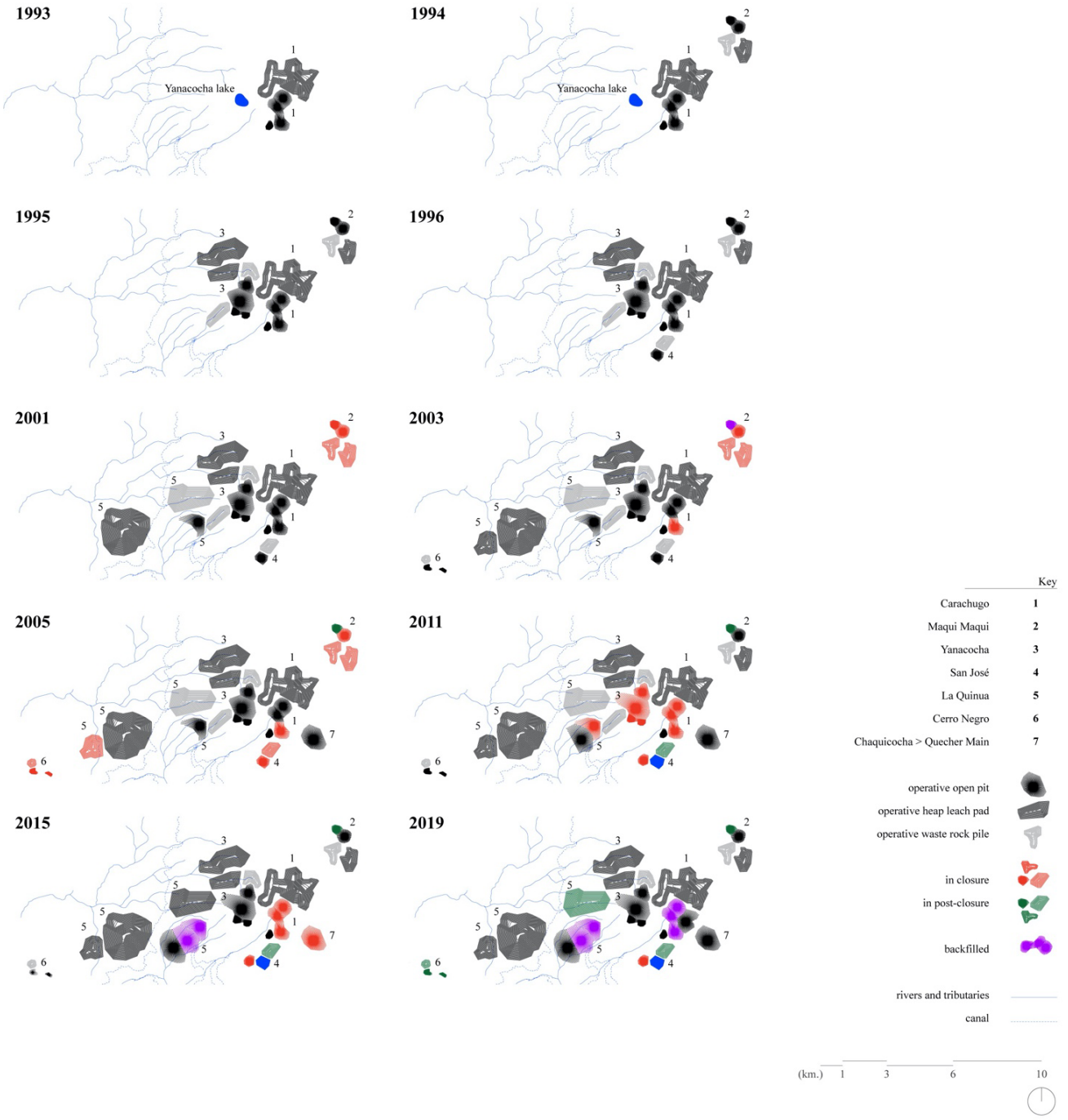

Figure 7. Yanacocha's mining (1993—2019) reveals iterative phases of exploration, exploitation and (temporary) closure occur in the different mining units. Sources: Elaborated by Margarita Macera, based on database from Gobierno Regional de Cajamarca (2015), Google Earth, Ministerio de Energía y Minas (2018) and MYSRL (2006, 2010).

ence of copper underneath gold-bearing deposits (Teal & Benavides, 2010), meaning a second wave of exploitation would be possible after gold deposits were exhausted.

Over the last twenty years, socio-environmental conflicts have increasingly halted the execution of mining expansion plans within the Minera Yanacocha S.R.L. (MYSRL) concession boundaries and also outside of them. Therefore, due to the difficulty of operating in new areas, MYSRL expanded its mining operations deeper within already operative sites. In 2023, the Quecher Main project is slated to begin operation and will be located in the existing footprint of the Chaquicocha open-pit. Quecher Main will exploit of the remaining oxide ores (gold) of the pit and expand to subjacent sulphide deposits (of copper; see Ministerio de Energía y Minas, 2018). This new project will stretch the mining cycle until 2039. In this sense, mining is becoming a more cyclic endeavour, catalysing a continuous wave of exploitation.

Nonetheless, in legal and planning terms, mining remains a linear operation: prospection, investment, exploitation, closure, and environmental repair.

Cajamarca's existing urban infrastructure facilitated mining operations. The region's mining did not require large investment in general infrastructure. Therefore, it is not surprising that the Yanacocha mine—which expropriated local communities in the headwaters and claimed the precious water sources—was contested from the beginning. The sequence of making, undoing, remaking, undoing and the repeated alteration of local and external development modes are quite remarkable. The resulting landscape occupies a particular place in palimpsest cases.

5. (Post)Mining Cajamarca

5.1. Transformation of Landscape-Ecologies by Mining

Goldmining activities in Yanacocha involve the excavation of open pits and the construction of haul roads, heap-leach pads and waste-rock piles. In addition to the mobilisation of earth, cyanide water flows allow for the processing and capture of gold. Through drip-irrigation, the massive heap-leach pads are infused with a constant flow of cyanide and water to distil ores into a rich solution, which then flows to a leaching pond (Trexler, Flynn, & Hendrix, 1990). From this pond, gold-cyanide solutions flow to the ore-processing plants where ores are smelted into *doré* (gold and silver) bars. The remaining solution subsequently loops back to the top of the heap for further rinsing. Cyanide, acid mine drainage (AMD) and freshwater flows are articulated by new water infrastructures (ponds, pipes, canals and treatment plants), intertwined with pre-existing canals and river tributaries.

Yanacocha's "low waste-to-ore strip ratios" (Teal & Benavides, 2010, p. 1174) sustain an accommodation of large volumes of soil in leach pads. While open pits reach depths of more than 300 meters, leach pads can be 100 meters in height. The design and planning of mining facilities answers to cost-efficient transportation and storage of ore-containing soils, as well as to the access of underground mineral deposits. The construction of new mountains and cavities are the collateral damage of mining. They significantly alter the hydric performance of *jalca*. New artificial water infrastructure creates new watersheds and fundamentally restructures the water management mechanisms in headwaters and ecologies of the basin (see Figure 8).

Yanacocha's mining excavations remove more than 70,000 tons of material daily (Ingetec S.R.L., 2003). They strip the *jalca*'s ancient topsoil, and disturb *ichu* pastures wetlands, lakes, river tributaries and upstream canals. Until its depletion, the old Yanacocha Lake was a primary water source. Since its demise, rainwater storage and recycling systems have been installed (MYSRL, 2006). At the same time, aquifers are pumped from open pits to keep them workable. To mitigate downstream water scarcity and pollution, AMD is treated, and the cleansed water is discharged into river tributaries. The mines and settlements of the Cajamarca Basin compete for the same locational resource, namely the local and larger water systems (Bridge, 2004). In an increasing number of cases over the past three decades, socio-

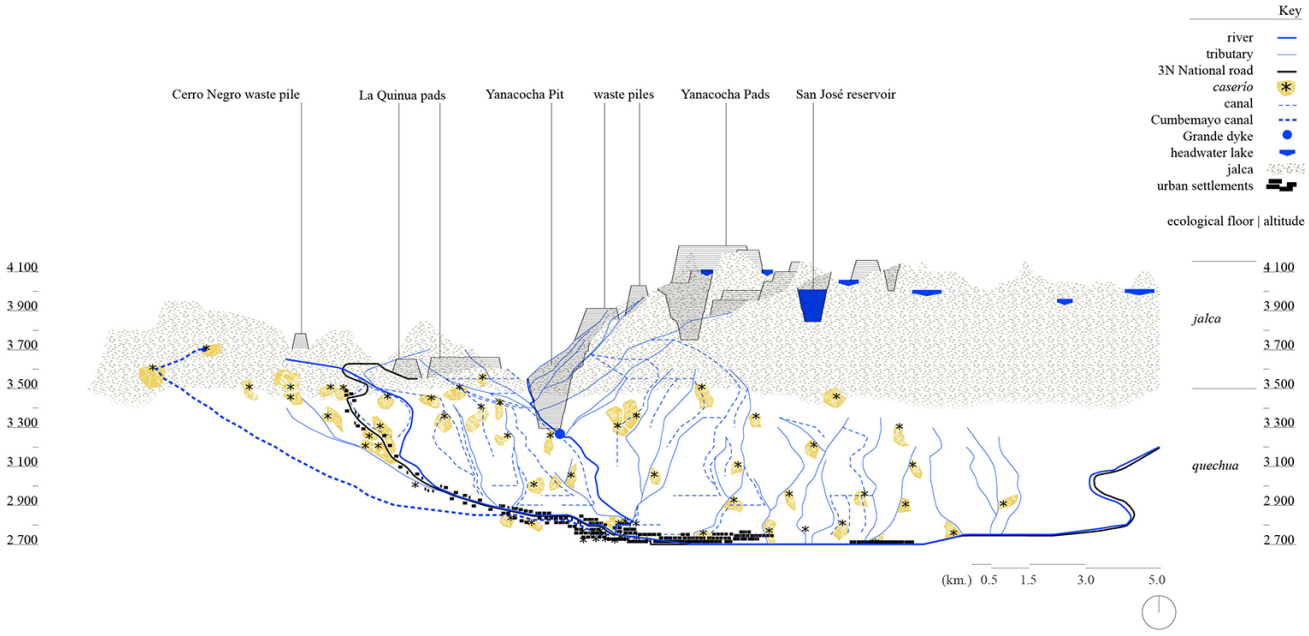

Figure 8. Historically, the basin-scale mechanisms of water included provision by canals and springs, both which depended upon the nourishment of headwater aquifers. Today, rural areas rely on the discharge of treated water and distribution networks from the San José Reservoir. Water consumption in the city relies on the regulated flows coming from the Grande River Dike. Sources: Elaborated by Margarita Macera based on database from Gobierno Regional de Cajamarca (2015), CGIAR-CSI Consortium for Spatial Information (2015, Version 4) and Google Earth.

environmental conflicts around water and land have challenged business-as-usual. Today, mining companies have to demonstrate expertise in water management.

Peruvian law requires the monitoring of Yanacocha's detrimental water use. The mining company is required to regulate upstream water quality and quantity, and to develop basin-scale water provision for downstream livelihoods (see Figure 9). In 2004, the company took over the construction of the Grande River Dike to regulate sediment discharge and increase urban water supply. The measure doubled the regular production of the city's potable water (Empresa Prestadora de Servicio de Agua Potable y Alcantarillado Sanitario de Cajamarca, 2019). However, the hard-engineered system breaks away from the traditional water paradigm in the Andes, where water supply comes from a multitude of sources and springs in the basin.

To compensate for the damage of upstream canals, and the loss in water flows from groundwater-dependent springs, the company constructed family water reservoirs in rural areas. However, these measures are insufficient to meet the increasing hydric demands of downstream populations, which have grown as a result of mining (Instituto Nacional de Estadística e Informática, 2017).

5.2. Post-Mining Interventions

Yanacocha's ongoing mining procedures occur in parallel to activities of progressive mining closure (see Figure 10). Although local communities have the legal right to validate post-mining visions, the mining closure activities to-date have been realized unilaterally. The imminent mining closure will leave not only a socio-environmental cri-

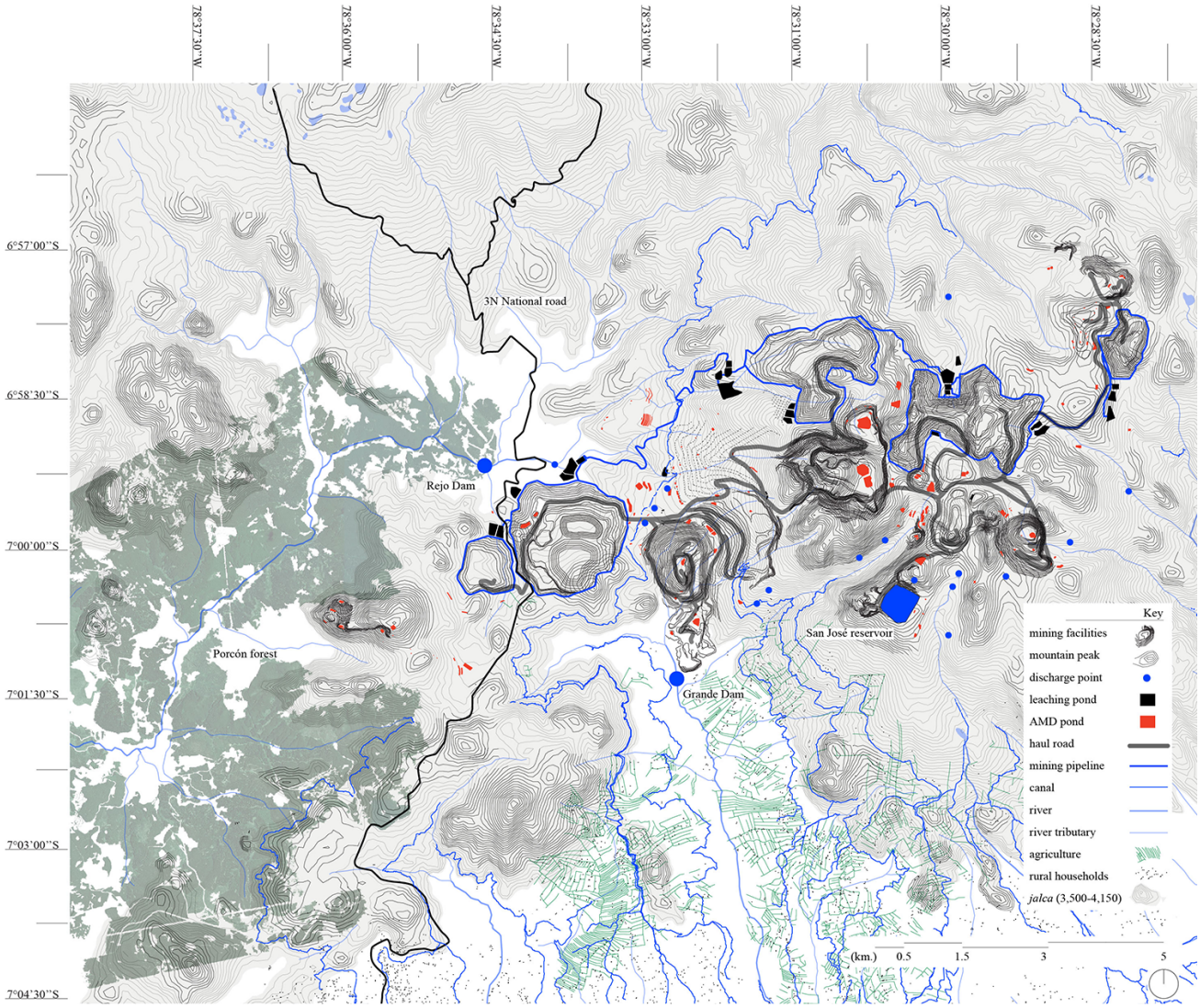

Figure 9. In Cajamarca's headwaters, the infrastructures of mining (pits, pads, waste-piles, pipes, ponds, dikes, haul roads) intertwine with remaining canals, lakes and mountain peaks. Meanwhile, downstream agriculture and forestry expand towards higher altitudes. Sources: Elaborated by Margarita Macera, based on database from Gobierno Regional de Cajamarca (2015), CGIAR-CSI Consortium for Spatial Information (2015, Version 4), Google Earth, MYSRL (2006), Teal and Benavides (2010), Vela-Almeida, Kuijk, Wyseure, and Kosoy (2016) and Yacoub López (2007).

Figure 10. In 2018, the higher altitudes in Maqui Maqui bear witness to disturbed, remediated and remnant *jalca* landscapes. Pre-existing and revegetated patches of *stipa ichu* and *polylepis* intertwine with rocky hummocks and rock-waste piles. Modern mining, post-mining and ancient headwater ecologies coexist in space and time. Source: Photography by Margarita Macera.

sis, but as well an economic one without precedent. It is not evident that the disastrous impact of mining on the territory's soil, vegetal and hydrological regimes can ever again become self-sustainable and non-hazardous. In order to guarantee safe freshwater provision, it will be necessary to install perennial water treatment mechanisms after mining closure (MYSRL, 2012). To this end, the company will need to maintain custody of the disturbed headwater sites. However, perpetual headwater management and water supply service by MYSRL poses a threat to the long-term stability of Cajamarca's water governance. MYSRL's reduced financial capital will undoubtedly become an excuse for passing on the post-mining water management costs to the population. MYSRL's 'responsible mining' policies are unlikely to ease the scepticism of communities that, de facto, will inevitably bear the costs of post-mining remediation or the consequences of the lack of remediation.

Progressive closure procedures are carried out when mineral resources are exhausted, or mining heaps have reached maximum storage capacity. Mitigating the effects of AMD is a priority with regards to environmental protection (Younger, Banwart, & Hedin, 2002). There are standard environmental engineering protocols to isolate AMD sources, re-contour slopes and cover them with new top-soil (Burley, 2001; MYSRL, 2019; see Figure 11). Re-vegetation aims to trigger processes of natural succession and re-colonisation by native species (Bradshaw, 2000). In Yanacocha, most progressive mining closure procedures start from default spatial configurations (dictated by the geometry of open pits, pads and waste piles), focusing on mitigating the ecological hazards of mining landforms (Tongway & Ludwig, 2011).

Other types of post-mining intervention include the re-programming of remediated areas. In 2000, a partial backfilling occurred in Yanacocha's Maqui Maqui Pit. Since 2006, the Mining Closure Experimental Centre has operated on the pit's re-contoured surface, in parallel to a continuous treatment of AMD effluents, monitoring and maintenance of the rehabilitated areas (MYSRL, 2007). Maqui Maqui includes a nursery for post-mining revegetation and *alpaca* farmyards. In 2005, other mining closure activities involved the re-contouring, overlining and flooding of the San José Pit, to turn it into a 6 million cubic meters capacity water reservoir. Since 2007, it has stored treated runoff water of mining facilities for ore processing and the feeding of upstream canals (that once fed directly from multiple headwater sources; MYSRL, 2008). The transformation of the pit—as in the case of the Grande River Dyke—centralises wa-

Figure 11. In 2015, excavated materials from La Quinua pit served to re-contour its adjacent north rock waste piles while expanding operations south, towards the headwaters of the Grande River. The measures involved revegetation of the area with native pastures and mimicking the surrounding environment. Source: Photography by Margarita Macera.

ter provision through large-scale water treatment and collection. With the extinction of former headwater sources, secure water provision for downstream rural populations now relies on the continuous maintenance of such infrastructures.

Compared to the large capital investment capacity of mining, closure procedures have economic and operational limitations. Exceptionally, progressive rehabilitation processes benefit from mining's earthmoving machinery to execute plans of large-scale "topographic reconstruction" (Toy & Chuse, 2005, p. 30). Other than the stabilisation of slopes and landscape revegetation, no explicit landscape architecture strategy is applied in the relocation of excavated soils. Artificial, centralised water collection, treatment and distribution mechanisms disguise ecological disturbances of the post-mining landscapes. The integration of landscape, infrastructure and water management protocols to local, downstream socio-ecologies of the Cajamarca Basin remains uncertain. Mimicking the site's former topography and vegetation are certainly not sufficient measures to integrate post-mining landscapes into a self-renewable environment.

The definitive cessation of Yanacocha's mining will intensify existing socio-environmental contestations. Therefore, a shift in reclamation methods is critical. It is no longer possible to wait for the end of mining activities in order to begin to re-shape the voluminous, hazardous, disturbed landscapes and ecologies. A post-mining vision must be developed immediately in order to initiate post-mining remediation activities that can substantially restore self-renewing hydrological regimes. Cajamarca requires the design of its future headwater landscapes, which includes the planning of mining activities themselves. Clearly, mining resources (financial and logistic) can be instrumental for the construction of transitional (post-mining) landscapes, where water flows can be progressively redirected and cleansed (Athanasiou, 2018; see Figure 12).

An alternative post-mining scenario proposes to recharge headwater aquifers and restore an overall 'sponginess' to the *jalca*. In this way, the ecological floors (and settlements) below Cajamarca's *jalca* can benefit from clean water. The strategy gradually converts Yanacocha's mining facilities into performative landscape infrastructures for water harvesting, retention and redistribution (Athanasiou, 2018). It proposes that haul road networks progressively become spines for water management. These networks can isolate clean runoff from polluted effluents, accommodate passive AMD cleansing systems (constructed *bofedales*), and guide clean water flows towards new irrigation systems that intertwine with pre-existing ones. While providing water for downstream communities, the new irrigation system also functions as new tributaries in the Grande River catchment. At the same time, the construction of *qochas* and *polilepys* forests in strategic catchment areas can guarantee minimum baseflows to nourish both surface (canals and river tributaries) and aquifer-dependant (springs) water bodies.

Figure 12. An alternative scenario for the transitional landscapes of La Quinua open pit in 2025 envisions to orchestrate ongoing earth works for the formation of new water flows and catchments. Constructed wetlands clean water before its distribution in downstream canals. Source: Athanasiou (2018).

The proposal builds on indigenous landscape infrastructure logics which can be rationalised, eventually upscaled and re-build Cajamarca's future ecologies. The focus on desirable future scenarios could re-direct local stakeholder's contentious discussions towards a shared post-mining vision, assuming that MYSRL can be motivated (or forced by government bodies and pressure from civil society, local and international NGOs, etc.) towards co-produced process of vision development.

In the context of Cajamarca's goldmining, interpretative mapping visualised the contested spatial, social and environmental dynamics within and beyond the confines of the MYSRL compound. The historical reading of Cajamarca and the Andes' long-term landscape evolution contextualised landscape transformations within broader, cyclic, systematic processes of socio-ecological disturbance—particularly the decimation of the *jalca* landscape by mining (from 1993 to 2020). Exploring the interactions between the *longue durée* of Cajamarca and the present, transitional mining landscapes of its *jalca* can better inform design strategies for post-mining development. Such a methodological approach can be applied to other contexts of large-scale, surface, mining of the broader Andean region.

6. Conclusion: (Post)mining Landscape Palimpsests

Historical continuums and ruptures—from geological to human scales—have made the Andes a palimpsest of landscape transformations. The rise and fall of indigenous and colonial civilizations have been fundamental to the overlapping processes of settlement and abandonment of Andean habitats. Among these processes, the modern mining of the neoliberal era is the latest sequel of successive waves of headwater colonization.

North Andean palimpsests follow new territorial logics over-writing old ones while preserving enduring structures. Colonial land structures coexist with ancient relations of reciprocity across ecological floors. Reformed rural land structures exist alongside sparse, but prevailing, pre-Hispanic productive pockets and urban niches (Mumford, 2012). Reductions over-wrote pre-Hispanic livelihoods, retained a substantial Andean population and became towns. Despite being colonial products, Andean towns, *caseríos* and cities are part of today's prevailing 'vertical archipelago.' As colonial products, they have been appropriated and taken over by local cultures. The reversal of meanings is one of the interesting, often re-occurring operations that palimpsests evince (Corboz, 1983). Indigenous techniques subsist for an extremely long time, next to predominantly colonial and modern landscape infrastructures. The resilience of indigenous landscape infrastructures is explained by their robust, but adaptative response, over centuries, to dynamic Andean environmental conditions.

In the last fifty years, an interplay of technological development and a never-satisfied market-driven gold hunger has magnified the impact of mining enterprises on the Andean headwaters. Automated modern mining technologies threaten to compromise future hydric balances of local and regional Andean ecologies. Post-mining scenarios consequently have not only to take the disrupted headwater areas into account, but also the entire water basin.

Cajamarca's future post-mining development demands looking back to deeply understand—and learn from—its palimpsest landscape dynamics. These dynamics can shed light on the critical headwaters attributes to restore and the techniques to do so. Although the exact reconstruction of the *jalca* environment is unrealistic, restoring its performance is a long-term possibility. Pre-Hispanic techniques of earth-formation and water management can induce water retention in soil and self-water-cleansing mechanisms in headwater areas. Rationalising, adapting and upscaling these techniques is a priority. If timely used, modern mining can then bring the tools to 're-naturalize' landforms in an efficient manner. While implementing this design-construction

method, beneficial, transitional landscapes (and new landscape palimpsests) can be intentional rather than accidentally created.

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Conflict of Interests

The authors declare no conflict of interests.

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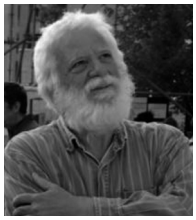

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Article

Red Chalk Palimpsest: The Logic of Somba Landscape

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Abstract
This article presents the results of a study on the traditional settlement patterns of the Somba people, living in the department of Atacora, north-western Benin. Adopting a methodology based on both a generative approach and André Corboz's (1983) territory–palimpsest analogy, the study specifically questions the 'dispersed' character of the Somba habitat. Built upon two hypotheses, according to which Tatas Somba settle approximately to pre-existing Tatas and near to watercourses, this study seeks to understand the reasons and conditions of this dispersal throughout history. By cross-checking on-site inventory and geographic information system data allowing to analyse the distances between Tatas, archaeological sites and nearby watercourses, and thus revealing the permanent, the persistent, and the disappeared landscape elements, this article aims to prove that the settlement of the Tatas Somba is not determined by geometrical compositions, landmarks, or infrastructures, but rather by a combination of social, agricultural, environmental, and subsistence factors.

Keywords
Atacora; palimpsest; Somba landscape; Tatas Somba; watercourses

Issue
This article is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

1. Introduction

This article presents the results of a study on the traditional settlement patterns of the Somba people, living in the department of Atacora, north-western Benin. Adopting a generative—or syntactic—approach, combined with Corboz's 'territory-as-palimpsest' approach (1983, 1993), this study particularly questions the 'dispersed' character of the Somba habitat and seeks to understand the reasons and conditions of this dispersal.

In many ways, the Somba landscape resembles a palimpsest. The Somba people's modes of production, especially agriculture and earthen architecture, are characterised by their fragility and their lightness. As a result, they leave few visible and tangible traces of previous occupation and make few changes to the topography and hydraulic network, so much so that the settlement of the Tata does not seem to be dependent upon the permanence nor the persistence of old buildings or previous infrastructure.

To understand the settlement of the Tata Somba in Benin, two hypotheses are proposed in this study. Inspired by anthropological studies on the habitat of the Tamberma people in Togo, the first hypothesis is that the Tata Somba settle near pre-existing Tatas, sometimes even on the sites of ancient ones, leading to the emergence of settlements or villages which, despite regular renewal, remain relatively permanent. The second hypothesis, suggested by the agricultural orientation of the Tata and by the water supply required for their construction, is that they settle near watercourses, thus making the hydrographic network the matrix of the Somba landscape. Based on the recent geographical maps of Benin published by the Institut Géographique National (IGN), on a geolocated inventory of Tatas Somba, counting 3,546 individuals, these two hypotheses are put to the test, us-

ing QGIS software, through the analysis of the distances between the closest neighbors.

The temporal permanence of these two hypotheses is also tested through a complementary analysis. The location of classic Tatas Somba is compared to the location of 'hybrid' Tatas Somba that appear to be the result of an evolution observed since the 2000s (Padenou & Pastor-Barrué, 2006). Furthermore, Tatas' location is compared to the location of 173 archaeological sites.

Without being able to draw a conclusion on whether there is a natural law or a social rule that mechanically determines the Tatas' settlement, ultimately, it remains dependent on local conditions and holds significant decision-making margins—the statistical results of this study nevertheless make it possible to confirm the existence of a 'common' spacing between the Tatas, and to affirm the existence of a preferential gap between the Tatas and the watercourses.

Furthermore, the comparison between classical and hybrid Tatas and the comparison between Tatas and archeological sites suggest, despite the impermanence of the Somba landscape, the perpetuation of ancestral settling habits.

2. Context

2.1. Geography

Located in northwest Benin, the Atacora department is bordered north by Burkina-Faso and the Alibori department, west by Togo, east by the Borgou and Alibori departments, and south by the Donga department. Atacora, covering an area of 20,499 km^2 (INSAE-Bénin, 2016), is divided into nine districts: Boukoumbé, Cobly, Kérou, Kouandé, Matéri, Natitingou—which is the administrative centre—Pehunko, Tanguiéta, and Toucountouna (Figure 1).

The topography of the Atacora is marked by the eponymous mountain range that divides the territory of the department along a North-North-East/South-South-West axis (Figure 2). This mountain range is the western outer part of the 1,000 km long Dahomeyide orogenic belt, which extends from south-eastern Ghana to southern Mali. Located on the Pharusian suture, it is the result of a tectonic thrust due to the collision between the West African craton and the Benino-Nigerian craton during the Late Precambrian (between 610 and 580 million years ago; Guillot et al., 2019). For the purposes of description, the topography of the Atacora can be divided into four topographical zones: the Gourma Plain, the Mekou Plain, the High Atacora Plain, and the Atacora plateaus. At an altitude below 250 m, the Gourma Plain extends to the west of the Atacora range, sloping gently down to the Pendjari. At a higher altitude, between 250 m and 450 m, the Mekrou Plain extends to the east of the Atacora. At the same altitude, the High Plain cuts the Atacora mountain range in two. And last, above 450 m altitude and up to 650 m, the Atacora plateaus dominate the region.

Several rivers flow across the Atacora, the main ones being the Pendjari, the Mekrou, the Koumagou, the Keran,

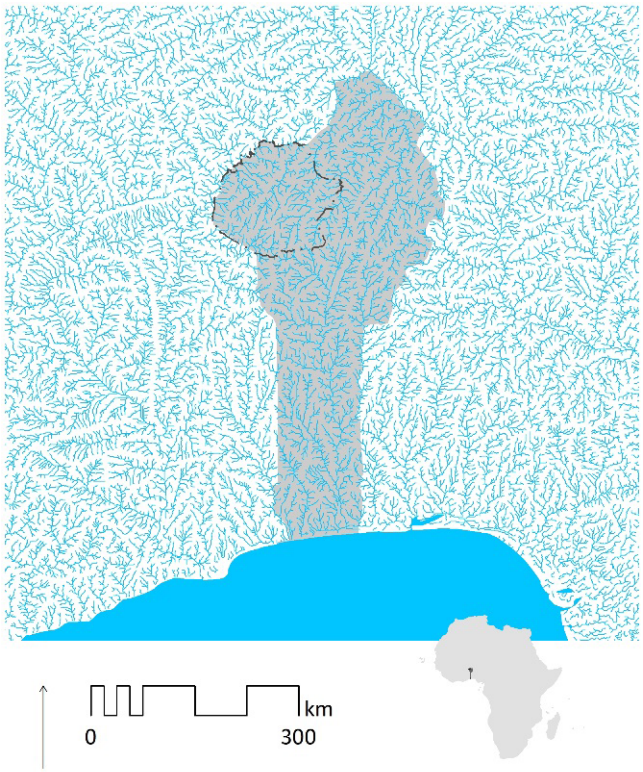

Figure 1. Benin and Atacora: Waterflows. Source: Authors.

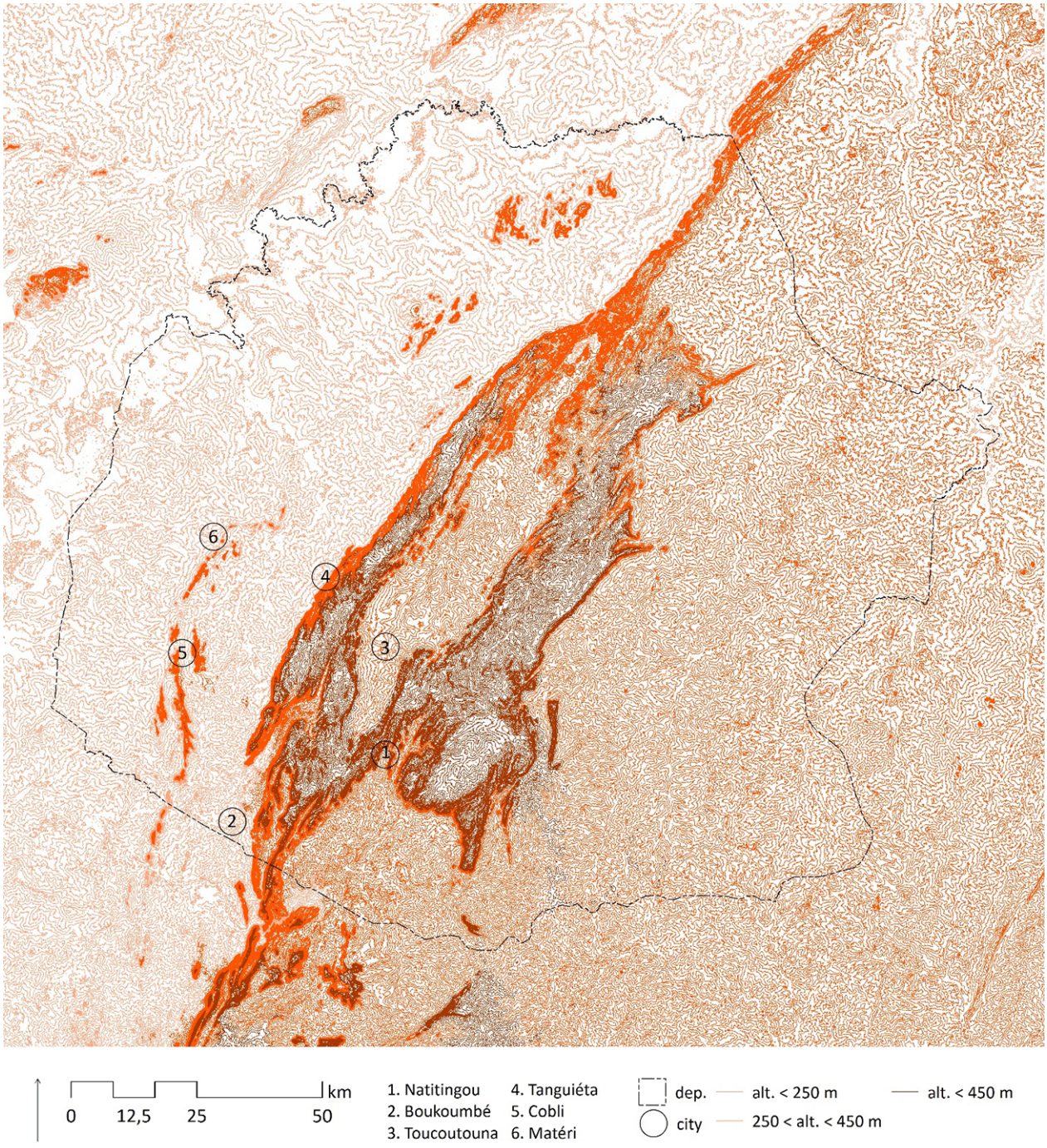

Figure 2. Topographic map of the Atacora. Source: Authors (with IGN data, 2019).

and the Magou (Figure 3). The Pendjari, which has its source in the high plain of the Atacora, flows through the town of Toukoutouna, joins the Gourma Plain, and flows into the Oti (tributary of the Volta river). The Mekrou rises in the east of the Atacora mountains and flows into the Niger River. The Koumagou River rises in the high plateaus of the Atacora, runs through the town of Boukoumbé, flowing into the Pendjari River in Togo. The Kéran River also rises in the Atacora highlands, runs through the town of Natitingou, and flows into the Pendjari River in Togo. Last, the Magou River draws its source in the Pendjari Plain, near Cobli, and flows further north into the Pendjari. It is fed by several rivers from the Atacora chain, such as the Mounhoun, flowing through Tanguiéta.

2.2. Culture

According to the latest census of 2013, the Atakora department has a population of 772,262 inhabitants, divided into three distinct ethnic groups: the Somba; the Bariba, and the Fula (INSAE-Bénin, 2016). The Somba population (59%) occupies the Atacora mountains and the Gourma Plain, covered by the districts of Boukoumbé, Cobly, Matéri, Natitingou, Pehunko,

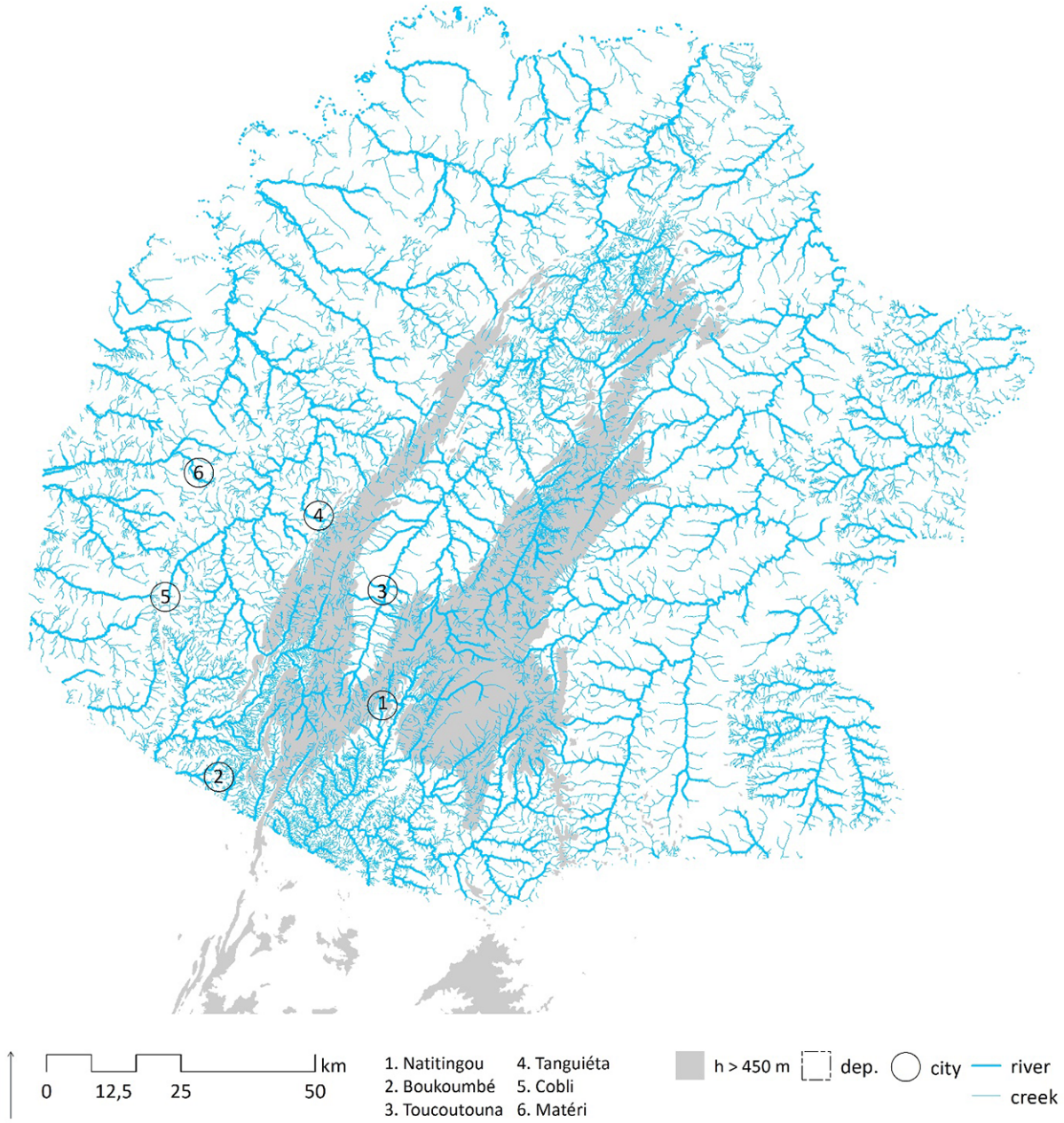

Figure 3. Hydrographic map of the Atacora. Source: Authors (with IGN data, 2019).

Tanguiéta, and Toucountouna. It includes several ethnic groups: Bétammaribé (including Bétammaribé, Béssoribé, and Bétchabé), Berba, Niendé, Natimba, Tayaba, and Waaba. The Bariba, for their part, are attached to the eastern part of the Atacora, covered by the districts of Kérou, Kouandé, and Péhunko. The Fula or Peulhs are nomadic pastoralists who set up their camps following the opportunities of transhumance.

The Somba population lives off rainfed non-mechanical agriculture on burnt land, and soil is mostly fertilised through fallowing. The available agricultural land is regularly redistributed according to the needs of the village members. The variation in soil and climate allows, from East to West, the cultivation of tubers and root crops (yam, cassava, and sweet potato), cereals (millet, maize, fonio, and sorghum) and legumes (beans and voandzou). Hunting is also quite common and takes place during the dry season from November to May.

The most recognisable elements of the traditional Somba habitat are the 'multi-storey dwellings' known as Tata Somba. Just as the term 'Somba' refers to a group of related ethnic groups, the term 'Tata Somba,' used here for its all-encompassing nature, refers without distinction to all the traditional dwellings of the Somba group. In ditammari, the language of the Betammaribé, the multi-storey dwelling is called *Takyenta* (plural: *Sykien*). The Tamberma of Togo call their dwelling *Tékyenté* (Blier, 1994; Padenou & Pastor-Barrué, 2006). Built of mud, the

Tata Somba is composed of several circular huts (approximately 2 meters in diameter) with conical roofs covered in straw. These huts are arranged in a circle and are connected to each other by curved walls (Figure 4). The first floor is made up of one or more terraces of rammed earth, supported by wooden posts and beams. The main terrace gives access to the rooms and attics on the first floor. The groundbreaking works of Maurice and Mercier revealed the existence of typological differences between the Tata of the different Somba subgroups. It is thus possible to distinguish the Tata of Otammari, Osori, Otiao, Berba, Tayaba, Niendé, and Waaba types. In addition to these different types that can be described as 'classical,' there is a 'hybrid' type of Tata Somba, which appeared in the region at the turn of the year 2000 (Padenou & Pastor-Barrué, 2006, p. 273). It is mainly characterized by the absence of the terrace and the addition of rectangular huts covered with tin roof.

3. Issues

3.1. Approaches

The studies devoted to the traditional habitat of the Atacora have mainly covered stylistic and symbolic aspects. The first studies focused on classifying and assigning the different types of Tatas to one of the socio-cultural groups that make up the Somba people—Bétammaribé (Bétammaribé, Béssoribé, Bétchabé), Berba, Niendé, Natimba, Tayaba, and Waaba (Maurice, 1957; Mercier, 1954b). The second studies highlighted the symbolism of the traditional habitat, the division between right and left corresponding to the opposition between men and women, the division between the ground floor and the first floor, and the opposition between life and death. Considering that "the house, in fact, can be studied on its own" or that "among all the components of the Tamberma space, the *Takyenta* as a building, is by far the most important and also the most interesting element to analyse" (Padenou & Pastor-Barrué, 2006), all these studies focus mainly on the Tata as such. As a result, most of the studies dedicated to the Somba habitat are limited to a typological or taxonomic approach of the Tata. Qualitatively, they identify the characteristic features of the structures (curvature of the walls, heights of the turrets, slope of the terrace, etc.) and define types (Mercier, 1954b) or 'models' (Padenou & Pastor-Barrué, 2006) to which the documented structures are supposed to correspond. On the contrary, all of the studies insist on the fact that the traditional habitat is dispersed without trying to understand its implantation principles: "The Tamberma habitat is a dispersed habitat. The houses are generally a hundred meters apart" (Padenou & Pastor-Barrué, 2006, p. 97).

Figure 4. Photo of Tata Somba in Kouaba. Source: Authors.

The study presented in this article adopts, first, a 'generative' (Pleitinx, 2019) or syntactic approach, complementary to the taxonomic approach. This means that the Tata is not considered as a model with a set of features subject to marginal variations, but as an entity made up of elementary units on the one hand, and as a part of larger groups, on the other. In a primary approach, these groups are, first, the domestic domain, which includes the Tata, but also the courtyard, the *apatam* (straw huts), the adjoining agricultural plots, etc.; second, the village, which includes the various family domains, paths, water points, etc.; and finally, the territory, which includes the villages, the roads, and the geographical lineaments of the Atacora. From this perspective, the aim is to understand, at each one of the three scales considered, the principles that rule the association of Somba habitat units, principles that constitute what could be called the "syntax of Somba architecture" (Pleitinx & Noukpakou, 2019) and that are at the source of the formation of the 'Somba landscape.' Adopting a generative approach calls for questioning the dispersal of Somba habitat. If it is accepted as a working hypothesis that the Tatas Somba are elements of a whole, their dispersal should be seen as a consequence of the principles of the formation of this whole, rather than as a lack of consistency.

The Somba modes of production, slash-and-burn agriculture, and earthen architecture are ephemeral. Without regular maintenance, fields and tracks disappear under weeds, and buildings quickly fall into ruin, eroded by rain and wind. No visible or tangible vestiges of the ancient productions remain. According to the information collected during the inventory of the Tata Somba carried out in the districts of Boukoumbé and Natitingou on the initiative of the French Institute of Cotonou, the average age of the Tata is 54 years, while the oldest Tata is said to be 140 years old (results obtained from a sample of 1,528 individuals). Archaeological prospecting campaigns have brought to light many sites that show evidence of an ancient occupation of the Atacora territory. These are mainly caves and rock shelters, whose occupation dates back to the prehistoric period: archeometallurgical sites, ruins of ancient villages, and low mounds, some of which have been dated from the 7th to the 15th century AD and may have been occupied by populations from which the current populations are descendants (N'Dah, 2009). Furthermore, the agricultural practices and construction of the Tata Somba do not require any heavy or invasive superstructure or infrastructure. While the Somba people's agricultural production methods may have played a part in the partial deforestation of the Atacora, they have neither transformed its topography nor changed its watercourses. The Somba landscape can be compared to a palimpsest whose red chalk text has been erased many times with the fingertips, leaving the fibers of the parchment intact.

Second, this study adopts a territory-as-palimpsest approach, questioning the dispersal of Somba habitat throughout history. Following Corboz (1983, 1993), this approach aims to reveal the permanency, the persistency and also the disappearance of landscape elements. In the particular case of the Somba landscape, it implies to also take into account the perpetuation of settling practices that bear witness to the existence of something like a 'common mental palimpsest.'

3.2. Hypotheses

The ephemeral and light nature of agricultural production and traditional housing does not exclude the persistence of their settlements nor the perpetuation of some settling practices. The study is therefore based on the working hypothesis that there is an order, a logic underlying the dispersal of Somba habitat. In this case, this article focuses on testing two hypotheses that are mutually non-exclusive.

The *Sikyen* of Togo settle at a distance from each other, saving a surrounding area, where fields are "cultivated by women" (Padenou & Pastor-Barrué, 2006, p. 110). However, for family reasons, they settle close to one another, "an arrow range away" (Cornevin, 1973). This principle of settlement is a factor both in the concentration of the Tatas and in the settlement of villages in a particular spot within the territory of some Tatas. If the Tamberma settlement pattern is the same among the Somba in Benin, it should be possible to observe, despite their apparent dispersion (Cornevin, 1973, p. 23), that they maintain a relatively constant spacing between two Tatas Somba. In addition, if these settlement principles are permanent, it should be possible to verify that the newer hybrid Tatas maintain the same distance to the neighbour. It should also be possible to observe a proximity between the Tatas and the various archaeological sites inventoried by archaeologists, especially the anthropic mounds (7th to 15th century).

The Tatas Somba are built in raw earth and are used, among other purposes, to store harvests. In this regard, they have an ambivalent relationship with watercourses. On one hand, water is a necessity for the construction of the Tata, required for mixing the mud, and for agricultural activity, as it needs a sufficiently wet soil. On the other hand, the rivers are a threat to the constructions, degraded by erosion, and to the crops, endangered by floods. It can be assumed that choosing a site for the construction of a Tata is the result of a balance between the need and the threat represented by water. If this is the case, it should be possible to observe a recurrent positioning of Tata in relation to watercourses. If this relationship to the watercourse is a permanent principle, there should also be a link between, first, the hybrid Tatas Somba and the watercourses and, second, between the most recent archaeological sites and the watercourses. Without being the sole or main determinant, the hydrographic network of the Atacora should thus constitute a matrix for the geographical location of the Somba habitat.

4. Method

4.1. Data

Both hypotheses are here tested by a statistical analysis conducted using the QGIS program. The analysis uses several data sets.

First, it uses the 1:50,000 scale maps produced by the IGN of Benin and accessible on its Geoportal since 2019 (www.geobenin.bj). It mainly uses data relating to watercourses. Drawn accurately and exhaustively, they are classified, namely, by type—river or stream—and by regime—permanent or temporary.

It then uses the geolocated inventory of traditional raw earth habitats carried out by the author and based on satellite imagery from 2019 as part of the HTC-Atacora project. Funded by the Walloon Air and Climate Agency (AwAC) and led by UCLouvain in partnership with Eco-Bénin and Yves Baudot, the HTC-Atacora project aims to preserve raw earth habitats and to promote the construction of raw earth habitats resistant to climate change and low timber and firewood consuming. This inventory covers a limited portion of the territory covering 4,507 km^2 (Figure 5) and allows the identification of 3,546 Tatas Somba, with a distinction between two types. The first type of Tata Somba corresponds to the multi-storey housing of which the variations were described by Maurice (1957) and Mercier (1954a) and represents almost 60% of the Tatas inventoried. The second type is a hybrid, maintaining the configuration of the traditional Tata Somba; it does not have a storey and occasionally includes blocks with a rectangular floor plan, and represents 40% of the inventoried Tatas.

Finally, the study uses the list of archaeological sites in the Atacora taken from the appendices of Didier N'Dah's (2009) thesis, defended in 2009 (Table 1). Of the 173 sites listed in our study area, 132 are located using geographical coordinates. These sites are of several types: caves, rock shelters, open-air sites, metallurgical sites, and anthropic mounds spread across the territory of Atacora (Figure 6).

Of all the archaeological sites, the study focuses mainly on the more recent anthropogenic mounds, which appear to correspond to a habitat.

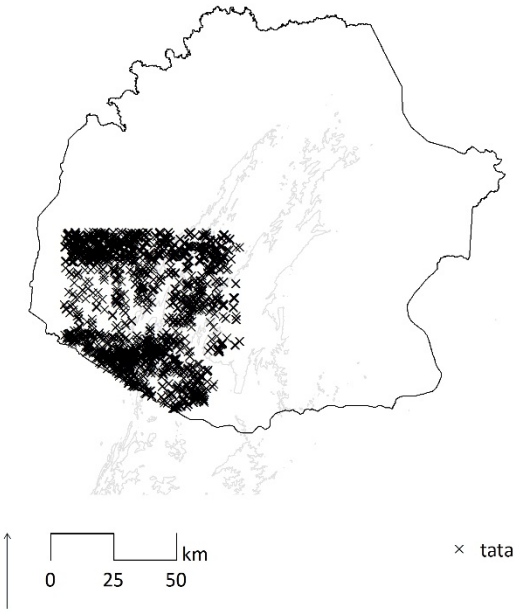

Figure 5. Tata Somba inventory. Source: Authors.

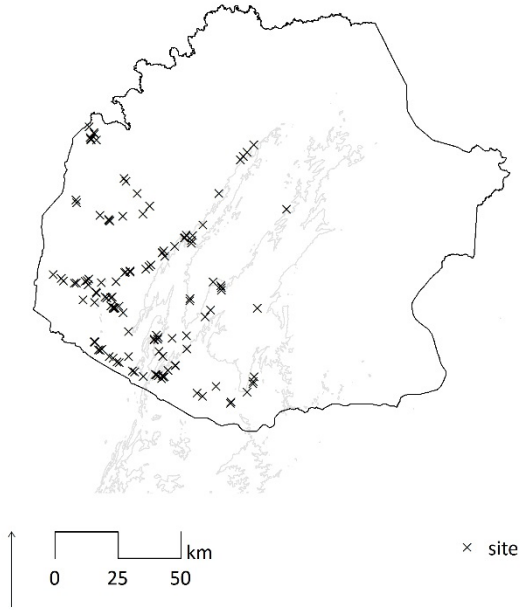

Figure 6. Archaeological sites. Source: N'Dah (2009).

Table 1. Number and types of archaeological sites.

Types	Listed	Geolocated	Non-geolocated
Rock shelters	10	10	0
Anthropic mounds	83	74	9
Caves	7	5	2
Open-air sites	64	36	28
Metallurgical sites	9	7	2
Total	173	132	41

Source: N'Dah (2009).

4.2. Statistics

The two hypotheses stated above are tested through a statistical analysis of the distances between the given hydrographic, architectural, and archaeological elements.

To test the first hypothesis whereby Tatas settle close to each other, or even in the location of former Tatas, the analysis focuses on the shortest distance between two inventoried Tatas. To test the historical depth of this hypothesis, the results between classical Tatas and hybrid Tatas are compared. The analysis is then extended to the shortest distance between Tatas and anthropic mounds. To test the second hypothesis whereby Tatas are settled in a way that ensures their access to water while protecting themselves from threats, the distance between a Tata and the nearest watercourse is first examined. To further investigate this hypothesis in time, we are also interested in the behavior of hybrid Tatas Somba and the distance between an anthropic mound and the nearest watercourse. In both cases the statistical results are interpreted by mapping the notable locations on the satellite images.

In Atacora, the topography and density of the hydraulic network vary considerably from one geographical point to another. Anticipating the fact that these variations may have an impact on the studied distances, the Atacora territory has therefore been divided into five study areas (Figure 7). Zone 1 corresponds to the plain irrigated by the Keran and its tributaries, where the majority of the Tatas of the Besoribé type are found. Zone 2 corresponds to the plain drained by the Koumagou River and its tributaries, where Tatas of the Bechabé type are found. Zone 3 corresponds to the high plain of the Atacora, where the Pendjari River takes its source and where a part of Tata Somba of the Betammaribé and Berba type are found. Zone 4 extends over the plain of the Gourma, where the Magou and its tributaries flow, and where the Tatas of Berba type are gathered. Zone 5, finally, corresponds to the Atacora plateaus, where the majority of Tatas Somba of the Betammaribé type are found. Zones 1, 2, and 4 cover the plains at the foothills of the Atacora, while Zones 3 and 5 cover the mountain range. Receiving the waters of the Keran and Koumagou rivers that flow down from the mountains, Zones 1 and 2 have a much higher density of streams than Zones 3 and 4.

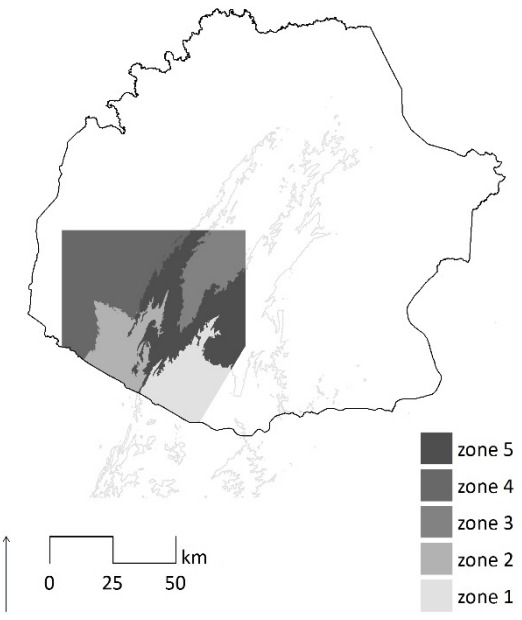

Figure 7. Study zones. Source: Authors.

5. Analysis

QGIS software allows to measure the shortest distance separating two points as well as between a point and a line. It provides statistics and histograms that allow to appreciate the position and the dispersion of the measurements.

5.1. Spacing

The statistics (see Table 1 in the Supplementary File) for the shortest distance separating two Tatas Somba reveal a wide range of spacing in all areas, from 11 m to 4309 m. In addition, for all areas, an important standard deviation is observed, indicating a wide dispersion of measurements. However, with the exception of Zone 2, this dispersion is very asymmetrical, as revealed by the large differences between the average and median values, but also by the fact that the average is greater than Q3 in Zones 3, 4, and 5. In such cases of asymmetry, the values Q1, median, Q3, and mode are statistically more indicative than the average and standard deviation. In terms of quartiles, there is a strong difference between Zones 1 and 2 and the other three zones with homogeneous results. For these three zones, in particular, the interquartile range is very narrow compared to the standard deviation. The two zones covering the Atacora mountain range, plain (Zone 3) and plateau (Zone 5), obtain almost identical results. But in all five zones, the mode, i.e., the most observed value, ranges between 50 m and 75 m (Figure 8).

These results show that the shortest distance between two Tatas is subject to great variations. However, Tatas tend to settle close to one another. These results show a tendency to maintain the modal distance (50–75 meters) between two Tatas. This confirms the hypothesis of 'dependency on the predecessor' that suggests a relatively fixed settlement pattern (Figure 9).

The comparison of modal distances to nearest neighbours for type 1 Tata and type 2 Tata shows a clear convergence. This suggests that, in spite of the changes in the type, the syntactic rule of distances remains unchanged.

Generally speaking, the averages and medians of the shortest distances calculated between an archaeological site and a Tata are two to three times greater than the

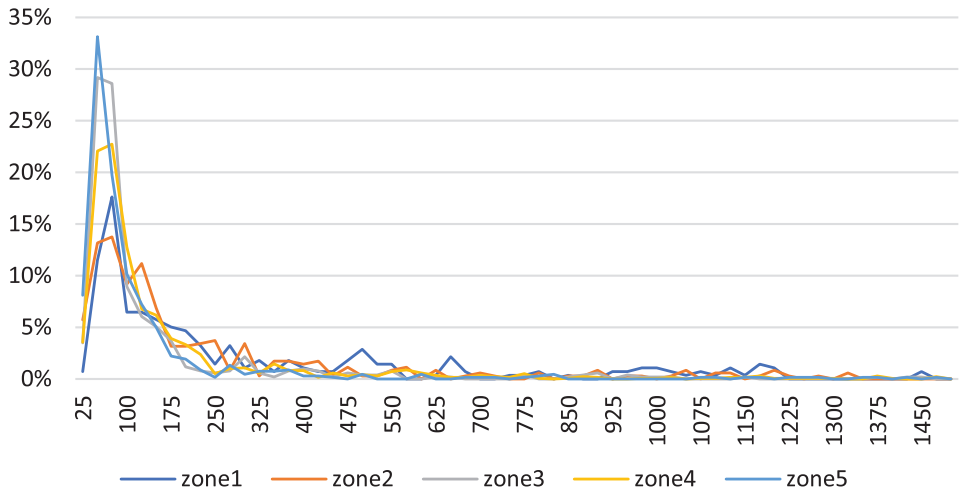

Figure 8. Histogram of shortest distances between two Tatas (Class width: 25m). Source: Authors.

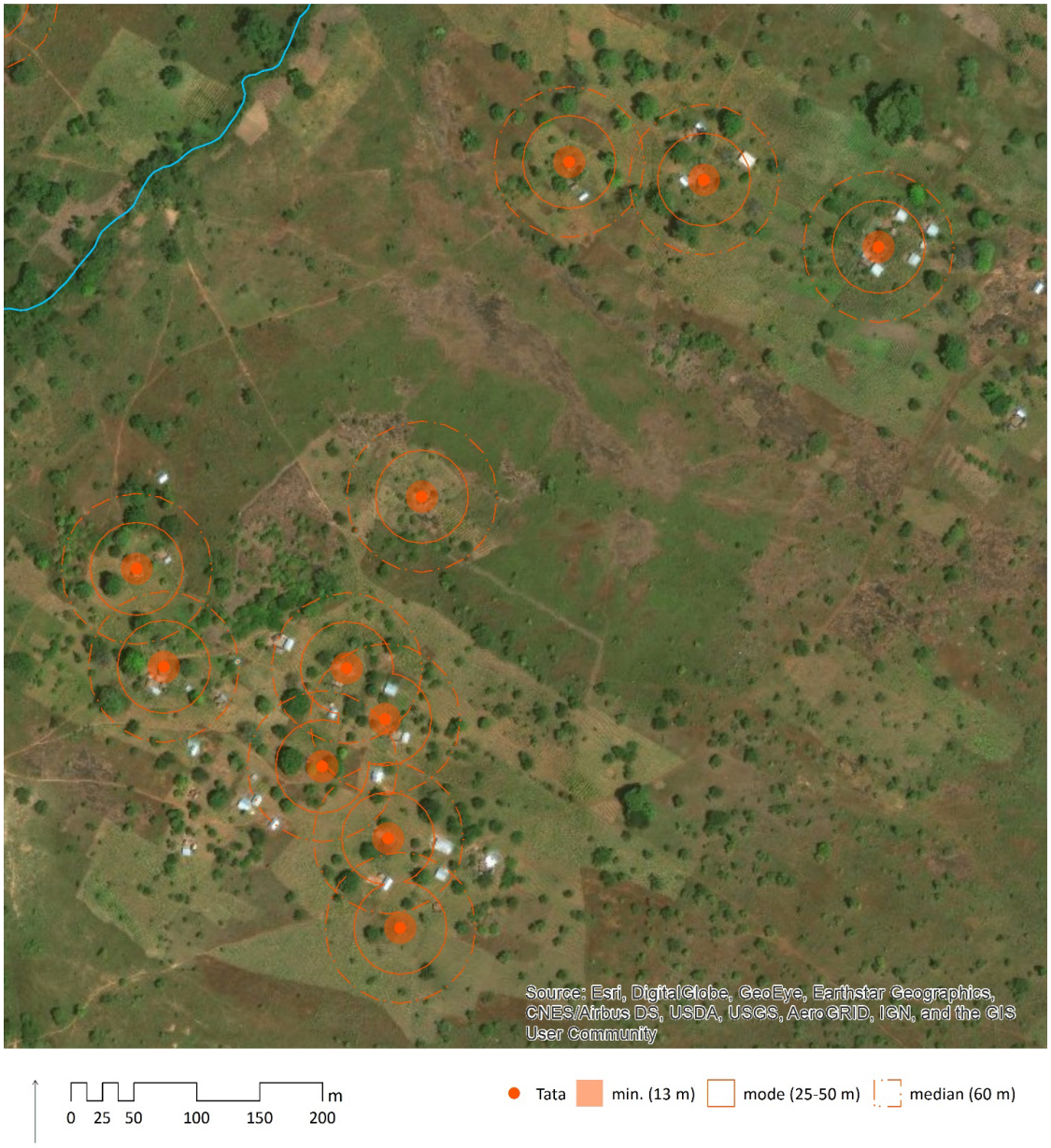

Figure 9. Analysis of shortest distances between two Tatas, Kouaba village (Zone 5). Source: Authors.

averages and medians of the shortest distances between two Tatas Somba (see Table 2 in the Supplementary File). A finer analysis of the shortest distance between an anthropic mound and a Tata, measured in each of the zones, does not improve the score (the analysis of the distances between the archaeological sites and the Tatas is limited to the inventoried area of the Tatas Somba). The statistics do not allow to establish a connection between the existing traditional Tatas Somba and the past settlements attested by the archaeological sites, and thus conclude that these sites have remained the center of settlements in spite of their disappearance.

5.2. Distancing

In order to verify that the observed distribution is not a simple reflection of the hydrological configuration, it is compared, for each zone, to the distribution of the same number of people randomly spread across the territory. The statistical values (minimum, Q1, mode, and median) obtained for this sample are significantly different from the observed values, which leads to the conclusion that the Tatas Somba are not randomly scattered over the territory (see Table 3 in the Supplementary File).

Like the distances between Tatas Somba, the distributions of distances between Tatas and rivers calculated for each area are asymmetric (asymmetry coefficient > 0), which reduces the informative value of the average and standard deviation. Once again, the position values: minimum, median, and mode are taken into account, as they are the most informative in the case of asymmetry (Figure 10). Considering these values, it appears that in the plain areas the minimum distance to the axis of the rivers is more or less 25 m, while in Zone 5, corresponding to the plateaus, it is 40 m. It also appears that, compared to the distance between Tatas (more or less 75 m), the Tatas generally settle close to the watercourses, with an average of observed modes of 185 m and an average of observed medians of 295 m. It also appears that the median and modal distances vary from one area to another. However, the results make it possible to divide the five zones into three coherent groups on a hydrographic level. In Zones 3 and 5, corresponding to the high plain and the Atacora plateaus, the median distance is overall of more or less 140 m. In Zones 1 and 2, corresponding to the Keran and Koumagou plains, the median distance is more or less 190m. In Zone 4, corresponding to the Gourma plain, the median distance is 403 m (Figure 11).

In general, the distances vary according to the slope of the land. The correlation coefficient between the variables 'slope of the terrain' and 'distance between a Tata and the closest river,' calculated for all the Tatas, is −0.25. Calculated for Zone 5, which has the highest average slope, the correlation coefficient is −0.29. Both coefficients are negative, indicating a trend away when the slope decreases, as expected. However, these two coefficients are relatively close to 0, indicating a weak linear correlation between slope and distance to the stream. This is because the slopes in question are relatively low and the distances are relatively short. These favorable conditions offer great leeway in choosing a place to settle.

The comparison of modal distances to nearest watercourse for type 1 Tata and type 2 Tata shows again an obvious convergence, which suggests that, despite the changes in the type, the syntactic rule of distances to watercourses also remains unchanged.

In order to test the historical depth of the hypothesis of proximity between the Tatas and water, the distance between an anthropic mound and the nearest watercourse was also calculated. Comparing the tables 'Tata-hydro' and 'mounds-hydro' (see Table 4 in the Supplementary File), it can be seen that, regardless of the area, the range of distances between a mound and the nearest watercourse is smaller, and sometimes significantly smaller (361 versus 1,247 meters). Overall, the mounds are closer to watercourses than the Tatas. There is a variation in average and median values between areas. They are smaller in Zones 1 and 2 than in Zones 3, 4 and 5. We see the same proportion in the distances

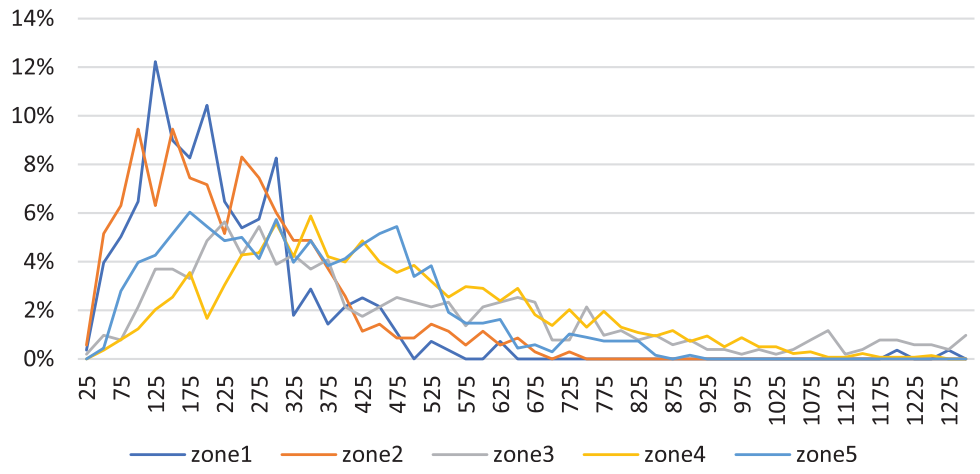

Figure 10. Histogram of shortest distances between a Tata and a watercourse (Class width: 25 m). Source: Authors.

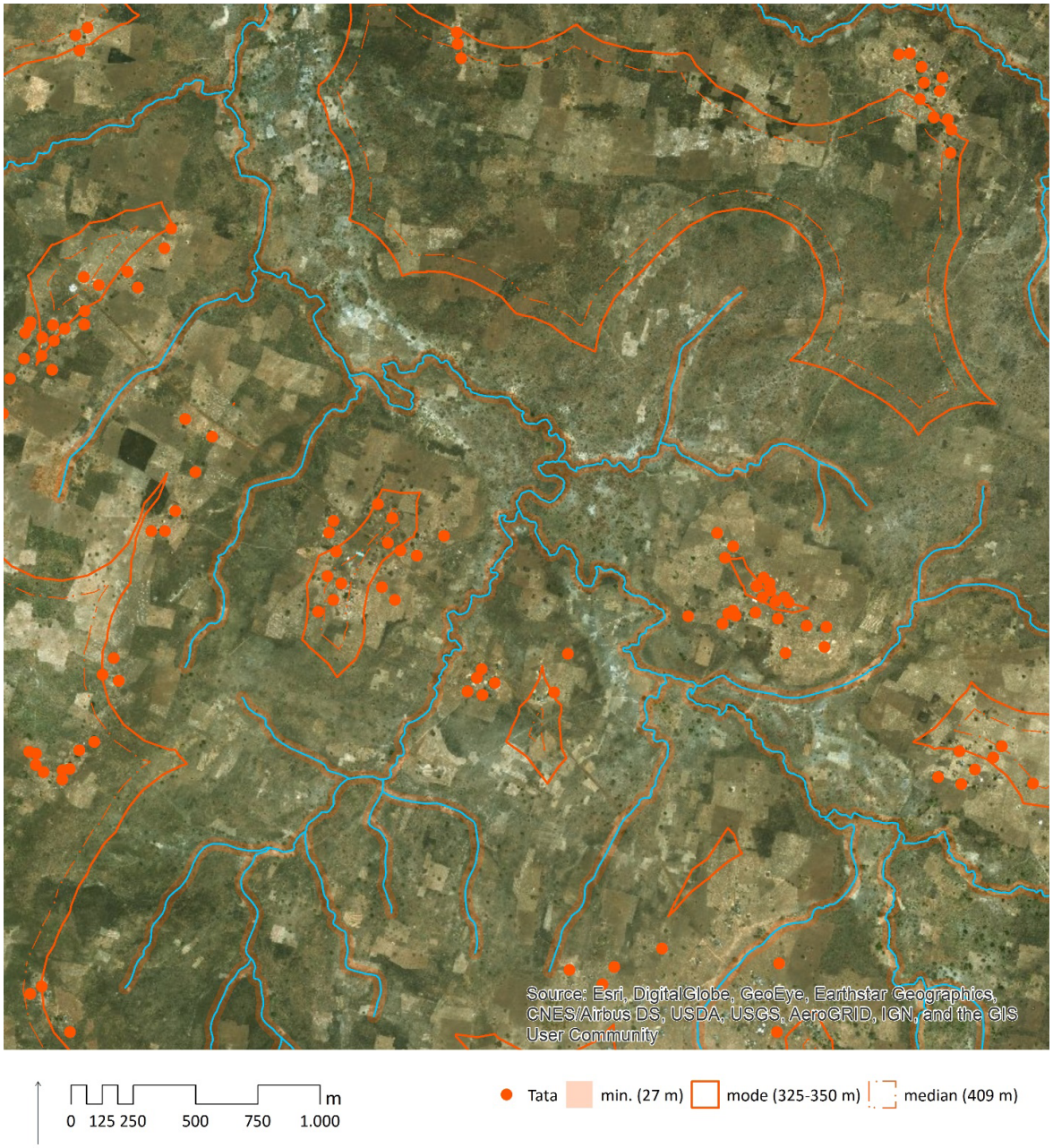

Figure 11. Analysis of shortest distances between a Tata and a watercourse, alongside the Kouloumbouanga river (Zone 4). Source: Authors.

between the Tatas and the watercourses. The values obtained in Zone 4, which has the largest number of mounds, are the closest to values found for the Tatas in this zone. The minimum distance of more or less 25 m is respected. The average and median distances are very close. The locations of the anthropic mounds correspond to those of the Tatas, as the differences, ranging from 3 to 5%, remain quite small.

6. Conclusion

By studying the Tatas Somba from a generative perspective and a territory-as-palimpsest approach, the research presented in this article sought to further understand the dispersal of the Tatas Somba, as it is one of the characteristic features of the Somba landscape. Two hypotheses were put forward regarding the links between the Tatas and their links to watercourses. The first of these two hypotheses was tested through an analysis of the shortest distance between two Tatas and then through an analysis of the shortest distance between an archaeological site and a Tata. As for the second hypothesis, it was tested through an analysis of the distance between a Tata and the nearest watercourse, and then through an analysis of the distance between an archaeological site and the nearest watercourse. Both analyses corroborated the hypotheses and allowed the identification of recurring distances.

In spite of great variations, it can be observed that Tatas settle close to one another, at a modal distance ranging from 50 m to 75 m. Frequently observed, especially in the areas around to the Atacora Mountains (high plain and plateau), this modal distance corresponds to the distance between Tatas belonging to the same village, and thus gives a more accurate measure of the famous 'arrow range' of Cornevin (1973). Despite wide variations, once again, it can be observed that the Tatas also settle near watercourses, at a modal distance that varies according to the areas studied, ranging from 75 m to 325 m. In all study areas, a 25 m wide buffer zone is maintained on both sides of the axis of watercourses.

The settlement of the Tatas Somba is not determined by geometrical compositions, landmarks, or infrastructures. The Tatas Somba are dispersed by the effect of centrifugal factors, e.g., family need for agricultural land and threat of water, but this dispersion is tempered by factors with centripetal effects—cooperation and need for water. The combination of these factors leads to the definition of equilibrium points or lines around which the Somba people establish their dwellings.

The hybrid Tatas that appeared around the year 2000, despite their typological modification, maintain the same distances as classic Tatas between neighbours. The state of abandonment and ruin of the archaeological sites discovered in Atacora attest to the ephemeral nature of the traditional habitat in Atacora. They are located outside and at a distance from the settlements. Following the same logic as the classic ones, the hybrid Tatas are settled at a modal distance ranging from 75 m to 325 m. Overall, the archaeological sites are located closer to the watercourses than the Tatas Somba. The anthropic mounds are also located close to watercourses, closer than are the Tatas to watercourses.

The Somba landscape is a moving palimpsest. Due to the ephemeral and fragile agricultural and architectural modes of production, the elements of the Somba landscape (Tatas, fields, tracks, etc.) appear to be impermanent and even nonpersistent. Nevertheless, this study suggests the perpetuation of the same settling habits, which shows the existence of a bolder mental palimpsest than the material one. Furthermore, it shows that proximity to water is an important parameter in the settlement of the habitat in Atacora, revealing the hydraulic network as the permanent underwriting of the Somba palimpsest.

This article calls for developments in the field of research and suggests some reflections on heritage preservation.

The present study is far from having exhausted the understanding of the Somba landscape. Indeed, the analysis should be refined by testing alternative social and environmental hypotheses. On one hand, it would be appropriate to study the impact of more specific social relationships, such as belonging to clans or kinship ties, on the settlement of the Tatas Somba in the same village. On the other hand, it would also be necessary to study the impact of environmental factors such as pedology or land exposure (Hahn-Hadjali, Braun-Yao, Franke-Scharf, & Fritscher, 2000).

Furthermore, the analysis could be extended by finely describing the agricultural and non-agricultural uses of the spaces separating neighboring Tatas, as well as the spaces between Tatas and watercourses.

The balances that structure the Somba landscape are unstable. Nowadays, these balances are threatened both by social changes, such as rural exodus and monetarisation of trades, and by climate change, which is speeding up the process of sahelisation affecting the Atacora (Agbanou, 2018). If not protected, it is doomed to disappear. However, the protection of the heritage of the Atacora should not only aim to maintain the current buildings, but rather to preserve and empower the Somba's agricultural way of life and to protect their living environment.

The Somba people live alongside the rivers. Despite their dispersion, they occupy and share the watersheds of tributaries of the Pendjari River flowing further south into the Volta River. Measures to preserve the Somba landscape cannot be decided and applied within the limits imposed by the administrative division of the Atacora, but should be concerted and implemented within the unitary framework of the watersheds, so as to take into account the river solidarity that is de facto essential for all the inhabitants of the Atacora (Garané, 2009).

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

On-Drawing South American Extent: Geo-Poetic Mapping Palimpsest in the *Travesías de Amereida*

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Abstract
Contemporary urbanization, as a process extended beyond the cities, requires original design practices to contribute to the critical understanding and visualization of the multiple spatial and temporal layers that shape the territories. In this account, this article examines the geo-poetic mapping developed by the Valparaiso School of Architecture, as a radical means of exploring the territories and elaborating their palimpsestic representations. This contribution unfolds the geo-poetic vision of the South American continent created in the sixties by the School of Valparaiso, in Chile, as fundamental groundwork to critically question the historic and ongoing urban occupation of territories and their representations following colonization. Besides, it presents the *Travesías de Amereida*, a collective and situated architectural study performed throughout the vast South American inland, as a unique geo-poetic practice in which freehand mapping becomes an original means of rethinking and redrawing the ever-changing American extent. Through the analysis of drawings made before, during, and after the *travesías* were undertaken between 1965 and 1985, this article outlines how the geo-poetic vision and mapping practices—that embodies iterative freehand drawings combining different temporality, spatiality, and situated experiences—have attempted to unveil the South American continent as a palimpsest: an open extent to trace the ever-changing footprints that reshape its content. To conclude, the article assesses the contribution of situated geo-poetic mapping as a critical design practice to study and visualize the ever-changing, multi-layered, and multi scalar-realities on virtually unknown territories of contemporary urbanization.

Keywords
geo-poetic mapping; palimpsest; situated practice; South American extent; urbanization

Issue
This article is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

1. Introduction

In recent decades, the urbanization process has become a global and fast-growing phenomenon, expressed in the multiplication of the urban population over the last 60 years, and reinforced by the estimation that by 2050 at least 66 percent of the world's population will live in cities or urban agglomerations that need to be studied and planned (UN-Habitat, 2016). However, an emergent understanding of contemporary urbanization as a process extended beyond the conventional cities and the hinterland boundaries has contributed to the territories being visualized as places where deep, but virtually unknown environmental and socio-cultural transformations are the result of the current local/global interdependencies driven by global capitalism (Brenner, 2016; Correa, 2016).

In effect, the contemporary process of urbanization (Brenner, 2014; Kaika & Swyngedouw, 2014) is re-shaping

the notion of territories towards multi-scale geographies, situations, and differences (Elden, 2013; Escobar, 2008; Raffestin, 2012; Santos, 2017). These new notions challenge the conventional binary means of reading urban and rural interactions, the geopolitical boundaries of countries and regions, and they call for new tools to read and represent the ever-changing territorial diversity.

This understanding of urbanization has provoked a territorial revival in architecture and urbanism to explore new critical design-practices and epistemologies as a way to overcome the conventional and dominant technocratic approaches to urban-planning (Bélanger, 2017; Correa, 2016; Ibañez & Katsikis, 2014; Waldheim, 2016). In this context, situated mapping (Corner, 2014; Havik, 2014; Viganò, 2014, 2016) has become a key practice to represent, analyze, and interpret territorial complexities because it investigates the spatial dimension between large-scale geographies and local situations, and in the temporal dimension between the many layers of historical milestones that have shaped the territory as a palimpsest (Corboz, 1983).

1.1. Case Study: The Travesías de Amereida

Regarding the contemporary process of urbanization beyond the conventional city's boundaries and facing the need for situated design practices to analyze and interpret the multiple spatial and temporal layers shaping territories, this article deploys the practices of the School Architecture and Design of Valparaiso (Pontificia Universidad Católica de Valparaíso) in Chile. The School of Valparaiso presents a radical approach to reading the historiography which has become embedded in the area since colonization (O'Gorman, 1958/2010) and the current occupation of territories in South America. Through the invention of a geo-poetic vision of the *extensión Americana* (American extent) created in the mid-sixties (Iommi et al., 1967, 1986) and continuing until today, the School of Valparaiso has developed the practice of the *travesías de Amereida*—collective and situated architectural studies performed mainly beyond the large cities located on the edges of the continent—which use situated mapping and design practices to radically explore, rethink, and redraw the American extent.

This contribution analyses archive documents, mainly drawings made before, during, and after the first *travesías* performed by the School of Valparaiso between 1965 and 1985. It traces the emergence of the geo-poetic vision of *Amereida* and its notion of extent—instead of territory—as a means of facing the geographical space of the South American continent without frontiers or preconceived definitions. Then, it investigates how this notion has been fundamental for the geo-poetic mapping developed in the *travesías*, which we envisage as an attempt to unveil the continent's territorial transformation as a palimpsest. Besides, the article unfolds the particularities of this geo-poetic mapping palimpsest, which are embodied in iterative drawings which combine different temporality, spatiality, and situated experiences. Finally, the article aims to show that situated geo-poetic mapping provides an important contribution to the discussion of how to represent the ever-changing, multi-layered, and multi-scalar realities within virtually invisible territories that experience contemporary urbanization.

2. Towards a Geo-poetic Mapping of South America

In the mid-1960s and after a decade of leading a school of architecture which linked architecture to poetry (Escuela de Arquitectura UCV, 1972), the poet and professor Godofredo Iommi echoed the traces of historical dwellings imprinted on the continent by asking this radical question: What is the origin and the present meaning of 'being American'? (Iommi, 1999). This triggered the realization of the first *travesía* in 1965 and lead to the invention of a geo-poetic vision of the continent which was subsequently embedded in the way of conceiving, studying, and practicing architecture within the School of Valparaiso. Thus, this geo-poetic vision allowed the School to expand its situated modes of learning architecture beyond the classroom (A. Cruz, 1959) towards the continent.

In 1965, the professors of the School of Valparaiso together with artists and philosophers, organized a trip throughout the interior lands of South America that they called *travesía*, an experience oriented to poetically "unveil" (Iommi et al., 1967, p. 26) the continental realities of territories far from the cities (see Figure 1). For them, the big cities tended to hide the original meaning of being American, because "they are dense of knowledge and splendid but empty of myth, inventing themselves quickly and fallaciously" (Iommi, 1983, p. 2).

The *travesía* was integrated by the Chilean architects Alberto Cruz and Fabio Cruz, the Argentinean sculptor Claudio Girola, the Argentinean poet Godofredo Iommi, the Panamanian poet Edison Simons, the English poet Jonathan Boulting, the French poet and philosopher Michel Deguy, the French designer Henry Tronquoy, the Argentinean painter Jorge Pérez Román, and the French philosopher François Fèdier. They began the geo-poetic experience and study (Iommi et al., 1986, p. 159) on 31 July in the city of Punta Arenas, in the extreme south of Chile. Their trip went through the hinterland of the Argentinean Patagonia and pampas, passing through diverse landscapes and visiting small villages spread in the territorial extent. Due to the presence of the guerrillas in the Bolivian region of Tarija, this *travesía* ended suddenly on 13 September (Iommi et al., 1986, pp. 200–201).

Even if the sudden disruption of the trip made their goal to reach the Bolivian city of Santa Cruz de la Sierra impossible, the group experienced 42 days of poetic adventure, guided by openness towards the "unknown" encounter with the continent (Iommi et al., 1986, p. 70). The openness embedded in the *travesía* arose from the aim to incarnate the modern metaphor of the unknown

Figure 1. First *travesía*, 1965, with Alberto Cruz, Chilean architect, Godofredo Iommi, Argentinean poet, Jorge Pérez Román, Argentinean painter, and a *gaucho* in the Argentinean Pampa. Source: Archivo Histórico José Vial Armstrong (1965). Reprinted with permission.

expressed in the poetry of Baudelaire and Rimbaud, which they explored in fortuitous encounters with reality through creative action (Iommi, 1982b). This metaphor guided their inquiries into the meaning of being and inhabiting America, and lead them to engage in poetic acts, the construction of ephemeral works of art, discussions with local communities, and to carry out architectural observations in the territory. All these collective experiences were gathered in the creation of a geo-poetic vision of South America, called *Amereida*.

During the trip, the group collectively drafted the poem *Amereida*, a title that alluded to their reflections on the meaning of being American weaved with the invention of a founding myth based on Virgil's Aeneid (Iommi, 1982a, 1982c; Iommi et al., 1967). The poem attempted to recreate the idea of *latinidad* in the Americas through a poetic that echoed the founding myth of the Greco-Roman culture represented in the wandering journey of Aeneas. Therefore, *Amereida* proposes a poetic understanding of *latinidad*, has the potential to trace back the meeting of multiple races, languages, and territories of the Americas (Iommi, Rodriguez, Emilfork, & de Nordenflycht, 1972), and to overcome the geopolitical conceptualization developed since the 19th century, when the notion of *latinidad* was related to dominion and colonial hegemony.

The book, *Amereida*, published in 1967, is a poetic narration written by the group in their diverse languages. The poem was composed by historiographical viewpoints about the "invention of America" (O'Gorman, 1958/2010), interwoven with words coming from classical and modern poetry, with the direct observations and creative actions performed in the interior of the South American continent. All these elements remain almost hidden within the poem which is written collectively in a non-linear chronology of the trip and without any formal references or quotations. Nevertheless, the poem presents ten cartographies (see Figure 2) that permit access to the geographical and territorial vision of the South American extent embedded in *Amereida*.

2.1. Ten Maps of Amereida

The ten maps in the *Amereida* represent the first transcription from the metaphorical space of the poem to the geographical space of the South American continent. By displaying a blanked continental extent (A. Cruz, 1995; Iommi, 1965, 1982a) without any of the geopolitical divisions which traditionally portray sovereignty and control over territories, the vast continent is represented as a primary form shaped by nature by the bathymetry of the oceans (Figure 2[1]), by the great rivers connecting lands (Figure 2[5]), and by the mountains dividing regions (Figure 2[6]). Concomitantly, the extent as a blank footprint map does not seek to represent the terra nullius—the governable void drawn by the imaginary, mastery, and control used in European mapping during colonization (Ashcroft, Griffiths, & Tiffin, 2013, p. 28)—on the contrary, the extent represents the possibility to unveil the lands as a palimpsest: an open blackboard upon which the ever-changing footprints that reshape the continent can be traced.

Subsequently, the representation of the Interior Sea (Figure 2[3]) refers to the vast inner lands of the continent, an interior conquered but ignored, sparsely inhabited, and almost strange to most of the urban popula-

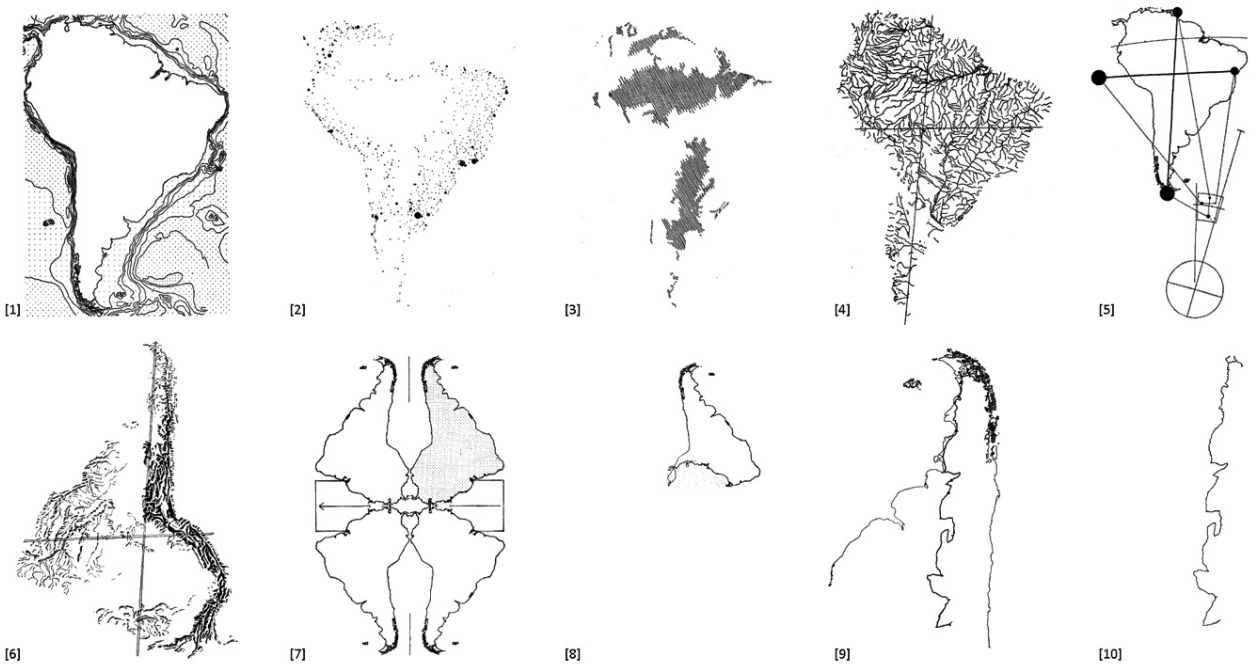

Figure 2. Maps from *Amereida*, 1967. Source: Iommi et al. (1967, pp. 9, 21, 29, 35, 39, 40, 171, 173, 186, 187). No Copyright.

tion occupying the edges of the continent (Iommi et al., 1967, p. 18). Poetically, the Interior Sea is the unknown (Iommi, 1984), a land for voyage, such as those taken by Aeneas and by the *travesía* (Iommi, 1982a, 1983). This map, made by lines without a backdrop or perimeter, represents the vagueness of the Interior Sea, and its open shape is an inversion of the dots-map (Figure 2[2]). The dots-maps shows—as NASA's nighttime satellite images have since 2009—the location of the big cities in the edges the continent.

Then, the radical action of rotating the map represents the notion of the Own North (Figures 2[6, 7, 8]), an operation aligned with the commonly used expression of 'to have a north,' which means to have an orientation or a goal. Thus, to conceive a proper orientation for the southern continent, to have a North is to look to the South (Eyquem, 1985; Iommi et al., 1967). The map is turned and inscribed with the Southern Cross constellation over the chart (Figure 2[4]) as an action to overcome the traditional Cartesian axes in colonial cartographies and to open up the multiple orientations that emerge from this intersection (A. Cruz, n.d.).

Finally, the two maps made with the route of the *travesía* (Figures 2 [9, 10]), followed by the final sentence of the book "*el camino no es el camino"* (the road is not the road; Iommi et al., 1967, p. 189), represent the incarnated metaphor of the unknown as the constant *equívoco* (equivocation; Iommi et al., 1986, p. 213). This means that the distance between what is known and what is to be known exceeds any plan and final purposes of a project, nevertheless, the openness towards the unknown allows one to encounter reality.

2.2. The Travel-Log of Travesía

The ten maps accompanying the poem *Amereida* are clearly not technical representations of the South American territory, but they do show the particular geo-poetic notion of the School towards the continental extent (A. Cruz, n.d.), based in the reflection between historiographic temporality and incarnated spatiality. From an architectonic perspective, these maps are the groundwork for a new exploratory mapping practice which aims to trace the links between the crossed continent and the human scale, captured through the *observación arquitectónica* (architectural observation). This is a situated drawing practice, which consists on making of freehand drawings accompanied by short notes, through a slow process allows one to contemplate and grasp the spatiality, gestures, and acts which shape everyday life. For the school, the architectural observation implies a poetic process in the sense of poiesis, that seeks to reveal and eulogize the reality, and a creative act in which the observations nourish the architectural study (A. Cruz, 1959, 1982; F. Cruz, 1993).

This geo-poetic mapping exploration—traced in the situated drawing practices developed by the architects and designers of the School of Valparaiso—seems to have its origins in the realization of the architectural travel-log of the first *travesía de Amereida* in 1965 (see Figure 3). The travel-log made by the architect and professor Alberto Cruz (A. Cruz, 1965) illustrate this new mode of mapping where freehand drawings such as the architectural observations, schematic maps, brief texts, and plans, are deployed as a collage to describe and in-

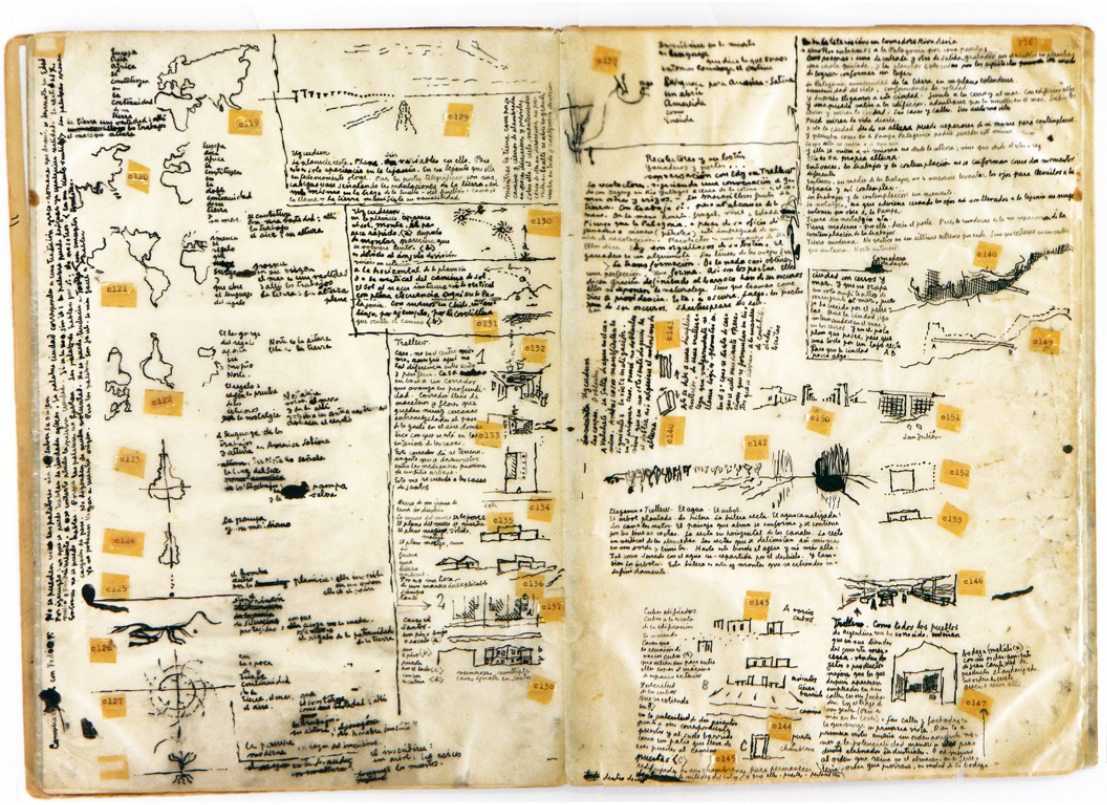

Figure 3. Travel-log of Alberto Cruz, *Travesía de Amereida*, 1965. Source: A. Cruz (1965). Reprinted with permission.

terpret the different territorial situations experienced on the trip.

In the pages of this travel-log it is possible to identify the original schemes of the continental rotation illustrated in *Amereida*, next to sketches and notes about the life in the vast pampas, and a series of observations of the landscape and buildings of the Patagonian villages of Uzcudum and Trelew (see Figure 3). In the same pages, a reflection on the South American *Plazas Fundacionales* with schematic plans and notes is followed by some statements describing the differences between creating towns and exploiting the territory. Architectural observations about the Argentinean villages of Santa Rosa, Dorotea, and Comodoro Rivadavia are mixed with the descriptions of some poetic acts performed during the trip.

The density of the content displayed in these mapping compositions can be understood as a palimpsest process because it brings together the diverse temporality and spatiality as experienced during the journey. It allows one to follow in their footsteps and the subtle historical traces imprinted on these South American territories which are normally omitted by conventional maps. Hence, these freehand drawings are different from those images captured by objective cartography or photography, because they seem to incorporate a variety of situations that move from two to three spatial dimensions, in different territorial scales, and different temporalities.

Furthermore, the travel-log that might be comparable to the ethnographer's notebook, did not only operate as a descriptive-analytical tool, but also as a creative-design tool to act and to make on the ground. In effect, the travel-log of Alberto Cruz is a set of large sheets folded to be carried during the trip. The 15 slides contain 321 drawings in aleatory order, creating a particular narrative composed by: (1) personal interpretations and architectural observation of landscapes, (2) the collective design of ephemeral works of art and poetic acts, (3) the encounter with the locals, and (4) the daily planning of the trip.

Consequently, the travel-log of Cruz and the book *Amereida* are two fundamental elements to understand the geo-poetic vision and the mapping practice developed during the *travesía*, in which poetry did not become only a metaphor of reality, but was conceived as an exploratory means to produce situated knowledge and to produce artwork beyond the conventional disciplinary boundaries of architecture and urbanism.

2.3. Tesis del Mar Interior y del Propio Norte

The poetic fundamentals which originated from the first *travesía de Amereida* became the groundwork for the architecture and design practices embedded within the School of Valparaiso. As such, the seminal works presenting their geo-poetic notion to the field of urbanism, *La Tesis del Mar Interior* (Thesis of the Interior Sea) and *La Tesis del Propio Norte* (Thesis of the Own North; Escuela de Arquitectura UCV, 1970), were both pre-

sented at the First International Seminar of the Pacific, held in 1970 in Viña del Mar, Chile. This meeting focused on the debate surrounding geopolitical and economic strategies for the development of the central and peripheral countries of South America towards the Pacific Front. In this context, and as a way to incorporate alternative viewpoints regarding South American urban development beyond the conventional political-economic discussion, the School of Valparaiso presented both theses as poetic-scientific bases for the exploration of new analogies and distinctions between specific data and criteria encompassing history and geopolitics (Buttazoni et al., 1971).

The theses manuscripts were accompanied by 15 large-scale maps to represent their proposal. One of these maps displays all the colonial and commercial routes in the Pacific Front during the 16th and 17th centuries. This map purposefully set the Pacific Ocean at the center of the chart to question the cartographies produced since the 16th century, in which the Atlantic Front and Europe occupied the central space (see Figure 4). Another map shows an aerial view of a South American continent without borders or geopolitical frontiers, representing the Interior Sea as postulated in *Amereida*. In the map, the red dots indicate the cities surrounding the continent, and the dark lines crossing the chart signal the first conquest expeditions performed in the 15th and 16th century, together with the current transoceanic industrial flows through the inland of the continent (see Figure 5). In spite of their careful elaboration, the 15 maps did not aim to show a territorial development strategy for South America, on the contrary, they were a speculative means to present the notion of Interior Sea and the continental extent of the Americas. For the School, these notions were fundamental to their thinking of the continent, the Pacific Front, and the World System; such notions lead them to question urbanism based merely on the productivity of a country, of a continent or a region (Buttazoni et al., 1971).

All these maps were redrawn and presented in the exhibition "30 Años de la Escuela de Valparaíso" celebrated in 1982 at the National Museum of Fine Arts in Santiago de Chile, to publicly affirm a geo-poetic commitment towards the Americas. Following the exhibition, the School decided to incorporate the *travesías* as a pedagogical experience to unveil the American extent.

3. On-Drawing Territories: The Iterative Mapping-Practice in the *Travesías*

Since 1984, the *travesías* prolong the study of the urban towards the continent, carried out mainly in remote places outside the comfort of city life. The professor Alberto Cruz described the *travesías* as a study of the American continent that requires crossing through its mainland and its oceans (A. Cruz, 1995, p. 8), because for him, travelling is the way to recognize the magnitude of the continent and to identify the constellation of elements and places through which the continental extent is exhibited and ordered (A. Cruz, n.d., p. 2,3).

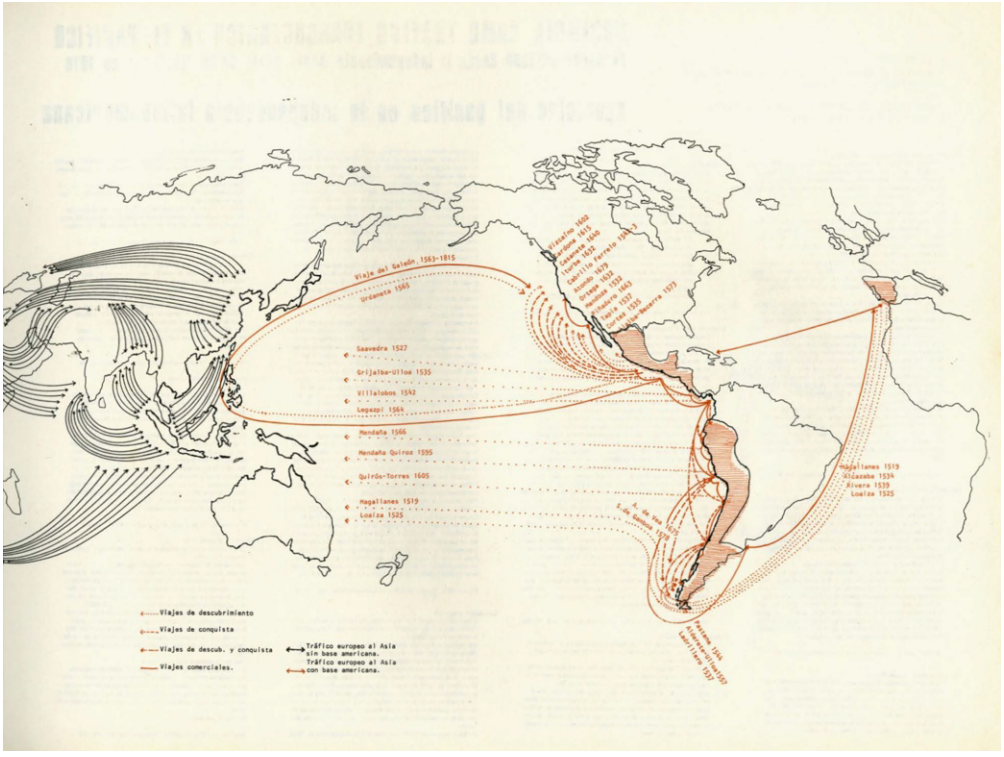

Figure 4. Map of nautical routes in the Pacific Ocean during the 16th and 17th century. Source: Buttazoni et al. (1971, p. 15). No Copyright.

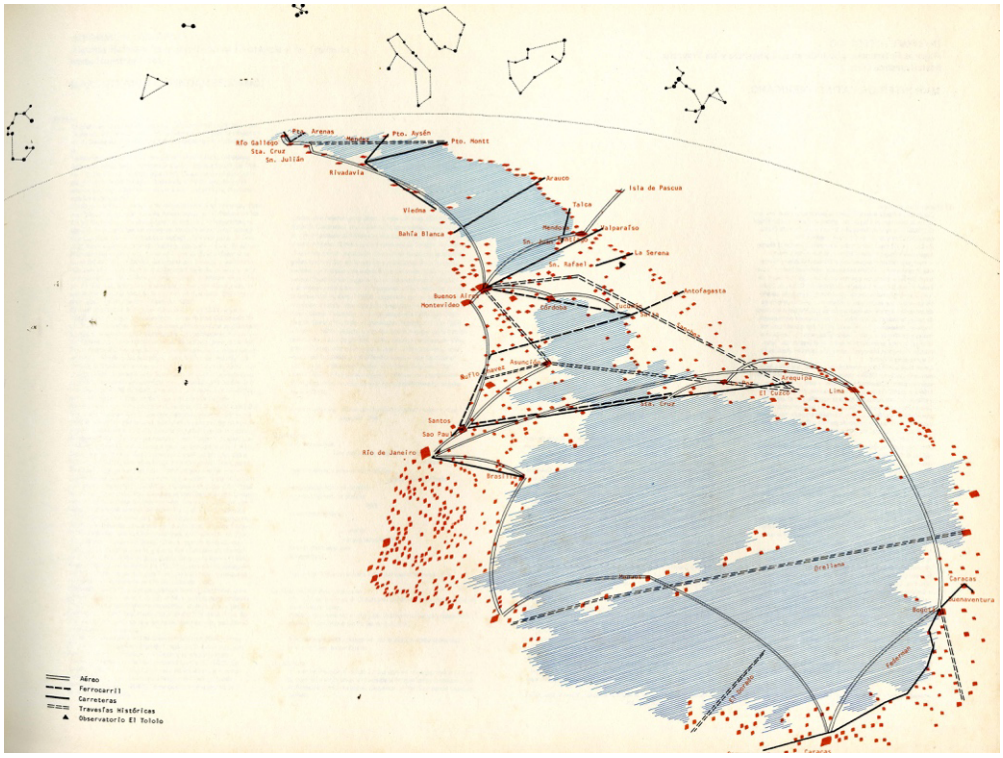

Figure 5. Map of the Interior Sea and South American cities. Source: Buttazoni et al. (1971, p. 29). No Copyright.

The *travesías* are trips performed every year by all the studios of the School of Valparaiso, in which of students and professors are engaged in a collective life, work and study (Escuela de Arquitectura UCV, 1996). This includes the organization of the trip, the permanence in the places of destination and, ultimately, the design and construction of an ephemeral Work of architecture whose purpose is to value the diverse situations recognized in the territory (see Figure 6).

In this way, the works of architecture erected in the *travesías de Amereida* are not conceived as projects to master the land or solve local problems (Jolly, 2017),

Figure 6. *Travesía* of Salar de Coipasa, 1987, Atacama desert, Bolivia. Source: Archivo Histórico José Vial Armstrong (1987b). Reprinted with permission.

but their goal is to create a place—in the poetic sense—for an active and celebrative encounter with otherness, namely the local community and nature.

Besides, the subject of study that each *travesía* seeks to approach, is associated with disciplinary questions decided upon before the trip in Valparaiso, which are gradually developed and reformulated on the ground. This process points out that the *travesía de Amereida* as a project has a temporality that exceeds the period of the trip, including the time for planning, the time for execution, and the time for the architectural summary back in Valparaiso. These three chronological periods are essential for the iterative mapping practice based on freehand drawing, conducted during the *travesías* project.

*3.1. Pre-*Travesía*: Mapping to Be Situated*

The pre-*travesía* is a period of three to four weeks before the *travesía* focused on collectively map the territory between Valparaiso and other places of the continent that are proposed by the members of the studio. It is a process to explore and trace the networks of urbanization shaping the territories, drawing up the potential routes and the places to be covered during the journey (see Figure 7). Hence, the pre-*travesía* mapping is composed of the major elements of urbanization, such as the road infrastructure, geo-political boundaries, settlements, and the urban services which both enable an understanding of the large-scale territorial complexities and enable one to get to the destinations. This mapping process remains open to the situated experience, and the discoveries coming from the architectural observation and the poetic acts. Then, every studio of the School produces portable collage maps (in different scales and with digital and analogue data) to be carried within the travel-logs and to be enriched during the *travesía*.

3.2. Travesía*: Situated Mapping*

The *travesía* is a period of two or three weeks of situated practices in the continent. In this period, the mapping consists mainly of the making of freehand drawing in the travel-logs of students and teachers, which are shared to reflect and to co-design the architectural Work. During the *travesía*, the mapping process is deployed in two moments, during the trip and at the destination. First, during the trip, the group redraws maps of the territorial urbanization to corroborate and redefine the path that is underway. Besides this, they execute architectural observations 'in motion' in which the landscape is drawn

Figure 7. Mapping of the Altiplano region in Los Andes Mountain with fragments of the *Amereida*'s poem. Pre-*travesía* of Salar de Coipasa, 1987, Bolivia. Source: Archivo Histórico José Vial Armstrong (1987a) Reprinted with permission.

through the window of the bus and during the brief stops in different places across the continent (see Figure 8 top). This mapping might last more than six days when the destination point is far away from Valparaiso (e.g., the north of Brazil), or when there is no road (e.g., the Patagonian Fjords).

The second moment is at the destination. After the arrival, the group performs a study of the place and its surroundings through the making of architectural observations and cartographic schemes of the landscape (see Figure 8, bottom row). After defining the site for the work, together with the local community—if there is one—a more exhaustive morphological and topographic analysis is performed. Simultaneously, the design and construction of the project are developed, in which local materials and artisanal techniques are implemented. This whole process of describing, documenting, and designing is iterative because it requires constant reflection upon the drawings made during the trip and at the destination, to confront them with the preconceived ideas set in Valparaiso, and to iterate consideration of the real possibilities and resources for the Work.

*3.3. Post-*Travesía*: Mapping as Narrative*

The post-*travesía* is a period of one to two weeks after the *travesía*, in which the studios summarize their experience through a public exhibition that gives accounts of the trip, the Work, and the new knowledge unveiled by the *travesía*. This period is fundamental for the School of Valparaiso because each experience can be incorporated into the collective knowledge since the *travesías de Amereida* are considered a single project with hundreds of shared experiences.

Therefore, the large amount of material produced in the travel-logs of students and teachers—such as the architectural observations and the collective design drawings—is shared to present a common vision about the architectonic work executed and about the travelled extent. To summarize the *travesía*, the description of the project is usually illustrated through a series of schematic maps, such as those displayed in this sequence of free-hand drawings (see Figure 9). Using schemes in different scales but in equal size, this sequence aim to describe: (1) the international path of this *travesía* following the

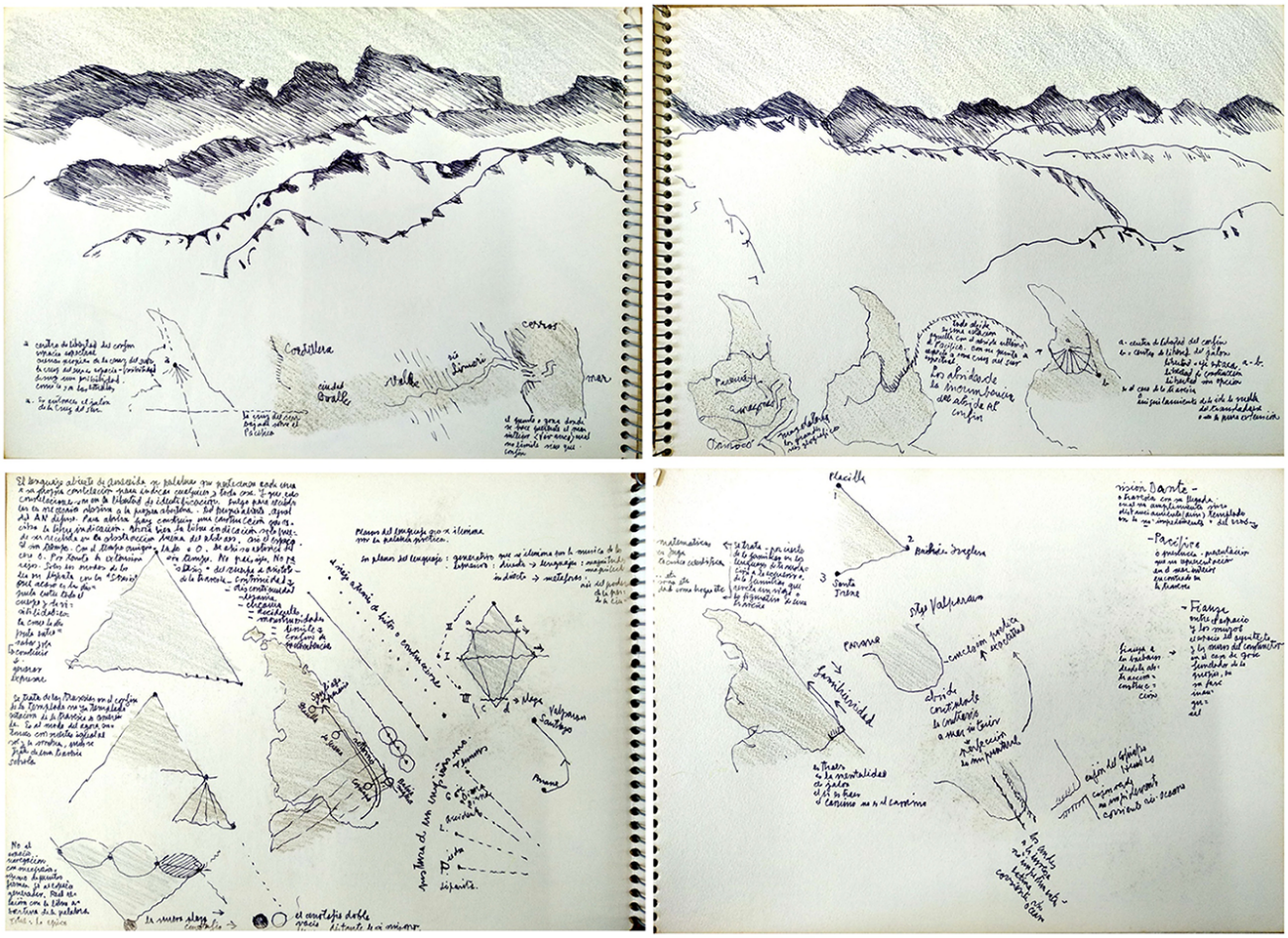

Figure 8. Travel-log of Alberto Cruz. Set of drawings in the Altiplano in Los Andes Mountain and schemes about the great rivers of South America and the site of the work in the *travesía* of San Andrés-Rosario, 1984, Argentina. Source: A. Cruz (1984). Reprinted with permission.

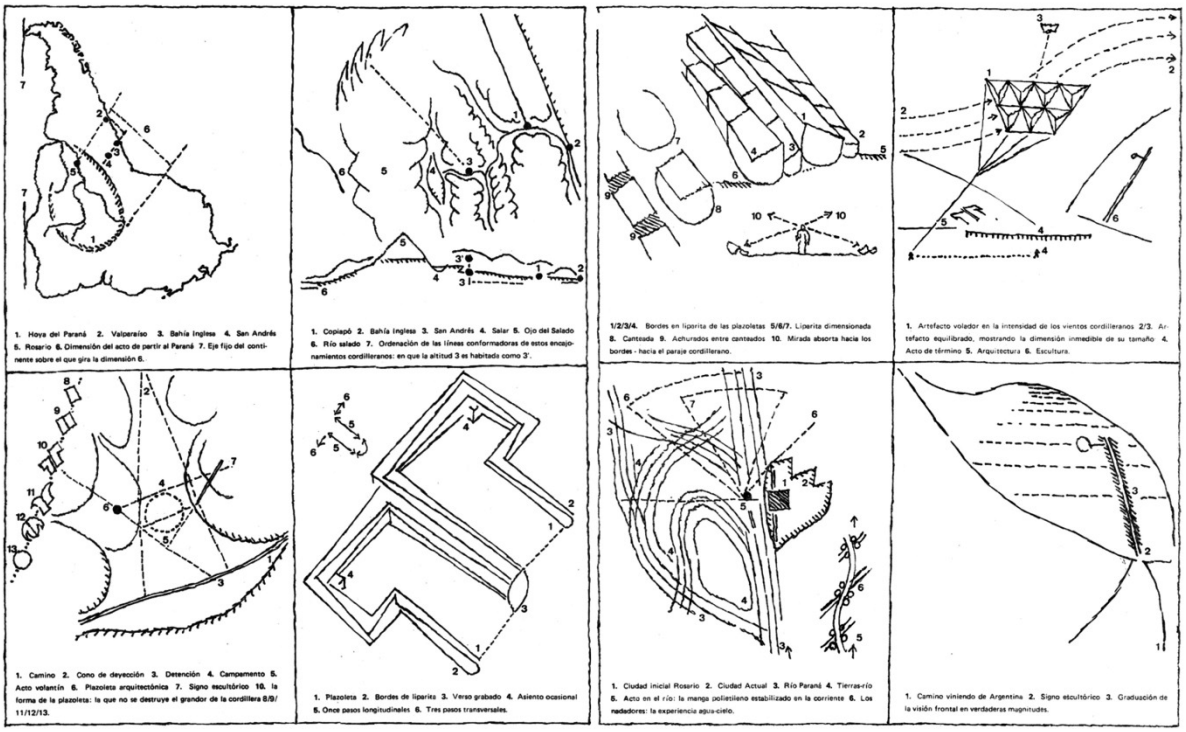

Figure 9. Sequence of maps describing the *travesía* of San Andrés-Rosario, 1984, Argentina. Source: Escuela de Arquitectura UCV (1991, pp. 184–185). No Copyright.

major hydrographic basin of South America; (2) the profiles of the territory surrounding the site of the work; (3) the layouts of roads and the camp; (4) the layout of the work traced on the ground; and (5) the isometrics details of the Work.

The mapping process made after the return to Valparaiso can be found in diverse exhibitions about the *travesías* until today. However, the most remarkable aspect of the schemes of the *travesía* of San Andrés, is the invention of the 'sequential frame,' in which the temporality and spatiality experienced are carefully represented in freehand drawings that shift from two to three spatial dimensions, and from the human to the continental scales. Then, the comments under the schemes highlight the relationship between the spatial intervention and the continental extent.

Thus, the iterative mapping practice permits to link and intersect the chronologies of the pre-*travesía*, the *travesía* and the post-*travesía*, with the ever-changing territorial realities, which is deeply attached to the situated experience of making the works in the place. This iterative and collective process to explore the documentation and the interpretation of urban and non-urban territories is understood as a palimpsestic mode to trace the territorial footprints of urbanization imprinted beyond the traditional city boundaries.

4. Conclusion

The School of Valparaiso—with more than 250 *travesías* performed in the South American continent—has been committed to unveiling the continent through their situated geo-poetic approach, is based on the fact that the *travesías* allow for the continual reinterpretation the territory beyond preconceived and conventional categories. This geo-poetic notion has permitted a critical regard of the historiography described since the Invention of America (O'Gorman, 2010/1958) in the 15th century, and the American extent has been a path to unveil the differences (Iommi et al., 1967, p. 84) of realities shaping urban and non-urban 'territories,' as opposed to the concepts of sovereignty and power relations over the lands.

The geo-poetic approach of the School of Valparaiso, which is a radical alternative to the usual technocratic attitudes towards territories, might be part of a turn toward critical thinking and practices emerging within academia, which range from decolonial epistemologies—that seek to bring into light the ever-changing territorial differences of territories which have been rendered virtually invisible by hegemonies inherited from colonization (Escobar, 2008; Mignolo, 2000; Mignolo & Tlostanova, 2012; Mignolo & Walsh, 2018)—to the exploration of new design practices committed to addressing these non-conventional issues in the field of design (Demos, 2016; Escobar, 2018; Javet, 2017).

Likewise, the geo-poetic mapping, envisaged as an exploratory and critical practice towards territories and urbanization, is an open field to radically rethink architecture and urbanism due to its engagement in direct experience such as situated hermeneutic mapping (Corner, 2014; Havik, 2014; Viganò, 2014, 2016). The latter performs descriptive and imaginative interpretations

Figure 10. Shaping the South American extent through the routes performed by the *travesías de Amereida*. Map by the authors.

on multiple dimensions of territories, which are virtually impossible to grasp solely through the use of remote analytical devices, such as those advocated by landscape urbanism (Thompson, 2012).

Looking back to the whole ensemble of *travesías de Amereida*, we state that their geo-poetic orientation to unveil the visible and invisible meanings embedded in reality (Heidegger, 1971/2001; Merleau-Ponty, 1964/1968) has been the base to sustain these experiences for more than four decades (see Figure 10). For the school, the metaphor of the unknown leads them to keep the territories unveiled by the *travesías* as an extent open to be permanently re-visited, as a palimpsest that can be continuously re-read and re-drawn (Corboz, 1983).

Consequently, the geo-poetic practices performed during the *travesía* are not actions conducted to master the lands, but rather to unfold new insights into the ever-changing transformations territories outside the cities. By incorporating design drawings and the building of Works into the geo-poetic mapping palimpsest, the *travesía* intends to restore the fundamental act of making (Ingold, 2013) as a means of engaging in broader reflection on the territories. Furthermore, the *travesía's* mapping and making are deeply embedded in the place and in the encounter with otherness. It is this which allows one to reinterpret situations and differences through a relational understanding beyond the conventional dichotomies of urbanization, such as rural/urban, public/private, country/city, or local/global.

Ultimately, the geo-poetic mapping palimpsest developed during the *travesías*, have been the medium to move from a passive-contemplation based on the analysis of data and the interpretation of reality, to an active-contemplation (Browne, Cáraves, & Jolly, 2011), oriented to make situations from which new insights about territorial and urban questions can be drawn. This active engagement to search for knowledge of the openness is embodied in *Amereida's* geo-poetic statement "the road is not the road" (Iommi et al., 1967, p. 189).

Conflict of Interests

The author declares no conflict of interests.

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Article

The Territory of the Grand Tetouan as Linear City: Between Description and Project

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Abstract
This article, based upon pedagogical experimentation in development in a master-level architecture studio at the ULB School of Architecture (Brussels), focuses on the concept of a linear city in a metropolitan context. This concept is proposed by the Grand Tetouan (North Morocco) spatial development scheme as a framework to think about the future of this territory. The interest of the concept lies in its being both a descriptive and project-oriented tool, which allows working with students on the intricate relationship between these two moments of urban design. The coastal region has been the subject of a proposal for a "linear garden city" by a follower of Soria y Mata, Hilarión González del Castillo (1929), a project that left traces on the "palimpsest" (Corboz, 1983/2001) of the actual territory. The idea of the linear city, which has been, throughout the 20th century, a recurrent thematic in urban planning theory and practice dealing with the issue of industrial development of the modern city can be, in the specific case of the Grand Tetouan region, re-examined through the lens of tourism as an industry. The exploration is based on an analytical approach by the use of the notion of urban material (Boeri, Lanzani, & Marini, 1993; Viganò, 1999), an approach that creates the conditions of understanding (describing/designing) the existing territory through the mapping of its physical elements, a description that can then be used to develop an analysis of the forms of production of these elements and the complexity of their uses: how the city is, formally and socially, built (Secchi, 1989).

Keywords
architecture teaching; city; linear city; Tetouan region; Morocco; urban planning

Issue
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1. Introduction

This article focuses on an ongoing pedagogical experience (still in process at the time of writing) developed in a master-level architecture studio at the ULB School of Architecture (Brussels). This experience is being developed in the context of the Grand Tetouan region (North Morocco), a context that allows reflecting upon the concept of the linear city. The interest of this concept lies in the fact that it is both descriptive and project-oriented: descriptive, as this expression can be (and is being) used to define specific forms of linear urban developments; project-oriented, as it has been proposed by several urban planners and/or thinkers, since the expression's coining by Arturo Soria y Mata for its project of linear developments for the extension of Madrid, in the years 1880 (Soria y Puig, 1968). The territory proposed for the study had been the subject, already in 1913, of a proposal for "the first linear city of Africa" by Soria y Mata (the north of Morocco was then under Spanish protectorate, an administration that lasted from 1912 until 1956; see Soria y Mata, 1913). The proposal—which gave birth to the development of a railway infrastructure connecting Ceuta to Tetouan (thoughtlessly dismantled after the end

of the Protectorate) and initiated a process of urbanization along the coastline—legitimates the use of the concept in the global framework of the urban planning development scheme (Royaume du Maroc, Ministère de l'Aménagement du Territoire de l'Environnement de l'Urbanisme et de l'Habitat , 2017) proposed by the provincial authorities.

The work being developed with the students started in the spring semester of 2019, with an attempt to compare the Tetouan-Ceuta territory with notorious paradigms of linear urban developments (i.e., the via Emilia, in Northern Italy; the swiss shore of the Leman Lake; the Belgian 'noordzee' coast) and linear city projects, realized or not: Soria y Mata's 'ciudad lineal,' in Madrid (Prandi, 2016; Soria y Mata, 1913); Miljutin's, and later Le Corbusier's, projects of industrial linear cities (Cohen, 2002); Victor Bourgeois and Renaet Braem's proposals of linear cities for the Belgian territory (Strauven, 1985; Strauven, 2017); Michel Ecochard's 'combinat' of Casablanca-Fedala (Ecochard, 1951, 1955). The comparison addressed both formal (regarding dimensions, in length and depth; architectural typologies…) and functional (infrastructures, facilities…) issues, focusing on the general idea of spatial distribution and social justice (Secchi, 2013). Students then developed urban and architectural design proposals, based upon congruencies between the existing territory and issues (or principles) identified in the paradigmatic examples studied. The underlying idea was to cross theoretical positions and formal principles with a territory already shaped by its history—with the 'palimpsest' formed by the territory (Corboz, 1983/2001), conceiving an overall project for the linear city of Tetuan as a bead necklace on the existing linear road and highway infrastructure. The students' design proposals, interesting as they were, showed a lack of grip on reality. This led us to set up a semester studio completely devoted to the task of describing how the city is being built, nowadays, using the concept of 'urban material' (Viganò, 1999). This concept, proposed and developed by Paola Viganò and Bernardo Secchi at the turn of the century, constitutes a methodological tool between description and project, as an existing, material reality can be described through the identification of such 'urban materials', while they can, at the same time, be seen as 'building material' for projects (built, or yet to come). 'Urban materials' are the materials that build the urban territory: in this view, their apparition, at specific times, and their use and combination, is what makes up the territory as a palimpsest.

The specific context of the Grand Tetouan region, and its being thought of as a 'linear city,' gives the opportunity to work on the intertwining of urbanism (as discipline) and urbanization (as a phenomenon), and to give the students an understanding of the importance of a disciplinary position that gives equal attention to both. The concept of 'urban material' appears to be particularly effective, not only to develop that understanding but more generally, in a pragmatic way, to work on these issues.

2. Elements of Conceptualization and Contextualization

2.1. A Rapid Overview of the Idea of the Linear City, Project and/or Phenomenon

The model of the linear city can be traced back to the end of the 19th century and the famous project of 'ciudad lineal' conceived for suburban development in Madrid by Spanish engineer Arturo Soria y Mata (Cohen, 2002; Collins, 1960). This development, structured upon a broad avenue equipped with a tramway line, has been carried on by Soria y Mata's own company. Even though only a small part of the project was built, and though lost its formal characteristics of being a linear urban development standing out in the countryside as it has been completely absorbed by further developments of the city (the neighborhood is still called 'ciudad lineal,' see Cohen, 2002; Collins, 1960), the idea raised great interest. It was soon adopted by urban planners, who saw in it a solution in their quest of rational planning for urban developments in the period of the industrial boom, mainly after World War I—and, therefore, after Soria y Mata's death in 1920 (Prandi, 2016). The success of the concept at the time can be illustrated by the creation of an international association devoted to it, the Association Internationale des Cités Linéaires (International Association for Linear Cities), founded in Paris in 1928 by Georges Benoit-Levy and endorsed by the CIAM (Hall, 2002, p. 117). The most famous sequel of Soria y Mata's concept can be found in Russia and more specifically in the work of Nikolaï Miljutine. Jean-Louis Cohen (2002), in his introduction to the second edition of Miljutine's book *Sotsgorod*, first published in Russia in 1930, describes the strange path the concept of the linear city had taken to reach the soviet country. He underlines the role of the French economist Charles Gide as a passer between Soria y Mata and the Russian urbanists. Gide's 1925 description of the principle of the linear city clearly identifies the issue of:

> A city that no longer has a center, where there would no longer be a brain but nerve centers scattered through the length of the backbone, in such a way that each one would have the possibility of staying close to its particular center, its factory, its trading house, these being themselves scattered all along the way. (Charles Gide, 1925, as cited in Cohen, 2002, p. 18, translation by the authors)

The influence of Miljutine's schemes over Le Corbusier, whose role in the diffusion of the concept through the modern architects and urban planning community is well-known, is very clear, despite being the object of debates between the main protagonists (see Cohen, 2002, p. 29). Le Corbusier's integration of the concept of the linear city in his writings came only after the Second World War, with the publication of *Les Trois Etablissements Humains* (Le Corbusier, 1945/1959) and

its famous sketch linking the three 'human settlements': the radio concentric city of exchanges, the industrial linear city and the unit of agricultural exploitation. The interconnection between the three is essential, as it is aimed at protecting the rural, open landscape from the threat of urbanization:

> Essential matter of principle nowadays, now that social misadventures together with war risks have encouraged the masters of industry to plan a relocation in terms of dispersion: dispersion of industry in the countryside. The industrial linear city creates, on the contrary, untouched farm reserves. (Le Corbusier, 1959, p. 102, translation by the authors)

Le Corbusier refers explicitly to the 'natural' power of linear infrastructures to attract, and command, urbanization in an incremental way ("the linear city follows a path inscribed in geography," Le Corbusier, 1959, p. 102). The urban development experienced worldwide after World War II has shown how strong this power was. In many places, it indeed assumed linear forms that tend to blur the distinction between the linear city as a project and as a phenomenon:

> Although linear planning has never won popular support among professional planners, it has, paradoxically enough, been the natural pattern of growth in our great urban regions. In the USA, a pernicious type of uncontrolled 'linear' or ribbon growth has occurred….Thus, linear growth receives acceptance as a fact, but not as a theory. (Collins, 1960, p. 345)

As Cohen states, concluding his introduction to Miljutine's *Sotsgorod*: "Dissociated from any revolutionary dimension, the linear city has become a theoretical reference that is rather unclear for the analysis of concrete urban systems in which devices parallel to shores or ways are structuring" (Cohen, 2002, p. 35, translation by the authors). This unclearness is the condition of the work we have developed around the idea of fragmentation: the contemporary linear city can be described as a patchwork of unfinished, fragmentary projects that are incrementally developed (Viganò, 1999).

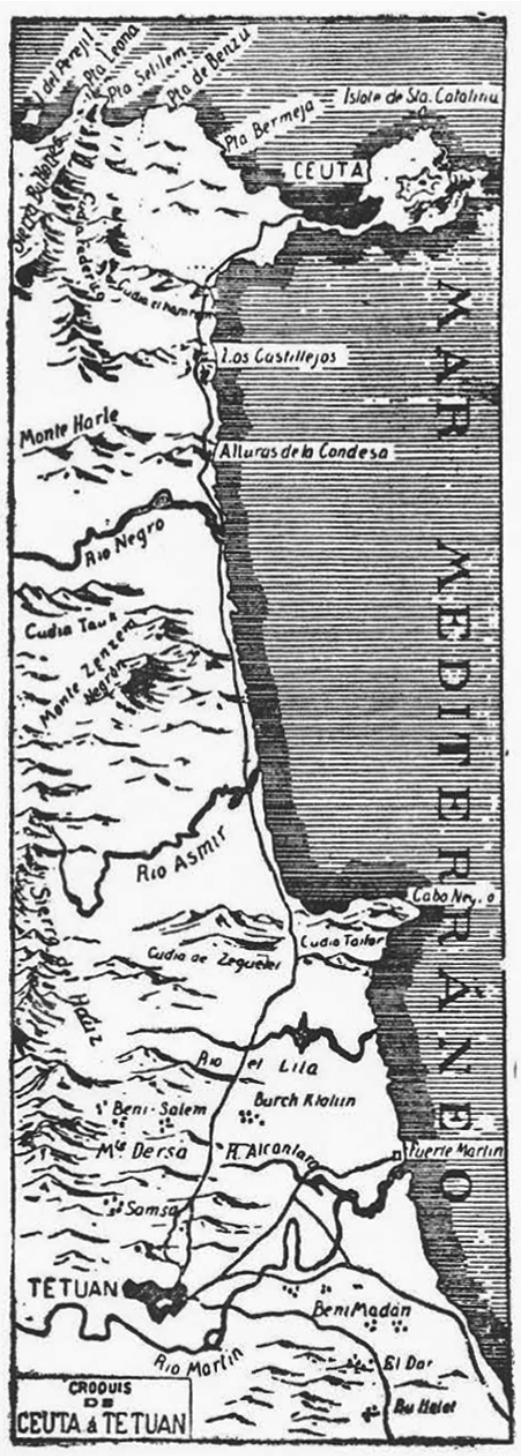
2.2. The Context: The Grand Tetouan Region

The Moroccan territory, as almost all colonized territories of the 19th and 20th centuries, but probably even more clearly than others (see Cohen & Eleb, 2004), has served as a laboratory for the implementation of innovative urban planning experiences by the colonial powers. It is clearly the case for the territory we are focusing on, where the imposition of a European-centered concept (that of the linear city) collided with the local logic of fabrication and governance of the land (see Boujrouf, 2005).

The Moroccan territory has seen two 'historical' projects of linear cities in the course of the 20th century: the first one, Ceuta-Tetouan, has been described but never drawn, nor built; the second was designed and implemented in 1951 in Casablanca by Michel Ecochard, a major 'modernist' urban planner who was head of the urban planning administration under the French Protectorate from 1946 until 1953; it was later heavily modified by urban developments. Michel Ecochard's influence on Moroccan urban planning practice is related to his invention, the so-called '8 × 8 grid,' also called the 'Ecochard grid' (see i.e., Avermaete & Casciato, 2014). The project is presented in an issue of *Architecture d'Aujourd'hui* (Ecochard, 1951) and in *Casablanca: Roman d'une Ville* Ecochard (1955) tells the story of his adventures as an urban planner in Casablanca. Cohen describes the project as a "derive from the corbusean lecture of Milioutine" (Cohen, 2002, p. 34).

The territory object of our study stretches along the Mediterranean sea for little more than 30 km, from the Spanish enclave of Ceuta (Ceuta is the Spanish name, Sebta in Arabic transcription), the northern tip of the African continent on the Strait of Gibraltar, to the city of Tetouan, in the South. It consists of a coastal, rather swampy strip, caught between the coast and the foothills that follow it. It is crossed by several natural obstacles, small rivers in the North and, in the South, the Cabo Negro massif and, farther south, the river Martil which connects the old city of Tetouan to the sea, evolving the linear pattern into a Y-shaped figure. Almost completely uninhabited, the littoral lands (plains, wetlands, and dunes along the sea) that used to be considered in pre-colonial times as 'commons,' collective property ('yemaa') for local mountain communities (in particular of the poorest families: Cantarino, 2008), were seen as a blank, open space by the Spanish colonists: an open field for experimentation. It had been considered by Arturo Soria y Mata at the beginning of the 20th century as perfect to host an attempt of the linear city, on the basis of linking the capital of the Spanish Protectorate, the city of Tetouan, to the port city of Ceuta, the main communication gate between the metropolis and its dependency (Soria y Mata, 1913; see Figure 1).

Even though it was pushed forward, after Soria's death, by its main follower Hilarión González Del Castillo under the form of a 'linear garden city' (Del Castillo, 1929), it ended up with the construction of nearly nothing, apart from a railway that was dismantled after the end of the Spanish Protectorate in 1956. Still, this infrastructure, together with the main coastal road, served as support for the development of small urban centers, F'nideq, M'diq, and Martil, later completed by touristic developments from the 1960's onward (the complex process of coastal development, sustained by contradictory governmental decisions, is described under the term of 'littoralization': see Berriane, 1978; Kheddoumi, 2013). The relevance of this dimension is acknowledged by the growing number of recent planification and governance tools specifically dedicated to this issue, from



Croquis de la región que se extiende entre Ceuta, plaza de nuestra soberanía, y Tetuán, capital de nuestro Protectorado, en que puede verse lo fácil, lo tentadora y lo hermosísima que sería una ciudad-jardín-lineal oriental que uniera sin solución de continuidad aquellas dos ciudades existentes y que se prolongara por la campiña marroquí frente al encantador Mediterráneo.

Figure 1. Map of the Grand Tetouan region. Source: Del Castillo (1929).

the *Schéma Directeur d'Aménagement Urbain du Littoral Touristique Tétouanais* (Ministère de l'Aménagement du Territoire de l'Environnement de l'Urbanisme et de l'Habitat, 1998) to the *Schéma Directeur d'Aménagement Urbain et Plan de Zonage du Littoral Touristique Méditerranéen de Tanger et de Tétouan* (Royaume du Maroc, Ministère de l'Aménagement du Territoire de l'Environnement de l'Urbanisme et de l'Habitat, 2004), or the *Programme de Développement Touristique Tamuda Bay—Tetouan 2009–2013* (Royaume du Maroc, Ministère du Tourisme, 2008).

Besides tourism politics, another driving force for a linear urban development along the coast, probably more powerful (or insidious) than the first one in terms of dynamics, is the presence of the Spanish enclave of Ceuta in the North end of the territory. Cross-border dynamics, i.e., informal trade and smuggling, have highly affected the urbanization and socio-economic patterns of development of the coast (and touristic developments are of course part of this process).

The recognition of the reality of the linear city is currently acknowledged by the decision to create a level of strategic planning and administration that coincides with the geographic territory for the metropolitan region of the Grand Tetouan (the term 'metropolitan' is here essential, as it recognizes the interaction between the different parts of the region in a metropolitan way; Royaume du Maroc, Ministère de l'Aménagement du Territoire de l'Environnement de l'Urbanisme et de l'Habitat, 2017). The spatial development scheme, called SDAU, for the Grand Tetouan identifies issues and challenges for the future. It recognizes the conurbation between Tetouan and Martil, along the river Martil, as a fact, and proposes schemes for a more balanced (or less anarchic) and more ecologically conscious development along the coastline. It creates the conditions for the reflection on the Grand Tetouan as a linear city in a transhistoric way by re-assessing the project of the linear city through a prism in which industry (the driver of the modern paradigm of the linear city) is replaced by the tourism industry. The project-oriented themes then become those of the post-industrial city as a whole (Ascher, 2001): How to deal with urban dispersion and social justice (Secchi, 2013)? How do we integrate environmental issues and agricultural practice in a metropolitan reality? How can we address the issue of intensification of urban activities in a metropolitan, scattered environment (Amphoux, 1999)? How can the informal economy, and informal settlements, be taken into account, and used as material tools of development? The interest of the work lies in the reactivation of a formal, theoretical concept, that of the linear city, in a multi-layered, palimpsest-like, territory: is the concept still relevant? The connection between spatial patterns and changing socio-economical uses of the territory is crucial here.

3. An Attempt to Describe

To deal with these issues, after having developed the first approach based on the comparison of the territory with paradigms of linear city/developments, we realized it was necessary to take a step back and assume a position Bernardo Secchi and Paola Viganò had denominated 'descriptive anxiety' (Viganò, 1999, p. 21). It meant going back, explicitly, to the 'descriptive season' of Italian architecture schools of the late 20th century (see, i.e., Boeri et al., 1993; De Rossi, Durbiano, & Governa, 1999; Macchi Cassia, 1998; Munarin & Tosi, 2001; Secchi, 1989, 2001; Viganò, 1999). The idea was to consider the territory we had to be working on as completely new, unknown (or to consider ourselves as strangers to the context), going back to a proposal made by Cohen (1987):

> It is at the same time a work on geometries, urban layout and physical components of the city that need to be done, in a disciplinary void situated at the border of the territory conventionally assigned to the architect, and that of other, diverse technical disciplines operating in the realm of the city. (p. 54, translation by the authors)

We based our investigation on the concept of 'urban material.' This concept is defined by Paola Viganò in her book *La Città Elementare*, in an analogy with music, as 'anything that can be combined in a composition; anterior compositions can become materials for a new composition, and if there was to be more than one world, each and every one of these would be a material' (Viganò, 1999, p. 206). It is clearly related to the Italian school of typo-morphological analysis, but with a clearer link to the project-oriented dimension. It is described by Viganò as 'a step backward from typological studies….It is about building up a sort of 'pending vocabulary' (Leroi-Gourhan) that tries not to lock in predetermined categories what might emerge, but might as well not emerge' (Viganò, 1999, pp. 39–40).

We divided the territory into twelve study areas that can be described as 'periurban,' where we put this descriptive approach into practice with a group of twenty-five students. We did not include in our study dense, historic urban fabric, as its analysis requires other methodological tools (we considered it as an urban material as a whole, without fragmenting it). The goal was to establish an inventory of urban materials of the areas and the attribution of names for every class of material. It proved to be a very complicated task for the students, as it requires negotiating between specificity, particularity, and genericity, and agreeing on scales of analysis. As Viganò, quoting Wittgenstein, puts it, the question of scale is of particular difficulty:

> Defining the constitutive parts of reality is, as was shown by Wittgenstein, rather complicated: "What are the constitutive parts of a chair? The pieces of wood that form it? Or the molecules? Or the atoms? Simple means: not composed. And that's where the difficulty lies: composed, in what sense?" (Wittgenstein, 1953, as cited in Viganò, 1999, p. 31, translation by the authors; Figures 2 and 3)

The notion of urban material implies that each material has to be considered as an artifact, or a grammatical element of the 'text' given us to read. This relates to the Italian tradition of typo-morphological analysis and its structuralist background (see for instance the various *letture di città*—literally 'readings of cities'—it

Figure 2. Grand Tetouan region: Synthetic map of the urban materials. Note: The graphic expression of the overall cartography was based on the one developed by Cesare Macchi Cassia's team in the study they realized on Milan in the late 1990s (Macchi Cassia, 1998). Source: Terrains d'Architecture, Master in Architecture Design Studio (2019).

Figure 3. Grand Tetouan region: Synthetic map of the urban materials, close-up of the Oum-Kaltoum area with corresponding legend. Source: Terrains d'Architecture, Master in Architecture Design Studio (2019).

generated, i.e., Berardi, 1970; Caniggia, 1963; Caniggia & Malfroy, 1986; Muratori, 1959; Panerai, Depaule, & Demorgon, 1999), and to the notion of the territory as a palimpsest developed by André Corboz: "The territory is the object of a construction. It is a sort of artifact. It constitutes therefore also a product" (Corboz, 2001, pp. 213–214, translation by the authors).

There is a clear link between this idea of territory as an artifact, or product, and the notion of urban material, as urban materials, artifacts themselves, can be seen as the pieces that 'build up' this territory. In pedagogical and scientific terms, a central idea in which to think the process of fabrication of this 'territory as a product,' is the concept of operation. The term operation can be understood in two different ways: as a *composition*, in Wittgenstein's sense (see Viganò, 2002, p. 31); but also, in a more disciplinary, pragmatic way, as *development*, in the urban planners' terminology: as a project. It allows the architecture students to understand that there is a clear relationship between description and project, on the one hand, and that the project itself is carried out, or even built, by different actors, the architect being only one of those (and certainly not the main one, against what is usually taught to architecture students: working in Morocco is, in this sense, very helpful, as inhabitant—driven self-construction and development is still very much present). The 'territory as a palimpsest' view also consents to understand or read the territory as a superposition of different projects. Going back to our work on the Grand Tetouan's urban material, it means that these can be viewed as superposed fragments of different projects, interacting on the territory and creating a specific urban phenomenon (Rossi, 1990, p. 232). One of these projects is del Castillo's linear city: Even though it wasn't built as such, the idea in some way still haunts the territory. As Aldo Rossi puts it:

> Projects have a proper existence, like built architectures; they are elements of a whole that is the real….[A project is real] in that it generates afterward a series of facts that can be explained only by its presence, meaning by its shape." (Rossi, 1990, p. 242)

Methodologically, we have proceeded in three phases. After having identified the twelve study areas, each group of students worked based on aerial photographs

to identify formal recurrences. This preliminary work was completed by an analysis of historical maps that gave a diachronic view of the evolution of the territory and led to a description of the territory in time-related layers (see i.e., De Rossi et al., 1999). The group of students then went on a ten-day fieldwork trip to Morocco, during which they confronted their first deductions with reality. Also, they were asked to work on the concept of operation, by trying to get information about what was called 'biography' of places. This survey was completed in meetings with local actors (architects, planners, professors, developers, and of course the Agence Urbaine du Grand Tetouan, the local planning agency) which helped the students better understand the variety of operations (see Figure 4).

The historical, diachronic approach intended to identify the chronology of apparition and, possibly, the spreading of specific urban materials on the territory. It showed a growth pattern characterized by discontinuity: more a leopard-coat-like pattern than a more classical oil-stain one (the influence of the city center of Tetouan is not relevant), revealing the influence of road infrastructures in the distribution of urban materials, and an economy driven by exogenous forces (mainly, the tourism industry and the presence of Ceuta as a source of informal economy and real estate speculation). In terms of urban materials, this process of growth is characterized by a limited number of artifacts or forms, and mainly based on two elements: the road infrastructure, on the one hand (very helpful in this regard to pay attention to minor urban materials, such as lines of palm trees, or a specific street light and their combination), and on the other hand, the land plot as a unit for the fabrication of the territory, be it large (in the case of tourism or planned housing developments) or small (in the case of private housing operations, i.e., informal settlements). These considerations consolidate the interest of working on urban material in terms of operations, in which one or more urban materials can be used and combined.

The whole work has led, at this point, to the realization of an overall map (see Figure 2) that identifies urban material at the territorial scale and, for each area, an analysis of how urban materials form system (i.e., roadway and built material) and a focus on specific types of operations (each area being characterized by the preponderance of a certain type, or, in historically more stratified areas, by a complex combination of operations). The synthesis map shows the 'leopard coat' pattern, rather complex, made of road systems, enclaves, incremental self-built housing neighborhoods, planned housing developments, and industrial compounds, with bits and pieces of left-over natural reserves, wetlands, and fields.

Without going into detail about the whole study, a few elements may be highlighted:

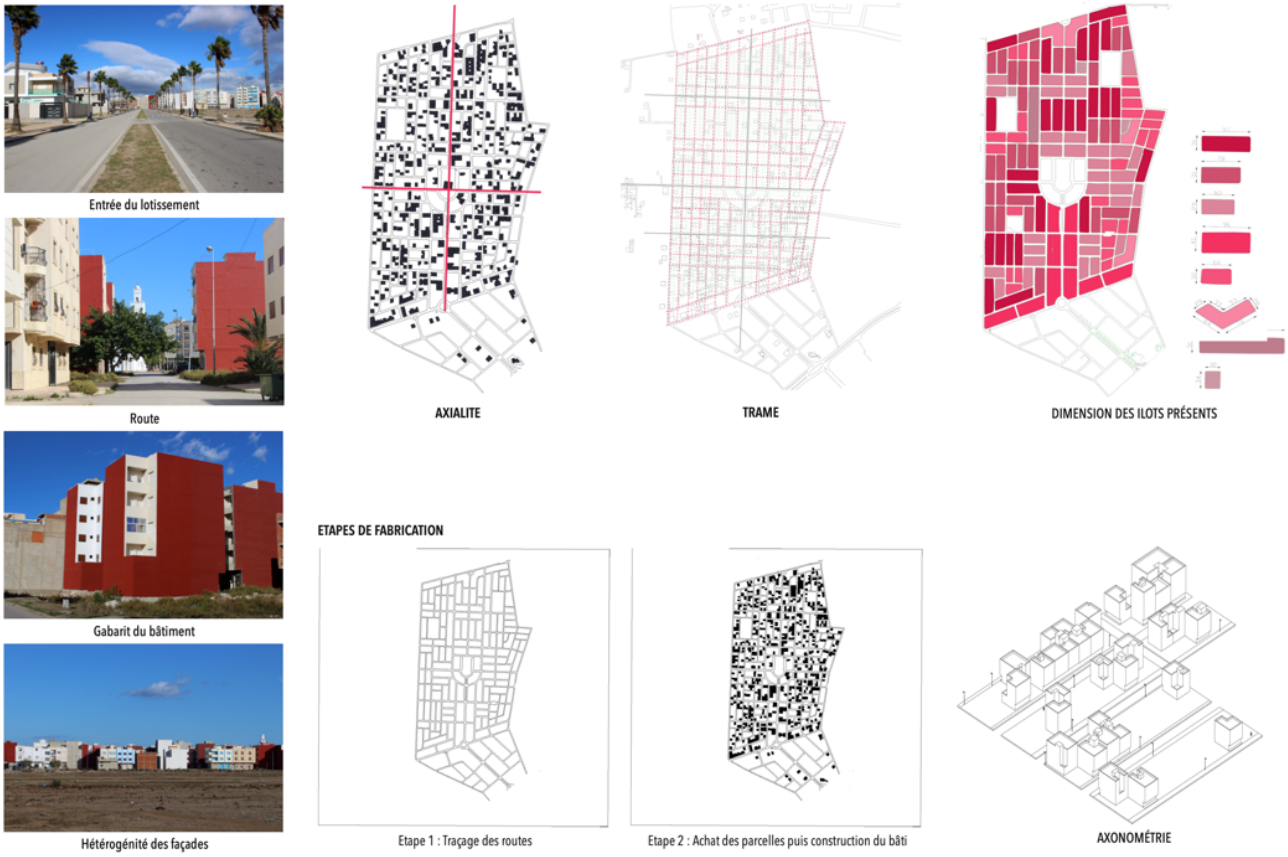


Figure 4. Grand Tetouan region: Example of the urban material, Oum Kaltoum area. Source: Terrains d'Architecture, Master in Architecture Design Studio (2019).

1. The influence of the geographical substrate and preexistences (built or functional, i.e., agrarian use) is very strong; for instance, topography, swamps and rivers, and land division dictate the development in many ways. Similarly, the presence of urban centers (F'nideq, M'diq, Martil) and leisure resorts act as catalysts for developments. The linear configuration is mainly linked to these natural, original characteristics, and very little to a "linear city" project-oriented vision. Specifically, the idea of a linear city in line with the modernist project experience in which tourism would act as industry and driver for the local economy and social practices is absent in terms of formal composition and configuration. There is neither reflection upon complementarity or mutualization whatsoever, nor upon the forms of tourism. The only urban material reference is the enclave, each self-centered, with a variety of 'formal fillings' (villas, apartment blocks, rows of houses) but absolutely no consideration for the public realm as a whole: it constitutes an issue for the future of this territory.
2. As for the 'urban materials,' the territory is fundamentally characterized by the contiguous presence of elements that tend not to work together as a system. A predominant material on the coastline is that of the enclave, touristic and residential closed compounds that work with the main road, slowly eating up the open spaces and blocking access to the seashore. The urban character of this fabric is questionable in terms of density, facilities, and social diversity; the enclave as an operation is also found in some areas that can be considered more urban (closer to densely-built city centers). Other elements making up major developments in the territory are self-built areas, characterized by square lots incrementally forming city blocks, on the one hand, and private developers blocks (either social, middle or high class) that include all the infrastructure facilities (roads, sewage, lighting, vegetation, and urban furniture) on the other. This last type of operation tends to be problematic as it more often addresses financial speculation than real needs.
3. The territory functions, in many respects, as a linear city: the presence of linear infrastructural elements (road, highway, disused railway) influences the distribution of 'urban materials' along the coast. Inhabitants make it work as one 'city,' i.e., in terms of choice of location (to live and/or work). This allows us to complement the formal description of the territory based upon the notion of urban material with that of practice: the territory is produced not only by materials but also, and mainly, by the uses and practices of its inhabitants, in terms of mobility, socio-economic and leisure activities, etc. In this respect, it should be underlined that the linear city as it has been produced, in an incremental, rather unplanned way, creates an urban reality characterized by social unbalance: the territorial distribution of facilities, mobility (with a very poor system of public transportation), the access to basic needs like water or education, are real issues for the future, and question the model of the linear city itself. The emergence of controversies on important environmental and social issues (as in the case of the destruction of the Smir Lagoon some years ago, to build a touristic resort, or the recognition of the existence of "fragile" minorities, such as Sub-Saharan African people in the area) demonstrates the growing social awareness of the territory that has to be taken into account by the authorities.

4. Conclusions

The main issues regarding the future of the Grand Tetouan territory concerning the hypothesis of consolidating a linear city scheme of development are the environmental issue (how can a balance between built and open space be maintained, taking into account the climate change that will affect the water system) and the social issue (how to cope with the tendency towards a socially segregated territory, i.e., in terms of spatial justice). The linear development scheme can address these issues, in accordance with some of the principles developed by modernists. Specifically, longitudinally, the idea of considering the linear city as a necklace of varied urban situations, where diversity of uses and population can be enhanced, separated by green buffer zones (as envisaged by the SDAU), linked by an efficient, metropolitan railway system; transversally, by assuring a complementarity between the inland countryside and the coastal developments, also by working on a transversal road system.

The linear city scheme is nowadays somehow contradicted by a project of developments on the Martil river banks, following the model of other Moroccan cities (i.e., the developments being built in the Bou Regreg Valley between Rabat and Salé). We have seen that the conurbation movement between the two cities of Tetouan and Martil is on its way. It can still be controlled, but it certainly is not a good option to opt for the urbanization of the valley, which constitutes a flood risk area. In this regard, the linear city scheme, developing northward along the coast, can be a pertinent alternative. What is obvious is that both options are to be considered as incompatible.

Recognizing, through description, the permanence of the linear pattern in the developments of the Grand Tetouan region is important. But as André Corboz puts it, describing is also envisioning the future:

> There can't be a description of the territory without an idea of that territory, an idea which filters the relevant features, confronts the qualities, and assigns di-

> mensions and values and neglects characters which another idea of the territory might retain as important. (Corboz, 2001, translation by the authors)

The work has shown that there is a need for project-oriented input on the very idea of the linear city, in terms of urban material. Apart from the roadway system, which shows a clear pattern of linearity, the described urban materials (and more specifically, the predominance of the enclave) do not show any specific way of "building up" a linear city.

The incremental logic of growth has led to a necklace-like structure that does not show any understanding of the specific qualities of the idea of a linear city, and its capacity to meet the need for social justice. More specifically, the integration of tourism as an industry needs to be confronted by the project, as for now, it has only created social segregation and spatial inequities.

This will necessarily include, in terms of a project, a reflection upon the integration of an efficient, linear, public transportation system, with new forms of urbanity based on social needs. This is the next step, not only for the work of our students but for the local planning authorities: what kind of urban materials can be created and composed to address these issues?

We have tried to show, through our work on the specific case study of Tetouan, how the palimpsest approach to contemporary territories can be enriched by intertwining it with the notion of the project, be it at large (the linear city pattern) or smaller scale (through the use of the notion of "urban material," and its connection to that of "operation"). The idea of the project as the transformation of pre-existing (natural, built, or socio-economical) structures is essential to understand the link between the layers of the palimpsest. The project transforms the pre-existing layers (the "substrate") but is also informed by the elements that constitute these previous layers. Unbuilt or unachieved projects (i.e., that of the linear city) can also act as conceptual structures for future developments.

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Conflict of Interests

The authors declare no conflict of interest.

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Article

Reading the Brussels Palimpsest in the History of the *Nouveau Plan de Bruxelles Industriel* (1910)

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Abstract
This article restores the dialogical link between the *Nouveau Plan de Bruxelles Industriel avec ses Suburbains*, published on the occasion of the 1910 Industrial Exhibition (Verwest, Vanderoost, & Xhardez, 1910a), and the *Inventaire Visuel de L'architecture Industrielle de L'agglomération de Bruxelles*, produced by Maurice Culot and the team at the Archives d'Architecture Moderne (AAM) between 1980–1982 (Culot & the AMM, 1980–1982). These two kinds of spatialised visual inventories of places dedicated to production brings out a layer of the Brussels palimpsest filled with information that goes beyond the categories of permanence, persistence and disappearance raised by André Corboz and Alain Leveillé's cartographic implementation of the palimpsest theory in the *Atlas du Territoire Genevois* (Corboz, 1993). This article compares palimpsest theory as applied to Geneva to the practice of inventory in Brussels. We propose visualising a *lisuel* layer intended as a visual reading revealed through a process of description, extraction, classification and juxtaposition. This process of visual analysis helps construct a typology of manufacturing production whose traces are embedded in urban space. It shows how a cartographic document informs the 1910 urban project and how local manufacturing companies contributed to its implementation. The contribution of this cartographic investigation is threefold. It concerns forms of manufacturing companies, forms of living, and production of urban space in 1910 Brussels. The Brussels Industrial Exhibition and the spatial story of Louis De Waele's public works company reveals two patterns of relationships between industrial production and the transformation of urban space.

Keywords
Brussels' industrial map; palimpsest-based urbanism; urban morphology; urban production

Issue
This article is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

1. Introduction

The notion of territory as a palimpsest was formulated in Switzerland by André Corboz in 1983. He continued his reflection in a text written for the *Atlas du Territoire Genevois* (Corboz, 1993). In applying palimpsest theory to territory, the traces of the triple structure of road system, land parcels and buildings are interpreted according to three modalities: permanence (when traces are present faithfully), persistence (when they are perceptible but modified) and disappearance (when they no longer exist). In the atlas the reading of the palimpsest results from the superimposition of maps for studying Geneva's territory development from the Napoleonic cadastre in order to understand what remains or differs from 1806–1818. The aim of the atlas is not to engage in heritage protection of these traces, but rather to record changes in order to understand them and inform future development projects. In Belgium, at the same time and with the same concern for territorial knowledge, Maurice Culot and his team conducted the *Inventaire Visuel de L'architecture Industrielle de L'agglomération de Bruxelles* (henceforth, the *Inventaire Visuel*), an archival corpus of twenty two volumes (Culot

& the AMM, 1980–1982). In the same way that the goal of the atlas was to reveal new knowledge, the visual inventory compiled archives to make an inventory of the architecture linked to productive spaces, leaving open the question of the 'patrimonialisation' of the remaining traces.

Each volume of the *Inventaire Visuel* starts by referring to the *Nouveau Plan de Bruxelles Industriel avec ses Suburbains* (henceforth, the *Plan Industriel*; see Figure 1). The *Plan Industriel* is a historical cartographic document that bears witness to an urban production regime. It is an advertising document celebrating industrial architecture. Produced in the spatial and temporal context of 1910 Brussels, the document shows the spatial organisation, volume and location of about fifty companies involved in the city's industrial growth. It also shows the plan of the 1910 Brussels Industrial Exhibition on the Solbosch plateau in Ixelles (south-east Brussels).

In each volume of the *Inventaire Visuel*, a detail of the *Plan Industriel* emphasises the companies subjected

Figure 1. *Plan Industriel* (Verwest, Vanderoost, & Xhardez, 1910a). Courtesy of the Archives de la Ville de Bruxelles (plan de Bruxelles no. 130, section cartographique).

to further historical research (Figure 2). These companies are then incorporated in a map of all the industrial buildings recorded in the volume of the visual inventory. Numbers refer to fact sheets which describe the construction, development and uses of industrial buildings.

In this article, we explore the relationship between manufacturing companies and the city through a visual reading that creates an interaction between morphological palimpsest analysis and archives. The relationship between the *Plan Industriel* and the *Inventaire Visuel* is dialogical. The palimpsest layer we intend to reveal is encompassed within the diachronic reading of these two documents which serve as a basis for a cartographic investigation. Starting with the description and history of the two documents, the investigation engages in a reading process which ends in a visual analysis aimed at going beyond the categories of permanence, persistence and disappearance raised by Corboz (1993). The neologism *lisuel*, which we use to refer to this visual reading, has been theorised by Gullentops (2001) regarding Jean Cocteau's poetry. In order not to lose this reference in translation, we kept the French neologism. *Lisuel* is a French contraction of what is both readable (*lisible*) and visual (*visuel*). This neologism is transposed to this cartographic investigation to free the palimpsest from a literal stratigraphic reading. Making several possibilities of reading and interpretation co-exist through a process of extraction, classification and juxtaposition, it forms a thought pattern which questions the roles of archives in urban production (Rao, 2009; Van Damme, 2012), of urban imagery (Pousin, 2005; Söderström, 2000) and of spatial analysis (Arnaud, 2008).

For Brussels, the archives compiled in the visual inventory are specific and depicted the relationship between industrial production and the transformation of urban space. As the latter dealt with the economic regime and forms of manufacturing companies, it fuels our cartographic investigation with material and spatial but also immaterial and socio-economic elements. The spatial stories of the industrial companies represented in the *Plan Industriel* configure the systems of relationships between the manufacturing companies and the city. In this article, we take the history of general public works contractor Louis De Waele, a family business founded in 1866 by De Waele and his brother Jean as a carpentry and woodworking company, as a case to illustrate our visual reading of this system of relationships. This specific family business has been chosen because of its important role in both the physical transformation of the urban space and the promotion of the *Plan Industriel*.

Indeed, as mentioned at the bottom of the *Plan Industriel*, Jules De Waele—one of the four sons of Louis De Waele, who took over the family business when the latter died in 1900—sponsored the drawing's publication. This led the authors of the *Inventaire Visuel* to call it the "plan De Waele". In the fact sheet on Jules De Waele's company, the authors state:

> In 1910, Jules De Waele took the initiative to publish a map of Brussels in which his enterprise is listed alongside the establishments most representative of the industrial boom at the beginning of this century: the *Nouveau Plan de Bruxelles Industriel avec ses Surburbains*. This initiative is undoubtedly commensurate with the importance that this enterprise had acquired when it moved into its premises on Saint-Hubert Street. (Culot & the AMM, 1980–1982; author's translation)

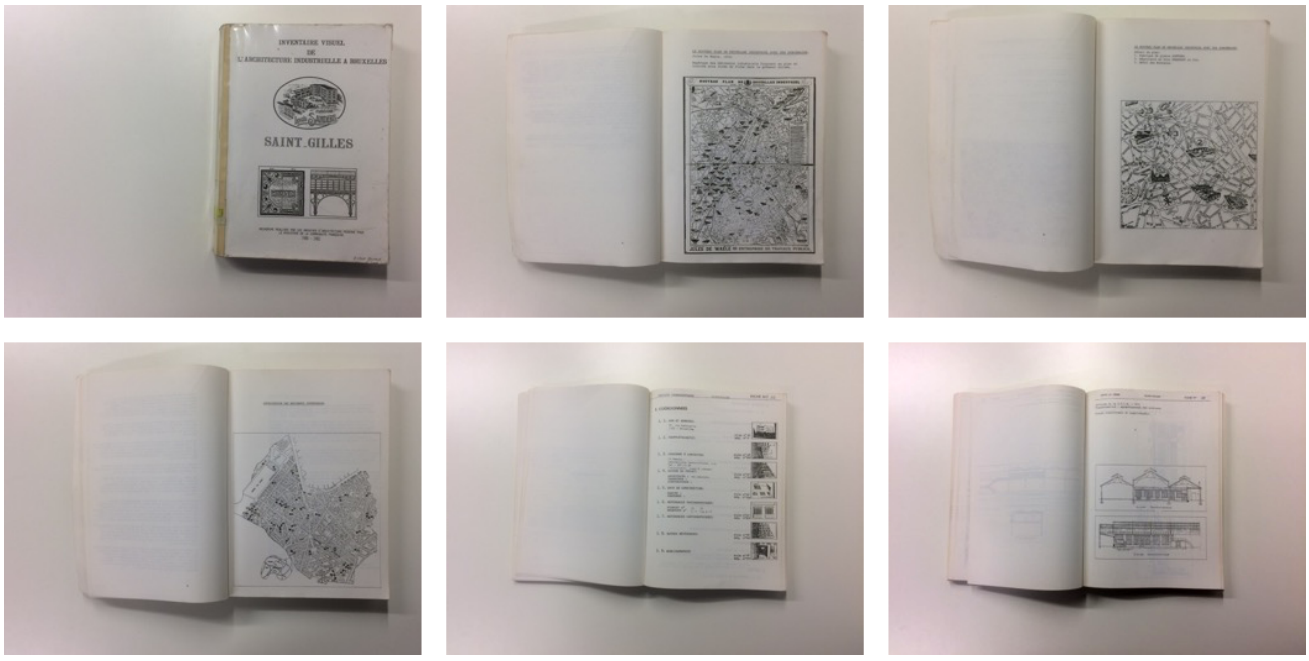

Figure 2. *Inventaire Visuel*. From the Bibliothèque Générale des Sciences Humaines (BGSH, UCLouvain). Photograph by the author.

The idea spread that the initiative to publish the plan was taken by De Waele. Nevertheless, different versions of the plan can be found in the archives. So far, we have found three: one advertising Jules de Waele's company, in the Brussels City Archives, one advertising the Virginal paper mills, in Ghent University Library (online collection), and one advertising Désiré Flamand's paving and asphalt company, in the National Library of Belgium (online collection). As in the 1980s the *Plan Industriel* recurred throughout the *Inventaire Visuel*; it reappeared also in 2014 to serve the vision of Brussels as a productive city. This recent resurgence motivates us to determine how it contributes to the understanding of the Brussels palimpsest.

2. Belgian Industrial Plans

The *Plan Industriel* was drawn up by a consortium of graphic industries on the occasion of the 1910 Brussels World's Fair. It initiated a series of similar maps for the cities of Charleroi (dated 1911), Liège (dated 1911), Ghent (dated 1912), Antwerp (dated 1914), and Verviers (dated 1914). These maps offer for each city a nomenclature or directory of industrial establishments which includes in a non-systematic way the company name, building type (workshop, office, warehouse) and address. The maps show the contemporary facades or buildings as etched vignettes without taking into consideration their orientation or scale. A red box highlights the company financing the plan's drafting or printing. The same colour is used for the description of its business, in the lower part of the print. These documents are not plans in the sense of urban planning. At the time when these advertising documents were published, the development of Brussels was governed by a process of "dotted-line planning" (Zitouni, 2010), the most eloquent expression of which was the Besme plan (Figure 3), named after the head of the provincial roads department which guided

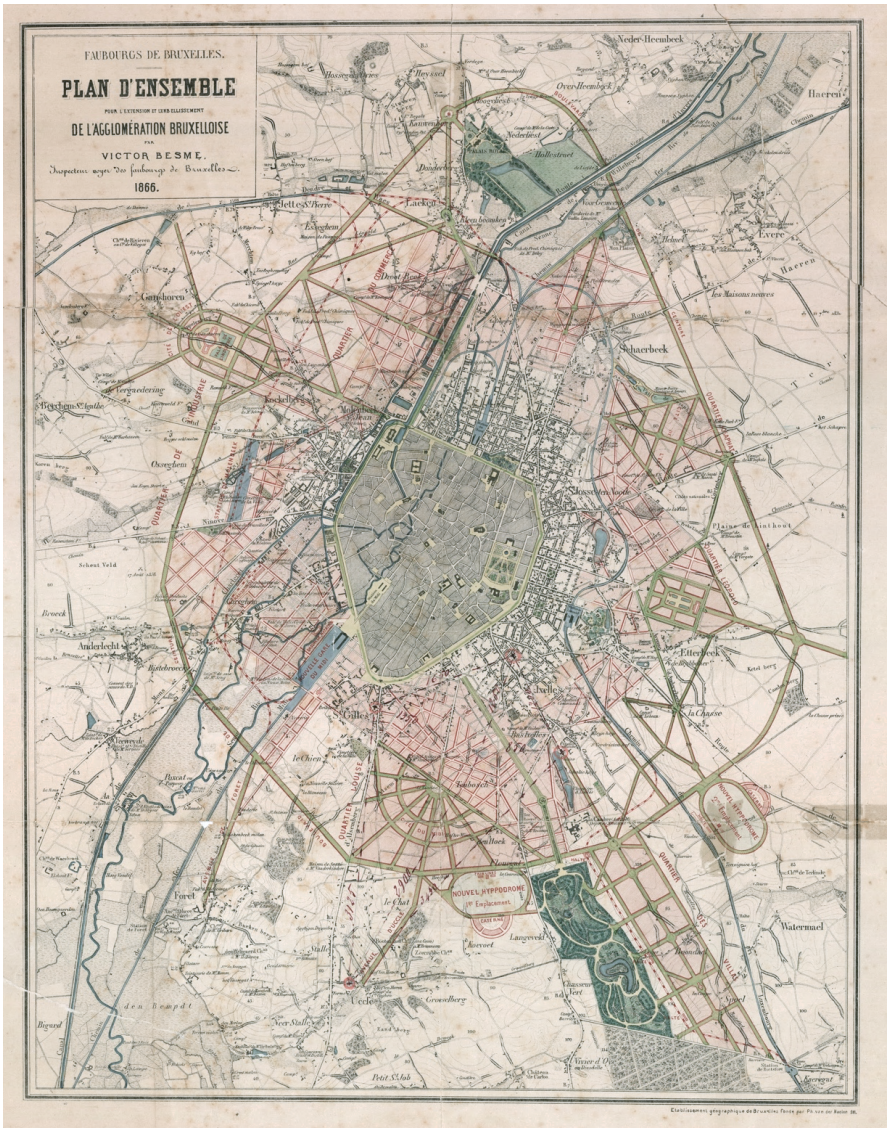

Figure 3. *Plan D'ensemble pour L'extension et L'embellissement de L'agglomération Bruxelloise* (Besme, 1866). Courtesy of the Archives de la Ville de Bruxelles (plan de Bruxelles no. 96/8, section cartographique).

the extension of the city beyond its walls, prefiguring what would today probably be called negotiated urban planning. The Besme plan was first drawn up in 1863 and redesigned in 1868 (De Beule, 2017). The industrial maps are cartographic documents with no projective or scientific aim. Nevertheless, they constitute a solid basis for a spatialised inventory of the productive activities contributing to the development of these cities. In the case of Brussels, it also showcases the latest city transformations linked to the implementation of the Besme plan.

The comparison with the 1910 Brussels official cartographic institute (IGN) map shows the plan's uniqueness. Indeed, one feature that distinguishes the Brussels map from the others of the series and from contemporary maps such as IGN's is that it shows the urban design of the 1910 Brussels World's Fair on the Solbosch plateau in Ixelles (Figure 4). During that era, several Belgian cities organised international exhibitions. World's fairs, however, like the one in Brussels in 1910, were defined as industrial, universal and international exhibitions when they assessed "the means and progress made or to be made in several branches of human activity" (Schroeder-Gudehus & Rasmussen, 1992). While the first two maps in the series, of Brussels (dated 1910) and Charleroi (dated 1911), were produced during a world's fair year, the latter does not include the fair's urban design and only mentions its location. This gives the map of Brussels new value since it is one of the few documents showing the essential impact of an event dedicated to science, arts, industry and commerce, and lasting a few weeks, on the city's urbanisation over the long term.

Urban production related to the 1910 World's Fair is quite specific, as it was designed by the World's Fair Company responsible for the urban development related to the event. This company had its own head architect (Gédéon Bordiau, assisted by Ernest Acker and Louis Van der Swaelmen) and chief engineer (Alfred Masion). The impact of the fair has two relevant aspects regarding urban production. The first is the urban development of Brussels, particularly the extension of the city towards Ixelles. The second is how the fair reveals the emerging concept of social economy. This aspect reflects the adoption of the law on workers' housing, which foreshadows the next episode in the history of Brussels's development and links it to Victor Besme's considerations of workers' housing support.

The story of the *Plan Industriel* is a reiteration that a cartographic document, like a territory, is a construction which is a process, product and project (Corboz, 1983), in this case related to a major event for the city. This plan represents spaces of which the industrial city can boast. In addition to private companies, facilities, and public spaces, it also includes gardens and parks that were linked at the time to hygienic requirements. The plan displays the pride a city can take in its industry and celebrates national prosperity. It envisions a city that claims its capacity for innovation and progress but also the know-how and technique of its craftsmen. It shows the city's transformation to accommodate industry, workers' housing estates, schools, and hospitals, but also emphasises rail and transport as city transformations that allow local manufacturing companies to function and, in doing so, promote a specific image and economy of the city.

These maps became eloquent witnesses to the spatial organisation of industry at the turn of the 20th century. The series began with the Brussels map as an official publication of the *Plans Industriels de Belgique*. This map was edited by Khiat and printed by Gouweloos. The base map was drawn and engraved by Auguste Verwest, while the vignettes were drawn by Fernand Xhardez and engraved by Marcel Vanderoost. The same consortium of graphic industries was responsible for the *Nouveau Plan de Bruxelles Mondain* from 1910 (Figure 5), its directory of commercial and elegant establishments in the centre of the capital (Danckaert, 1989), and World's Fair brochures and tourist maps (Figure 6) that show the tramway lines built to reach the fair site in Ixelles (Jaumain, 2010).

Figure 4. Detail of the Solbosch plateau, site of the 1910 Brussels World's Fair (IGN, 1910; Verwest et al., 1910a). Courtesy of the Ghent University Library and of the Archives de la Ville de Bruxelles (plan de Bruxelles no. 130, section cartographique).

Figure 5. *Nouveau Plan de Bruxelles Mondain* (Verwest et al., 1910b). Courtesy of the Musée royal de l'Armée (cartes, Bruxelles 60).

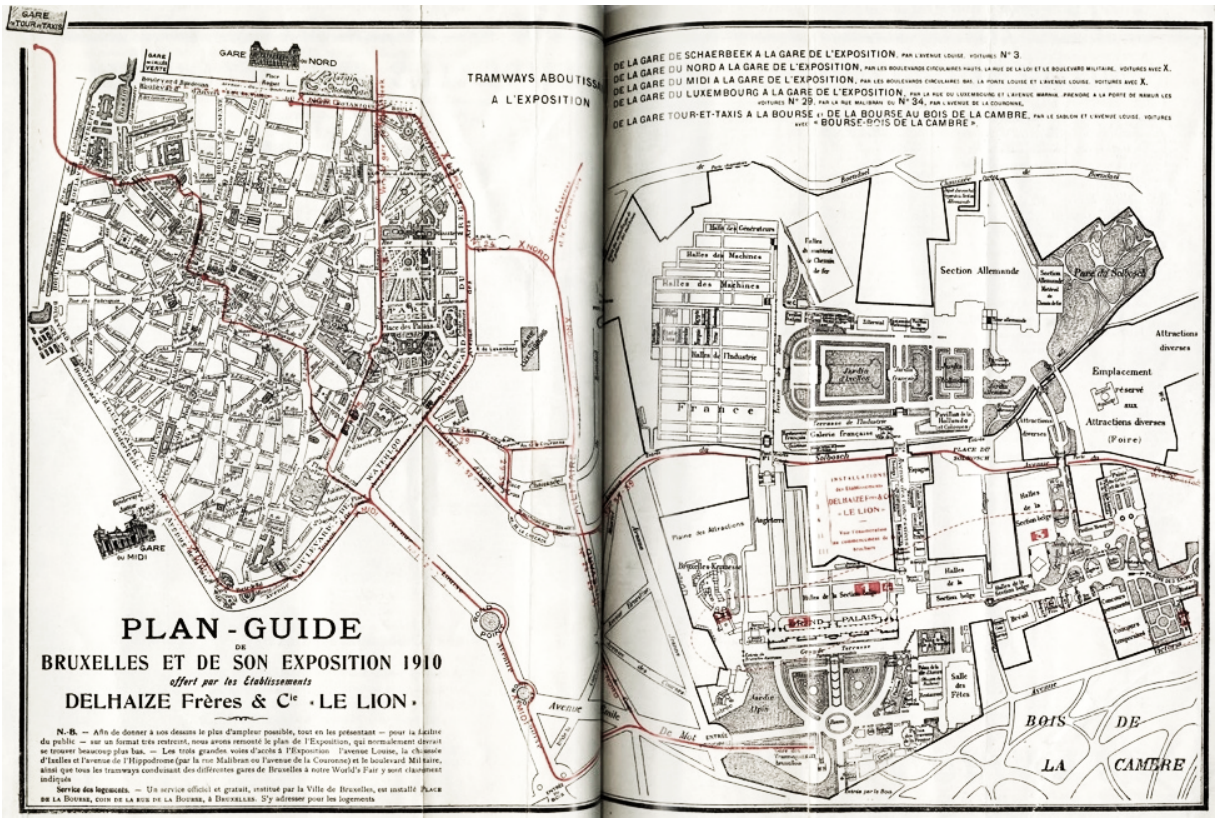

Figure 6. The World's Fair and the redevelopment of the tramways (Jaumain, 2010, pp. 88–89).

3. The Visual Inventory of the Industrial Architecture of the Brussels Agglomeration

Culot's *Inventaire Visuel* of 1980–1982 covers the territory of the nineteen municipalities of what was then called the Brussels Agglomeration. This agglomeration took shape in 1971. It was revised in the 1980s when the regionalisation agreements were negotiated, leading first to the creation of the Walloon and Flemish regions and then, in 1989, the Brussels-Capital Region.

The inventory's aim was to integrate knowledge of industrial heritage into the toolbox of the city's economic redevelopment, at a time when the modernist frenzy was condemning secondary economic activities to the benefit of the tertiary sector (and hygienist zoning) and conceived urban renewal only through the filter of a tabula rasa. In Brussels, the phenomenon of the city's radical transformation earned the name "bruxellisation" (Schoonbrodt, 2007). The project to conduct this *Inventaire Visuel* followed the emergency pre-inventory published and carried out in 1975 by the non-profit organisation Sint-Lukasarchief (Région de Bruxelles-Capitale, 2019). To complete this pre-inventory the Ministry of the French Community commissioned thematic inventories of, for example, industrial architecture and social housing, or *maisons du peuple*. These inventories were conceived as knowledge tools to provide an overall view of the agglomeration's significant specificities in terms of architecture and urban history. Today they have been integrated into the *Inventaire du Patrimoine Architectural* (Région de Bruxelles-Capitale, 2019) and are a prerequisite for adopting conservation and protection policies.

The volumes are organised by municipality. The introductory text to each volume details the municipality's industrial profile and describes the variety of urban landscapes, which are classified into three types: residential, working class, and industrial.

The *Inventaire Visuel* included fact sheets aimed at restoring the architecture of one hundred industrial buildings still present in 1980. Selected buildings had to have been constructed before 1940 and be representative of industrial or manufacturing building types. Other selection criteria ranged from pure architectural quality to the building's impact on the urban morphology. Fact sheets were classified according to the original use of each building. Each fact sheet addresses a single building and summarises identifying and builder information. It characterises the type of industry for which the building was built, details its successive uses, describes its architectural character and the urban context in which it is located. The buildings were identified on the basis of field surveys, archive research, cadastral extracts, and aerial photograph analysis. Fact sheets also detail, in an appendix, the archives' classification system.

Each fact sheet's appendix also contains a compilation of archival documents collected at that time. These appendices show a diverse range of archival documents such as plans and building permits, official letters, company advertisements, and newspaper articles. While the fact sheets focus on categorising the buildings, the archival documents provide information on the relationship between industrial companies and their urban context, unveiling the economic regime underlying the city's development.

4. *Lisuel* Layer of the Palimpsest

Beyond the modalities of permanence, subsistence, and transformation depicted by Corboz (1993) for the study of the development of land parcels, buildings, and roads, the study of the uses and their evolution through spaces allow for reconfiguring the conditions in which traces passed from one category to another. The effort made by Culot and the AAM to carry out the visual inventory was driven by the desire to document the stories behind the traces. The inventory managed to complete the picture of the De Waele plan and enrich it with the specific histories of the companies. These particular histories reveal the relationship that exists between a territory, its architecture, and the diachronic lifestyles which it hosts.

The *lisuel* layer of the palimpsest we propose is a visual reading of these histories behind the traces. It ties them to political, social, and cultural changes. Our visual reading was a process of extraction (showing the featured situations), classification (setting up a typology), and juxtaposition of archives (engaging the visual analysis). Extraction depicted featured situations on a base map to establish the architecture of the city from a specific document; classification, by cross-checking another document, helped organise these features under a theme linked to urban production chains; juxtaposition of archives reveals the impact of a manufacturing company in the transformation of urban space.

4.1. Extraction

Extraction is a delayering of the featured situations represented on the *Plan Industriel* (Figure 7). Although there is no legend, the map of Brussels delivers several levels of information. First are municipal boundaries. This may seem anecdotal, but when the plan was being drawn up, the communes were not merged under a common trusteeship and the extension of the territory of Brussels gave rise to intense conflicts. The framework of the *Plan Industriel* is centred on Brussels City, but companies appear also in surrounding municipalities despite the extension of Brussels City urbanising agricultural land. One of the etched vignettes even concerns paper mills located in Virginal (Wallonia). Regarding water and land transport, we can distinguish the canal and its basins, paved roads, paths, and plant-lined avenues. Also, the plan mentions squares and street names. Some of the streets' lines are dotted, testifying to the process of dotted-line planning which accompanied the extension of Brussels during the industrial era (Zitouni, 2010). Regarding rail-

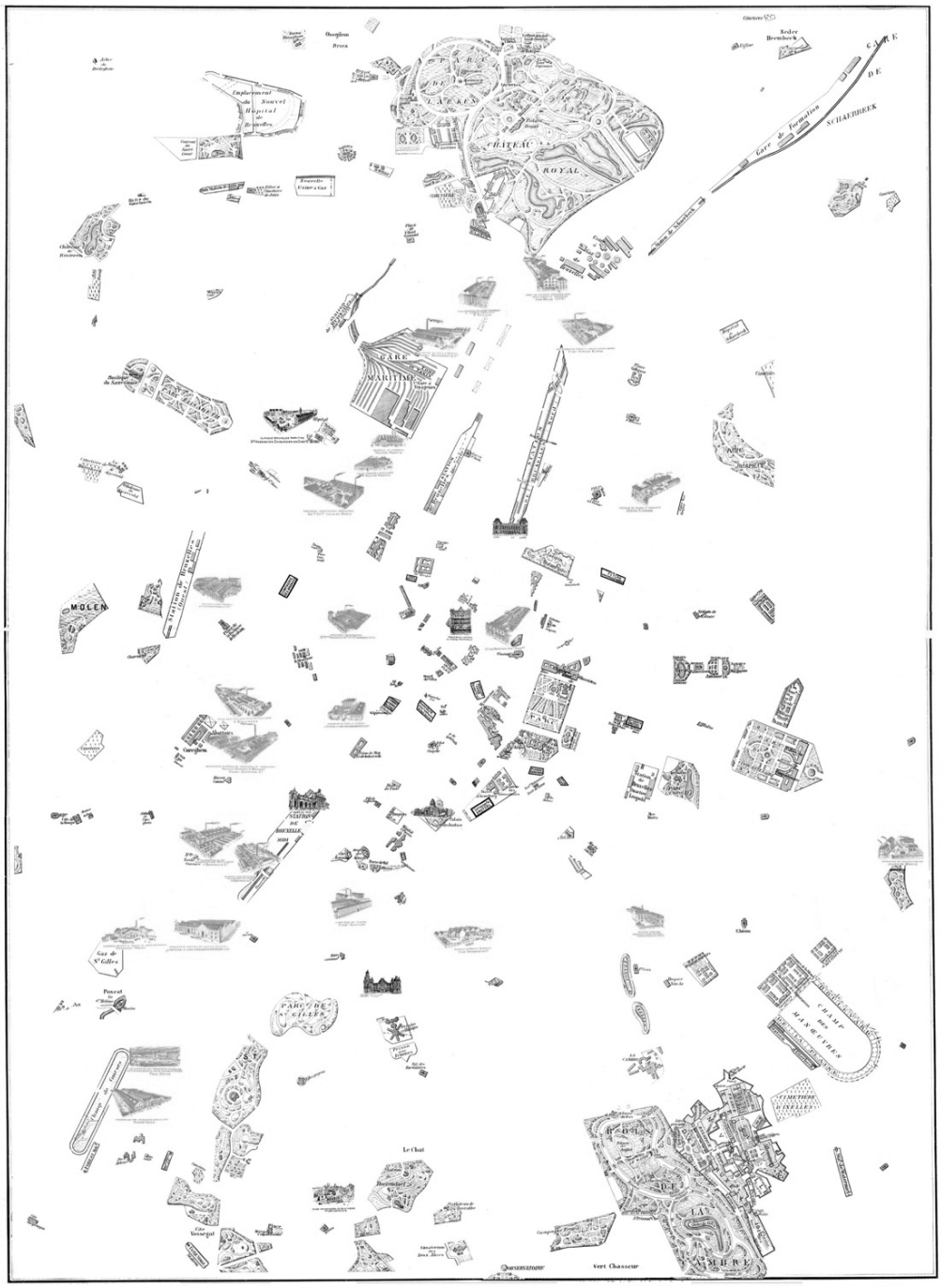

Figure 7. Extraction from the *Plan Industriel* (Verwest et al., 1910a, extraction made by the author). Courtesy of the Archives de la Ville de Bruxelles (plan de Bruxelles no. 130, section cartographique).

roads, the map of Brussels differs from those of other cities in that it does not differentiate passenger, industrial, local, and tram rail. Indeed, the legends of Antwerp, Ghent, Charleroi, Verviers and Liège city maps differentiate paved roads, paths, and passenger railways, local railways, industrial railways, and electric tram lines. This difference may be meaningless, but it does indicate the adherence of the collective transport networks to Brussels territory, notably through the extension of the network of local tramways. Regarding open spaces, one can see on the map of Brussels woods, fields, parks, and cemeteries. The drawings of the parks are as accurate as those of the vignettes. Finally, regarding infrastructure, the map shows churches, communal houses, barracks, farms, gasworks, convents and abbeys, castles, workers' housing estates, train stations, mills, fountains, hospitals, palaces, the observatory, slaughterhouses, the stock exchange, theatres, and covered passages. This delayering informs the analysis of the forms of living, in a city in which manufacturing companies took part as builders of the urban project envisioned by the Besme plan and supported by King Leopold II.

With regard to Corboz's theory of territory as palimpsest, the process of extracting featured situations concerns mainly territorial apparitions which are superimposed on the initial palimpsest. This is the spatial expression of a new narrative rather than the expression of the 'old soil grimoire' on which it is based.

4.2. Classification

The purpose of classification is to establish a typology for highlighting a specific thematic layer. In the *Inventaire Visuel* the fact sheets are classified by the industrial category to which the building is related. These categories refer to the original use of the building related to the company's production (tobacco, sugar, cars, printing, etc.). Other categories appear in relation to building types (shops, warehouses, factories, workshops, etc.). The category 'workshops and buildings of unidentified (original) use' applies to small-scale buildings which host craft activities. The categories 'reconversions' (distinguishing in particular reconversions from a non-industrial to an industrial function, from an industrial to a commercial function, from an industrial to a cultural function) and 'disappeared buildings' refer to transformations. The classification system of the fact sheets therefore gathers building types (workshops, warehouses, dwellings, shops, etc.), uses (enamelling, printing, cigarette manufacturing, etc.) and conservation statuses (preserved building and use, demolished building, reconverted use). Classification by conservation status considers the resilience of industrial architecture.

The collage of the industrial buildings' location (Figure 8) retrieved from maps in each of the twenty-two volumes of the *Inventaire Visuel* reveals a regional geography. It shows geographical location factors, the logic of clustering by production sectors, and how these clusters determined the specialisation patterns of neighbourhoods in 1910. It highlights the two main dynamics of development of the Brussels economic urban fabric during the industrial era: the importance of the manufacturing axis in the valley occupied by the Senne-Canal system and the railways, and the proliferation of more arti-

Figure 8. Location and classification of industrial buildings from the *Inventaire Visuel* (Culot & the AMM, 1980–1982, Vols. 1–22; collage made by the author).

sanal companies along the tributaries of the Senne River in old rural villages and newly urbanised districts (Atelier de Recherche et d'Action Urbaine, 1984). It also helps to investigate relationships of competition, complementarity, or convergence between companies operating in the same part of the territory at the same time.

The manufacturing axis consists of several subgroups. To the south, in Anderlecht, were textile factories (wax cloth, dyeing, cotton weaving). To the north, in Cureghem, the slaughterhouse engendered meat and leather industries (leather goods, shoe manufacturing). Breweries, flour mills, and tobacco factories settled in Molenbeek, on the opposite side of the canal from Brussels. In Ixelles, the integration of economic activities into the residential fabric shows a concentration of craft activities more directly related to domestic services (wood craftsmen, musical instruments, furniture, ironwork). To the south-east, in Boitsfort and Auderghem, the Sonian Forest spawned breweries and forestry activities. Businesses involved in the production of habitat and public space are scattered. This geography of activities can be found today in the toponymy of streets and extended by researching commerce and industry almanacs (available for the period 1820–1969).

Going back to the *Plan Industriel*, we distinguish seven themes to classify featured situations related to specific urban production chains: domestic infrastructure (public equipment such as train stations, court halls), imagery production (publishing activities such as printing, engraving, newspapers, etc.), food production (agricultural fields, beer, grains, etc.), household goods manufacturing (textiles, musical instruments, etc.), residential services (landlord offices, laundry, hotels, shops, waste collection, etc.), energy production (petrol, gas, etc.), and habitat and public space production (public works companies, wood and metal processing, building sites, etc.). This last group is the one we highlight for this visual analysis. It enables us to address both construction sector businesses and smaller-scale craft workshops. This classification informs the analysis of the forms of living to which each business contributes.

4.3. Juxtaposition

The featured situations extracted from the *Plan Industriel* and the cross-checking with archival documents extracted from the *Inventaire Visuel* reveal two patterns of relationships between industrial companies and the transformation of the urban space. The juxtaposition of the different categories of archives offered by the two documents helps visualise the urban production related to each company. We focus on analysing the spatial history of Louis De Waele's company, because it is part of the habitat and public space production theme of featured situations and relevant to the publication of the *Plan Industriel*. We begin with the extraction of the etched vignettes representing its two factories and proceed to locations associated with the production chain (workshops, warehouses, houses, offices, shops, construction sites).

Louis De Waele's spatial management has been studied in depth recently by Degraeve, Dobbels, Bertels, Deneweth, and Van De Voorde (2018). Nevertheless, the visualisation of its footprint on the Brussels palimpsest, showing the company's successive establishments within the city and its construction sites up to 1910 (Figure 9), has been retrieved here from the reading of the appendix of archives collected in the *Inventaire Visuel*.

The relationship between the company and the transformation of the urban space is based on two aspects. The first is the company's footprint and development of establishments within the city. Successive establishments of De Waele family companies during 1867–1927 can be deduced from four archival documents in the fact sheet appendix. The first is a very complete article written by Eugene Dhuicque and published in *L'Emulation* in 1927. Dhuicque (1927) locates company sites and describes the development of the family business. This description helps us understand the link between the two etched vignettes extracted from the *Plan Industriel*. The three other archival documents are plans: a building permit introduced in 1885 to build up a hangar on rue Ribaucourt (see Figure 9, aerial map, B), a request for a permit in 1912 for the *Grand Atelier* on Lavallée street 23–25 (see Figure 9, aerial map, C), and another request for a permit in 1921 for the extension of a factory on Léopold II boulevard 22–46 (see Figure 9, aerial map, D). These documents are set in an aerial photograph of Brussels which dates back to 1930 to visualise how Louis De Waele contributed to the urbanisation of the industrial neighbourhood of Molenbeek as envisioned by Victor Besme at the end of the 19th century (Figure 9).

By extrapolating from the fact sheet appendix, the spatial story of Louis De Waele's company can now be told. Its first workshops were established on the Quai aux Pierres de Taille. In 1867, carpentry and parquetry workshops moved to the l'Intendant street in Molenbeek. They were then transferred in 1888 to Lavallée street, in a vast building whose plans were drawn up by Henry Beyaert. At the time, the factory was electrified by its own means. In 1889, the company set up its offices and warehouses on boulevard Leopold II. In 1890, the architect Janlet drew up the plans for Louis De Waele's residential house (used later for administrative services), which was built alongside the boulevard. The building extensions of 1921–1922, per the plans of the architect Dhuicque, provide information regarding the firm's continuous development. At the turn of the 20th century, Louis de Waele's company became a very powerful general construction and public works company in Brussels, owing to Louis De Waele becoming the royal family's official contractor. The name of Louis De Waele evokes a period of construction in Belgium when the efforts of a series of craftsmen were combined to modernise the building trades:

Figure 9. *Lisuel* layer of the palimpsest. Juxtaposition of archival documents (juxtaposition made by the author). From left to right: location of industrial buildings in Molenbeek (Culot & the AAM, 1980–1982, Vol. 2); aerial photograph mission Brussels 1930–1935 (BUP-CIRB); building permits (Culot & the AMM, 1980–1982, Vol. 2); advertisement for Louis De Waele's company (Culot & the AMM, 1980–1982, Vol. 3); etched vignettes (Verwest et al., 1910a).

> Among the carpenters, cabinetmakers and parquet floorers was Joseph Godefroy, to whom the city of Brussels later owed the foundation of its school of carpentry; they were Henri Pelseneer and Louis De Waele, and shortly afterwards Edouard François; among the decorators, Gustave Janlet and then Henry Base; among the blacksmiths, Pierre Desmedt; among the plumbers, Gustave Pierre and Verhoogen; among the ornamentalists, Georges Houtstont and many others. (Dhuicque, 1927, as cited in Culot & the AMM, 1980–1982; author's translation)

The know-how and expertise of Louis De Waele's company was celebrated at the exhibitions of Antwerp (1888–1894, Grand Prix), Amsterdam (1883, Gold Medal) and Scheveningen (in 1892), among others. The firm was incorporated in 1902 as a limited company. After Louis's death in 1900, management was entrusted jointly to his four sons, Albert, Gaston, Oscar, and Jules. Subsequently, another Louis (Gaston's son) ran the business until 1982. After 1982, Louis-Marc (Gaston's grandson) and his cousin Jean-Thomas (Albert's grandson) took over the family business. In 1927, its factory employed no fewer than 450 workers, while its building sites employed 500 workers.

The second aspect of the company's relationship to urban space transformation is its locating its construction sites within the city. Retrieved from the fact sheet appendix in the *Inventaire Visuel*, an advertisement for Louis De Waele lists some of the works it carried out at that time. Sixteen sites can be located as featured situations extracted from the *Plan Industriel*: the national exhibition of the Jubelpark (plans by Bordiau in 1880), the reconstructed National Palace (plans by Beyaert, burnt down in 1883), the reconstructed Royal Palace of Laeken (plans by Balat, burnt down in 1894), the Royal Farm of Stuyvenbergh in Laeken (plans by Janlet), the new warehouses in Brussels (plans by Van Humbeek), the barracks in des Petits Carmes street (plans by Van Ysendyck), the galleries adjoining the Jubelpark arcade (plans by Girault), the extension of the Royal Palace in Laeken (plans by Girault), the joinery and parquet flooring of the Royal Palace in Brussels, the Royal Observatory, the post and railway stations, Saint-Gilles prison, the Hotel des Monnaies, Saint-Jean and Saint-Pierre hospitals, the public prosecutor's offices in the town halls of Brussels and Saint-Gilles, and the General Society for the Promotion of Industry.

This advertisement also contained four views of the showroom, of a wood store, of the workshops and of the engine rooms.

The representation of this juxtaposition is a graphic indication of the impact of these establishments and their activities on Brussels morphology in which the production of urban space is seen both as the product of the work of local manufacturing companies and as space induced by their presence and forms.

Forms of manufacturing companies are influenced by both the production chain (referring to machinery and work organisation) and type of entrepreneurship. On the *Plan Industriel*, the very detailed etched vignettes reveal microcosms. These are groups of buildings in which a whole production chain is taking place. As local companies were building the city and shaping its image, urban space became the showcase for exhibiting the know-how of Brussels entrepreneurs. The particular case of De Waele shows the destiny of a flourishing company that has grown so much that it is now global. Other companies may have left their traces but disappeared, while still others were able to continue their activity on a small scale. The forms of manufacturing companies have to consider the types of entrepreneurship, such as the four characterised by Cooney in 1955 and described in Bertels, Deneweth, Horemans, and Van De Voorde (2016): the self-employed master craftsman, the master craftsman responsible for all construction, the builder, and the master builder. This discerns all-inclusive manufacturing companies from fragmented manufacturing companies or associated manufacturing companies and considers their scales as they adapt to the urban environment. Understanding the evolution in the forms of manufacturing companies also requires considering historical aspects such as the development of the Arts and Crafts Movement in England (from the 1880s) or *Art Nouveau* in Brussels (from 1890) and the systematisation of the scientific organisation of work by Frederick Taylor (1911), who set out his method in *The Principles of Scientific Management*.

Other elements of the *Plan Industriel* serve to identify forms of living, which resulted in part from the conditions in which workplaces were laid out in relation to residences and places of public life. The *Plan Industriel* says little about how the relationship between workplaces and residences was defined in 1910. However, it does provide some significant clues. In the case of Louis De Waele's company, for instance, the house occupied by the contractor until his death in 1900 is drawn since it was integrated into the factory. The plan also mentions the existence of workers' housing estates (Cité Fontainas, Cité Jacquemyns), which testifies to the value that was placed on the production of affordable housing already supported by Victor Besme in 1868 but which truly took off in Brussels with the rise of garden cities from 1915 to 1930. Concerning places of public life, the plan focuses on train stations, hotels, and covered passages. Other contemporary documents such as the *Nouveau Plan de Bruxelles Mondain* (on which Louis De Waele's company is depicted as a joiner's workshop) or the Delhaize advertisement show landmarks of a sociability specifically linked to work (shops, department stores, luxury craft factories, markets, galleries, hotels, museums, and theatres) but also schools (including the vocational school of joinery and the industrial school) and the *maison du peuple*. Some of these facilities are financed either by companies (which already use the term 'social economy'), workers' cooperatives, or trade union organisations.

5. Conclusion

In the end, after a journey through an investigation which began with a cartographic document, what does the *lisuel* layer bring to the palimpsest theory? In this article, we contextualised the contribution of Corboz (1993) relative to the palimpsest theory and the methodology of the visual inventory exercised during the same period by Culot and his team. While they share the goal of revealing territorial knowledge to inform future development projects, their outputs differ. Corboz and Leveillé's superposition of maps to record changes in the evolution of land parcels resulted in cartographic documents. These cartographic documents revealed modalities of permanence, subsistence, and transformation. Culot and his team's inventory work recorded the changes in building use and associated each building with a compilation of archives. Inventory practice allowed for reconfiguring the conditions in which traces passed from one modality to another.

The methodology of building up the palimpsest's *lisuel* layer consists in connecting these different categories of archives. It combines the interpretation of a cartographic document with that of the visual inventory. It attempts to visualise the role played by archives in urban production, their uses, and the connection between different kinds of archives. Instead of arguing for a stratigraphic reading, the *lisuel* layer aimed at visualising a 'thickness' in the present use of these archives. It emphasised the role of historical analysis in the ongoing definition of an urban project, exploring how the reproduction of a document interacts with the transformations of architectural or urban spaces. By visualising a system of interactions, the *lisuel* layer provides room for critical analysis of the urban project.

To illustrate the possibility of constructing a thought pattern around the notion of *lisuel*, we started with the history of the *Plan Industriel* as a specific cartographic document which dates to 1910. Its description led us to gather a series of maps produced by the same consortium. The *lisuel* layer features information that was not visible at first glance on the *Plan Industriel* but that was made readable by consulting archives. The representation of the *lisuel* is constructed as a thought pattern that reveals the process through which the sources were consulted. It acts as a visual translation of a reading of the historical sources that provide information on the urban history of Brussels. The representation of the *lisuel* layer has been explored using three methods. The first, extraction, started with a deep reading of the *Plan Industriel* as a fragmentary image envisioning the past with very detailed etched vignettes. Extraction helps visualise the production of urban space by focusing on featured situations. The second method, classification, organised these featured situations into themes linked to urban production chains, revealing the economic regime that conditioned forms of living in the city. The third method, juxtaposition, linked the first two methods to a specific spatial story that revealed the relationship between forms of manufacturing companies and the production of urban living conditions. Applying juxtaposition to Louis De Waele's spatial story showed how this general public works company (which was also a royal contractor) was involved in the configuration of a system of social relationships and contributed to the implementation of the Besme plan.

Comparing the *Plan Industriel* (as a document without a projective aim) to the Besme plan and the IGN map produced by the official cartographic establishment allowed for assessing its value as an image representing the economic regime of urban production in 1910 Brussels. The contribution of the visual analysis does not concern urban form specifically as a spatial form but as an imagery that supports a strategic discourse. The workers' housing estates, industrial district, and green boulevards projected by Besme, supported by King Leopold II, and built by local entrepreneurs are featured situations displayed on the *Plan Industriel*. It is also noticeable that the plan does not place any emphasis on *Art Nouveau* architecture, which nevertheless marked the city's image.

The World's Fair shows a specific form of interaction between entrepreneurs and urban project actors. The World's Fair Company was indeed a powerful actor in an all-inclusive urban project. Entrepreneurships influence the way in which other entrepreneurs as well as architects, craftsmen, and political figures generate patterns of collaboration and cooperation. The forms of manufacturing companies mentioned with regard to the analysis of De Waele's company show that the more a local economic player becomes globalised, the less significant is its spatial footprint on the local space. The study of the history of De Waele's company also underlined its belonging to a Belgian movement that brought together craftsmen influenced by the arts and crafts. Focusing on the arts and crafts movement led to distinguishing two patterns of circularity: an all-inclusive cluster on one hand and a cooperative network of craftsmen disseminated through the urban space on the other hand.

More than being a cartographic investigation, this work clarifies an understanding of the challenges we face today in envisioning Brussels as a productive city. It argues for a critical stance regarding the tools for visualising a palimpsest-based urban project.

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Conflict of Interests

The author declares no conflicts of interest.

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Commentary

Reconsidering Hilberseimer's Chicago

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Abstract
The German architect and urbanist Ludwig Hilberseimer spent the second half of his career as an internationally influential urbanist, author, and educator while living and working in Chicago. The city of Chicago provided both context and content to inform his theories of planning the American city. While in Chicago, Hilberseimer taught hundreds of students, authored dozens of publications, and conceived of his most significant and enduring professional projects. Yet, in spite of these three decades of work on and in Chicago, the relationship between Hilberseimer's planning proposals and the specific urban history of his adopted hometown remains obscure. This commentary reconsiders the role that Chicago played in Hilberseimer's work as well as the impact that his work had on the planning of the city.

Keywords
decentralization; economic order; regional pattern; settlement unit; urban renewal

Issue
This commentary is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

Ludwig Hilberseimer spent the second half of his career living and working in Chicago. The city provided both context and content for Hilberseimer's internationally significant urban planning theories. In the three decades following his arrival in Chicago in 1938, Hilberseimer taught hundreds of students, authored numerous publications, and developed his most significant planning projects. Despite nearly thirty years of work on and in Chicago, the relationship between Hilberseimer's planning proposals and the form of the city remains obscure. In spite of the international influence of his ideas and his decades-long campaign for Chicago's replanning, Hilberseimer ultimately had little impact on the form of the city (Danforth, 1993, p. 70). While his reputation as an educator and urbanist grew during his long career, Hilberseimer himself denied that he had made any discernable difference in the planning of the city of Chicago: "There is nothing in this city that reflects my planning" (Danforth, 1988, p. 12). While he made little contribution to the shape of the city, Hilberseimer developed his planning proposals for Chicago by reading the city's existing gridiron structure as a palimpsest, erasing it completely in his earliest projects, and adapting an incremental and incomplete erasure in later works.

Rather than a site for the realization of his ideas at scale, Hilberseimer's Chicago offered a set of geographic and demographic conditions for his rethinking of the American city in the terms of economic determinism. Hilberseimer's mature planning theories derived spatial order from principles of industrial economy. These principles stand in sharp contrast to the history of regional planning based in geological determinism, as advocated by Patrick Geddes, Benton MacKaye, and Ian McHarg. This reading of Hilberseimer's economic determinism as spatial order is evident in his post-war plans for Chicago, his numerous English-language publications on planning the contemporary city, and his proposals for the redesign of the Marquette Park and Hyde Park neighborhoods in Chicago.

Beginning with his arrival in 1938, Hilberseimer drew upon the specific conditions of his new city to support his teaching and research. Chicago's neighborhoods and

territorial extents informed his Socratic method of teaching. He developed original spatial, geographic, climatological, economic, societal, and demographic readings of the city. He also began to recruit students to embark upon self-commissioned research projects focused on the replanning of Chicago. These drawings were often the work of students enlisted to imagine the radical spatial restructuring of the entire metropolitan region, an area of several thousand square miles. Among these students was the landscape architect Alfred Caldwell. The drawings that Caldwell completed illustrate a Chicago metropolitan region in which the economic order of decentralized industry—a dispersed pattern of industrial organization—is realized at the territorial scale in relation to larger geological and ecological systems shaping the distribution of transport infrastructure.

These images (see Figure 1) postulate the reordering of Chicago's urban fabric toward small, walkable "settlement units," imagined as neighborhood enclaves insulating populations from automobile traffic in a distributed network of public parks and gardens. These drawings foreground how economic and ecological factors were transformed into the spatial determinates of Hilberseimer's radically revised urban order. The principles of this new order did not derive from a detailed study of Chicago; rather, they preceded his exile entirely. The planning principles and intellectual commitments that underpinned Hilberseimer's reimagining of Chicago were formed in the context of the first half of his life in Germany, and they remained remarkably consistent throughout his career on both sides of the Atlantic, from the 1930s in Berlin to the 1960s in Chicago.

In 1943, Hilberseimer was invited to curate an ambitious exhibition on planning for the post-war future at the Art Institute of Chicago. He was only the third architect to be granted an individual exhibition at the Art Institute, following Frank Lloyd Wright in 1930, and Ludwig Mies van der Rohe in 1938 (Colman, 2014). The resulting exhibition, "The City: Organism & Artifact," opened in October 1944 and was cosponsored by a coalition of organizations, such as the Chicago chapter of the American Institute of Architects, the Illinois Institute of Technology, and the University of Chicago's Division of Social Sciences. The exhibition was widely covered in the popular and professional press and elevated Hilberseimer's visibility and status in Chicago planning circles.

The exhibition was accompanied by an extensive lecture series shared across the Art Institute and University

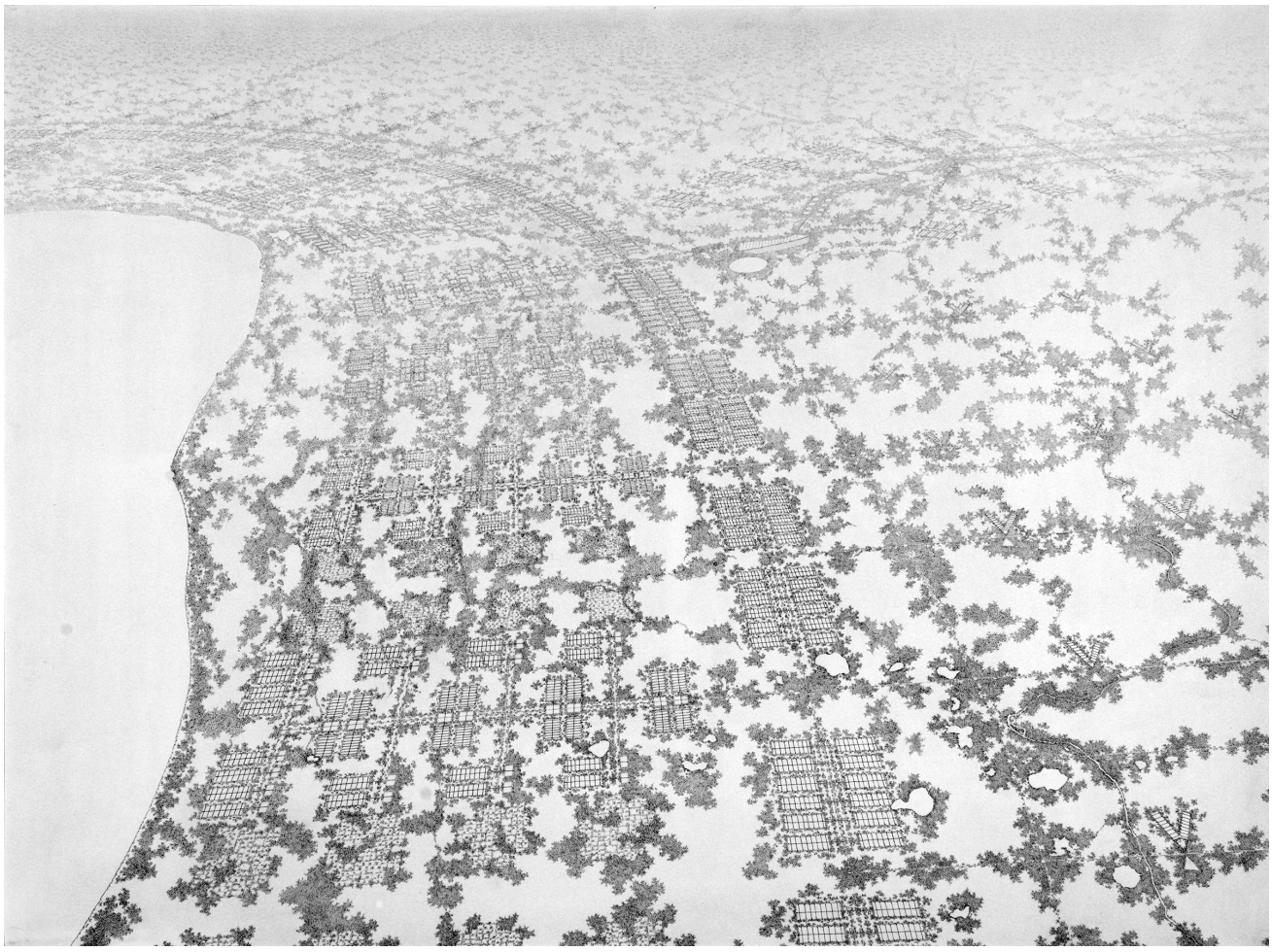


Figure 1. The city in the landscape: Ludwig Hilberseimer, planner, with Alfred Caldwell, delineator, 1942. Courtesy of the Canadian Centre for Architecture, Montreal, Gift of Alfred Caldwell.

of Chicago. The program gathered an impressive roster of speakers, including historians, sociologists, economists, political scientists, planners, and architects. Several lectures featured the work of University of Chicago sociologists Louis Wirth and Robert Park. At the peak of his influence in Chicago, Hilberseimer remained an economic determinist committed to delineating the spatial and architectural order of the city during the decades when American planning decisively turned toward the political and social sciences as embodied by the Chicago School (Carriere, 2012; Colman, 2014). In an era when policy and planning moved toward describing urban conditions through empirical observation, data, and mapping, Hilberseimer's resolute commitment to spatial order as an expression of social order rendered his large-scale visions for Chicago as abstract and apparently totalizing. The exhibition and lecture series were accompanied by the simultaneous publication of Hilberseimer's first English-language book on planning, *The New City: Principles of Planning* (Hilberseimer, 1944). Based on the positive reception of the exhibition and publication, Hilberseimer was invited to consult the newly formed South Side Planning Board as it considered the renewal of that portion of the city after the war.

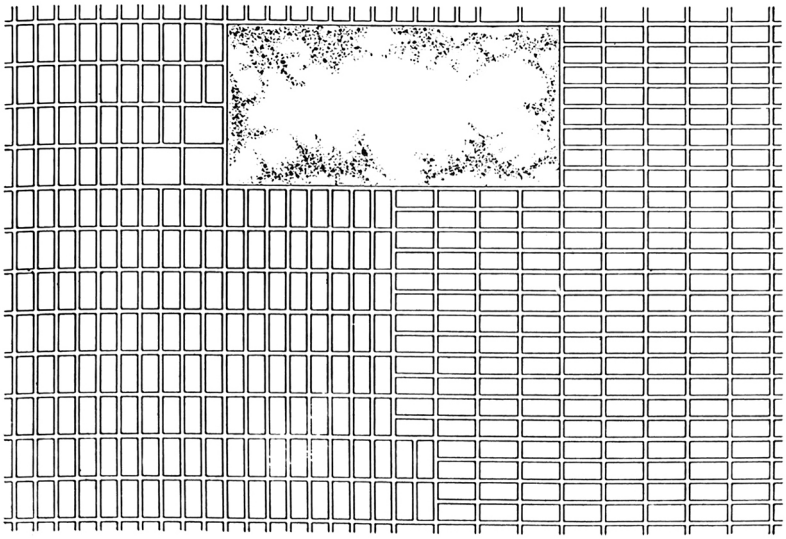
When Hilberseimer moved to Chicago, he brought with him a lifelong commitment to socialist principles of equity. He arrived as a middle-aged European intellectual with a mature vision for shaping the contemporary city. But there was little in Hilberseimer's education or experience that would have prepared him for the politics of urban renewal and race in the United States. Moreover, he was either incapable of, or unwilling to engage in the realpolitik of Chicago's planning and development culture, and resolute in his refusal to compromise the clarity of his ideas. Mies famously remarked of his longtime colleague's stubborn refusal to compromise with Chicago planners and developers: "With Hilbs you take everything or nothing. And these people don't want that." (Danforth, 1988, p. 13). The politics of urban renewal in mid-century Chicago were complex, and Hilberseimer's lack of either political will or savvy all but ensured that his ideas were often lost in the shuffle of committee discussions. Nevertheless, his involvement in the redevelopment of Chicago's South Side demonstrates Hilberseimer's limited capacity to influence decision-making in a complex planning apparatus guided by empirical data and social science (Harrington, 1988).

Hilberseimer published his second major English-language book on planning in 1949. *The New Regional Pattern* built upon *The New City: Principles of Planning* and restated his principles of planning while republishing several key diagrams and drawings. In contrast to the latter, the 1949 publication is explicitly regional and national in scope, focusing on the infrastructural networks, geological determinates, and ecological potentials of Hilberseimer's decentralized urban order. Chicago continued to play a role as context for some of this work yet, given the territorial scale of natural ecology and industrial ecology, the city proper was far less significant in the formulation of *The New Regional Pattern.* With this publication, Hilberseimer returned to his rhetorical strategy of empirical diagnosis followed by an ambitious prescription for future replanning.

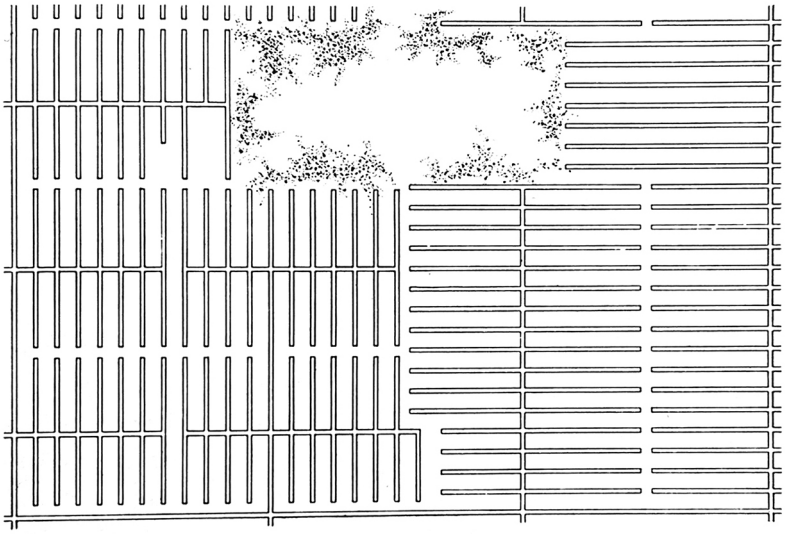
Following on *The New Regional Pattern*, Hilberseimer continued to advocate for the replanning of Chicago, and was increasingly engaged in individual projects in Chicago. These undertakings were primarily, although not exclusively, associated with sites on the South Side, developing in the wake of urban renewal (Harrington, 1988, pp. 79–80; Heald, 1949; Rich, 1949; South Side Planning Board, 1946, 1947, 1948, 1949). They are characterized by Hilberseimer's interest in deriving an incremental approach to his transformational replanning. In contrast to his city—and territorially-scaled planning diagrams of totalizing spatial order, these projects are more tactical and measured, presented in discrete stages of work, and best described as processes of editing extant portions of the nineteenth century street grid. Two examples of this kind of experimental incrementalism can be found in Hilberseimer's projects for Marquette Park (c. 1950) and his involvement in the South Side Planning Board's (1952) *Community Appraisal Study: Report on Housing and Social Survey* (see also Hilberseimer, 1949).

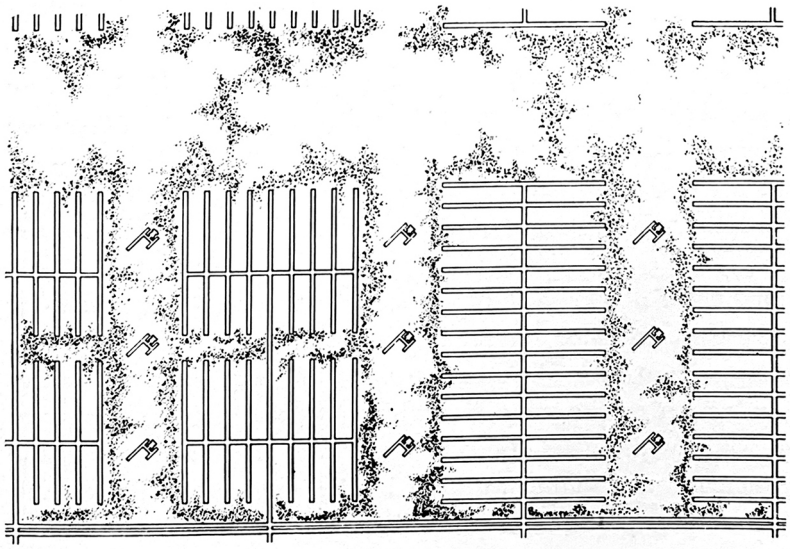
In the early 1950s, Hilberseimer began an academic exercise focused on the incremental replanning of the Marquette Park neighborhood in southwest Chicago. This study concerned the restructuring of the existing residential street grid surrounding the park. Hilberseimer's proposal describes two stages of alterations illustrated in a set of plan drawings (see Figure 2). Through this incremental approach, Hilberseimer offered a patient method of urban redevelopment, vastly distinct from the disruptive techniques being implemented elsewhere in Chicago (Hilberseimer, 1949, pp. 226–227; Spaeth, 1988, p. 62).

The *Community Appraisal Study: Report on Housing and Social Survey*, coordinated by the South Side Planning Board between 1950–1952, proposed a range of alternative approaches to redevelopment in the city. Considering an area of more than four square miles, or slightly greater than half of the Board's full planning area, the study was largely conducted by student teams under the leadership of eminent planning professors, including Martin Meyerson of the University of Chicago, Walter Gropius and Reginald Isaacs of Harvard University's Graduate School of Design, and Hilberseimer at the Illinois Institute of Technology. Although the Board's planning concerns were specific to Chicago, the South Side Planning Board's report offered a range of general techniques that could be reproduced elsewhere (Harrington, 1988, pp. 81–88). Two characteristics of the IIT team's redevelopment plan presented clear, iterative developments on the principles derived from the earlier Marquette Park proposal. First, a phased redevelopment plan, and second, the tactical restructuring of the extant street grid. Neither of these approaches was in



207. CHICAGO MARQUETTE PARK *and Two Proposals*





227

Figure 2. "Chicago Marquette Park and Two Proposals," 1955. Source: Hilberseimer (1955a, p. 227).

itself novel, but what is unique to their appearance in this study is the fact that they are deployed at the scale of the city.

The Nature of Cities, Hilberseimer's third and final major, English-language planning book, appeared in 1955. As with both *The New City: Principles of Planning* and *The New Regional Pattern*, this third publication was followed by a spate of planning projects evincing Hilberseimer's principles. Among these, Hilberseimer's collaboration with Mies and developer Herbert Greenwald on a pair of urban redevelopment projects in Detroit (1955–1956) and Chicago (1956–1959) offer a compelling pair of contrasts (Hilberseimer, 1955b). The team of Greenwald, Mies, and Hilberseimer developed the scheme for Chicago's Hyde Park neighborhood in 1956 following directly upon the success of their work in Detroit's Lafayette Park, but their design is not wholly reducible to the terms of the Detroit project. One significant difference concerned the status of the site: The Hilberseimer plan for Hyde Park was submitted as an alternative to a plan already put forth by the city's Land Clearance Commission, the government body authorized to clear urban land for redevelopment by eviction, eminent domain, and other procedures. Rather, the Hyde Park plan had more in common with the approach developed for Marquette Park several years prior (Hilberseimer, 1955a; Mertins, 2004, 2013; Spaeth, 1988, pp. 62–66).

In the last decade of his life, Hilberseimer received a flurry of awards in recognition of a long career in architecture and planning. The most significant of these, a "Citation for Planning and Teaching," was granted to him by the Chicago Plan Commission in December 1964. The award left Hilberseimer puzzled and embarrassed: If the Commission truly saw it fit to commend his ideas, why had they always resisted their implementation (Danforth, 1988, p. 12)? In spite of his nearly three decades of internationally renowned work imagining the future of Chicago, Hilberseimer left behind little trace of his efforts as evident in the shape of the city.

Acknowledgments

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Recording Permanence and Ephemerality in the North Quarter of Brussels: Drawing at the Intersection of Time, Space, and People

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Abstract
Lying in the Senne River Valley, the North Quarter of Brussels is a physical record of spatial transformations unevenly distributed over time. Waves of developments and unfinished plans colonized its original landscape structure, erasing, writing, and re-writing it with large-scale metropolitan projects and transportation systems, around which an industrial and urban fabric developed. Accumulated expansions left an assemblage of incomplete infrastructures in which a multi-faceted and highly identifiable quarter lies punctuated by weakly defined morphological mismatches. At the center of this diverse and mutilated fabric, Maximilien Park stands as pars pro toto. From a combination of research methods that includes ethnographic fieldwork and interpretative mapping, three drawings are overlaid with the moving dimensions of space, time, and people, and assembled in a reinterpreted triptych to investigate the production of that public space. The first panel "Traces" overlaps lost urban logics and remaining traces on the urban tissue. The second panel "Cycles" traces the uneven deconstruction of the North Quarter during the last century, identifying scars of its past. The third panel "Resignifications" focuses on recent events in the area, examining how people have appropriated and transformed the park since 2015. With this triptych, the article aims to re-interpret the palimpsest of the North Quarter, represent the area's transforming character, and unravel a spatial reading of the lived experiences of the place through time.

Keywords
cycle; mapping; Maximilien Park; North Quarter; palimpsest; resignification; urban ethnography; urban regeneration

Issue
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1. Intermittent Cycles of Urban Regeneration

In his analogy between land and palimpsest, Corboz (1983) stresses the multiple processes that constantly shape and reshape a territory, oscillating between natural transformations and human activities. The land is a moving project, a draft forever erased and re-written by a countless list of authors, such as inhabitants, public authorities, market changes, and time. Engaged in an intermittent dialogue, small-scale adjustments and radical shifts range from planned to unpredictable and institutionalized to insurgent. In a recent essay, Latour and Yaneva (2008) pursue this conceptualization around the movement of space, and condemn conventional architectural representations limited to three-dimensional Euclidean space. They deplore the traditions of picturing buildings as static objects and omitting the complex environment in which physical spaces keep transforming (Latour & Yaneva, 2008). Architectural drawings fail to address the mutual relationship between space and the relentless flows of change that activate it, alternating between the deterioration of time, users' active appropriations, and renovation projects. Between land and buildings, cities are evolving fabrics. Constructions and

destructions succeed each other in an imperfect circle, interrupted by gaps and cracks that generate the most striking and permanent urban oddness; they also accommodate the most hidden and ephemeral occurrences. Looking at the recent history of the North Quarter, a neighborhood of Brussels physically enclaved between regional infrastructures, and using Maximilien Park as a spatial anchor in its fabric, this study is an empirical investigation on permanence and ephemerality in the development of urban intersections. The question addressed in this article is: How do different movements of space, time, and people manifest themselves and contribute to the transformation of a central urban tissue and its public spaces?

Four years of ethnographic fieldwork between 2015 and 2019, as well as urban design projects explored during two postgraduate design studios in the fall semesters of 2017 and 2018, conducted in the MaHS-MaUSP masters programs at the University of Leuven (d'Auria, Daher, & Van Daele, 2019), constitute the background knowledge to address this question. Like an illustrated and contextualized reinterpretation of Lefebvre's spatial triad, the project assembles and confronts everyday spatial practices, as well as conventional representations of space and its multiple symbolic values (Lefebvre, 2014).

Quantitative and qualitative data are assembled and edited in an experimental triptych articulating three panels, picturing the interplay between the apparent stability of an urban environment and the less tangible occurrence of social practices rhythmed by their tireless repetition. The first panel, "Traces," overlaps layers of urban systems that have partially been replaced or have completely disappeared, like the stratification of an excavation site. The second panel, "Cycles," traces back a century of urban regeneration in the North Quarter, unfolding cyclical changes that alternate between components of decay and reclaim, further generating residues open to resignification. The third and last panel, "Resignifications," represents the everyday reappropriation of one of these residues. Across the entire triptych, Maximilien Park stands out, selected as an illustrative example of the North Quarter's recent history: It is a local public space situated along global migration trajectories since 2015, and in which an emergency refugee camp was set up; it is about to be renewed soon and is thus positioned at a moment of transformation. Exploring the methodological question of how to record the temporal conditions of permanence and ephemerality in space, the drawings interrogate and reverse the strict dichotomy that opposes them. Through a case-based process of mapping that is subjective and interpretative, this article aims to present an alternative and differentiated reading of neighborhoods under transformation, showing how perpetual everyday rhythms play an important role in the iterative cycle of urban construction, and how in turn, the spatial layout of a place determines the conditions in which everyday life unfolds.

2. An Urban Trilogy: Space, Time, and People

2.1. Planning Space in Time: The North Quarter

Like a territory on top of converging tectonic plates, the North Quarter has been continuously re-shaped by external forces of remarkable intensity. In the last decade, large-scale projects flourished all around the area, not only springing up on vacant land, but also demolishing and replacing older structures. This is exemplified today by large-scale real estate development projects, such as "Möbius" (ongoing construction by Assar Architects for Immobel) and "Quatuor" (ongoing construction by Jaspers-Eyers Architects for Befimmo), that replaced the Modernist TBR tower (1976–2017) and the Flemish government's office building Baudouin (1989–2018), respectively. Similarly, temporary occupations preparing the ground for private redevelopment have also been institutionalized in iconic buildings, like the World Trade Center and the Centre de Communication Nord in Brussels in 2018 and 2019, respectively. This activity of demolition and replacement has been initiated and mediated by the application of planning visions and instruments put forth by overlapping governmental institutions in the area. The North Quarter falls within three municipalities, Schaerbeek, Saint-Josse-ten-Noode, and the City of Brussels, all three of which additionally fall under the Brussels-Capital Region (BCR), resulting in a *mille-feuilles* of superposing urban visions for the area.

These urban planning visions and instruments produced several well-known urban projects, most notably the Manhattan Plan by Groupe Structures (1967–1972)—a joint project of the three aforementioned municipalities. Because of the notoriety of the Manhattan Plan, the neighborhood witnessed a pause in urban development for more than two decades. However, since the late 1990s, a renewed interest in the area instigated an appetite for new urban projects. Neighborhood Contracts "Quartier Nord" (1999–2003) and "Masui" (2010–2014) are two such projects initiated by the City of Brussels together with the BCR. Additionally, Urban Renewal Contract "Citroën-Vergote" (2017) by CityTools and Studio Viganò, the "Maximilien-Vergote" Masterplan (ongoing till 2020) by 1010au and Grue, and the upcoming "Vision Territoire Nord" are some notable projects launched by the BCR.

Last year, the BCR in coordination with the public housing company Le Foyer Laekenois launched "Héliport: vers un socle plus ouvert," a call to re-imagine the demolition or renovation of a controversial Modernist plinth built in 1974 by Manhattan Plan author Groupe Structures, in between six high-rise social housing buildings: Héliport (designed by architects Pepermans, Brunfaut, and Lacroix, 1970–1974). Even more recently, in an effort to redefine its public spaces, the BCR announced an open call to redevelop Maximilien Park in November 2019. The call's title, "Max sur Senne," refers not only to the park, but also to the Senne River, which

was deviated and canalized in the 19th century, then further buried and forgotten since the 1930s, yet continues to flow almost invisibly under the evolving urban fabric. This association of past and present figures to address future changes in space is inherent to the exercise of mapping.

2.2. Mapping Time in Space: The Palimpsest

The necessity to explore new formats to visualize interwoven time and space processes, as well as volatile fragments of uncertainty, has been raised at multiple occasions (Corner, 1999; Latour & Yaneva, 2008). Theoretical approaches have celebrated the map to bear this potential. Mapping, as opposed to tracing, is a creative and qualitative method to analyze and project the local complexity of urban environments. First, it is an iterative process that seeks to understand the formation and composition of a place. Second, it is a filtering exercise, the performance of a subjective and critical layering: maps are abstract objects, purposely showing and hiding elements (Corboz, 1983; Corner, 1999).

Iteration and filter are components that Corboz (1983, p. 24) found in the evolving format of a palimpsest. By overlapping imprints of different eras, a palimpsest records time and tracks changes on the fixed format of a manuscript. The analogy between territory and palimpsest brings in the physical aspect of time. This approach is very inspiring for spatial designers like architects and urbanists, whose main graphic tools include plans and perspectives with the tendency to fix space in a static aesthetic.

Mapping space as a palimpsest could say a lot about previous changes induced by the identification of *traces*, partly erased layers, and *holes*, strong erasures, left on its fabric (Corboz, 1983). In these forgotten spaces, the memory of the past seems to prevail on the present (de Solà-Morales, 1995). Paradoxically, such exclusions also contain seeds of future transformations. 'Reality is itself pregnant with fictions that architectures, alternating between the roles of analyst and midwife, can bring into the world,' wrote Marot about Koolhaas' design fascination with the Berlin Wall (Marot, 2013, p. 33). In that context, the word "fictions" evokes the multiplicity of potential futures projected by a multitude of actors on a site. In this research, these latent projects are explored through the active performance of resignifications. Identifying these traces (and holes), resignifications and their contribution to the production of urban space lies at the core of this research, which takes the North Quarter of Brussels and Maximilien Park as test sites.

Additionally, it is important to note that this study takes on a spatial approach to set a methodological framework with which to explore the overlay of spatial conditions with ethnography, and to understand the socio-spatial reproductions that shaped and continue to shape the North Quarter. The site is perceived as a mobile ground, a site that is elastic and provisional, open to continuous change and transformation, where 'diverse realities tip over, into, and out of each other' (Kahn, 2005, p. 290). This concept sets the groundwork for the way in which each piece of the triptych, elaborated on below, is thought about. The illustrations take on a dynamic process that attempts to understand the relations and forces at play, not to 'stabilize meaning, but rather to challenge the very idea of a stable site' (Kahn, 2005, p. 290).

2.3. (Un)Making Space: Time and People

Traces and holes materialize as physical mismatches in the urban fabric, as leftovers of uncoordinated additions deconstructing the North Quarter. Assimilated to *terrain(s) vague(s)*, a term first coined by de Solà-Morales in 1995 to describe residual spaces fertile with possibilities, they combine movement and fluctuation, emptiness and availability, imprecision, and uncertainty (de Solà-Morales, 1995). Becoming a canvas open to appropriations, they invite a multitude of resignifications, implicit urban projects performed by everyday users.

Spontaneous and moving urban makers, however, remain largely absent from conventional architectural drawings, like other less tangible but crucial aspects such as economy, logistics and regulations, among others. Progressively, architectural ethnography is emerging as a practice, forcing different perspectives into the urban project. Graphic experimentations have multiplied, enriching the vocabulary and toolbox of spatial designers with more formats and less rules (Daher & Bosmans, 2019; Kaijima, Stalder, & Iseki, 2018). Hybrid experiments have brought spatial drawings closer to other disciplines: analogies between art and urbanism (Ungers, 1982), ethnographic fieldwork notebooks (Atelier Bow-Wow, 2010; Trottin, Masson, & Tallon, 2017), and biological metaphors in architecture (Picon & Ponte, 2003), to name a few.

This research, conducted at the convergence of social and spatial mapping by three architects and urbanists engaged in ethnographic work, embraces that experimental context. To address urban regeneration in the North Quarter through the interplay of moving space, time, and people, the authors developed a triptych (Figure 1), an illustration composed of three vertical panels side-by-side, corresponding to the article's three sections focusing on traces, cycles, and resignifications, respectively. Each panel is designed to illustrate a different view on the same story.

3. An Urban Triptych: Traces, Cycles and Resignifications

3.1. Space and Traces

Located at the intersection of the three (even four, before the City of Brussels integrated a part of Molenbeek called Faubourg de Laeken in 1921 as part of its maritime extension) municipalities mentioned above, the

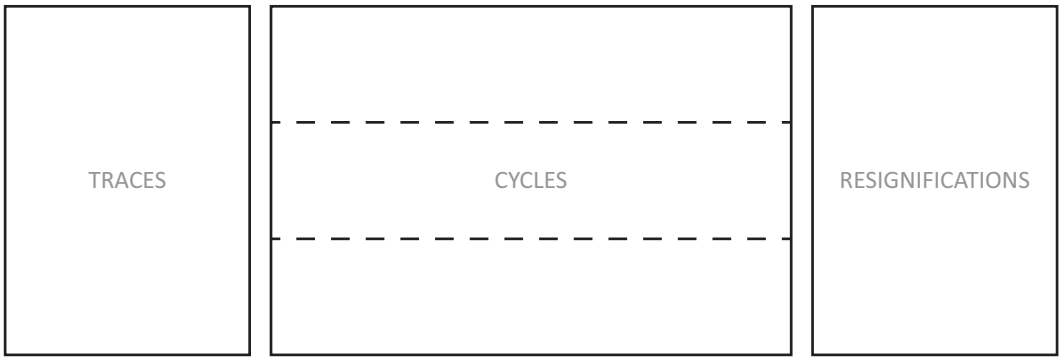

Figure 1. Schematic presentation of the North Quarter's triptych as interpreted by the authors.

North Quarter is an accumulation of socio-spatial diversities: It mixes industrial, artisanal, and office uses, it hosts the city's red-light district, and it has a history of acting as an "arrival city" for migrants hosting thriving multi-ethnic residential neighborhoods (Daher & Bosmans, 2019; Saunders, 2012). This assemblage of differences physically materializes into three distinct districts. To the north, the old and dense urban block fabric of Masui is composed of small popular houses, ateliers, and warehouses. To the south, Harmonie—former Faubourg de Laeken—displays a 1990s eclectic urban tissue, mixing low, medium, and a few high-rise collective housing buildings. In between those two, Manhattan—named after the business district model that inspired its development—includes a concentration of office towers and a few high-rise social housing blocks. It is this in-between district that this article focuses on.

The North Quarter's location is squeezed between and isolated by regional infrastructures and mobility routes, as well as at the center of Brussels—a capital continuously reshaped by (inter)national politics—and has generated a chain of uncoordinated cycles of investment and abandonment. Construction and destruction are largely ruled by an accumulation of larger-scale visions and unfinished projects, alternating between permanence and ephemerality. This includes the infamous Manhattan Plan, designed to breathe new life into what was then considered a neglected area, with a vision to turn it into an attractive office district with international allure. This Modernist masterplan to regenerate the area projected the demolition of 53 hectares of traditional urban blocks and the reconstruction of 80 office towers on plinths, but it was canceled a few years after the site's razing, and left a stretch of vacant land for several decades in the middle of Brussels. The area became a "terrain vague," an 'unincorporated margin, an interior island void of activity, oversight,' 'internal to the city, yet external to its everyday use,' a forgotten space 'where the city is no longer' (de Solà-Morales, 1995, p. 120). This traumatic episode, even though it was planned to extend, upgrade, and modernize the region, is part of a longer history of massive destructions dictated by decontextualized interventions. Since the 16th century, larger-scale systems colonized, mutilated, and left traces on the original landscape of the Senne River valley: the intricacy of medieval roads linking Brussels to its hinterland, the 1840s building block grid, the 19th century railway and tramway network and corresponding stations, the canals and harbor network, the Senne deviation and coverage between 1931 and 1955, and the 20th century urban highways, viaduct, and metro lines. The area witnessed regional logics overlap, bypass, interrupt, replace, and erase one another with little regard to local realities. Along with time-deterioration, this imperfect assemblage has severely carved the neighborhood's contours and locally produced a constellation of incoherent urban figures, physically inscribed in the fabric but disconnected from its inner logic (de Solà-Morales, 1995).

The left panel of the North Quarter's triptych illustrates the neighborhood's deconstruction through the perspective of space. Figure 2 represents the accumulation of the systems mentioned above. First, in shades of blue, the reader perceives layers of erased urban systems that once composed the urban environment. Second, in red, stand visible traces—the uncertain heritage of the addition and replacement of systems. The following paragraph elaborates on a selection of these lost urban logics and their residues.

In the northern part of the quarter, Rue Masui is a former railway line that connected the industrial harbor of the early 19th century. Rapidly bypassed after the introduction of the Allée Verte station (1835), it evolved into an industrial road which today has an increasing commercial character. Chaussée d'Anvers was first a medieval road (*chemin*), then called Route d'Anvers, that connected Brussels to Antwerp, but it lost its linking function, and hence its influence, when its role was replaced by new infrastructures, resulting in its downscaling to a local street for popular entertainment studded with small bars and eateries. Avenue de l'Héliport (1958) lies in place of the former Allée Verte railway line—the first built in Belgium—which was demolished in 1954 following the opening of the North-South Junction; the latter's long and intermittent construction (1935–1952) further erased yet another set of urban layers in the eastern part of the district. Part of the obsolete Allée Verte tracks were then converted into a wide street, keeping its remarkable original curvature and width, punctu-

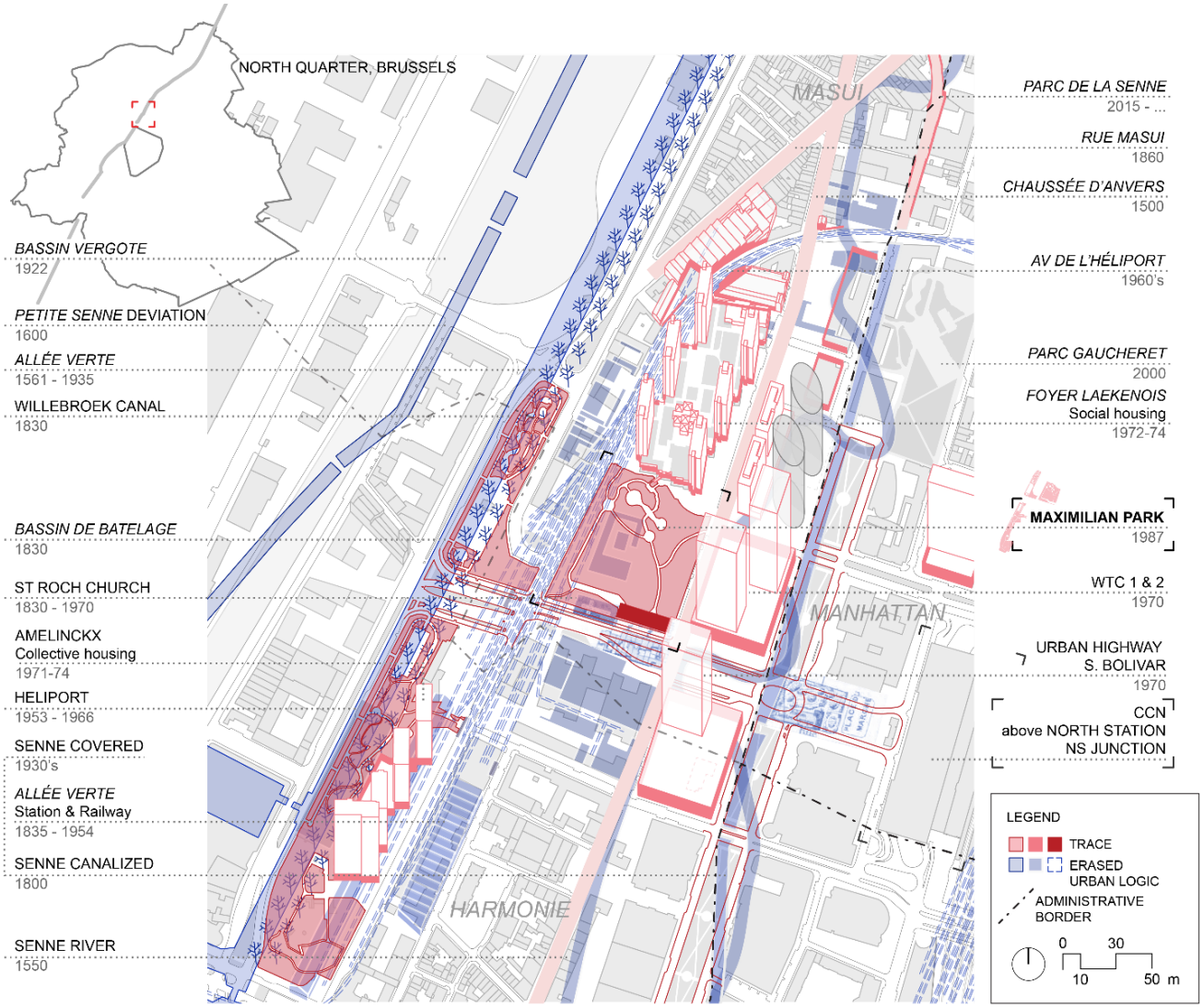

Figure 2. Meshwork of traces and erased urban systems in the North Quarter, Brussels. Credits due to the authors based on a drawing produced by C. Bosmans for the Venice Biennale 2020.

ated by a few industrial backsides and relatively loose alignment. Additionally, Simon Bolivar and Roi Albert II boulevards (1980), neither completed to their planned visions, are testaments to a passed Modernist ambition to turn the North Quarter into a national intersection of highways, crossing in front of a newly inaugurated North Station, rebuilt in 1952 just a few hundred meters away from the original one to serve the North-South Junction. These double, dead-ended, urban highways maintain the oversized width of their unrealized program. Further up north, Parc de la Senne (2015-ongoing) is a linear public space being developed in-between backsides, on the trace of the canalized river. Similarly, Gaucheret Park was implemented in 2000 on land that had remained vacant for three decades, a hole left behind the Manhattan Plan's demolitions and abandonments. Finally, a series of Modernist plinths belonging to the World Trade Center office towers, the Foyer Laekenois social housing complex, and the Amelinckx collective housing buildings pierce the built fabric. These architectural elements, once imagined as part of a network of elevated pedestrian platforms connected with footbridges hovering above urban highways, become "traces" of a vision which never came to life but enriches the area's palimpsest.

Additionally, a significant trace of a lost and unrealized project is Maximilien Park. This seamed patchwork is the result of large pieces torn down from the original fabric as part of the Manhattan Plan, but that also never saw the light of day, leaving large empty holes in the palimpsest, further becoming abandoned and forgotten sites. This undefined series of patches, loosely aligned and fronted by blind plinths and backside walls, were all given the name Maximilien Park in 1987 (Daher & d'Auria, 2018), as compensation for the troubled implementation of the plan. The longitudinal western part of the park covers centuries (16th–20th) of canal and industrial basin modifications. Moreover, the 18th century bourgeois promenade, Allée Verte, initially the result of digging Willebroek Canal as a towpath (1550), was later

widened and lined with trees connecting posh leisure activities. The railway line and station's construction shifted attraction away from the promenade and downgraded its reputation. Later, a heliport (1953–1966) was built on a buried basin (*bassin de batelage*) on the site to serve the World Exposition of 1958, eventually giving its name to the parallel Avenue de l'Héliport. The popular squared part of the park near the World Trade Center towers was developed as a temporary park while waiting for the ever-postponed, and eventually cancelled, construction of towers. On the southern portion of this site also sits the imprint of the old parvis of the Saint-Roch church (demolished in 1971), as an asphalted surface—a *mise en abyme* of a trace.

3.2. Time and Cycles

The central panel of the North Quarter's triptych illustrates the neighborhood's transformation through the perspective of time. Figure 3 pictures the cyclical interaction of traces and resignifications that have shaped the area. To comprehend the complexity of the entanglement, the drawing is elaborated as an iterative timeline on the scientific template of a graph.

The interpretative map reconstructs the urban regeneration processes that stratified the territory over the last century. This technique of highlighting "cycles" of investments, decay, and reclaim was first elaborated in São Paulo, as the legend of a map that explains the production of the city center by social movements and the performance of occupation in an abstract way (Bosmans, De Beukelaer, Monteiro, & Van Den Eynde, 2016). Derived from that experience and explored in the design studio with master's students, the North Quarter's production upscales the generic legend to a specific map. In the map shown below, a selective extraction of urban fragments from the fabric allows a detailed investigation of their contribution in the production of the city.

Illustrated in shades of purple, grey, and orange, Figure 3 distinguishes cyclical process of decay and reclaim that predates the appearance of a trace, from top to base as institutional investments, vacancy, and insurgent forces. The upper part of the diagram stages a selection of strategic projects, plans, buildings, and infrastructures extracted out of the enumeration listed in the previous section. The lower part contains swarms of people to represent the occupation of residual spaces, the myriad of resignifications that the neighborhood implicitly contains, which are entangled in migration discourse as will be illustrated later. Displaying cycles of construction, destruction, and reconstruction, the scheme questions the so-called permanence—or stillness—of physical spaces. Getting naturally deteriorated or artificially replaced, urban figures lose their coherence. Finally, illustrated in red on the drawing, stand the traces left by this erosion.

Due to the importance of Maximilien Park in the context of current realities taking place in the North Quarter in recent years, as well as its position as a case study in the doctoral trajectories of both authors, its reproduction is selectively highlighted in the illustration, underlined with a red string (Figure 3). The drawing fol-

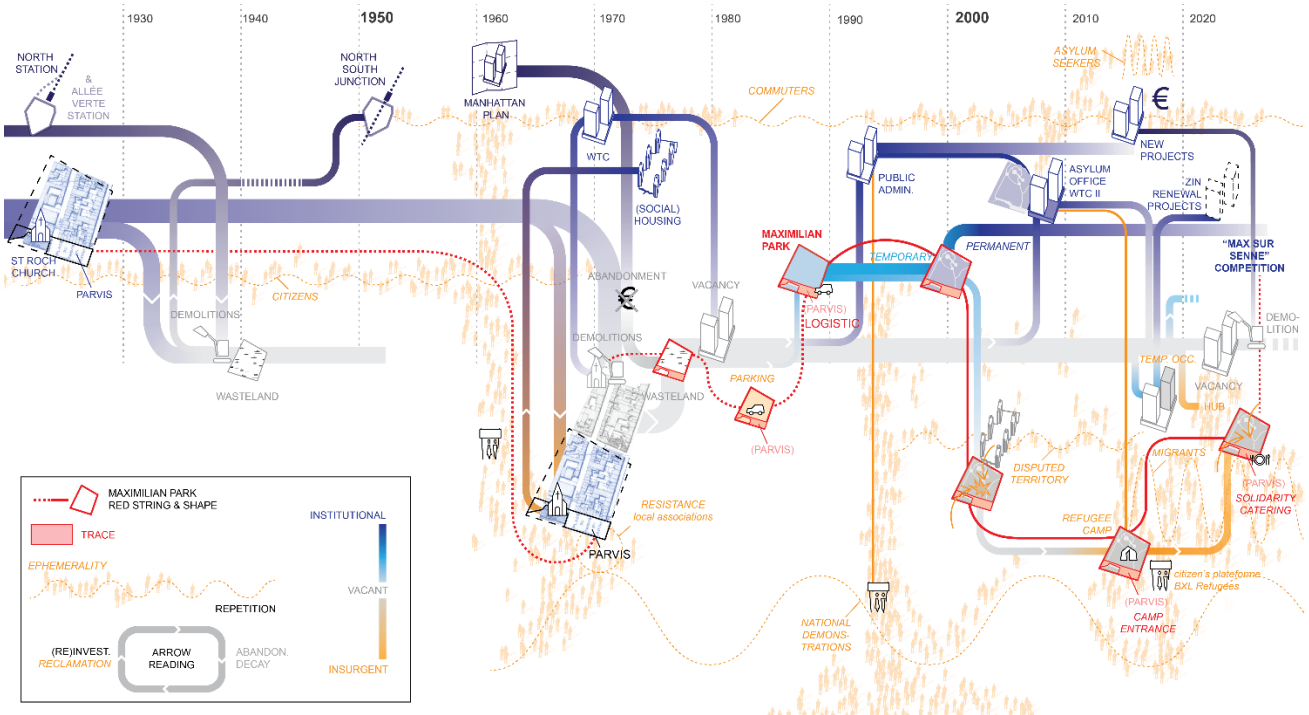

Figure 3. Cycles of decay and reclaim in the North Quarter of Brussels, highlighting Maximilien Park as a trace. Credits due to the authors based on d'Auria et al. (2019) and the Bruxelles Institut Cartographique Militaire (1894).

lows the evolution of the old parvis of the Saint-Roch church. As a central public space of 19th century fabric and everyday life, it was at the core of local resistance against the Manhattan Plan. The Saint-Roch parish and its social housing service played an active role during the first years of the masterplan's implementation, collecting keys of vacated houses before their imminent demolition and opening them up temporarily to evicted residents and newcomers (mostly immigrant workers) attracted to the area by the growing emptiness and affordability. Close to that square, several local associations and resistance groups were constituted, in response to the demolition (Martens, 2009). After the destruction of the church and the two urban blocks framing the northern part of the parvis in 1971, and following the bankruptcy of the project that delayed reconstruction, spreading its implementation out to forty years, the vacated space turned into a two-decade-long, under-utilized wasteland, used occasionally as parking. In 1987, with the slow reprise of the construction sector in the neighborhood, the City of Brussels set up a temporary park on the vacant building site (Iris Consulting, 1999, p. 11). Today, the southern corner, an asphalted piece inherited from the imperfect demolition of the church site contains the park's maintenance facility, which includes storage of gardening material; it also functions as a parking lot for logistic vehicles. In August 2015, with the increasing influx of refugees fleeing war in their home countries and the so-called "refugee crisis," the park situated across the street from the World Trade Center II Belgian Immigration Office received international attention. The park became an emergency campsite, accommodating up to 1000 migrants and supported by a myriad of volunteers, religious and non-profit organizations. The camp's main entrance was installed on the asphalted surface aforementioned, becoming a strategic meeting point for donation (Depraetere & Oosterlynck, 2017). Since the dismantlement of the camp about one month after its installation, the southern corner continued to serve both park and migrant logistic needs, including daily coordinated citizen-hosting-action between 2015 and 2019. Additionally, it continued to act as a site for food distribution until the park's closure in April 2020, as a measure to prevent gathering during the Covid-19 pandemic.

As the case of Maximilien park exemplifies, cycles of investments and abandonments are rhythmed by the permanence of traces and ephemerality of spatial appropriations. However, long-term projects typically driven by market speculation and public authorities, and prolonged silences that follow the abandonment and decay of large systems alternate, or rather overlap, with more volatile occurrences performed by users. In parallel to strategies set up by institutions, or according to market interests, de Certeau (2004) highlights the tactics of citizens' appropriations. Identifying a constructive tension that relates tactics to strategies, he claims a comparable evaluation of their impact in the production of space. These tactical uses—both conditioner of and conditioned by space—remain largely unrecorded by spatial representations. Nevertheless, some of these practices happen on a recurrent basis, as part of a daily routine like commuting, or an extraordinary yet repetitive event like a public demonstration, to cite a few. This chronic repetition highlights another paradox, inducing the permanent character of ephemeral practices.

On public spaces of the North Quarter, ephemeral uses succeed one another: every day or occasionally, ranging in scale and length, from insurgent to institutionalized, performed out of necessity or to serve profitable interests. On regular occasions, national demonstrations transform its urban highways into claiming stages, stretching out before the ground floors of office towers accommodating public government and large company headquarters. Meeting on the public square in front of the North Station, these massive gatherings pass by Boulevard Roi Albert II, flowing away through urban highways in the direction of the city center and European Quarter. In the built tissue, the World Trade Center I and II towers, emblematic figures of the Manhattan Plan, are now undergoing massive renovations (the "ZIN" project by 51n4e for Befimmo). Between September 2017 and December 2018, before current renovations began, some portions of their interior spaces were converted for temporary usage, coordinated by the real estate consortium Up4North (AG Real Estate, Allianz, AXA, Banimmo, Befimmo, Belfius Insurance, Immobel and Triuva) in partnership with several design offices (51n4e, Architecture Workroom and Vraiment Vraiment), under the label LabNorth. These temporary uses included renting out office spaces to creative profiles, university-led educational design studios which the authors were part of, and the Rotterdam Architecture Biennale 2018 exhibition "The Future Is Here."

In the shadow of these larger-scale extraordinary events, everyday flows at street-level manipulate the urban space. Masui, a local market selling everything from food to clothes and household devices, opens every Wednesday on the northern section of Chaussée d'Anvers, blocking off vehicular traffic for several hours. Five days a week, commuter flows cross and fill the urban highways that divide the neighborhood into three districts: Harmonie, Masui, and Manhattan (locally called "les Blocs"). Walking through the physical and psychological borders created by Simon Bolivar and Roi Albert II boulevards, the masses move along the edges of inhabited territories, carving the separating lines as they open and close shop frontages and terraces serving business lunches.

3.3. People and Resignifications

The right panel of the North Quarter's triptych, Figure 4, illustrates the neighborhood's through the perspective of individuals occupying Maximilien Park and utilizing its infrastructure. It pictures the everyday life that unfolds, recording fluctuations and patterns of local uses

by documenting the behaviors of its current users—undocumented migrants, volunteers, and inhabitants, among others. The focus shifts from the spatial arrangement of traces and the transformation of the city through cycles in time, to tactical resignifications that react to and adjust its loose physical reality. The drawing illustrates the re-appropriation and use of spatial features in the park, materializing conflicts and negotiated meanings. By this re-appropriation, the park is constantly in motion, transforming with and by its users manifesting their struggles in urban public space.

Spending extended periods of time in Maximilien Park on many occasions, throughout different times of day and weather conditions, allowed the collection of

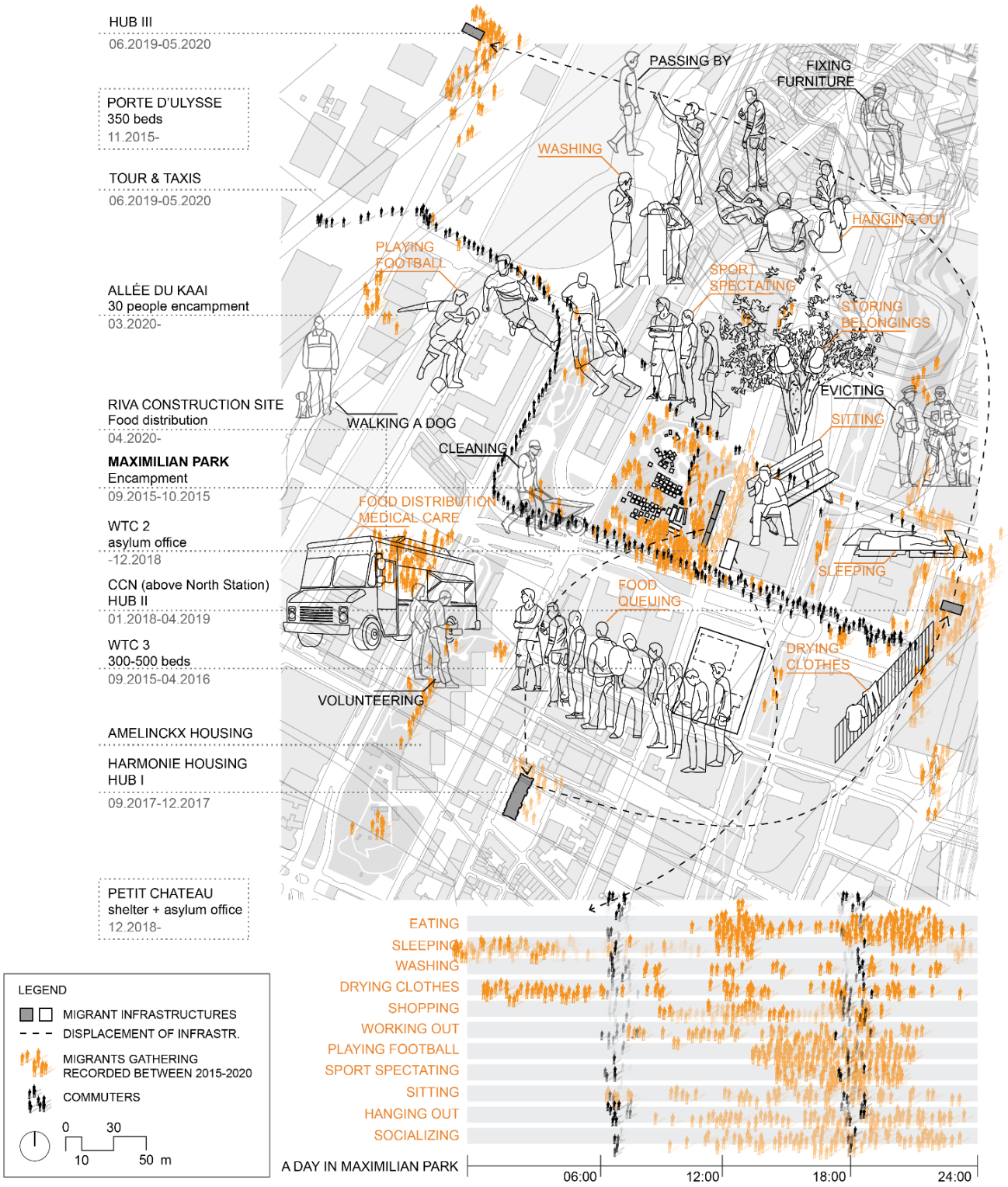

Figure 4. Maximilien Park: Occupation and resignifications. Credits due to the authors based on Daher & Bosmans (2019).

data through observation, writing, sketching, drawing, and interacting with users through formal and informal conversations. Their embodied presence is synthesized in Figure 4, overlaid onto a plan of the park within its urban context.

The illustration first shows how the park's public space and its infrastructure are re-signified for the uses of undocumented migrants currently inhabiting it. For example, a water fountain serves as shower and laundry service for washing, and a fence is used as a drying rack for clothes; vast grassy spaces under trees become open-to-sky bedrooms, with flattened cardboard boxes serving as mattresses to sleep on. Some days, tree branches are curiously charged with backpacks, used as storage for personal belongings. Other more common park activities such as sitting on benches, playing sports, and group-socializing occur in the park too. However, the presence of undocumented migrants for entire days converts its use from a place of recreation to one of collective domesticity (Daher, 2019), and not without conflict. From the many conversations had during ethnographic work, neighbors recurrently expressed empathy about undocumented migrants being forced to use the park for their most basic needs, as well as feeling unsafe by their presence. In contrast, the migrants expressed that their collective presence offers a sense of safety, despite frequent police-raids occurring unexpectedly or according to a locally well-known weekly schedule: every Wednesday morning before seven-thirty.

In addition to the re-appropriations by undocumented migrants, other users' activities are also illustrated, including facility workers cleaning the park or fixing an object, inhabitants passing by or walking their dogs, as well as citizen-volunteering efforts, contrasted by police evictions. The bottom of the figure displays a time-sharing interpretation of uses that seemingly dominate Maximilien Park's daily rhythm, composed mainly of the mundane activities of domestic life: eating, sleeping, shopping, and group-socializing activities that make life in the park livable (Daher & Bosmans, 2019). More about the park and activity of undocumented migrants have been described in previous writings (ARCH, 2019; Daher, 2019; Daher & Bosmans, 2019; Daher & d'Auria, 2018).

A second layer of information is revealed in Figure 4: the changing locations where clusters of undocumented migrants congregate (represented as orange silhouetted human figures). The illustration shows masses that once existed (faded orange silhouettes) at important moments in time, since 2015. Similarly, commuter pathways through public spaces of the North Quarter are represented as black silhouetted figures. This group turns the park into passage—a shortcut on their way from home to work across the canal. In parallel, undocumented migrants on their long journey towards asylum occupy the park; for them, the park is also a place of passage—a pit-stop in their larger journey toward the UK. Their numbers, changing demographics, and activities have reshaped the park since 2015, fluctuating with different political events related to asylum in the past few years, marked by that moment when the emergency camp turned the park into a contested space for the playing out of citizenship and acts of citizenship (Depraetere & Oosterlynck, 2017).

Along with moving masses, Figure 4 further shows the three relocations of the Humanitarian Hub (operated by the Citizen's Platform for Refugee Support) which provides access to professional and domestic services to undocumented migrants. Its displacement had an effect on their movements, changing their spatial pattern in the area, while maintaining the Hub's state of precarity in its temporary occupations. In September 2017, it first opened in the Harmonie district near Amelinckx collective housing complex; it then relocated to an empty space on the first floor of the Centre de Communication Nord building in the North Station, from January 2018 to May 2019, before finally moving to another empty office building near the Tour et Taxis site, where it currently operates from. Similarly, night shelters opened and closed in empty local spaces: the World Trade Center III between 2015 and 2016, and the underground entry level of the North Station's bus platforms, between February and May 2019 (Daher, 2019). In 2018, the Immigration Office was relocated to "Le Petit Chateau," a nearby shelter for asylum seekers. Even though the queue in front of the former location which once filled up the sidewalk at World Trade Center II on Chaussée d'Anvers disappeared, Maximilien Park remains a strategic meeting place for the gathering of undocumented migrants. Ultimately, the park behaves as pars pro toto of the North Quarter, inseparable from its palimpsest. It has become an intersection of crossing agendas, inhabited districts, infrastructures, and public spaces, as well as multiple scales—global, national, and local—and is continuously reshaped by them.

Like the cycles of physical transformation illustrated on the central panel, periodic manifestations recorded in the park also leave other traces on the neighborhood. From waste material scattered across public space, to deteriorated vegetation after a large gathering, to the personal belongings left behind, these "traces" betray their users' absence when they are not in the park. Such manifestations sometimes cause volatile situations with building residents nearby. Spatial practices leave marks and continuously participate in the production of the urban environment. The collective presence of users and materialization of their activities imprints an image of misappropriation in the memory of local inhabitants, transforming the meaning of a place, as has been experienced in the North Quarter. As such, they further create conditions for contestation and conflict. As a counter-reaction, fences and control devices, as well as the suppression of benches, have occurred to alter the lived experience (Dresler, 2019).

The illustration of users and their repetitive daily activities in the park, the relocation of services addressed to undocumented migrants, and the movement

of masses are all attempts to expand on architectural ethnography in urban representations, providing insight on the social production of space in the city. It is also a proposition to illustrate the non-fixity of public spaces' meanings and their transformative and changing nature. Additionally, humanizing the architectural and urban drawing with its user-groups and appropriated spaces describes spatial settings as provisional and constantly negotiated. However, both architectural ethnography and sensitivity towards undocumented migrants' political status highlight the ethical question of their representation. By portraying their embodied presence, the drawings expose only what can already be seen, but is usually ignored by urban projects. As users involved in the space of city, this group has as much right as any other to be represented by and of the city.

Importantly, this type of mapping goes beyond the dominant conception of public spaces, alluding to the notion of 'right to the city' as the right to an urban life—a value system that consists of the interests of the entire society and those who inhabit the city without distinction (Lefebvre, 1968, p. 35). As such, solidarity movements like the Citizen's Platform for Refugee Support are important to include in urban discourse, because they operate out of moral and humanist values that may conflict with legal structures in place. They highlight activist and citizen positions about the kind of city they want to live in, manifesting the right to the city as Harvey (2003, p. 939) described it: the right to 'change ourselves by changing the city…a collective right rather than an individual right….The freedom to make and remake ourselves' by remaking the city. Celebrating this right through mapping, this work is also an attempt to bring and force this claim up to planning levels.

Insurgent appropriations find fertile terrain in residual spaces; gaps and cracks in the urban fabric open up opportunities to creatively inhabit the city in alternative ways, reacting to or taking advantage of looseness and disorder. De Solà-Morales (1995, pp. 119–120) describes these gaps as places of possibility and freedom, liberated from constraint, places of 'movement, oscillation, instability, and fluctuation' and places of contrast between 'void and promise.' Like a void, a "hole" in the fabric, the trace of destruction and aborted vision, Maximilien Park as represented in Figure 4 is exemplary of that claim. Public and green by default, this space lying in-between urban highways and blind walls was not framed by any residential façade until recently. Its situation on the edge of the residential neighborhoods Harmonie, "les Blocs," and Masui, amplifies its bordering and interstitial character. On that unbuilt terrain, successive additions, transformations, and demolitions, as well as abandonments, temporariness, and over-design, accumulate to co-produce a space that challenges the conventional park. For undocumented migrants, the park has become a place of promise of a future only possible through migration (Meeus, van Heur, & Arnaut, 2019). Their embodied presence in this urban site makes them 'social actors who are integral to city-making as they engage in the daily life' of the city (Çağlar & Glick Schiller, 2018, p. 5). Using the framework of the triptych, we perform a 'multiscalar analysis' in which we include migrants and their everyday, city-making processes within the 'historic conjuncture' (Çağlar & Glick Schiller, 2018, pp. 13, 16) of the multiple actors, users, and forms of power that have affected the North Quarter over time, composing its palimpsest.

From a spatial perspective, conflicting and negotiated practices have produced, adjusted, and maintained the interstitial condition of the space for a few decades. Yet, the lack of power over the activity in the park instigates a sense of anxiety, among politicians and residents, of the area becoming a physical expression of 'fear and insecurity' (de Solà-Morales, 1995, p. 121). However, even before being appropriated by undocumented migrants, the park was already identified as disputed territory between different youth groups in the first Neighborhood Contract "Quartier Nord" (Iris Consulting, 1999, p. 16).

4. Conclusion

This article elaborates on interpretative and subjective forms of mapping and takes the North Quarter, a central and highly diverse area under regeneration, and Maximilien Park as pars pro toto, as a case-study to theoretically contribute to the notion of the "palimpsest" in urban design. The empirical exercise mobilizes drawing as a critical and analytical, as well as an illustrative and projective, tool. The palimpsest in this article is built up as a triptych, conceptually divided into three panels picturing three perspectives: space as traces, time in cycles, and people in resignifications.

In "Traces," the panel identifies a constellation of spatial mismatches and *terrains vagues* in the area that articulate the imperfect urban collage through an apparent emptiness. Their presence simultaneously informs the existence of lost meanings that once activated the place in previous times, and recall the diversity the place has been constructed on and accumulated.

In "Cycles," the panel traces back the formation of traces to unravel and understand the different logics that animated and produced the urban fabric. The drawing presents the important tension between institutional and insurgent forces underpinning this construction, rhythmed by half-realized, long-term visions, as well as lifelong projections being performed on a daily basis.

In "Resignifications," traces appear not only to be passive remnants, but also to carry opportunistic potentials. Traces possibly stage and prefigure spatial interventions and practices that are continuously adjusting the urban tissue with their own means and perspectives, and according to their own interests. Traces represent resilience because they transcend the circumstances that created their existence, or rather attempted to eliminate them, as articulations in time. They are the result of fictitious visions, for better or worse. They

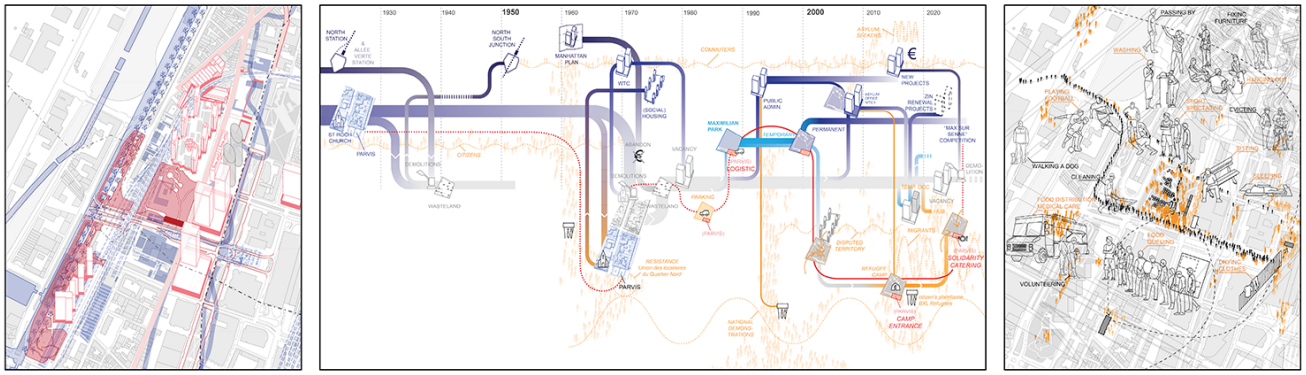

Figure 5. The North Quarter's palimpsest as a multi-scalar triptych.

are spaces where futures are imagined, projected, and tested. These spaces become spatial resignifications being performed and therefore implicitly brought to reality by a long list of local stakeholders and everyday life. Tirelessly reiterated and continuously adjusted, resignifications transform local meanings and lived realities, in turn leaving marks in the local fabric and in local memory. Resignifications of traces can also be collaborative productions between different levels of power, including real estate developers and institutions, as the explosion of temporary occupation attests. However, in the shadow of the radical transformations that architecture and urbanism tend to project on vacant land, traces are implicit and almost self-reproducing. Seemingly, resignifications are not only waiting for architects to realize them. Unravelling the palimpsest is a patient encounter and unravelling of fluctuations, ephemeral forces and rhythms that formulate the continuity on which an urban environment regenerates itself.

As the example of Maximilien Park shows, undocumented migrants found, out of necessity, openness, and flexibility to survive in an interstitial space bordering several neighborhoods in the area. Their collective presence sheds light on forgotten spaces—traces—located in the urban fabric of the North Quarter. By their massive appropriations—which are not without conflict—they have transposed a new set of meanings on the "terrain vague," requalifying its role in the disrupted urban ecosystem. These resignification processes are fluid and mobile, triggering new dynamics that challenge vacancy and looseness, to open up new spaces for upcoming needs. Resignification calls for more resignification: The slow but incremental construction and consolidation of hospitable, yet temporary, infrastructure since 2015 is encouraging. However, as the example of undocumented migrants and the perpetual relocations show, resignifications tend to stay in loose spaces and in precarity. The internal movement and temporariness that characterize their situation is quite explicit, not only in their presence and appropriations in the park, but also in the support structure they receive, such as the Humanitarian Hub which relocated three times in four years. Similarly, "Max sur Senne," the latest public call by the City of Brussels to renew Maximilien Park, never mentions its current occupants.

Finally, the representation of the North Quarter's palimpsest in the framework of the triptych (Figure 5), allows the creation of a layered, multi-scalar, and analytical reading loaded with meanings. It is also a way to illustrate the non-fixity and fluidity of an area, as a space subject to constant change, further opening up room for future flux. It offers the potential to document the permanence and ephemerality of an area, the multiple forces at play, as well as user appropriations of space.

After having mapped the palimpsest as a mobile ground, a new question emerges: If traces are locally reproduced into resignifications, what is the role of the spatial designer? In an era of rapid changes, intensified flows, and increased speeds, a next challenge would be to integrate these local fluctuations in the urban project: to focus on designing a process that is always negotiated, rather than designing a fixed project. As Latour and Yaneva (2008) call for in their essay, the spatial designer must embrace this moving complexity as a working framework. The palimpsest as a triptych bears that potential.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Mapping Urbanization as an Anthropedogenetic Process: A Section through the Times of Urban Soils

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Abstract
Current trends of spatial planning policies give a strategic role to soils, the multifunctionality of which must be considered as a crucial driver facing cities' forthcoming social-ecological transition. However, soils within urban areas are insufficiently studied as a long-term record of environmental history and heavy anthropization. This article investigates the extreme qualitative variability of urban soils by presenting a conceptual model and cartographic workflow highlighting soil evolution processes as a value which co-variates with urbanization. Based on a case study in West Lausanne (Switzerland), the layers and map series of an atlas underscore the applicability of different types of information and spatial analysis for documenting the influence of anthrosediments and land cover changes. Combined with empirical profile descriptions, such a consolidated concept map defines a template, in the form of a complex spatio-temporal figure, on which to apply the state factor approach. Instead of using a simple spatial transect or gradient, the increasing anthropic dominance over original landscape conditions is explained using a section through time. An urban anthroposequence consequently retraces contrasting soil development pathways as a coherent bundle of historical trajectories. Such a narrative integrates various facets of land use, including one-off construction techniques and recurring maintenance practices, planning tools, and morphologies, into a specific 'project for the ground' which brought forth the mixed mesh of the Swiss Plateau 'city-territory.' Ultimately, the dynamic vision conveyed by these intertwined soil–urbanization coevolution trajectories outlines opportunities for the regeneration of the resource deposit made up of both West Lausanne's urban fabric and its soils as a palimpsest.

Keywords
conceptual model of anthropedogenesis; anthrosediments; anthroposequence; ecosystem history; land cover change; soil mapping; spatial planning; urban soils; urban history

Issue
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> Soil landscapes and their spatial variation are exciting and complex. But to understand soils fully, they must be studied in space *and* time. Indeed, we embrace Daniels and Hammer's (1992) statement that soils are four-dimensional systems, not simply the one-dimensional profile. (Schaetzl & Thompson, 2015)

1. Introduction: Documenting and Projecting Urban Soils as a Long-Term Record of Environmental History and Heavy Anthropization

Motivated by ever-increasing soil degradation due to past and present urban growth dynamics (Gardi, 2017), the current trend of spatial planning policies at the Swiss

and European levels is to promote increased soil protection (European Commission, 2016; Swiss Spatial Planning Act, 2019). These policies aim to avoid new developments on agricultural and natural land, and to reorient urban growth towards existing urban areas which must be restructured and densified. Such an objective, formulated as "inward urbanization" (Häberli, Lüscher, Praplan Chastonay, & Wyss, 1991), shifts the emphasis onto soils situated within urban areas, which are cast as priority development opportunities. The strategic role that is currently given to urban soil management as a key determinant of spatial planning decisions evokes an essay published by Bernardo Secchi in the late 1980s: *Progetto di Suolo*, the "project for the ground" (Secchi, 1986). In this seminal writing, the urbanist criticizes that, during the 20th century, urban soils were insufficiently conceptualized, represented and projected through the graphic productions and designs of the discipline. He affirms that soil's spatial and functional dimensions are essential to the understanding of contemporary cities and suggests that they should be considered as a new paradigm for the urban project.

In this context, urban soils, which include remnants of natural soils as well as a large proportion of 'Anthrosols' and 'Technosols,' as described in the World Reference Base for soil resources (IUSS Working Group WRB, 2006), can no longer be reduced to an idealized or neutralized surface. On the contrary, as products and agents of environmental and human history, urban soils must be documented in light of the processes which they support and are supported by, both in a retrospective and prospective way. In the first place, they represent a highly complex three-dimensional material that developed as a long-lasting legacy of heavy anthropization (Barles, Breysse, Guillerme, & Leyval, 1999). The predominance of anthropized substrate generates relatively 'young' transitioning soils, on which pedogenetic processes may, in some cases, resume actively and rapidly over the course of a few decades. Consideration for urban soils must therefore account for their future developmental stages (Burghardt, 2001; Leguédois et al., 2016). In addition to these significant historical characteristics, geographer Claude Raffestin refers to open soils embedded within urban structures as "an anti-hazard system mechanism" or "a time pocket" (Raffestin, 1989, p. 186). These phrases underline the various functions of urban soils and the role they will have to play in the future of cities, as protections against increasing environmental risk and as a potential resource for forthcoming social and ecological transitions. Besides food and biomass production, soils have the capacity to deliver localized ecosystem services (Dominati, Patterson, & Mackay, 2010) that are essential for maintaining the habitability of cities (Economic and Social Council, 2019), by absorbing storm water, mitigating local effects of climate change, containing contaminants, capturing and storing carbon, and supporting biodiversity, among other functions (Morel, Chenu, & Lorenz, 2014). A time dynamic approach to urban soils should therefore inform the various ongoing interdisciplinary initiatives that integrate soil's multi-functionality as a driver for spatial planning (City of Stuttgart, 2012; Grêt-Regamey, Kool, & Kissling, 2018; Robert, 2012). In the purpose of implementing such an evolutionary and multifunctional 'project for the ground,' two main knowledge gaps must be addressed.

On the one hand, accurate methodology is needed so that researchers, stakeholders and designers can properly survey urban soil's quantitative and qualitative diversity, based on rapidly evolving general knowledge about human impacted soils and their specific features (Craul, 1992; Howard, 2017; Lal & Stewart, 2017; Levin et al., 2017). The anthropic influence on soils in the urban environment is conditioned by architectural and infrastructural interventions stratified over many historical periods. This anthropic space and time scale generates extreme spatial and chronological variability, which cannot be entirely explained by the landscape-soils models traditionally used in soil science and originally developed to study natural ecosystems (Burghardt, 1994). In the last three decades, mostly for North American and Central European cities, soil scientists have therefore produced so-called 'concept maps' in order to facilitate the very difficult task of empirically surveying urban soils (Burghardt, Morel, & Zhang, 2015). This kind of map serves to overcome several technical and organizational difficulties in urban soil mapping, to determine deductively the boundary of individual soil units and potential associated properties, and provide a digital platform for further operational uses (Schneider, 2000). However, the conceptual frame of urban soil concept maps remains rudimentary, due to the lack of a supervised model that would extensively articulate the various kinds of urbanization-related influences on soils relative to natural pedogenetic processes (Leguédois et al., 2016). Such maps are usually limited to roughly superimposed past land use and contemporary evidence of landforms' evolution (Howard, 2017; Lal & Stewart, 2017; Levin et al., 2017).

On the other hand, it is necessary to clarify the planning and design rules by which a 'project for the ground' could today reactivate the qualities and functions of the urban soils that we have inherited, according to a coherent and sustainable vision articulated at different scales. Among other natural resource management processes, the successive processes of soil transformation through deforestation, cultivation, mining, infrastructure development and urban settlement have ensured the habitability of the territory over time (Secchi, Viganò, & Fabian, 2016). These land reclamation efforts successively correspond to coherent cultural, social and technical projects throughout history (Mantziaras & Viganò, 2016). The evolution of these "geocultural settings" (Howard, 2017, p. 11) have generated complex territorial and spatial patterns which partially overlap as a "palimpsest" (Corboz, 1983). Facing the heterogeneity of contemporary urban territory, ongoing zoning policies, which are formulated in terms of stock, surface

and perimeter, struggle to overcome a solely conservative approach based on an oversimplified and divisive urban/rural dichotomy (Viganò, Barcelloni Corte, & Vialle, in press). The lack of a conceptual model that fully integrates the agency of spatial development and urbanism with regards to soil development, the likes of which has been developed for other ecosystem services (Jaligot, Chenal, Bosch, & Hasler, 2019), reduces urban soils to static objects. On the contrary, Ian McHarg defines, in his seminal book *Design with Nature* (McHarg, 1969, p. 103), the notion of "process as value" as a fundamental paradigm of the ecological planning discipline. Such a statement, which equates the evolutionary processes of landscapes and functional qualities of territories with social, if not economical, values, has not yet been transitioned to soil formation in anthropogenic ecosystems. The implementation of more innovative strategies playing on both the evolution of urban forms and soil functionalities over time (Berger, 2006; Corner, 2006; Kennen & Kirkwood, 2015; Orff, 2016; Spirn, 1984) is consequently hampered.

In order to fill these epistemological and methodological gaps, this article will highlight the human history of urban soils by (I) synthetizing a causal chain model of urbanization, and its related project, as a crucial factor of pedogenetic processes and by, (II) retracing urban soils' specific historical trajectories according to a cartographic narrative constructed from various source documents. This dynamic vision will be explored through the creation of an atlas based on the case study of West Lausanne district in the canton of Vaud, Switzerland. Our approach aims at extending the concept map used by soil scientists to the framework of advanced urbanism, by bridging spatial planning with the fields of historical ecologies (Amossé et al., 2014; Beller et al., 2017; Sanderson, 2009) and layered spatial analysis (McHarg, 1969), based on innovative remote sensing and four-dimensional data management techniques. Such consolidated concept mapping underscores the usefulness and applicability of different types of information and analytic operations for documenting various human-induced soil evolution processes. It also reveals the extreme spatial variability and chronological versatility found in soils by linking them to both the distribution of urban patterns and the evolution of urbanization techniques. The gradually decreasing influence of site condition and increasing anthropic dominance on soils' evolution are therefore explained more systematically. In turn, retracing urban soils' development pathways reveals the logics that have informed the evolution of a 'project for the ground' and also contributes to the definition of soil quality as a dynamic and co-variable value of urban morphologies and uses. Spatial planning and urbanization can therefore be considered not only as a threat to soil capital, but also as a means through which it is possible to act intentionally in order to valorize this resource. Ultimately, establishing a causal link between the current physical state of a soil and the transformations it has undergone through urbanization helps to predict and potentially guide the future influence of spatial planning policies and land management practices on soils' functionality.

In sum, this article will exemplify that drawing spatial sections through the vertical depth of soils as a human-influenced living material, and transects through the horizontal variations of soils as a support for human habitat, enables the construction of a retrospective and prospective time sequence spanning the history of both their graphic documentation and physical transformation as a more or less intentional design-project.

2. A Theoretical Framework and Methodology for the Study of Anthropedogenesis as a Coevolution Process

The 9×4.5 km extent of the atlas covers a large portion of the eight municipalities forming the 25.81 km^2 West Lausanne district, encompassing the hills of the Swiss Plateau in the north to Lake Geneva in the south. This longitudinal transect crosses several heterogeneous ecological milieus, each associated with various geological features shaped by the Rhone Glacier, such as molassic outcrops, morainic, glacio-lacustrine and fluvio-glacial superficial deposits. The East/West boundaries of the atlas correspond to a transversal gradient from the edge of Lausanne historical center towards the periphery of its metropolitan area. The soils in this area have been affected by gradual dismantling of a landscape previously dominated by agriculture, starting with industrialization in the 19th century and including tertiarization, periodic high-rate population growth, as well as implementation of large-scale transport and sanitation infrastructure. Today, this mixed-used district has 57,000 jobs and 75,500 residents, with a residential density of 2,925 inhabitants per square kilometer. This territory still retains a large amount of cultivated and/or undeveloped land, the future of which is the subject of a planning policy currently in development.

How can the general influence of such an anthropized ecosystem on its soils be understood? Soil scientists Dan Yaalon and Daniel de Richter evoke the concept of soil as a "human–natural body" (p. 767) in terms of a "mutual co-genesis, with soil and humanity developing jointly and interactively" (Yaalon & de Richter, 2011, p. 775). The anthropic transformation of soils, coined as 'anthropedogenesis,' not only stratifies soils' parent material, but also permanently reprocessed it into what is, here again, referred to as a 'palimpsest' by many soil scientists (Vialle & Verrecchia, 2018). Yaalon and de Richter define consequently soil changes according to three coexisting and superimposing "overlapping time scales":

> The multi-millennial natural soil system…; the historic soil system, affected by both natural processes and legacies of human impact usually lasting up to several thousands of years…; and the contemporary human-affected system, affected by natural and historic processes and ongoing management typically for less

than 100 years. (Yaalon & de Richter, 2011, p. 768; see Figure 1)

Our case study will focus on the emergence of the contemporary anthropized soils system, corresponding to West Lausanne urbanization over the last century. It is therefore necessary to transition the conceptual model of natural pedogenesis in order to integrate the logics of urbanization to this framework. Pedology comprehends soil transformation according to Jenny's model (Jenny, 1941) defining five external state factors of pedogenesis—climate, biology, topography, lithology or parent material (PM), and time—the influence of which can be studied in the form of a sequence. The combinations of these factors trigger different pedogenetic processes, leading to various soil evolution or development pathways (DP) including specific biogeochemical characteristics and associated functional properties, which can be interpreted as ecosystem services.

Following Yaalon and Yaron (1966), numerous authors (i.a. Burghardt, 1994, 2001; Burghardt et al., 2015; Effland & Pouyat, 1997; Huot et al., 2017; Leguédois et al., 2016) discussed the human influence on soils in relation to Jenny's external state factor model and revealed that the impact on PM through anthroturbation is of primary importance. This influence at the Earth's surface is indeed straddling between *constructional* and *destructional* landforms (Riddle & Levin, 2017). In the first case, superficial anthropic deposits, or anthrosediments, are moved horizontally, while in the second case, human-altered soils are modified only vertically in place. This distinction between the geological and pedological levels in the delineation of the anthropogenic footprint determines whether human influence is to be consid-

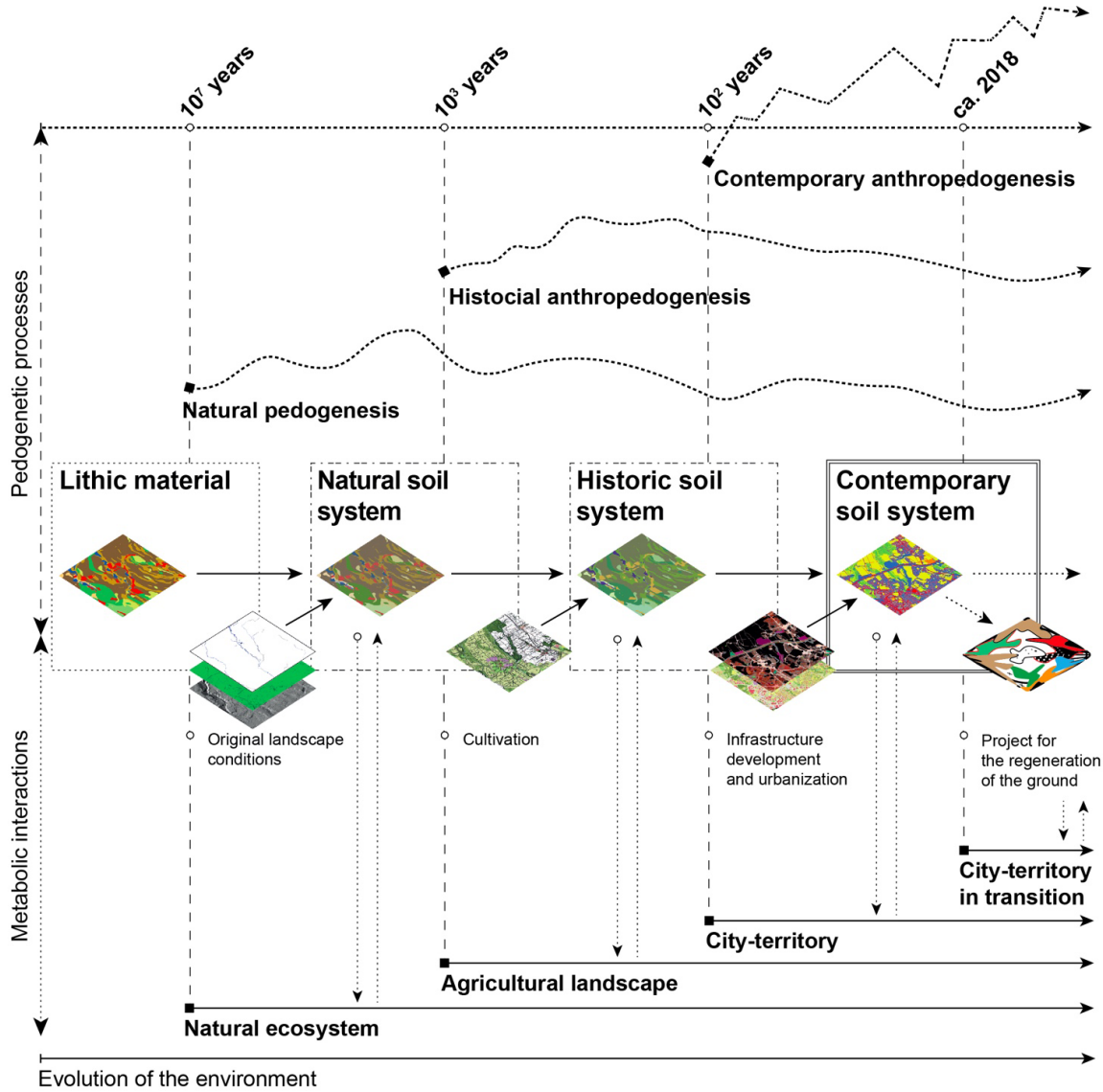

Figure 1. Diagram of human–nature pedogenesis: from top to bottom, coexisting and superimposing time scales, processes of polygenesis, soil systems and corresponding factors, interactions with natural–anthropic environments. Source: Authors, after Yaalon and de Richter (2011).

ered as an independent and additional lithogenetic state factor, or as an interdependent biological state factor. In the first case, *neopedogenesis* is defined as a short-term anthropic intervention, such as cut and fill, that "resets the pedological clock" (e.g., Schaetzl & Thompson, 2015, p. 299) by external disruption of the preexisting soil profile which becomes new PM. Natural pedogenetic processes may resume on new PM in pseudo-natural or human-altered combinations. In the second case, *metapedogenesis* is defined as a longer lasting intervention, such as ploughing, that doesn't interrupt the internal soil development happening on a constant PM, but modifies the resulting profile by chronically or cyclically changing the intensity and combination of pedogenetic processes. In addition to the primary influence of changes in the soil material regime linked to topography and lithology state factors, urbanization induces other impacts on soils, such as sealing or modification of the vegetal cover. These impacts lead to changes in the water, and fauna–flora regimes (Burghardt, 2017a; Leguédois et al., 2016) respectively linked to the climate and biology state factors. Although they have been relatively little studied so far, it is now acknowledged that such disturbances also modify the intensity and combination of pedogenetic processes (Burghardt, 2017b).

The above-mentioned authors (i.a. Burghardt, 1994, 2001; Burghardt et al., 2015; Effland & Pouyat, 1997; Huot et al., 2017; Leguédois et al., 2016) agree that urban soils are byproducts of combined natural and anthropogenic factors interacting on different time scales and modifying the intensity and extent of pedogenetic processes which, nevertheless, remain natural. Results presented and discussed in this article will show that soil management practices and morphological patterns related to urbanization adapt to the different components of the landscape and, in turn, transform them. However, urbanization-induced factors also evolve over time, according to technical and socio-cultural logics. This evolution explains why anthropic land uses are gradually taking precedence over natural factors in soil evolution and how they define new functional links and flows between soils (Burghardt, 2017a).

We propose to synthesize the diverging combinations of this causal chain in the form of a flow chart diagram presenting various representative trajectories, which depend on urban history and which will be exemplified below. Among the different urbanization-related changes in soil conditions documented in the atlas, at least seven main urban soil historical trajectories can be identified (see Figure 2). The various biogeochemical impacts on soils in the course of these trajectories generate specific pedogenetic processes, which trigger or deviate various soil DP. Trajectory A (Traj. A) is characterized by permanence of natural landscape conditions as predominant state factors. In this case, pedogenesis occurs on original PM without disturbance, and the soil follows a natural DP. Traj. B is characterized by the establishment of agricultural or horticultural use, then eventually other landscaping maintenance practices, which chronically modifies natural factors. Metapedogenetic processes occur on original soil, following a deviated DP determined by both natural and anthropic metafactors. Traj. C is characterized by punctual alteration and/or displacement of soil material, or even complete destructuration of the original soil profile as in the case of the construction of an urban structure and/or related earth disposal. Neopedogenetic processes resume on anthrosediments as modified or new PM, following a pseudo-natural but deviated DP which is determined by both natural factors and anthropic lithogenesis, with less influence of preexisting geomorphological conditions. Traj. D is similar to Traj. C, but with drastic PM alteration, such as strong compaction or change in soil geochemical composition. Neopedogenesis resets at a much lower rate, or in different combination, following a deviated DP mostly determined by anthropic lithogenesis as external factor. Traj. E is a combination of Traj. B and Traj. C characterized by both punctual alteration of PM due to construction, then chronic modification of natural factors due to cultivation. Metapedogenetic processes occur on modified or new PM, following a deviated DP determined by both anthropic lithogenesis and metafactors, with less influence of preexisting geomorphological conditions. Traj. F is characterized by sealing, causing both punctual alteration of PM and drastic chronical modification of natural factors. Pedogenesis resumes at a very low rate on new PM, following a slow or nearly inert DP which is mostly determined by anthropic lithogenesis and the quality of the sealed layer. Finally, Traj. G is characterized by soil stripping following the establishment of building foundations on bedrock. Destruction of PM and maintenance of the built structures temporarily annihilates the necessary conditions for pedogenesis by precluding the formation of new PM by aerial deposition.

The conceptual causal chain model and the trajectories elaborated above define the various links of a soil ecosystem compartment model (Burghardt, 1994): spatial planning decisions distributed in time and space; natural and anthropic factors of pedogenesis; pedogenetic processes and soil DP; and the resulting soil profile and associated properties. As a spatial transcription and case application of this model, the atlas is a consolidated cartographic device composed of various layers (Schneider, 2000). The relations by which the layers inform each other were determined by a workflow of mapping operations consisting of various graphic/analogical spatial analyses (Makowsky & Schneider, 2017). The workflow consists of the following steps (see Figure 3).

Various soil-related information sources were compiled into three base layers corresponding to the interacting natural and anthropic state factors. Base layer *I Geomorphology* represents the geological formations and their specific reliefs, the geotypes (Parriaux & Turberg, 2007), which correspond to lithology, topography and major hydrological systems, as a synthesis of preexisting landscape conditions. It gives an idea of pre-

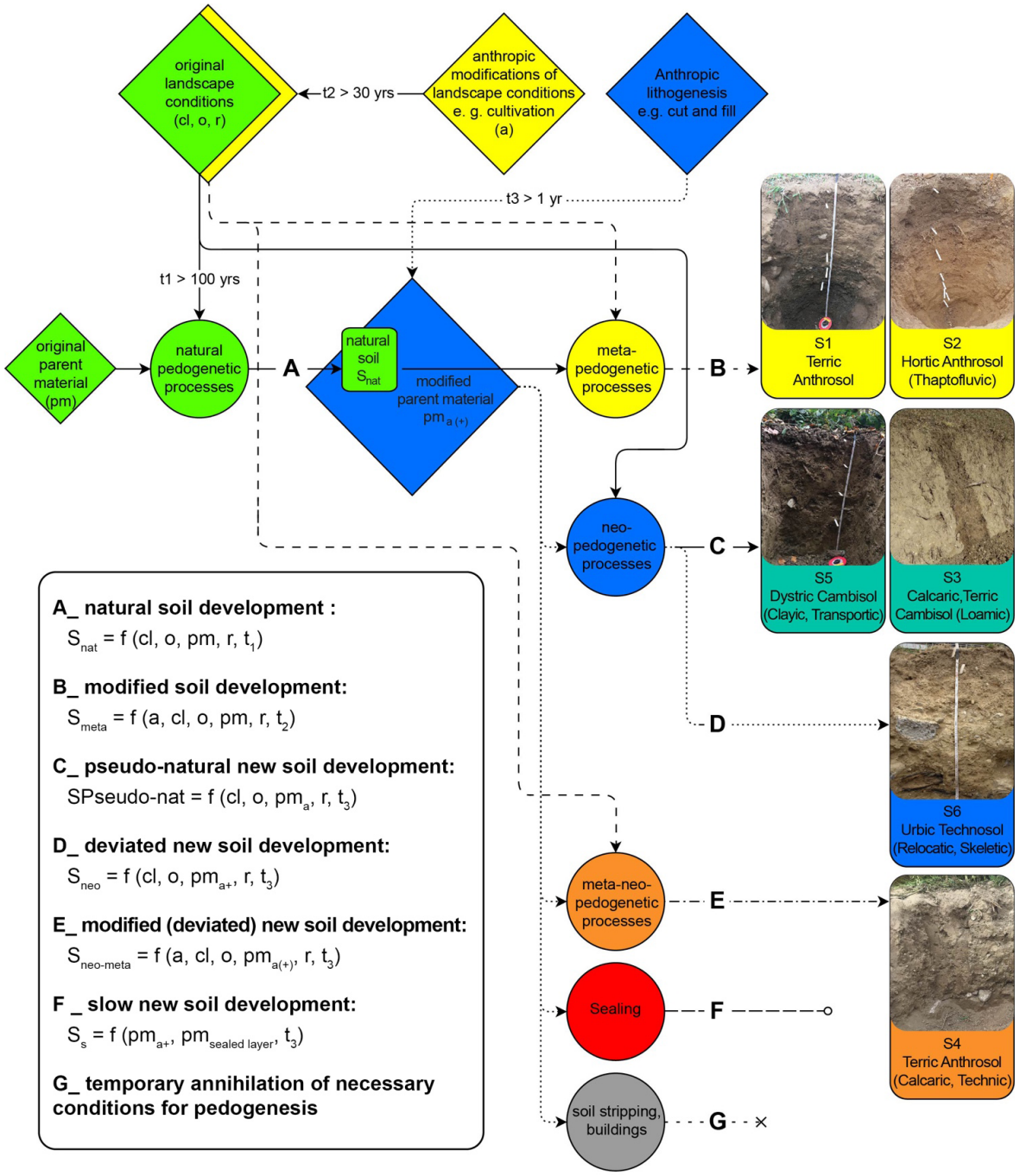

Figure 2. Causal chain conceptual model of anthropedogenesis. Source: Authors, after Yaalon and Yaron (1966), Effland and Pouyat (1997), and Yaalon and de Richter (2011), with photos from UNINE–UNIL Biogeoscience Master's Degree, Fall 2018.

existing natural soils and anthropogenic superficial deposits which partially reflect the changes in the material and water regimes. Base layer *II Land cover* represents spontaneous and man-managed vegetation, which corresponds to the biological factor strongly modified by cyclical soil maintenance practices as an overarching metafactor, as well as sealed and built surfaces, which correspond to changes in material and water regime. Base layer *III Anthrosediments* focuses on the various urban structures implemented in the area, the construction of which correspond to changes in material regime through anthropic punctual lithogenesis as neofactor. These base layers were separated into historical map series in order to trace the evolution of factors across space and time as an urban anthroposequence of pedogenesis. Such intermediary outcomes explain the agency of the 'project for the ground' on soils' evolution according to past and future spatial planning decisions. Based on the anthroposequence supplemented by soil profile descriptions, the various combinations of natural and anthropic fac-

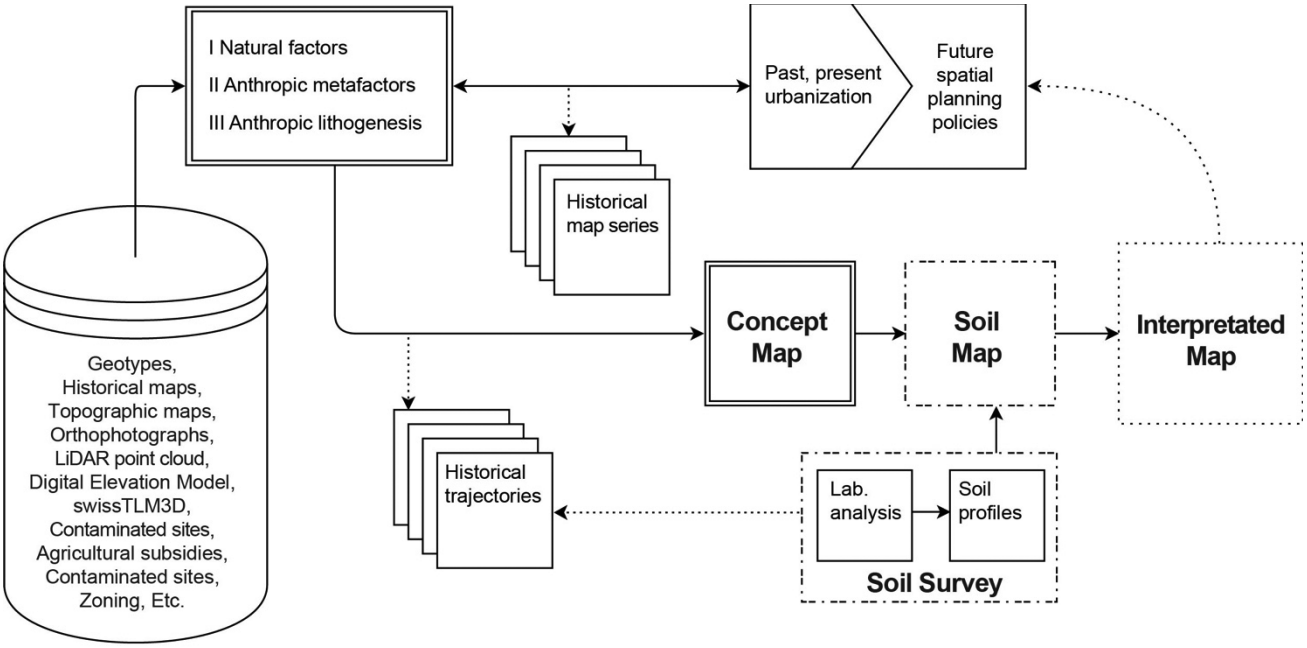

Figure 3. Workflow including source documents and outcome layers informing each other according to various mapping operations. Source: Authors.

tors were finally synthesized into a new concept map to spatialize the main soil historical trajectories, effectively distilling the workflow presented in this article.

3. Mapping Time: Aggregating Datasets into a Four-Dimensional Platform for an Historical Reconstruction of Urban Developments and Land Cover Changes

On the soil map of the canton of Vaud (Canton de Vaud, n.d.), as well as on those produced at the national level by the Federal Office for Agriculture (Geocat.ch, n.d.), urban areas appear as white spots, illustrating a fairly common epistemological gap (Hernandez et al., 2017; Makowsky & Schneider, 2017; Van De Vijver, Delbecque, Verdoodt, & Seuntjens, 2020). Documents collected from various private and government sources are therefore required to overcome the dearth of available soil data for this case study. They revealed a fluctuating practical and cultural consideration for soil.

Two sets of hand-drawn topographic maps (DAVEL, n.d.) produced at the municipal scale and respectively dated ca. 1830 and ca. 1880–1900 (further mentioned here as 1900) at a 1:10,000 to 1:5,000 depict in detail the texture of the ground, without establishing any hierarchical distinction between the elements belonging to the natural, agricultural and urban realms. In such documents, the land cover, and therefore how the soil is used, appears as a central feature of landscape and territorial management. Each village is depicted as a coherent spatial entity, among which wilderness, human habitat and agronomic productivity are of equal importance (see Figure 4a). In different versions of a national topographic map (Federal Office of Topography swisstopo, n.d.-b, n.d.-c, n.d.-d) which successively appeared at a scale gradually decreasing from 1:100,0000 in 1840 to 1:10,000 today, land cover is no longer represented per se, as a continuous element with a varying texture. Focus is instead given to urban developments and infrastructures that stand out against an abstract background (see Figure 4b). Orthophotographs (Federal Office of Topography swisstopo, n.d.-a) and picturesque postcard-type views (Bonzon, Marendaz, & Pahud, 1987; Marendaz, 2007) supplement these maps and provided a new medium of territorial representation. As opposed to maps, these intrinsically anecdotal documents mechanically record valuable if unintentional information about anthropic impact on soils, such as the spatial coexistence of rural, industrial and urban activities, or the actual footprint of large construction sites (see Figure 4c). Finally, today the most recent developments in remote sensing techniques provide new datasets initially developed primarily for risk management. In particular, airborne light imaging, detection, and ranging (LiDAR) point clouds combined with orthophotography provide a refined classification which can be used to distinguish sealed soils from open ones, as well as different vegetation strata (Gachet, 2013). Continuous land cover is therefore available at an unprecedented centimetric resolution, which is comparable to the aforementioned municipal maps (see Figure 4d).

These compiled documents where rasterized, georeferenced, and classified in a geographic information system (GIS) according to a consistent classification system at a 1:10,000 scale. This process allowed for comparison between categorical layers and across temporal group-

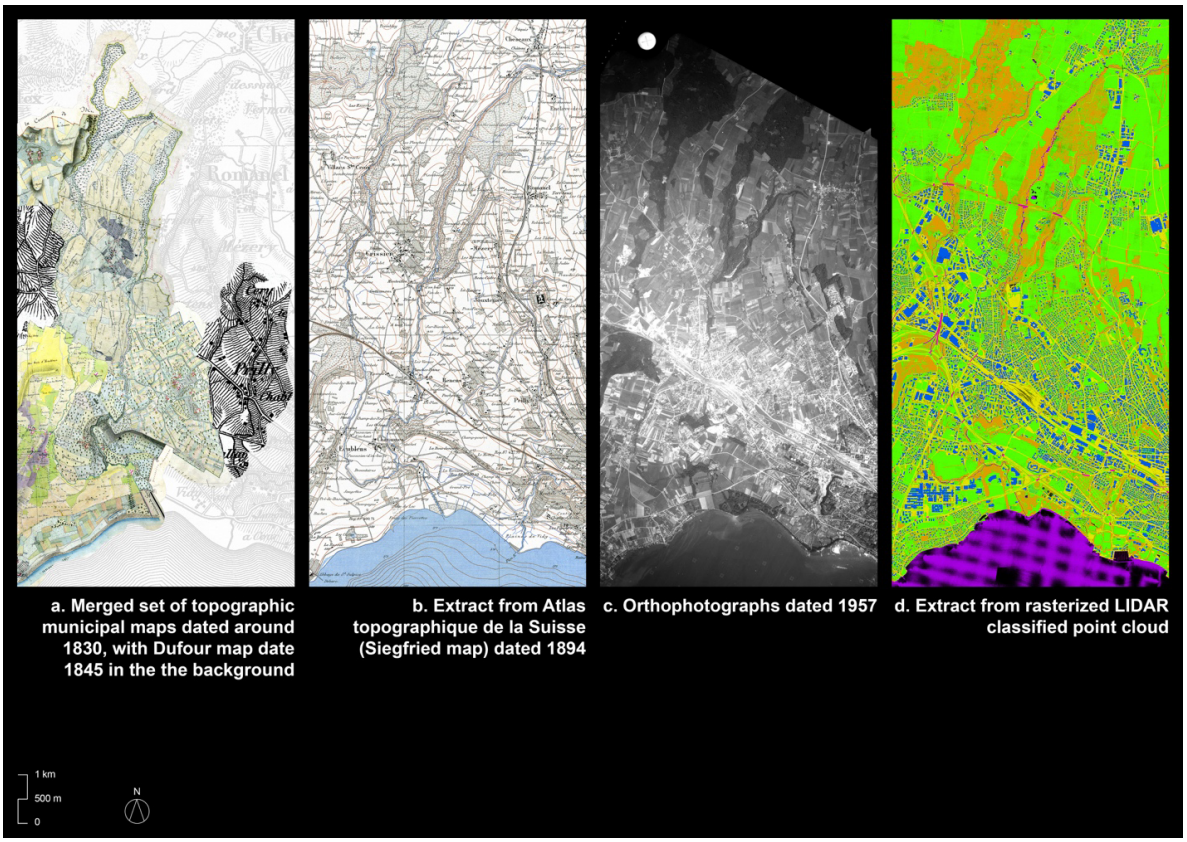

Figure 4. Examples of source documents available through time. Source: Authors, based on geodata and archival sources provided by Archives Cantonales Vaudoises, Swisstopo, and Canton de Vaud–Office de l'information sur le territoire.

ing. Following the evolution of knowledge on soil and its representation through various mediums, such a chronological approach then produced an original cartography integrating history as a fourth dimension of the map, tracing urban development and land cover transformation within the study area.

While the information in base layer *I Geomorphology* (see Figure 5a) comes from a single source (Association pour le Système d'information du Territoire, n.d.), base layers *II* and *III* were elaborated from a combination of various source documents. Base layer *II Land cover* contains two maps corresponding to the end of the 19th century (see Figure 6a) and to the contemporary period (see Figure 6b). A unique classification was established based on the rudimentary legend accompanying the communal maps (see Figure 6d), with the term 'garden' used to designate open soil surfaces in the immediate vicinity of homes, without distinction between ornamental greenery, non-subsidized food producing uses, or vacant lots. Base layer *III Anthrosediments* (see Figure 7a) contains 11 non-exhaustive types of urban structures which have generated anthrosediments and therefore potentially impacted urban soil PM. The extent of anthrosediments was determined by the effective footprint of an urban structure, the diffusion of its impact around it according to a buffer estimated from historical orthophotographs, or based on the right-of-way of a functional entity or landholding, such as a parcel.

Base layer *I* remains relatively stable over the study time period, with the notable exception of major anthropic changes in the topography related to urbanization further documented in base layer *III*. Therefore, this layer was not separated into a proper historical map series. However, its classification into five main categories of geotypes does give a sense of the multi-million year time scale of geomorphological processes (see Figure 5b). In turn, the historical map series that comprise base layers *II* and *III* are sequenced according to a unique timeline. The sequence starts in 1830, which corresponds to the earliest available municipal maps, at which point West Lausanne was still a rural landscape, and terminates in 2018, which corresponds to the current state of urbanization. Intermediate stages on the timeline were determined in order to properly cover the main waves of urban growth and infrastructure development.

The urban structures represented in base layer *III* were dated according to their first emergence on the historical source documents. A color-code was assigned to each of the 11 elements. Taking inspiration from the more or less long exposure of photographic paper to light in order to graphically represent a chronological gradient, the intervals of the timeline were transposed in seven shades of a grey. Such a typological and chronological (see Figure 7d) sequencing created a bivariate choropleth map, which allows both a diachronic (see Figure 7b) and synchronic (see Figure 7c) interpretation.

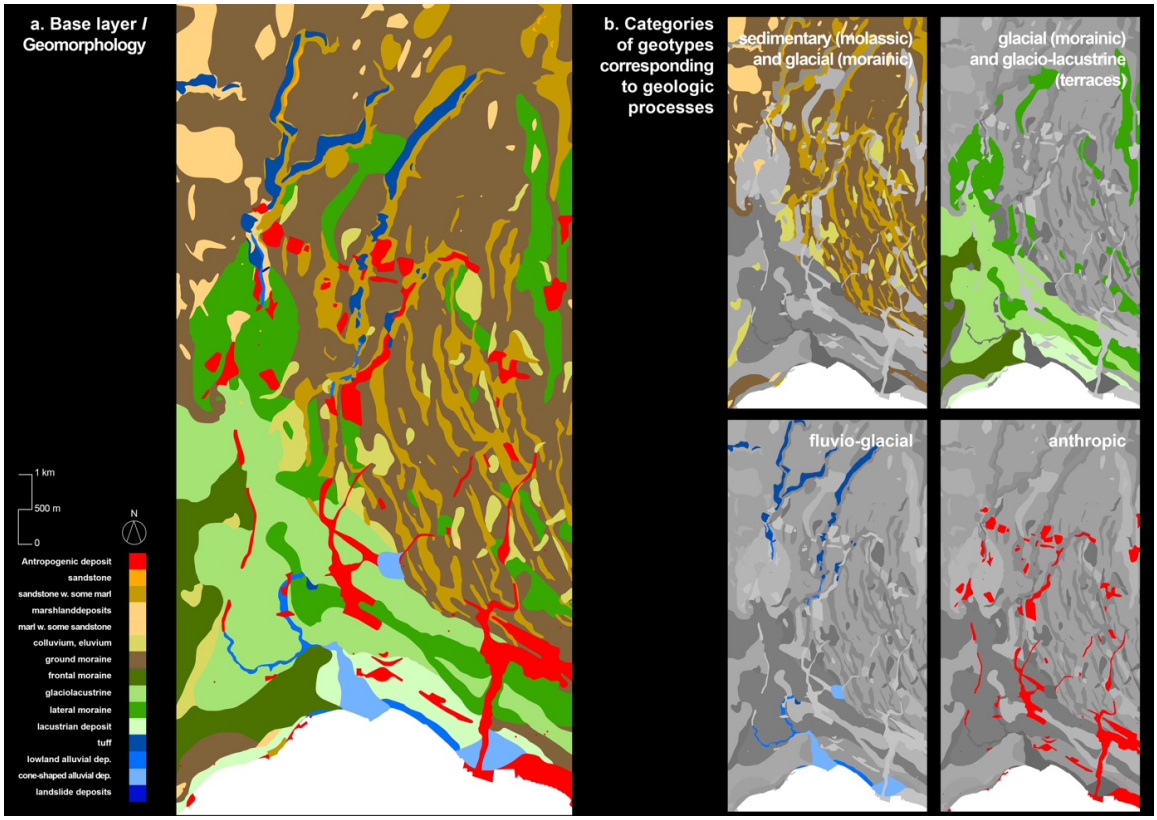

Figure 5. Base layer I. Source: Authors, based on geodata provided by Canton de Vaud–Office de l'information sur le territoire.

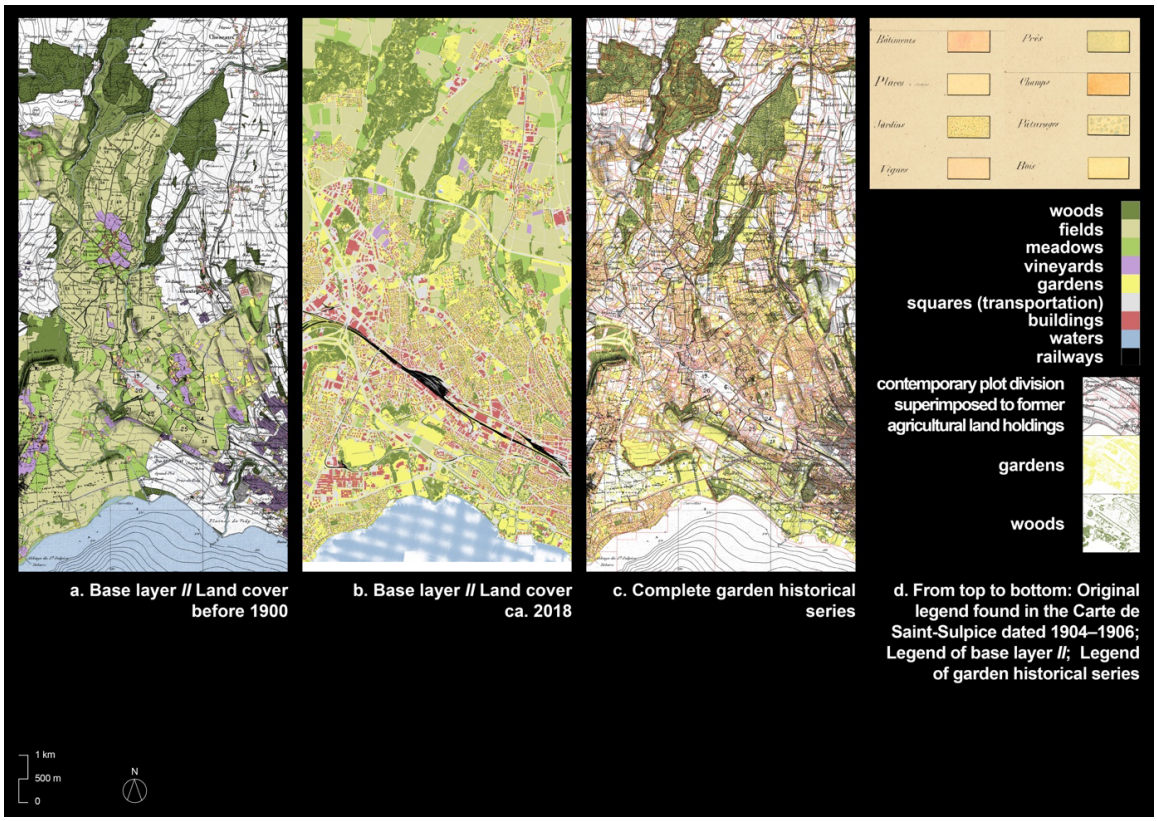

Figure 6. Base layer II. Source: Authors, based on geodata provided by Archives Cantonales Vaudoises, Canton de Vaud–Office de l'information sur le territoire, and Direction générale de l'agriculture, de la viticulture et des affaires vétérinaires.

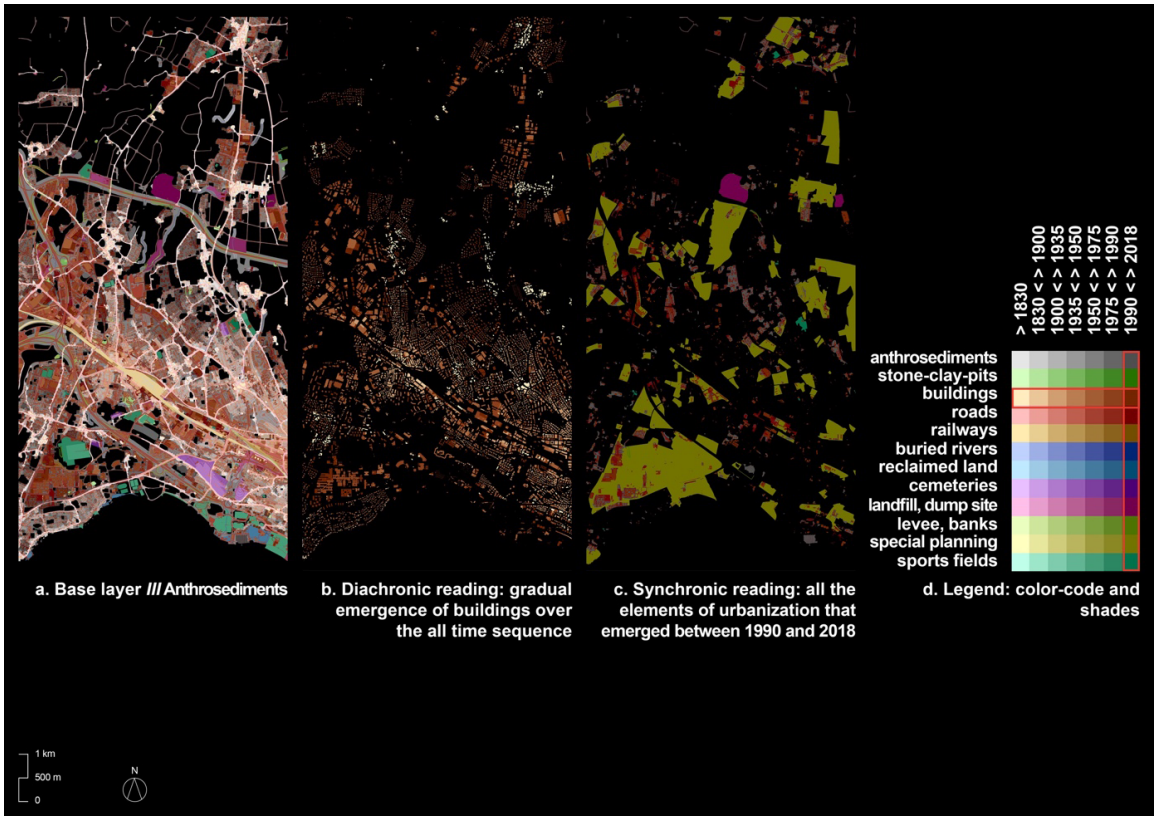

Figure 7. Base layer III. Source: Authors, based on geodata provided by Swisstopo and Canton de Vaud–Office de l'information sur le territoire.

The historical sequencing of base layer *II* was limited to a comparative analysis between its two stages of evolution in order to determine land cover permanence, disappearances and emergences. If the historical reconstruction and dating operations performed on layer *III* allow for an incremental reading of urbanization as an evolutionary process, the comparative analysis provides for an interpretation of land cover evolution in terms of disruption. We therefore sought to go beyond this first interpretation by trying to better understand the incremental process which produced the disaggregation of the initial agricultural landscape. For each interval of the time sequence, the former agricultural land holdings represented in the municipal maps were superimposed with the contemporary plot division, which was dated according to the time on which each plot was gradually urbanized and turned into a 'garden' (see Figure 6d). This operation provides us with a second historical map series (see Figure 6c) retracing the diachronical emergence of the 'garden' as an ambiguous typology of land cover, in relation to the dismantling and reconversion of former agricultural land holdings.

4. Connecting Soils' Contrasted Development Pathways to Historical Trajectories: An Urban Anthroposequence

If placed side by side, the 'anthrosediments' and 'garden' map series can also be read synchronically, in order to correlate the specificities of both land cover changes and urbanization processes for each time period. Such a reading provides an integrated vision on the chronological evolution of the anthropic factors impacting urban soils. The two historical map series were therefore used along with empirical profile descriptions to exemplify and to locate in space and time the typical soil trajectories mentioned above. In order to highlight anthropogenic lithogenesis and metapedognenesis, the research focused on profile descriptions of various soils corresponding to Traj. B, Traj. C, Traj. D and Traj. E. The impacts observed on these soil profiles in the context of historical urbanization processes informs our understanding of soil DP.

Until the end of the 19th century, the West Lausanne region was characterized by a 'project for the ground' in the form of a mesh of villages, which is clearly depicted in the historical municipal maps. These small urban entities were distributed equidistantly, located in the center of the municipal territory and surrounded by successive belts of gardens, vineyards, meadows and fields, taking advantage of the geomorphological characteristics of each site. However, the diachronic reading of each map series placed side by side shows that during the first half of the 20th century (see Figure 8), a diffuse and mixed urbanization logic was established. Agriculture, industry and housing were gradually closely intertwined throughout the entire southern part of West Lausanne, crossed

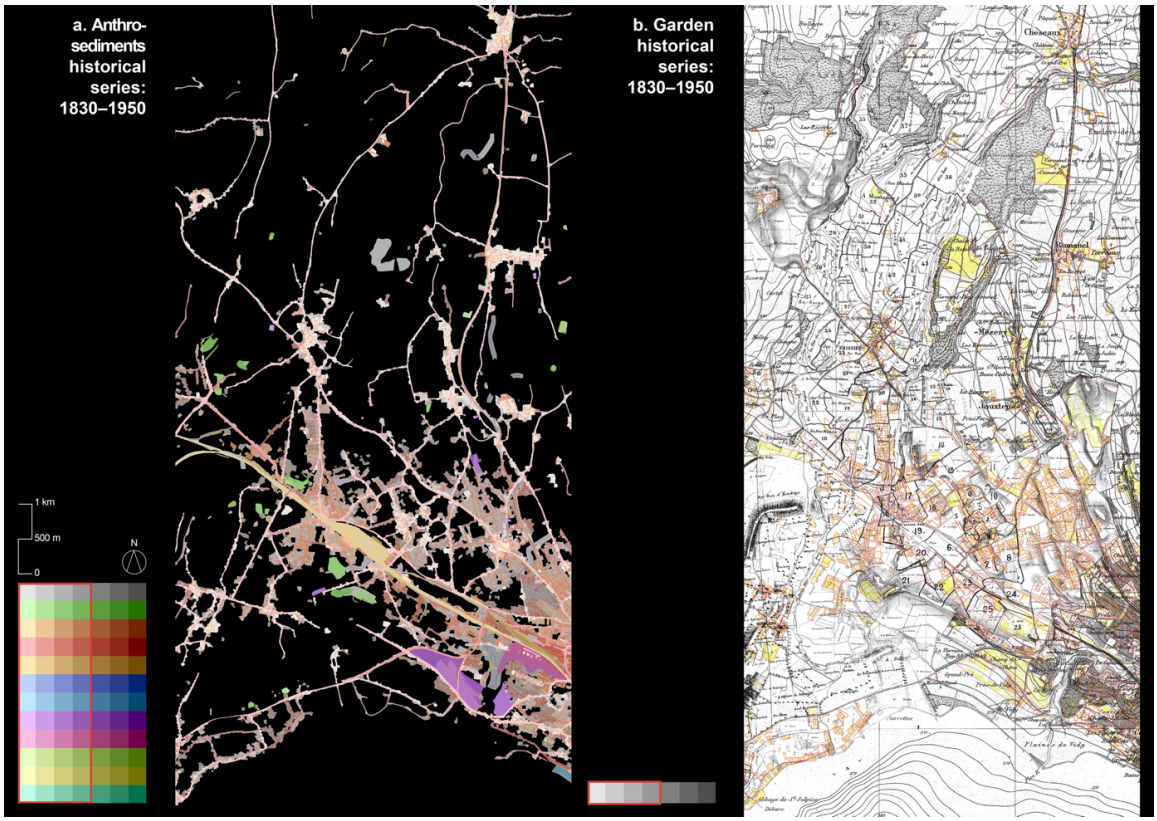

Figure 8. First half of the 20th century: Historical map series of base layers II and III. Source: Authors.

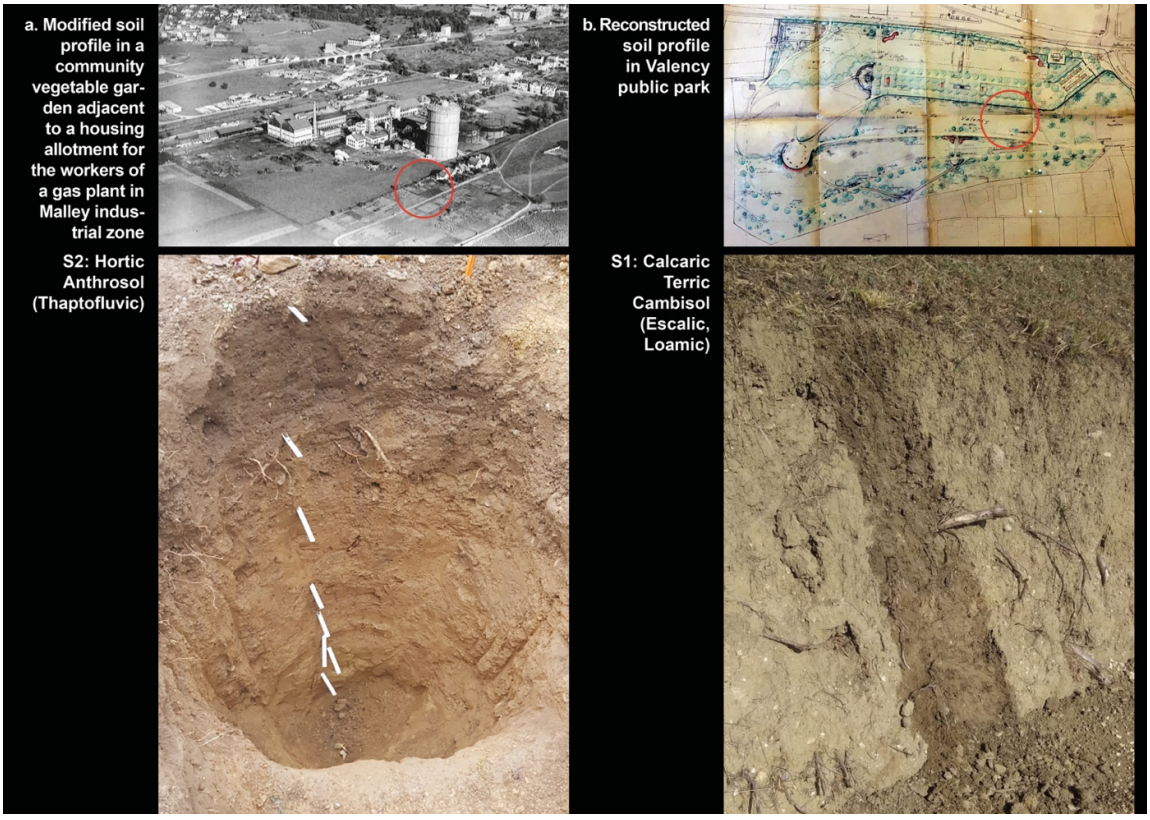

Figure 9. First half of the 20th century: Soil profiles, accompanied by historical source documents illustrating the urbanization processes which produced them. Source: Authors, based on photos and archival sources provided by Marendaz Collection, Ville de Lausanne–Service des parcs et domaines, and UNIL–UNINE Biogeoscience Master's Degree, Fall 2018.

on its central axis by new railway lines. This process of urbanization was essentially structured by the creation of roads and developed according to land opportunities plot by plot. Such close-scale operations tend to preserve the productive role of open spaces often dedicated to domestic food production in the immediate vicinity of new dwellings. Such traditional use of soil corresponding to Traj. B is illustrated by a profile we have excavated in a community vegetable garden adjacent to a worker housing allotment in the Malley industrial zone (see Figure 9a). Although it is located in the heart of the city in an area that has been urbanized for a century, the soil profile's physical qualities are minimally impacted. Its original structure, linked to fluvio-glacial geological processes, remains intact, with no major earthwork or compaction, but only a thin layer of fertile material added in the upper part of the profile which is characterized by a high organic matter content. On the chemical level, however, laboratory analysis shows the soil has been subject to pollution from neighboring industries and long-lasting horticultural practices. Another soil profile, excavated in Valency public park which was created in the 1940s, was subjected to notable landscaping including earth tipping (see Figure 9b). However, it can be observed that the addition of earth materials was carefully implemented thanks to relatively unobtrusive technical means, which allowed for a rapid resumption of natural biogeochemical processes according to Traj. C.

During the second half of the 20th century (see Figure 10), the characteristic fabric of West Lausanne was then restructured through fast-growing housing developments and tertiarization. This period was marked by the construction of major infrastructures, such as the first Swiss highway, and larger sectorized operations (i.e., large housing or office complexes, a university campus, logistics or recreational platforms). Such evolution was made possible by the introduction of special planning tools, which facilitated the gradual dismantlement of agricultural land holdings, starting with larger 'bourgeois' estates, and then smaller horticultural units. This modernist urban planning project for the ground conferred soils of new landscaped green spaces a highly ornamental, recreational, and hygienic value, albeit at the expense of their former productive functions. Therefore, as shown in historical orthophotographs, it is not surprising that more invasive building techniques, affecting the whole surface of each development site by a global management of cut and fill material, had a much greater impact on soil quality. Examples of this increased anthropic impact can be observed in two soils situated on the university campus and in an agricultural field along the highway embankment (see Figure 11). In both profiles, the disregard for soil quality is indicated by the presence of a layer of miscellaneous construction site waste which had been 'hidden' under a reconstituted topsoil. These two highly compacted tipped soils present a lower level of biogeochemical activity than those mentioned previously, although they have been restructured more recently and are now respectively dedicated to extensive park and agricultural uses, following Traj. D and Traj. E.

In the context of urban history, such examples of soil trajectories allow us to examine the influence of urbanization on soil in different ways. First, a spatial variation in urban development according to geomorphology and associated topography has been observed along the North/South transect. Until the end of the 19th century, for example, villages and vineyards were generally established on hillsides, while woods were preserved mainly on the steepest slopes along rivers. Since the end of the 19th century and during the 20th century, major transportation infrastructure, industrial platforms and campuses were mainly located in lower sunken reliefs, corresponding to a glacio-lacustrine geomorphology. However, these correlations tend to diminish with more major anthropogenic modification of the original landscape, such as river burying, as well as with recent developments progressively covering the urban fabric. Our case study, which covers an intermediate area between Lausanne historic city center and Vaud canton's rural area, also shows that the greatest anthropic impact on soils cannot be interpreted in a linear East/West or center/periphery gradient. Indeed, the soil profile displaying the highest level of chemical contamination, yet with relatively intact horizonated structure, is located in one of the most central and oldest industrialized locations; whereas the most compacted tipped soil, also displaying the highest content of technogenic artefacts, is located in one of the most peripheral and recently developed locations (see location of the soils studied in Figure 12a). These empirical observations are in line with the idea currently accepted within the field that—contrary to historic city centers characterized by homogeneity of highly impacted anthropogenic substrate, more dispersed and/or contemporary forms of settlements, such as West Lausanne—display more heterogeneous soil conditions (Burghardt, 1994; Hernandez et al., 2017; Howard, 2017; Huot et al., 2017; Prokof'eva & Martynenko, 2017). Framing conditions in terms of center/periphery gradient, as well as simple land-use categories, are therefore relevant in macro-perspectives. Yet, when applied to close territorial reading, they should be reconsidered in favor of more sophisticated spatial patterns such as, in our case, a diffuse and mixed urbanization, interweaving villages, agriculture, industry and sectorized developments within a mesh which was gradually densified.

Rather than by a simple spatial transect or gradient, the influence of urbanization on West Lausanne soils can therefore be mainly explained by a section through time. Such an historical narrative integrates various facets of land use, including construction and maintenance techniques, planning tools, and urban morphologies, into a specific 'project for the ground' which urban historian André Corboz designates as Swiss Plateau "city-territory" (Corboz, 1990, pp. 631–635). The atlas therefore offers a template, in the form of a complex figure in both time

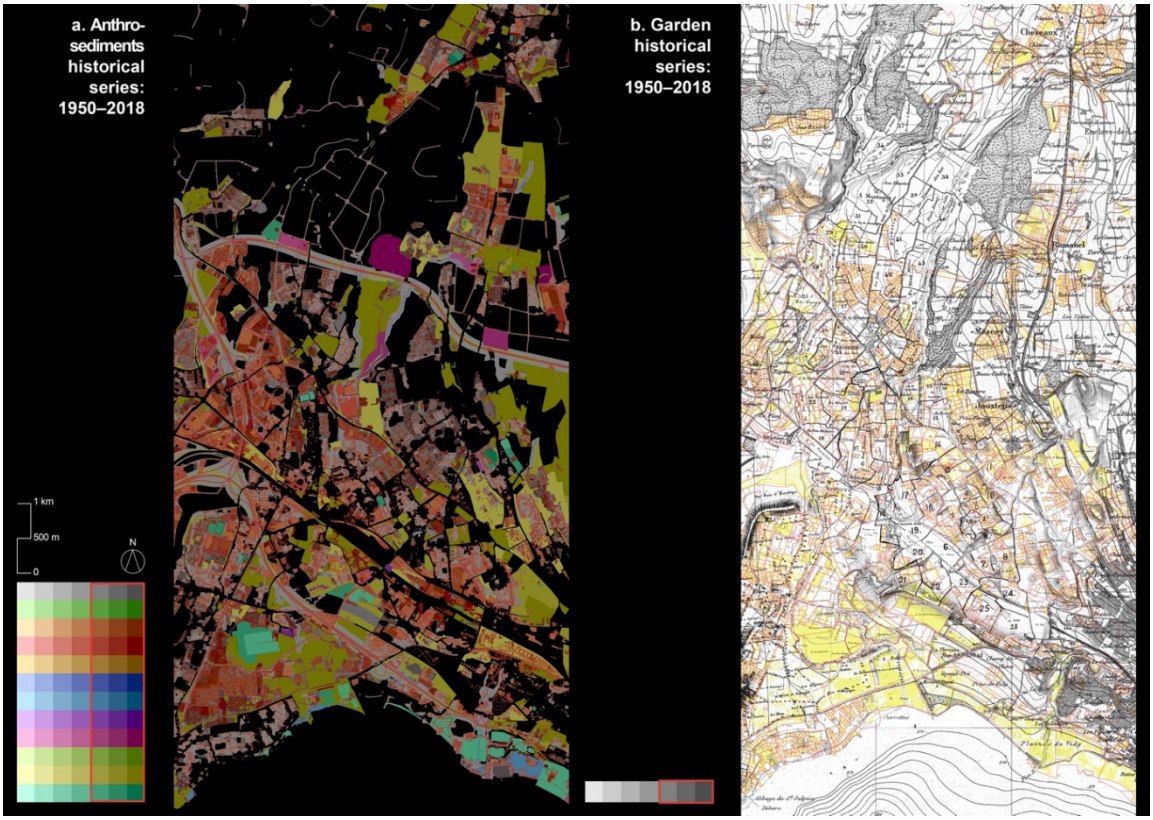

Figure 10. Second half of the 20th century: Historical map series of base layers II and III. Source: Authors.

Figure 11. Second half of the 20th century: Soil profiles, accompanied by historical source documents illustrating the urbanization processes which produced them. Source: Authors, based on photos and archival sources provided by Swisstopo, and UNIL–UNINE Biogeoscience Master's Degree, Fall 2018.

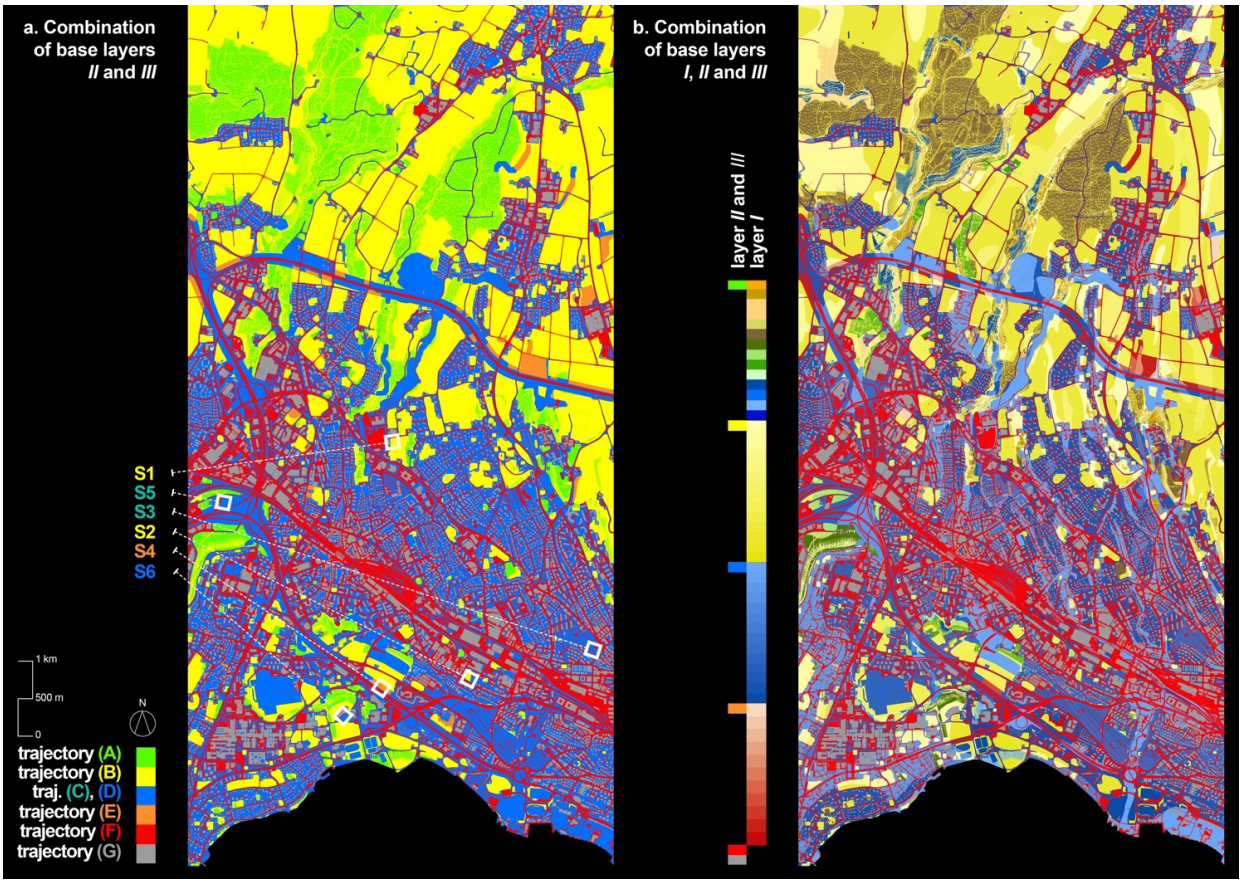

Figure 12. Draft concept map of potential urban soils, including the location of the soils studied. Source: Authors.

and space, on which to apply the factor approach in order to explain the variation of contrasted soil DPs as a coherent bundle of historical trajectories. In this respect, our case study demonstrates the theoretical validity of an urban anthroposequence of pedogenesis (Effland & Pouyat, 1997).

At this stage of the research, we can therefore consider the possibility of extrapolating, at the territorial scale of West Lausanne, a concept map of potential urban soils based on a supervised classification of soil historical trajectories a priori. A first draft of such a map is obtained by combining the information about anthropogenic meta—and neo-state factors of pedogenesis contained in the base layers *II* and *III* through their sequencing as historical series of maps, with only Traj. C and Traj. D remaining undifferentiated (see Figure 12a). A second draft supplement the first one by introducing the preexisting landscape conditions synthesized in base layer *I* (see Figure 12b).

Although statistically substantiated in previous case studies (Schneider, 2000), the validity of the concept map should be demonstrated through the collection and classification of a greater number of soil samples and profile descriptions. Such empirical survey would ensure iterative improvement of the conceptual model and its application to the concept map though historical trajectories. In particular, empirical survey is necessary to properly determine the actual quality of altered soil PM and to verify the location of potential informal cultivation practices. Empirical survey would finally allow us to obtain a proper urban soil map, by associating specific soil properties to the map units and therefore by defining soil volume characterized by constant profile, designated as pedons or polypedons (see dashed boxes in Figure 3).

5. Conclusions: Foreseeing the Interrelated Regenerations of Both West Lausanne City-Territory and Its Urban Soils

In the forthcoming developments of the research, the urban soil map could be interpreted in terms of soil functionalities and their related capacity to deliver ecosystem services. As envisioned by several authors (City of Stuttgart, 2012; Grêt-Regamey et al., 2018; Robert, 2012), such an interpreted map would therefore allow for the assessment of the relevance of current zoning principles from the perspective of actual soil functionality in relation to the estimated future need for ecosystem services (see dotted boxes in Figure 3). More importantly, such a functional approach could lead to the development of alternative strategies to business-as-usual. As required by the imperative inward urbanization principle, the dynamic and systemic vision induced by the coevolution of the city-territory and its soils outlines oppor-

tunities for the requalification and valorization of both the specific urban fabric of West Lausanne and its urban soil mosaic.

Indeed, from land and ground to four-dimensional soils, the consolidation of theoretical and practical knowledge regarding the agency of punctual and chronical urban practices on soil development would point toward potential positive impacts on urban soil capital. Based on our historical study, we can assume that current decisions on urban planning and design will result in land use changes, corresponding to the establishment of new land covers and related recurring maintenance practices, as well as new urban structures and related anthrosediments. If guided by a comprehensive *project for the regeneration of the ground*, these future prototypical trajectories could lead to the expression of alternative soil DPs which could potentially improve the quality and multifunctionality of inherited urban soils. This continued evolution could lead to alternative planning scenarios.

In this respect various resource deposits can be identified from the atlas. For instance, the 20th century productive platforms, which are now extensively mineralized, would have to be reconditioned. The heterogenous 'garden,' the formation of which accompanied diffuse urbanization, could be reworked as a fine grain local network. Finally, the open soils still in agricultural use, which, according to the actors interviewed for this study, constituted a 'reserve' during the process of gradual infill of the urban mesh, could now be envisioned as an ecological reserve and territorial green infrastructure. Urban reconversion and improvement to urban soils' functionality would therefore imply innovative processes based on reclaiming soil trajectories. Large-scale de-sealing would lead to a shift from abovementioned Traj. F to Traj. C. The implementation of regenerative agricultural, horticultural, and ornamental open soil maintenance practices would shift soils from Traj. B or Traj. D to a more resilient Traj. B' or Traj. C.

The elaboration of such strategies rests in the understanding of both West Lausanne city-territory and its urban soils as 'palimpsests.' As a snapshot in time, such composite images contain reprocessed material evidences of spatiotemporal evolutions, whose trajectories were retraced here as an urban anthoposequence in a time-dynamic map series.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Rhythmanalysis of Urban Events: Empirical Elements from the Montreux Jazz Festival

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Abstract
This article proposes an original approach to urban events mapping. At the theoretical level, the article is based on rhythmanalysis and recent research on urban rhythms. It contrasts with previous research by departing from everyday rhythms to tackle the specific rhythms of urban events. Drawing on this theoretical framework, the article proposes to analyse the rhythms of the Montreux Jazz Festival. The article proposes two main types of rhythmic scales, linked with the historical development of the Festival and its annual performance. The methodology is based on a mixed method of data collection and an original analysis framework. The analysis of the historical rhythm is carried out based on the analysis of the festival archives and interviews with experts. The analysis uses the Time Machine visualisation device that reveals three processes of urban resonance: the spread, which shows how the festival is integrated into the existing urban fabric; the openness, which shows accessibility; and the grip, which seeks to evaluate the urban sphere of influence of the event. These different visualisations are enriched by the addition of other data, including ticket scanning and commercial transactions that show the alternance between high and low-intensity periods. These allowed us to not only confirm the impact of programming on flows, but also the effects of the wider organisation of the leisure system. The results of the analysis show that the intertwining of the two rhythmic scales produces a hyper-place that resonates both internationally and locally.

Keywords
eventful city; GIS; hyper-place; mobility; Montreux Jazz Festival; rhythmanalysis; rhythmic scales; Time Machine; visualisation

Issue
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1. Introduction

During their development, large public events lead to major yet temporary reconfigurations of urban forms, whether in the use of buildings and public spaces, flows, or even individual and collective behaviour (Boullier, 2015; Viot, Pattaroni, & Berthoud, 2010). However, their resonance often extends beyond the time of their performance through the constitution of various institutional, memorial, and spatial traces that might modify dominant “urban assemblages” (McFarlane, 2011). In the case of a festival like the one in Montreux, which is at the heart of this article, the development and reputation of the city have gradually been merged—symbolically and spatially—with the development and reputation of the event. At each rehearsal, the festival’s sphere of influ-

ence extends over the city, through new buildings or the expansion of parts of the city affected by the flows of visitors and the multiplication of stages. This integration of a public event into the urban fabric and life of a city can be compared, in an urban planning point of view, as the active production of what Michel Lussault calls a "hyper-place" that functions "intensively at all political and spatial scales at the same time, from local to global" (Lussault, 2017). In this perspective, this article does not focus on stabilised everyday life rhythms, as the majority of recent urban rhythms researches. It claims the necessity to account for the spatial and temporal reconfiguration of urban rhythms induced by temporary large events that have strong and often lasting effects on ordinary city fabric and life. To respond to this conceptual challenge, we propose to use the conceptual framework of rhythmanalysis, which allows both the analysis of the rhythms of growth of the festival throughout history and the urban rhythms analysis during the period of the festival.

In the first part of the article, we develop the concept of 'rhythmic scale' to suggest the active interpenetration of temporal and spatial elements; any urban rhythm scaling up its material and immaterial territory. In the second part, we offer a narrative analysis of the transformation of the Festival and Montreux as a hyper-place through its careful branding and the increased intensity of the event. The following parts are dedicated to the analysis and visualisation of the rhythmic scales of the Festival. After tackling the methodological stakes of the research and the data we use, we offer the first set of visualisations of the historical rhythmic scales of the event, measuring among other the evolution of the openness, spread, and grip of the festival. The annually collected data allow for the use of the EPFL "Time Machine," and its linear rhythmic visualisation, to show the transformation of the grip of the Festival on the urban context. The last part of the article offers some statistical analysis of the performance rhythmic scales especially through the variation of public attendance.

2. Background

2.1. Rhythmic Approaches and Urban Rhythms

Henri Lefebvre's work has inspired many works in Sociology over the past 20 years, as evidenced for example by the recent publication of the *Routledge Handbook of Henri Lefebvre, The City and Urban Society* (Leary-Owhin & McCarthy, 2019). Within Henri Lefebvre's extensive work, rhythmanalysis (Lefebvre, 1992) constitutes a major contribution to the field of urban studies, particularly in sociology and geography. To situate our perspective, it is important to briefly present the main trend of the vast literature inspired by rhythmanalysis. Among other, rhythmanalysis has inspired many studies and scholars on the analysis of daily activity programmes (Axhausen, Zimmermann, Schönfelder, Rindsfüser, & Haupt, 2002; Ellegård & Vilhelmson, 2004; Hallin, 1991), management of daily time balance (Rosengren, 2019), analysis about the transformation of social and political relations (Hassan, 2007), acceleration of mobility (Bauman, 2013; Drevon, Kaufmann, & Gerber, in press; Viry, Ravalet, & Kaufmann, 2015), life rhythms (Kristensen, 2018; Rosa, 2013), body experience in public space (Edensor, 2012; McCormack, 2014; Simpson, 2008), and territorial times (Klein, Drevon, & Gwiazdzinski, 2017; Mareggi, 2013; Pradel, 2010).

As suggested by this non-exhaustive list, rhythmanalysis is not yet a well-defined field of research and science of rhythms is yet to be founded (Brighenti & Kärrholm, 2018). As Brighenti and Kärrholm (2016) claim, such science of rhythms could be integrated into a general science of the processes of territorialisation and socialisation (Brighenti & Kärrholm, 2016; Kärrholm, 2007) by putting into perspective the melodies and refrains revealed by the deployment of daily activities that take place with varying degrees of intensity (Brighenti & Kärrholm, 2018).

In this perspective, the literature that advocates a rhythmic approach proposes to take into account both the spatio-temporal shapes of rhythms as suggested, for example, by time-geography (Lenntrop, 1976; Pred, 1977) and the social interactions generated by periods of social synchronisation (Launay, Tarr, & Dunbar, 2016). The association between the shapes of rhythms and the social relationships that result from them tend to reify places and define different forms of territoriality (Edensor, 2012; Mels, 2016). This perspective refers in particular to Henri Lefebvre's approach to the production of space, which depends on the location in time and space of social relations and their intensities (Lefebvre, 1974).

Other work on the relationship between rhythm and territory also suggests that rhythm is a powerful way of reducing the social and cultural tensions generated at the territorial level by demographic pressures such as tourism. In this perspective, rhythm becomes a tool for regional planning and a lever for public policies. Indeed, the regulation of rhythms through restrictions is likely to redistribute the different forms of affluence in time and space and consequently reduce pressures on territories (Flemsæter, Gundersen, Rønningen, & Strand, 2019). This original approach to rhythm regulation calls for a broader reflection on a rhythm policy that would tend to limit pressures on environments and individuals (Antonioli, Drevon, Kaufmann, Gwiazdzinski, & Pattaroni, 2020).

As we see here, a large proportion of current research is mainly concerned with daily social and urban rhythms. Approaches that propose a rhythmanalysis of urban events are rarer. However, recent works (Antchak, 2018; Edensor & Larsen, 2018) show the interest of analysing urban events using the concept of rhythm to put into perspective the deleterious effects of strong rhythmic pressures on territories and the need to regulate and manage major events. The article positions itself in the continuation of those works by proposing a

rhythmanalytic approach to the Montreux Jazz Festival and large urban events. Nevertheless, even though we shift the focus of the analysis, we also consider rhythms as a central feature of both territorialisation and coordination processes.

2.2. Events Resonance, Traces, and Rhythmic Scales

A rhythmic approach of large urban events requires descriptive and analytical tools allowing to account not only for the temporary social and spatial reconfigurations whilst the event is happening, but also for the larger changes in urban forms and usages that it induces over time and space (Viot et al., 2010). Indeed, the performance of any public event implies important "investment in forms" (Thévenot, 1984)—such as public justifications, planning, security protocols, spatial settings—where it finds its political legitimacy and practical layout. Those investments are essential as events are potentially disruptive of daily routines and urban assemblage. They need on the contrary to be carefully framed and regulated in order to confer them their expected qualities, be it in terms of intensity, security, profitability, or hospitality. In other words, the expected outcomes and qualities of any large events stem from their active "enrolment"—to borrow the terms of actor-network theory (Callon, 1986)—in the broader mechanisms of social and spatial (re)production of urban order. It is in the constitution of this broader scope and territory of the event that it acquires its rhythmic complexity.

We use the term resonance to subsume the different ways a specific event produces spatial and temporal effects under one concept—the multiple connections it constitutes while it is performed and the traces it leaves over time. Those traces can be material, as is the case of remaining infrastructures produced to host a large event, or they can also lay in memories as the recursive and haunting narratives of the fire that destroyed the Montreux Casino in 1973. But there are still many more types of traces such as the various security protocols, spatial regulations, or institutional innovations that are transmitted through the years. Hence, resonance and traces are about how the performance of one large event has a structuring effect on its host territory and future events.

To account for this situation in geographical terms, we can use the concept of "hyper-place" as recently developed by French geographer Michel Lussault (2017) to oppose Marc Augé's (1992) characterisation of the airport as "non-place," reflecting the homogenisation of the world. For Lussault (2017), airports have been poorly observed and described and they must be, on the contrary, conceived—with their heterogeneous population of travellers and workers, their shopping areas, their connections and tensions—as exemplary places of the "hyper-spatiality" (Lussault, 2017) of contemporary work, mixing accessibility, co-presence, and virtual connections.

According to Lussault (2017), the paragon of such "hyper-places" is Times Square as : 1) it is "intense," not only in terms of the diversity of "activities and realities" assembled but also in term of interactions; 2) it illustrates "hyper-spatiality" (Lussault, 2017), i.e., it articulates the three central aspects of space: access (the question of mobility, that is, one needs to go there), co-presence (one needs to experiment it, find its place), and connection (to be there is also to communicate with other places); 3) due to its hyperspatiality, Times Square is also "multi-scalar" (Lussault, 2017): through its multiple connections, it is simultaneously a "local, regional, national, world" place but also its "well delimited space inscribes itself into an undefined communicational outer-space"; 4) it actively participates in the experiential dimension of social and spatial practices, i.e., of the cognitive, emotional, and volitive experience of the situated body; and 5) finally, it produces a spatial affinity between all the people that came to experience it, building up a specific form of commoning. We argue that those different characteristics apply to the situation of large events. Hence a 'large' event is not a quantitatively 'big' events but rather an event that transforms not only the spatialities, but also the temporalities of the place where it occurs. Its 'size' matters, but relatively to the size of its host environment or its capacity of absorption as in the case of the Montreux Jazz Festival doubling the population of the city during its performance.

The event's rhythmanalysis can, therefore, be understood as an attempt to concisely comprehend the different spatiotemporal patterns within which the event's performance and resonance occur. It is more broadly part of the procedural approaches of the city stressing the multiple temporalities that compose it (Antchak, 2018; Crang, 2001). As Henry Lefebvre (1992) suggests, it is the intertwining of rhythms that give different cities their spatial dimension and their uniqueness. More fundamentally, we should consider that rhythms constitute themselves within a spatialisation—or better a linking and scaling—process. From this perspective, the urban analysis of large events requires us to consider their spatial dimension from a set of what we can call 'rhythmic scales.' We organise our demonstration around two groups of rhythmic scales which account for the structuration of any urban order.

First, we analyse historical rhythmic scales, corresponding to the historic evolution of the event in terms of length and frequency, size, and spatiality along its resonance over time. Those historical rhythmic scales are essential to understand the genesis of the festival as a 'hyper-place.' Secondly, we propose to consider a performance rhythmic scale linked with the repetitive occurrence of the event. Those are the rhythms and assemblages of Montreux at the time of the Festival. It involves paying attention to the performance of the event, its timings, the influx of people during the evening, or indeed the flows of people in public spaces (congestions, etc.) and the various configurations of actors that are involved

in its organisation and regulation. Attention must also be paid to the wider modifications of the region and the uses caused by the event.

We need to start visualising those two rhythmic scales to analyse and reflect on the multiple effects of the Montreux Jazz Festival on its urban environment, following up the temporal turn of cartography and space visualisation techniques.

3. Case Study: Genesis and Performance of the Montreux Jazz Festival as a Polyrhythmic 'Hyper-Place'

The genesis and growth of the Montreux Jazz Festival, which celebrated its fiftieth anniversary in 2016, appears to be a good example of the festivalisation of culture over the last few decades. In 1961, Claude Nobs (future founder and director of the Festival), when employed at the Tourist Office, was instructed to help in the collective effort to put Montreux back onto the world map. Because of his work over the years, the Jazz Festival very quickly became internationally renowned and, by the end of the 1960s, was able to draw major artists such as Ella Fitzgerald, Aretha Franklin, Frank Zappa, and Chuck Berry. In 2016, Deep Purple came back to Montreux, 45 years after their debut there in 1971, when the musicians were part of the famous fire at the Montreux Casino. The event that would be inscribed in the Festival's history (and in rock history as well) is told in the legendary song 'Smoke on the Water.' The two faces of the music, immaterial and material, allow such exchanges of energy and inspiration and enabled the development of the Festival into a hyper-place. Before going into the cartographic detail of its spatial expansion, a few more elements allow us to observe the spread of resonances of the Jazz Festival, both locally and internationally (Figure 1).

Between 1968 and 2018, the Montreux Jazz Festival's budget went from 10,000 CHF to 28,000,000 CHF. The event now attracts an attendance of around 250,000 people over the two weeks it is held. For a city of around 25,000 inhabitants, it means that during 16 days, its population is increased daily by 60%, hence the importance of a rhythmic regulation of the arrival and circulation of this public. The visual and material traces that broaden the presence and impact of the Festival to the rest of the world are many and go beyond the music alone. They run from the festival's logo printed on Coca-Cola bottles to the Montreux Jazz Café franchise, managed from Montreux by Montreux Jazz International.

The Montreux Jazz Café restaurants appear as real ambassadors of the Festival's spirit across the world. Yesterday in Paris and London; today in Montreux, Lausanne, Geneva, Zurich, and Abu Dhabi.

The Festival's resonance in Switzerland can also be seen through its attractions area. As shown in Figure 2, the Festival's attraction area reaches all of Switzerland. The spectators' origin is nevertheless unequal. The Festival appears as an event aimed at residents of larger cities, the main consumers of culture in Switzerland (Figure 3). However, the analysis is more complex since regional proximity is also added to the urban dimension. The density of participants by place of residence thus shows four main polarities in terms of spectators' origins. The first centre is peripheral: Zurich. The second two centres are regional and are situated in the Leman metropolis (Geneva and Lausanne). The fourth centre is local, corresponding to Montreux and its surroundings. This hierarchy of centres and the origin of the flows of participants suggest, on the one hand, that the Festival receives spectators from far away and on the other hand, that they are mainly from quite close by. The distribution of participants according to where they are from (Figure 4) confirms this observation. Indeed, 70% of participants live in the Leman region. The large flow of participants who come from all over Switzerland and, to a certain extent, from abroad, suggests that the Festival benefits from a large breathing space. Apart from media and commercial resonances, the coming together of these people and the regions that they represent physically contribute to the hyper-place of the Festival as a gathering place for people coming from both very close and very far.

Figure 1. Bottle of Montreux Jazz Festival Coca-Cola (left) and the Montreux Jazz Café at Geneva airport (right).

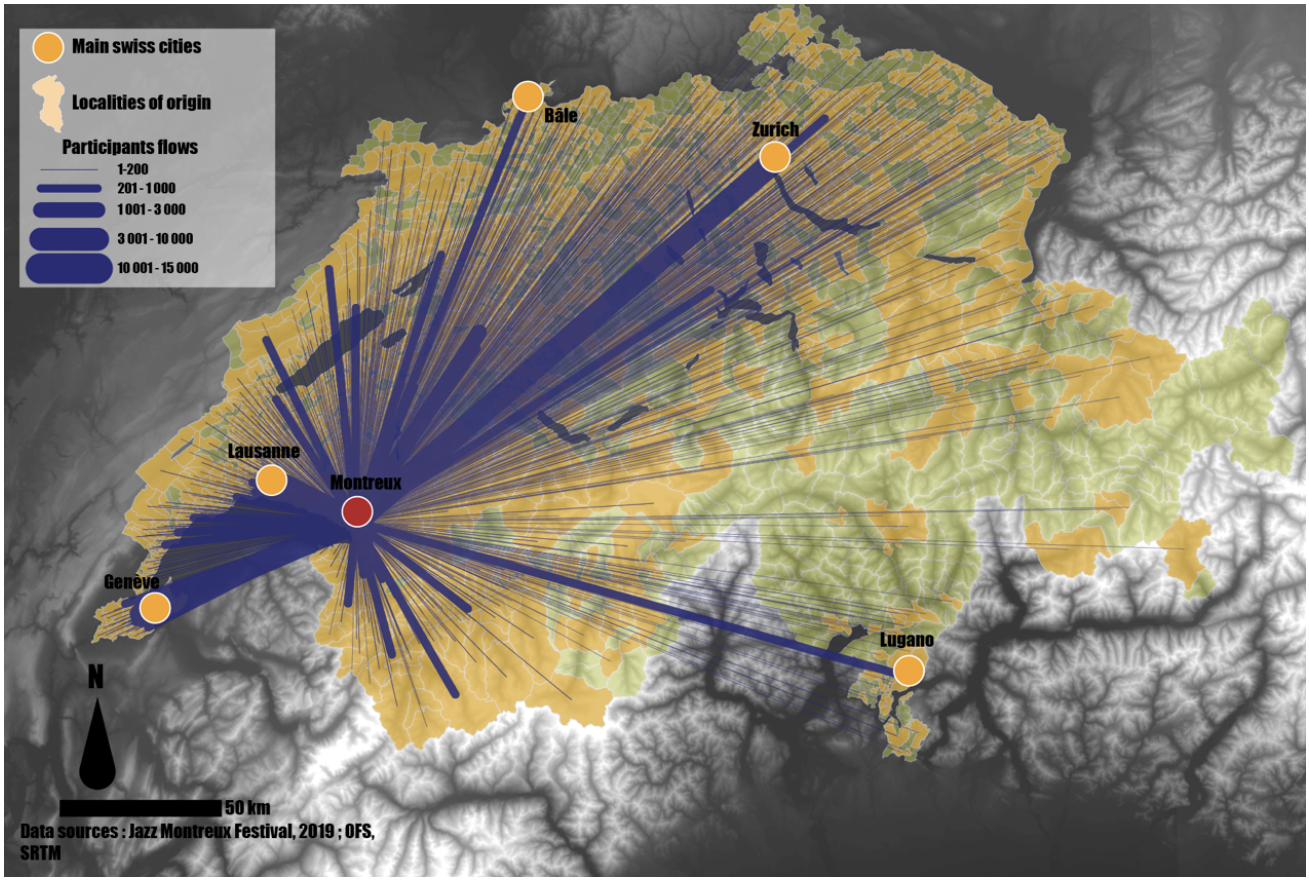

Figure 2. Cartography of the flows of participants to their place of origin. Source: Drevon, Pattaroni, Romany, & Delley (2019).

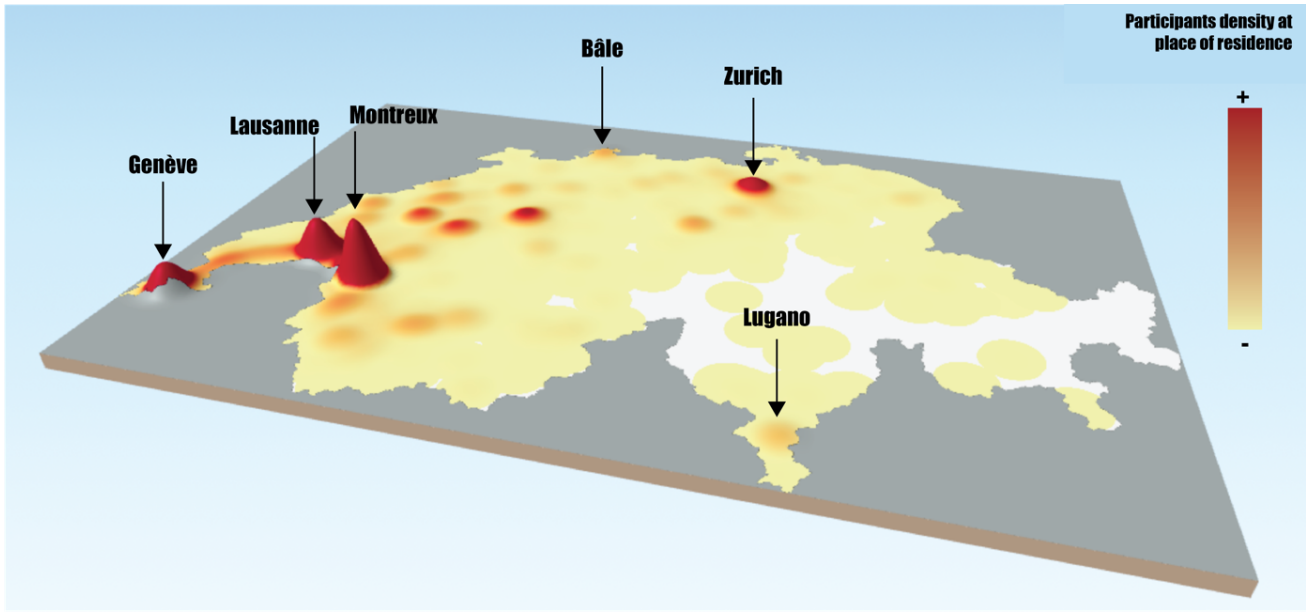

Figure 3. Three-dimensional visualisation of the density of participants by their place of origin. Source: Drevon et al. (2019).

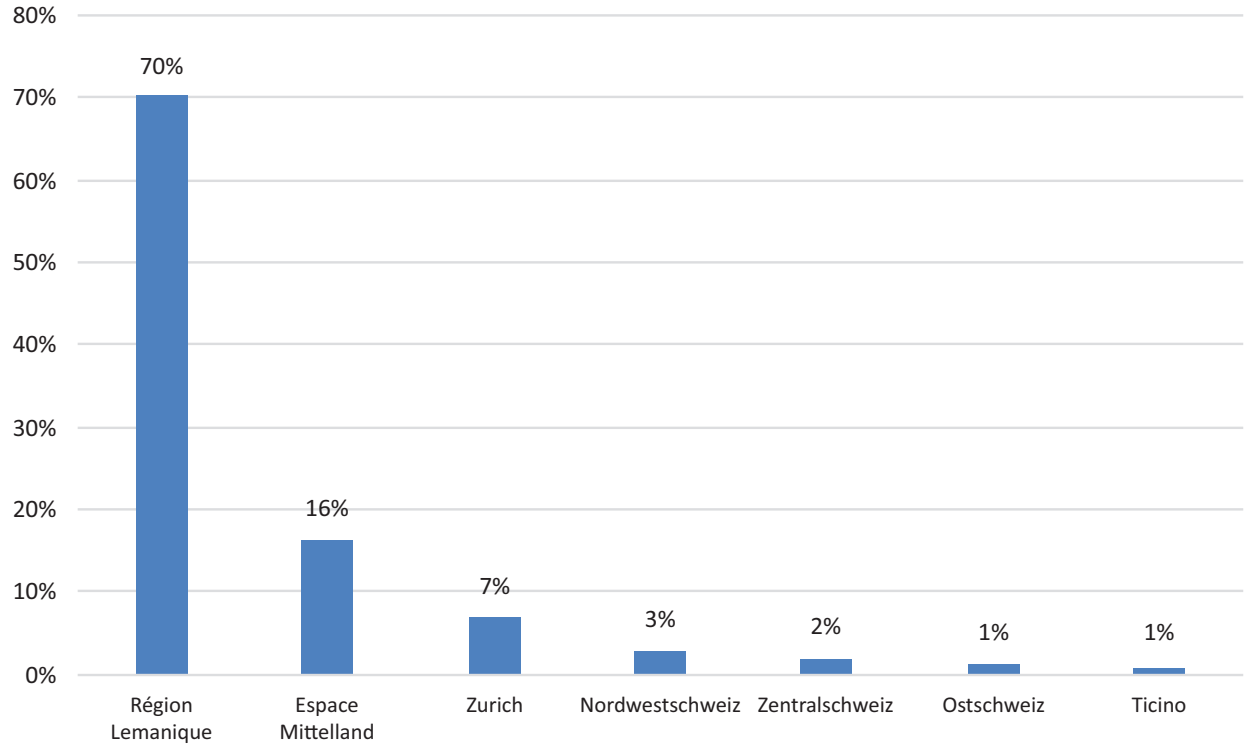

Figure 4. Distribution of participants according to the region of origin. Source: Montreux Jazz Festival (2019).

4. Data and Methodology

The methodological challenge raised by the analysis of rhythmic scales of the Montreux Jazz Festival requires the pooling of historical data—knowledge of experts about the festival's history and data about the performance of the event. This research perspective implies, therefore, the implementation of a mixed methodology of data collection (Bergman, 2008; Teddlie & Tashakkori, 2009).

4.1. Data

Data collection and analyses were carried out in the spring of 2019. The data collection methodology used in this research is based on the principle of triangulation between the three sources (archives and interviews, ticketing data, and transaction data of information). The triangulation is commonly used in the social sciences to ensure complementarity between collected data and cross-fertilisation (Alavi, Archibald, McMaster, Lopez, & Cleary, 2018; Denzin, 2017; Frias & Popovich, 2020). In the social sciences, this approach offers multiple perspectives concerning the object of research, which can thus be observed from different angles. In the context of this article, this multi-perspective approach makes it possible to analyse historical and performance rhythmic scales together. Indeed, the objective of the adopted approach in the analysis is to collect data that reinforce each other in order to reduce analytical uncertainties (Bergman, 2008). Data collection is structured by the previously mentioned rhythmic scales. The two orders of data were diversely collected and then originally cross-referenced. The collection of data about the Festival's historical development tended to bring together elements relating to the evolution of the Festival's influence within Montreux, especially since the 1990s. It was based on the Festival archives and press analysis along semi-structured interviews with stakeholders, allowing the spatial and temporal composition of the festival to be retraced over the last thirty years. The analysis of the archival documents—especially the complete set of festival programmes—made it possible to reconstruct the location of the festival's stages and the programming of the various concerts and events. The data collection allowed the location of the paid and free-access stages to be differentiated. Interviews with experts were particularly helpful to validate the data collected and understand the grip of certain localisations. The experts allowed the collection of supplementary information on the evolution of security and mobility arrangements put in place to welcome and manage the public. For this reason, the experts interviewed were selected on the basis of their organisational and safety skills and their experience concerning the organisation of the Montreux Jazz Festival (Table 1).

Archives and interviews analysis enabled the creation of a spatiotemporal database of the stages, integrating their location in Montreux over the period 1990–2019. This first database made it possible to establish the evolution of the Festival's spatial influence, thus enabling us to draw an initial visualisation of the historical rhythmic scale of the Festival.

Performance rhythm analyses are based on two sources of information. The first source is the ticketing

Table 1. Semi-structured interviews' profiles.

N°	Stakeholders functions profile
1	Municipals heads of departments (authorities)
2	Socials workers in charge of urban mediation
3	Chief of the Police
4	Security partners of the Montreux Jazz Festival (fireman, medical staff, etc.)
5	Organisation members of the Montreux Jazz Festival (permanent office and staffs)

data that shows the rhythm of the audience's entry to the Festival venue from ticket scanning. The ticket scanning data was provided to the research team by the festival organising committee. These data allow us to know the exact time and place of entry at the different stages of the festival. From the analysis of these data, it is possible to put into perspective the rhythms of attendance at the different festival stages and thus to measure the rhythmic intensity of the festival in terms of attendance and co-presence. However, these data give a partial view of the attendance by reflecting only access to the festival's paying stages. It is for this reason that a second database of commercial transactions was used to analyse attendance patterns outside of the paid-access stages. Similar to ticket scanning data, commercial transaction data offers the possibility to measure attendance rhythms outside of pay-access stages. This data reveals the location and timing of various commercial transactions, particularly food and drink purchases. By using this data in addition to the ticket scanning data, the overall analysis gives a more complete picture of the reality of the festival's attendance rhythms.

The data collected in the course of the research made it possible to build an original and diversified corpus of information on both the historical and performative rhythms of the festival. This mixed methodological approach and the triangulation system made it possible to improve the quality of the data collected and to propose the most robust possible basis for analysis. However, several limitations must be considered. First of all, the confirmed cross-referencing between the analysis of the archives and the interviews conducted with the experts does not necessarily guarantee the exhaustiveness of the census of the different festival stages. The second cross-reference between the data from ticket scanning and commercial transactions only provides a trace of the passage and only very partially reflects the reality of the rhythms of the attendances at the different places of the festival.

4.2. Data Analysis

The methodology of the analysis is based, on the one hand, on spatial analysis, that is, the spatiotemporal visualisation of data collected from the archives of Montreux Jazz Festival; on the other hand, it is also based on the statistical analysis of ticketing and transaction data (cyclic rhythms). The first analysis of the historical rhythmic scales of the Montreux Jazz Festival uses the technique of standard ellipses of variability (Gong, 2002; Kent & Leitner, 2007; Raine, 1978) to understand the evolution of the Festival stages' dispersion (1990–2010), and to put the spaces influenced by the different performances into perspective. In addition to the spatial analysis, an initial spatiotemporal visualisation was produced based on Time Machine. The Time Machine tool is based on a discretisation of space and time that is used to drive the data storage and access (Kaplan, 2013). It follows that geographical information is organised and stored according to both space and time dimensions (Hamel, 2020).

In order to bring data in the tool, the geographical information needs to be associated with a precise time value before to be imported. This leads to a 4D approach for data management and storage. The tools also come with a 3D interface that addresses spatio-temporal queries to the storage of the data in order to retrieve the required information to build a 3D representation of the geographical information at a given position in time. The interface allows browsing the 3D representation through space similarly to Google Earth, but also allows changing the position in time, creating a new 3D representation. By considering a predefined spatio-temporal trajectory, the tools allow to create a dynamic visualisation of the evolution in time of the geographical information. As a result, any data coming with both geographical footprints and a precise time code can be considered through the tool to create a 4D visualisation of their evolution regardless of their rhythm and geographical description.

The data considered in the visualisation attempt using the Time Machine tool are the geographical footprints of the Montreux Jazz Festival. For each year, the Festival footprint is described in geographical terms and associated to its year time code. The footprints are then imported in the tool. In addition, a wireframe representation of the Swiss geography and topography is also imported to obtain a context in which the footprints can be interpreted. To create the visualisation, a spatiotemporal trajectory is defined around Montreux city in space and spanning from the year 1990 to the year 2019. The obtained visualisation then shows the evolution of the Festival's geographical footprint on the studied time range.

The analysis of the performance rhythmic scales that occur during the Festival is based on the ticketing and transaction data. The times at which tickets were scanned and drinks were ordered were analysed in par-

allel, to measure the different rhythmic intensities and their recurrences during the week of the Festival. The analyses were based on descriptive statistical techniques from a temporal perspective. Thus, the analysis focuses on identifying the periods of the day and week when the attendance intensity is greatest.

5. Results and Discussion

5.1. Analysis of Historical Rhythmic Scales: Spatialities of Festival Growth

The historical rhythmic scale approach corresponds to the evolution of the Festival throughout its history on several spatial levels (scaling). The first level concerns the evolution of the Festival's influence and more particularly the dispersion of stages and event venues within Montreux. The second level refers to the different spaces of the Festival by integrating places such as stages, but also its immediate surroundings, which offer potentials of socialisation, conflict, and common space-time. Three types of analysis were carried out using the spatiotemporal database: on the extent of the Festival's influence; on the nature of the stages; and on the impacted spaces. They demonstrate a wider range in terms of spread (dispersion), openness, and territorial grip, which shows the profoundly spatial nature of the Festival:

- Spread: The first analysis shows, on the one hand, the spread and the dispersion of the Festival sites, and on the other hand, the event's centre of gravity. Figure 5 shows the evolution using the analysis of the years 1990, 2000, and 2019. The results show an extension of the spread and an increase in the dispersion of the event's sites. The Festival's centre of gravity tends to position itself gradually towards the Stravinsky stage.
- Openness: The second analysis (Figure 6) shows the evolution of the financial accessibility that accompanies the Festival's spatial dispersion looking at the extent of free over paying accesses. While confirming the extension of the Festival over the years through the multiplication of the different stages, the codification—paying in orange; free in green—shows that it is closely associated with the reinforcement of the open-access offerings within the Festival. In particular, we note the considerable impact of moving the Festival to the new Palais des Congrès in 1993, which helped to place the Festival in the heart of the city. Indeed, along with this move, the Festival began in 1994 to develop a larger 'off' offering at the city level while extending the reach of its core (which has now become a perimeter with more than 70 food stands and other consumer products). This evolution is typical of the festivalisation of public space, which increased in the 1990s (Cudny, 2016).
- Grip: The third analysis (Figure 7) shows the evolution of the zones affected by the Festival. It takes into account, on the one hand, the dissemination of the zones, but also the progression of their spread depending on the evolution of the location of the event, thus confirming the hypothesis of festivalisation of public space. Using historical data of different Festival sites, there was a first attempt at visualising using the Time Machine tool (Figure 8). It shows the relocation of Festival stages from 1967 to 2019 and confirms the observations made in the previous analysis. By covering a longer time-span and enabling a year-by-year visualisation, the Time Machine tool reveals multiple spatial reconfigurations and the events that affected the spatial organisation of the Festival. For example, the Kursaal Casino, the historical cen-

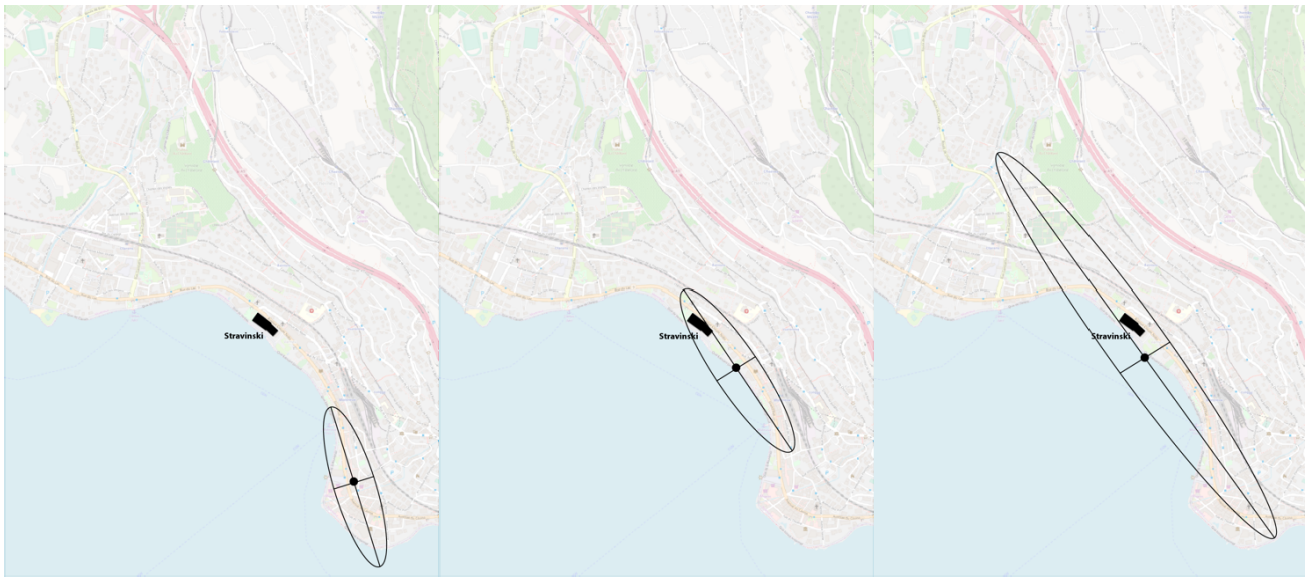

Figure 5. Centro-graphic analysis of the evolution of Festival sites (spread). Note: From left to right: 1990, 2000, and 2019.

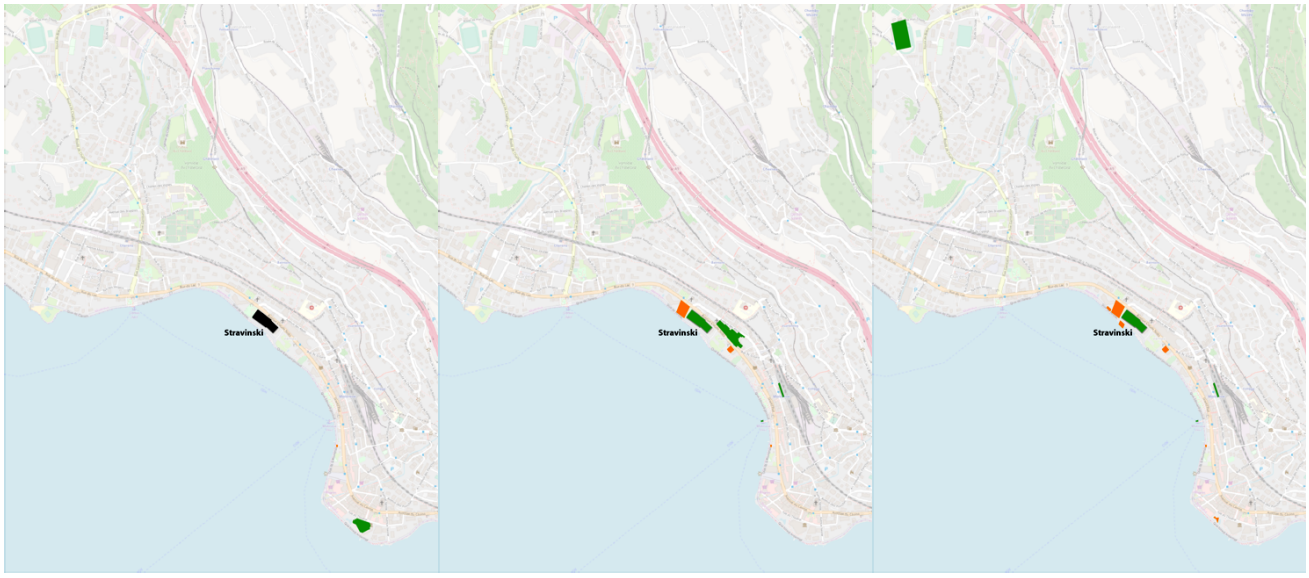

Figure 6. Analysis of the evolution of Festival sites and their access (in green: stages with paid access; in orange: freely accessible stages—openness). Note: From left to right: 1990, 2000, and 2019.

tre of the Festival, had a major fire in 1971 (the one from Deep Purple's song). Following this event, the 1972, 1973, and 1974 editions took place in the Pavilion of Montreux Palace and the Maison des Congrès.

These preliminary analyses show the Festival's progression in terms of spread, site dispersion, and accessibility (free/paying). Analytically, it allows tackling the question of the influence of the Festival on the city. The serie of visualisation isn't a mere visual reconstruction but it represents real transformations of urban spaces and practices. Indeed, the localisation of the festival within the city centre has had a major impact on the way Montreux has developed over the last decade. As suggested by geographer Antonio Da Cunha (Arboit, 2016), the "Festival has structured the space and transformed the geometry of the uses and walking habits of its inhabitants all year long." Among others, the main commercial street developed itself between the old and the new centre of the Festival, shifting to the west the city centre in comparison to its earlier development. Investments in the setting of public spaces and parks followed this impulse. This articulation between the Festival development and the city structuration has an impact both on the daily rhythms and the event rhythms, especially linked with commercial activities and pleasure strolling. As the Festival performs in the city centre—that it contributed to delineate—it is now difficult to block the ordinary daily mobility roads to build up the performance

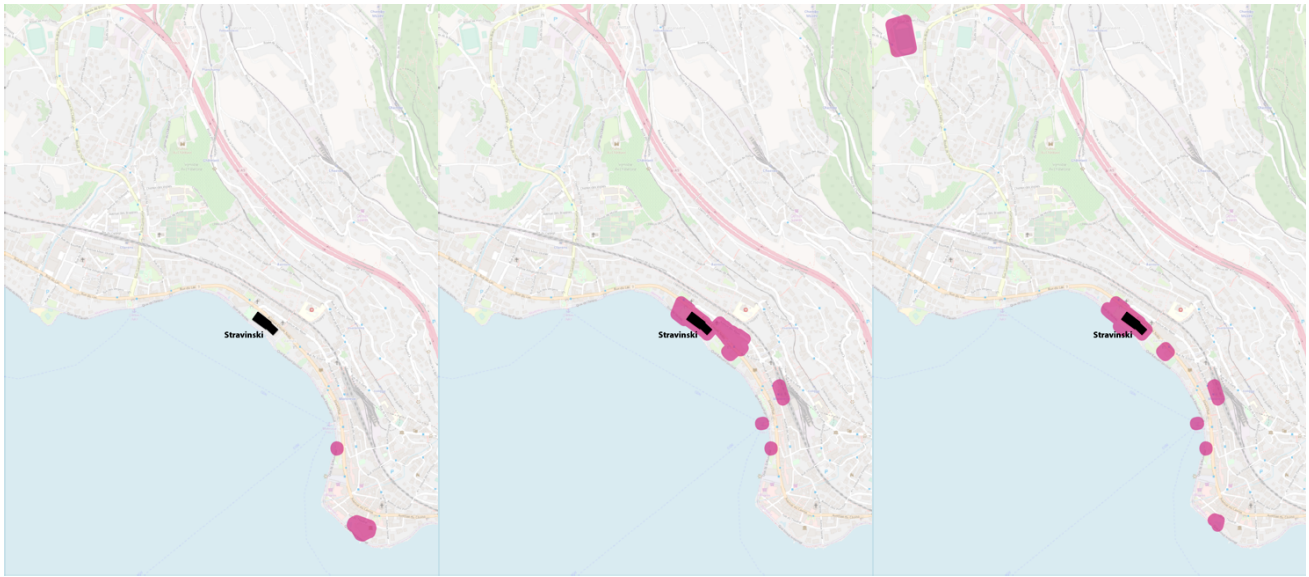

Figure 7. Analysis of the evolution of areas affected by the Festival (territorial grip). Note: From left to right: 1990, 2000, and 2019.

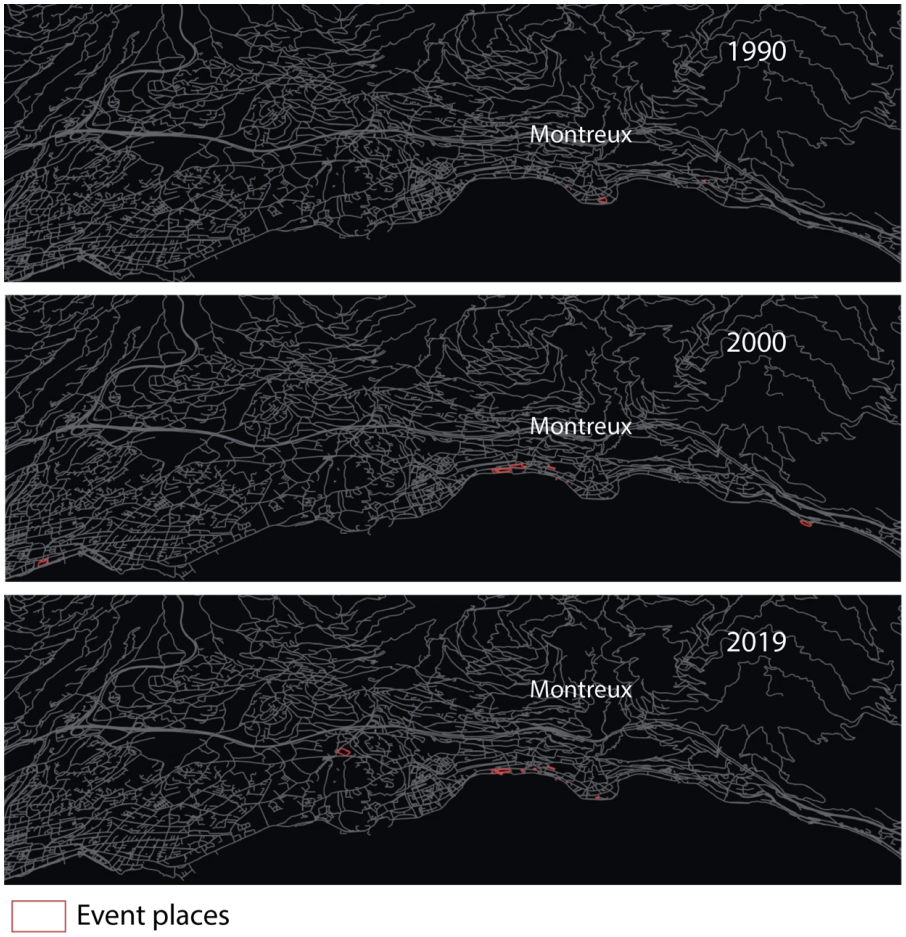

Figure 8. Visualisation attempt using the Time Machine tool.

spaces of the Festival. The choice of developing the lakeside as the public space of the Festival appears not only as a scenic choice but also as a good compromise with the localisation of the Festival.

At an operational level, the analysis suggests that the spatiotemporal system of the event has become more complex over the years. From this point of view, it is a relevant analysis tool for planners in terms of evaluating and forecasting their regulation systems. Also, the visualisation created using the Time Machine tool also makes it possible to revive the collective memory by highlighting significant events that have influenced the historical rhythms of expansion of the Montreux Jazz Festival.

5.2. Analysing Performance Rhythms of the Event

The second result developed in this article refers to the measurement of cyclic rhythms during the Festival held in the summer of 2019. The analyses are primarily based on the ticket scanning carried out by the Montreux Jazz Festival security teams. The scans show the access to the paid-for stages (day, time, and site). Also, the analysis of transaction data relating to the consumption rate of drinks makes it possible to measure the attendance at the free-access Festival venues. This involves bars and restaurants in particular. For this part, and depending on the available data, the analysis focused on the 'Music in the Park' stage. With a capacity of 3,000 and its central position at the heart of the Festival, this venue receives a significant percentage of festival-goers. Therefore, the analysis of transactions made at this establishment gives a relatively representative overview of the Festival's busy periods. The joint analysis of these two sets of data makes it possible to put into perspective the rhythms of the Festival in different time scales: the period of the Festival, weekdays, and weekend days.

Based on the ticket-scanning data (Figure 9), the second analysis shows the average attendance intensity according to the days of the week and weekends during the Festival period. The two curves follow equivalent trends. Indeed, for weekdays and weekend days, the maximum attendance intensity is between 19:15 and 20:00. On average, during this period, about 600 people per hour flock to watch the show. Complementary analyses also show that this rhythmic pattern is repeated throughout the days of the Festival with relatively variable intensities. Behind this variation in intensity is the effect of programming on audience attendance. Fixed-time programming tends to concentrate the audience for a relatively short period on both weekends and weekdays.

The analysis presented in Figure 10 shows the average number of transactions made during the day on

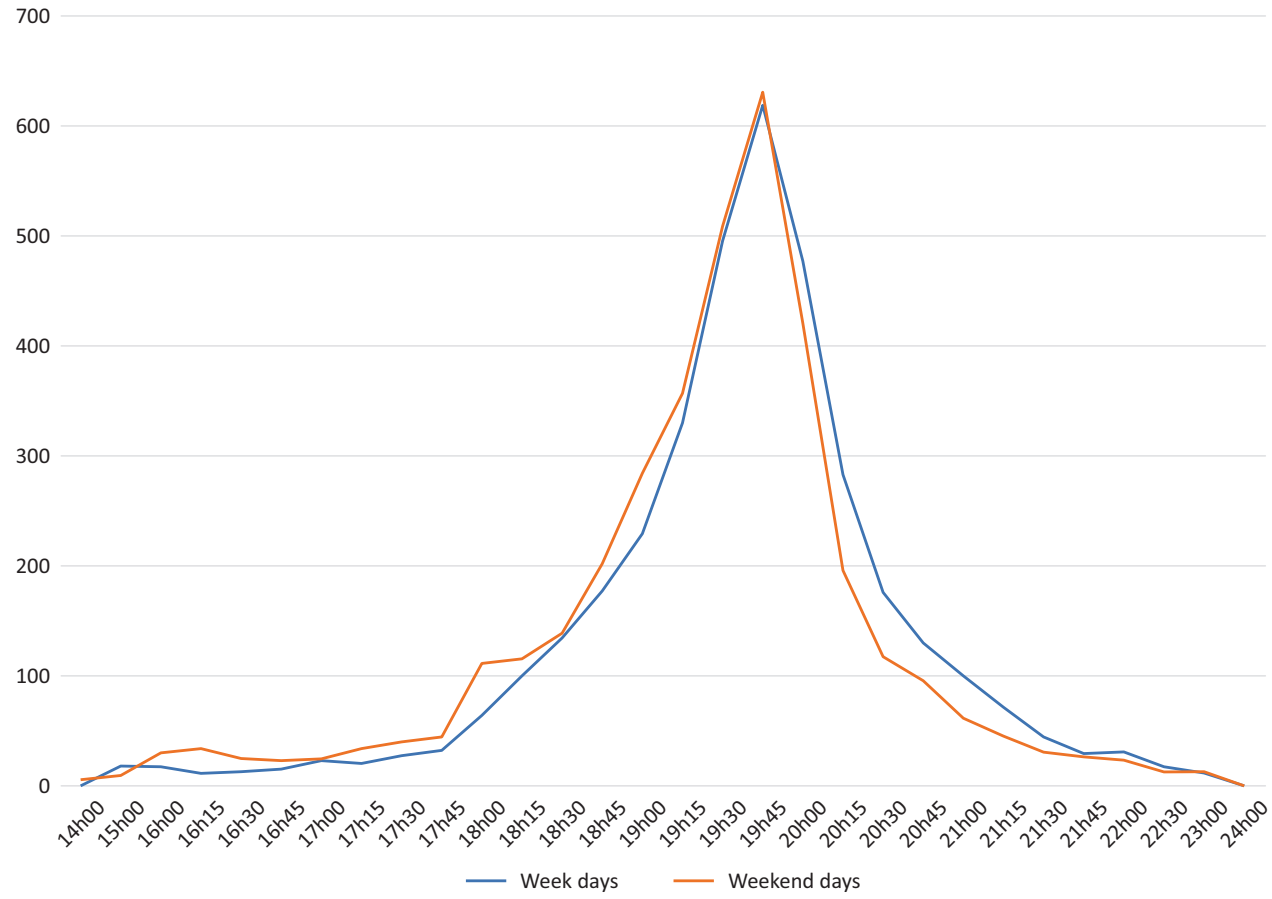

Figure 9. Average attendance according to the time of day (data from ticket scanning).

Figure 10. Average number of transactions according to the times of the day.

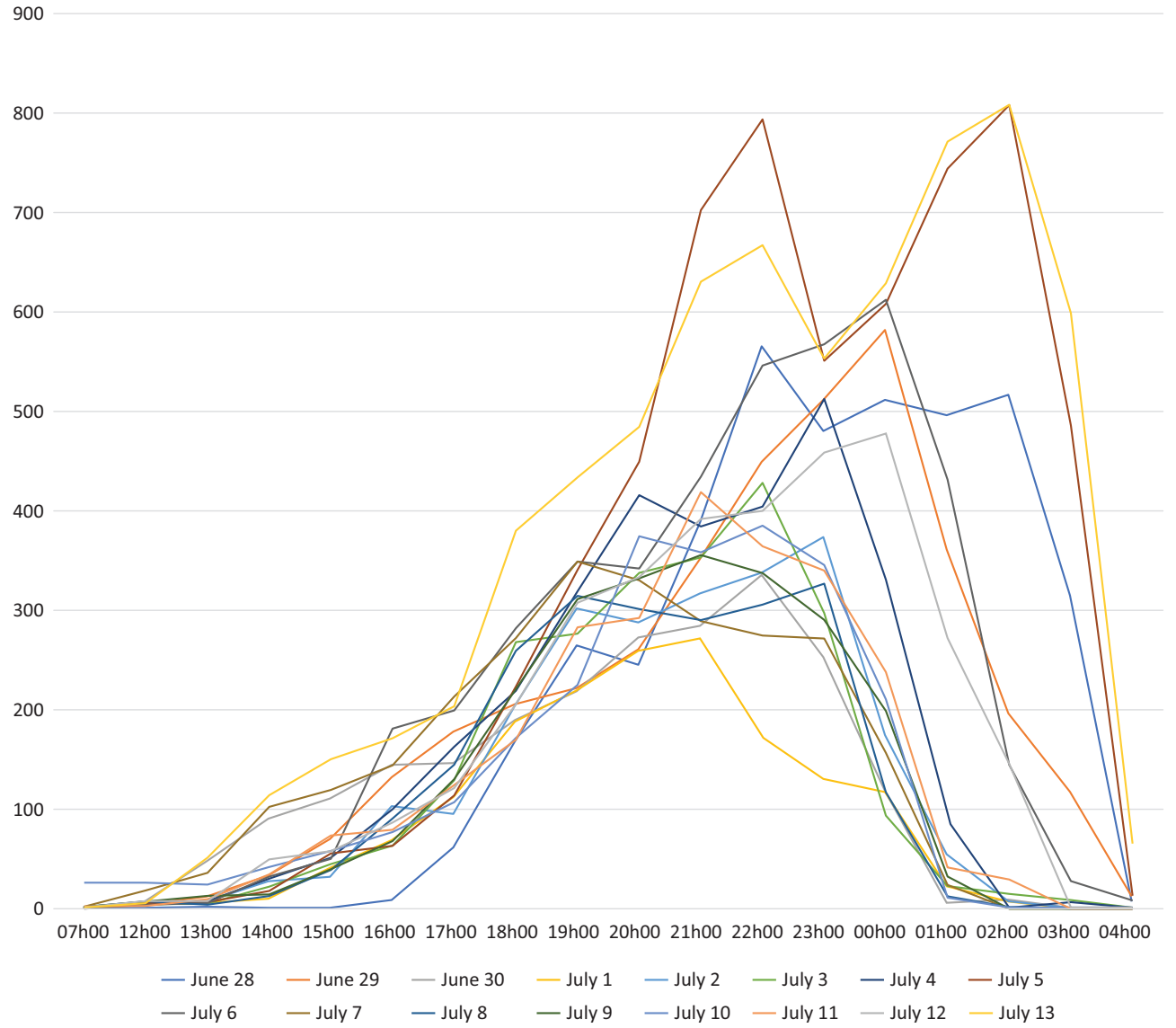

Figure 11. Number of transactions according to the days of the Festival.

weekends and weekdays. The two curves also follow equivalent trends. Compared to the previous analysis, an important contrast is observed. The increase in attendance appears less sudden than in the first analysis. Indeed, the number of transactions increases progressively from about 13:00 and decreases more abruptly from midnight to 1:00. Also, the greatest rhythmic intensity in terms of transactions occurs later during the weekend. This result indicates a more progressive attendance compared to ticket scanning.

Complementary analyses on each of the days of the Festival (Figure 11) show particularly contrasted rhythmic configurations. Even though for all of the days, the progressive growth in the number of transactions tends to start at around 13:00, the rhythmic peaks are more strongly contrasted in their temporal registering and intensity. For example, the days of the 5th (Friday) and the 13th (Saturday) July 2019 have the greatest intensities and the longest temporal spreads. This second analysis confirms the hypothesis of cyclic rhythms that repeat throughout the days of the Festival. However, these rhythmic regularities tend to be more or less intense depending on weekdays or weekends. This differentiation between the week and the weekend invites us to reflect, beyond the effects of programming, on the more fundamental rhythms of the leisure practices of which such Festivals are a part. In fact, programming schedules—and audience practices—do not deviate much from usual weekday or weekend outings. The Festival does not use new rhythmic forms such as, for example, the dawn concerts that take place in summer at the Bains de Pâquis in Geneva.

6. Conclusion and Discussion

In this article we followed up recent calls to develop a rhythmanalysis of urban events, shifting away from the sole focus on everyday urban rhythms. Such a rhyth-

manalysis is necessary to account for the temporary and lasting effects of large events on the spatial and temporal organisation of cities, a question that has become a major concern for urban development (Richards & Palmer, 2010). As discussed in the first part of the article, this rhythmanalysis is based on the idea that the development and regulation of such events imply active processes of connecting and ordering—in time and space—the various entities engaged in its performance. We consider 'rhythmic scales' as both the process and the outcome of such reconfigurations producing new 'hyperscalar,' 'hyperspatial' and intense urban territories, what the French geographer Michel Lussault (2017) calls "hyper-places." Rhythms appear as an inherent and key feature of the composition of heterogeneous urban assemblages.

The visualisations show the expansion of the concerned territories along the shift of its centrality. Those evolutions had lasting effects on the Montreux urban fabric (re-localisation of its commercial centre, public space rehabilitation, leisure practices), but they are also the reflection of the transformation of the Festival policy as since the 2000s it began to be conceived as a broader open-access public fair where a large part of the public never enters the paying areas. This expansion of the concerned spaces and public lead to other rhythmic performance modifications such as the temporary transformation of the Public Transport offer (night service, increase of the frequency) at the regional but also national level. On a more institutional level, social workers now have to work all night long to monitor teenagers who hang around the event. Along with the fire service, policemen, and special public units, there is a large network of involved actors that are directly paid by the city of Montreux, reflecting the central dimension of the Festival for their branding and touristic policies. The performance rhythmic scale is therefore particularly concerned with how the public has access to the event and takes its place within it. The combined analysis of ticketing and transaction data shows the alternance between high and low-intensity periods. These allowed us to confirm the impact of programming on flows, but also the effects of the wider organisation of the leisure system.

The continuation of this reflection between the rhythms of the Festival and the wider societal rhythms seems essential to us. Indeed, the Festival is part of the twofold framework imposed by the rhythmic scales of work and leisure. Generally speaking, the rhythm and supply of transport in European cities is calculated based on work needs. The challenge for major events is to fit these rhythmic scales into this established framework: adapting the transport supply but also the pedestrian flows. From an operational perspective, the articulation of these different rhythmic scales is central to improving event management, but also to thinking more broadly about the ripple effect of such an event on urban development. The immediate and distant resonance of the event, meaning its power as a hyper-place, is, therefore, the result of the confluence of different rhythmic issues such as programming, systems for allocating seats for concerts and, more broadly, the organisation of leisure practices. Each of these elements refers to specific performance regimes, and thus require work on the event's rationales, its planning tools, and its regulation devices (Viot et al., 2010). Only an increase in the number of these 'levers' is capable of influencing the rhythmic scales of the Festival and its inclusion in an ideal policy of large events. Urban event policies are thus in urgent need of visualisation tools capable of showing the articulation of the temporal and spatial effects of events and how they produce the renewed scales of the territorial commons.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Editing Cumulated Landscapes: Point Cloud Modeling as a Method of Analysis in Landscape Design

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Abstract
Pragmatic planning juxtaposed with conflicting agendas has led to metropolitan territories with little quality for urban life. Rapidly growing urban agglomeration, synchronous with the Great Acceleration of the global society, is causing massive landscape change leading to radical breaks with traditional landscapes. By drawing from the formal properties of the environment that include existing qualities, it is possible to develop solutions that respond to both a broader and more specific context. The method resorts to laser scanning technology to produce three-dimensional point cloud models and use them as a prospective medium to perform informed transformations in the landscape. Laser-scanned 3D models can help take advantage of subtle topographic differences to support water management, capture significant site features, and provide an accurate site inventory that could reduce the cost of displaced terrain and replanted trees. The article discusses how point cloud models can support the site investigation as part of a digital design method in the field of landscape design. The approach engages formal characteristics of a physical landscape and results in a transformative workflow linked to the survey and the analysis of the site. By using modes of visualization and coloring to emphasize shapes, densities, and heights, the model can reveal relevant landscape features and patterns that are otherwise not noticeable. Section 1 introduces the methods used in other disciplines; Section 2 provides explanations about how the methods apply to a case study in landscape design; Section 3 presents the possibilities offered by the approach to integrate formal characteristics of the environment during the design process. Design development based on documented features in the point cloud model increases the control to shape environments that contribute to the process of accumulation occurring in the landscape.

Keywords
change detection; digital landscape design; geometric analysis; geometric documentation; point cloud modeling

Issue
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1. Introduction

The perpetual transformation of landscapes by the people who inhabit them constitutes a fundamental characteristic in the morphology of the landscape. The idea that anthropogenic activities shape the environment promoted the concept of cultural landscapes (Sauer, 1925). Cultural landscapes embody a historical accumulation and, with the growth of societies, evolved to become specialized landscapes at large scale (Conzen, 2001). The continuous adaptation of cultural development to the changing conditions of terrestrial dynamics has called for more holistic views that blend the dualism of natural and artificial landscape formation (Ingold, 1993).

The cartographic view of the environment influences the temporal perception of landscape transformation. Attempts to include imprints of time were explored with the layering of geologic maps that lead to a prospective use of overlay maps in landscape design (Berrizbeitia, 2014). At the same time, the cartographic representation

of the territory weakened the understanding of space, which regressed to a flat and set concept (Massey, 2005, p. 28). In reality, the process of accumulation occurring in the landscape is a diachronic process that continues to form the land (Corboz, 1983). The analogy of the palimpsest describes the process of progressive erasure and overwriting that forms a place by comparing it to partially-erased writings that have been covered by a new one. The analogy explains the phenomenon of accumulation, but it does not specify the relation that may exist between accumulated residues of older landscape forms. The entanglement physically manifested in architectural palimpsests is more likely the result of a succession of preconditioned states (Ooijen, 2019). Like architectural palimpsests in which residues of old forms are absorbed in the new layout of walls, residues of the former site configuration become part of the transformed landscape.

Any design aimed at transforming the landscape contributes to an ongoing accumulation of environmental and anthropogenic changes. It is hence useful to explore how the accumulation, physically manifested in landscape forms, can be addressed during a design process. In the context of urban renewal, the transformation of a site ensues from an assessment followed by particular decisions on preservation or replacement (Lynch, 1976, pp. 29–41). In the field of landscape design, a similar relation to the environment calls for specific management of site characteristics. Consequently, information is collected by surveys to undertake landscape analysis that encompasses parametric, areal, and historical approaches (Stahlschmidt, Nellemann, Primdahl, & Swaffield, 2017). Landscape analyses use generic modes of representation to study the physical configuration of the landscape and often fall short of addressing specific forms of landscape features, such as the varied vegetation of a grove, the form of a rocky riverbed, and the feeble but consequential human alterations to the environment. The capacity to document the landscape form influences the decision of which landscape features are to be included or removed in the design. The absence of specificity when giving form to a new landscape during the design process results in a conceptual break between form and information. The methods of geometric documentation and geometric analysis with 3D models open the possibility to include accumulated properties of a site in the design process.

1.1. Geometric Documentation

Various disciplines indirectly analyze an object or a site using geometric documentation. The approach, also referred to as geometric recording, consists in producing a digital 3D replica based on measures. It is used in heritage conservation to register the position and the shape of monuments at a particular moment in time and helps to provide necessary information for inventory and research (International Committee of Architectural Photogrammetry, 1972). A range of acquisition tools for surface measures enables the production of 3D geometric records (Georgopoulos & Stathopoulou, 2017). Laser-scanning technology can be combined with photogrammetry to document the form of heritage sites such as historical pavements (Martínez, Ortiz, & Gil, 2015), heritage monuments (Bariami, Faka, Georgopoulos, Ioannides, & Skarlatos, 2012), and large-scale historical settlements (von Schwerin et al., 2016). The approach applies to other fields that require measured 3D models to investigate the form of objects, such as monitoring tunnel excavations (Gikas, 2012) and measuring topographic surface change (Lague, Brodu, & Leroux, 2013).

The quality of 3D models produced for geometric documentation depends on the occlusion, the precision, and the resolution of the measures, prompting to select the appropriate tool to acquire the object of study (Boardman & Bryan, 2018). The survey of complex environments such as tiered vegetation and urban landscapes has experienced a leap in definition with laser-scanning technology that acquires surface measures at a long range and penetrates porous geometries. Airborne laser scanning measures the land cover with multiple returns and simultaneously reaches and documents the ground (Liu, 2008). The technology has thus been useful to reveal marks left by the passage of time in large-scale landscapes (Mlekuž, 2013). Meanwhile, in the context of landscape planning, small topographic differences can have severe implications for land management. For this reason, institutes carry out scanning missions on a regional scale for purposes such as to assess the flood risk in the Philippines (Blanco, Tamondong, Perez, Ang, & Paringit, 2015), to monitor water flow and dikes in the Netherlands (Nationaal Georegister Netherlands, 2007, 2014), and to supervise coastal areas in the United States (Davidson & Miglarese, 2003).

1.2. Geometric Analysis

The 3D geometric record of a site enables an indirect analysis of its geometry. Laser-scanned geometry in the form of point cloud models can be analyzed to classify and separate terrain points from vegetation, buildings, and unconventional types of geometry (von Schwerin et al., 2016). A detailed analysis distinguishes geomorphological elements based on their geometric properties across multiple scales (Brodu & Lague, 2012). Once filtered, the bare geometry of the terrain can be visualized by elevation or by local relief shadings to emphasize meaningful features (Chase, Chase, Fisher, Leisz, & Weishampel, 2012; Evans et al., 2013; Hesse, 2010). The vegetation geometry in point cloud models provides the assessment of the habitat structure for animal species diversity (Simonson, Allen, & Coomes, 2014), the separation of vegetation clusters (Cabo, Ordóñez, García-Cortés, & Martínez, 2014; Cabo, Ordóñez, López-Sánchez, & Armesto, 2018), and volume estimation of individual trees (Lefsky & McHale, 2008).

In addition to inspecting the geometric characteristics of point cloud models, the geometric comparison of datasets recorded at different intervals can determine how much the site has changed in time (Mukupa, Roberts, Hancock, & Al-Manasir, 2017; Okyay, Telling, Glennie, & Dietrich, 2019). The precision of change detection depends on the data quality of the 3D model (Kromer et al., 2015) and implies high standards for producing geometric documentation, since noise such as irregular surfaces recorded by photogrammetry may introduce errors (Du et al., 2016; Stal, Tack, Maeyer, Wulf, & Goossens, 2013). Detecting the change in the canopy profile can indicate the growth rate of forests (Yu, Hyyppä, Kukko, Maltamo, & Kaartinen, 2006) and variations in the complex topography of landslides (Lague et al., 2013). For the analyses on both shape and change, a majority of studies will rather work with projected and filtered data such as digital elevation models. However, the data translation, the low sensitivity, and the one-dimensional comparison of changes could lead to a potential loss of information (Mukupa et al., 2017).

2. Methods

It is becoming common practice for designers to personally collect spatial data of the site with the support of laser scanning devices (Rekittke, Ninsalam, & Paar, 2015). The modeling process, based on the ability to collect, append, densify, and update data from the site, offers the possibility to develop a holistic understanding of the space (Pirokka, Ellis, & del Tredici, 2015). In the context of urban landscapes, such understanding is necessary to mend modern cities that were fragmented, among other things, by functionalist planning practices (Girot, 2006). Geometric documentation of the environment offers clues to past and ongoing events occurring in the landscape. In studies on archaeological landscapes, large-scale data acquisition by airborne laser scanning provides information to explain how anthropogenic transformations and constructions appear in the terrain. The vegetation layer, of little interest for such studies, is therefore filtered out (Doneus & Briese, 2011). In contrast, a project development in landscape design encompasses the complete physical form of the site in transformation, including features of varying kinds and duration.

2.1. Geometric Documentation of the Environment

The physical form of the landscape can be separated in two principal categories that are the landform—topographic shapes from small-scale ditches and slopes to large-scale riverbeds and valleys—and the land cover—from grasses, shrubs and fences to forests, power lines, and buildings. Consequently, the survey with laser scanning technology aims at producing 3D geometric documentation of both categories and must be planned accordingly to ensure that features are recorded with an adequate extent and point density (Boardman & Bryan, 2018, pp. 44–53). For the use of point cloud models in landscape design, the minimum distance between points should ideally be about 25 cm to distinguish smaller objects, such as fences and light poles, and detailed forms, like the vegetation structure and steps in the ground. High-density datasets like the aerial laser-scan of the city of Dublin (Laefer et al., 2013) provide detailed documentation of both the topography and the form of the above-ground urban inventory but are very rare. However, surveys with aerial laser scanning are occurring in an ever-growing number of regions and have densities of 50 cm or less between points, which already provides a useful definition for large-scale landscape design. In locations where these datasets are not available or are of low density, terrestrial laser scanning can be used to produce the missing information. The survey with terrestrial laser-scanners might be an arduous and time-consuming operation, depending on the extent and the complexity of the site, which must be scanned piece by piece from strategically defined positions to reduce occlusions. The resulting datasets are then registered together with algorithms such as the Iterative Closest Point (Besl & McKay, 1992) to form a continuous topology of surface measures. Practical procedures are described in various literature (Boardman & Bryan, 2018; Crutchley & Crow, 2018; Vincent, Bendicho, Ioannides, & Levy, 2017).

To be used as a 3D model for geometric documentation, raw laser-scanned data requires a basic preparation that includes the removal of noise and the registration of overlapping scan sources. Noise, moving objects, and imprecise registration could trigger false positives during geometrical change detection. The quality of point cloud models, determinant for the analysis of geometrical features, is commonly affected by scanning procedures such as a high angle of incidence (Boardman & Bryan, 2018, pp. 26–30). Especially in the case of near-ground terrestrial laser-scanning, the radial point distribution combined with a grazing incidence to the terrain will affect the point density significantly at an increasing distance. The geometric documentation as a 3D point cloud model is a representation of the present form of the landscape, as natural processes and human activities have shaped it over time.

2.2. Geometric Analysis of Landscape Features

The analysis of the geometric documentation is useful to highlight features of the point cloud model. The analysis requires a point cloud model with a sufficiently dense and continuous point distribution to support the identification of geometric features. Visual documentation with laser scanning might appear very similar to geometric documentation when they are compared in the right perspective. However, shown in a planar view, the visual documentation omits information essential to reveal the accumulated characteristics of the landscape, such as the depression left by the former railway passing below the road intersection (see Figure 1). Missing data has to be

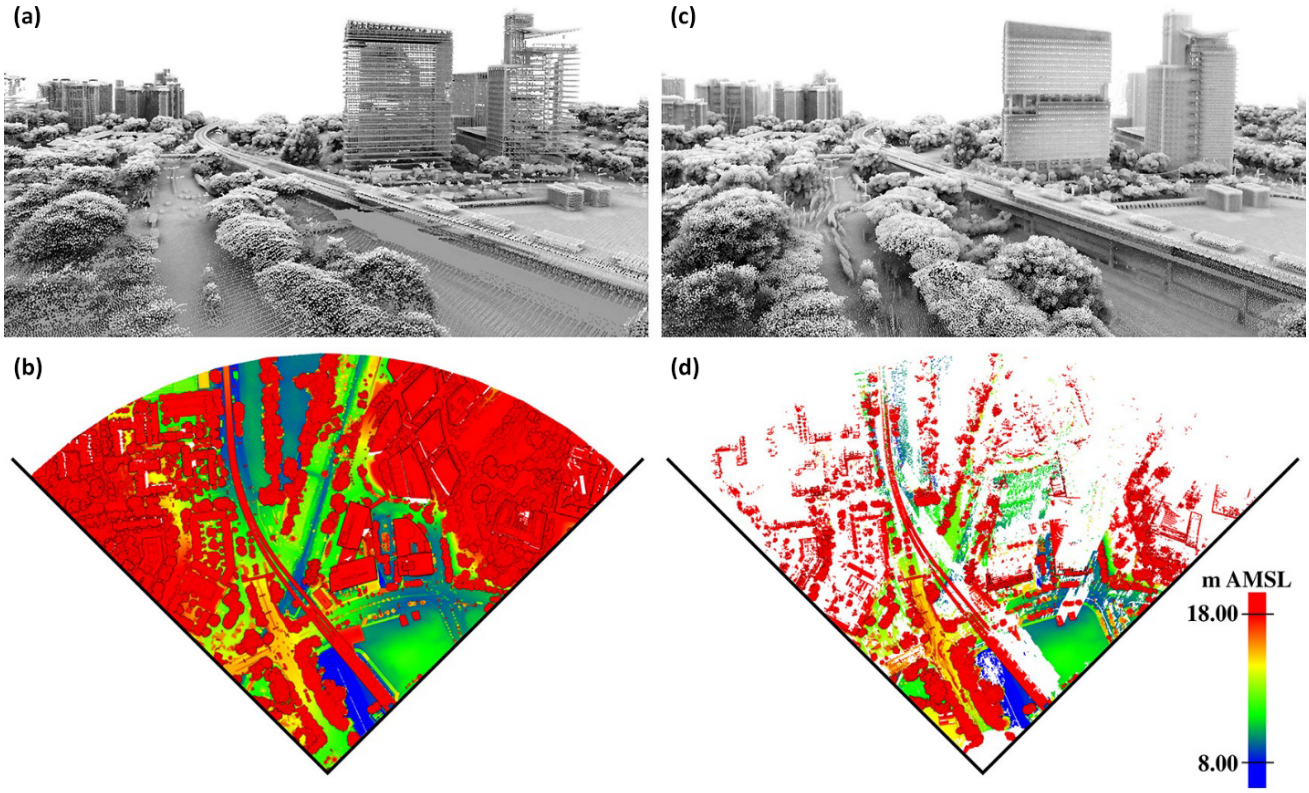

Figure 1. Geometric and visual documentation of a landscape near the Buona Vista station in Singapore. The point cloud models were recorded with aerial (a, b) and terrestrial (c, d) laser scanners. Data combined from three terrestrial scanning locations on rooftops close to the viewpoint of the perspective (c), are suitable for visualization purposes and resemble the perspective view with the aerial data (a). Explicit in plan view, there is insufficient information on features relevant to landscape design, as the topography is mostly occluded and trees are scanned on one side only (d). There are fewer occlusions during aerial laser scanning, which only needs to penetrate about 30 m of vegetation height to document the vertical structure and canopy (b).

compensated by combining different scanning locations. This process can be expensive and time-consuming for large-scale landscapes with a high amount of occlusions to cover and with locations sometimes difficult to access.

Geometric features are displayed on point cloud models with scalar values. Each point can store scalar values based on the laser pulse—e.g., the intensity and the number of returns—or based on the scanning procedure, such as the scan direction and scan angle (ASPRS, 2019, Version 1.4–R15). A further type of scalar values can be computed from the geometric analysis of point cloud models. For example, the elevation of the model can be computed along the Z-axis to visually emphasize details otherwise difficult to notice (e.g., Mlekuž, 2013). The elevation can also be calculated relative to the distance of a reference object such as the topography, as it is the case for calculating the height above the ground of the tree canopy (e.g., Yu et al., 2006). To compute the height of objects, the ground needs first to be identified as such, which can be done with classification algorithms (e.g., Uysal & Polat, 2014; Zhang et al., 2016). The classification of ground points is necessary to expose the topography and analyze its geometric properties.

2.3. Geometric Change Detection in Landscape Transformations

The method of geometric change detection is used to show how a design physically implemented in the landscape is manifested in a 3D model. The result indicates how 3D point cloud models can be manipulated for prospective use in landscape design to operate a physical transformation between two moments in time. A pair of point cloud models recorded at different times on the same site is compared geometrically with a fine registration and a distance calculation, both performed in this case with the processing software Cloud Compare (Girardeau-Montaut, 2019). Occlusions and unequal extents may cause the analysis to detect false positives. Therefore, the compared point cloud models must have an equivalent coverage area and point density. First, the point cloud models have to be precisely aligned using the fine registration that is applied through a rigid body transformation (Besl & McKay, 1992; Rusinkiewicz & Levoy, 2001). One model is taken as a reference and remains in position while the algorithm minimizes the point-to-point distances of the second model iteratively by apply-

ing translations and rotations. After a successful registration, one model is again taken as the reference, and a distance calculation is computed in relation to the second point cloud model. The distance calculation is saved as a new scalar field displayed on the geometry of the compared point cloud model. Adapting the threshold of the scalar field highlights the geometry that has changed more than a given distance. It is worth noting that the comparison is meaningful only when applied to comparable geometries. If buildings have replaced trees, the distance comparison between the two models will show that parts of the buildings look wrongly unchanged as they coincide with the former position of trees. Features need therefore to be separated by classification, as explained in the previous section, before comparing the distance separately for topographic, vegetal, and built features.

The geometric change detection applied to comparable features helps to evaluate physical changes to the landform and land cover. The transformation of Fort Vechten by Jonathan Penne Architects and West8 illustrates how a design implementation influences the landscape. The project, completed in 2016 near Utrecht, transforms the historical fort to include the National Waterline Museum. The comparison of two aerial laser-scans of the Netherlands by the Dutch register reveals to what degree the topography and the land cover of the former fort were transformed (Nationaal Georegister Netherlands, 2007, 2014). The aerial laser-scanned data already included classification and geolocation. The scalar fields based on the distance between the geometries revealed changes applied with great attention to the slopes of the fort and the trees (see Figure 2).

The transformations visible in the laser-scanned model coincide with specific design intentions. A 90 m × 450 m cut in the vegetation, not fully completed at the time of the second scan, was being made to reveal the former look of the bare military earthwork. The topographic modifications restored the deteriorated earthwork according to the original fort design. A new car park has been leveled for visitors at the new north-east entrance of the fort. Excavated terrain was moved west to

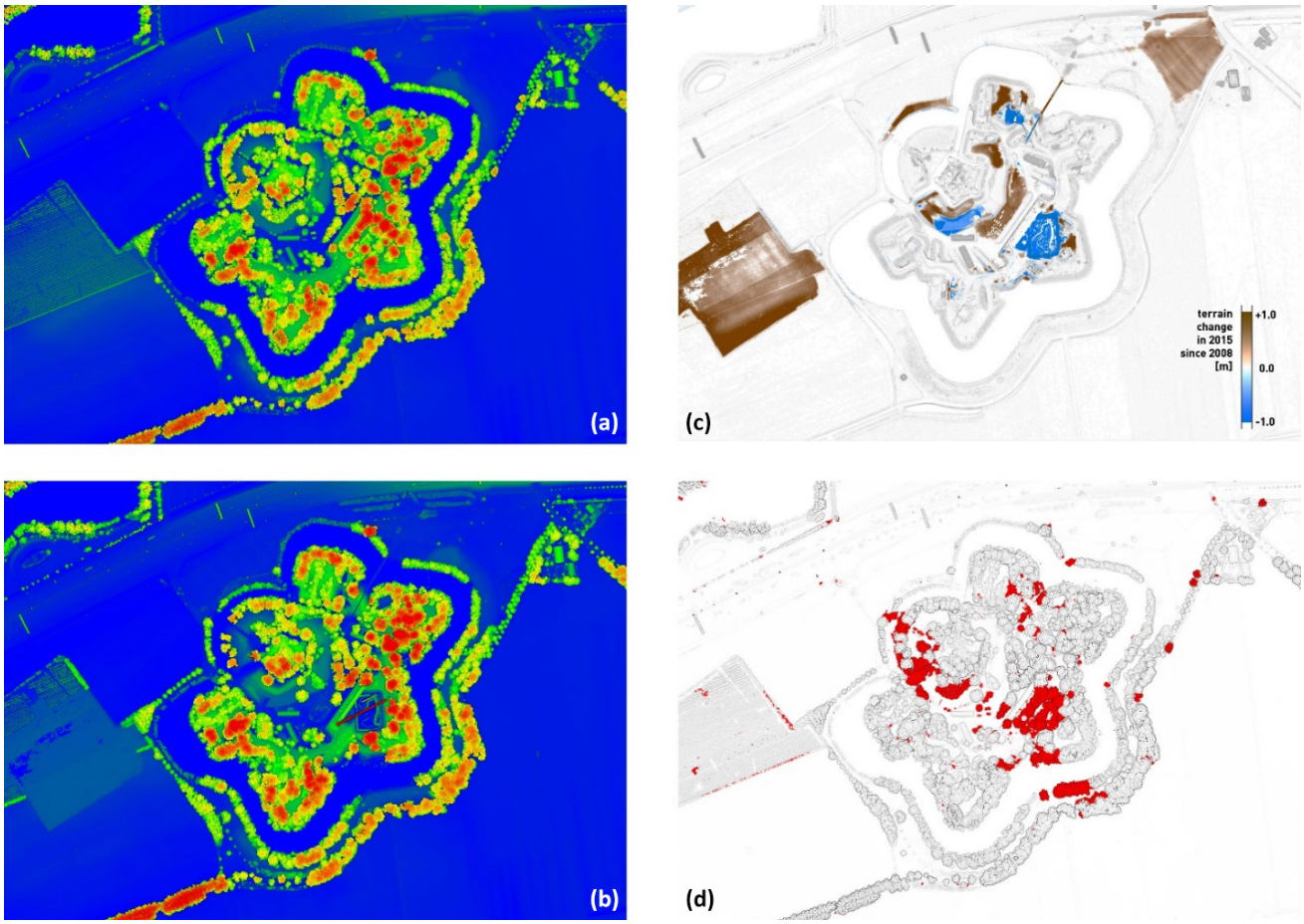

Figure 2. Change detection between point cloud models shows a landscape design implemented at Fort Vechten, in the Netherlands. The two models, shown in plan view, were produced from the aerial laser scanning data collected by the Dutch government in 2008 (a) and 2015 (b) and are colored by height (0–30 m AMSL). A geometric change detection, performed on ground points only, highlights the terrain volume that has been added or subtracted by 1 m height or more on the 2015 point cloud model (c). The distance calculation of 2 m or more highlights the trees removed since the 2008 record (d).

a nearby field to minimize the transportation costs and later partly reused, as confirmed by the designers. The change detection between several geometric records shows how a point cloud model can be modified to correspond to physical changes. The design process involves a prospective use of the 3D model that goes beyond the descriptive role of point cloud models representing a set moment in time.

2.4. Application in Landscape Design

Methods of geometric documentation and analysis were applied during a design studio. This section illustrates how the methods presented above are used for design investigation by following specific steps (see Figure 3). The assignment consisted in developing the open space along a former railway crossing the island of Singapore to mitigate the urban heat with new landscape configurations. Design development relied exclusively on the medium of point cloud models. The first two steps consist in acquiring laser-scanned data and preparing it as a model. Data personally collected from rooftops surrounding the railway with a long-range terrestrial laser scanner was registered onto the georeferenced airborne laser-scanned data from the government (Singapore Land Authority, 2014). The datasets (see Figure 1) were then cleaned from atmospheric noise and moving objects for the geometric documentation of existing topography and vegetation structure. The colors of the aerial dataset were interpolated in 3D from the terrestrial dataset or projected in 2D from aerial images, where the former was missing. The resulting 3D point cloud model was made available to the studio in the form of LAZ files (Isenburg, 2013) and on the visualization platform Potree (Schuetz, 2016). Geometric documentation visualized in three dimensions provided us with a base to understand landscape forms and to inspect details during studio discussions, such as the water drainage of a plot or probable breezeways in the existing vegetation. The platform enabled us to visualize transects and to take measures in real-time (Scheiblauer, 2014). The transects expose spatial correlations of landscape features and were used to systemically extract sections through the model. Measures were taken to determine the size of the road and water infrastructure and to investigate the flow direction in water channels with minimal inclination.

The next step consists of geometric analysis. The visualization of elevation values enabled different observations by changing the threshold of the scalar field. Students were able to highlight landforms too large, complex, or subtle to grasp, such as the graded hillsides of the Kent Ridge, the drainage network near the Alexandra hospital, and the traces of a former railway junction in Bukit Timah. Although we received the aerial data with the classification of ground, vegetation, and built objects, the quality of the terrestrial dataset was found to be inadequate for classification as extensive occlusions of the terrain (see Figure 1) would have led to misinterpretations. Using Cloud Compare, the analysis of geometric properties was therefore only performed on the aerial dataset, since the computation of height above ground, planarity and normal orientation requires geometric documentation with a continuous point distribution and the classification of ground points.

In the last step, analysis of the geometry allows us to disassemble point cloud models. Due to their particle structure, the models are well-suited for segmentation based on sections, classifications, filtering, and manual segmentation. The scalar values computed from the geometric analysis allow us to perform selective segmentation and extract chosen portions of the existing landscape. The scalar values are filtered by their range and enable the disassembly of the model in geometrically defined groups. In this way, we could integrate and configure useful landscape features anew during the ensuing modeling process.

3. Results

Although it is difficult to assess the influence that the methods have on all decisions made during the design process, the geometric change detection allows us to compare the laser-scanned models of the site and the manipulated point cloud models produced

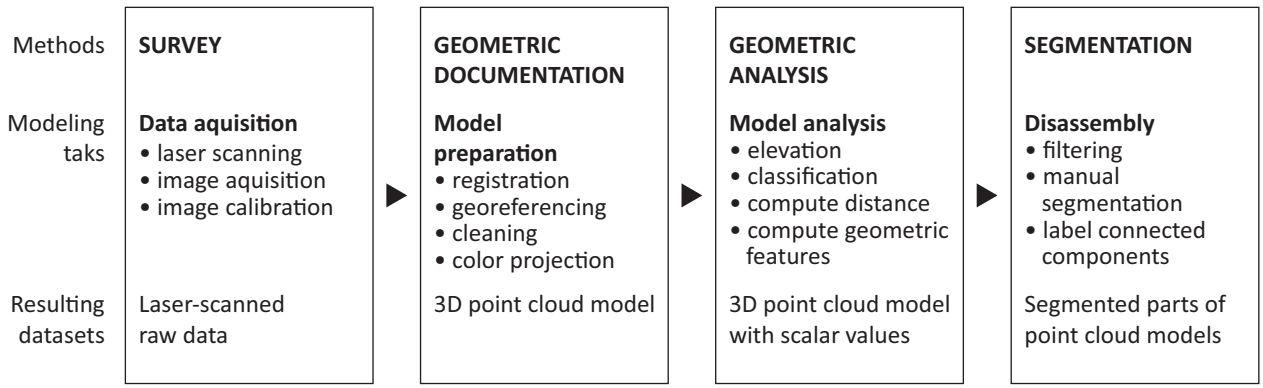

Figure 3. Steps to use laser-scanned data as a source for geometric documentation and analysis for an investigative purpose in landscape design.

at the end of the studio. The geometric change detection reveals landscape transformations envisioned through manipulated point cloud models (see Figure 4). The comparison highlights a series of approaches that carefully manage site characteristics by keeping selected features in their georeferenced position. The approaches can be distinguished between landform and land cover transformations.

Landform transformations have three different approaches to handle existing topography. The approaches consist of an extensive alteration, a selective replacement, and the preservation of existing landforms. First, an extensive alteration of landforms occurs through the change of more than 30 cm in height to the terrain surface, e.g., modeled in Rhinoceros 3D (McNeel, 2018, Version 6.0). Despite the high degree of change that may alter the perception of the site, this transformation is not a tabula rasa since it evolves from the existing topography taken as the starting point for the manipulation. This approach applies to the case of the canal south of Alexandra Hospital, whose engineered edges were reshaped into a soft topography (see Figure 4). The altered landform is always connected seamlessly to the unchanged topography. Second, a selective replacement of landforms involves the interweaving of topographic changes with the existing terrain. The example of Fort Vechten (see Figure 2) shows that landform transformations, being expensive, can be strictly local, and yet result in significant changes. A similar approach took place in the Wessex area along the railway, where the elevated topography, occupied by former military barracks, was segmented by elevation to be conserved. Third, many areas of the manipulated point cloud models preserve existing landforms. However, depending on the surface treatment, these landforms have not necessarily remained intact. For example, scraping them clean of vegetation by using classification values required smoothing their surface to make them aesthetically pleasing. This approach provided the opportunity to retain portions of the graded slopes, reminiscent of the former railway, by filtering out high dip values computed through the normal orientation of ground points.

Land cover transformations offer two approaches for addressing existing vegetation and buildings, either by using them as a context for adding features or transforming them through the selective removal of features. First, the contextual addition consists of inserting landscape features within the existing context. Visual appreciation of the point cloud model provides the basis for identifying potential open spaces that can be developed by adding features, leading us to make important decisions early in the design process. This approach worked for the conversion of a temporary parking lot (upper-right corner of Figure 4a) into a buffer park with newly-planted trees between Queensway road and Alexandra Hospital. The second approach is a selective removal of land cover features, which is a costly and incisive operation for the identity of the site and therefore needs careful planning. The selective removal involves identifying specific features and removing them in the point cloud model. Topographic transformations inevitably lead to the removal of existing trees. The removal of land cover points above the transformed topography is achieved by computing the cloud-to-cloud distance between the scanned and manipulated terrain, then using the distance values interpolated on the land cover to remove the affected points. This semi-automatic operation is complemented by manual segmentations to correct irregularities. The approach was used to selectively remove vegetation near the corrected edge of the canal after the topography was altered (see Figure 4b). In other instances, where land cover remains unaffected by landform transformations, visual appreciation and geometric analysis of the point cloud model assessed the inclu-

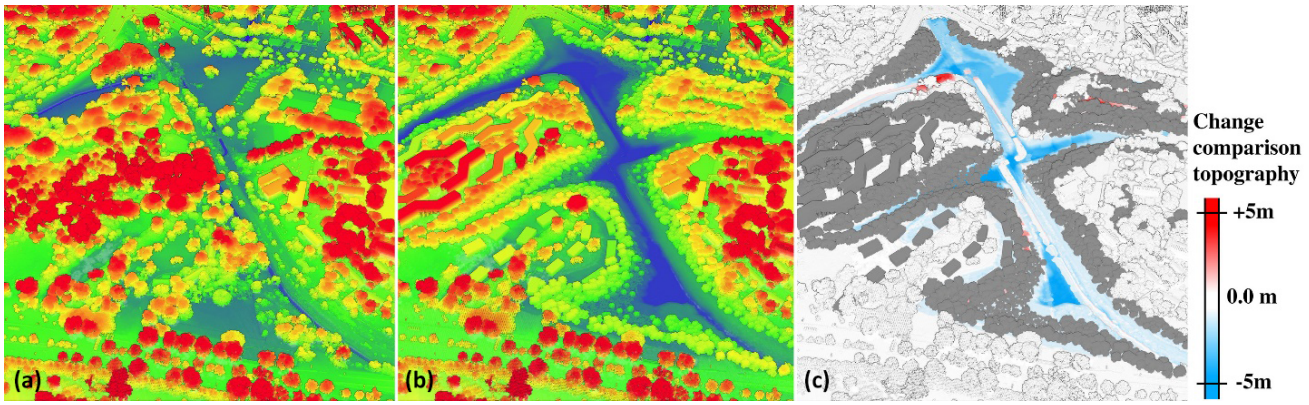

Figure 4. Change detection between laser-scanned and modified point cloud models. A point cloud model from aerial laser-scanned data, colored by height 3–40 m AMSL, shows a 3 m-wide canal (in dark blue) aligned to the former railway (a). The point cloud model is manipulated to improve the capacity of water catchment, shown with the same height gradient (b). The design maintains the original depth of the canal and height of the railway, both colored in white in the topographic change comparison (c). The comparison shows how existing features can be retained locally during the design process, while changes occur in less-significant parts.

sion of existing land cover features. Geometric analysis, like the height above ground, has facilitated the identification of vegetation patterns and possible heritage trees worthy of integration. Tall trees were extracted from the vegetation points by applying a threshold to height-above-ground values and by computing the cloud-to-cloud distance between the canopy above the threshold and the remaining points to extract the base of the trees. This semi-automatic operation required segmentation by hand or by label-connected components to correct probable errors. This approach was useful to identify potential breezeways oriented in the predominant wind direction, across the railway corridor, and to develop them by selectively removing existing trees and buildings (see Figure 4b).

This set of approaches for the landform and the land cover allowed us to make conscious decisions about how to include or transform existing site characteristics that contribute to the accumulation process of the landscape. The approaches were combined in different forms during the design process, resulting in the development of spatially complex solutions, such as the use of existing flyover bridges over transformed topography and the rearranging the vegetation over an existing drainage system.

4. Conclusion

As a discipline of spatial transformation, landscape design has the task of responding to the context in which it operates. It is therefore relevant to integrate site-specific knowledge into the design process from the outset. Landscape change has important consequences for the site, which are sometimes so abrupt that they leave holes in the cultural imprint of the land (Corboz, 1983). Vast urbanization combined with unconcerned planning policies has provoked irreversible breaks with traditional landscapes (Antrop, 2005). As with any planned landscape transformation, even contextually weak designs must respond to the reality of the site, at the latest when they are implemented on the terrain. Although some features of import to the identity of the site may disappear in the course of careless operations, others will eventually prevail over design schemes that have not taken them into account. Modern cities are so young that they have not yet absorbed the long-term dynamics inherent in the landscape, confronting them with increasingly recurring consequences such as floods and urban heat islands.

Although all the landscape design methods currently in use result in the physical transformation of a site, only a few approaches allow us to take a stance on the accumulation that characterizes a site. Technological advances provide deeper insight to understand the accumulation and refine our observations. Digital Elevation models may provide important information on large-scale landscape change, like topographic transformations for land reclamation in Singapore (Wang, Belle, & Hassler, 2015), but are not sufficient to explain the mutual relation between landforms and land cover. Geometric documentation in point cloud models, on the other hand, enables the cultivation of a relationship to the full form of the landscape from the early stages of design. Informed choices for shaping the site can respond to the underlying morphology of the landscape, avoiding contradictory operations. Features revealed by the geometric analysis of point cloud models still require a knowledge of interpretation, also necessary in the identification of archaeological traces (Johnson & Ouimet, 2018). Although the distinction between landform and land cover can be effectively made with software such as Lastools (Isenburg & Shewchuk, 2019), advanced multi-scale classification could strengthen analysis and modeling capabilities for landscape design (Brodu & Lague, 2012; Yang, Dong, Zhao, & Dai, 2015). Semantics are still in their infancy and remain difficult to implement systematically on large-scale landscapes.

From a spatial point of view, landscape designs can extend horizontally over many kilometers but are vertically limited to a few dozen meters above and below existing topography. For this reason, the planarity of maps is often considered sufficient to provide information on changing landscape configurations. Considering a large river like the Mekong on a map does not suggest that it flows in a curve around the curvature of the earth, contained by small topographic variations that cause it to reverse its flow in some segments during a monsoon. Temporal phenomena on a large scale such as flooding, sea-level rise, forest fires, and thermal radiation are determined specifically from the physical landscape structure along the elevation axis and call for adequate attention. The temporal dimension of point cloud models seems to form a contradiction since landscapes are changing while models are continuous (Davis, 2015). But the passage of time is imprinted in the landscape palimpsest, physically formed by processes at multiple scales of time and space. Working with geometric documentation increases the sensitivity and criterion for site-specific design. A design process informed by point cloud models can move central decisions regarding the implementation of a landscape project from the construction phase to the development phase. The application of laser-scanning technology in landscape design opens the possibility of handling the environment as a constructed interlinkage of parts that has different durations and has evolved gradually. In the end, the investigation for landscape design could be less the reading of a palimpsest than it could be the taphonomy of a diachronic construct.

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Conflict of Interests

The author declares no conflict of interest.

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Commentary

The Advent of the 4D Mirror World

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Abstract
The 4D Mirror World is considered to be the next planetary-scale information platform. This commentary gives an overview of the history of the converging trends that have progressively shaped this concept. It retraces how large-scale photographic surveys served to build the first 3D models of buildings, cities, and territories, how these models got shaped into physical and virtual globes, and how eventually the temporal dimension was introduced as an additional way for navigating not only through space but also through time. The underlying assumption of the early large-scale photographic campaign was that image archives had deeper depths of latent knowledge still to be mined. The technology that currently permits the advent of the 4D World through new articulations of dense photographic material combining aerial imagery, historic photo archives, huge video libraries, and crowd-sourced photo documentation precisely exploits this latent potential. Through the automatic recognition of "homologous points," the photographic material gets connected in time and space, enabling the geometrical computation of hypothetical reconstructions accounting for a perpetually evolving reality. The 4D world emerges as a series of sparse spatiotemporal zones that are progressively connected, forming a denser fabric of representations. On this 4D skeleton, information of cadastral maps, BIM data, or any other specific layers of a geographical information system can be easily articulated. Most of our future planning activities will use it as a way not only to have smooth access to the past but also to plan collectively shared scenarios for the future.

Keywords
3D models; Mirror World; photo archives; photogrammetry; virtual globes

Issue
This commentary is part of the issue "Territories in Time: Mapping Palimpsest Horizons" edited by Chiara Cavalieri (UCLouvain, Belgium) and Elena Cogato Lanza (EPFL, Switzerland).

The 4D Mirror World can be defined as a global spatiotemporal platform offering diachronic 3D representations of the entire Earth. In its asymptotic form, it features a quasi-continuous representation of the world in motion, virtually embedding all the photographic perspectives, all the data gathered and simulated, both for the foreseen future and the recorded past. This digital twin of the Earth is an object impossible to see in its entirety, a future world-size machine to live "inside." Its territory is potentially so big that many parts will only be "seen" by machines and not by a single human. The platform does not exist yet, but it already has a long history, being in some sense the extension of century-long enterprises to model cities, landscapes, and territories. It is important to replace its most recent technological developments in the long transformation of the photographic medium enabling not only to document and measure the present but also to build a time-indexed metric model of the past and the future on a planetary scale.

The first key innovation took place between 1860 and 1870, when the photogrammetric method, which combined the technical characteristics of triangulation with the photographic survey, was introduced simultaneously in France and Germany. In 1862, Aimé Laussedat sug-

gested the French administration adapt the surveying methods using photographic measures instead of the traditional geodesic methods. Laussedat, an engineer from Ecole Polytechnique and an astronomy scholar, realized that measurements based on photographs could serve to geometrically map very significant extensions of spatial territories. He first used stereoscopic views, invented by David Brewster in London, during the measurement process by combining them with the principle of Wollaston's polished chamber. Laussedat called this new method *métrophotographie*, the iconometry applied to photographic evidence (Laussedat, 1899).

Meanwhile, in Germany, Albrecht Meydenbauer was applying the principles of geodesic triangulation to the study and preservation of monuments, when he discovered Laussedat's photography instruments. In 1867, he made demonstrations on how photography could be used to survey terrain and architectural objects and coined the term "photogrammetry" to describe this new way of measuring using photographic survey (Meydenbauer, 1869). His work contributed to the largest 19th century photographic archive of cultural heritage in the world and his research led to the foundation of the Royal Prussian Photogrammetric Institute, the first photogrammetric institution in the world. Between 1885 and 1909, the institute took about 11,000 survey photographs of around 1200 Prussian monuments.

Laussedat and Meydenbauer's methods implied taking photographs from different positions, which formed intersecting rays. Homologous pairs of points define underlying pivot points and the internal articulation of all the pivot points allows constructing an underlying virtual model. This virtual reality has a precise geometrical structure as each pivot point could relate to the source photographs and one another through simple rotation and translations.

The advent of photography has made possible not only the development of photogrammetry but also an epistemological revolution regarding cartographic representation. The first aerial photograph of the city was taken by Felix Tournachon, alias Nadar, in 1858 from an aerostatic balloon over the Bievre valley in France. However, the real breakthrough in the technology of photographic representation of urban spaces was introduced by Julius Neubronner in 1903, who patented a system for attaching small cameras to pigeons which, connected to a timer, took photos every 30 seconds. The serial photo for the urban landscape and the aerial photographic survey was born. This invention immediately found application in the military field, and the evaluation of natural disasters, as is the case of San Francisco after the terrible earthquake in 1906. The first photo plan of a city was realized in 1911 by Cesare Tardivo, who documented the city of Venice thanks to the aerostatic balloon. To do so, a "mosaic" technique was developed which from then on was the most used method, and still is today, in other urban cases. Aerial photography has moved cartography towards the total coincidence between the map and the world.

In the first decades of the twentieth century, the aim was then to increase the altitude of the photographic more and more and, thus, to map ever-larger portions of the territory. After many expeditions, it was Captain Albert Stevens who managed to raise the point of survey so high that he could capture, in 1930, the first image of the curvature of the earth. With the first satellite images, in 1957, the history of cartographic representation changed profoundly, abandoning the idea of the optical model embraceable by the human gaze, to the symbolic, virtual model of the entire terrestrial globe, understandable in detail only thanks to a sophisticated mathematical model.

The symbolic and practical use of globes to represent planetary-scale maps has a history of its own (Sloterdijk, 1999/2014). During the 19th century, several globes were implemented or projected to be used as giant immersive exhibition setups permitting the embrace of the entire planet: Wylde's Globe in Leicester Square in 1851 or Elisée Reclus' 160-meter wide Globe, an unrealized project for the Universal Exhibition of 1900 (Alavoine-Muller, 2003). Closer to us, Buckminster Fuller's Geoscope in 1962 planned a large spherical 3D display, connected to an array of computers, claimed to be 'the most accurate global representation of our planet ever to be realized' (Buckminster Fuller, 1981). With the Geoscope, Buckminster Fuller developed a series of core ideas for displaying and interacting that would then be implemented in the context of Virtual Globes.

In 1992, the Science Fiction writer Neal Stephenson anticipated the forthcoming arrival of a virtual model of the Earth in his novel *Snow Crash* describing a piece of software called Earth as 'a globe about the size of a grapefruit, a perfectly detailed rendition of Planet Earth, hanging in space at arm's length in front of his eyes' (Stephenson, 1992). The novel was mentioned as an inspiration for the software EarthViewer that John Hanke, Avi Bar-Zeev, and their team started to develop in 1999 at Keyhole (Crampton, 2008). Just a year before, Al Gore had given a speech picturing the concept of a digital Earth model: 'I believe we need a Digital Earth. A multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data' (Gore, 1998). Thanks to Al Gore's political impulse, previously classified satellite imagery became commercially available, opening a concrete avenue for high-resolution virtual globes.

Keyhole's EarthViewer was not the first virtual globe ever, but certainly one of the best that would run nicely on a normal personal computer, enabling smooth rotation and zooming. In 2005, after Keyhole was bought by Google, the software would ultimately become known as Google Earth. By 2006, Google Earth, as a free-of-charge service, already had an important cultural impact. Beyond the planetary scale representation, the zooming feature, itself reminiscent of the 1978 film *Powers of Ten* (Boeke, Eames, & Eames, 1978), was certainly one of the most impressive features. As an article in *Nature* summa-

rized: 'The appeal of Google Earth is the ease with which you can zoom from space right down to street level, with images that in some places are sharp enough to show individual people' (Butler, 2006).

Natural navigation inside a digital twin of the Earth rapidly became a feature that would go beyond the historically anchored globe metaphor. The process of machine-based documentation of street-level images had already been engaged by some artistic works. On July 8, 1973, Ed Ruscha documented Hollywood Boulevard back and forth, loading a continuous strip of 10-meter film into a motor-drive camera, shooting the boulevard in its entire length frame-by-frame (Ruscha, 2005). In 1978, the Aspen Movie Map developed in Nicholas Negroponte's Architecture Machine lab at MIT made the first prototype of interactive navigation inside a "scanned" city. These early experiments paved the way to the first version of the Mirror World Concept. David Gelernter, Professor of Computer Science at Yale University coined the term in 1991, introducing it in the following way:

> You will look into a computer screen and see reality. Some part of your world—the town you live in, the company you work for, your school system, the city hospital—will hang there in a sharp colour image, abstract but recognizable, moving subtly in a thousand places. This Mirror World you are looking at is fed by a steady rush of new data pouring in through cables. (Gelernter, 1991)

In 2019, Kevin Kelly stressed the relevance of revamping the Mirror World concept as the proper way of envisioning the advent of a "third platform," a kind of convergence of the now extremely advanced Google Earth Computational Engine and a planetary-scale virtual environment:

> The first big technology platform was the web, which digitized information, subjecting knowledge to the power of algorithms; it came to be dominated by Google. The second great platform was social media, running primarily on mobile phones. It digitized people and subjected human behavior and relationships to the power of algorithms, and it is ruled by Facebook and WeChat.…We are now at the dawn of the third platform, which will digitize the rest of the world. On this platform, all things and places will be machine-readable, subject to the power of algorithms. (Kelly, 2019)

For Kelly (2019), the Mirror World will not only be a digital twin of the entire planet, but it will also be a temporally adjustable 4D Model (3D + Time):

> History will be a verb. With a swipe of your hand, you will be able to go back in time, at any location, and see what came before…or you'll scroll in the other direction: forward.…These scroll-forward scenarios will have the heft of reality because they will be derived from a full-scale present world. In this way, the Mirror World may be best referred to as a 4D world.

Buckminster Fuller's Geoscope was already anticipating its virtual globes as a time machine, in the past and a collectively simulated future:

> The Geoscope's electronic computers will store all relevant inventories of world data arranged chronologically, in the order and spacing of discovery, as they have occurred throughout all known history.…The consequences of various world plans could be computed and projected, using the accumulated history-long inventory of economic, demographic, and sociological data. All the world would be dynamically viewable and picturable and radioable to all the world, so that common consideration in a most educated manner of all world problems, by all world people, would become a practical every day, hour and minute event. (Buckminster Fuller, 1981)

More recently, the development of this 4D World is the core objective of the Time Machine Project, selected in 2019 by the European Commission as one of the six most important large-scale research initiatives for Europe's future (Abbott, 2019). Central to the project vision is a series of new concepts fed by the recent progress of artificial intelligence and science, articulated around the structuring processes of "Big Data of the Past," a distributed digital information system re-documenting Europe's extremely dense archival recording and its realignment with high-resolution 4D models. Conducting at industrial scales these redocumentation processes and the alignment of multiple fictional spaces resulting from the interpretation of this massive wealth of new data sources are some core challenges of the introduction of the 4th dimension (Kaplan & di Lenardo, 2017).

In some sense, the 4D World closes the loop of the historical journey that has led from the massive photographic campaign of the 19th century to the Mirror Worlds. The underlying assumption of early large-scale photographic campaigns, responsible for this huge documentary impulse, was that image archives had deeper depths of latent knowledge still to be mined beyond the initial project that leads to their collection (Mitman & Wilder, 2016). The technology that permits the advent of the 4D world today through new articulation of dense photographic material combining aerial imagery, historic photo archives, huge video libraries, and crowd-sourced photo documentation precisely exploits this latent potential. In a natural extension of the methodology developed by Laussedat (1899) and Meydenbauer (1869), homologous points can connect not only different photographic perspectives of the same site but also articulate photographic material in time, opening the avenues for hypothetical reconstructions of the past. Thus, as the

network of homologous pairs extends in time and space, the 4D world emerges as a series of sparse spatiotemporal zones that get progressively connected forming a denser fabric of representations. Information of cadastral maps, BIM data, or any other specific layers of a geographical information system can be easily articulated on this progressively extending 4D skeleton (Kaplan & di Lenardo, 2020).

Prospects are immense. If indeed 4D Mirror Worlds are the "third platform," most of our future planning activities will use the 4D World as a way not only to have smooth access to the past but also to plan collectively shared scenarios for the future. Giving both decision-makers and citizens an intuitive interface enabling to go backward in the collectively reconstructed past and forward in the commonly negotiated future is likely to profoundly change our understanding and everyday engagement of the city, the landscapes, and the world.

Conflict of Interests

The authors declare no conflict of interest.

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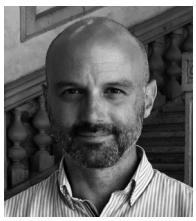

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