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Mapping Landscapes in Transformation: Multidisciplinary Methods for Historical Analysis

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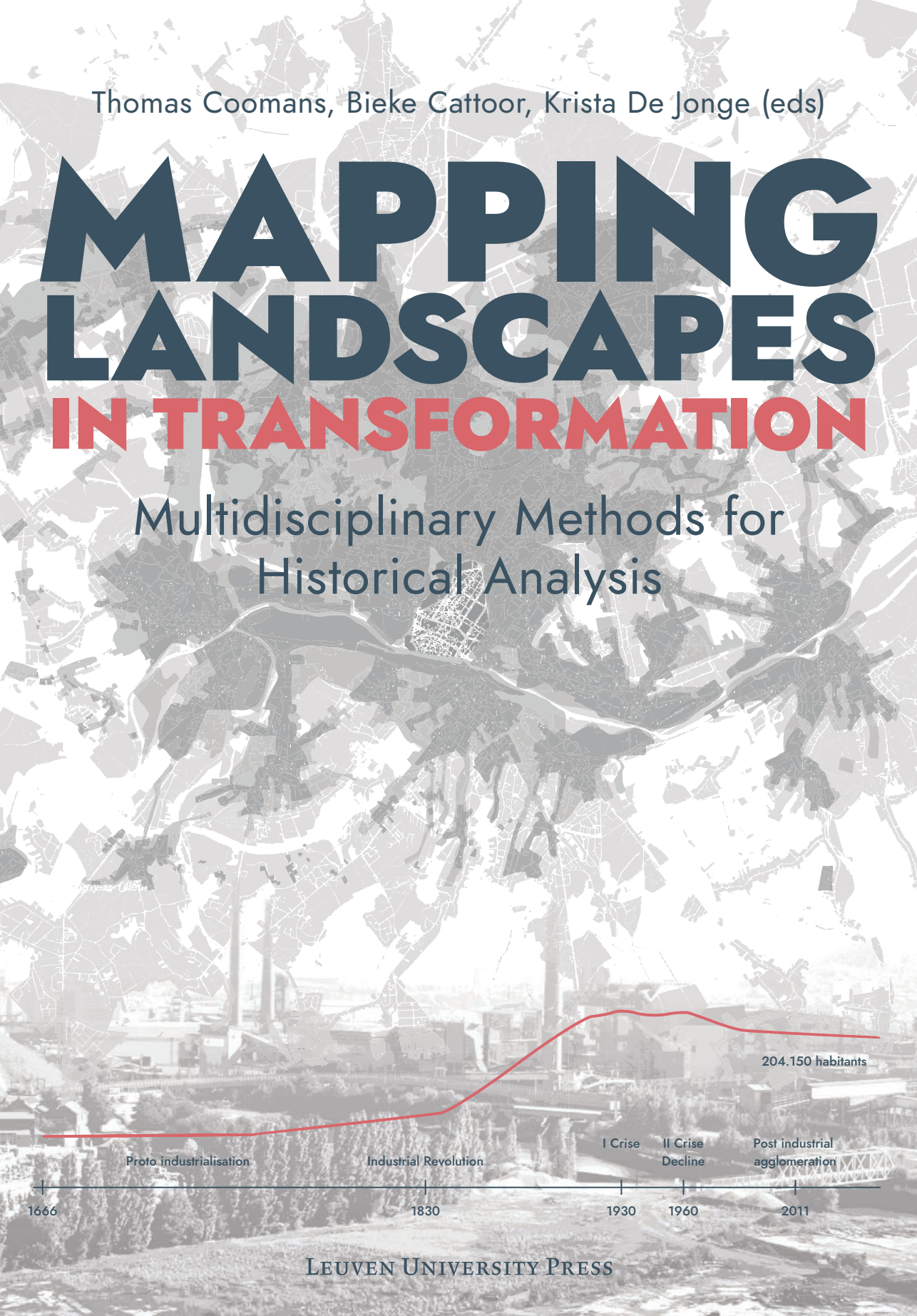
Thomas Coomans, Bieke Cattoor, Krista De Jonge (eds)

MAPPING LANDSCAPES IN TRANSFORMATION

Multidisciplinary Methods for Historical Analysis



Leuven University Press

Mapping Landscapes in Transformation

Multidisciplinary Methods for Historical Analysis

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Edited by

Thomas Coomans, Bieke Cattoor, and Krista De Jonge

Leuven University Press

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PREFACE

Mapping Landscapes in Transformation

Multidisciplinary Methods for Historical Analysis

Thomas Coomans (University of Leuven)
Bieke Cattoor (Delft University of Technology)
Krista De Jonge (University of Leuven)

Innovation in mapping methods for historical landscape research is flourishing, largely because this type of research is situated at the very fertile intersection of ongoing technological development and sustained critical reflection. On the one hand, the development of digital tools for data capturing, data analysis and data structuring has revolutionised our ability to extract and plot out data of all sorts and to combine, mix and re-mix these data in order to discover spatio-temporal relationships that have previously remained hidden. On the other hand, the humanities' sustained interest in spatiality as well as its growing involvement with the new digital tools make for a continuous critical reflection accompanied by ongoing methodological experiments that stretch, morph and bend these digital tools in order for them to reflect context and source specificity, to include different theoretical perspectives on landscape, to enable narrative formats, etc.

A major challenge for cartographic research into cultural landscape history concerns methods for mapping landscape transformations in all their complexity. How can one define and translate the concept of landscape transformation? How can one combine data from various sources, various types and of varying accuracy when part of these sources is not even explicitly spatial, such as a text? How can one map the palimpsest-like composition of layered urban and rural landscapes? How can one visualise the different speeds of interwoven spatio-temporal processes? How can one deal with missing sources and hypothetical interpretations of transformation processes, at both micro and macro scales? How can one

simultaneously incorporate an array of spatial scales as well as a set of timeframes within one single map, or even a map series ?

This book brings together experts from different disciplines — historians, geographers, architects, urban and landscape designers, and archaeologists — who are active in the fields of historical geography, urban and landscape history and heritage conservation in a wide variety of time-space contexts, from Antiquity and the Middle Ages to the twenty-first century in Europe, America and Asia. Each author deploys mapping methods to construct a very different reading of landscape transformation. Together the contributions make up a widely varying set of mapped space-time dialogues, and have the intention to open up a broad range of multidisciplinary research questions.

This edited volume contains thirteen chapters, grouped into two parts: 'Projection' and 'Focus'.

In the first part, six chapters present reflections and methods that refer to the double sense of 'Projection' as a cross-disciplinary approach to visualisation on the one hand and a leap into imagining landscape futures on the other hand:

- Jill Desimini demonstrates that conventional cartographic techniques are powerful projective tools for investigating and negotiating the time-lapses between past, present and future landscapes. Through a detailed analysis of cartographic methods of incorporating time into topographic maps as well as design plans, she makes a plea for revaluing and updating these conventional techniques as a way of grounding landscape architectural practice in times when data-driven GIS analysis dominates spatial research in the field.
- Karl Beelen explores the empowerment of local actors caused by increased access to digital urban data and to digital mapping technologies, fostering countermapping practices and feeding into grassroots design. A test case in peri-urban Chennai (India) shows how this empowerment, or 'the rescaling of the frontier of urban data and urbanisation' takes shape despite restrictive regimes, but also feeds on the voids purposely created by them.
- Bieke Cattoor unravels how the practice of re-cartography unites two seemingly contradictory cartographic ontologies at the heart of urbanism: the consideration of the map as a (partial) workable mirror and an engagement with the post-representational quality of the map as a project. Three cases in south-west Flanders (Belgium) illustrate how re-cartography can be a tool for designers and researchers to negotiate time, simultaneously practising the territory and the map as-a-process.

- Steffen Nijhuis develops a method for GIS-based spatio-temporal analysis that explores designed landscapes as products of time. By systematically mapping different aspects of landscape architectonic composition at several important time stages (their time of conception, development, and mutation), Nijhuis reconceives of designed landscapes as long-term and dynamic compositions. An elaborate case study in Stourhead demonstrates the significance of the method for landscape design research and its relevance to landscape and heritage practice.
- Cecilia Furlan takes a reverse approach to understanding cultural landscapes as palimpsests. Making wasteland her object of study, she concentrates on those physical and mental entities that temporarily seemed unfit for investment, by this detour gaining knowledge of the drivers of human-induced spatial transformation. A thick mapping of post-industrial Charleroi aggregates spatio-temporal morphologies, oral histories and historical landscape imaginaries to compose a multi-layered story of its industrial (waste)land transformation.
- Cristina Purcar develops an interactive spatio-temporal landscape catalogue, in which mapping is deployed as a linguistic device that facilitates associative operations between different data sets. Focusing on railway cases from Transylvania (Romania) she interrelates a corpus of historical photographs, maps and plans, cross-fertilising the intertwined histories of landscape photography and railway development, to combinedly analyse the transformation of the Transylvanian railway landscape from a material and iconographic perspective.

The second part, 'Focus', presents seven cases from different time-space contexts, each innovating by adapting existing methodologies to their specific research questions and sources:

- Piraye Hacıgüzeller, Jeroen Poblome, Devi Taelman, Ralf Vandam and Frank Vermeulen — all archaeologists working on Mediterranean-Antique landscapes — present complex multi-scalar GIS reconstructions of the (past) humanscapes of the Roman city of Potentia (Marches, Italy) and the Hellenistic, later Roman, city of Sagalassos (Anatolia, Turkey).
- Arlo McKee and May Yuan analyse the transformation of historical landscapes with remains of proto-historic settlements within a small stream valley in East Texas (USA). Their methodology for micro-mapping is supported by high-resolution data collection techniques (including drone mapping) and multi-scalar data analysis. This research aims at contributing to the preservation of historic native sites.
- Bram Vannieuwenhuyze studies the urban development of early-modern Bruges, Antwerp and Paris (Belgium and France). He pleads for a methodology

that merges urban topographic analysis based on early-nineteenth-century parcel plans and digital thematic deconstruction of sixteenth-century maps.

- Reinout Klaarenbeek studies the afterlife of religious houses in Brussels, Antwerp and Bruges (Belgium) after their suppression at the turn of the nineteenth century. Based on accurate surveyors' plans for sales and early cadastres as well as architectural plans for adaptive reuse of the former monasteries and convents as barracks, courts of justice, prisons, factories, schools, etc., he uses tools of historical GIS to map the complex gradual transformation of the urban landscape.
- Sanne Maekelberg follows the itineraries of Duke Charles of Croÿ in the Southern Low Countries (present Belgium and Northern France) at the turn of the seventeenth century by reference to his correspondence. Her maps illustrate the mobility of the duke and his court in a regional historical environment marked by geopolitical tensions.
- Ian Gregory, Christopher Donaldson and Joanna Taylor implement GIS technologies in literary-historical research. By applying methods and perspectives from cultural history, literary studies, and geographic information sciences to a large corpus of texts, they investigate how the landscape of the Lake District (England) was represented by nineteenth-century poets and tourists.
- Chang-Xue Shu builds her study on a systematic empirical mapping based on historical big data covering spatio-temporal dimensions of large scales in China. Her methodological challenge combines geographical visualisation, algorithmic thinking and text mining that use word frequencies to investigate how they might advance our understanding about Chinese architecture in the dimension of the literati's knowledge in the long term (significantly from the sixteenth to the twentieth centuries).

In the Postface, John Bintliff highlights key themes — social interaction and network analysis, space syntax, urbanism and the organisation of landscapes, the structural transformation of cities and regional communications, urban changes and class, deceptions of mapping and townscapes views, phenomenologies of landscapes and of globalisation, neural networks, and heritage — and elaborates on them from his anthropological, archaeological and historical expertise on townscape and landscape research.

Eleven contributions were presented at a workshop held in Leuven on 24 and 25 November 2017. Three of these contributions are adaptations of earlier published texts (Jill Desimini, Bieke Cattoor, Ian Gregory et al.). Two contributions (Chang-Xue Shu, Arlo McKee and May Yuan) are additional to the workshop. This book benefited from funding from the Research Foundation Flanders, in the

context of FWO research project 73605: "Redeveloping the city. Urban transformation and 'heritagization' after the secularization of religious houses in Belgian towns at the dawn of the modern age (1773/1796-1860)".[1]

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1. See the contribution of Reinout Klaarenbeek. Promotor of the research project: Prof. Thomas Coomans (University of Leuven); copromotors: Prof. Jan De Maeyer (University of Leuven, KADOC), Prof. Inge Bertels (University of Antwerp) and Prof. Tom Verschaffel (University of Leuven, KULAK).

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Part one
PROJECTION

1.
Cartographic Grounds
The Temporal Cases[1]

Jill Desimini (Harvard University)

A map is inherently static and out-of-date. In the translation of information from the real world to the projected image there is a time-lapse. Even in the most real-time applications, there exists a lag. Thus, the map describes the near past — or even the far past intentionally in the case of historic maps — while often contributing to a reading, and even constructing, of a future. These relationships to time beg two questions: how is time implicit in the production of cartographic and design drawings? And what are the methods of explicitly introducing time onto the map and the plan, to contend with static representations of dynamic conditions?

In order to investigate these questions, I will focus on two specific types of drawing: the topographic map and the design plan.

Maps are too easily mistaken for objective depictions of a present-day geographical condition, and their complexity often obscures the fact that they are, in fact, distortions. Their uses, limitations, and subjectivity must be understood and respected. Distortion can stem from the underlying data, editorial choices, and representational method. This distortion relates to time and space. Maps of a particular place often rely on data collected from different sources and time periods, but represent the space as if the underlying data were uniform (Kurgan 2013). Maps utilise a set of malleable yet rigorously defined representational techniques capable of persuasion, description, and, above all, projection.

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1. This text is an adaptation of texts that appear in Jill Desimini and Charles Waldheim, *Cartographic Grounds: Projecting the Landscape Imaginary*. New York: Princeton Architectural Press, 2016.

Often as a foundation to intervention, the map — whether it is of networked relationships or a geographically precise location — precedes the plan. The plan, both as an idea-driven spatial strategy and a projective drawing, is forced to respond to the map. This dichotomous and sequential practice has limitations. Instead, the realignment of map and plan as equally projective, precise, detailed investigations allows for a smooth, informed, and non-linear process. The base material and the project documentation are not separate entities. This is not to say that the project is geospatially or site determined but rather that the making of the map is analogous to the making of the plan.

Mapping in design culture has been enhanced and even supplanted by data-driven research, yet the map remains one of the main tools of documentation, though its proximity to the physical properties of the surface of the earth has been de-emphasised. The production of data-dependent drawings by designers has resulted in a distancing from the ground, scale, material, and temporal aspects of the métier and a loss of spatial and temporal precision at the human scale. The plan as a spatially precise drawing of a grounded, material, and topographically rich landscape has been unseated, rather than enriched, by the complexity of available information. Seen as antiquated, static, and allied with the 'master plan', the plan has been deemed incapable of addressing the dynamic relationships and spatial complexity of design in a globalised context. It could be argued, however, that a reconsideration of the plan as a typological drawing that can express the surficial, spatial, and temporal qualities of the earth is necessary to complement the complex systemic diagrams that point to the underlying social, economic, and political drivers. Grounding is necessary — and the conceptual framework and representation surrounding the spatial and temporal manifestations must match the intricacy and deliberation of the systemic thinking. This implies a greater dedication to the means of drawing as well as a return to visual perception, legibility, and the veracity of the work.

The distinction between spatial visualisation of non-geospatial data, cartographic representation driven by advanced systems of projection and symbolisation, and speculative design drawing in planar projection at the scale of the map is fundamental. Before elaborating on the advantages and limitations of the overlaps between these approaches, the terms 'the topographic map' and 'design plan' require clarification.

Topographic map

The topographic map is a class of general maps that tacitly describe a variety of physical phenomena at large scales. The scope of a topographic map once reflected

the known observations of the cartographer or the scale of human perception. It is now a hybrid practice, reliant on highly accessible data, augmented and verified through the personal collection of information and ground-truthing. These maps can be distinguished from geographic maps, which used distant means to describe the entire world (Harvey 1980); from topological maps, which ignore scale and geographic location, like a subway map; and from thematic maps, which focus on a single characteristic, often geo-locating statistical information. Weather and census maps are common examples. The topographic map, like its counterparts, does not resemble the land itself, but is a flattened representation coded with information illustrated by lines, colours, textures, and conventional signs. It is a constructed depiction of a piece of the surface of the earth (or the sky or another planet), showing the distribution of physical features, with every representational element corresponding to an actual geographical position, following a fixed scale and projection. Information is compressed, edited, and filtered, as well as codified to promote legibility. A topographic map requires a legend, and the act of reading a map requires a back and forth between this key and the drawing. In its final form, the topographic map offers a precise reading of landform, material, and occupation at a humanly accessible scale. It allows for immersion, through which the landscape can be seen, imagined, and ultimately designed.

Design plan

The plan is a representation of a design or a proposal. It is drawn at a relatively large scale — rarely exceeding 1:10,000 — except when denoting broad context or location. By definition, the plan is a projection of a three-dimensional space onto a horizontal plane or surface, though this distinction is of less importance than its purpose as a 'directive document that serves as a guide for some action in the future' (Treib 2008: 113). The plan is a view of the future landscape, used to show the relationships between elements as well as the total expression of those parts. It is an abstraction that often favours geographic and geometric coherence but can be embedded with human perception and experience. Like the map, it requires skill in drawing and reading to understand the phenomenological and atmospheric qualities of the landscape. Limited in its ability to express the temporal and dynamic, the plan — as with the map — often expresses one place in one view at one future moment in time. It is most revelatory as a compression and notation of a larger spatial idea that can transcend pattern and two-dimensional composition to engage the four-dimensional environment. The plan, then, becomes a generator to envisage and make space, a tool to project, design, speculate, imagine, and propose what is possible.

Here, I return to the question of time and argue for maps and plans to be more deliberate about their relationships to time as well as more provocative about their expressions of temporal conditions.

Maps and plans are composites, amalgamations of data and imagery from multiple perspectives and times. Yet, they take a singular form that often masks their multiplicity. Only in the fine print of the legend or buried in the metadata is there reference to the many origins and points of view instrumental in the translation from the real place to the projected drawing. This is true of older physical maps and their digital contemporaries. For example, National Geographic's stunning *The Heart of the Grand Canyon* map [**Map 1**] from 1978 is based on an aerial photograph from 1972, four and a half years of field survey that began in 1974 and 1,075 hours of relief painting to translate the three-dimensional topography into its two-dimensional form. Upon publication, the map appears to be a present-day depiction of a singular moment in time, rather than a layered image, built up over years, describing a recent past. This complex relationship to time is even more masked in digital production — where maps and aerial images are craftily constructed communication devices that seamlessly blend large quantities of data and imagery into one impossible view. As Laura Kurgan provocatively explains in a discussion of the new generation of *Blue Marble* images,[2] the contemporary ability to manipulate and distribute images is profound.

> 'The difference between the generations of Blue Marble images sums up a shift in ways of thinking about images, what they represent, and how we are to interpret them.'
>
> 'The new blue marbles now appear everywhere: in advertisements and as the ubiquitous default screen of the iPhone. So where you might think you're looking at image number AS17-148-22727, handcrafted witness to earthly totality, in fact what you're seeing is a patchwork of satellite data, artificially assembled — albeit with great skill and an enormous amount of labor. This is not the integrating vision of a particular person standing in a particular place or even floating in space. It's an image of something no human could see with his or her own eye, not only because it's cloudless, but because it's a full 360-degree composite, made of data collected and assembled over time, wrapped around a

2. *The Blue Marble* is a circular image of the entire globe. The first image was produced in 1972 and labeled image number AS17-148-22727. Recent updates include versions from 2005 and 2012.

wireframe sphere to produce a view of the Earth at a resolution of at least half a kilometer per pixel — and any continent can be chosen to be in the center of the image. As the story of the versions suggests, it can always be updated with new data. It bears with it a history that mixes, unstably, both precision and ambiguity and that raises a series of fundamental questions about the intersection between physical space and its representation, virtual space and its realization' (Kurgan 2013: 11-12).

In other cases, the map depicts not only different times but also different levels of resolution, different sources, and different points of view. For example, OpenStreetMap, an open-source repository of geo-spatial information, celebrates its local, community-driven enterprise as a means to increase the number of people gathering and using information. The idea is that local knowledge will increase the extents and resolution of the data while making the information freely accessible will increase access and distribution. Yet, the multiple contributions and translations further muddy the map's temporal reading. The composite nature of the map is extremely extensive. The map has many sources, so many that it is arguably source-less. It becomes impossible to date. It exists only in the present, and while some features are out-of-date the idea is that someone will soon notice and re-map the conditions. Time is beautifully continuous while the accountability is frustratingly absent.

OpenStreetMap, like Google maps, Waze, and other navigational aids, becomes an underlying source, the base for the way we see, understand, move through, and imagine our world. We must be cognizant of the collapses of time and space that occur in mapping as well as the representational choices that govern how we use and interpret both the map and the space for which it stands in. Techniques of drawing have changed with time, both as the technology advances and the use of maps and spaces fluctuate. For example, the Google Map — introduced as a web-based product in 2005 — radically changed the map-user's experience. The web-interface allows for mass customisation of a dynamic map, through zooming, panning, rotating, and changing views and visible layers. The practicality and functionality rate so highly with users that they become desensitised to the underlying representational choices. The continuous integration of additional features — routing, traffic, transit routes, perspectival views, terrain depiction, satellite imagery — pushes the product beyond traditional map capacities. In fact, the map is rarely used for its pure map capacities, and the representation of the roads, for example, has lost some clarity, coding, and specificity in newer versions. It is harder to read the distinction between road types as all roads are rendered orange

and grey, forcing some to disappear into the background landscape (Demaj and Field 2012). Routes are generated through the typed directions rather than read visually from the lines on the map. The map becomes a repository of linked data rather than a legible depiction of a given geography.

Furthermore, these ubiquitous repositories are rarely explicit about the choices that they are making, about what is shown and what is omitted, about what is known and unknown, and the relationship of this information to time. This is the role of the legend on a traditional map, itself a repository buried during digital translation. On the legend, the conventions and symbols used on the map are extracted, amplified, and explained. These contain references to the content and aim. In addition, on the margins of the map, often close to the legend, there is information regarding the making of the map: its date, its sources, its ownership, and its scale and projection. Embedded in these keys are references to time. For example, in the legend of the 1966 Nimrod Glacier map [**Map 2**], one of the Topographic Reconnaissance Maps of Antarctica from the United States Geological Survey (USGS), there are notes regarding the mapping process: the document was compiled in 1964 from US Navy trimetrogon aerial images[3] taken between 1960 and 1962. These facts are unremarkable, pointing only to the aforementioned time lapse in mapping. However, what is remarkable in this particular image is: the graphic integrity of the terrain visualisation — with spot elevations, contour lines, and relief shading — and the overt recognition of the resolution of knowledge. The contours included show three levels of confidence relative to the topography. They make a distinction between *definitive* contours (solid lines), *approximate* contours (long dashed lines) and *conjectural* contour lines (short dashed lines). Here, there is the idea of an incomplete picture, one that may become more complete with more survey time, but one that can never be complete in a single image, given the dynamic nature of the glacial landscape. The map also distinguishes between *ice* and *ice-free* areas, again a fluctuating condition. It also provides a necessary warning for the intrepid: *absence of the crevasse symbol does not necessarily indicate a crevasse-free area*. Through simple text and line variation, the *Nimrod Glacier* maps key pays homage to the complex, dynamic, dangerous, and difficult to capture qualities of the remote landscape. Without obfuscating the

3. This is a system of aerial mapping where three cameras are used — one from a vertical, one from an oblique left and one from an oblique right point of view — to create a single assembled image of the area being mapped. These aerials are taken at regular intervals across the territory.

representation of the terrain itself, the mapmakers have addressed the temporal and ephemeral characteristics behind the physical formations.

This leads to the critical question: what are some of the methods of introducing time onto the map and the plan? Here, I will discuss a few simple means: line variations, color gradients, and hierarchical layers.

Line variations

The *Future Cities Lab* design office, through its *Aurora* project, tackles the cartographic and projective challenge of the changing Arctic landscape. The maps present the changing territorial boundaries of the region at multiple scales. They use variations in line type and date annotations to mark the fluctuations of the ice area as well as the shifting locations of buoys as they respond to the climate and territorial claims [**Map 3**].

The line is a simple and powerful tool. A line, broadly speaking, is any elongated continuous mark or discontinuous series of marks (as a line of dots) on a map that serves as a sign for some geographical phenomenon or concept. Lines represent both physical features and distances between places. The line typology describes a hierarchy of physical presence and character in the landscape. The thickness or density of lines alone can reveal patterns of movement, settlement, and urbanisation while choices of type encode information [**Maps 4 and 5**].

Time is often a variable dictating the type of line symbol. For example, the atlas *Les Travaux de Paris* uses colour-coded lines to demonstrate engineering feats to a public audience. The individual plates show the evolution of the subterranean Paris landscape and its utilities over time. For example, plate VII illustrates the sewer system in 1878, showing those sewers existing in 1855 in blue and those constructed between 1855 and 1878 in red. Both time and function are highlighted through simple and powerful representational techniques, making it possible to imagine the intricacy of underground infrastructure expanding in response to the city above [**Map 6**].

Colour gradients

Geological maps use rich colours to express time directly through the stratigraphic column. The stratigraphic column accompanies the planar geologic map as a diagram used to order and date rock units and as an index to identify those

units on the map. Colour is fundamental to a stratigraphic column. It is the near universal system of coding. The wide range of rich colours is alluring, but the transition between the diagram and map is difficult for the untrained eye. The colours reveal the unseen, and, for the non-geologist, the unfamiliar with very few significant landmarks for orientation [**Map 7**].

While surficial geographical information is buried, temporal information is foregrounded. In some cases, the colour relates directly to the stratigraphic age of the rock, representing geological time: younger rocks have paler colours and older rocks suffer darker shades [**Map 8**]. The result is a tonal map of time, overlying a geographical map of space.

Hierarchical layers

Time is often invoked in layers, with the graphical hierarchy corresponding to age and resolve. The result is a composite image where multiple time periods are visible simultaneously. Through line weight, tonal change, and level of detail, different conditions — from past to future — are highlighted. For example, in urban designer Joan Busquets' *Old Town Barcelona* plan [**Map 9**], the buildings are coded by era and historic status. The listed buildings have articulated plans, revealing the structural elements and interior spaces in black. The associated archeological ruins are similarly detailed in red. Time is collapsed, merging the present and past fabrics. Residential buildings frame these fine-grained elements, themselves coded by type and era of construction. The result is a highly differentiated and layered depiction of the urban fabric. While the map is static, it portrays an understanding of the old city as an ever-changing condition, built and un-built over time. Through a clear and sophisticated coding system, the complexity of the city is revealed.

Overlays and hierarchies serve to introduce past conditions and future intentions onto maps and plans. In the 1911 *Plano General de Barcelona* [**Map 10**], the deep ochre blocks of Eixample fade to ghosted lines of planned blocks, distinguishing between the inhabited city and the growing city of the future. Here, the plan and map collapse, the built and the projected coexist in a single document. This type of coexistence is a powerful tool to envisage the transformation of a landscape, to render the imaginary, to communicate design intentions. For landscape architect Charles Eliot, the topographic plan was the ideal base for his proposal for a metropolitan park system [**Map 11**]. Eliot was an early advocate of the overlay method of representation and design. He collected, from printed resources and extensive

fieldwork, and mapped many layers of information in order to locate the ideal properties for the parkland expansion. The vision, as mapped, could be seen in relation to the geological and cultural layers of the existing city.

The French engineers involved in the nineteenth-century transformation of Paris too understood the power of the overlay as a means to collapse time. In the *Plan des Courbes de Niveau du Parc des Buttes Chaumont* [**Map 12**], parks director Jean-Charles Adolphe Alphand and his associates render the existing topography in black contour lines and proposed in red contour lines. The technique allows both for the visualisation of a dynamic process and for the communication of procedural mastery to a public audience (Komara 2009).

The plan and the map become means to understand the past spatial conditions of a given territory as well as its future potentials. Through variations in lines and tones, and through the overlay and differentiation of temporal information, the dynamic character of landscapes can be imagined. Cartographic conventions serve to articulate the space between the past — what is no longer — the present — what is given — and the future — what is yet to come.

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Maps

Map 1: Richard Rogers Peele, Bradford Washburn, Tibor Tóth (1978), *The Heart of the Grand Canyon* [Reproduced with permission from Ng Maps/National Geographic Creative, Courtesy of the Harvard Map Collection, Harvard Library, Harvard University].

François Emile Matthes, a renowned topographer and geologist, completed the first real survey of the Grand Canyon Bright Angel area between 1902 and 1904. Inspired by Matthes' work and motivated by their own sense of cartographic adventure, Bradford and Barbara Washburn led an expedition to re-map the Grand Canyon in 1974. The effort focused on the 170-square-mile heartland of the canyon — the area most visited by tourists — and the same area included in 1902–04 Matthes survey. The mapping expedition required 146 days of fieldwork spread across four and a half years. The process included extensive climbing and exploration and a recorded 695 helicopter flights, as well as a recently introduced laser beam, allowing for new degrees of precision across massive distances. The final map, a National Geographic classic, embodies incredible precision, both in its underlying survey and in its drawing technique.

'The Heart of the Grand Canyon was the largest (36 x 36 inches) and most time consuming (1,075 hours) acrylic relief that I painted during my twenty-two years at the National Geographic. I like to think of it as my "relief thesis" because it effectively incorporated all that I have learned about relief shading up to that point. It was produced approximately half-half with airbrush and brush. The contour base was the result of a 1972 aerial photography and field survey, so I am confident that the relief is the most accurate and detailed acrylic painting even to this day' (Tóth 2008).

Map 2: United States Geological Survey USGS (1966), *Nimrod Glacier, Topographic Reconnaissance Maps of Antarctica* [Courtesy of USGS].

The USGS began sending surveyors to Antarctica annually in 1957 to work with the navy in establishing geodetic control and to gather mapping-quality aerial photography. The topographic reconnaissance maps that resulted are visually extraordinary, with a combination of terrain rendering techniques that bring a visceral quality to a remote environment. Contours, shading, hachures, and colour are all used to describe the topography and ground condition (moraine, glacier, crevasse, ice shelf, iceberg, fast ice). Distinctions are made between known information and conjectures (solid versus dashed lines). The proximity of the cartographer to his material is registered through the drawing conventions. The relationship with the landscape is embedded in the process of depiction.

Map 1: The Heart of the Grand Canyon.

NIMROD GLACIER
PRINCE PHILIP MOUNTAINS
PRINCE PHILIP GLACIER
FERRANT GLACIER
GRAY GLACIER
SWITHINBANK GLACIER
Turret Nunatak
Mt Koonen
Littleton Nunatak
Bagley Nunatak
Mt Kosciusko
Mt Lister
Mt Weaver
Cambrian Bluff
Kon-Tiki Nunatak
Cooper Icefalls
Inaccessible Cliffs
Kleiner Knoll
Mt Gerhart
Mt Sandwich
Mt Sperry
Mt Carl
Mt Bonham
Mt Minshew
Mt Mannering
Mt Tetrick
Mt Rigsbee
Mt Ingoglia
Mt Brolick
Mt Pelzel
Mt Rippey
Mt Rutford
Mt Rea
Mt Rosenbaum
Mt Rumpf
Mt Rhodes
Mt Rayburn
Mt Rosenbaum
Mt Rumpf
Mt Rhodes
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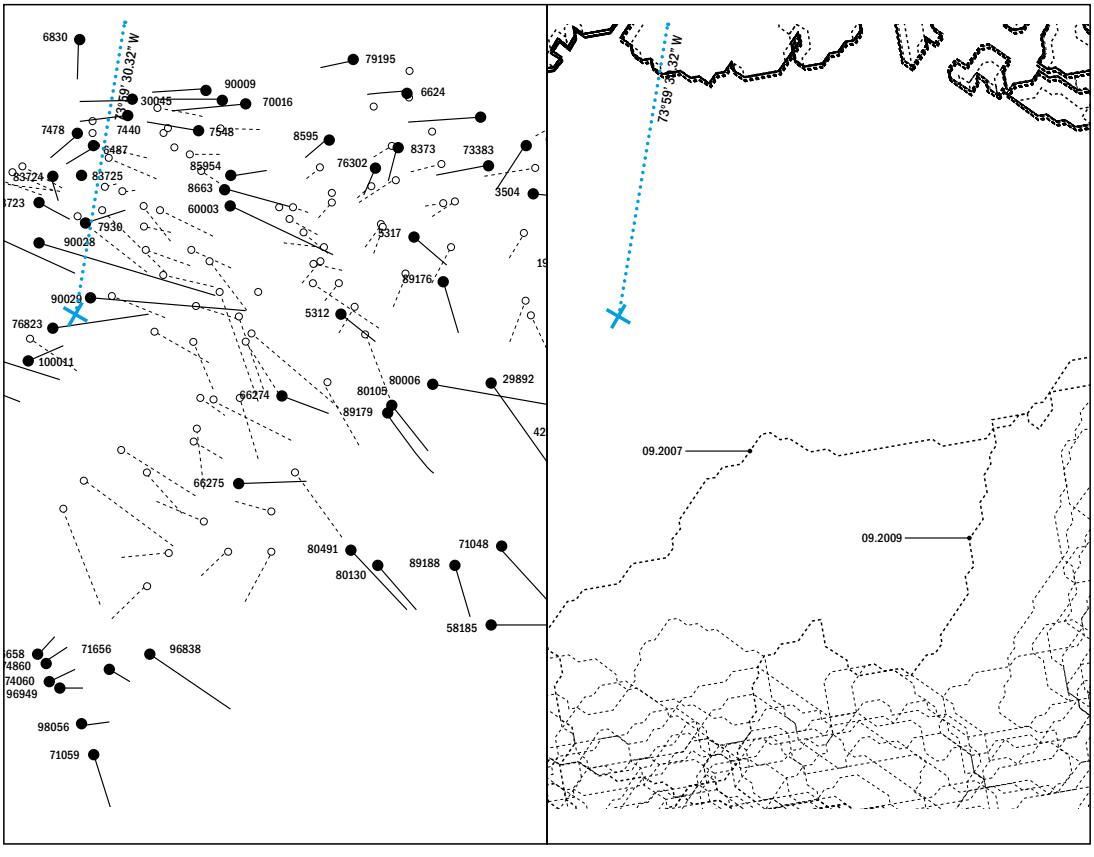


Map 3: Future Cities Lab (2009), *Aurora* [Courtesy of Future Cities Lab].

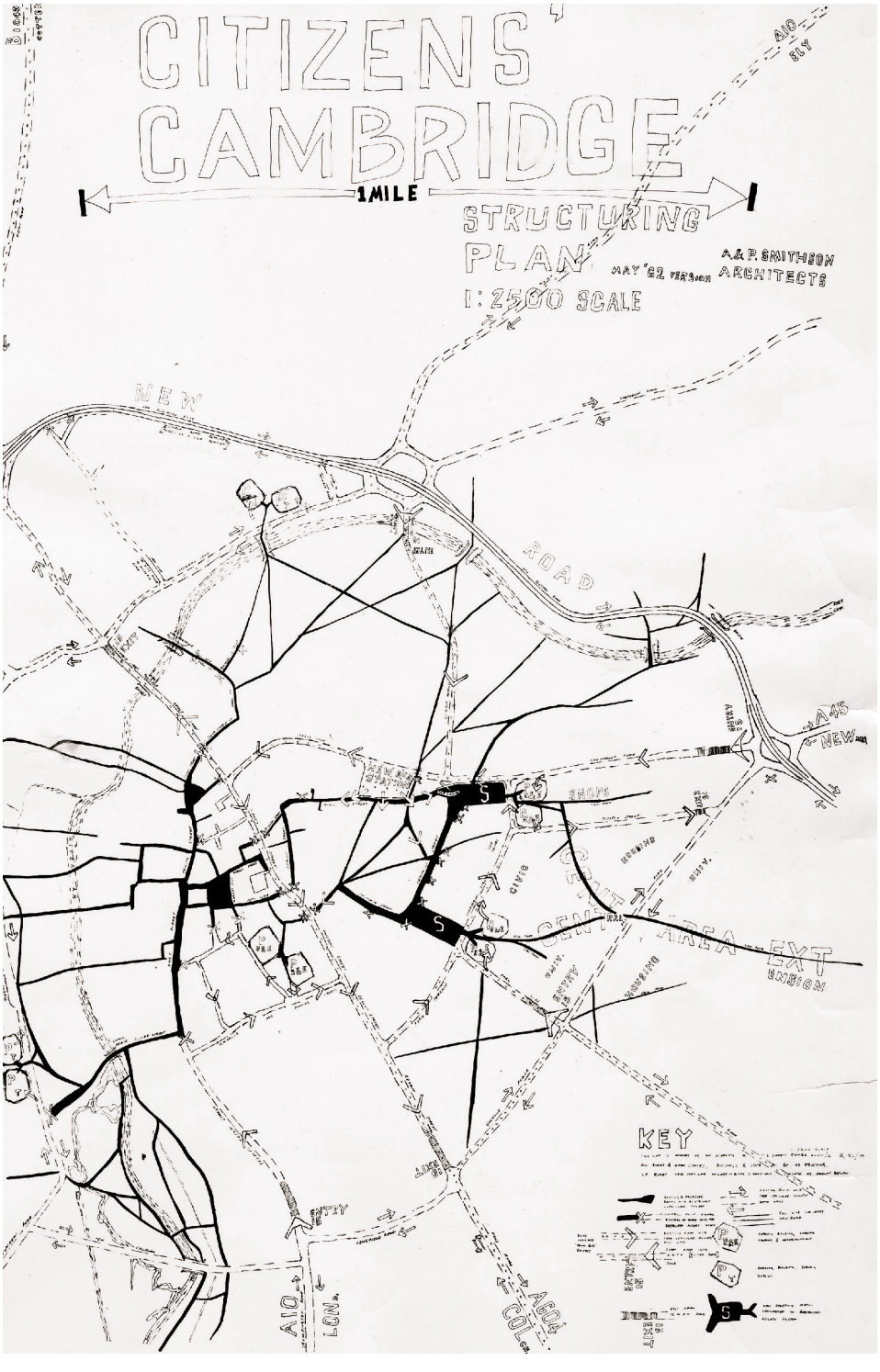
A true synthesis of cartographic and design process, these drawings represent the fluctuating territorial boundaries of the Arctic while providing the groundwork for possible sites of intervention. They offer a complex reading of the landscape through restrained representational tools — repetitive lines and forms, hatches, vectors, and dots. Through repetition and variation they show shifts over multiple time scales. The overlapping lines in *Erode* track the fluctuating extents of the Arctic sea from 1983 to 2009 while the shifting dots and lines in *Drift* articulate the temporal and ephemeral qualities of buoy displacement.

Map 4: Alison Smithson and Peter Smithson (1962), *Citizen's Cambridge Structuring Plan: the Nature of Place Restored* [Courtesy of Alison and Peter Smithson Archives, Frances Loeb Library, Harvard University Graduate School of Design].

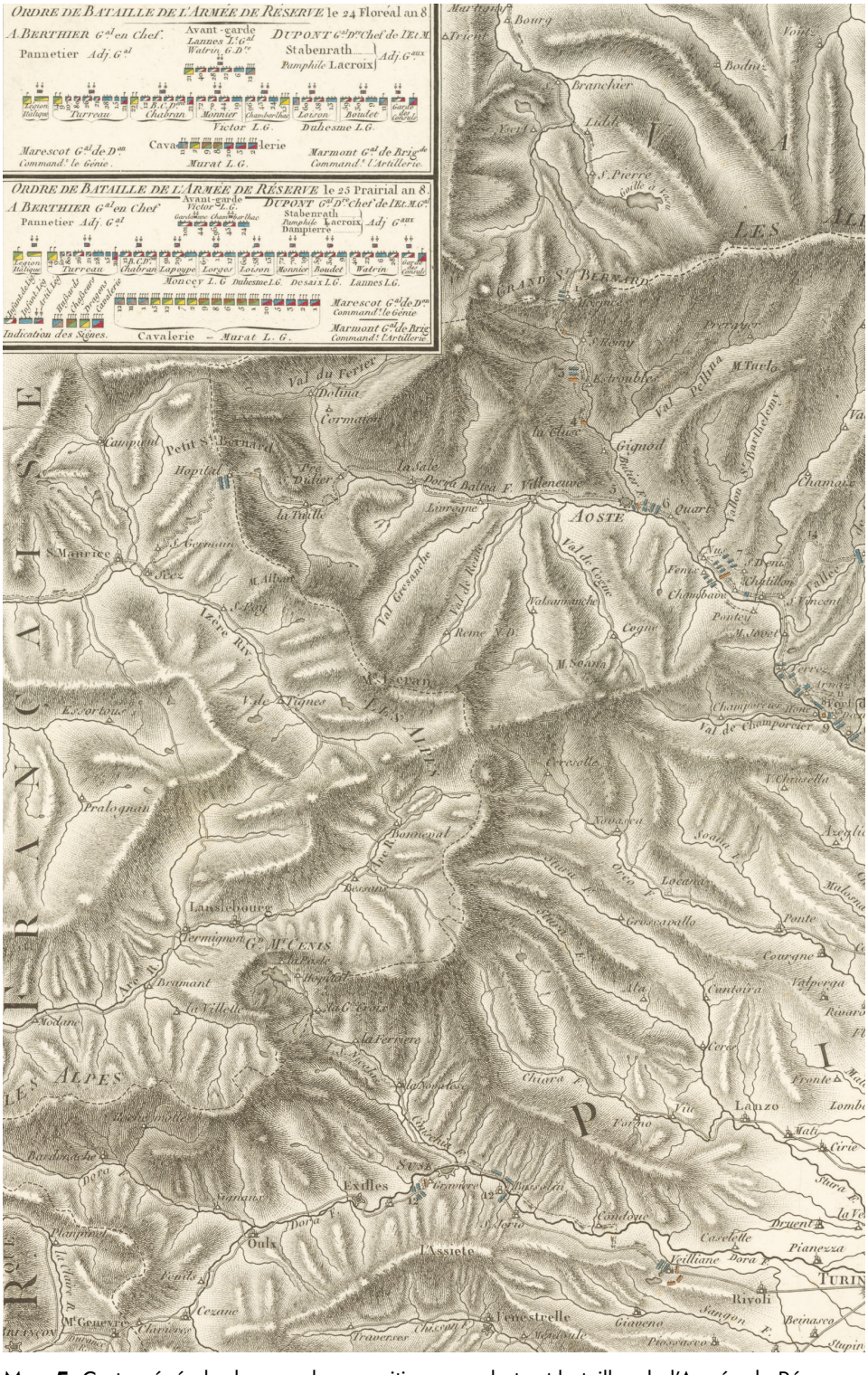
The Citizen's Cambridge project proposed a re-structuring of Cambridge to relieve the pressures of population growth and increased traffic on, and reinstate the character of, the historic centre. The idea was to integrate the residential, civic, and university areas better and to redistribute commercial activity to lessen the toll on the historic fabric. A hierarchy of new roadways and walkways is suggested, as well as changes to the existing traffic patterns. Use restrictions by time of day and the re-orientation of traffic direction in certain cases concentrate traffic on fewer roadways and improve bus and bicycle access. The Smithsons treated the historic centre as a 'big building' to preserve through the insertion of a 'contra-centre' linked to parking and motor vehicle culture. The drawing conventions cleverly describe the traffic pattern changes, the new car-dominated structures, and the mobility-driven structure of the plan. A reading of the key alone is sufficient for understanding the underlying concepts behind the plan.

Map 5: Pierre Lapie (1803 est.), *Carte générale des marches, positions, combats et batailles de l'Armée de Réserve depuis le passage du Grand St. Bernard, le 24 Floréal An 8 jusqu'à la victoire complette & décisive remportée à Marengo, le 25 Prairial*. Paris: Tardieu [Courtesy of Pusey Map Collection, Harvard Library, Harvard University].

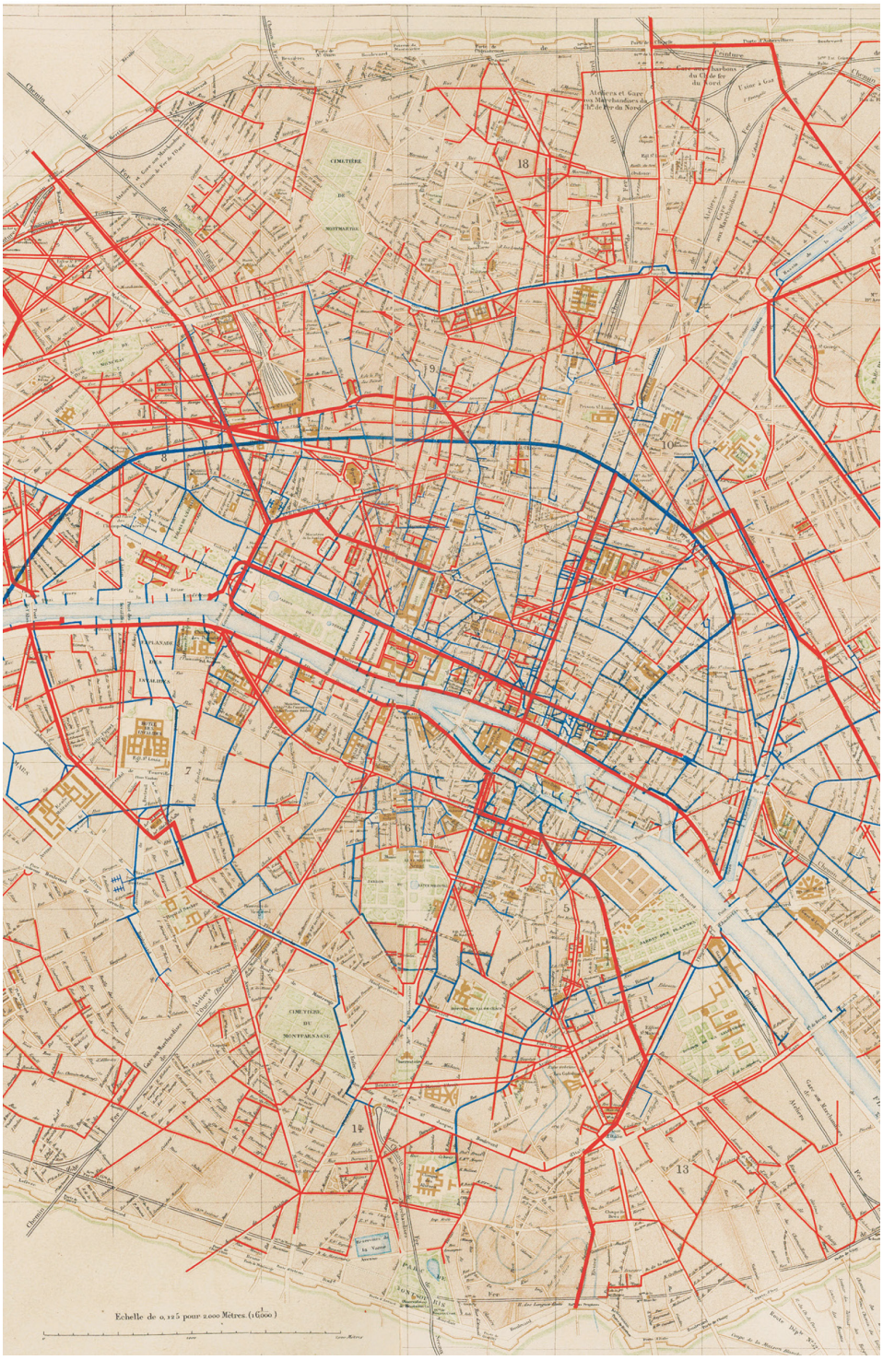
Lapie has developed a graphic method to depict troops moving through the Alpine landscape. The convention allows for both the portrayal of the hierarchical system of troop orders as well as the non-linear positions of the troops within the terrain. This map celebrates Napoleon Bonaparte's victory over Austrian troops at the Battle of Marengo on 14 June 1800. The graphic key is paired with a written table that provides a day-by-day account of military advances and retreats, sieges and skirmishes (Garver 2009).



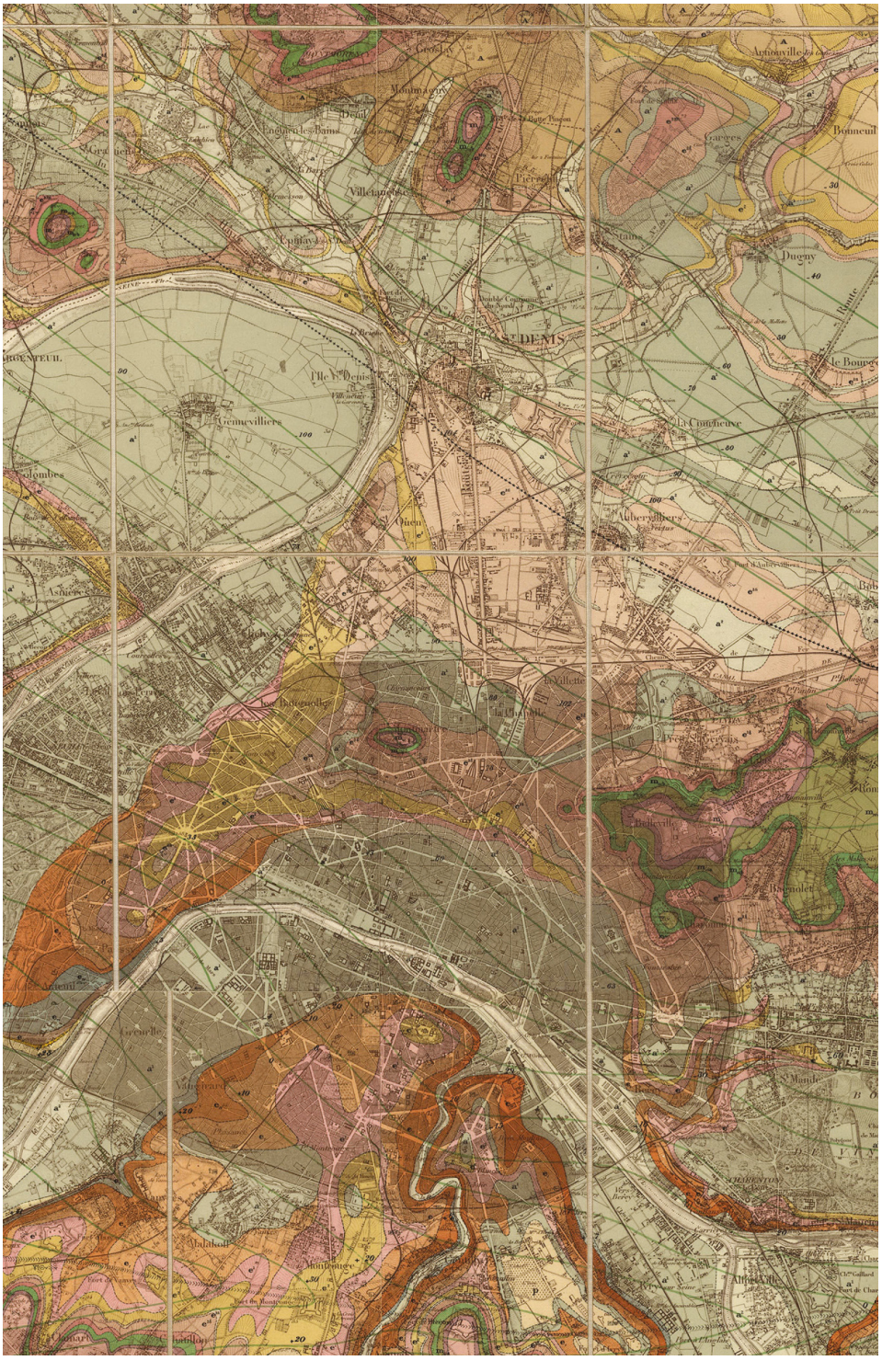
Map 4: Citizen's Cambridge Structuring Plan: the Nature of Place Restored.



Map 5: Carte générale des marches, positions, combats et batailles de l'Armée de Réserve.



Map 6: Les Travaux de Paris.



Map 7: Paris et ses environs.

Map 6: Imprimerie Nationale (1889), *Les Travaux de Paris*, plate VII [Courtesy of Frances Loeb Library, Harvard University Graduate School of Design].

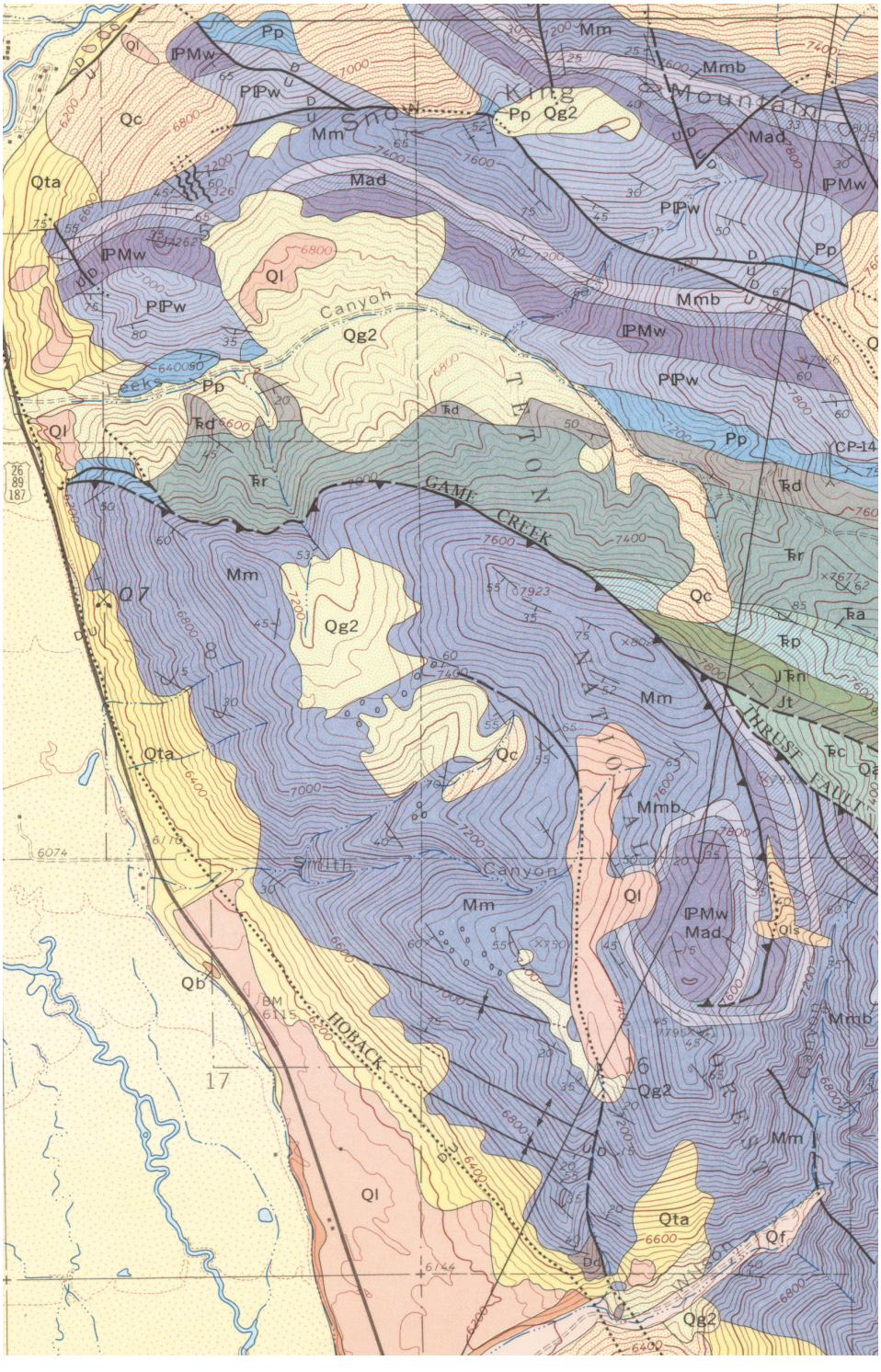
The urban subterranean zone is marked by its geological strata and its infrastructural network. *Les Travaux de Paris* is an atlas that focuses on the latter as a means to describe the technical advancement and modernisation for the World Exhibition held in Paris in 1889. The plate shown illustrates the sewer system in 1878, showing those sewers existing in 1855 in blue and those constructed between 1855 and 1878 in red. The collapse of the vertical space between the physical features of the surficial city and its underground support structure makes the interdependence of the two evident. Both time and function are highlighted through simple and powerful representational techniques.

Map 7: Service Géologique des Mines (1890), *Paris et ses environs* [Courtesy of David Rumsey Map Collection].

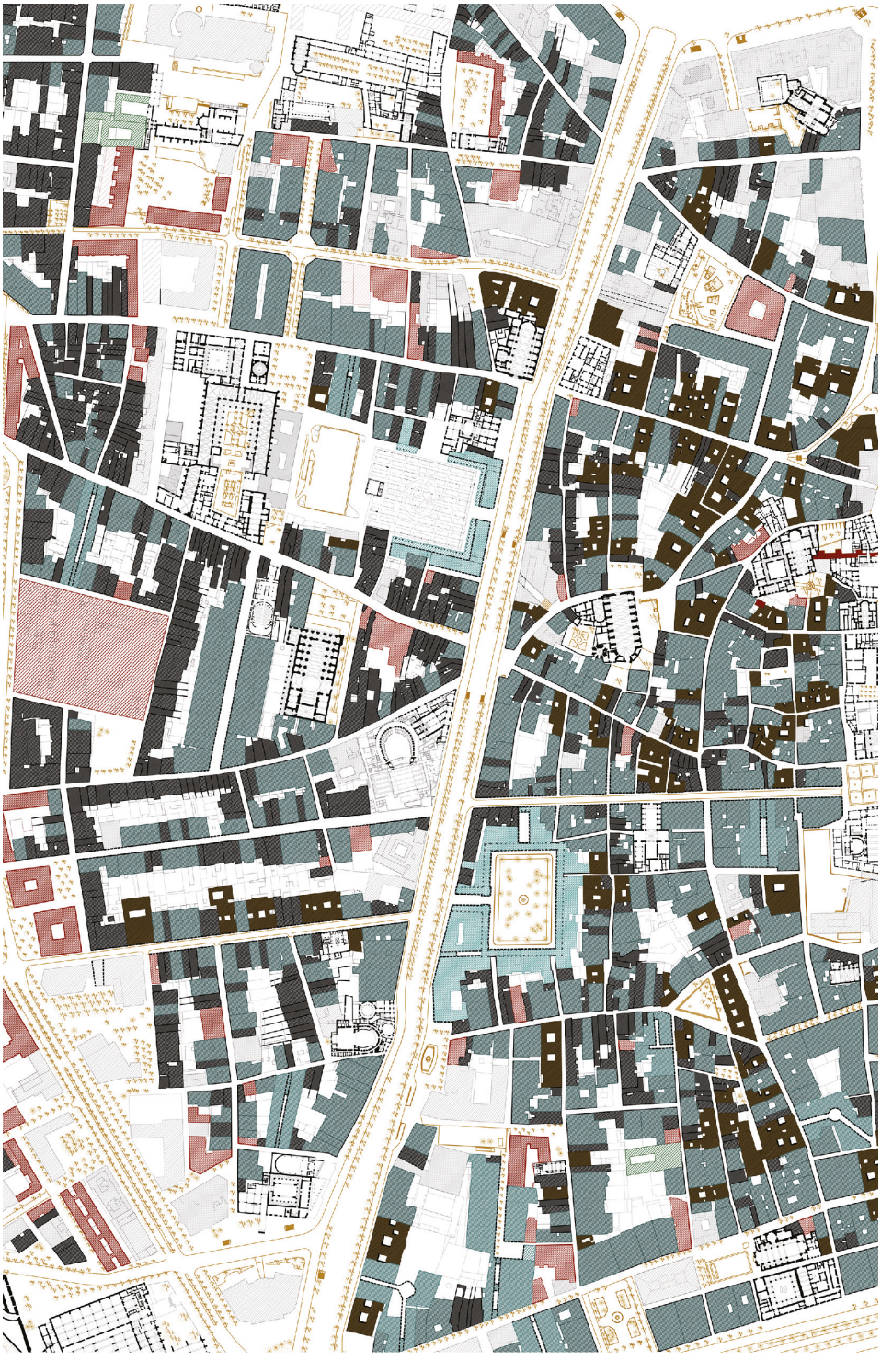
While *Les Travaux de Paris* focuses on the subterranean infrastructural network, this incredibly detailed geological map of the city from the same period correlates the layers of underground rock with the extents of urbanisation above. Structured around the meandering River Seine, the map shows known, invented, and hidden geological contours, fold lines, fossil sites, and colour-coded rock types that roughly correspond to their natural appearance. It also shows roads, buildings, fields, and vegetation in great detail. The geological information is coded and requires a legend, while the rendering of surface habitation reads without translation: the roads have thickness, the vegetation has texture, the building footprints are filled in, and the topographic relief is hatched.

Map 8: J.D. Love and Howard F. Albee (1972), *Geologic Map of the Jackson Quadrangle, Teton County, Wyoming* [Courtesy of Cabot Science Library, Harvard University].

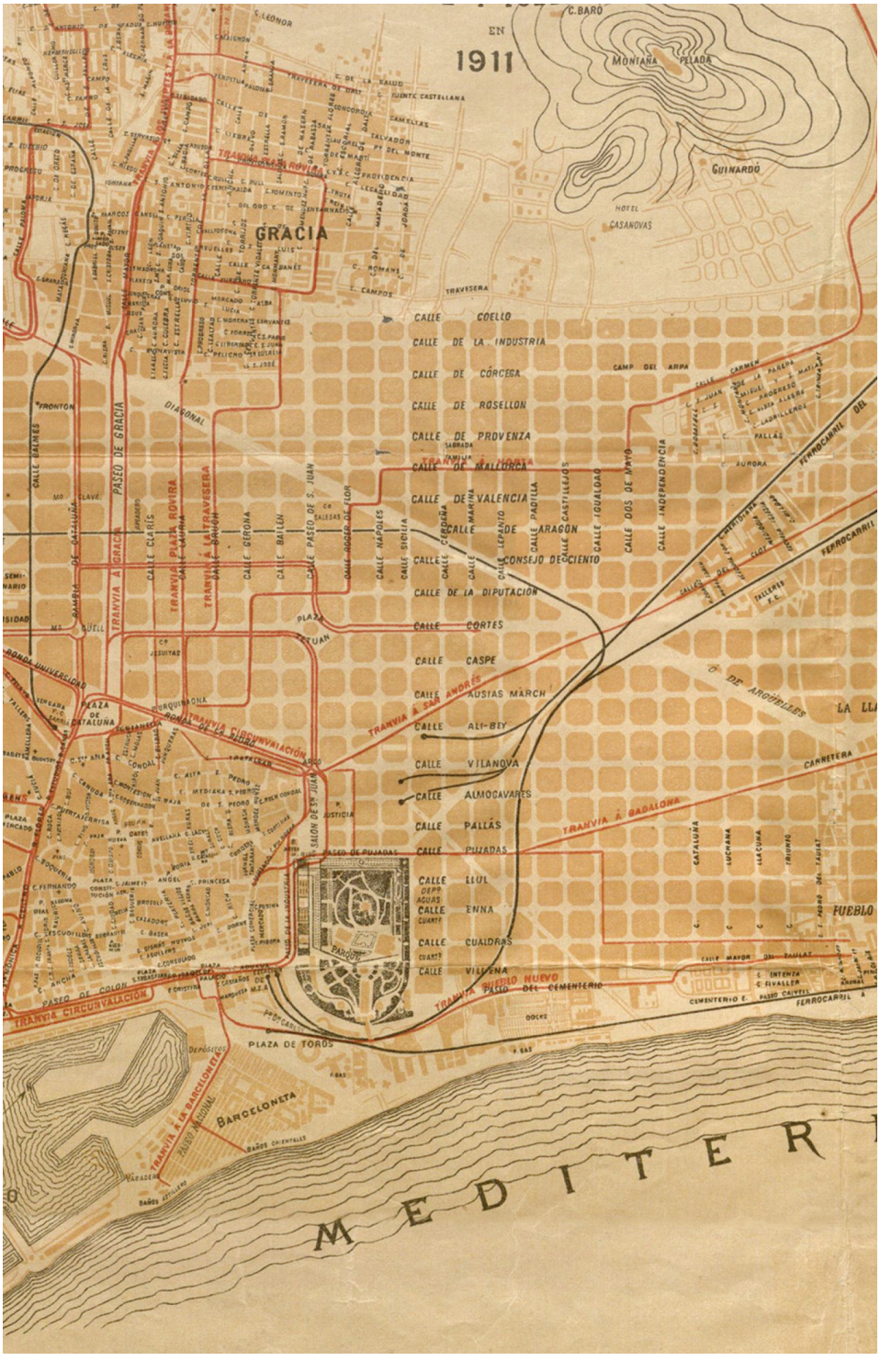
American geologist J.D. Love is a central figure in the history of geological cartography known for his exemplary fieldwork, surveys, and maps of his native Wyoming. Educated at the University of Wyoming and Yale University, Love worked for the United States Geological Survey. He was commissioned in the 1950s to create the first statewide geological map of Wyoming, standardising data and representation conventions across a large and complex territory. His Jackson Hole map is considered one of his most significant accomplishments. Historian Alex Maltman elaborates: 'The Precambrian rocks that make the spectacular Teton Mountains, back-drop to many a movie; the complicated, still active tectonics; and the intricate terraces of the Snake River have all been subjected to Love's unrivaled abilities and beautifully recorded in a series of 1:24,000 sheets' (Maltman 1998: 213).



Map 8: Geologic Map of the Jackson Quadrangle, Teton County, Wyoming.



Map 9: Old Town Barcelona.



Map 10: Plano General de Barcelona.

Map 9: Joan Busquets (2000), *Old Town Barcelona* [Courtesy of Joan Busquets].

Urban designer Joan Busquets has devoted much of his career to the city of Barcelona, as a researcher, a planner, and a designer. His analytical drawings reveal the morphology of the city and describe its transformation through time. His plan of the Old Town, an adaptation of a Nolli-type plan, uses a rich coding system to depict monuments, open spaces, and building typologies of the historic city. Listed buildings and archaeological ruins are drawn as architectural plans, showing the scale and texture of the urban fabric, allowing the viewer to enter the buildings through the drawing. National monuments are hatched over in red, linking them to the similarly rendered contemporary and modern public buildings. The residential fabric is shown in tones of black and grey.

Map 10: Francesc Puig (1911), *Plano General de Barcelona* [Courtesy of Pusey Map Collection, Harvard Library, Harvard University].

The 1911 general plan of Barcelona depicts the projects for the widening of streets and the extension of the city towards the surrounding mountains (indicated loosely with contours). The map is dominated by the regularity of the Barcelona blocks, juxtaposed against the organic figures of the older parts of the city. Using the signature colour of the route and contrasting nicely with the ochre blocks, the newly-electrified tramway lines indicate the pull of urbanisation outward. The solid blocks of the *Eixample* fade to ghosted lines of planned blocks, distinguishing between the inhabited city and the growing city of the future.

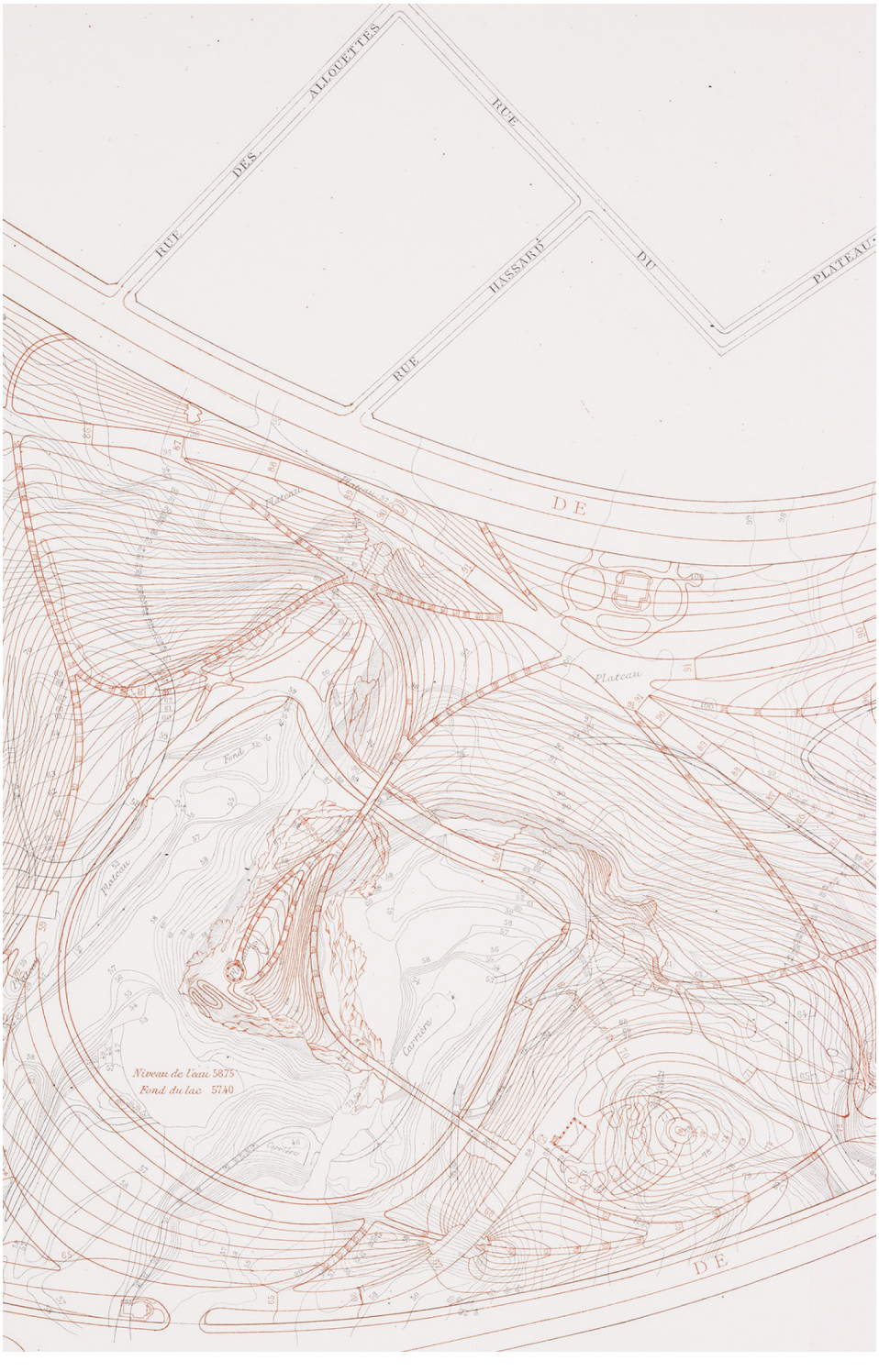
Map 11: Charles Eliot (1893), *Map of the Metropolitan District of Boston* [Courtesy of the Frances Loeb Library, Harvard University Graduate School of Design].

The landscape architect Charles Eliot and the journalist Sylvester Baxter conceived of and promoted a system of interconnected parks and parkways ringing the city of Boston. The Map of the Metropolitan District of Boston of 1893 delineated the existing public reservations in green and those proposed by Eliot in orange. The map was printed, folded, and attached to Eliot's bound report to the Metropolitan Park Commission. In this copy, the colour registration is slightly off but the correlation between the topographical, geological, and hydrological systems — included as part of the base map — and the proposed park system is evident. Eliot was an early advocate of the overlay method of representation and design. He collected, from printed resources and extensive fieldwork, and mapped many layers of information in order to locate the ideal properties for the parkland expansion.

Map 12: Jean-Charles Adolphe Alphand (1867–71), *Plan des Courbes de Niveau du Parc des Buttes Chaumont*, Promenades de Paris. Paris: J. Rothschild [Courtesy of the Frances Loeb Library, Harvard University Graduate School of Design].

Under the direction of Georges-Eugène Haussmann, engineer and parks director Jean-Charles Adolphe Alphand transformed a former quarry and refuse dump into romantic parkland. The technique of overlaying the before and after contours, with the proposed highlighted in red, shows the dynamic process in a single image. The curvilinear design language emerges from the rough site, accentuating and amplifying the existing landforms, while deliberately leaving rough edges in places. The drawing demonstrates the merger of the technical and aesthetic mastery found in the design.

Map 11: Map of the Metropolitan District of Boston.



Map 12: Plan des Courbes de Niveau du Parc des Buttes Chaumont, Paris.

2.
Data Friction

Mapping Strategies on a (Peri)urban Frontier – Chennai, India

Karl Beelen (Karlsruhe Institute of Technology)

I am meeting Satheesh and Krishnan in a small room on the first floor above a dental clinic off Nungambakkam High Road, Chennai. It is late November and the dark rain-laden sky promises imminent relief of the leaden heat that has pushed on far beyond summer. Monsoon rains will start any day now, or so everyone seems to hope. In mixed Tamil-English lingo Satheesh and Krishnan are getting engrossed in a technical issue on QGIS — how to close a complex multi-edge polygon and measure its surface. Satheesh is an uneducated fisherman from Vaithikuppam, a fishing village in the centre of Chennai's urbanised coastline. Over the past few years he has been taking training classes with Krishnan to operate a hand-held GIS device, and he has been passing on that same knowledge ever since to other fishermen from his village and beyond.

Satheesh has been 'mapping' fishing villages in and around Chennai, and he is instructing fellow fishermen how to map features within their own settlements. Krishnan tells me how Satheesh is trying to scale up that effort now. Throughout the hottest months of summer, Satheesh travels down the southern Bengal Bay coast, hopping from one fishing village to another, offering anyone who is interested teachings in the fine arts of geo-tracing, GIS, and self-mapping. As I sit in that office, I see data flying by that appear to exist only in the eye and the imagination of these fishermen and their handheld devices: sites and structures, edifices, and practices that, if not left out intentionally from most government-approved maps, certainly cast a different eye on what it means to occupy and dwell on those sites.

This field note describes the rather contested and chaotic landscape of (geo)spatial data in cities in South India. The case of Satheesh not only shows that there are gaps and holes in the acts of translation by which we constitute our maps — liable as they are to acts of power, bias, and subjectivity. But more than that, the case also hints at the fact that these gaps, restrictions, and obstructions in access to data and information are themselves a crucial point around which the physical reality 'out there' is being organised and taking shape.

Historically speaking map-making, surveys, and spatial data have always had a rather contorted relationship with governmentality in India (Edney 1997). India has known a long history of mapping: it has been deeply implicated right from colonial times in the production and reproduction of fault-lines within society, reflecting long-lasting oppositions of the coloniser vs. the colonised, elite vs. subaltern, or civil society vs. political society (as sparked by Ranajit Guha, Gayatri Spivak, or Partha Chatterjee). With recent shifts in technology these conflicts have moved on as well. As the access to spatial and other forms of data is changing, and the distinctions between who produces it and who consumes it have become increasingly blurred, data are themselves becoming a major feature of the current fast-urbanising landscape. Data are contested and fought over, obfuscated and shielded, counter mapped and un-mapped.

In the field note above Satheesh and his companion fishermen essentially double up as counter-mappers: they map things that had been left off the map — intently or not. Absent as they may be, these missing features are of crucial importance to the fishermen. They include sites as diverse as vernacular shrines, collectively stretches of the beach, areas for knotting and repairing fishing nets, or areas simply to store boats overnight away from the ocean's surf. Any such features may obstruct and jeopardize public-private planning efforts, particularly when an area is 'slated for redevelopment' (*kuppams*) or cleared legally for industrial development (Sriperumbudur). So, one rather effective way to by-pass these obstructions, it seems, is to actively 'unmap' them and eradicate them from the maps that are required for legal planning sanction. Countermappers like Satheesh make use of the proliferated access to mapping technologies through GPS devices and smartphones. They record the contours of the features that are important to them and then process those data in such a way that they are admissible at local state courts. Dressed up in the same style and fashion as official maps, these maps mimic the eye and imagination of the state to reclaim legal control over areas which had been rightfully 'theirs' in the first place.

This text seeks to analyse how this fault-line — I call it a frontier — is not only rallied over and appropriated as it re-emerges in the digital urban landscape, but

also seeks to show how this frontier is being adapted, transformed, or repurposed/hacked for conventional land development as well as for more activist, grassroots purposes, including forms of design. As data tools and their access disperse across a multitude of users, data become a means of engagement, not only in a political or commercial sense, but also in terms of their (designerly) imagination. To quote the anthropologist Anna Lowenhaupt Tsing, 'A frontier is a zone of unmapping: even in its planning, it is imagined as unplanned' (Tsing 2005b: 51). While Tsing speaks about the frontiers of predatory resource extraction in Borneo, the text's focus will come to bear on the use and imagination of data as a resource in the context of Indian urbanisation, and the struggles that go with it.

This chapter is based on fieldwork that I conducted in Chennai, the state capital of Tamil Nadu, India's southernmost state, from November 2015 to June 2016. Most of it occurred in preparation of a lab that I organised at IITM aiming to bring researchers and designers together to explore alternative techniques and methodologies of data collection in the context of India's massive wave of urbanisation (Bypasslab & IGCS 2016). While I shuttled between Chennai and Bangalore, I got to meet repeatedly with a motley group of coders, hackers, geospatial analysts, and designers, some of which eventually volunteered to take part in the ensuing lab. In this chapter fieldwork observations are split out into two different vignettes, both of them centred on Chennai, India's fourth largest metropolitan region. These vignettes are labelled 'the *kuppams*' and 'Sriperumbudur'. Whereas in the textual section *kuppams* (fishing hamlets) serve to frame the context of data and urbanisation in South India, the visual section about Sriperumbudur then applies that analytical framework to the outcome of the lab, finally to come up with a number of observations and questions about the methodologies and techniques used.

Sriperumbudur serves a double purpose here. It is the practical testing site and occasion where some of the tools and strategies, discussed more broadly in the first vignette, are tried out and applied. But it is also a metonym for the rescaling of the frontier of data and urbanisation that is currently taking place. Sriperumbudur is a panchayat town and taluk currently within the Chennai (Madras) metropolitan area and some fifty kilometres from Madras' original core. Currently transforming from a largely agrarian area into an industrial and residential zone, the town stands for a vast swath of peri-urban transformations (in land use, construction, migration, or environmental degradation) that will define 'urban India' in the coming decade or more.

In this text I want to bring those questions of 'translation' that we meet as urban researchers or designers to bear on the case of Sriperumbudur as a case in point of

the entangled issues with map-making in (peri-)urbanisation. But first, let us turn back to the site of Krishnan and Satheesh: Vaithikuppam.

Cartographic f(r)ictions

Walking along Chennai's thirty-odd kilometre coastline it is hard to notice what is being qualified as *kuppams* or fishing villages. Fishing 'village' proves a rather misleading translation both linguistically and cartographically. *Kuppam* (குப்பம்) is a Tamil word that roughly translates into English as a 'coastal settlement' or 'hamlet', but it carries strong undertones of low social cast and standing (Fabricius 1972: 95). In the city *kuppam* has come to designate merely a 'slum [area] typical of fishing communities along the coast' (Ramakrishnan 2006).

In origin *kuppams* are makeshift settlements or hamlets whose logic is premised on having direct access to the sea, but as they became absorbed into the city they also became areas of prime real property, and therefore rather contentious political concerns to deal with, from the side of public administration and that of the 'public' at large in or outside the *kuppams*.

From the outside, however, apart from a narrowing of the roads or the absence of a finished pavement, there is little in the way of the *kuppam*'s appearance that would betray it as being a village. Buildings rise up to four stories or more, and are built with the same reinforced concrete cement that is used throughout India; street shops crop up on the corners of the roads, as they do elsewhere in town, and the *kolams* that one finds on the thresholds of houses dissolve and wear off just as easily as they do elsewhere in this state.

What gives the *kuppam* away is its conflicted relationship with the map. More than its physical presence it is the *kuppam*'s 'absence' that explains its existence. A *kuppam* is an ossified anomaly, a settlement that is not being acknowledged on official maps. Like many 'informal' settlements in India, or indeed the Global South, its very existence is based on the precariourness and ambivalence of access to housing, typically strung between formal recognition on the one hand and informal redistribution (Appadurai 2003) on the other. Without going too much into detail here, to map a *kuppam* would be to acknowledge and honour the same types of (land) entitlements as the rest of the city.

More importantly, a *kuppam* is a fault-line where two systems meet: on the one hand urbanisation, with its set of rules and regulations to order and regiment

construction, ownership, and occupation; on the other hand, the less formalised rules and regulations that stem from leading urban lives in close (economic) proximity to the sea. While it is possible to describe the development of a *kuppam* as an informal or subaltern kind of settlement (governed by the rules of political society rather than those of civil society), the production of the *kuppam* is so much entangled with the overbearing forces of urbanisation, politically and physically speaking, that it might make more sense to see it as a dynamic encounter.

To explain this, Anna Tsing's metaphor of 'friction' (2005) might be helpful. Friction — the force that resists relative motion between two bodies in contact — gives 'grip to the encounter' of the *kuppam* and the groundswell of surrounding urbanisation (Tsing 2005: 1). My point is that the *kuppam*'s seeming absence from maps is a result of this friction. Rather than this just being a case where the map chooses to remain 'silent' (Harley 2001), the case of the *kuppam* is a case in point that urbanisation in India knows many friction zones that develop around, and that are intrinsically *produced* by, restrictions in access to (geographic) data.

All along Chennai's entire coastline construction juts out and pulls back beyond the buildable area limit at many points and locations. Different policies and instruments govern the extent of that seaside urbanisation. The National Coastal Zone Regulation (CRZ) for one prescribes a 200 to 500 metre setback from a hypothesised High Tide Line, 'the line on the land up to which the highest waterline reaches during the spring tide' (Ministry of Environment and Forests 2011). But even when this line seems rather hard and solid from a policy point of view, it is also, simultaneously, very ethereal and unreal, like a perpetual shadow that will not allow itself to be pinned down. Coastline data are notoriously difficult to obtain or verify — even in view of the larger public interest, and in spite of legal procedures like Right To Information appeals (RTIs) which were specially drawn up for this purpose. The *kuppams* offer one of those locations, though certainly not the only one.

What this example illustrates here is that these restrictions to data (mapping data in particular) are generative of a kind of urbanisation that leads to distinct patterns like that of the *kuppams*. These patterns are both physical and social, without any neat division line between the two; if not directly resulting from the map, then mapping data, and the restrictions that govern access to them, certainly offer an important trope in their production.

Mapping data constitute friction zones across the Indian urban landscape that mobilise a multitude of groups, initiatives, and collective actions. These zones

of dynamic encounter — or 'entanglements', as Tsing would call them — pose methodological issues: how does one map such areas when the very act of translating or transposing alone is so terribly co-opted in the continuous production and reproduction of frictions? Can one avoid perpetuating a status of deprivation such as the one in a *kuppam*? Accepting that data, much like maps, can never be objective, is there any emic standpoint left to take as a designer when the partiality of data is so much ingrained into the production of the territory as it is in the case of the Indian urban landscape?

However, apart from raising methodology in the designerly use of maps, the friction that surrounds the usage of data and maps also offers distinct opportunities, particularly now that geospatial data and information have started to circulate so differently, in 'Digital India' as much as elsewhere. Let us turn to one more example here.

India's new old geospatial bill

On 4 May 2016, the Indian Government released its draft Geospatial Information Regulation Bill (Ministry of Home Affairs 2016). Its publication caused alarm among the country's data activists, start-up GIS industries, and the geospatial community at large, most of which are operating from the South Indian city of Bangalore, 350 kilometres west of Chennai.

This Geospatial Bill seeks 'to regulate the acquisition, dissemination, publication and distribution of geospatial information of India which is likely to affect the security, sovereignty and integrity of India' (Ministry of Home Affairs 2016: 1). Part of the Indian government's motivation was old-fashionedly territorial: to fight the misrepresentation of India's international state boundaries, and to reclaim legal sovereignty over the use and publication of spatial information, mostly through harsh penalties. Google Maps' representation of India for instance, and its depiction of the Jammu and Kashmir borders with Pakistan and China in particular, had been a thorn in the side of the Indian government on more than one occasion. The draft bill now sought to make such offences effectively prosecutable by extending the national arm of justice up to the level of the offending companies' (Indian born) CEOs. But the impact of the bill was much larger, and its vast scope implied that almost any computational application requiring its users' geolocations would be within the purview of the bill.

This rather broad definition of 'spatial information' caused immediate concern among activists, hackers, and think tanks, especially within Bangalore's geospatial

startup community. From the moment the bill was drafted up to the Indian Parliament's monsoon session where it was to be discussed, there was a sudden flurry of initiatives. The most visible of these was the save-the-map campaign (2016), which maintained that the bill 'disregards the actual feature of digital geospatial data and how it forms a fundamental basis (and asset) for today's digital economy' (Chattapadhyay and Garg 2016). What save-the-map's critique hinted at is that the production of geospatial data had become intrinsically dispersed and that the old boundaries between those who create and those who acquire map data — typical of a pre-digital map-making age — had become inextricably blurred, especially with the arrival of big geospatial data in India and with networked georeferenced apps taking off as hugely as they did in most of the country's cities.

As mentioned already, India's contorted relationship with spatial data is not a recent one but dates back to the origins of modern cartography. India has been home to one of the most far-reaching and boldest efforts in the history of map-making. A little over two hundred years ago, one William Lambton persuaded the Madras Government to fund a triangulation right across the Indian peninsula, south of the river Krishna. Lambton was a crown officer and surveyor in the English East India Company at the time, but his request in Madras would lay the foundation of the Grand Trigonometrical Survey (GTS) of India — the fulfilment of a 'scientific gaze' that took close to seventy years to accomplish.

Here, 'imperialism and mapmaking intersect in the most basic manner,' as Mathew H. Edney writes at the start of his monograph on the GTS (Edney 1997). It is a generally accepted feature in the history of cartography that imperialism and mapmaking were 'both … fundamentally concerned with territory and knowledge' (Ibid). In the eye of the surveyor (and here I am paraphrasing Tsing) India was a 'frontier', 'a zone of unmapping: even in its planning, it [was] imagined as unplanned' (Tsing 2005b: 51). What is generally less emphasised is the fact that the GST's project of 'unmapping' and that of early (colonial) suburbanisation intersected geographically and ontologically in the case of Chennai, or Madras as it was known at the time.

In 1802, Lambton set out to measure the base of the GTS's starting triangle, from Fort St. George's Wallajah Gate in the heart of colonial Madras to St. Thomas Mount in the outskirts of the town. As his measuring chain recorded the distance, Mount Road — Madras' future backbone and its main commercial point of orientation to this day — would become permanently enshrined as the survey's starting reference, the eponymous Madras *baseline*. For every distance recorded and for

the duration of the Grand Trigonometrical Survey, Mount Road, measuring 12.1 kilometres in length, would serve as the entire subcontinent's geographical point of reference. If, in the predominant cartographic illusion of the time, the survey's resulting territorial archive was believed to be India itself (rather than just representing India), then Mount Road was essentially the yardstick for that particular way of looking and *constructing* empirical, on-the-ground information.

From a historical point of view, there seems to be a rather pragmatic overlap in imagination and a remarkable degree of conjuncture between the physical emergence of the city's main armature, Mount Road, and the construction of those empirical survey data. In Lambton's time, the end of the Carnatic wars had heralded the end of Madras' fortifications and the emergence of a wide-open hinterland waiting to be appropriated and absorbed into the contours of the unleashed colonial city. It would be fascinating to learn how the act of tracing out Mount Road got to be systematised and upscaled to eventually produce a gaze on the scale of an entire subcontinent. Even if survey and Mount Road were not linked formally, survey and urbanisation certainly seem to have walked closely hand in hand. From the moment of its inception, spatial data were so innately intertwined with, and engrained in, the imagination of the territory and the way that it was physically constructed that it makes sense to consider both data and urbanisation as part of the same 'frontier'.

That data/urbanisation frontier has reproduced itself up to this day, including its frictions over access. But the recent shift in technology has also brought on a more fundamental change in the frontier's line-up of actors. All sorts of data — from pollution measurements to smart-phone data to information scraped right off the net — have been pushing the map's gaze to shift from that of the State to that of a fledgling group of app developers, counter-mappers, environmental activists, and regular phone users, who (unwittingly or wittingly) build a new map with every picture and movement that they make. This kind of technological shift, this new 'Digital India', does not occur in a spatial vacuum, however. It plays out on a massive canvas of territorial transformation, a vast landscape of predatory development, land speculation, migration, and industrialisation that rewires and recolonises the South Indian 'hinterland', like a torrential outburst of monsoon (peri-)urbanisation.

It is this kind of frontier of data and urbanisation — this active reimagining of something as being unmapped and unplanned in the service of mapping and urbanisation — that the text has sought to bring up and render visible. In this

first part it invoked the notion of friction to show how everyday encounters over spatial data have invited strategies and counterstrategies in the everyday shaping of this frontier; how potholes, hiatuses, and restricted forms of access to spatial data are more than merely 'blanks', gaps, or bottlenecks in the landscape of spatial data that are being produced; instead, this new frontier presents radically different practices, agencies, and imaginations whose frictions are fought out and coalesce in the 'unplanned' landscape that is out there: land is erased, obstructions are bypassed, and gaps counter-mapped.

The agency of geospatial data being as diffracted as it is, it leaves the question of what this means for urban design practice. In his essay on the speculative agency of mapping, landscape designer James Corner once famously claimed that the map's partiality in the production of power and knowledge is also the very trait that grants it traction in a design context (Corner 1999). Precisely because they are so inherently 'speculative', he argued, maps help to produce novel design propositions. But this leaves the question unanswered as to how one navigates — let alone translates — a landscape that is already occupied and claimed by many frictional practices of the map. When the map is so bumpy and riddled with potholes and obstructions that it turns into a virtual no-man's land, then it becomes crucial to ask what sort of position there is left to take in the event of any designerly cartographic 'translation'.

To investigate those friction strategies and to explore this peri-urbanised data frontier, I have been using the setting of Sriperumbudur in the west of Chennai as a launching point, which is presented cartographically in the following vignette. During my fieldwork of 2016, I ran a design and research lab in the industrial township of Sriperumbudur, home to a growing number of gated communities, migrant shanties, industrial enclaves (SEZs or SIPCOTs), and other highly insular zones of global capital investments. The main purpose of the Bypasslab was to experiment with the potentials in urban research of on-the-ground, empirical observations, using both conventional fieldwork tools as well as other forms of data that have recently come within the ambit of designers, researchers, and activists.

Acknowledgements

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Maps

Data fiction: peri-urban bypasses

Sriperumbudur, in the Kanchipuram district fifty kilometres west of Chennai, is an exemplary place to witness the frictions of urbanisation on the Indian subcontinent. The region is a mutating zone made up of ancient villages, gated townships, fledgling infrastructures, and manufacturing enclaves (SEZs, specialised economic zones), where local laws of labour and taxation are expediently suspended to attract global capital (Foxconn, Saint-Gobain, Hyundai &c), and where speculation and aspirations clash to make a rather unruly mix of reinforced concrete structures, walled-up plots, road-side shrines, and degrading agricultural ecologies.

Sriperumbudur is also at the heart of a sweeping expanse of ephemeral rivers (*āṟu*) and seasonal monsoon lakes (*ēṟi*) that slope from the foot of the Eastern Ghats mountain range down to the creeks and backwaters of Bengal Bay and its western Coromandel coast. This coast is not only the source of heavy seasonal rains and cyclones that cut the area off during its annual North-East Monsoon, but it is historically also the frontier from which transnational urbanisation emanated to settle and colonise the entire Indian 'hinterland'.

Finally, Sriperumbudur also represents a condition on the edge, a leap into seemingly 'uncharted' territory, where strategies of speculative land-grabbing and clean-slate industrialisation (unmapping) are met with everyday counterstrategies that bypass, evade, and re-appropriate whatever purpose can be salvaged in the mutual encounter.

This is the 'friction zone' that the Bypasslab sought to map and triangulate as part of its first edition. The bypass road — circumventing the city while at the same time facilitating its expansion — is a paradigm of Indian (peri-)urban development, and of its inherently contradictory nature. But it is also a paradigm of the many vernacular initiatives that, while bypassing restrictions, re-inscribe the subject and try to make sense of place and space.

Challenging the view that the peri-urban always involves an edge, the following two lab contributions develop the notion of the 'bypass' as a double metaphor for peri-urbanisation. Bypass refers both to the tactics that people come up with in everyday 'peri-urban' life, as well as to the methods and data strategies, old or new, that urban researchers will have to develop if they want to circumnavigate the potholes, obstructions, and gaps in information that working in peri-urban India often entails.

Liminality of water

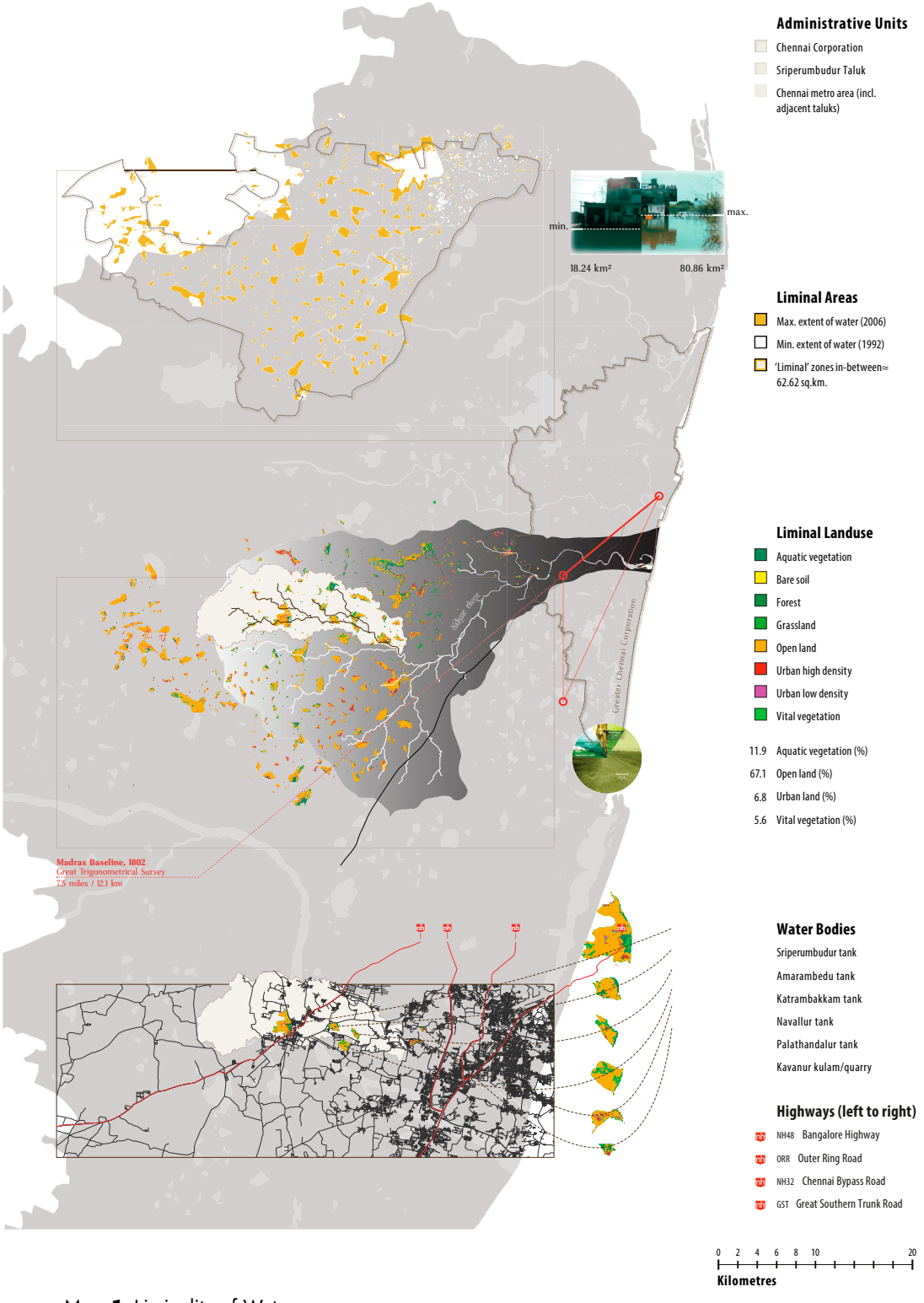
Starting from on-the-ground observations that water tanks within the area (man-made water bodies that store monsoon precipitation, known in Tamil as *ēṟi*) hardly ever align with cartographic representations, this contribution builds on a critique of the representation of water in local maps to suggest that, rather than their extent, the crucial variable to depict in the representation of these tanks should be their liminality and fluctuation. By transposing this notion to practices that take place in the tanks' border zones (licensed or unlicensed, built or unbuilt), the map hints at the fact that water and urbanisation may not be entirely antithetical after all, if only their mutual fluctuations could be aligned better in time.

Map 1: Karl Beelen (2018), *Liminality of Water.*

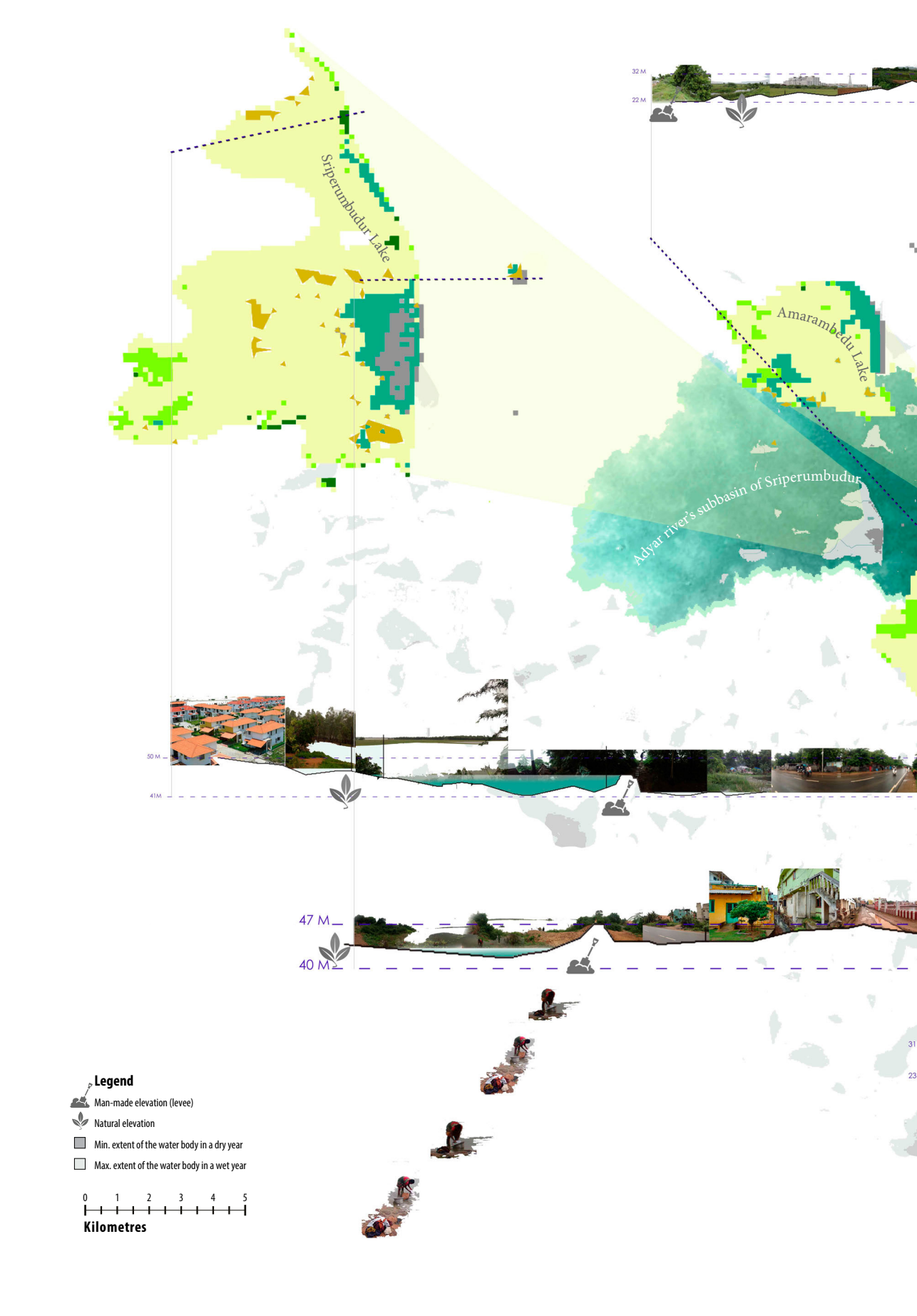
Liminal zones within the peri-urban, administrative unit of Sriperumbudur taluk.
Liminal land use in the Sriperumbudur subbasin of the Adyar river watershed.
Liminal transformations in response to (peri-)urban development pressures – six instances of lakebed 'encroachment'.

Map 2: Anuradha Suryavanshi, Henrik Otte, Paras Tyagi, Vivek Rakotu (2016), *Liminality of Water.*

Cross-sectional views of six water bodies in the Sriperumbudur area, indicating their minimum and maximum boundaries and the land-use patterns within the water bodies' 'liminal' edges.



Map 1: Liminality of Water.


Sriperumbudur Lake
Amarambedu Lake
Adyar river's subbasin of Sriperumbudur
32 M
22 M
50 M
41M
47 M
40 M
Legend
Man-made elevation (levee)
Natural elevation
Min. extent of the water body in a dry year
Max. extent of the water body in a wet year
0 1 2 3 4 5
Kilometres

Map 2: Liminality of Water.

Negotiability

This contribution spotlights the very short time span over which urbanisation seems to occur along main access routes and intersections in Sriperumbudur, such as State Highway 13 (SH13) and Melattur Junction. Its visualisation strategy is derived from a glitch in a smartphone video app called Mappilary, and the camera algorithms that it uses to produce panoramic pictures.

Camera Panorama Algorithms are rather versatile for curved 360-degree photos, but they cause distortions when applied to linear photographs, including those taken while driving along SH13. Such distortions slice and repeat the background when movement is slower, and repeat foregrounds when moving at faster paces. This produces stark 'pause points' which can then be taken as an instance of 'mobile negotiability'. Repeating this over a wide variety of places produces temporal events which are (somewhat paradoxically) represented by stationary visuals.

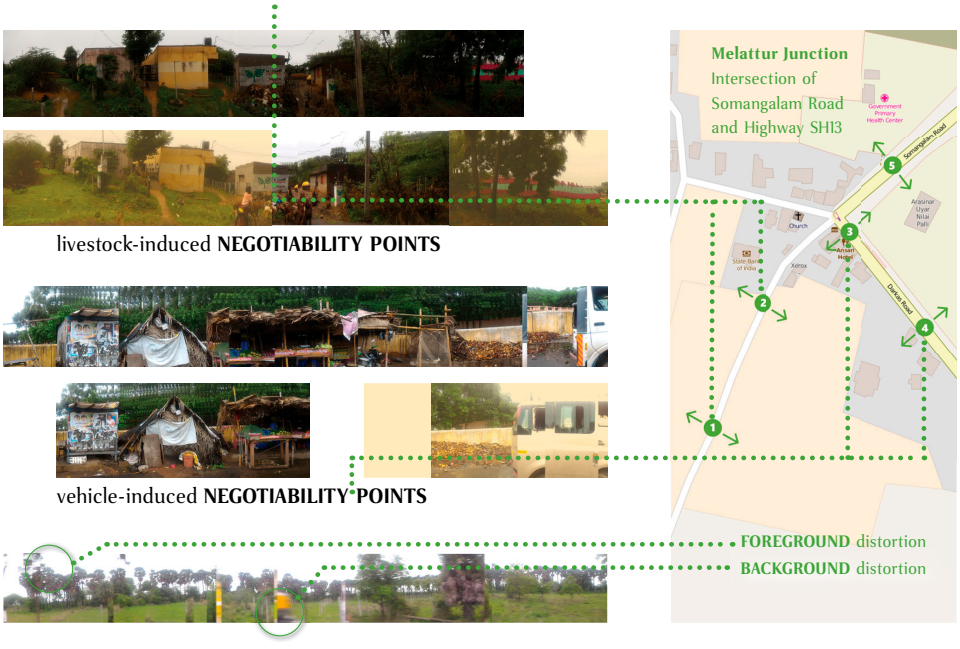
Looking at these static-yet-temporal visuals caused us to realise that most mobile negotiability events in the fringe are due to livestock and vehicles and that local cattle negotiate traffic in ways that allow them to continue plying their old routes — long after the pastures they frequented have given way to plots, walls, and traffic. The maps explore how people and cattle negotiated the structures, buildings, and obstacles that were cropping up at one of the crossroads along their routes.

Map 3: Ashwin Suresh, Iswarya Ramachadran, Nirupama Jayaraman, Parisutha Rajan A. (2018), *Pause Points*.

Negotiability: 'Pause points' resulting from algorithm-based distortions.

Map 4: Ashwin Suresh, Iswarya Ramachadran, Nirupama Jayaraman, Parisutha Rajan A. (2018), *Temporal Shifts*.

Negotiability: Temporal shifts marking out different actors at Melattur Junction.



Map 3: Pause Points.

Map 4: Temporal Shifts.

Map 5: Ashwin Suresh, Iswarya Ramachadran, Nirupama Jayaraman, Parisutha Rajan A. (2018), *Negotiability.*

Top: livestock activity around Melattur Junction / State Highway 13.

Bottom: approximate transformations in land use from 2002 onward (note the overall disappearance of grazing lands along the highway).

3.
Mapping and Design as Interrelated Processes

Constructing Space-Time Narratives[1]

Bieke Cattoor (Delft University of Technology)

I present a short processual account (Kitchin et al. 2013) of three re-cartographies of one and the same region, south-west Flanders, which touches upon some contemporary issues that cut across the disciplines of cartography and urbanism. The three re-cartographies re-imagine the territory of south-west Flanders in contemporary terms. Produced within the context of urbanism, they adopt a designerly approach to research by cartography, implying an orientation towards (re)shaping the environment. The re-cartographies are purposefully contextual. They aim to rediscover and reactivate the potentials inherent within the site, while at the same time attempting to formulate a (partial) response to contemporary spatial problematics. Critical re-mapping is a way to expand the spatial imagination, and in this sense augments the capacity of designers and stakeholders to engage constructively with the environment. Re-cartography is a partly accumulative and partly iterative urbanist practice, one that oscillates between re-inscribing and re-constructing, between re-imagining and engaging with the territory; simultaneously practising the territory and the map as-a-process.

The three re-cartographies (Cattoor and De Meulder 2011; Cattoor, Louwette and Thomsen 2013; Cattoor 2016) are discussed in detail in the Maps section accompanying this chapter. An introductory section sketches the current state of urbanism and links it to the renewal of interest in mapping; after that, a section on methodology examines the re-cartographies in terms of designerly mapping practices.

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1. The text part of this chapter is a partial reprint, partial adaptation of: Cattoor Bieke (2015) Designerly Mapping Practices at the Crossroads of Cartography and Urbanism: a Processual Account of Three Re-cartographies of Southwest Flanders, *Environment and Planning A*, 47(6), p. 1283–1297. Copyright © [2016] (SAGE Publications). Reprinted by permission of SAGE Publications.

The discussion demonstrates the capacities of re-cartography as an urban design tool, while highlighting its significance to cartographic theory.

Urbanism: a renewed engagement with the critical capacity of maps and mapping

Contemporary social, economic, environmental, and cultural issues all possess a significant spatial component that appeals directly to urban designers as well as to planners and landscape planners. The commitment of the spatial design sciences to such wide-ranging problematics has given rise to a number of different theoretical approaches: reformulating the contemporary spatial condition in terms of a palimpsestic territory (Corboz 1983), reconsidering the city as a relational, open intensity (Massey et al. 1999) addressing processes of urbanisation on a planetary scale (Brenner 2014), to cite but a few. The common denominator of these diverse theories is the conviction that contemporary spatial problematics cannot be adequately addressed without first challenging dominant spatial epistemologies. This crisis of the typical spatial model is a question not only of representation, but of agency as well: urban designers and planners no longer feel able to tackle the mounting spatial challenges via traditional design and planning tools.

This partial summary of the issues urban designers are facing today should not detract from the fact that the complexity and scope of what is at stake have reached a critical point, and they cut to the very heart of the discipline. This implies the need to rethink urbanism in terms of its disciplinary object, methodology, and agency. The resulting disciplinary quest is accompanied by a renewed of interest in the critical capacity of maps and mapping. Experimenting with cartographic formats not only expands the scope of our spatial imagination, but also enables us to dismantle the ways in which our visions of cities and regions are held hostage to systemised and standardised cartographic procedures that to a large extent still reflect nineteenth century and early twentieth century spatial ideologies (Brenner and Schmid 2011). Amongst other things, these standardised procedures perpetuate spatial thinking in terms of hierarchical scale and in terms of the nature-culture or city-countryside nexus. They focus on discrete objects rather than on relationships between objects and rarely question the assumption of linear time. The persistence of such cartographic models — unambiguous, neatly layered and hierarchical — compromises the spatial designer's ability to deal with the heavy, often contradictory, claims that today are being laid on space. To be able to accommodate contemporary spatial complexity in an era of scarce natural and financial resources and when space itself is at a premium implies that the territory

needs to be rethought in terms of multiplicity, heterogeneity, and hybridity as a dynamic layering of different historical moments with important regenerative qualities (Tschumi 2012).

Yet the reinvestment in cartography by urban design disciplines is not limited to a revaluation and redefinition of maps and mapping as tools of analysis and instruments for visual thinking (Söderström 1996). The groundswell of interest in mapping has caused urban designers to (finally) accord full value to mapping as an agency for the production of territory and as a maker of place (Corner 1999). Today, maps are no longer considered to be subordinate instruments to the actual design process, but rather as active urbanist practices that complement the established design categories of plan and project. Some designers have gone to great lengths to experiment with, and critically expand, the cartographic language. Cattoor and Perkins (2014) have reviewed some of the most sophisticated results of these experiments, labelling them 'architectural atlases' and highlighting their potential as a different kind of counter-mapping.

Three re-cartographies of south-west Flanders

The somewhat abstract challenges and difficulties will be rendered tangible in the Map section of this chapter, via a brief excursion into three re-cartographies of south-west Flanders. All three re-cartographies have been published as atlases: *Chronologies of a (Sub)urbanized Territory* (Cattoor 2013), *Figures Infrastructures* (Cattoor and De Meulder 2011) and *E17 Motorway Landscapes* (Cattoor 2016). The three re-cartographies were either produced in close collaboration with or commission by Leiedal, the inter-communal planning and development agency.

A designerly approach towards research by cartography

The re-cartographies perform research by cartography that significantly differs from traditional cartographic analyses, because they explicitly adopt a designerly approach. Each of the three re-cartographies is conceived, designed, and produced by urban designers. Urban design, much like architecture, is essentially 'a design-led discipline oriented towards (re)making and (re)shaping space. Geography, in contrast, is at core an analytical discipline oriented towards description and diagnosis of already-existing spatial circumstances' (Jacobs and Merriman 2011: 219). Heylighen et al. (2009: 98) have argued that a designerly approach 'seem[s] to be dominated by a world-to-mind direction of fit. [implying that] Designers are

concerned not predominantly with what is, but with what can be. Their attention is focused on possibility.' This projective attitude has profoundly influenced the development of the case studies in question and permeated all aspects of cartographic production.

The re-cartographies all share the same aspiration: to counter the on-going deterioration of the regional landscape. The 'indeterminacy' (Buchanan 1992) or 'wickedness' (Rittel and Webber 1973) of this aspiration is fundamental to design problems: they lack a definitive condition or problem statement, cannot fall back upon an exhaustive list of possible strategies, and have no stopping rules. At the same time, very few of the potential solutions to design issues can be judged in absolute true or false terms (Buchanan 1992; Rittel and Webber 1973). While the maps and atlases under consideration might, at first glance, appear to be concerned with regional history, they are all, to a greater or lesser degree, directed towards the future. They are not devised to meet scientific criteria but should be viewed as speculative attempts to construct a shared (by the stakeholders) and projective re-imagination of the territory. In this they aim to open up and demonstrate novel and more appropriate possibilities for future spatial development. To this end, each of the three re-cartographies follows a strategy of de- and reconstruction: deconstructing previously existing cartographies of the site and recomposing them into a series of alternative maps, and collating these into an atlas (or series of maps) that recasts the landscape in a set of territorial and cartographic figures. The territorial figures either reveal or provide insight into forgotten or previously overlooked spatial constellations, many of which are imbued with a landscape restructuring potential. The reformulation of the landscape in terms of cartographic figures (in the figurative sense, 'figure' as in 'figure of speech') is the methodology of the work. It represents a conscious attempt to extend cartographic language and to thereby challenge the imagination as well as to facilitate the discovery of novel territorial patterns. In addition, it aims to foster critical reflection upon more conventional maps and also the more traditional projects for the site in question (Cattoor and Perkins 2014). The crystallisation of meaning into a formal artifact, which condenses both content (territorial figures) and container (cartographic figures), is a typical act of design.

This designerly approach has significantly and overtly influenced the choices made during the mapping processes. While it can be argued that designerly decisions are essential to every mapmaking process, they are often rationalised or obscured in favour of scientific liability or in favour of the credibility of the national cartographic body (Wood 1992).

Figures Infrastructures: constructing hybrid and dynamic infrastructural figures

Figures Infrastructures (Cattoor and De Meulder 2011) focuses on the major infrastructure networks within the area [**Maps 1-4**]. A major challenge to the work was to avoid analysing these infrastructural networks in terms of how they are usually presented or in terms of how they were planned. Infrastructures is typically classified by type or category: national roads versus motorways, category-one roads versus local roads. These typologies and categories are most often managed separately, and not always to great success. *Figures Infrastructures* reimagines the infrastructure networks as hybrid and dynamic spatial figures: dynamic in the sense that the maps incorporate both the historical evolution of the infrastructural lines and the shifting interrelations between the different networks over time; hybrid because they merge many different typologies and cross different spatial categories, e.g. infrastructure and tissue, because they incorporate the planned as well as the unplanned, and operate across different scale levels.

Figures Infrastructures is a through-composed 'architectural atlas' (as elaborated by Cattoor and Perkins 2014). Developed in the context of urban design, the scope of the cartographic research was not limited to the pursuit of historical knowledge: the mappings aim to reconstruct emerging infrastructural figures that have both the power and the potential to act as frames for a more sustainable regional development. The infrastructural figures foregrounded in the atlas are, in most cases, only latently or implicitly present in typical cartographies, and therefore rarely feature within the contemporary spatial imagination. These infrastructural figures are given shape by means of a through-composed atlas structure, which fosters the accretion of various types of interactions between the maps [**Map 1**], such as: structural interactions on the level of the overall atlas set-up, figural (as in 'figure of speech') constructions on the level of the sites or chapters and inter-textual, or more precisely, inter-cartographic relationships on the level of the individual page layout. The structural, figural, and inter-textual cartographic constructions of meaning, as described in this paragraph, intermingle and accumulate as the reader works through the pages, chapters, and finally, the book as a whole.

Chronologies of a (sub)urbanized territory: reconsidering processes of (sub)urbanisation

Chronologies of a (Sub)urbanized Territory (Cattoor, Louwette and Thomsen 2013) investigates the perpetual reproduction of the heavily urbanised territory of south-west Flanders [**Maps 5-7**]. This atlas is an attempt to reconsider the question of urbanisation, which has long been centred on the city, in terms of the territory. Increasingly convinced that historical knowledge helps to make regional planning and development policies more relevant and effective, Leiedal (the inter-communal planning and development agency) commissioned a uniform cartographic chronology. The objective was to establish a common denominator for the variations in the generalisation and symbolisation schemes within successive series of national topographic maps. *Chronologies of a (Sub)urbanized Territory* is a structural, ideological, and academic elaboration of Leiedal's original request. The Dutch-language version of this cartographic research forms the backbone of a spatial biography of the region aimed at a wide audience and was published as part of the book *Metamorfosen* (De Meulder et al. 2010).

Time is a crucial variable within the composition of the atlas: three diachronic map series — *Frames*, *A Classic Chronology,* and *Interrelations* — offer an equal number of substantially different perspectives on the history of the region. The central map series answers the original design brief in a very literal sense: *A Classic Chronology* is conceived as a succession of snapshots that range in date from 1850 to 2005. A second series of maps entitled *Frames* aims to eradicate at least some of the chaos portrayed in the chronological sequence, by situating the region within a larger geographical context and thereby interpreting the area as part of, or embedded within, large-scale spatial systems. The final series of maps, *Interrelations*, brings the overly positivist attitudes displayed in the first two map series into perspective. Each of the maps is explicitly selective and deliberately interpretational, consciously reimagining the urbanisation of the area in terms of a systemic territory.

The different map series composing the atlas are tuned to one another in terms of their consistent, diverse, and complementary strategies applied to periodisation, scaling, and legend, which are furthermore explicitated in a metamap [**Map 5** top, **Map 6** top, **Map 7** top]. This far-fetched explicitation of cartographic relationships promotes a two-fold engagement: it enables the reader to construct alternative, synchronic readings of the territory [the vertical lines seen in **Maps 5, 6, 7**] and encourages the addition, especially to the third map series, of new maps treating different themes (Cattoor 2013). In this sense, the atlas can be compared to the

writerly maps that Pickles (2004) foregrounded, with the proviso that, at this point in time, broader participation is hindered by the limited accessibility and practical interactivity of the atlas. The self-imposed rigidity of the atlas' structure gave rise to formal restrictions that serve a didactic purpose: complex suburbanisation mechanisms become clear and intelligible, and thus accessible, to a broader audience. Yet, at the same time, the simplicity of the atlas set-up establishes a multiplicity of possible narrative pathways through the maps, thereby generating different views on the plural, dynamic, and diverse historical processes affecting the territory.

E17 Motorway Landscapes: revealing relational rhythms of landscape

E17 Motorway Landscapes (Cattoor 2016) is a cartographic exploration that complements a design workshop on the E17 coproduced by Leiedal and OSA/RUA. This series of maps draws greatly upon the experience and knowledge that was gathered during the designing of the two atlases previously discussed. *E17 Motorway Landscapes* pictures the E17 motorway as it crosses the heavily urbanised Leie-Scheldt interfluvium. Motorways are mostly mapped, and therefore commonly perceived, as alien elements superimposed upon the territory. By setting alternative rules to element selection, generalisation and symbolisation, this re-mapping describes the rhythmic quality of the motorway landscape. It can be seen as an assemblage, one that is characterised by the interplays between the E17 and a variety of other spatial systems, such as the topography, hydrology, local road networks, and land-use patterns in the vicinity. The cartographic assemblage of these interplays [**Map 8**] reveals a complex symphony of patterns. It highlights the plurality, dynamism, and transcalarity of the different metamorphoses that have culminated in the present-day motorway landscape. The cartographic strategy of assemblage — as collage and compositional practice (McFarlane 2011) — engenders the assemblage-capacity of the motorway landscape as a productive 'multiplicity constituted by heterogeneous terms and which establishes liaisons, relations between them' (Deleuze and Parnet 2007: 52, in McFarlane 2011). The assemblage capacity of the map has proven to be a solid point of departure for a design proposal that incorporates water retention basins, reveals a rhythmic landscape quality, multiplicates forest patches, and also provides a structural frame that begins to interweave the hard and soft, within an integrative approach towards the motorway landscape (Cattoor and De Meulder 2011).

In this sense, *E17 Motorway Landscapes* goes much further than *Figures Infrastructures* or *Chronologies of a (Sub)urbanized Territory* in its attempts to formulate a cartographic answer to specific spatial problems: a critical decline in the groundwater level, conflicting spatial claims (mostly provoked by the particular location of the E17 motorway in the midst of the river valley) and the rapidly vanishing qualities of the surrounding landscape, which is overgrown by seemingly uncontrolled sprawled development.

Discussion

The three re-cartographies of south-west Flanders operate at the crossroads of urbanism and cartography. They adopt a designerly approach towards research by cartography, which is reflected in the design capacities of their authors, the intentions of the collaborator-client, the 'wicked' nature of their aspiration, and in the directionality of the maps presented.

Each of the re-cartographies roughly re-maps the same area. Taken together, they represent a broad selection of the widely differing manifestations that designerly research by cartography can assume. They span the entire gamut of cognitive artifacts that constitute design knowledge, while at the same time blurring the boundaries between the traditional categories of tools, visions, and projects (Manzini 2009). The Dutch-language version of *Chronologies of a (Sub)urbanized Territory* is consulted as a reference document by the inter-governmental planning and development agency on a regular basis. Leiedal considers the atlas to be *a tool* that supports policy makers and designers, as well as the other actors involved in local design processes. According to Leiedal, *Chronologies* generates insight into a territorial perspective on the urbanisation of the region, and facilitates the communication of this insight to various actors involved. Yet, *Chronologies* operates beyond the instrumental: the atlas remains open to extensions and revisions, thereby stimulating a process of continuous re-inscription. In *Figures Infrastructures*, the orchestration of multiple levels of meaning culminates in a strategic vision on the potential of hybrid infrastructural figures to act as frames for greater sustainability in regional development. Just like a more traditional design vision, the atlas is deliberately selective but, at the same time, incorporates professional as well as amateur knowledge of the region, by means of intercartographic dialogues substantiating each of its single maps. While *Figures Infrastructures* has been at the basis of strategic design proposals, such as the proposal for a new tramway in Hoog Kortrijk (OSA/RUA, 2012), the atlas also operates on a methodological and conceptual level. As a codifier of analytical techniques and identifier of

meta-patterns (Scheer 2013), a through-worked architectural atlas such as *Figures Infrastructures* can help designers to identify the potential of emerging infrastructural figures on other sites, while also encouraging attention to the uniqueness of their context-specific manifestation. The map series *E17 Motorway Landscapes* selectively remaps the interactions between the motorway and a wide variety of other spatial systems in an attempt to formulate a cartographic answer to specific spatial problematics. The assemblage capacity of the map provides a solid base for an integrative design proposal while simultaneously rethinking the perception of the dual carriageway as a thick, continuously evolving, but resilient, motorway landscape.

Time is a crucial variable in all three re-cartographies: all three cases experiment with cartographic strategies that incorporate time as a dimension, thereby recasting urbanisation as an on-going *process*. *Chronologies* questions linear time by juxtaposing three map series, each of which presents a substantially different take on the history of the region. The open set-up of this atlas stimulates its extension and reinterpretation and, beyond this, presents the spatial history of the region as an evolving narrative. *Figures Infrastructures* presents emerging infrastructural figures via 'figural' cartographic constructions. These picture the dynamic interrelations between infrastructure networks in a variety of ways including, for example, through a multi-perspectival spatial chronology. *E17 Motorway Landscapes* assembles the processes of interaction between the motorway and a variety of other spatial systems. The idea of change is not only reflected in the re-cartographies' approach to the landscape; the re-cartographies themselves are envisaged as flexible and dynamic as well: in iterative confrontations with the territory (territory is broadly considered here, containing the context and condition of the terrain as well as the people involved), the re-cartographies are elaborated, extended, replaced, or even completely displaced.

The re-cartographies display a huge diversity in the way they oscillate between maintaining the illusion of systematic precision and, on the other hand, promoting the specific, explicitly forwarding a subjective reinterpretation of a site-related problematic. Contrary to many other cartographic practices, the re-cartographies openly express and exploit this tension in a careful orchestration of their atlas set-up, be they a fully-fledged architectural atlas, a more modest semi-didactic atlas, or a mere map series. *Figures Infrastructures* respects infrastructure lines as a topographical given but, at the same time, abandons the aura of comprehensiveness that emanates from a regular roadmap. Instead, it favours the construction of an interpretative, multi-layered and narrative composition. The three map series

included within *Chronologies* question each other's version of the region's spatial history, though the atlas as a whole incorporates many of the characteristics associated with a standard didactic atlas. The elements mapped as part of *E17 Motorway Landscapes* were selected on the basis of their relationship to the motorway, the objective being to address multi-sectoral and multi-scalar spatial issues via an integrative approach.

Dealing simultaneously with the systematic and the subjective, and dealing simultaneously with both the territory and the map as on-going processes, should be considered fundamental to the discipline of urban design, which incorporates both the science of the city and the practice of intervention (Pinson, 2004). The three re-cartographies jointly pursue these objectives by means of a designerly approach to research by cartography. In this sense, they reflect the almost pragmatic coexistence of two seemingly opposing cartographic paradigms at the heart of the discipline of urbanism: the consideration of the map as a (partial) workable mirror and a concomitant engagement with the post-representational quality of the map as a project (Pickles 2004; Kitchin 2010).

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Maps

Three re-cartographies of south-west Flanders

Flanders, the northern part of Belgium, is one of the most densely populated regions in Europe (Meeus and Gulinck 2008). South-west Flanders, also known as the 'Texas of Flanders', can be viewed as emblematic of the dispersed urbanisation of Flanders, characterised by the simultaneous presence of multiple spatial systems that cross different scale levels, that affect large territories, and that unfold over the course of extended time periods. These systems overlap and often conflict, especially because the historical border position of south-west Flanders has further intensified and complexified claims on space. The three re-cartographies reimagine selections of these complex and dynamic spatial systems to reveal patterns that mostly remain implicit in the urbanist discourse and hidden in everyday maps.

These complex patterns and phenomena usually remain opaque to the observer; the spatial complexity of the region is far beyond the representational capacity of a single map. Atlases, by multiplying maps and relating them to each other, often present a more sophisticated representation of a territory. The deliberate editing of a set of single maps into the format of an atlas not only elucidates the meaning of the individual maps through the logic of the book (Akerman 1995: 3), but adds an extra geometric layer to the logic, or geometry, of the individual maps: '… being a book, an atlas charts out the World according to a different geometry than its constituent maps' (Akerman 1991: 2). Deliberately editing the structure of the atlas (as defined by Akerman 1991: 2) can thus add clarity, as well as complexity, to a collection of maps. In addition to clarifying their meaning, it is also possible to nuance the unidirectional image of a territory by arranging the maps in a sequence. All three re-cartographies are involved in the exploration of the territory as much as in the exploration of cartographic language. They work on unveiling and counteracting the established and seemingly self-evident cartographic conventions and procedures that were described in the introductory paragraph. For example: standardised conventions of scale and routine procedures of selection, categorisation, generalisation, and symbolisation, and the failure of traditional methods adequately to address the issue of periodisation (Cattoor and Perkins 2014).

Figures Infrastructures: constructing hybrid and dynamic infrastructural figures

Figures Infrastructures (Cattoor and De Meulder 2011) focuses on the major infrastructure networks within the area. A major challenge to the work was to avoid analysing these infrastructural networks in terms

of how they are usually presented or in terms of how they were planned, typically classified by type or category. These typologies and categories are most often managed separately, and not always to great success. *Figures Infrastructures* reimagines the infrastructure networks as hybrid and dynamic spatial figures: dynamic in the sense that the maps incorporate both the historical evolution of the infrastructural lines and the shifting interrelations between the different networks over time; hybrid because they merge many different typologies and cross different spatial categories, e.g. infrastructure and tissue, because they incorporate the planned as well as the unplanned, and operate across different scale levels.

These infrastructural figures are given shape by means of a through-composed atlas structure which fosters the accretion of various types of interactions between the maps [Map 1], such as: structural interactions on the level of the overall atlas set-up, figural (as in 'figure of speech') constructions on the level of the sites or chapters, and inter-textual or, more precisely, inter-cartographic relationships on the level of the individual page layout.

The structural, figural, and inter-textual cartographic constructions of meaning, as described in the previous paragraph, intermingle and accumulate as the reader works through the pages, chapters, and, finally, the book as a whole.

The Maps on the following pages [Map 1-4] are excerpts from: Cattoor B. and De Meulder B. (2011) *Figures Infrastructures: An Atlas of Roads and Railways*. Amsterdam: SUN.

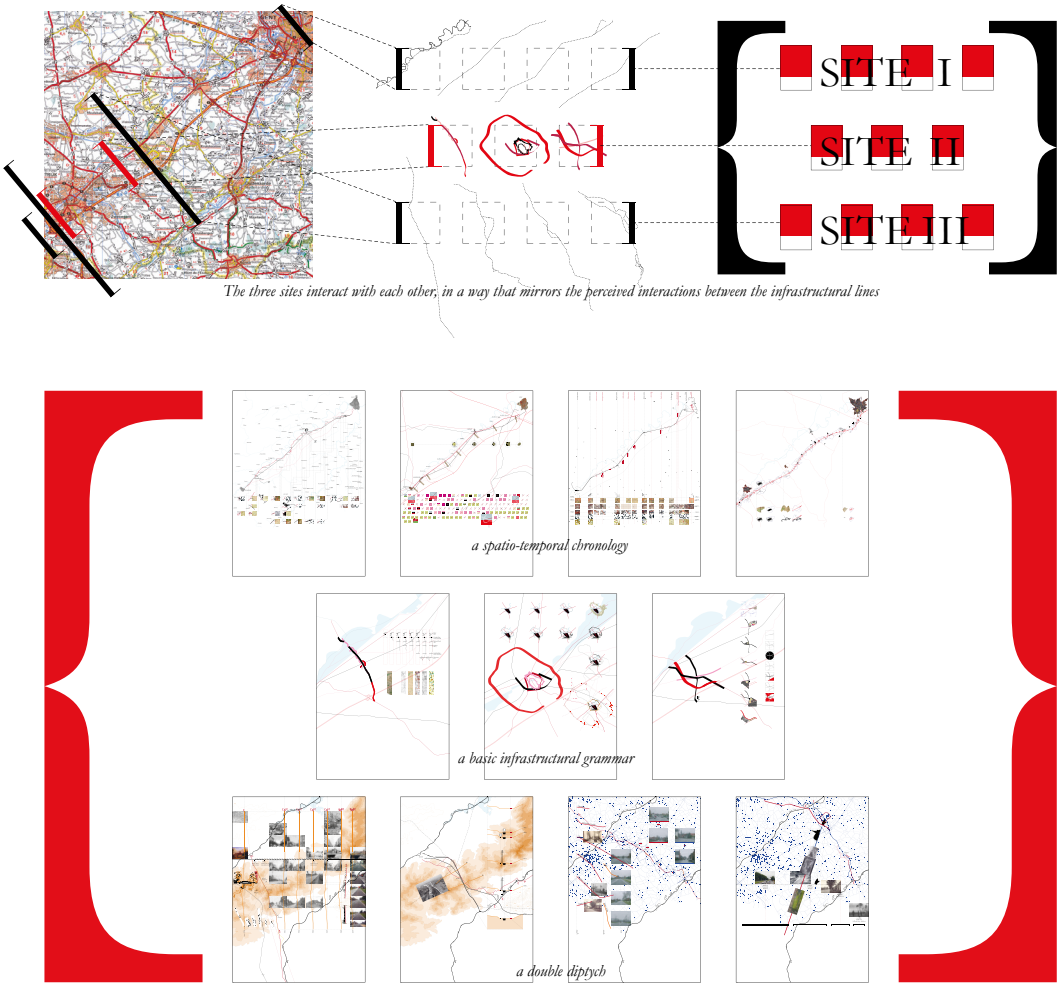
Map 1: Bieke Cattoor (2011), *Figures Infrastructures: Diagram of the Interrelations between the Different Maps Composing the Atlas*.

A diagram shows how the atlas structure fosters the accretion of various types of interactions between the maps.

On the level of the overall atlas set-up, the topological structure highlights the dynamic interdependence of the infrastructure networks as they develop historically over time into complex interrelated systems [Map 1 top a, b, c]. In general, the atlas is set up in three parts, called 'sites'. The interaction of the three sites mirrors the perceived interactions between the infrastructural lines.

On the level of the sites, each site (or chapter) constructs both a cartographic and infrastructural figure [Map 1 bottom]. Site I develops a spatio-temporal chronology [see also Map 2], Site II breaks down the infrastructures according to their compositional logic [see also Map 3], Site III focuses on one type of infrastructure and explores the diversity within its historical and present-day appearance [see also Map 4].

On the level of the page layout, the maps enter into dialogue with cartographic references [Map 1, top right]. These inter-cartographic constructions recognise, incorporate, or refute the significance of deeply ingrained cartographic principles for the visualisation, conception, and planning of infrastructure networks. The cartographic references include both historic and contemporary maps, and were created by a broad community of professional planners and cartographers, as well as by local spatial experts, such as amateur historians and regional entrepreneurs.



Map 1: Figures Infrastructures: Diagram of the Interrelations between the Different Maps Composing the Atlas.

Map 2 top: Bieke Cattoor (2011), *Figures Infrastructures, Site I*.

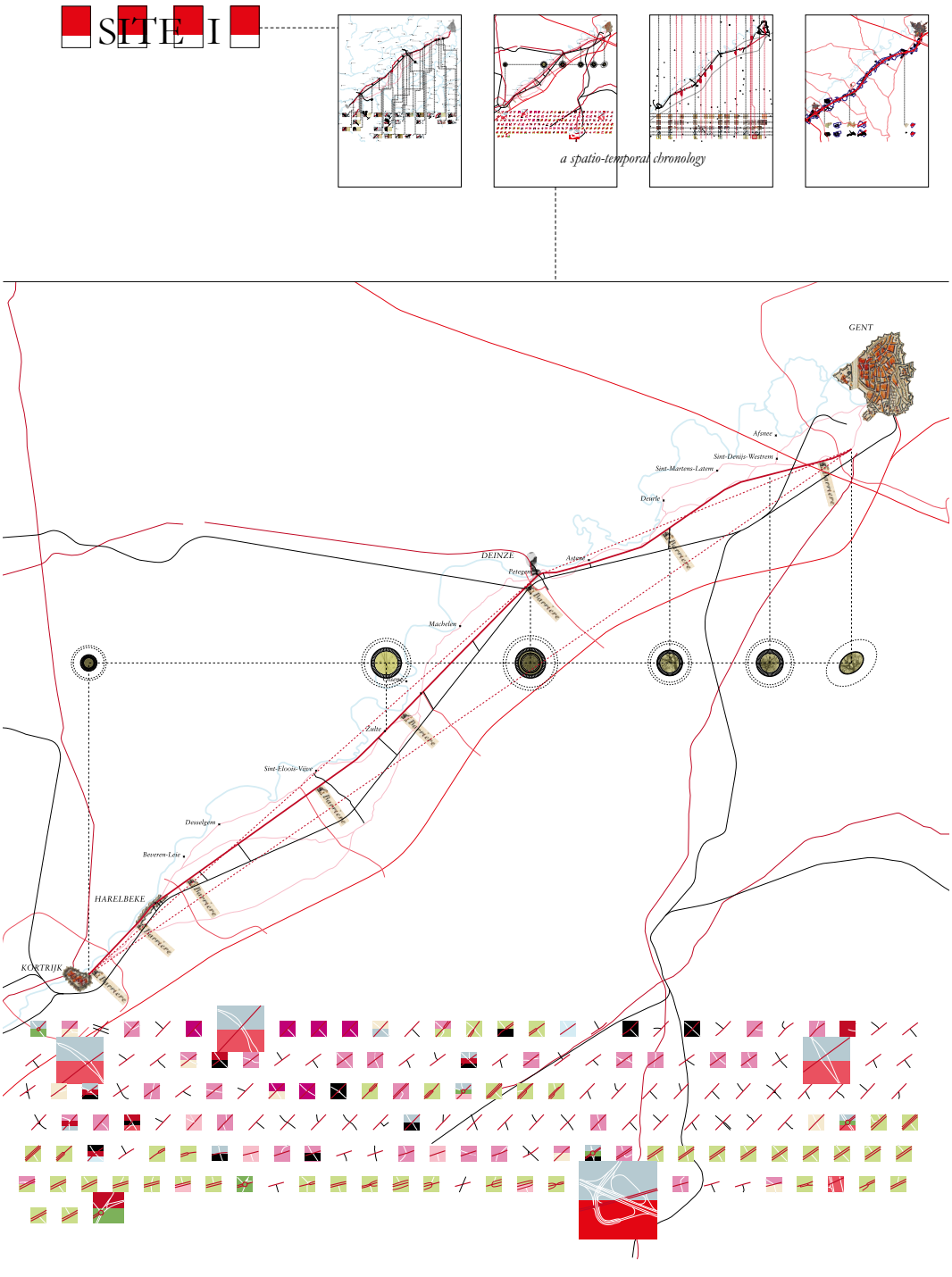
Site I develops a spatio-temporal chronology and examines the perpetually evolving bundle of parallel infrastructure lines between Kortrijk and Ghent. Two distinct strategies of temporal atlas composition determine the set-up of this Site.

The first temporal strategy is the de-construction of the bundle's history into a straightforward chronology: four successive maps follow the bundle's growth over time in four distinct historical phases: the river and adjacent ancient country lane [Map 2 a], the construction of the N43 national road in 1722 [Map 2 b], the construction of railway line 75 in 1839 [Map 2 c], and the construction of the E17 motorway in 1973 [Map 2 d].

Within this straightforward frame of the spatial chronology, each of the infrastructures is subject to on-going change. A second temporal strategy consists of making these changes tangible: each of the maps shows how the infrastructural line adapts or changes role drastically, is made redundant, or regains importance. Each of these composing maps takes on the historical perspective of its protagonist: the country lane, national road, railway, or motorway. Their transformations over time render the image of the map less permanent, the infrastructures themselves seem to offer resistance to the rigidity of the linear chronological construction.

Map 2 bottom: Bieke Cattoor (2011), *Figures Infrastructures, Site I, N43 national road breaks into segments of a line*. (Cattoor and De Meulder 2011: 49)

The second map of Site I, *N43 national road breaks into segments of a line*, illustrates the above-mentioned cartographic strategies. The map traces the history of the N43 national road, the second addition to the bundle of parallel infrastructures between Kortrijk and Ghent. Conceived as an almost independent communication route, the trajectory bisects, in a perfectly straight line, an otherwise organically formed territory. In the successive stages of its life-cycle, the N43 was demoted from its inaugural role as the prime protagonist in the handling of traffic: as new and better performing infrastructure lines were added to the bundle, the construction of supply routes saw the N43 become ancillary to these more dominant networks. These supply routes split the national road into segments, each time anew. The successive divisions are plotted in different colours on the section-boxes at the bottom of the map (e.g. the reorientation of the national road to service the railway is marked in black, to service the motorway in light red). The significance of the intersections is multiplex: some intersections define more than one segment of a line. The impact of each reorientation varies, and is reflected in the scaling and rhythm of the respective section-boxes. By illustrating how the N43 keeps breaking down into segments, at various time periods, and in different ways, the re-cartography not only refutes the presupposed status of the national road as a salient colossus, but also its existence as a solid type. The uppermost section of the map inverts the narrative of the N43's degeneration and transforms it into a tale of newly emerging, hybrid infrastructural figures. With the national road (dark red) and the railway (black) or motorway (light red) acting as stiles, and the respective supply routes acting as rungs, the map reveals two overlapping infrastructural ladders with the potential to frame the deconcentrated development in the area.



Map 2: Figures Infrastructures, Site I, N43 national road breaks into segments of a line.

Map 3 top: Bieke Cattoor (2011), *Figures Infrastructures, Site II*.

SITE II breaks down the infrastructures according to their compositional logic, thereby formulating an alternative infrastructural syntax and problematising the sequence of decomposition and recomposition that lies at the very heart of classic cartography, in other words, the act of breaking down wholes into easily categorisable parts.

Hand in hand with the growth of the large-scale infrastructural bundle depicted in Site I [Map 2], new figures arise and old ones fade. Secondary patterns emerge between the lines of the bundle, because built-up centres want to establish a link to new and faster infrastructures. SITE II deals with three such figures that are inscribed in between the parallel lines of the Kortrijk-Ghent infrastructural bundle and that bind the lines of the bundle to form a band city.

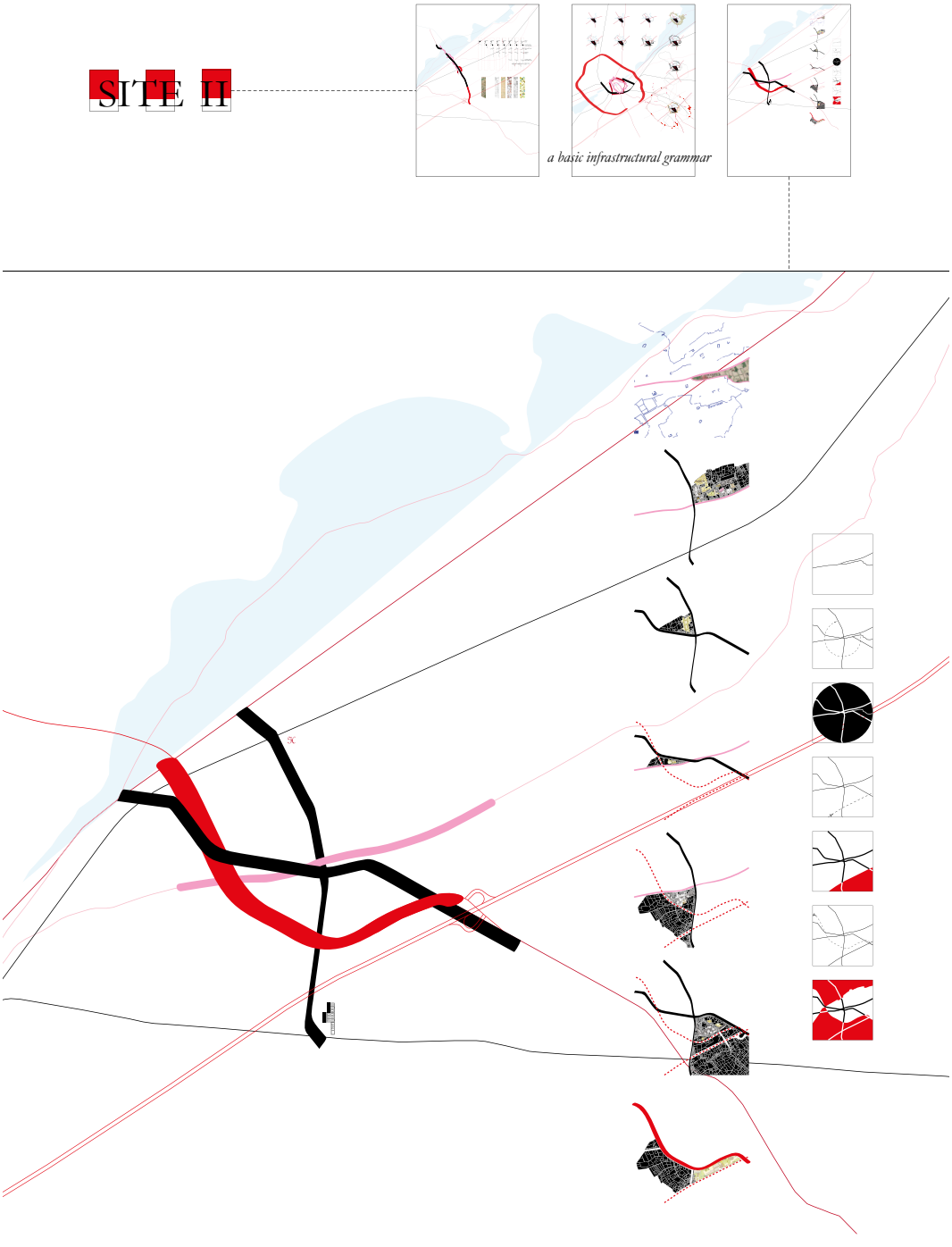
The infrastructural figures of Desselgem [Map 3 a], Kortrijk [Map 3 b], and Deerlijk [Map 3 c] can be reduced to compositions of straight and curved routes — lines and circles — laid at different periods in time. A time-related symbology is applied to each of these straight lines and curves composing the figures: pink and curved for ancient times, burgundy and straight for the era of national roads, black and smoothed for the era of railways, and red smoothed for the motorway era. By repeating this symbology in each of the three maps composing SITE II, the idea of a time-related infrastructural grammar appears.

Map 3 bottom: Bieke Cattoor (2011), *Figures Infrastructures, SITE II, Deerlijk Mixed Figures* (Cattoor and De Meulder 2011: 119).

The map excerpt illustrates the temporal strategy employed in SITE II. Deerlijk was a straightforward linear roadside hamlet until it put out four radial tentacles (in black) to grope for the newly constructed railways halfway through the nineteenth century. Near the end of the twentieth century, its attachment to the motorway exploded in a half ring figure (circle) around the village centre. These new infrastructures, the groping lines and a deviating half circle, have determined to a large extent the final configuration of the village.

The central map figure [Map 3 bottom left], outlines the principles of Deerlijk's time-based infrastructural syntax. The elementary modules within this syntax are the straight and curved routes with which an infinite variety of infrastructural figures can be composed. Straight lines extend and connect. Bends shy away, they bypass. Any figure of a town or village can in fact be reduced to a composition made of these straight lines and circles.

However, when zooming in, the straight line is not exactly straight. When zooming out, the bypass also forms a connecting link. Zooming out confronts us with the impossibility of attaching a univocal meaning to the figures. Zooming in shatters the illusion that the basic modules are pure. These modules themselves are in fact not unambiguous: dissecting them further keeps opening up new uncertainties. The border between module and composition is vague; the distinction between part and whole is never beyond doubt. These paradoxes reside in the maps. Schematic and more figurative cartographic representations [Map 3 bottom right] make apparently contradictory movements. It is the friction between the planned and the ad hoc, the abstract idea and the conditions on the ground, the resistance of the territory to planological simplification that finds its expression here.



Map 3: Figures Infrastructures, Site II, Deerlijk Mixed Figures.

Map 4 top: Bieke Cattoor (2011), *Figures Infrastructures, Site III, N50 from Archetype to Total Degradation*.

SITE III makes a start to explore the large diversity in the histories of how different national roads were formed. The distinct genesis of these national roads also has far-reaching consequences for the way in which they are approached in redevelopment projects up to the present day.

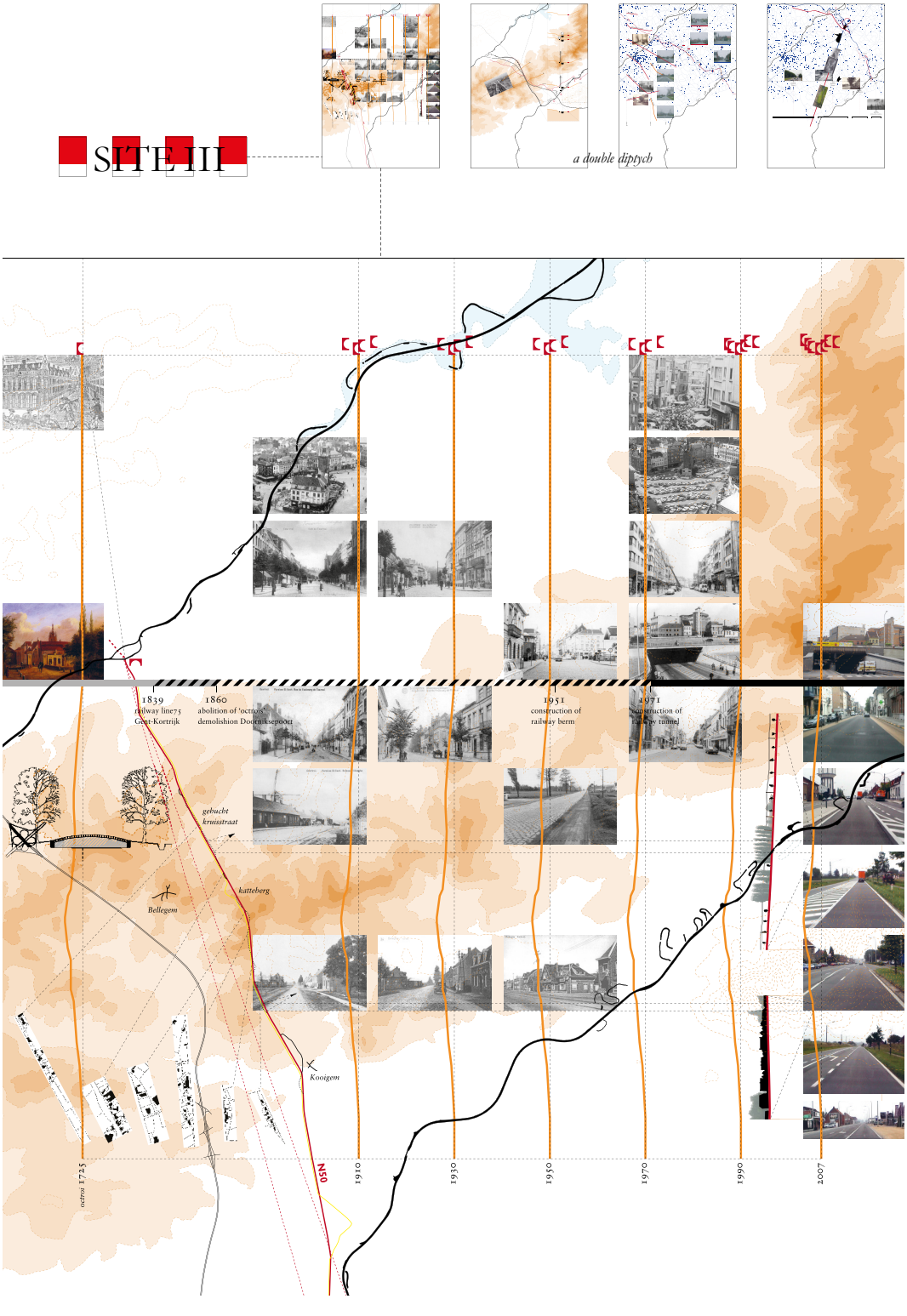
To stimulate the exploration of the wide variation in the historic appearance of national roads, SITE III was set up as a double diptych. The first two maps, in diptych, develop a contrasting story on the historic evolution of two different national roads (the N50 and the N8) in relation to topography. The second diptych explores how the N36 and the N382 engage in a very different way with the evolving local road networks. To facilitate comparison between these different road histories, each of the four maps juxtaposes a different stage in their historical development.

Map 4 bottom: Bieke Cattoor (2011), *Figures Infrastructures, SITE III, N50 from Archetype to Total Degradation* (Cattoor and De Meulder 2011: 133).

The first diptych featuring in SITE III articulates the contrast between the N50 [Map 4 bottom], situated up high, and the N8, down the valley.

The evolution of the N50's historical route and profile is reconstructed in the following periods: ca 1725, 1910, 1930, 1950, 1970, 1990 and 2007 on the basis of plans, legal documents, and photographs. Road profiles and their on-going adjustments are a significant cause and effect of the distinctive and ever morphing characteristics of the identity of the four national roads. The notion of 'profile' is tackled broadly, ranging from profiles perpendicular to the road (lanes, ribbon development) or in alignment with it (bridges, tunnels, etc.) to broader sections through the landscape (profiles of the relief and longitudinal visual axes…).

The juxtaposition of historical periods shows that, at first, the N50 'Herstrate van Cortryck nar Doornick' has a clear typology. As a bridge road between the bridge towns Kortrijk and Doornik, and probably going back to the Romans, it conforms to an archetype. Modifications to the longitudinal profile such as the construction of a town gate, the tunnel on the outskirts of the town, and a multiplication of bridges have disrupted this typological clarity. In spite of the flexibility of the transverse profile, the entire N50 has been bypassed by the E403. That is why recent structure plans do not designate the N50 even as a secondary road. Since the category of a road is strictly related to the desired flows of traffic in the road network, spatial characteristics such as typological origin are irrelevant to such considerations. The non-categorisation has eventually earned the N50 the label of a local road — ironically enough, from now on that label is the basis for planning redevelopments. All that is left of the archetype is the unintentional side-effects of its genesis: a dominant presence in the landscape because of the raised ribbon development that has grown on either side of it in the course of time.



Map 4: Figures Infrastructures, Site III, N50 from Archetype to Total Degradation.

Chronologies of a (sub)urbanized territory: reconsidering processes of (sub)urbanization[2]

Chronologies of a (Sub)urbanized Territory explores the perpetual reproduction of the heavily (sub) urbanised territory in south-west Flanders, as a consequence 'time' was a crucial variable within the composition of the atlas. With *Chronologies*, we aimed to develop a structure for an atlas that can include the plural and often very diverse historical processes affecting the territory without jeopardizing the coherence of the atlas as a whole. Special attention has been given to how the depth and scope of an atlas can furthermore be increased through a careful engineering of the interplay between its constituent maps.

Time is a crucial variable within the composition of the atlas: three diachronic map series — *I Frames* [Map 6], *II A Classic Chronology* [Map 5], and *III Interrelations* [Map 7] — offer an equal number of substantially different perspectives on the history of the region. Each series follows a different logic regarding the scale, the map's categories, and its approach to the passage of time. Taken together, they offer three diachronic variations on the processes of (sub)urbanisation in the region. Perpendicular to these diachronic readings a synchronic reading of the territory can be constructed. The maps within the different series interact with each other and form a multi-angled point of view through which to examine specific urbanisation phenomena at delimited periods of time. The lines of interaction across the pre-defined map series add a second narrative dimension, although the possible readings are less immediately obvious. A metamap or, in other words, a map of maps (Akerman 1995: 3) opens up this multi-dimensional quality of the atlas, revealing possible trajectories across its pages. The selective display of relevant parts of the metamap illuminates the different aspects of the atlas structure described in the following sections.

The maps on the following pages [Maps 5-7] are excerpts from: Cattoor B. (2013) Chronologies of a (Sub)urbanized Territory: Reimagining (sub)urbanization processes in south-west Flanders, Belgium. *Journal of Maps* 9(1): 76–83.

2. This cartographic section is a partial reprint, partial adaptation of: Bieke Cattoor (2013) Chronologies of a (sub)urbanized territory: Reimagining (sub)urbanization processes in southwest Flanders, Belgium, *Journal of Maps*, 9(1): 76-83.

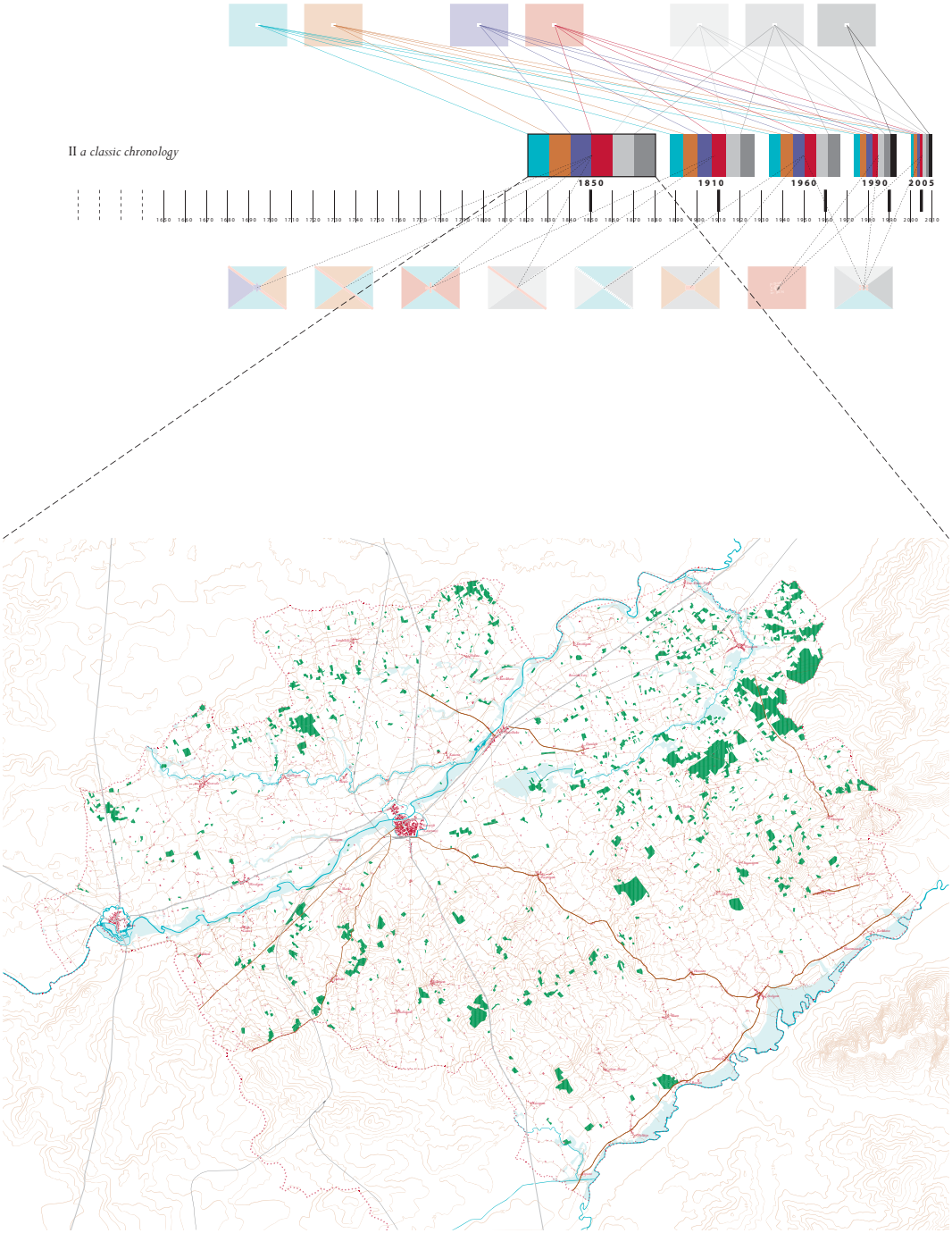
Map 5 top: Bieke Cattoor (2013) *Chronologies of a (Sub)urbanized Territory, Metamap* (Cattoor 2013, Supplementary material: 14).

The central map series, *A Classic Chronology* (map series II), is conceived as a succession of snapshots that range in date from 1850 to 2005 [see timeline]. Each map is framed according to Leiedal's administrative sphere of influence and repeats the same element categories, roughly selected on the basis of the agency's areas of competence: infrastructure, built environment, forested areas, and water. The maps depict the spatial transformation of the selected categories in great detail, underlining the often-chaotic character of on-going (sub)urbanisation, stressing entropy rather than structural quality. To complement the limitations of this classic chronology two map series were added to the atlas on the initiative of the designers [see Maps 6 and 7].

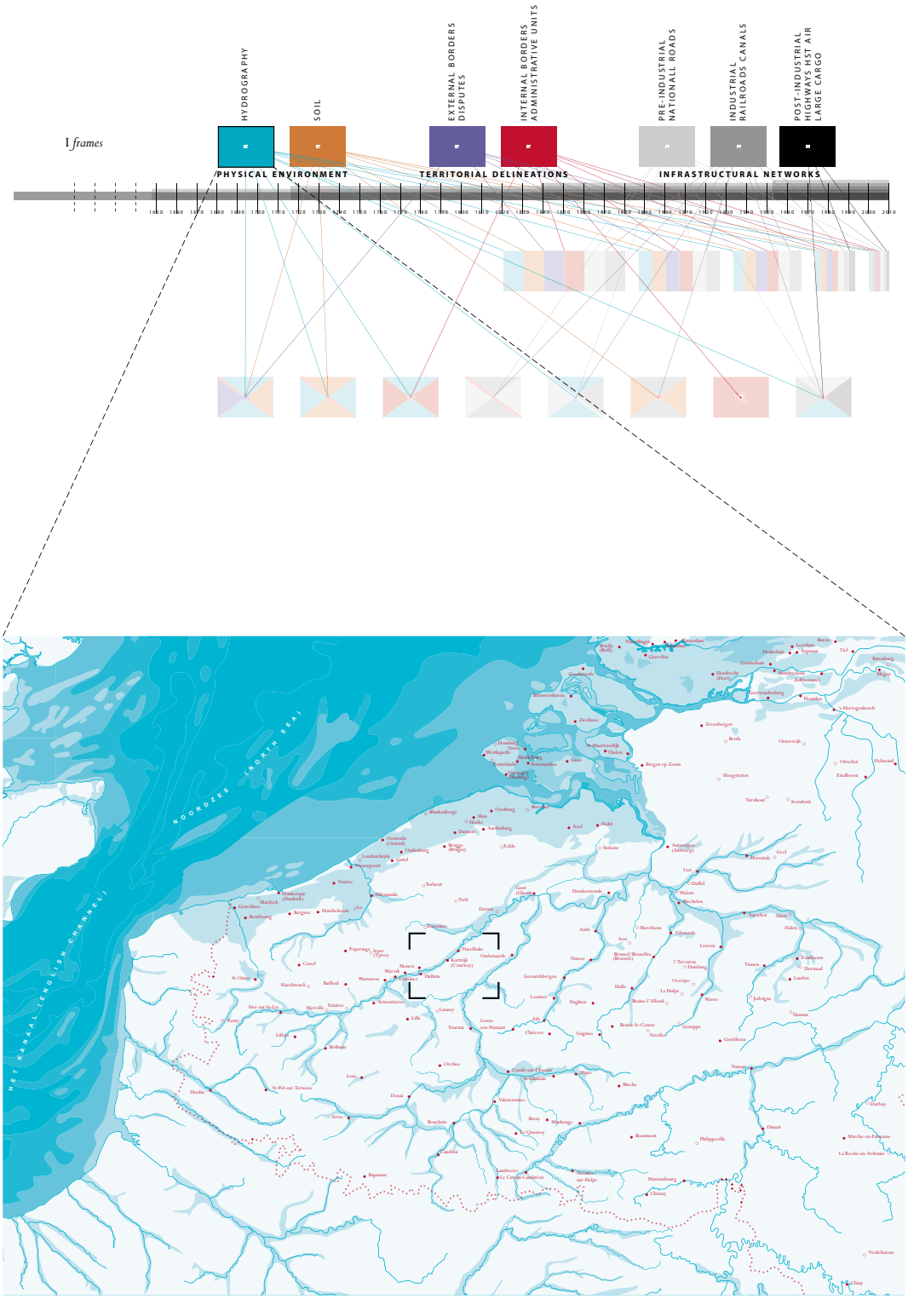
Map 5 bottom: Bieke Cattoor, Tom Louwette and Karin Thomsen (2013) *A Classic Chronology, ca 1850* (Cattoor 2013, Supplementary material: 15).

This map is the first of the map series *A Classic Chronology*, dating from 1850 to 2005. These maps, with an ever smaller time interval between them, bring the territory into focus. The maps show how, at particular moments in time, the different historical layers either link to each other, thwart, or simply reinforce each other.

Until the end of the eighteenth century, space in the Kortrijk region had mainly been organised around the duality of city and countryside. Land usage was determined to an important degree by the properties of the soil and water management. The end of the Ancien Régime (1795) marked the start of a large spatial metamorphosis that unfolded at an ever-increasing pace. The advent of modernity led to an unprecedented increase in the growth of development and the splintering of the landscape. The space is no longer organised according to the duality of city and countryside, or according to water and soil structure. New infrastructure layers slide over the traditional landscape of the Ancien Régime, reorientating the fabric and introducing new organisational principles.



Map 5: Chronologies of a (Sub)urbanized Territory, Metamap and A Classic Chronology, ca 1850.



Map 6: Chronologies of a (Sub)urbanized Territory, Metamap and Frames, Physical Development, Hydrography.

Map 6 top: Bieke Cattoor (2013), *Chronologies of a (Sub)urbanized Territory, Metamap* (Cattoor 2013, Supplementary material: 5).

Frames (map series I) was included as an introductory map series to the classic chronology, with the aim of eradicating at least some of the chaos portrayed in the chronological sequence. This series of small-scale, mono-coloured maps situates the region within a larger geographical context and interprets the area as part of, or embedded within, large-scale spatial systems. The maps have a diagrammatic quality and function along the lines of a guide, consciously simplifying the grand historical narratives and thereby making them accessible to a wider audience.

The frames are ordered in three thematic groups: physical environment (two maps), territorial delineations (two maps), and infrastructure networks (three maps). These frames are arranged, generally speaking, in chronological order according to the approximate date at which they appeared within the territory. All seven frames nevertheless have a degree of contemporary relevance. One predominant colour is chosen for each frame. The colours of the first denote the physical environment and mimic those found in nature: blue for water, brown for soil. The colours of the second set are deliberately artificial, in keeping with the fact that drawing a border is ultimately an artificial act. The grey used to indicate the infrastructure pictured in the third set of maps darkens in relation to the increases in the speed with which the infrastructure enables us to move over the territory.

Map 6 bottom: Bieke Cattoor, Tom Louwette and Karin Thomsen (2013), *Frames, Physical Development, Hydrography* (Cattoor 2013, Supplementary material: 6).

The *Frames* map series starts off with a set of two maps that show how the physical environment determined the location of human settlements. The first of these two maps elaborates on the role of the rivers Schelde and Leie in the long history of the region.

Very early settlements sprang up along the banks of the rivers and their tributaries, and these later flourished into a dense network of villages and cities. The abundant water was not only used for agriculture. For a long time, the inland waterways of the Leie and the upper Schelde belonged to the densest net of navigable waterways in the country. The connection with France via the canal network was essential for the early development of the region. A line of small cities formed, which determined part of the commercial flow between the Low Countries and Italy. From as early as the High Middle Ages, the region of Kortrijk was one of the most urbanised areas in Northern Europe. Water, and the composition of the soil, continued to define the fortunes of the region in a Post-Agrarian society. Thus the Leie represents the life-giving artery for flax, from its origins to the thriving flax industry of the nineteenth and twentieth centuries. The rich clay layers on the line of hills between the Leie and Schelde also made an important contribution to economic development.

Map 7 top: Bieke Cattoor (2013), *Chronologies of a (Sub)urbanized Territory, Metamap* (Cattoor 2013, Supplementary material: 21).

The final series of maps, *Interrelations* (map series III), brings the overly positivist attitudes displayed in the first two map series into perspective. *Interrelations* aims to counteract the oversimplification generated by the clear periodisation put forward in *Frames* and, at the same time, attempts to offer a designerly alternative to the entropy portrayed in *A Classic Chronology*.

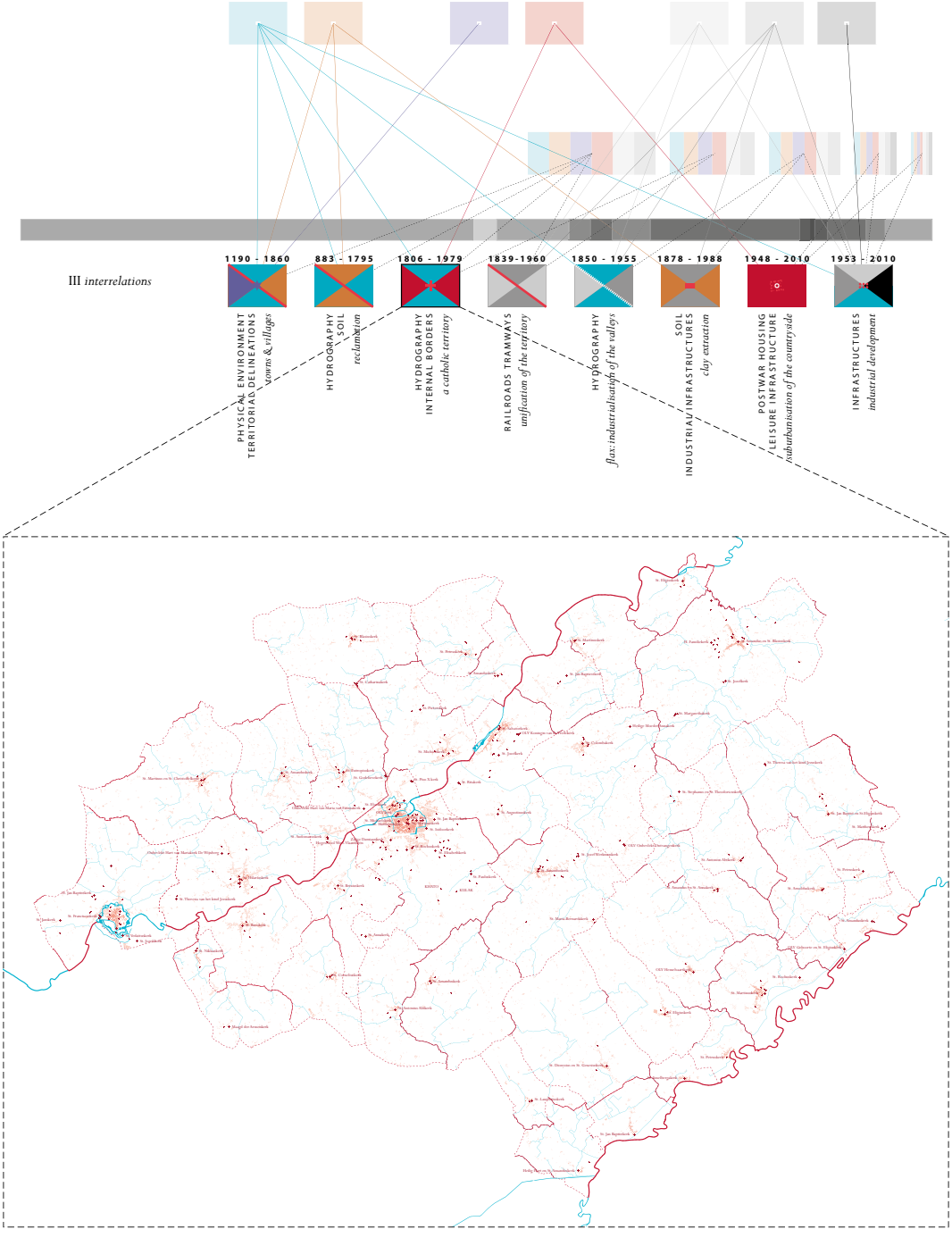
The eight maps in *Interrelations* offer systemic readings of the territory: each gives visual form to a historical theme, mechanism, or development that had a fundamental and enduring impact upon the suburbanisation of the region over a well-defined time-span. They are not snapshots, but more like thematic cuts. The time-spans covered in the eight maps overlap: the processes of urbanisation that are displayed cannot be isolated in time because different urbanisation mechanisms operate simultaneously.

Each map contains material that has been selected and extracted from the first two maps series. They explore and interpret the dynamic interrelationship between the *Frames* pictured in the first series and the accumulation of the built-up areas as illustrated in the *Classic Chronology*. At the same time, they endeavour to make sense of the interplay between the macro and the micro scale. Each of the maps is explicitly selective and deliberately interpretational, consciously reimagining the urbanisation of the area in terms of a systemic territory. The series is intended as an open-ended collection upon which further elaborations and extensions, as well as divergent interpretations of the region's history and visions of its future, can be grafted.

Map 7 bottom: Bieke Cattoor, Tom Louwette and Karin Thomsen (2013), *Interrelations, Hydrography/Internal Borders, A Catholic Territory* (Cattoor 2013, Supplementary material: 24).

The above excerpt from the *Interrelations* series develops a narrative on how hydrography and internal borders steered the shaping of a catholic territory.

The development of the parishes was always closely linked to the water structure: water formed the centre and/or the borders of the parishes. Historically, the church always stood prominently in the centre of the parish. For centuries, it structured the whole rural space, together with the cemetery, and later the presbytery and the village school. The parish borders continued to live on in the municipality borders laid down by the young Belgian nation state in the municipality law of 1836. During the nineteenth century Catholic revival until well into the twentieth century, the church confirmed its all-determining influence on society. This manifested itself in the region as a rhizome of churches and institutions that, even today, structures the landscape.



Map 7: Chronologies of a (Sub)urbanized Territory, Metamap and Interrelations, Hydrography/Internal Borders, A Catholic Territory.

E17 Motorway Landscapes: revealing relational rhythms of landscape

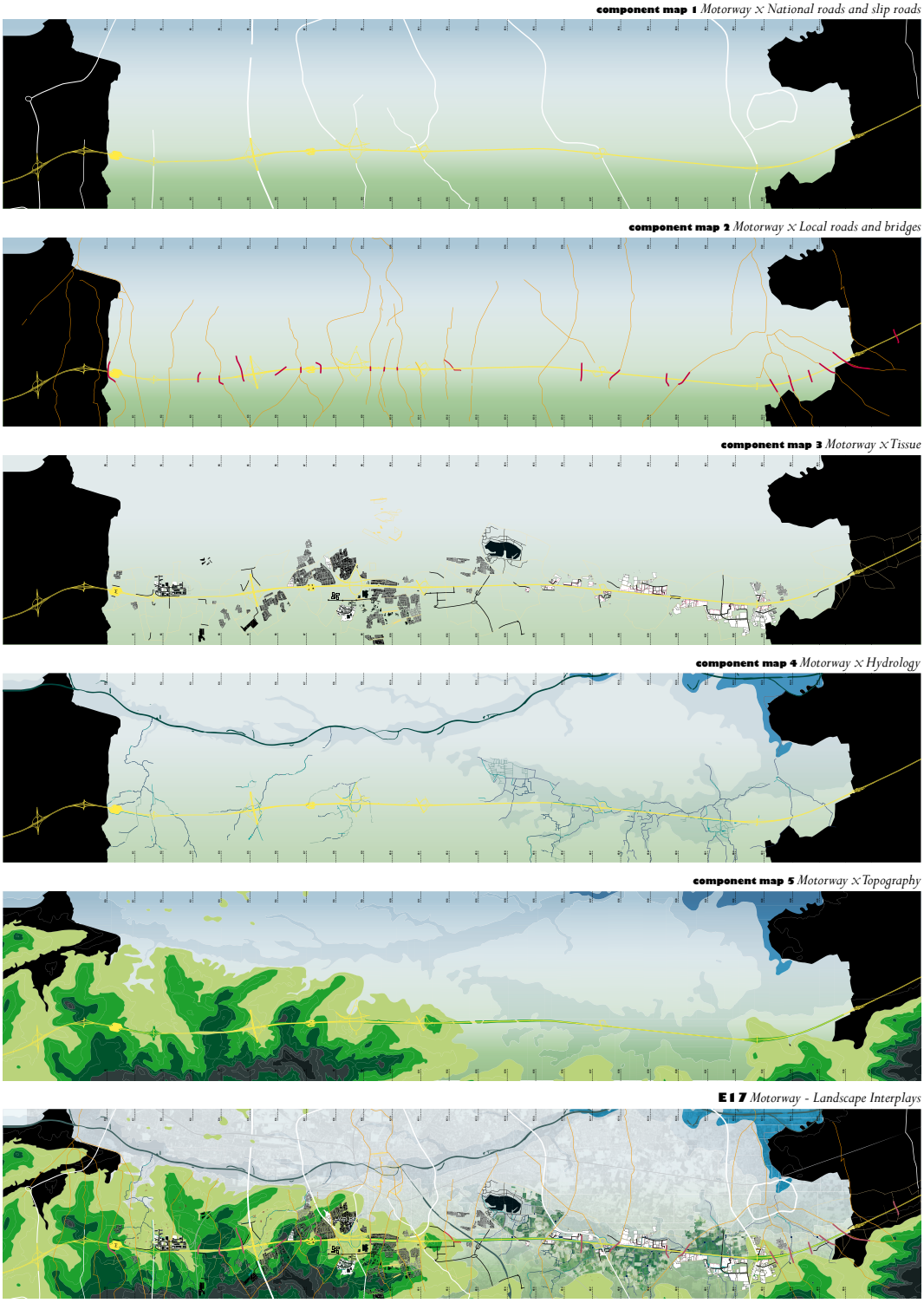
E17 Motorway Landscapes pictures the E17 motorway as it crosses the heavily urbanised Leie-Scheldt interfluvium. Motorways are mostly mapped, and therefore commonly perceived, as alien elements superimposed upon the territory. By setting alternative rules to element selection, generalisation, and symbolisation, this re-mapping describes the rhythmic quality of the motorway landscape. It can be seen as an assemblage, one that is characterised by the historic interactions between the E17 and a variety of other spatial systems, such as the topography, hydrology, local road networks, and land-use patterns in the vicinity.

The Map on the following pages [Map 8] is an excerpt from: Cattoor B. (2016) *E17 Motorway Landscapes*. Map series in: Cattoor B. and De Meulder B. (2016) A relational and processual re-cartography of infrastructure: E17 Motorway Landscapes. *Journal of Maps* 12(4): 707-710.

Map 8: Bieke Cattoor (2016), *E17 Motorway Landscapes*.

As the latest addition to a bundle of infrastructures, the E17 motorway (in yellow) runs parallel to the River Leie, a country road, national road, and a railway line. Slip roads and exits formed part of the original construction and connected the E17 with the pre-existing national roads at each intersection. This had a fundamental impact upon the constellation of national roads: originally part of an assemblage of radio-concentric systems connecting municipalities, the construction of the motorway saw them transform into the rungs of a linear and rhythmic double comb figure — with the motorway figuring as a backbone [Map 8, component map 1]. Hydrology is in direct relation to topography [Map 8, component maps 4 and 5], and introduces a finer and more nuanced perpendicular division than those previously described. The River Gaverbeek, a main tributary of the Leie, intertwines with the E17 to the east, which results in a broadening of the motorway's body. Tributaries to the Gaverbeek generate rhythms that run perpendicular to the motorway, with the water on both sides of the trace. In the central part of the investigated segment, artificial devices have overtaken the natural hydrology, with pumps removing the motorway run-off water. To the west, foothills alternate with three creeks that run perpendicular to the motorway, strangely coinciding with the motorway exits. Noted in red are the bridges that cross the motorway [Map 8, component map 2], and which stitch the rifts in the local road network caused by the construction of the E17 back together (the transverse roads interrupted by the construction of the motorway are shown in orange). These local road networks become denser in the vicinity of cities such as Menen, Kortrijk, and Waregem, where the intervals between the bridges automatically reduce. The re-cartography reveals the remarkably sculptural presence of the bridges. These bridges, moreover, introduce a rhythm of contrasting landscapes: in the sections between the bridges, newly erected industrial and suburban developments alternate with age-old pastoral settings [Map 8, component map 3]. The dark and light blue lines trace, in turn, the ways in which the local streams and creeks have been ruptured, repaired, and altered in order to accommodate the E17 as well as post-E17 development [Map 8, component map 4].

The cartographic assemblage of these interplays [Map 8 bottom] reveals a complex symphony of patterns. It highlights the plurality, dynamism, and transcalarity of the different metamorphoses that have culminated in the present-day motorway landscape.



Map 8: E17 Motorway Landscapes.

4.
Mapping the Evolution of Designed Landscapes with GIS

Stourhead Landscape Garden as an Example

Steffen Nijhuis (Delft University of Technology)

Landscapes change because they are the expression of the dynamic interaction between natural and cultural forces in the environment. As such the landscape is a palimpsest that evidences many successive transformations by human interventions, changing land-use and management, natural succession of vegetation, but also caused by climatological and geological chances. Here the concept of the *longue durée* is crucial, understanding the landscape as a long-term and dynamic structure and process (Braudel 1966). The first level of dynamics is related to the natural environment and is characterised by a slow, almost imperceptible, process of change, repetition, and natural cycles. The second level of dynamics is related to the long-term social, economic, and cultural history. The third level of dynamics is that of short-term events, related to people and politics. In short, the landscape is an on-going development resulting from action and interaction of both natural and human structures, patterns, and processes that depend on ecological, socio-cultural, economic, and political factors. The related physical traces that time has overlaid can reinforce or contradict each other. Understanding of these layers is an important starting point for the management and preservation of landscapes, but also an important basis for new transformations or for adding a new design layer. In the field of landscape architecture the evolution of gardens and designed landscapes is therefore an important subject for design research.

This contribution aims to identify and illustrate some methods and techniques for GIS-based modelling, analysis, and visualisation for exploring designed landscapes and their evolution from conception to the present day. Stourhead landscape garden is used as an example. Stourhead is a well-known historical landscape garden and for centuries a top attraction in Wiltshire, UK (Fig. 1).

Fig. 1. Stourhead landscape garden in 2011, view towards the Pantheon.

Landscape design research

Knowledge of spatial design is at the core of landscape architecture. This means that the development of skills for exploring and defining landscape designs as architectonic compositions is a necessity for landscape architecture researchers. The concept 'composition' refers to a conceivable arrangement, an architectural expression of a mental construct that is legible and open to interpretation. In that respect the landscape design is regarded as an architectonic system by which rules of design common to all styles are established (Colquhoun 1991). Landscape architectonic compositions embody a great wealth of design knowledge as objects of our material culture. They carry knowledge about how to satisfy certain requirements, how to perform tasks, and it is a form of knowledge that is available to everyone (Cross 2006). In particular, by studying landscape architectonic compositions knowledge can be acquired of the possible relationships between conceptual thinking and the three-dimensional aspect (Steenbergen and Reh 2003). Landscape design research is a vehicle for acquiring knowledge of spatial composition via architectonic plan analysis. It is a matter of developing and deploying spatial intelligence, the architectural capacity or skill to think and design in space and

time (Gardner 1999). Through landscape design research it is possible to acquire design knowledge, design principles, or typological knowledge that can be used in the management and preservation of historical gardens and designed landscapes, but also for the creation (or refinement) of a new design.

Grounded in the notion of precise geographic and geometric delineation of landscape architectonic compositions Steenbergen *cum suis* proposed a framework for landscape design research (Steenbergen et al. 2008; Nijhuis 2015). This analytical framework consists of four general categories that lay out the relation between the various aspects of the architectonic form and its perception in a systematic way. By application of this analytical framework the design principles that constitute the design can be understood. It provides the basis for a deeper understanding of the landscape architectonic composition via analysis of the (Nijhuis 2015):

- Basic form: the way in which the natural or the man-made landscape is reduced, rationalised, and activated in the design plan. It is about its place in the natural landscape (*topos*), its place in the matrix of the cultural landscape (*locus*), or its place in the topology of the urban system (*nodus*);
- Visible form: the form and functioning of three-dimensional landscape space and refers to the corporeal and visible form of the composition. It is about understanding the organisation of the space-defining elements (Euclidian space) and their appearance (relative space). This refers to perceptual space relative to bodily movement and eye-level. Routes are regarded as important operative structures since they determine how individuals move through space and experience the composition;
- Symbolic form: the way in which symbolic, iconographic, and mythological images and architectonic structural forms are connected with one another and with elements from nature, such as water, the relief, and vegetation. It refers to the morphological conditions for reception – which is the compositions 'interface' between the intentions of the designer and the reception of the users – while provoking and promoting a rich palette of emotions, ideas, and stories;
- Programmatic form: this addresses the functional zoning and the organisation of the programmes aimed at production, recreation, and culture in relation to functional patterns of movement in terms of logistics and accessibility.

This framework serves as the basis for exploring Stourhead landscape garden in which GIS is used as the primary analytical tool. By mapping the mentioned aspects in several important time stages one can grasp the development of the composition, understanding it as a long-term structure.

GIS as tool in landscape design research

Geographic information systems (GIS) offer means with great potential for thinking and communication in landscape architecture. Because GIS is an integrating technology that ties together diverse types of data and information through location, in combination with wide-ranging analytical capacities, GIS is directly related to the very heart of landscape architecture, which is about the understanding of, and designerly intervention in, the natural and man-made topography of a certain location. By integrating computer-guided applications – such as image processing, CAD, mapping, data modelling, and database management – GIS is a tool for getting a grip on complex geographic situations in the present, past, or future. GIS can execute analytical and graphical operations accurately and quickly while handling large amounts of information (DeMers 2009).

The application of GIS in landscape design research is here understood as an extension of the fundamental cycle of observation, visual representation, analysis, and interpretation in the process of knowledge acquisition, with alternative visualisations and digital landscape models as important means for this process. By utilising the calculating power of computers, combined with inventive modelling, analysis, and visualisation concepts in an interactive process, opens up possibilities to reveal new information and knowledge. There are at least three operations in which GIS could be useful for landscape design research exploiting GIS in its powerful integrating, analytical, and graphical capacities (Nijhuis 2016):

- GIS-based modelling: data acquisition and the description of existing and future landscape architectonic compositions in digital form;
- GIS-based analysis: exploration, analysis, and synthesis of landscape architectonic compositions in order to reveal latent architectonic relationships, while utilising the processing capacities and possibilities of computers for ex-ante and ex-post simulation and evaluation;
- GIS-based visual representation: representation of (virtual) landscape architectonic compositions in space and time, in order to retrieve and communicate information and knowledge of the landscape design.

Stourhead landscape garden

The critical, information-oriented case of Stourhead landscape garden is an example of a designed landscape that covers the scope and remit of landscape

architecture design (Nijhuis 2015). Stourhead has a long history and was designed and developed by the Hoare banking family from the beginning of the eighteenth century (e.g. Woodbridge 1970 and 2002). In that period Henry Hoare II 'the Magnificent' (1705-1785) set about designing the Stourhead landscape garden, assisted by Henry Flitcroft (1697-1769) and other architects, resulting in one of the finest English landscape gardens in Europe. Though Stourhead includes a Pleasure Garden around the house and agricultural land with pastures and woodland, the Valley Garden with the village of Stourton is the nucleus of the landscape architectonic composition. The Valley Garden was created around a lake in the period from about 1743-1770, at a place called 'Paradise', three hundred metres south-west of the house where the grounds fall steeply and two valleys converge. This lake was made by building a dam across the south-west corner of the valley to contain the headwaters of the Stour. Around the lake he built an Arcadian landscape with framed views containing classical temples. In addition to the classical architectural features, Gothic and oriental features were integrated to become part of an interconnected system of visual relationships. As each feature was constructed, it also became a goal in its own right; a stage in a pictorial circuit walk providing individuals with a sequence of views with sightlines directed across the lake, terminating in the architectural features placed in the valley landscape and beyond. In 1785, Richard Colt Hoare (1758-1838) inherited the estate. He broadened the palette of plant material as an increasing number of exotic species became naturalised in England. He removed features and changed the path structure considerably.

Modelling the estate

The *Digital Landscape Model* (DLM) is the basis for the GIS-based analysis of Stourhead landscape garden. The DLM consists of a ground layer, which is a *Digital Elevation Model* (DEM) supplemented by a terrain layer of 2D and 3D referenced objects, such as buildings, trees, and other artefacts (Li et al. 2005). Since there is no complete DEM or DLM of Stourhead landscape garden available, these models had to be constructed based on available analogue and digital data. In order to incorporate time, a sequence of time-slice snapshots was used (Langran 1992). The periodisation is primarily based on the available topographic data, since these convey the physical shape and pattern of the site at certain points in time. The topographic data represent the 'cartographic time', which is the time of the actual recording or measurement of the topography. This is usually earlier than the map was made, and thus not the same as the time of map-making.

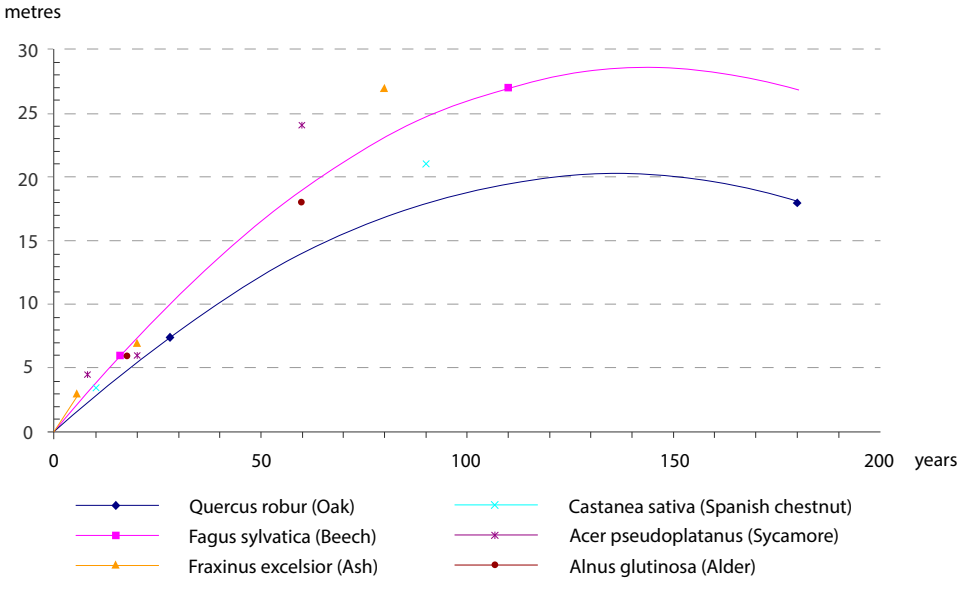


Fig. 2: Distribution of measured growth in height over time for different tree species augmented with a logarithmic plot of the growth curves of beech and oak (analysis by Steffen Nijhuis. Data derived from: Colvin 1972; Ruyten 2006).

The topographic data were assembled based on their incidence, chronology, and nature. This resulted in four GIS-based DLMs: Stourhead 1722 (t_0), Stourhead 1785 (t_1), Stourhead 1887 (t_2), Stourhead 2010 (t_3). The DLMs represent important stages of the composition's development, taking into consideration actual and estimated heights of vegetation, buildings, etc. In order to reconstruct vegetation heights in past situations, to create accurate DLMs, plant-physiological models and contemporary etchings were used to estimate and calibrate the heights (Fig. 2 and Fig. 3).

The DLMs are constructed based on a multitude of contemporary and modern sources in analogue and digital form (Nijhuis 2015). Contemporary sources include: estate maps, historic ordnance survey maps and estate maps, etchings, and drawings. Also estate documents, inventories/planting lists, as well as guide books and visitors' descriptions proved to be useful. The material is evaluated for its relevance and reliability by triangulation, using different data sources that mutually reinforce each other. Also cartometric analysis was employed, reviewing the accuracy and reliability of (historic) maps (Fig. 4). This served as the basis for correction of deviations in historical cartographic material in the interest of reconstruction of important stages of the landscape's development. Modern sources include: maps of physical, biological, and cultural features (e.g. topography, land

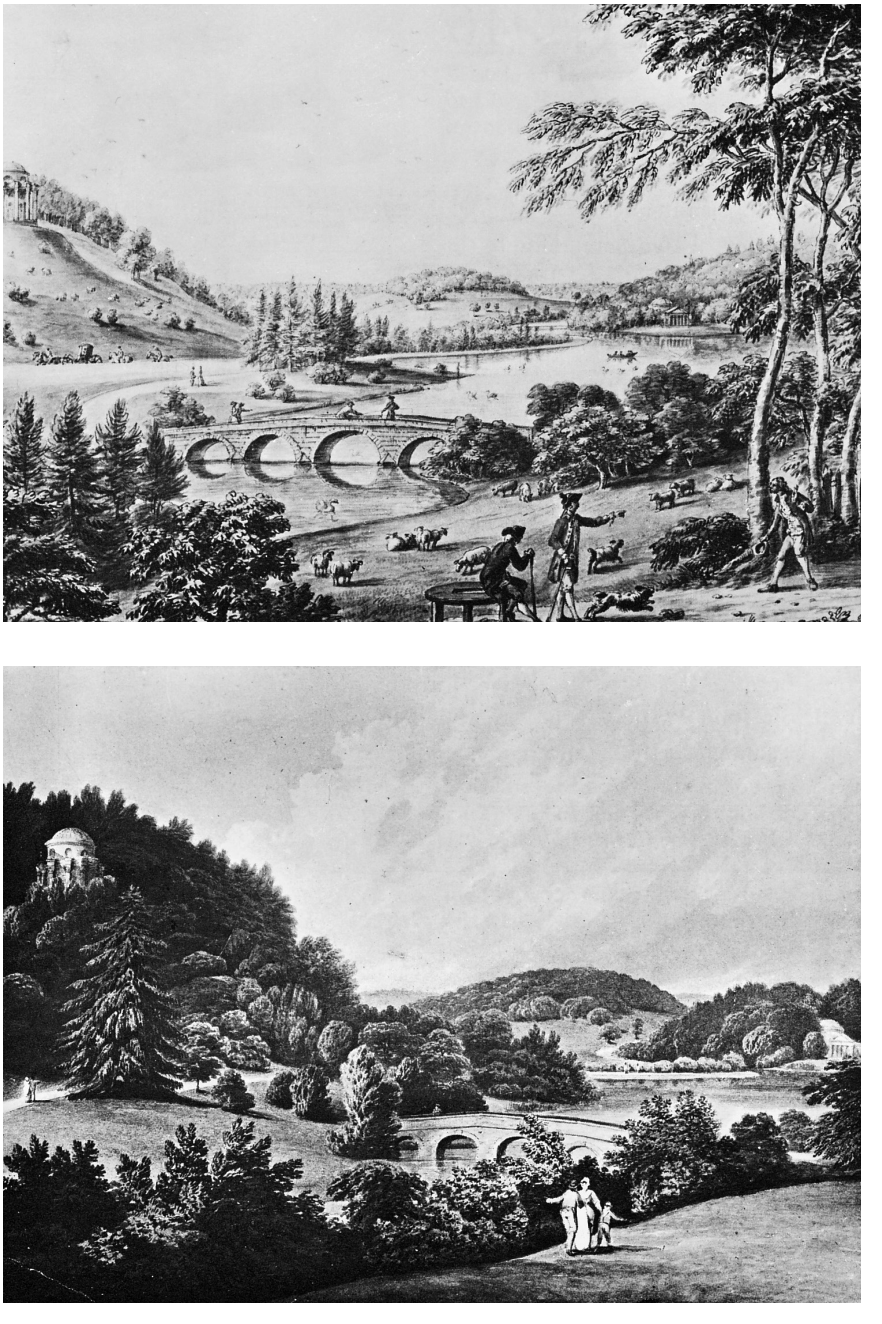


Fig. 3: The spatial densification of the Valley Garden exemplified by comparing the views of Bampfylde, 1770 (top) and Nicholson, 1813 (bottom). The effect of forestation efforts is visible on the ridges at the South bank of the Great Lake (images from: Woodbridge 2002).

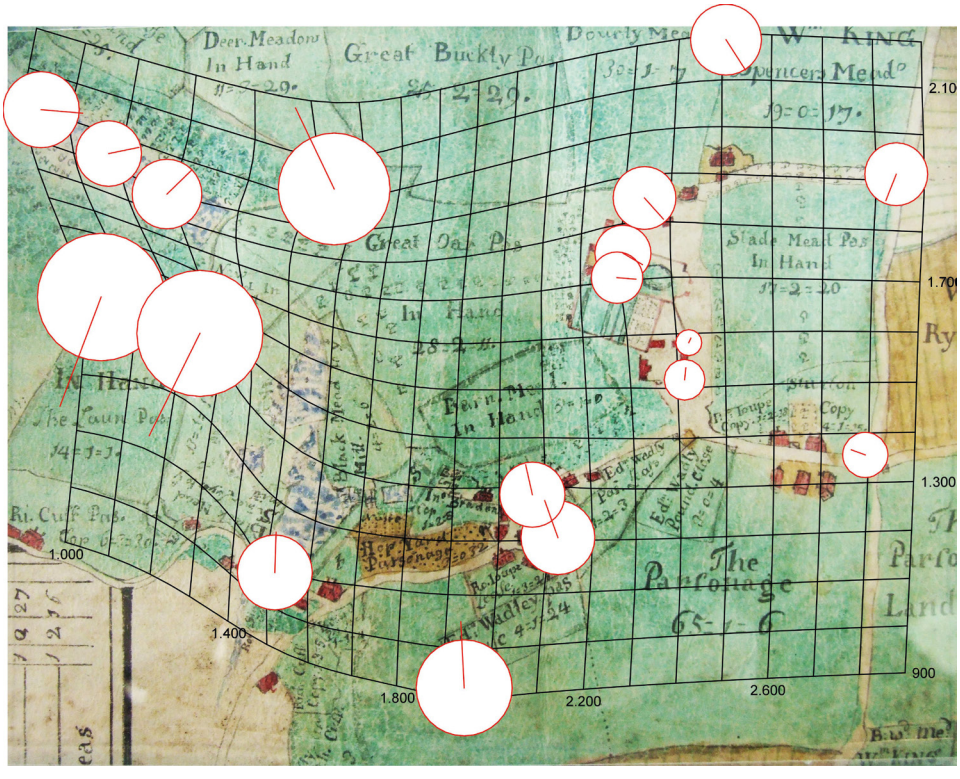


Fig. 4: Cartometric analysis of the 1722 map represented as distortion grid with a cell size of 100 metres. The map has a very low planimetric accuracy (RMSE 5.2 metres), with large local variances, particularly in the valley. The vectors show the direction of distortion and the circles indicate the amount of distortion (analysis: Steffen Nijhuis; map source: Wiltshire Record Office 383.316).

use, vegetation maps), photographs, aerial photographs, geo-databases. Also these are critically evaluated on their validity and use. For the bottom of the lake a recent bathymetric survey with sonar was of crucial importance (Fig. 5).

In this stage of the research the modelling and visual representation capacities of GIS are exploited for the (1) collection, evaluation, and interpretation of contemporary and modern data, (2) digitising, geo-rectification, and vectorisation of data, and (3) integration and processing of the topographic data into a DLM.

Exploring the grounds

The GIS-based landscape design research encompasses the analysis of the basic, spatial, symbolic, and programmatic form of the composition and its development

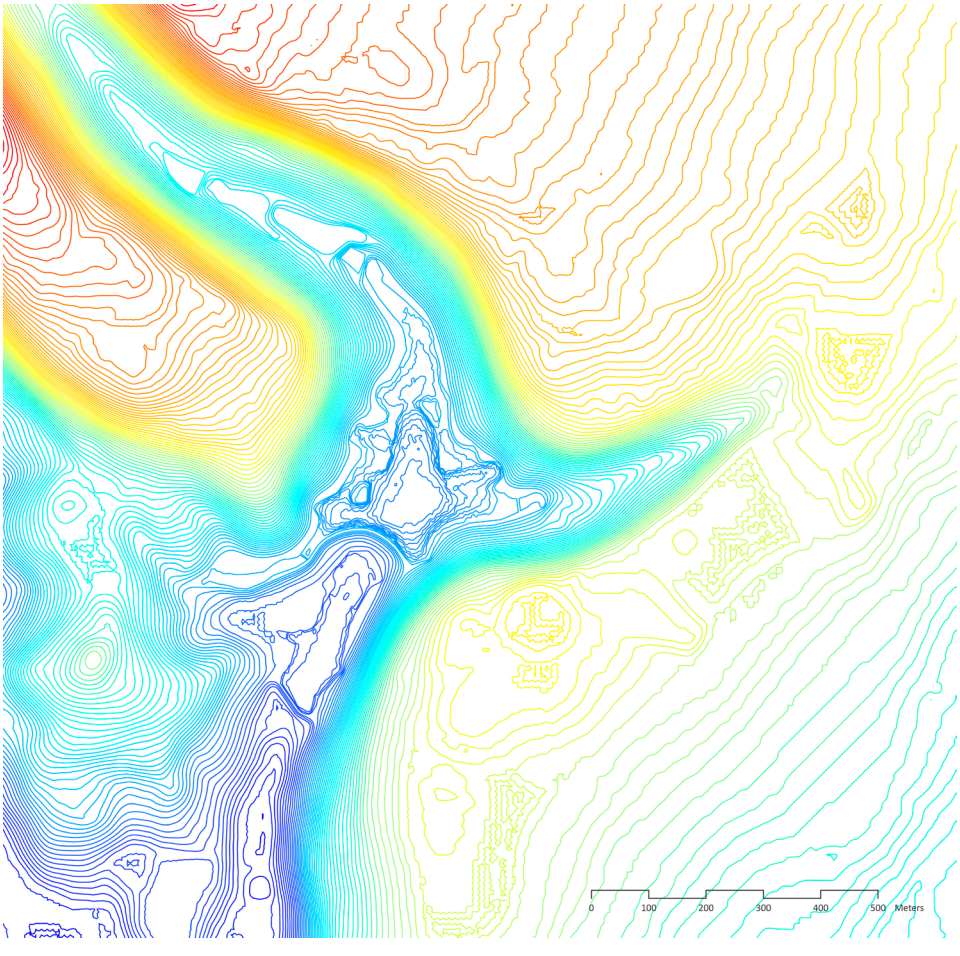


Fig. 5: Bathymetric data of the lakes at Stourhead landscape garden. The relief in the water body is geo-referenced, vectorised and merged with a contour map derived from point vector data of terrain heights (map: Steffen Nijhuis & Michiel Pouderoijen).

while employing different principles for GIS-based analysis (Nijhuis 2015). The DLMs of Stourhead landscape garden are the basis for these explorations.

The GIS-based analysis of the basic form addresses Stourhead landscape garden's adaptation to the terrain conditions. It explores how natural features such as ridges, plains, valleys, and availability of water were considered in the design, and how man-made features and patterns were integrated (Fig. 6). Overlaying and integrating cartographic models on soil, geology, hydrology, and land-use provides a basis for the analysis of formal and geometrical configurations from the vertical perspective, addressing topological and chorological relationships. Basic principles for

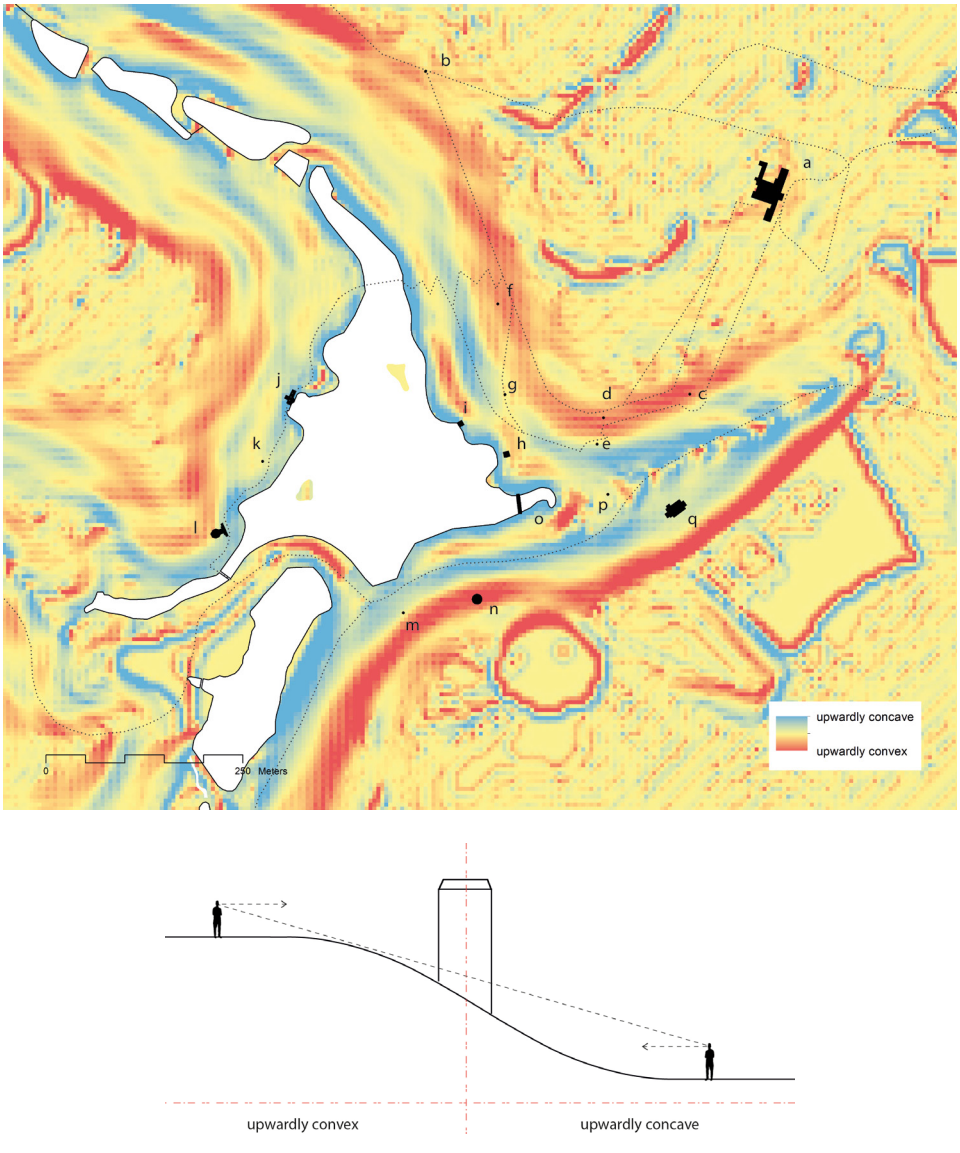


Fig. 6: Correlation between architectural features in the Valley Garden 1785 with upward curvature of the slopes (Stourhead t1). Most architectural features take advantage of the valley's curvature dramatising and ensuring exposure by their placement: Stourhead House (a), Obelisk (b), Statue of Apollo (c), Temple on the Terrace (d), Umbrella Seat (e), Turkish Tent (f), Chinese Alcove (g), Temple of Flora (h), Rockwork Boathouse (i), Grotto (j), Gothic Cottage (k), Pantheon (l), Hermitage (m), Temple of Apollo (n), Palladian Bridge (o), Bristol High Cross (p), St. Peter's Church (q). Bottom: Upward curvature of the slopes. Building placed on the transition from a concave to a convex upward slope. This dramatises its position: making the slope visually steeper ensures the building's exposure.

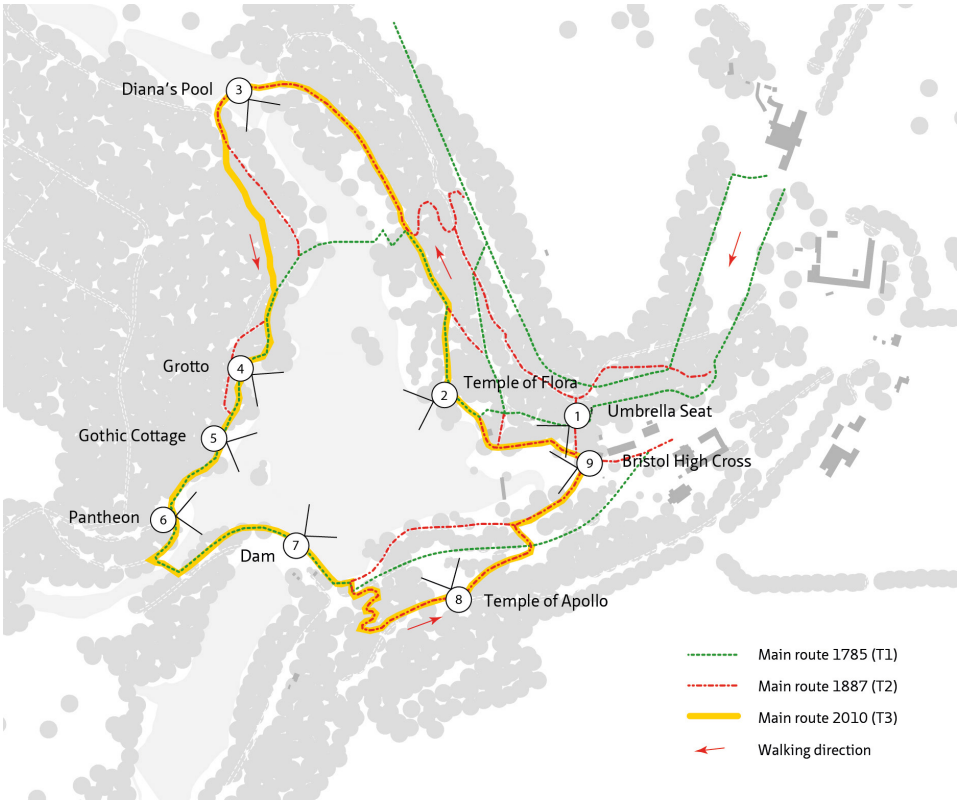


Fig. 7: Important viewpoints related to the pictorial circuit of Stourhead landscape garden throughout the ages.

GIS-analysis employed here focus mainly on location/allocation, distance, change, and quantities. Geo-statistical operations such as morphometric, solar radiation, and hydrological analysis and interpolation, as well as attribute-based querying, play an important role. The GIS-based analysis of the basic form concentrates on:

- Stourhead in context: the natural landscape and land-use: analysis of the major features and processes of the natural landscape like geological formations (incl. soil), landform, climate, and water, as well as the related patterns of vegetation and agricultural land-use [**Map Series 1**].
- Layout and development of Stourhead House and garden: formation of the Great Lake; the analysis of the allocation and orientation of the house; the layout of the garden around the house (Pleasure Garden and Valley Garden); and the allocation of architectural features and the tracing of routes across the estate [**Map Series 2**].

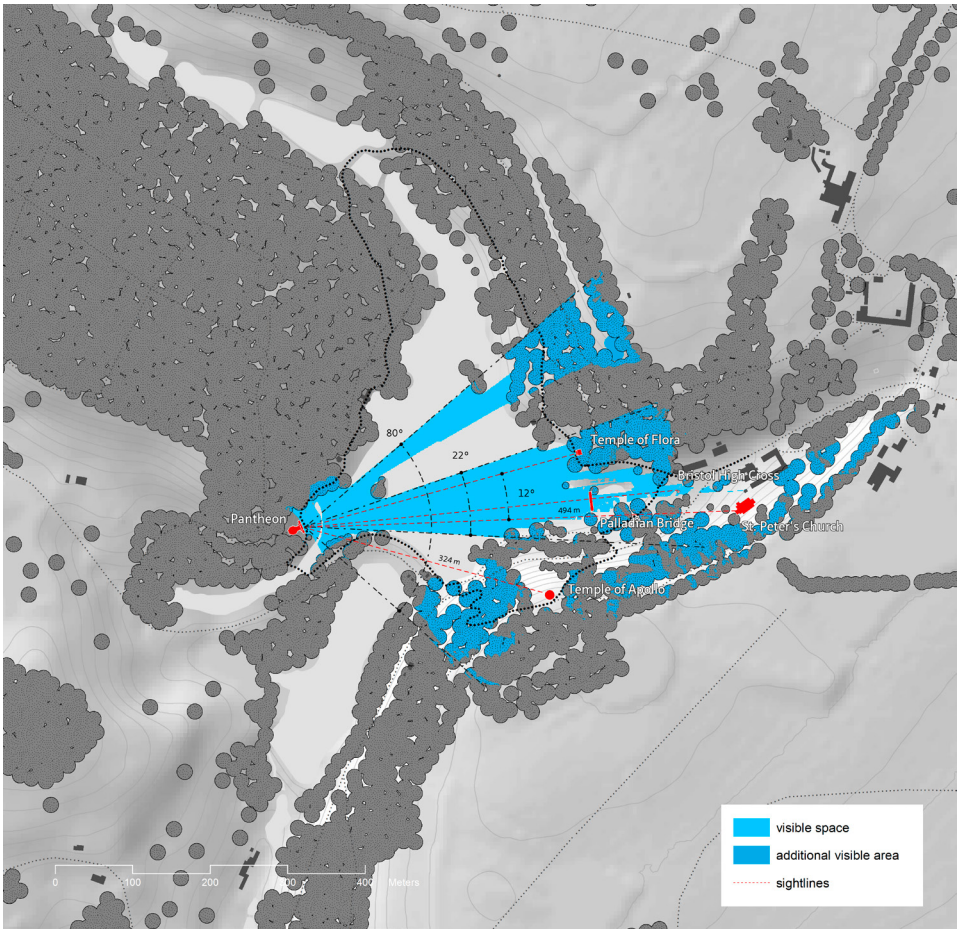


Fig. 8: Visibility analysis from the Pantheon (viewpoint 6), Stourhead 2010.

The GIS-based analysis of spatial form addresses the spatial and visual characteristics of Stourhead landscape garden. It elaborates on the definition and arrangement of space and space-defining elements, as well the views, sightlines, and panoramic views (Fig. 7). On one hand the investigation focuses on the corporeal form, analysing the three-dimensional forms made by the spatial patterns of open spaces, surfaces, screens, and volumes (Euclidean space). On the other hand this investigation looks at the visible form, the appearance of the landscape (visible space) as it would be seen by an observer moving through the space, taking into account atmospheric conditions of visibility. Here the horizontal perspective is important, considering the composition from inside out (Fig. 8 and Fig. 9). Basic principles for GIS-analysis employed here see virtual 3D-landscapes and visibility analysis with

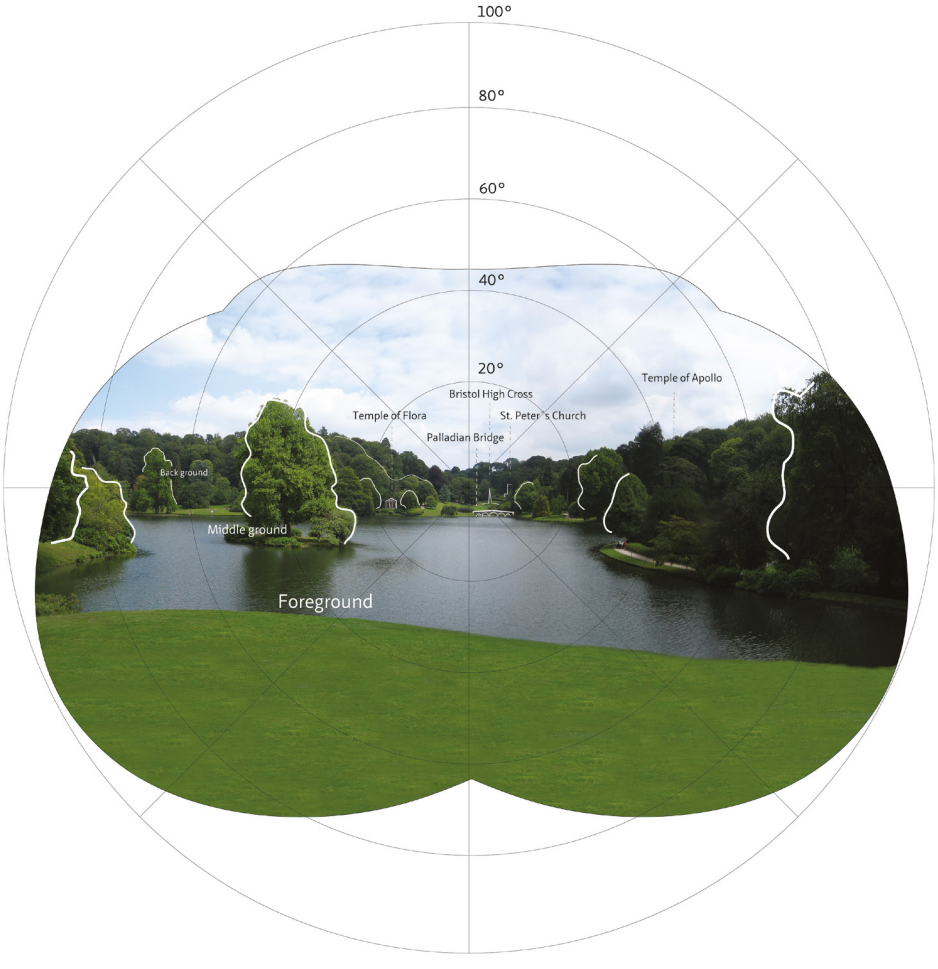


Fig. 9: The field of view gazing straight ahead from the Pantheon at eye-level, Stourhead 2010. The Temple of Flora, the Palladian Bridge, Bristol High Cross, and St. Peter's Church are important foci in this view. The Temple of Apollo was also an important focal point in this view but is now overgrown.

single, cumulative, and sequential viewsheds — a viewshed is an area that is visible from a specific location — as well as hemispherical visibility analysis as the main important operations. GIS-based analysis of the spatial form focuses on the:

- Characteristics of the three-dimensional composition: analysis of the corporeal form and its development through time [Map Series 3].
- Visual manifestation of the three-dimensional composition: analysis of the visible form; space visibility and views; the scenography of specific routes; and the visual integration of the different parts of the estate and its environs [Map Series 4].

Physical and natural structures are the point of departure in trying to get a grip on the meaning of the symbolic elements of Stourhead landscape garden; the GIS-based analysis of the symbolic form. The investigation focuses on exposing the morphological conditions for reception — which is the composition's 'interface' between the intentions of the designer and the reception of the users and provokes and promotes a rich palette of emotions, ideas, and stories (Hunt 2004). In particular the sequence of images with iconographic elements, organised by the composition and the imposed routes, connecting tactile experience and visual appearance, are of interest. Different intensities of light influenced by patterns of sun and shadow are also important in the experience of the composition (Fig. 10). Contemporary and modern sources are employed to understand the composition's appraisal via map-distortion analysis and crowd-sourcing. Here the basic analytical GIS-principles from the vertical and horizontal perspective are combined and focus on location/allocation, distance, change, duration, quantities, and visibility. GIS-based analysis of the symbolic form concentrates on:

- The potential relationship between space and meaning: analysis of the organisation and distribution of elements that dictate views (focal points) and the relationships between routes, views, and iconographic elements, in terms of sequence and timing; and: analysis of the experience and reception [**Map Series 5**].

This GIS-based analysis of the programmatic form elaborates on the functional zoning and organisation of the programme aimed at functions (e.g. production, recreation, and culture) and activities (e.g. living, recreation, and agriculture). It also addresses the functional patterns of movement in terms of logistics and accessibility. Basic cartographic models on land-use and network-accessibility models are employed in order to analyse functional patterns, cohesion, and interaction from the vertical perspective. Basic principles for GIS-analysis employed here focus on location/allocation, distance, movement, densities, and quantities. The following aspects in particular are addressed:

- Organisation of the programmatic domains: analysis of land use in relation to *otium* and *negotium* [**Map Series 6**]. Functional relationships of space: analysis of the patterns of activity and their relationships.

In this stage of the research the analytical and visual representation capacities of GIS are exploited for (1) the exploration of the DLM in order to reveal patterns and relationships employing analytical principles from the horizontal and vertical

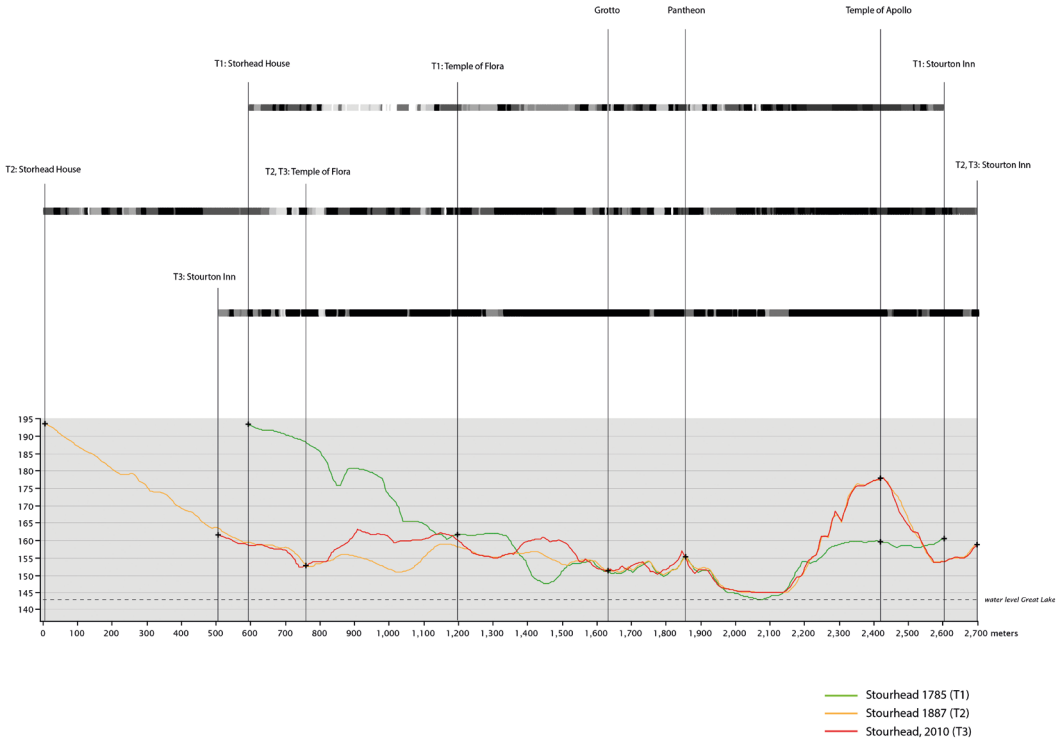


Fig. 10: Comparison of light-shade experience along the main routes in Stourhead 1785, 1887 and 2010.

perspective, and (2) the measurement, simulation, and experimentation of aspects of the designed landscape.

Conclusion: Understanding the landscape as product of time (Δt)

As exemplified by Stourhead landscape garden it is important to conceive and understand cultural and designed landscapes as products of time: the time of conception, development, and mutation. The landscape garden has evolved over a long period of time and is characterised by several important stages in its development. The landscape garden changed over time by modifications of its respective owners and natural succession of vegetation, but also follows certain rhythms of change over various time scales (e.g. diurnal, seasonal, and geological changes). The movement *through* landscape, the movement *of* landscape, and the interaction *with* the landscapes are also important temporal aspects (Ervin 2001).

For understanding the development of the landscape architectonic composition GIS was employed as a tool for the systematic analysis of the basic, spatial, symbolic, and programmatic form. The spatial structure, changes, and coherence over time of the landscape garden are explored from horizontal (eye-level) and vertical (bird-eye) perspectives. Insights gained by such explorations open new perspectives on the situational and cultural-historical aspects of the designed landscape, which can play a part in value assessment and decisions regarding the use and management of this living green heritage. GIS offers a broad range for visualisation of temporal aspects (e.g. structural change, growth of vegetation), capturing data of particular objects (e.g. high-definition 3D laser scanning), reconstruction of time-slice snapshots, and evaluation of topographical sources. By involving time, movement, and process (e.g. erosion and sedimentation, vegetation growth), GIS provides a tool to engage in the development of landscape by offering means for fresh thinking about the preservation and development of (heritage) sites and landscapes through its modelling, analytical, and visualisation capabilities. In retrospective approaches, heritage can be brought back to life through realistic reconstructions displayed on novel digital interfaces (e.g. mobile technologies, multi-touch interfaces) and in prospective approaches it offers means to study design proposals for their implications and impacts. The role of time in geodata of cultural and designed landscapes and the challenges of its construction, management, and preservation is an important issue that needs to be elaborated upon.

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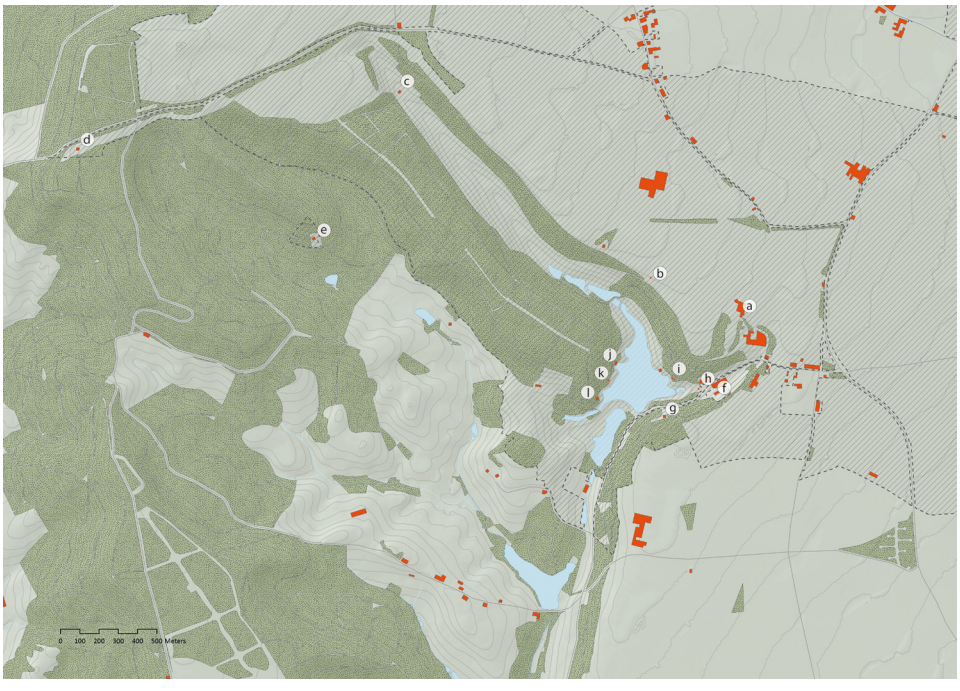
Maps

Mapping Stourhead landscape garden

Visual representations such as maps are fundamental tools for knowledge discovery in landscape design research. They facilitate knowledge acquisition of landscape architectonic compositions by making information visual in a spatial manner (Nijhuis and Pouderoijen 2014). Maps have served as tools for handling spatial data for millennia; they are informative as well as persuasive and are therefore important means of knowledge acquisition. Maps facilitate a spatial understanding of things, concepts, conditions, processes or events in the human/natural world (Harley and Woodward 1987). Mapping is an activity of constructing and communicating spatial knowledge, and the map is a result of that. The physical creation of maps is the process of map-making. This can be distinguished from information acquisition and the processing of spatial data which is termed mapping (Dorling and Fairbairn 1997). Mapping entails exploration, analysis and synthesis of data and information in a visual way. It refers to a process, rather than a completed product (Cosgrove 1999). The process of mapping helps us acquire new or latent information, which is the basis for generating spatial knowledge (Corner 1999). Mapping as such can help to reflect upon the emerging insights, appraise the composition in its totality, and observe the relationships between the parts and the whole. In this visual chapter the evolution of Stourhead landscape garden is mapped while employing the framework for landscape design research as described before.

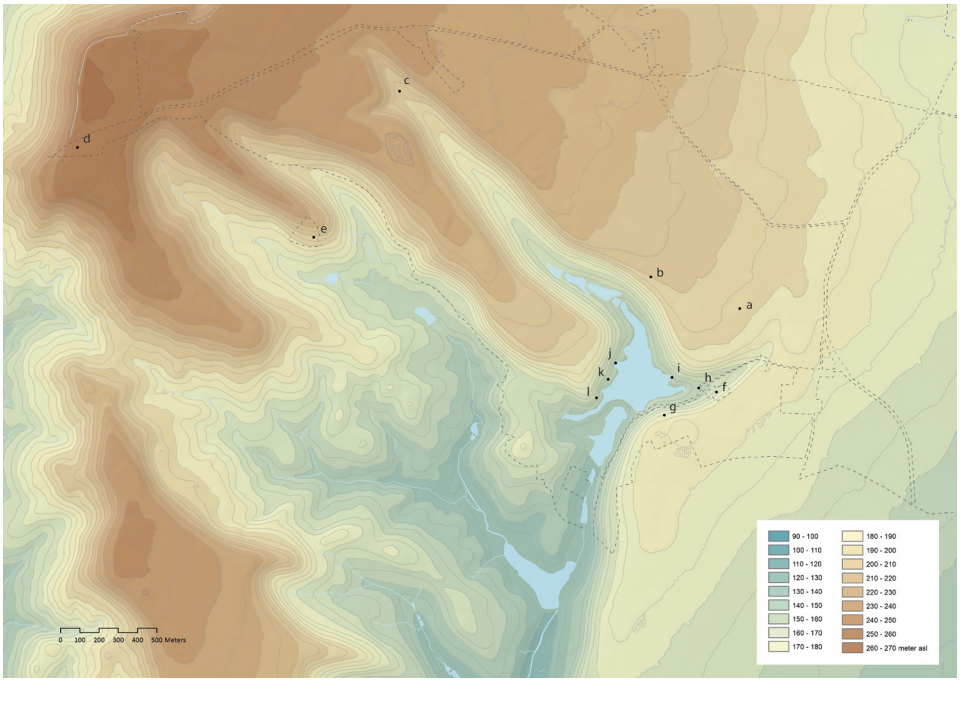
Map series 1: Terrain conditions as prerequisite

The basic form of the landscape architectonic composition of Stourhead landscape garden is largely determined by two geomorphological complexes: the plateau and valley. Next to the possibilities for practical land-use offered by the basic form of the plateau and valley, geomorphology and water form are the basis for a landscape architectonic composition and activate and articulate the natural forms and processes of the site and its use. The differences in natural terrain conditions like elevation, slope, and aspect, as well as the variation in soil and presence of welling groundwater, were the prerequisites for the allocation of the built elements, the tracing of the routes, and the creation of the Great Lake. The built elements, with their distinct architectonic forms, are generally built on a rise, shoulders, or particular contour lines, such as slope edges, ridge lines, etc. The routes link the features to the house and respond to the landform and its opportunities for walking in order to dramatise the relationship between different parts of the basic form: on the plateau the Pleasure Garden, and in the Valley Garden to frame the lake. The form of the lake demonstrates a designerly sensitivity to the delicate interplay between water level and curvature of the slopes.

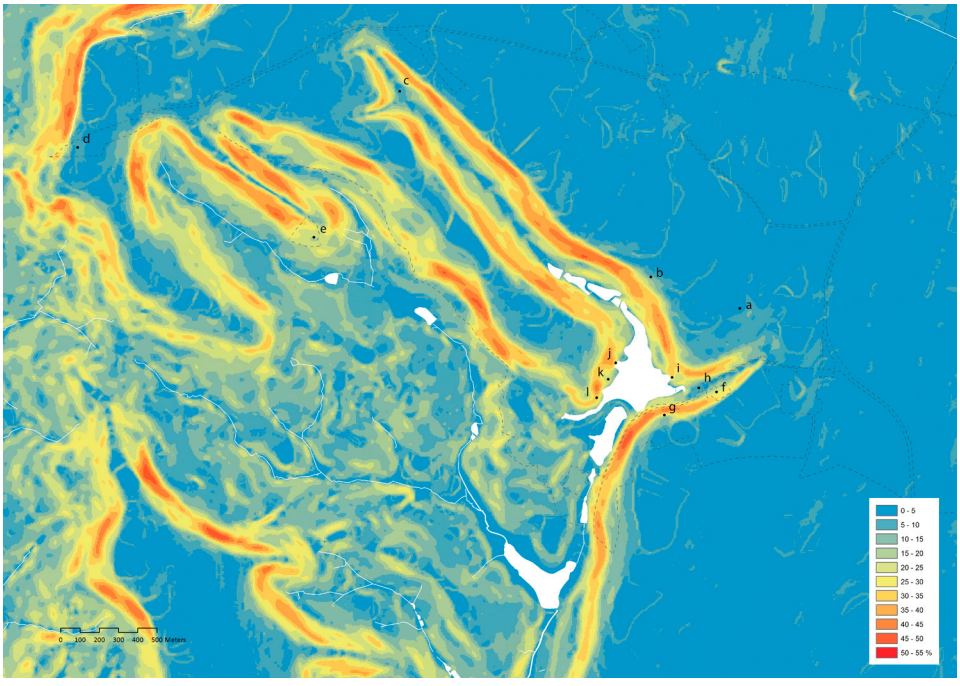


Map Series 1, Map 1: Steffen Nijhuis, *Stourhead Landscape Garden with the Locations of Important Features*.

Stourhead House (a), Obelisk (b), St Peter's pump (c), Alfred's Tower (d), The Convent (e), Stourton Church (f), Temple of Apollo (g), Bristol High Cross (h), Temple of Flora (i), Grotto (j), Gothic Cottage (k), Pantheon (l).



Map Series 1, Map 2: Steffen Nijhuis, *Stourhead Elevation*.



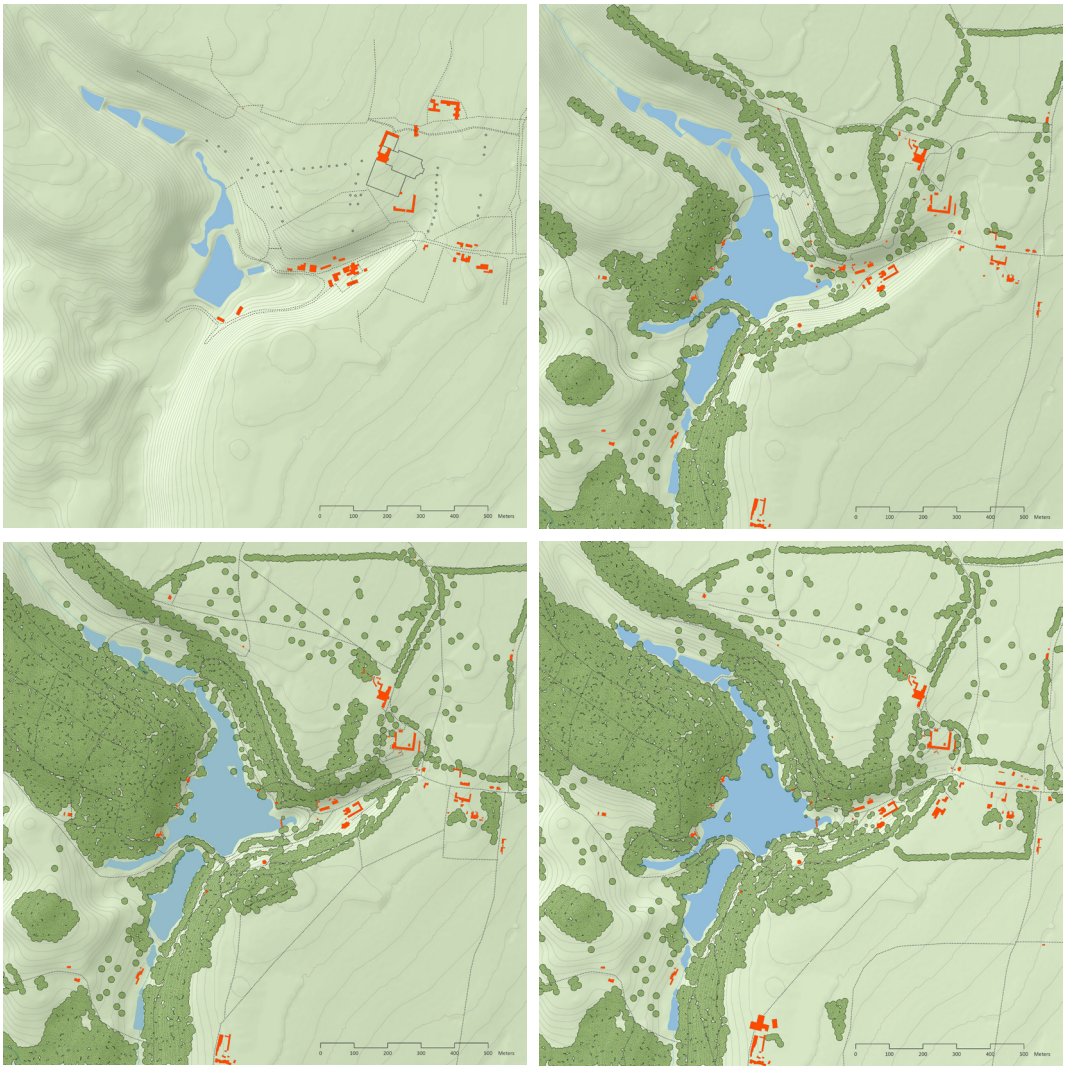
Map Series 1, Map 3: Steffen Nijhuis, *Stourhead Slopes*.

Map Series 1, Map 4: Steffen Nijhuis, *Stourhead Distribution of Soil*.

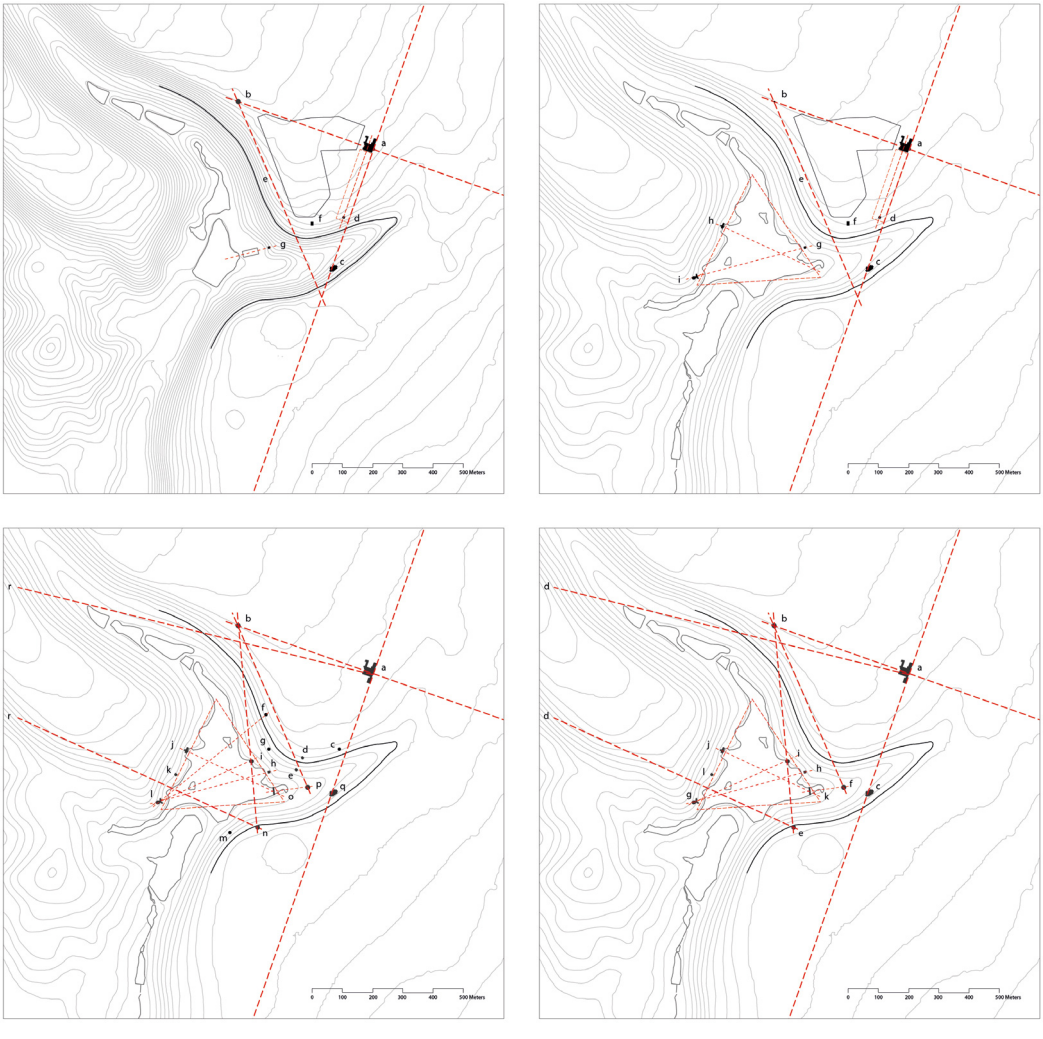
Based on BGS 1:50,000 soil database.

Map series 2: Successive development of the composition

The landscape architectonic composition of Stourhead landscape garden is the result of a successive development characterised by three main landscape architectonic transformations. It started with the construction of the house and the surrounding Pleasure Garden on the plateau, followed by the development of the garden in the valley, and finally the incorporation of the rest of the grounds with their patterns of natural vegetation (e.g. afforested ridges), and agricultural land-use. The gradual integration of the different landforms into a cohesive basic form was mainly constituted by landscape architectonic interventions, including the placement of the house, the design of the lake, several built architectural features, and a system of routes accentuating the different landforms and at the same time connecting them. Over time, the basic form of the plateau and the valley became more autonomous parts of the composition, as the articulation of their transition decreased through the removal of features. At the same time, the Valley Garden became the more dominant part of the landscape gardens' composition, especially as the architectural features that had made up the 'former' Pleasure Garden were demolished. This is also visible in the development of the route system. The initial route dramatised the differences between the basic form of the plateau and the valley, while at the same time tying them together. The later routes focus more on the valley itself and articulate its differentiated, intricate, and rich natural form with a circular walk around the lake.



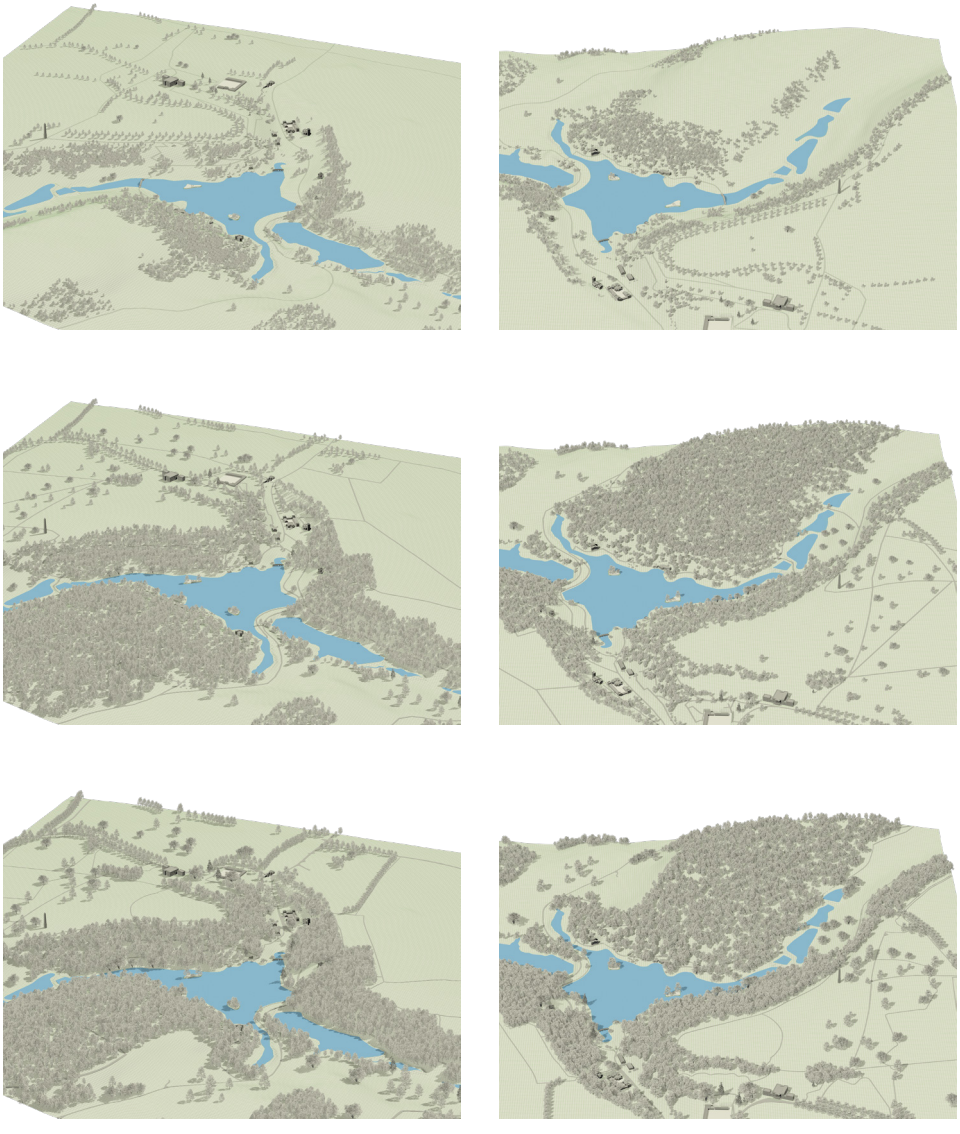
Map Series 2, Map 1: Steffen Nijhuis, *Evolution of Stourhead 1722, 1785, 1887 & 2010.*



Map Series 2, Map 2: Steffen Nijhuis, *Interpretations of the Development of Stourhead's Basic Form*.

Map series 3: From articulation of spaces to autonomous spaces

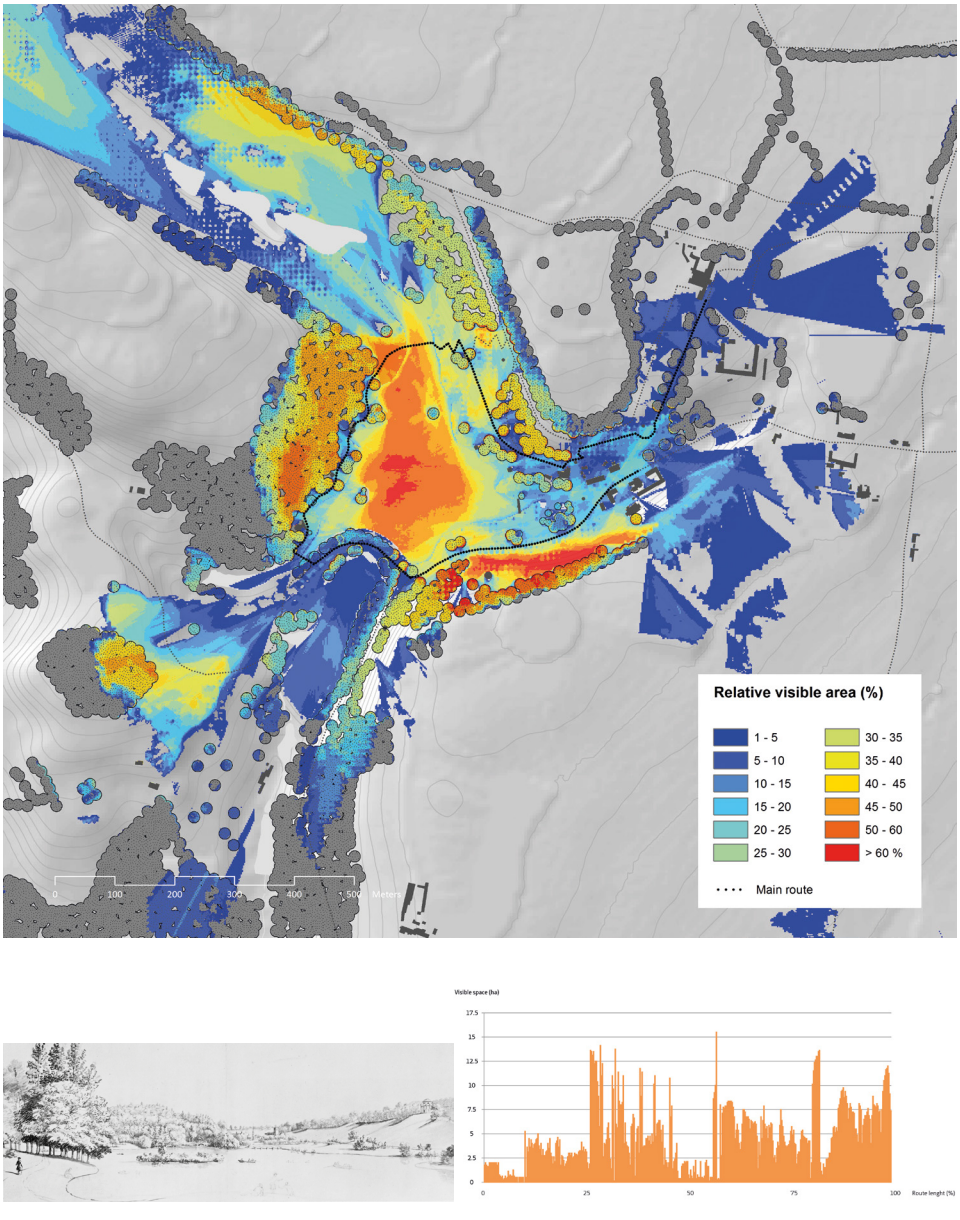
The successive development of the corporeal form of Stourhead landscape garden started with the articulation of the spatial relationship between the plateau and the valley by planting masses and creating transitional spaces with architectural features on the edges of the plateau and the slopes of the valley. The architectural features were positioned at strategic locations as attraction points opening up views towards the valley. The Fir Walk was an important feature acting as a transparent spatial interface integrating the upper and lower parts into an overall composition. In the valley, the planting mass emphasised its asymmetrical nature and articulated the open space by the contrasting treatment of the slopes, creating a particular space-mass dynamic between the foliage on the western slope and the mostly open southern slope with the planted top edge. Over time, the Valley Garden became the dominant part of the composition through densification via the planting of trees with under-planting on the slopes and the removal of architectural features in the transition zone from the plateau to the valley. As a result of the extensive planting programme, the slopes became continuous spatial boundaries emphasising the introverted character of the valley, with the central position of the lake creating an autonomous space. Selected views became framed by the plantings and later more pronounced or overgrown as these grew. The addition of incidental strong colours by individual trees and shrubs in the scenery as well as the variety of individual exotic species also toned down the variety in space. In the early stages of the development of the corporeal form, the accent was on the articulation of the relationship between the plateau and the valley and the spatial variation of the spaces themselves. Later, the autonomous character of spaces became more dominant, toning down the spatial variation in structural terms.



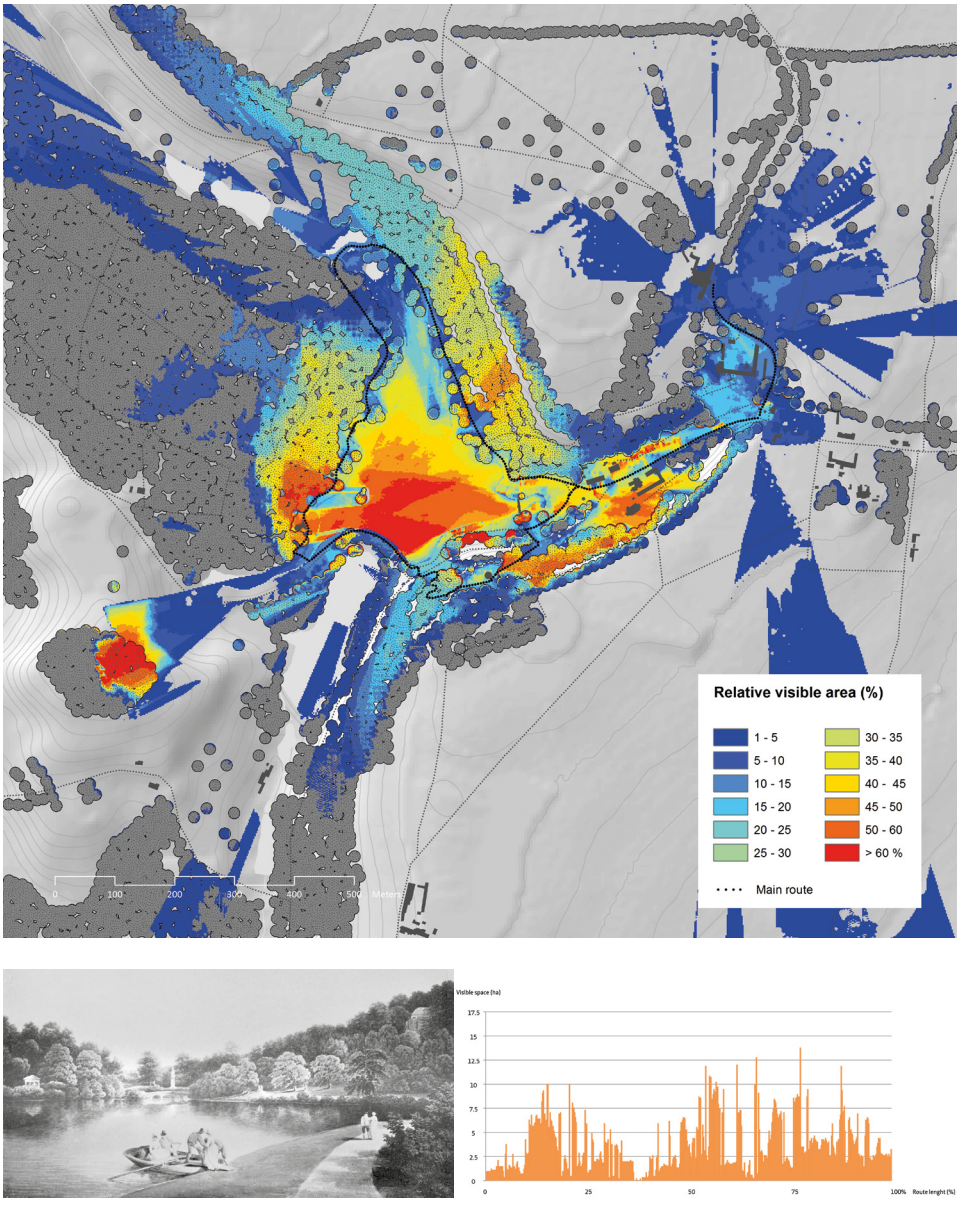
Map Series 3, Map 1, Steffen Nijhuis, *Evolution of the Three-Dimensional Composition Stourhead 1785, 1887 & 2010;* Left: *Views from the south.* Right: *Views from the northeast.*

Map series 4: Designed from the observer's point of view

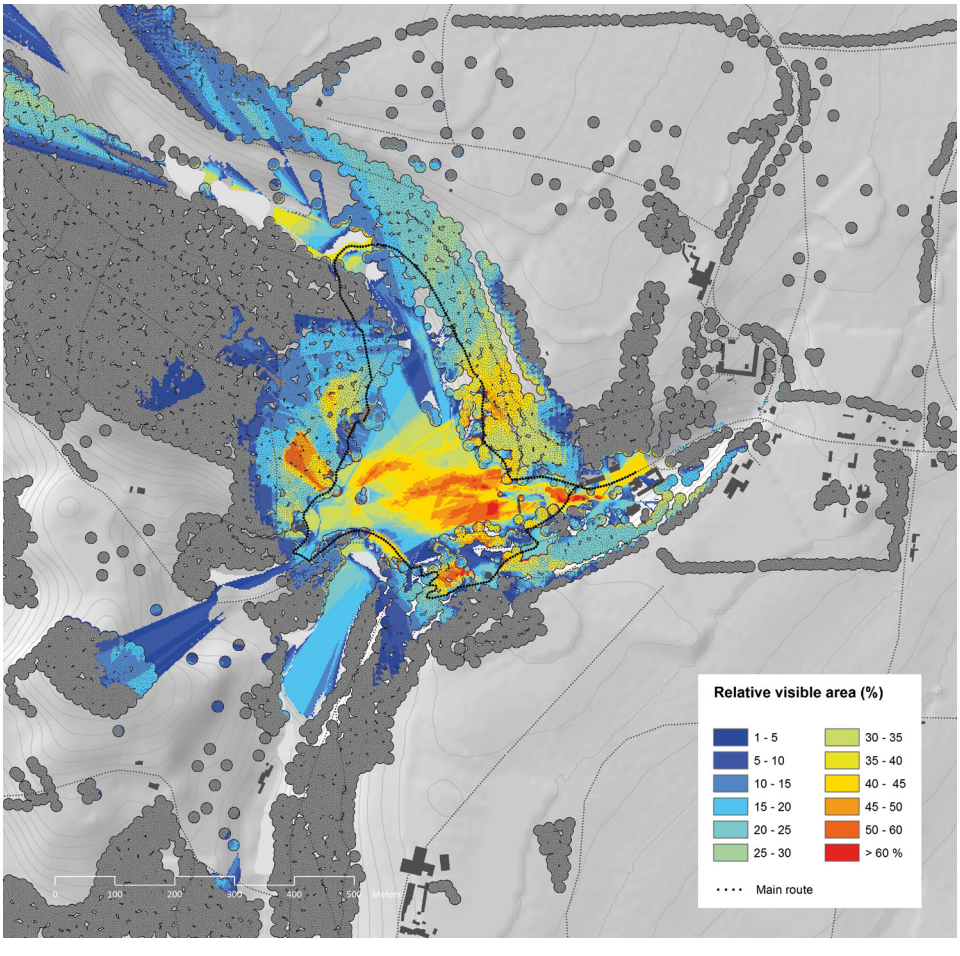
Visual connections are important to the visible form of the landscape architectonic composition of Stourhead landscape garden. Sightlines virtually organise and connect the features on opposite sides of the lake. Here, portrayal blends with the landscape at hand. The relationship between the house and the broader landscape context is established by sight-relationships between the Temple of Apollo, Alfred's Tower, and the Obelisk. Stourhead House is located on a moderate rise on the plain and responds to the orientation of the regional landscape, and is also aligned with the church tower of Stourton. Alfred's Tower marks the highest point of the estate and virtually connects the house, Great Oar Pasture, and Valley Garden with the scale of the estate and beyond, overlooking the region. The visual form of the Valley Garden consists of a progression of views linked to the steps of the walking individual. The designed views and resting points, as well as the related routes that circulate and lead, demonstrate sensitivity towards the mechanics of visual perception and kinaesthetics. The views are carefully designed, employing depth cues, optical illusions, and critical horizontal and vertical viewing angles. Movement is not suggested but truly experienced by following the routes and their scenography with formal, transitional, and progressive elements. The visible form of the Valley Garden is a four-dimensional composition with a gradual experience of garden scenes (transitory views) via progressive movement guided by the circular route and its destinations.

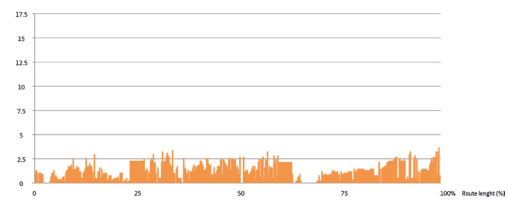


Map Series 4, map 1, Top: Steffen Nijhuis, *Relative Visibility at Eye-Level Following the Main Routes of Stourhead in 1785*; Bottom left: C.W. Bampfylde, [*View of the Valley garden*], ca. 1770; Bottom right: Steffen Nijhuis, *Comparison of the Amount of Visible Space Following the Main Routes of Stourhead in 1785*.



Map Series 4, Map 2, Top: Steffen Nijhuis, *Relative Visibility at Eye-Level Following the Main Routes of Stourhead in 1887*; Bottom left: F. Nicholson, [*View of the Valley garden*], *around 1813*; Bottom right: Steffen Nijhuis, *Comparison of the Amount of Visible Space Following the Main Routes of Stourhead in 1887*.

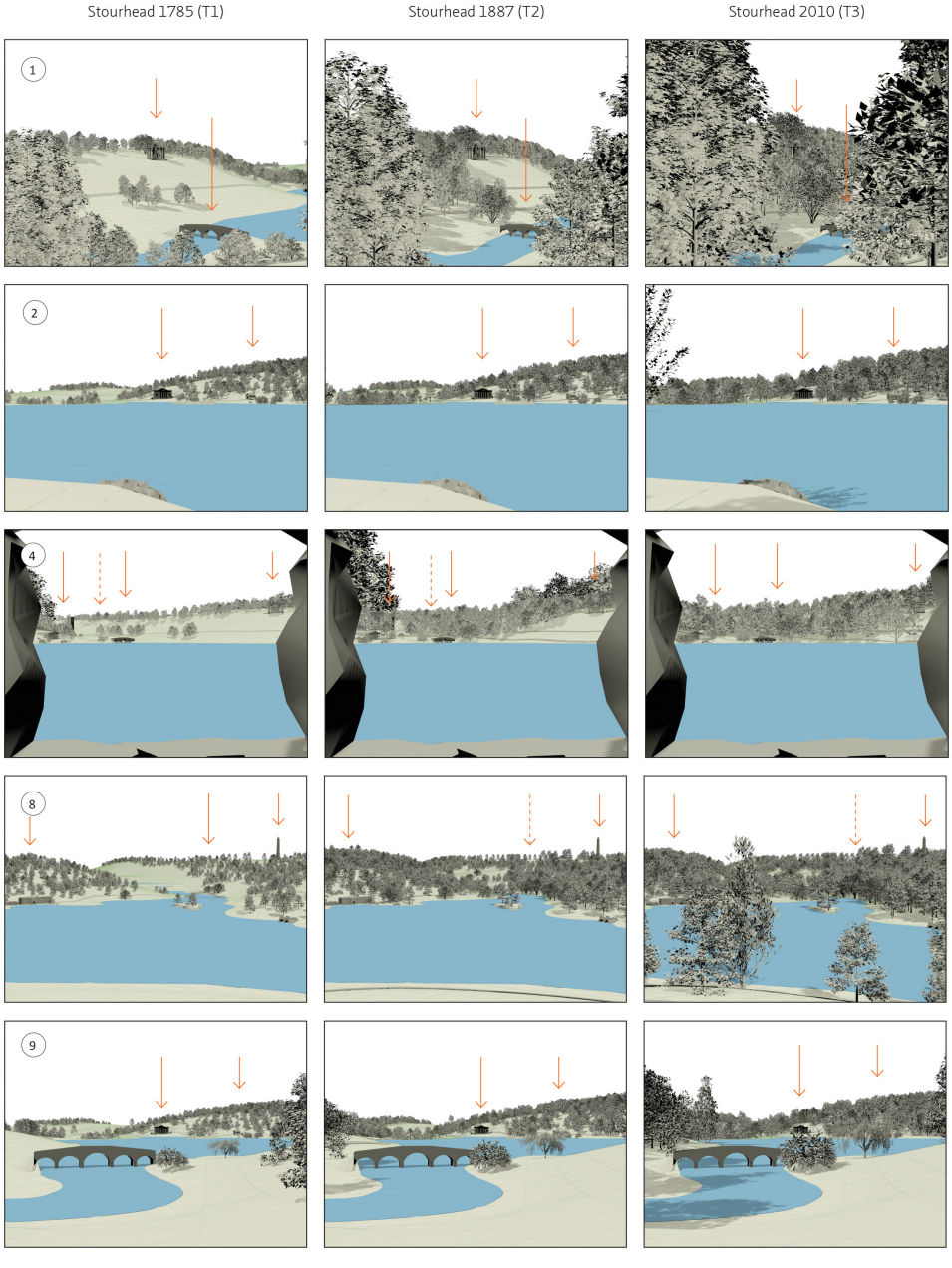




Map Series 4, Map 3, Top: Steffen Nijhuis, *Relative Visibility at Eye-Level Following the Main Routes of Stourhead in 2010*; Bottom right: Steffen Nijhuis, *Comparison of the Amount of Visible Space Following the Main Routes of Stourhead in 2010.*

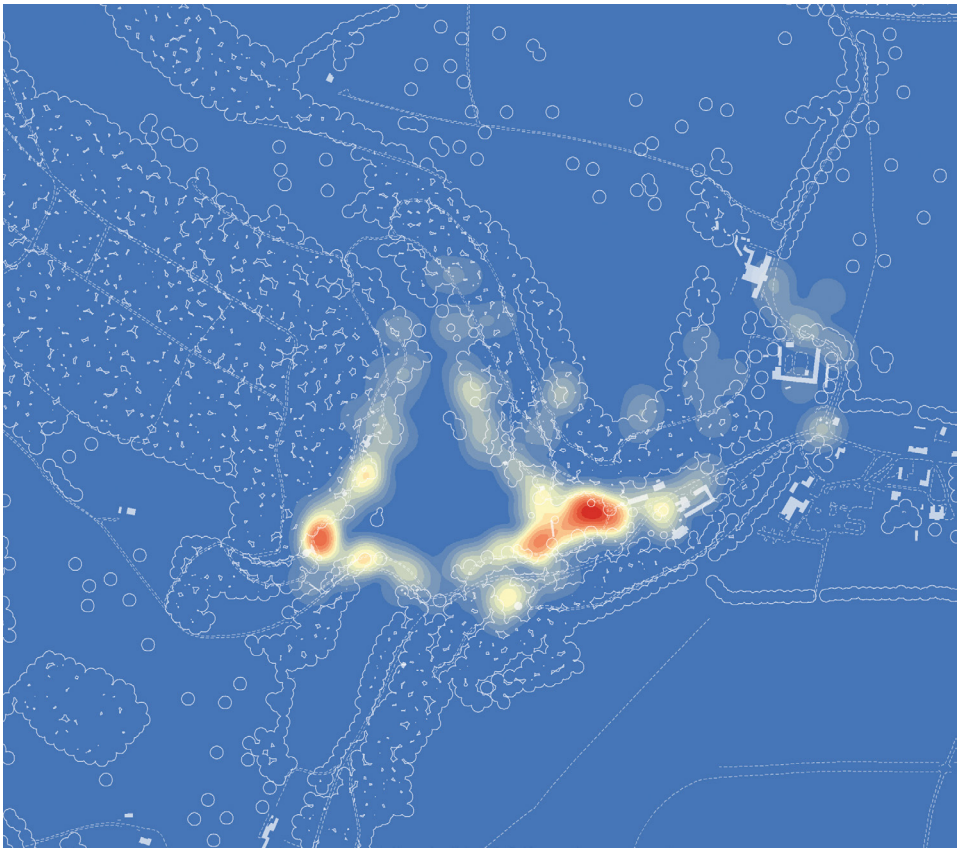
Map series 5: The quality is in the richness of meaning

Transformations in presentational and referential elements of the symbolic form demonstrate that it is not possible to impose a fixed meaning on Stourhead landscape garden. In presentational terms the development of the spatial composition suggests a changing meaning of nature and landscape. The Arcadian landscape changed from a varied pastoral landscape into a more closed forest landscape that emphasised the Great Lake, and where the effects of nature were more important. Finally Arcadia became a 'product', a place to experience 'authentic' history, study arboriculture, and daydream — focused on a tourist's gaze intent on certain determined views and a structured experience. In parallel, space definition and light-shade experience show a gradual change from a half-open park landscape with great variety of undirected, open spaces with light and shade effects alike, into a closed and shady landscape with a central position for the light and open space of the lake. In referential terms the architectural features play an important role as iconographic elements in the views. The appearance and sequence of paired classical and medieval features, strolling around the lake, suggests a double dialoguing allegorical structure that evokes historical or moralistic narratives with references to mythical heroes and England's past. However, here too it is not possible to impose a fixed meaning since several (mainly oriental) features have been removed over the centuries and some views are changed by the planting and growth of trees. Whether the landscape garden contains a story with a deeper meaning or is a kind of memory system facilitating pleasure and relaxation, it has above all over time accumulated into a richly layered site that promotes and provokes a wide range of narratives, ideas, and emotions. The quality of the landscape garden is thus in the richness and not in the clarity of meaning. Despite the richness of the site it seems that the view towards the Pantheon (viewpoint Bristol High Cross) and the view towards Bristol High Cross (viewpoint Pantheon) in the experience of past and present-day visitors capture the very essence of Stourhead landscape garden.



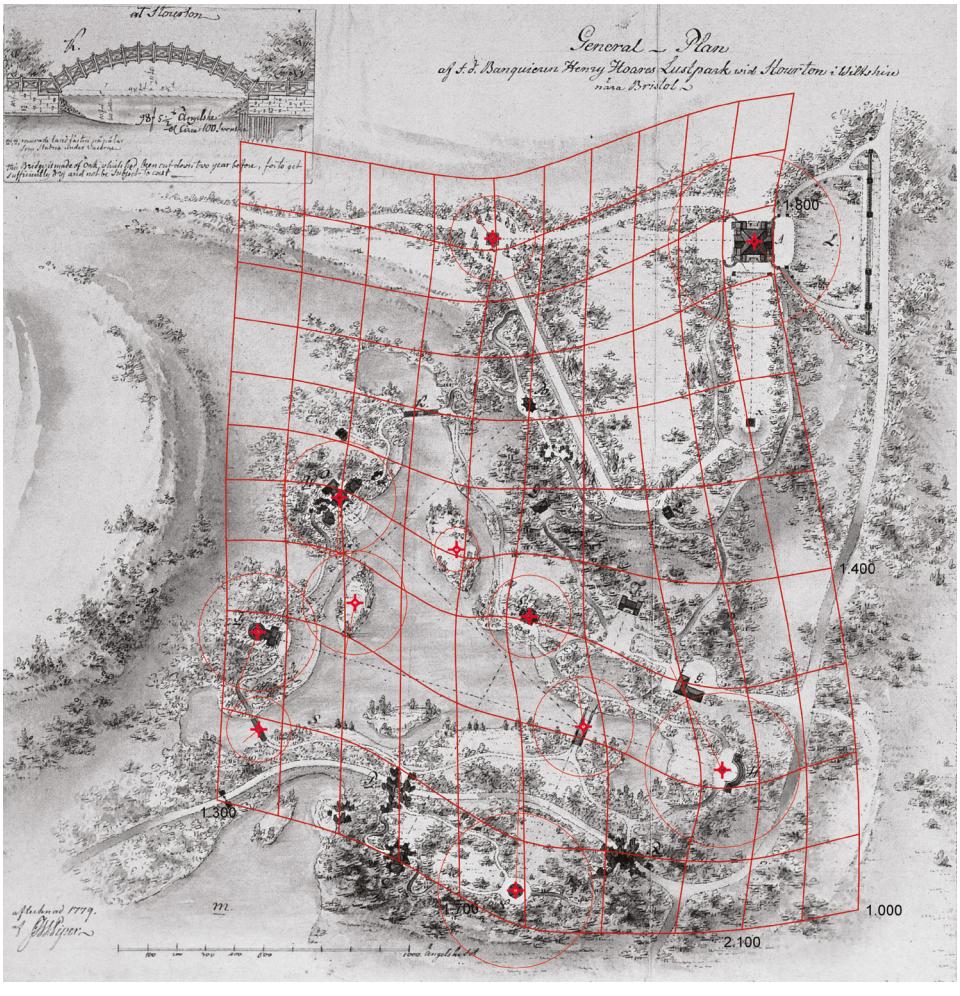
Map Series 5, Map 1: Steffen Nijhuis, *Development of the Views with the Architectural Features as Focal Points.*

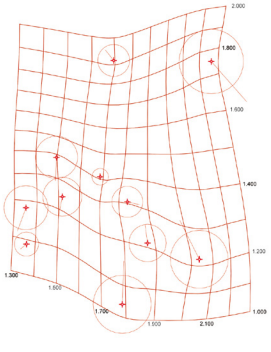
Arrows indicate important focal points; dashed arrows indicate focal points that have disappeared. The viewpoints are indicated in Figure 7.

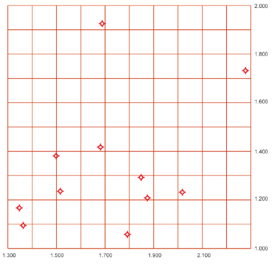


Map Series 5, Map 2: Steffen Nijhuis, *GIS-based Density Analysis of the Amount of Geotagged Photographs (n = 279).*

In 2010 the most popular is the view towards the Pantheon (38.35%), followed by the view towards Bristol High Cross.







Map Series 5, Map 3: Steffen Nijhuis, *Cartometric Analysis*.

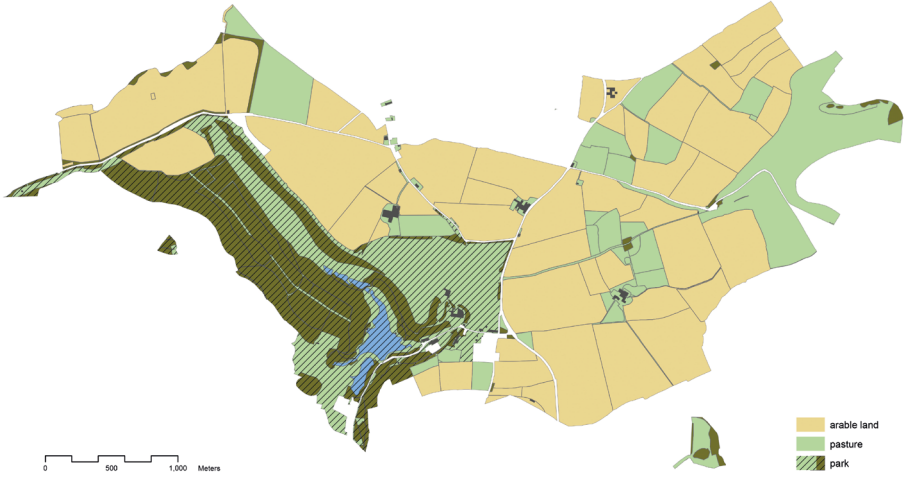
In historical times the view towards the Pantheon also seems to be important as exemplified by the Piper-plan (1779), which highlights the viewpoint at Bristol High Cross (bottom-right corner) by its proportional distribution in positional accuracy.

Map series 6: The landscape garden as an adaptive framework

Stourhead is a multifunctional landscape, focused on production, recreation, and cultural functions. The programmatic form displays a mix of agricultural land use, forestry, and park land (pleasure programme). The functional zoning is directly related to the possibilities allowed by the underlying natural landscape (e.g. soil, hydrology, and microclimate). The well-drained plateau is mainly in use as arable land next to pastureland and the woodlands are located on the hills and ridges with relatively dry and poor soil conditions. The pleasure programme is mainly centred in the valley, with the Valley Garden full of exotic tree species and under-planting, which thrive on the sandy soils derived from the Greensands. Though in general the programmatic form changed little over time, the intended balance between *otium* and *negotium* did change dramatically. In the early stages of its development there was a delicate balance between leisure, cultural, and business activities, which all co-existed in the landscape garden (agriculture, forestry, fishing were part of the landscape garden). Nowadays the landscape garden is in the service of thousands of visitors, and focusses mainly on business activity. It became a product itself, a popular tourist attraction with hardly any space for agriculture and forestry. These functions are still an important part of the estate but function organisationally as well as visually autonomously. The trend of simplifying the route structure of the Valley Garden, increasing the efficiency in terms of accessibility (ease to move) and duration, is in line with this development, but decreased the kinaesthetic effect related to the three-dimensionality of the route. Though the landscape architectonic composition developed over time, it acted as an adaptive framework, organising the varying programmes and adapting to functional changes.

Map Series 6, Map 1: Steffen Nijhuis, *The 1.049 Hectares of the Stourhead Estate as Owned by the National Trust in 2010.*

Based upon National Trust Ownership and GB 12.5 cm AerialPhoto2005 which is reproduced by permission of British Ordnance Survey. © Crown copyright and database right 2010. All rights reserved. Ordnance Survey license number AL100018591.



Map Series 6, Map 2: Steffen Nijhuis, *Land Use at Stourhead in 2010.*

Arable land is the most dominant form of land use on the estate as owned by The National Trust. GIS-based tracing based on the vertical aerial photograph.

5.
Unfolding Wasteland

A Thick Mapping Approach to the Transformation of Charleroi's Industrial Landscape

Cecilia Furlan (Delft University of Technology / University of Leuven)

> 'The land, so heavily charged with traces and with past readings, seems very similar to a palimpsest' (Corboz 1985: 190).

Any territory is the result of multiple and simultaneous processes; some are taking place spontaneously, others as the direct result of human interventions. (Secchi 1990; Secchi and Viganò 2009) For urbanists, a territory is a constructed physical and mental entity, where several socio-economic and cultural processes generated a juxtaposition of urban elements that at first sight seem to lack any coherence (De Meulder 2008). Nevertheless, a closer look allows an understanding into the ordering logics that determine through time the continuous production and reproduction of space (Harvey 2001). These logics are embodied in the territory itself, making it comparable to a 'palimpsest', in which the traces of recent and ancient modifications 'lie' (Corboz 1985: 190). As Vittoria Di Palma suggests, each action on the territory, either good or bad, leaves traces and 'we cannot wish them away' (Di Palma 2014: 01).

Wasteland, in the form of abandoned built and un-built spaces, can also be seen as the remains of ancient transformation (Furlan 2017). An *a posteriori* mapping observation of these remains, as latent elements being temporarily unable to undergo transformation, allows us to understand what resists the flow of time, as well as what adapts or opposes itself to it (Viganò 2013). The presence of these traces can then be interpreted as signs of change. Consequently, mapping today's wastelands is instrumental to unfolding historical landscape in transformation throughout a thick description in time and space.

Fig. 1: Charleroi's wasteland, seen from the Terril des Piges (photo Cecilia Furlan, winter 2016).

Considering the landscape as a dynamic entity whose spatial features are *permanently emerging* and constantly undergoing modification (De Meulder 2008: 29), it is important to assume that the processes of transformation are grounded in a given space in ways that are both geographically and historically specific. Therefore, this chapter proposes to illustrate and test a thick mapping description through the case study of Charleroi's post-industrial landscape. The region of Charleroi is situated in the centre of Belgium and was historically manipulated to accommodate first coal-mine, glass and steel industries and then the wasteland generated by the shrinking industry (Fig. 1). Investigating Charleroi's wastelands and related landscape gives a unique opportunity to explore thick mapping as an approach to unfolding cultural context and meaning of historical landscape in transformation.

Mapping as way of inquiry transformations

Maps are powerful tools to inquire into the changes that have occurred through time, the traces left behind, as well as to indicate potential future changes (Secchi 1992). Based on Euclidean perspective, maps feature from above the land surface and consequently abstract the territory. Through time many mapping experiments

emerged, challenging each other on how to represent the dense surface of the Earth, with all its multiple layers and mutations. Many of these experiments, however, tend to simplify the historical territorial transformations as outcomes of linear processes of changing. This simplification often visually results in a chronological sequence of maps, frequently focused on one changing element, without featuring the relationship with the other landscape components. In order to address this challenge an interesting approach was proposed by the landscape architect, Ian McHarg (1920-2001). According to him, a systemic reading of the landscape and process of layering the different elements of the territory can reveal the logic behind how each element influences the others.

> '… historical geology, climate, physiography, the water regimen, soils, plants, animals and land use. This is the source from which the interpretation is made although the grain becomes finer. … We have explained that the place was "because" and to explain "because" we invoke not only natural evolution but cultural evolution as well. To do this we make a distinction between the "given" and the "made" forms. The former is the natural landscape identity, the latter is the accumulation of the adaptation to the given form which constitute the present city' (McHarg 1969: 106).

In distinctive ways, the impact of McHarg's approach influences several contemporary mapping and design practices, amongst others the works of Corner (1999), Mathur and Cunha (2001), Berger (2006), Shannon (2008), and Bélanger (2009). A common feature between these different mapping practices is the strategic overlaying of several layers/elements. This overlay allows the correlation among different information, revealing their interrelations, their synergy, and enabling the interpretation of the territorial body of content.

This approach, however, has some limitations. Firstly, mapping does not provide one-to-one copies of the existing situation, but requires continuous interpretation and reformulation. Secondly, by observing the territory from above and consequently abstracting it, a mapping approach often frustrates the reader. This method requires an effort from the viewer to change perspective, to understand how spaces transformed over time and how spatial relativities emerge and develop. Thirdly, the static nature of maps contrasts with the constant mutable condition of the territory. According to Cattoor and Perkins (2014) maps are visual descriptions of a present situation; they are like photographic shots of a portion of landscape surface at a precise moment in time. Therefore, how can the abstract forces that shape urban landscape be rendered artistically, spatially, and informatively in the

form of static maps? In what way can alternative visualisation provide a deeper insight capable of unfolding historical landscape transformations and revealing what conventional maps cannot reveal?

A possible answer to the question of how to represent in maps the transformations developed in time can be explored throughout a 'thick' or 'deep' mapping (Presner et al. 2014). The potentialities of mapping operations will be explored, focusing on the possibility of allowing maps to express narrative, complexity, and landscape changes in a densely descriptive thick mapping.

Mapping: a thick question

Following McHarg's approach and despite their flat nature, maps can be rather thick (Favaro, 2017). Thick maps or thick mapping is a well-known idea derived from the approach developed by the anthropologist Clifford J. Geertz (1926-2006) to describe cultural context and human practices in space (Presner et al. 2014). Following Geertz's notion of 'thick description', thickness connotes a kind of cultural analysis of the landscape through time trained on socio-economic and cultural realities which human beings act upon (Favaro 2017).

In this chapter, we use the concept of 'thickness' as a polyvalent way of revealing, collecting, and visualising several layers of landscape environmental and socio-ocultural information and synthetising them all in a map (Presner et al. 2014). The over-imposition of several layers allows one to correlate different materials, revealing their interrelations and generating a synergic thickness of content. Going beyond the idea of objective tools of representation, maps become revelatory and productive: they bring to light the invisible potential and contradiction within a greater milieu (Corner 1999).

Like in writing, thick mapping operations entail multiple explorations such as surveying, listening to the inhabitants, discovering the past and present everyday uses of the landscape, drawing, selective tracing and re-tracing of contemporary and ancient cartographies. Systematic explorations aim to reveal what normally seems invisible in conventional topographical cartography and geographical representations, and to disclose landscape variations. Landscape variations emphasise the dynamic relationship between aesthetic experiences, the modification of the natural environment, and social practices. The work of the geographer Denis Cosgrove (1998) is exemplary. His study focuses on revealing the ideological significance of landscape, aiming to trace the relationship between visualisation of

the natural environment, the social production of space and its development along with symbolic landscape (Gandy 2016). Cosgrove's position is also confirmed by Harley's who states that maps are 'constructions of the reality (…) laden with intentions and consequences that can be studied in the societies of their time. Like books, they are the products of both individual minds and the wider cultural values, in particular societies' (Harley and Laxton 2001: 36). Thus, how to represent in a map the cultural construction of the environment in a distinctive moment in time according with specific values?

In order to answer this question, maps need to become figuratively tridimensional, generating a thickness in representation. Like the actions promoted by Patrick Geddes (1854-1932) during his territorial exploration, thickness here intends to overlap more conventional geographic information with 'lateral views'. Following the French school of geography, Geddes's survey focused on a panoramic observation of the territory, preferably from a high vantage point; on historical cartographic analyses that would recognise the territory as an element in time; and on collecting narrative of the present and ancient transformations developed by direct contact with the inhabitants (Dehaene 2002). Here historical photography, geographic and literary descriptions, classifications, narratives, and collections of design strategies are taken as lateral views complementing the landscape mapping approach (Potteiger and Purinton 1998). Together with the tracing of territorial elements, these views help us to study and to understand the relationships between the spatial dimensions of historical transformations and the mental images that society projects upon them.

The simultaneous use of lateral views to look at the territory shows an interpretation from above, but also through the eyes of those who have experienced the territory, who have studied it, maybe even from an experimental perspective (Boeri 1998). Mapping offers a way to deal with complexity, an opportunity for extracting a synthesis image from a complex interpolation of different specific knowledge coming from different fields regarding the territory. They are deep sources of landscape transformations because they embody temporal dynamics through a multiplicity of layered information, sources, and data.

Representing a historical landscape in transformation is thus a 'thick' issue because of the multiple possible ways to address it. Indeed, how this issue is originally posed is fundamental: it generates more questions and consequently more answers (Favaro 2017). Therefore, thick mapping needs to be flexible, iterative, and constantly tested by exploring different regions. To test this approach, the

following paragraphs describe a thick mapping exercise through which the historical transformations of the region of Charleroi are observed and unfolded.

A thick mapping exercise in Charleroi

Through time, the territory of Charleroi has constantly been claimed and re-claimed, spawning the ideas of exploration, occupation, and regeneration [**Map 1**]. Founded in 1666 as a strategic military place by the Spanish rulers, Charleroi became one of the cradles of the industrial revolution in Belgium (Hasquin 1971). From the end of the eighteenth century, Charleroi's landscape has been intensely manipulated to accommodate industrial activities, starting with coal mining, subsequently with steel, chemical, and glass industries and the associated urbanisation (Schaeffer 1995; Remy 1962). Growth without planning resulted in the emergence of a chaotic network of railway lines, streets, buildings, factories, and mining sites (Brüggemeier 1994). In less than a century speedy technological-industrial development and strong capital investment brought wealth to the region and generated one of the most flourishing urban/industrial landscapes in Europe (Pirsoul 1952). However, the close proximity of houses, industries, and agricultural lands led to the dispersed condition of living and working together and an excessive proliferation of rail-road infrastructures.

Although sluggish overall and without any major economic structural change, the period between the conclusion of the nineteenth century and WW2 registered the beginning of a relatively slow decline and transition. The decline was characterised by the slow shift of industrial production from the Walloon axis (Liège-Charleroi) in favour of the more central and northern parts of Belgium, and by the change in the mode of production (Vandermotten 1998: 85). The decay of the mining, glass, and steel industries radically transformed Charleroi's territory, generating sixty years of transition and leaving a legacy of different levels of wasteland (Vagman 1991). This physical legacy is a constant reminder of the several processes that Charleroi underwent, some of which are still on-going.

Mapping wasteland, therefore, is the first step to understanding this transition. Today, Charleroi counts more than 1,000 identified wasteland spaces covering a surface of approximately one fifth of the 30 x 30 kilometres of its region. The research has mapped wasteland according to the spatial typologies observed on site and with the contamination data provided by the Walloon Region and other semi-public agencies. Within Charleroi, a territorial portion of 30 x 30 kilometres

and three particular zoom-ins of 1 x 1 kilometres were simultaneously cartographically investigated (Furlan 2017).

This operation aimed to extract specific elements from the territory and isolate them from the noise background. Practically, the proposed exercise is based on the juxtaposition of the direct observations of the site, on the photo interpretation of Google Maps' aerial imagery of 2013, 2014, 2015, 2016 and on the official survey done by the Walloon Region in 2003.[1] Each wasteland, represented in white, was identified during several survey operations across the territory done by foot, bicycle, and car. The resulting landscape image is composed by a variety of macro (industrial platforms/sites, railways, spoil tips, or 'terrils', greyfields) and micro (single building, warehouses) pieces of architecture and urban structures, as well with 'vacant land' like green-field and grey-field areas which, despite their appearance, are deeply environmentally degraded. The necessity to describe the quality and the differences of wasteland is addressed by overlapping the tracing of wastelands geography with pictures of the sites. The sequence of vertical pictures corresponds to the figures identifiable following a hypothetical vertical section across the region [**Map 2** and **Map 3**].

As the series of maps shows, it is possible to identify a milieu of wasteland situations. Each situation is the result of one or more distinctive processes of urbanisation related to specific industrial production and urban development. However, grasping the multitude of processes in an objective and systematic way is challenging. Therefore, the chosen mapping operations rely on unfolding the transformations of four systems that mainly generate in time the contemporary wasteland geography, namely: infrastructures, urban tissue, productive tissue, and afforested landscape.

The unfolding operation consists of:

1. Systematic tracing procedures of each system through 1777, 1939, 1969 and 2015 [**Map 4**]. The historical cartographies are: a portion of the Ferraris map or Map of the Austrian Netherlands (1770-78), produced by Joseph de Ferraris on the scale of 1:11520; topographic maps from 1873 and 1969 conserved at the Royal Library of Belgium in Brussels and drawn on a scale of 1:20.000.

1. http://dgo4.spw.wallonie.be/DGATLP/DGATLP/Pages/DAU/Dwnld/SAEDinventaire/SAED-InventaireAnn2CHARLEROI.pdf

2. The evolution of each system is synthetised in four coloured maps, in which emerge where and how the urbanisation processes developed and how the territory changed to accommodate this transformation.
3. Along with unfolding the historical spatial urban palimpsest, these mapping exercises overlapped the analytical layer that emerged by a selective tracing operation with the series of alternative visual elements. An analysis from above indeed demands to be complemented by an observation from below where an understanding of the Charleroi territory and the transformation of its landscape can be mapped from lateral views.

These lateral views consist of: historical pictures of the industrial production, paintings of pre-mining and mining period, for example the paintings of Pierre Paulus (1881-1959), ancient texts and postcards of formers workers and inhabitants of Charleroi [**Map 5**]. These data were informally collected during several surveys across Charleroi by directly engaging with people.

The combination between the more traditional cartographic analysis and the other type of sensible representation allowed us to understand, compare, and describe ancient transformation as well as the latent capacities of the landscape.

Particular maps [**Map 1** and **Map 5**] amalgamate, as a collage (McFarlane 2011), the topographical landscape features, economic data, industrial urban transformation (highlighted in different colours), and sequences of historical greyscale pictures of Charleroi. By modifying colour hue and saturation, the juxtaposition of different elements allows us to visualise through time the complex and unplanned urbanisation and industrialisation processes described by Pirsoul (1952). The central part of the map [**Map 5**] shows how the process of urbanisation related to industries developed mainly along the Walloon Meuse-Sambre river. Since the early seventeenth century, the river Sambre has attracted the establishment of a number of activities such as quarries, mills, sawmills, and stoneware potteries. Simultaneously, the bottom series of figures describes in time the technological transformation and the enlargement of the built structures.

The mapping assemblage of these interplays allows us to associate urban processes with socio-economic information and the lifestyle of Charleroi workers. This communicates to the viewers an inside knowledge of the distinctive features of this region. Moreover, it highlights the dynamism and trans-scalarity of the industrial metamorphoses that culminated with the present wasteland landscape.

Conclusion

This chapter proposes an alternative approach — thick mapping — to tackle a crucial issue of cartographic representation: the relation between space and time. In particular, we propose to address this relationship by observing firstly the contemporary landscape, the traces of recent and ancient modification left upon it, and then go back in time to map the processes that generate these traces. Maps, however, often have the prevalent position of representing the landscape as a two-dimensional plane in a precise moment in time. Therefore, the thick mapping approach tends to move forward from this static perspective of maps.

Thick mapping transforms maps into artefacts that allow us to read territorial changes and simultaneously identify the relationship between the different landscape components. Throughout the study of Charleroi wasteland's landscape, the use of thick mapping enables us to systematise different types of materials into analytical and denotative schemas. Therefore, maps become systematic montages, where multiple and independent layers are addressing social, economic, and urban transformations, being incorporated as a 'synthetic composite'. Specifically, in the case of Charleroi, thick mapping involves collecting oral history excerpts, associating them with other media (photographic images, paintings), and aggregating lots of multi-layered stories of the industrial wastelands. Consequently, the construction of each map requires a complementary reading from above with a reading from below. The former consists in a critical use of the available information produced by cartographic techniques from aerial views, historical maps, to GIS, while the latter includes systematic surveys across the territory, construction of narratives and the practice of tracing and re-drawing spaces. The use of distinctive techniques reflects the awareness of the study on Charleroi about the different intentions and logics behind the construction of each chosen map. As Farinelli (1992, in Pellizzi 2001) maintains, the cartographic logic upon each map depends on: a) the primary goal to be achieved; b) the correspondence between 'things' and signs (conventions), c) the reduction of the complexity of the reality to a phenomenal form.

In conclusion, we can therefore maintain that mapping wasteland is both a way of reading transformations and a form of knowledge production (Viganò 2010). It is thus not simply about visualisation and representation. Moreover, unfolding wasteland and related historical process through a thick mapping aims to clarify the complexity of landscape transformations in time in relation to socio-economic processes. As André Corboz (1985) highlights, representing the territory already means mastering the same. The obtained representation is not a cast, but a construction. A thick map is firstly made to gain knowledge, and subsequently to act upon it.

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Mertens S., Stas M. and Vanbrabant B. (2016). *Exploring le Pays Noir. Design Investigations for a Productive Landscape in the Charleroi Region* [map].

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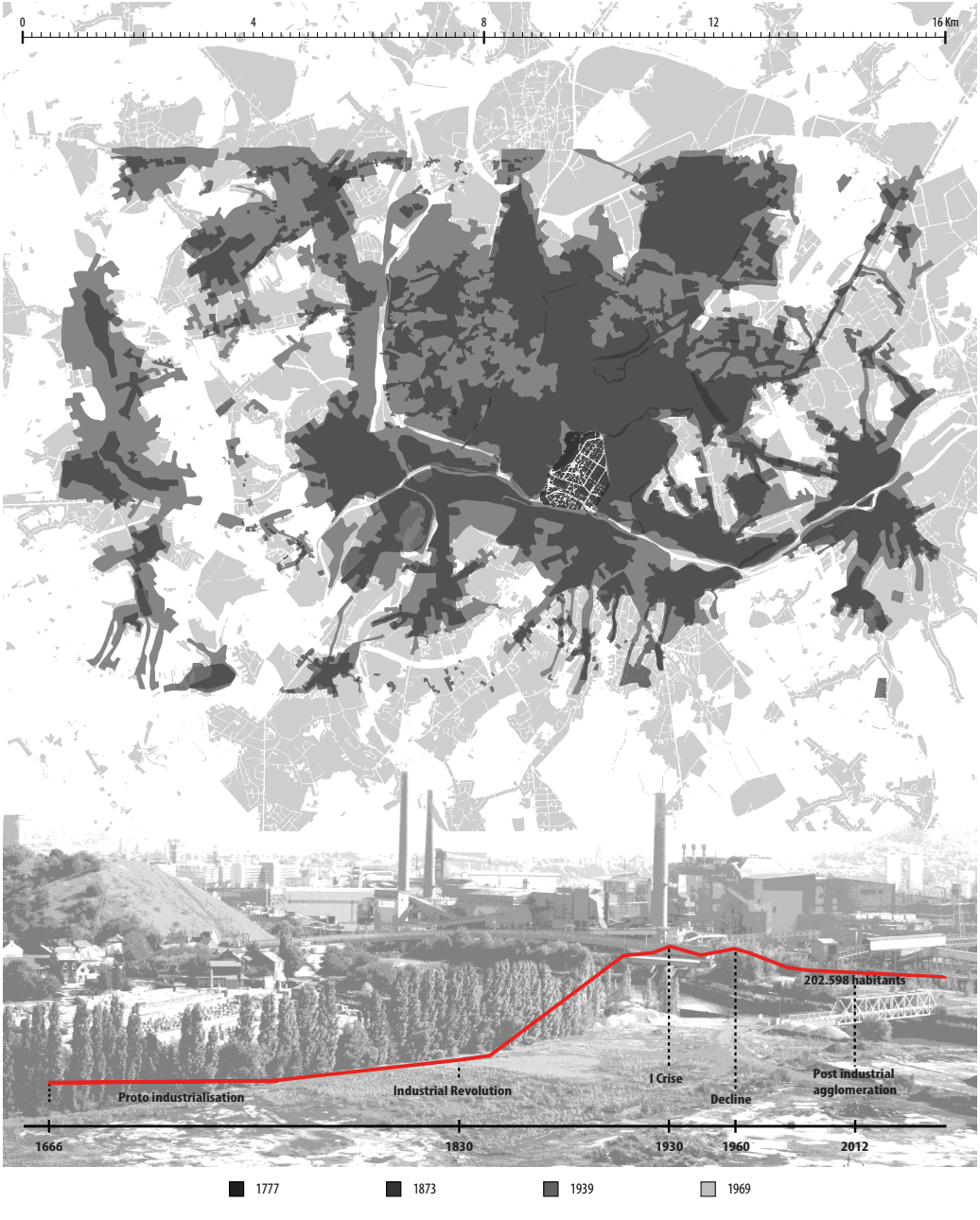
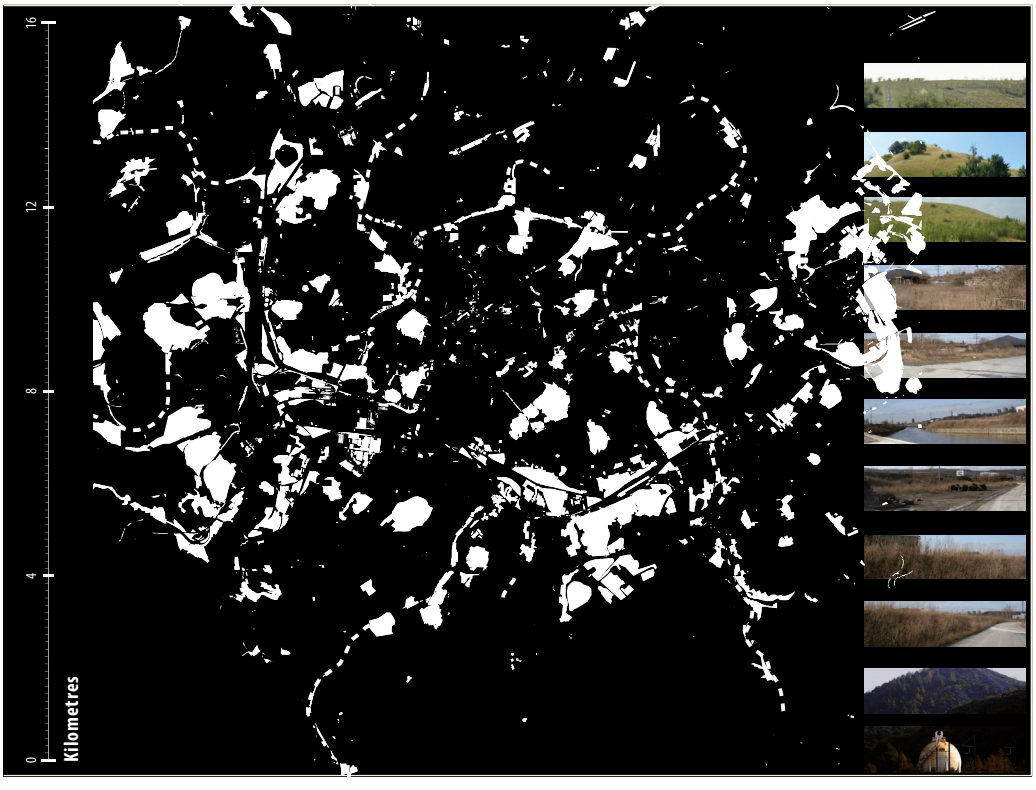
Maps

Map 1: Cecilia Furlan (2017), *Map of the Main Urbanization Phases in Relation with Several Waves of Expansion of the Urban Landscape.* [Source: Florence Vannoorbeek (2005) *Recherche en banlieue industrielle Charleroi-Nord*, KU Leuven, MAUSP, promoter Bruno De Meulder.]

Situated in the centre of Europe, along the Walloon coal '*dorsal*' and in a strategic position next to the Sambre river, the region of Charleroi is one of the symbols of the European mine industrial revolution. Following the industrial revolution from 1850, in less than 150 years the territory has passed from a small rural centre into one of the largest industrial cities in Belgium: 'Le Pays Noir'. The presence of mines, glass, and steel industries have generated an urban transformation, creating a polycentric, dispersed territory around the historical core, which is defined by a series of linear settlements along the main road and the industries.

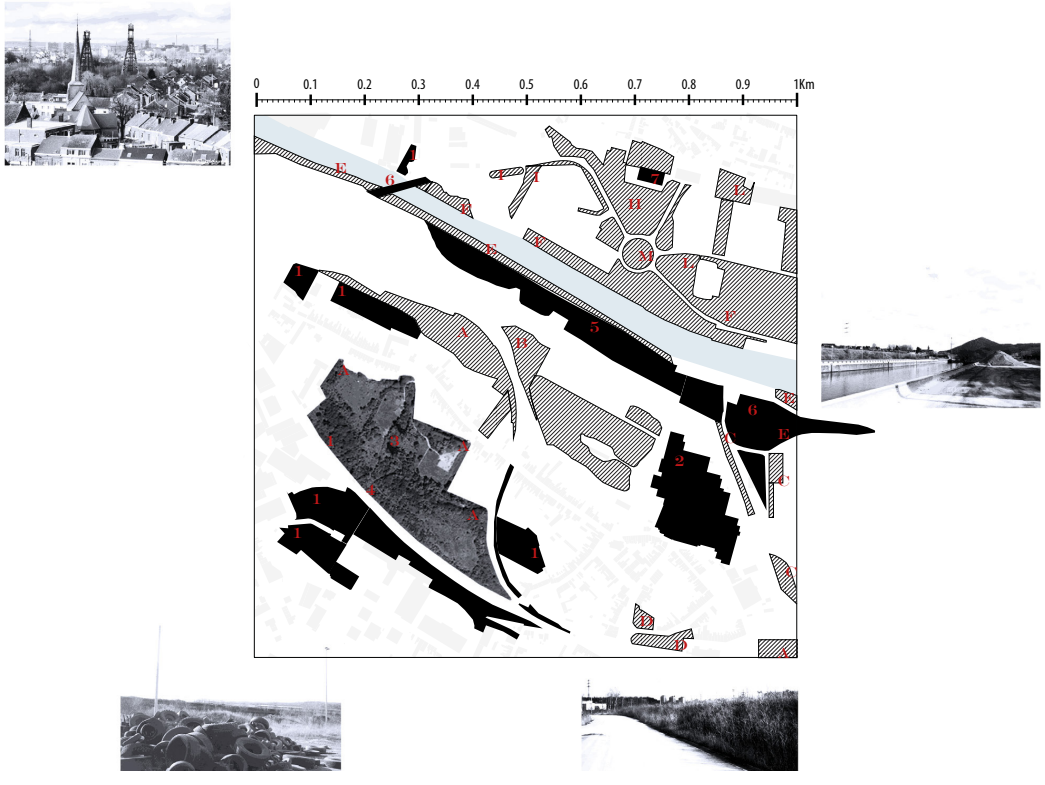


Map 1: Map of the Main Urbanization Phases in Relation with Several Waves of Expansion of the Urban Landscape.



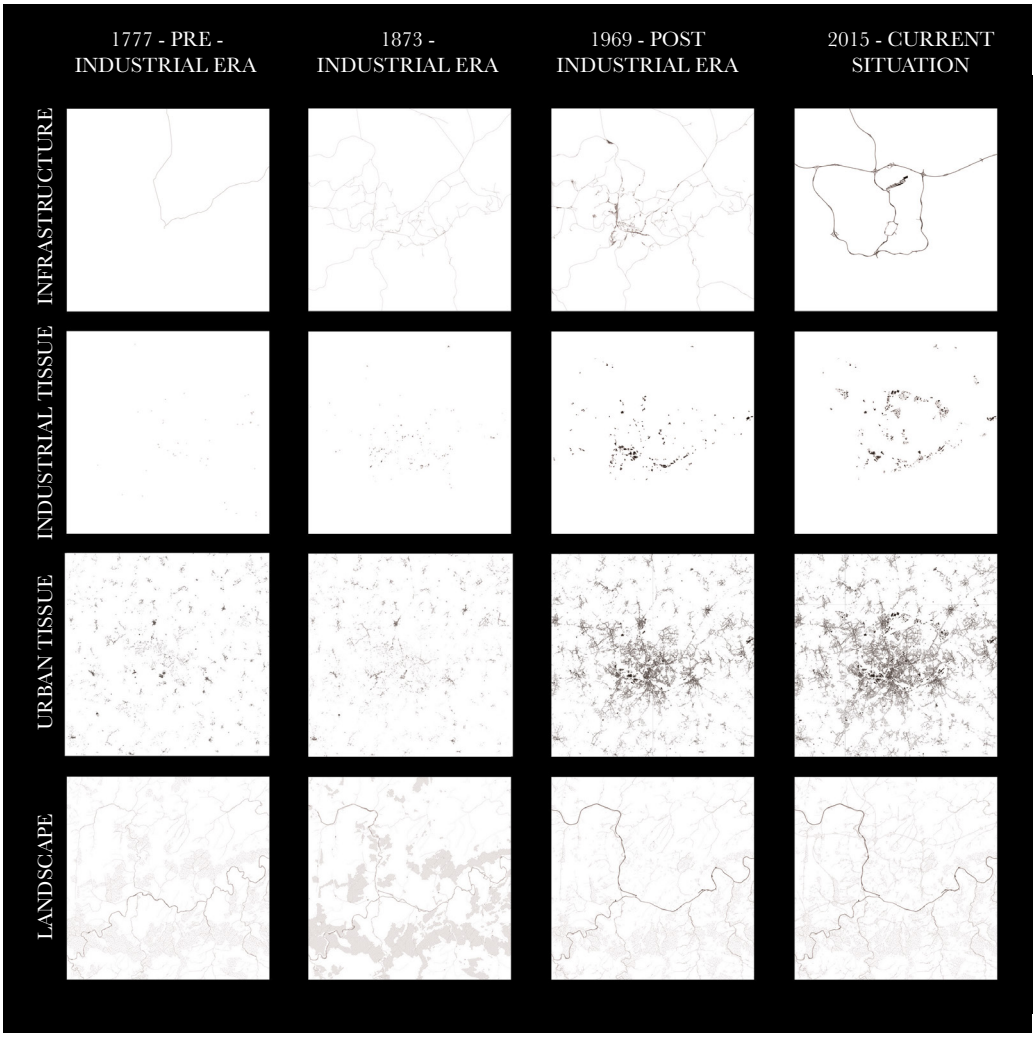
Map 2: Cecilia Furlan (2017), *Distribution of Wasteland across a Portion of 16 x 16 Kilometre of the Charleroi Region, Captured between 2013 and 2016*.

Each wasteland, represented in white, was identified during several survey operations across the territory done by foot, bicycle, and car. The result of the survey was constantly compared with observation through aerial pictures and official archive done by SPAQuE, and the Walloon Region environmental agencies. Although mapped all with the same colour these spaces are very different from each other. A series of pictures taken according to a hypothetical north-south section shows this differentiation.



Map 3: Cecilia Furlan (2014), *Observation of a Territorial Sample of 1 x 1 Kilometre, Winter 2014*.

This assemblage shows the heterogeneous character of wasteland. The sample is located in the central part of the Charleroi region illustrating the former mining site of Couillet: le Pechon, located along the Sambre river. The site points out the massive presence of large abandoned green-field and huge former industrial buildings located across and along the river, and the existence of the ruins of the former mining site and infrastructures hidden by tall spontaneous vegetation, as consequences of the historic process of de-programming of different production models. The combination of map and pictures aims to show the complexity of wasteland. In an abstract way, this combination highlights the coexistence of diverse materials, forms, and dimensions that characterised this wasteland.



Map 4: Systematic Inquiry through Time of the Transformation of Four Landscape Systems, Namely: Infrastructure, Industrial tissue, Urban Tissue and Afforested Landscape.

Map 4: Sven Merten, Michael Stas, Benjamin Vanbrabant (2016), *Systematic Inquiry through Time of the Transformation of Four Landscape Systems, Namely: Infrastructure, Industrial tissue, Urban Tissue and Afforested Landscape. In: Exploring le Pays Noir. Design Investigation for a Productive Landscape in the Charleroi Region*. Promoter Bruno De Meulder; co-promoters Cecilia Furlan and Racha Daher, KU Leuven. [Source: *Ferraris Map or Carte de cabinet des Pays-Bas* is a complete cartography of the Austrian Netherlands; drawn up between 1770 and 1778 by Count Joseph de Ferraris and his team of military` topographers.

The topographical map of Charleroi region is a highly refined cartographic endeavour to visualise the first territorial survey recorded by the officers of the Dépôt de la Guerre, between 1860 and 1873. Topographical map of Charleroi region representing the territorial survey executed between 1804 and 1939 and published at the scale of 1:20.000. Series of NGI-IGN topographical maps of 1969, 1981 and 2016 on a scale of 1:25.000 drawn up by the Belgian geographical military institute, Institut Géographique national/Nationaal Geografish Instituut.]

The territory of Charleroi underwent drastic changes to accommodate forestry, agriculture, underground mining activities, heavy industries, different types of infrastructures, and dwellings. These changes are shown through a delayering operation of a portion of 30 x 30 kilometres of the Charleroi region.

Map 5: Cecilia Furlan, Sven Merten, Michael Stas, Benjamin Vanbrabant (2016), *Transformations of the Industrial Activities in Charleroi Region between 1777 and 2015.*

Three juxtaposed layers comprise the map. The top layer highlights with four main colours the different industrial tissue accumulated through time. The second layer shows in light grey the distribution of the contemporary infrastructural system of river, railways, and road network. The background layer shows historical images relative to industrial activities. The image at top left describes different sections of mining construction building. The image in the centre illustrates an everyday activity of a worker in Couillet (a Charleroi neighbourhood) painted by Pierre Paulus. The photography, in the bottom part, illustrates the succession of different types of industrial activities in time.

6.
Photography, Railways and Landscape in Transylvania, Romania

Case Studies in Digital Humanities

Cristina Purcar (Technical University Cluj-Napoca)

'An idea, not a thing,' landscape is the cultural perception of the physical environment, 'created by our minds and emotions' (Clark et al. 2003: 3). The environment as physical place and the landscape as culturally determined perception and representation of the physical place, therefore, form a complex unity. Among the different representations of the environment (or landscape-construction means), cartography and statistics are allegedly more objective, while photography, painting, and literature provide rather subjective readings. Through mapping, contemporary geo-positioned data-management tools allow for a multi-layered relatedness between these two components of landscape.

Through mapping, this paper investigates the triple relationship between photography, railway, and landscape. Hereby, mapping is understood as the associative operation that topologically connects sets of iconographic data to cartographical sets, more specifically in this study, historic railway photography to contemporary and historic cartography. Railways and photography appeared at the same time, around 1830. Both are mechanical technologies and industrial media: a medium for transportation and a medium for the creation of images respectively. Both railways and photography ushered in a modern understanding of space and time, a new awareness of, and relationship with, landscape. Railways reshaped places, indeed entire territories, while landscape photography created a visual discourse about these transformations, often apologetic, sometimes evasive, and sometimes critical.

How should one read, analyse, and interpret this peculiar object, railway, and the landscapes it formed and transformed? In this study we argue that historic

photography, investigated as a coherent body of images, *corpus photographicum*, rather than as individual images, can prove an effective means to this end. Focusing on railway cases from Transylvania, Romania, we propose a mapping system wherein mapping is understood more as in mathematical linguistics — as associative operation between different data sets — rather than as in cartography proper, as the creation of graphic representations of parts of the Earth's surface. A system is proposed of interconnected geo-located data, using the photographic image as an entrance gate to a multi-layered investigation of change in the railway landscape, or as a nexus around which diverse types of historic documents may revolve and confront each other.

Photography and the railway landscape

Remarkably, the development of railway and photography, both icons of modernity, unfolded in parallel: as railways spread their net across the continents, making mobility more accessible than ever before, photography became a mass media, especially in the form of postcards and printed-press illustrations. By the late 1850s, the major European railway trunk lines were in place or under construction, while photographers' studios were functioning in all major cities. After 1870, the practice of publishing, posting, and collecting postcards proliferated, with Austria as the first country to introduce postal cards in 1869 and picture postcards after the 1880s (Carline 1971: 37-38). Imaged postcards quickly gained enormous popularity and were promoted by central administrations as tokens of democratic governance, providing large population strata with affordable access to communication and information (Thirkell and Scullion 2004: 6-13). Simultaneously, the railways were expected to provide democratic access to mobility and work, business, but leisure railway travel also flourished between the last quarter of the nineteenth century and the outbreak of WWI.

By the early twentieth century, topographic photography, mass printed and distributed in the form of picture postcards, became virtually ubiquitous and place-postcard collection a popular hobby among the Dualist Empire middle classes (Degen n.d.). The railways were not only a crucial favouring factor, but also an important picture-postcard subject in their own right. Photographers used the railways for their photographing travels, but also frequently pictured the railways; travellers used the railway system to reach daily or exceptional destinations, but also sent images thereof via a postal system which was tightly related to and dependent on the railway system. Indeed, both railway travel and topographic

postcard culture are essential ingredients for the emergence of an idealised collective image of the *Belle Époque*.

In Transylvania, the north-western part of present-day Romania and part of the Austro-Hungarian Empire at the time, the first railway lines (Arad – Alba Iulia and Oradea – Cluj – Braşov) were open for traffic by 1873. During the same period, pioneer photographers opened and led successful photographic practices, such as Ferenc Veress (1832-1916) in Cluj since 1853 or Leopold Adler (1848-1924) in Braşov since 1870. A highly substantial contribution to the dissemination, often also to the creation of documentary photography belonged to the postcard publishers, who flourished around 1900. In Braşov they were Zeidner, Hiemesch, Müller, Ciurcu, Samu, Gust, Lang, or Netolitscha (Căncescu 2008: 8-9).

The railway project devised a self-coherent territorial-scale construction, tackling a multitude of spatial planning scales: the overall line trajectory; the insertion within the countryside topography; the by-passing of settlements and the location of stations within the urban fabric; the layout and architectural expression of stations and works of engineering art (Purcar 2007). As a result, the regions traversed by the railway contain this 'built-in' territorial structure, sometimes still perceivable, sometimes eclipsed or partly erased by subsequent developments, a genuine territorial-scale palimpsest. The railway territory is defined by its backbone rather than by boundaries, because boundaries shift according to which scale-level of the railway project is brought into discussion. As already argued, addressing the railway infrastructure from a landscape historical perspective provides a unique territorial 'stratigraphy' that correlates — and could be used to reconcile — the tensions between network and place, town and region, the pastoral and the industrial, nature and culture, conservation and renewal (Purcar 2009b: 10). In the early days, railway photography was intended for advertising and documentation purposes, with the intention of depicting triumphant, progressive visions. By doing this, railway photographs naturally captured fragments of the urban/rural environments, thus also documenting, albeit rather not purposefully, the neighbouring places which would undergo, for better or for worse, the ineluctable influence of this new force line of the territory.

Consequently, there exists today a rich heritage of railway images, in the form of genuine photographs and postcards, scattered in the collections of public libraries, in deltiologist collections, (local) historical monographs or blogs, railway-fan sites, in physical or digital form and with different degrees of alphabetic, chronologic, and/or thematic/key-word systematisation.

A case in point, Cluj-based photographer Ferenc Veress sent images for the 1873 World Exhibition in Vienna, just after the inauguration of the Transylvanian trunk lines — the backbone of the regional railway network — that both facilitated his travels and constituted an important subject of his photographs. Károly Kincses mentions Veress applying for a free train pass to allow him to travel from the capital Budapest to the south-eastern border Predeal, in order to systematically photograph sites along the railway (Kincses 1993: 47, cited in Újvári 2014). He was as eager to document these contemporary highlights as the country's historic monuments; in his articles he called on his fellow photographers to join in the task of creating 'a great photographic collection,' being aware of the historic monuments' fragility as well as of photography's documentary power (Veress 1860, *apud* Újvári 2014: 147). Meanwhile, his (railway) images, contemporary with their subject matter, have also acquired the historical value initially grasped in relation to the earlier monuments: they reveal to us, one century later, the railway territory in its original state.

Mapped images and image maps: a framework for studying change in the railway landscape

Drawing on Transylvanian case studies, this chapter outlines a framework for studying change in the railway landscape, starting from railway photography. Susan Sontag speaks of the photograph as an extension of Baudelaire's middle-class *flâneur's* eye and of the photographer as an 'armed version of the solitary walker' who 'discovers the city as a landscape of voluptuous extremes' (Sontag 2005: 43). Paraphrasing Sontag, the railway *corpus photographicum* reveals the territory as a landscape of contrasts connected by narrative lines, the railway lines. In terms of the collective imagination, railway photography contributes enormously to creating the railway landscape, for railway landscape only exists in as far as it is represented — in this case, photographed. Railway photographs are significant not only for what they show, but also for what they do not. The image of the railway created by the mapped photographs, *i.e.* the railway landscape, overlaps only fragmentarily the railway's cartographic representation.[1] While in cartography the railways are rendered as continuous lines, mapped railway photography reveals an incomplete geography of unevenly dense dotted lines, with concentration hotspots and blank — as if invisible — sections. Constructing the railway landscape through the mass medium of photography appears therefore as a highly selective mapping operation.

1. Thanks to Karl Beelen for having pinpointed this insight.

In structuring our database we are inspired by Roland Barthes' writings on photography, namely by his two notions, s*tudium* and *punctum,* which are borrowed and displaced. For Barthes, *studium* represents the cultural attributes of a photograph, allowing for a rational, enthusiastic yet detached reflection on the image, while *punctum* is the irrational, the poignant detail or accident which disquiets the viewer, triggering an intense engagement therewith; by the co-presence of *studium* and *punctum*, the photograph in question acquires a higher value (Barthes 1981: 25-42). Our diversion goes to consider the topographic photograph or postcard as being the *punctum* that touches us, captures our attention, stirring a desire for *studium*, i.e. for exploring the history of the place in question by bringing in other sources, such as cartography, historiography, statistics, etc. Thus a seizing, powerful image becomes the fragment that sets off a search for what is beyond the image itself.

A system of geo-located railway image galleries, connected with cartographic and other, non-iconographic data, can serve both for the chronologic and thematic ordering of railway images, as well as for the study of these images within specific time and space contexts. Currently implemented partially, the designed framework consists of five main image galleries, ordering railway photography according to five species, which are significant for the study of landscape as well, for defining five specific types of railway sites: (1) reception buildings viewed from the city side; (2) views of station yards; (3) tramways or railway lines in the street; (4) railways in industrial sites; (5) railways in the countryside. All images included in galleries are geo-located by being attached to the Google Earth map: they are mapped images. The photos can be accessed either as mapped images, by surfing the map, where their locations are indicated by place markers, or by browsing one of the five thematic galleries, presented as image maps, wherein one can choose whether images are sorted by creation date or by the place-name alphabetical order. The structure and main functions of the database are summarised in the following table.

images are archived as five-type placemarkers on Google Maps or browsed from five MAIN GALLERIES				
(1) RECEPTION BUILDINGS VIEWED FROM THE CITY SIDE	(2) VIEWS OF STATION YARDS	(3) TRAMWAYS / RAILWAY LINES IN THE STREET	(4) RAILWAYS IN INDUSTRIAL SITES	(5) RAILWAYS IN THE COUNTRYSIDE

an image is chosen: *PUNCTUM*
image 'ID': schematic map with image location and geographic coordinates in WGS84; place; viewing position; date; type (medium); source

to each *punctum*, three research contexts are assigned: *STUDIUM* SUB-GALLERIES		
(I) DIACHRONIC PLACE SURVEY studies long-term change at the *punctum* site	(II) TYPE DECLINATIONS surveys synchronic developments in similar locations, elsewhere	(III) ALONG THE LINE surveys the problematic of the *punctum* image along the same railway line

SUB-GALLERY CONTENT		
(i) geo-located and calibrated historic or contemporary map with placemarkers	(ii) geo-tagged text / table / audio / video	(iii) geo-tagged photograph a new *punctum*

The database not only is devised to present research results so far, but also is an instrument for on-going and future research, by ordering and presenting the currently available material, providing a framework for the study of new documents, and facilitating new insights. Creating multiple interconnections between two different forms of spatial representation — maps and photographs — allows us to construct new space and time narratives, through geo-location, calibration, overlapping, juxtaposition, in and out zooming, etc.

Two examples from the United States could be evoked at this point, along with their specific relevance and differences. The Center for Railroad Photography & Art aims 'to preserve and present significant images of railroading' and 'telling railroading's stories through imagery'. (http://www.railphoto-art.org/) It offers links to libraries and documentation centres, organises exhibitions, and publishes books and albums, as well as the trimestral journal *Railway Heritage*. It is a valuable source for studying the history of the US railway landscape, although images are not geo-tagged and the geographical context of imaged places must be researched separately. The railpictures.net portal is another US-focused, partly international, website of geo-tagged railway photographs, which can be sorted according to locomotive type, railway line, country, photographer, keyword, year — but relatively very few images from before 1945 — grouped in several railway-focused categories (such as steam locomotive, tunnels, yards, night shots, snow shots, etc.).

Although the site is neither focused on historic material, nor does it allow for the introduction and geo-referencing of other documentary sources such as historic maps or written documents, it is interesting for being open-access and for connecting image, place, and basic information via GIS.

The following paragraphs present some of the research possibilities offered by each of the five main galleries.

Reception buildings viewed from the city side

During the nineteenth and early twentieth centuries, railway stations were perceived as status symbols of their towns. Not only were they the main entrances thereto, but they also replicated, in a minor scale, the essential urban functions such as public service, commerce, industry, and housing. Publishing images of a town's railway station in the form of postcards was a matter of pride, synecdochically identifying the settlement with its utmost modernity asset [**Map 1**]. This insight has been memorably expressed by Proust in *Remembrance of Things Past* and recalled by Wolfgang Schivelbusch in his seminal book on railway's cultural impact:

> '[…] the mysterious operation that is performed in those peculiar places, railway stations, which do not constitute, so to speak, a part of the surrounding town, but contain the essence of its personality, just as upon their signboards they bear its painted name' (Proust 1943: 489-490).

Among the *Belle Époque* railway photography species, the images capturing the urban side of reception buildings and the public interface of railway stations were almost ubiquitous. Commissioned either by the railway companies or the local administrations, it is possible to find such a 'business card' for almost every town endowed with a railway station. Mapping these images configures the regional railway network, prompting a dot-and-line map wherein the reception building photos represent the network nodes. The sub-galleries prompted along with the enlarged photo allow three different types of investigations:

1. Diachronic place survey: studies the chronologic transformations of the railway station and its area at several scales: the building itself; the public space in close proximity — the station square; the adjoining urban fabric — the station's quarter, the station's boulevard.

2. Type declinations: brings forth, as mapped images, contemporary reception buildings belonging to the same category/station class; this is highly valuable when restoration is considered, as very often initially identical buildings suffered different types of transformation in time, a less transformed building may serve as a reference for the original state of a heavily altered one.
3. Along the line/'co-linear' reception buildings: allows the study of all reception buildings serving a specific railway line; this helps to document settlement hierarchy at a certain time, in both territorial-administrative and railway-network terms, the reception building size and elaboration being directly related to the rank within a station-class typology.

Tracks inside stations: the railway yards

Inner views of station yards are another widespread species of early railway photography: often commissioned by the railway companies to document the extension and endowment of stations, they can also be the subjects of postcards [**Map 2**]. The view is usually biased towards the reception building and waiting platforms, often a steaming locomotive or train carriages as eye-catchers. Sometimes the view is framed symmetrically, using a railway track as the vertical composition axis of the image, in this case resulting in a balanced presentation of the two sides of the tracks with the passenger or with the train operation-maintenance facilities. Often, the reception-building side of the tracks is shown on the image left, so that it gains more importance, as we tend to 'read' images from left to right. Also, an all-embracing, higher viewpoint is often employed in order to facilitate the descriptive, inventorying attitude of these images.

The three sub-galleries connected to this type of railway image are:

1. Diachronic place survey: documenting, through plans and photos, the timeline transformations of the precinct, such as surface enlargements, line prolongations, edifice replacements and/or transformations, platform covering structures, footbridge crossovers, lighting systems, etc.
2. Type declinations: allows for comparisons between similar station yards: same period, same station class, different/same railway company.
3. Along the line: documents stations along the same railway line according to a station-class hierarchy, in terms of the size and number of their facilities, such as passenger buildings, goods warehouses, water towers, coal sheds, locomotive and carriage sheds, railway employee housing. This is based on historic

documents such as photos and cadastre plans, but also on custom-made graphics illustrating the relationship between station classes and a regional-scale settlement hierarchy.

Street lines: historic tramways

Around 1900, in parallel with the development of the main railway network, local railway lines and tramways were open in the more important Transylvanian towns. They connected the centre with the industrialising suburbs and with the rapidly expanding residential areas, often former villages integrated during the same period within the municipal boundaries of the mother-town. Together with the railway station, the tramway — successively horse-, steam-, diesel-, and electrical-powered — was immediately assumed as an important status symbol of a modern city [**Map 3**]. This is proved by the numerous historic images of these street trains. The most typical composition places the tram as the image focal point, usually avoiding its geometric centre, in order to potentiate the dynamic character of the photographic *veduta*, as a trope of modernity. Even when the tram itself is absent from the image, the bending or straight tracks, emphasising the street trajectory, remain the image force lines. In some tramline shots the tram and/or the line do not always seem to be the main protagonists, but the tramline streets, rather than other streets, tend to be depicted the most frequently. These streets were the town's hotlines just as the tram stops were its hotspots.

When a tramline view is the selected *punctum* image from the main galleries, the three related sub-galleries are:

1. Diachronic place survey: documents timeline changes of the same urban spot.
2. Type declinations/other *Belle Époque* tramways: allows comparison with contemporary urban tramlines.
3. Along the line/tram-way hotspots: retraces the original trajectory, often completely or partly altered in time, along with the opening and closure dates of the different segments; provides a synchronic selection of the urban landscape in the historic centre, the pericentral districts, as well as in the rural and/or industrial peripheries; it also documents the spatial connections between the local, vicinal and regional railway lines having the city in point as their hub and the dynamic thereof (such as relocated lines and stations).

Tracks, mineshafts, furnaces: railways in industrial sites

A large corpus of late nineteenth-century railway photographies consists in views of industrial sites, wherein tracks are always included. These were intended to document the assets of state and private companies as a matter of pride and as tokens of modernity and prosperity of the state and the companies. Cultivating monumentality and orderliness, the images would also have acted as incentives for shareholders' trust and investment [**Map 4**]. The powerful, dynamic compositions, foregrounding the neat verticals, horizontals, and diagonals of the industrial buildings and installations are often seconded by the softly blurred, undulating lines of the natural surroundings: a telling overlapping of the two colliding realities in the rapidly growing mining regions, formerly remote, archaic rural places: the pastoral and the industrial (Purcar 2009a).

A special group within this category is formed by post-war photography. Between the 1950s and the 1970s, the intensive industrialisation promoted by the Communist regime was documented with the same propagandistic aims as before. However, monumentality now also acquires a dramatic note: closer, bird's-eye perspectives, more smoke and steam, in contrast with ever stronger force lines of the built masses. Certain views, of the Hunedoara steel works for instance, evoke an industrial sublime, quite reminiscent of the late 1920s photography and painting of the American artist Charles Sheeler (1883-1965) at the Detroit Ford plant. As remarked by Hal Foster, in such images, the industrial process and the industrial landscape appear timeless and natural, matter-of-course, like the succession of seasons through nature (Foster et al. 2007: 222-225).

This image category triggers three types of investigation:

1. Railway, industry, urbanisation/diachronic place survey: analyses the urbanisation process related to the industrialisation of the *punctum* place, displaying diachronic maps, calibrated and geo-located, as well as other geo-located and dated historic photos.
2. Type declinations: surveys and allows comparison between the same type of industrial sites, e.g. mining sites, foundries, mills, etc.
3. Along the line/industrial region: maps and documents the other components of the industrial system to which the selected site belongs, together with the railway connections that made the system possible.

The 'machine in the garden': railways in the countryside

In *The Machine in the Garden …*, Leo Marx notices the long-lasting vitality of the pastoral myth in the American culture, in spite of, or perhaps just because of the force of industrialisation. He explains this by the fact that 'the pastoral ideal has been incorporated in a powerful metaphor of contradiction' through its encounter with the 'counterforce' represented by industrialisation (Marx 1964: 4; Purcar 2009a). A large family of railway photography, consisting in track (and train) views within a natural or agricultural context — more often than not focusing on engineering art works such as trenches, tunnels, bridges, viaducts — can be read as illustrations of Marx's 'metaphor of contradiction', much like the above views of industries within pristine natural contexts [**Map 5**]. Railway construction images, documenting the freshly-cut earth or still scaffolded bridges, spectacular viaducts, light at the end of a tunnel, or mysterious tunnel entrances, but also mediaeval monuments or remarkable natural spots as viewed from the train, were created, published, and collected as symbols of progress and taming of nature by civilisation.

The 'machine in the garden' sub-galleries bring up the following three themes of inquiry:

1. Diachronic place survey: highlights permanence and change about the depicted railway structures and around the spot; these range from replacements and modernisation, trajectory changes, to closure and dismantling of industrial lines, but also to 'heritagisation' and 'touristification' of narrow-gauge forestry lines.
2. Type declinations: surveys similar engineering artworks or similar places in contemporary views.
3. Along the line: documents and characterises, possibly together with written travel accounts, landscapes of the same railway line according to landscape character sequences; highlights landscape change at the level of sequences, both as the railway was constructed and in time.

Conclusion

'As Wittgenstein argued for words, that the meaning is the use — so for each photograph', notes Susan Sontag in her famous critique of photography (Sontag 2005: 82-83). Clearly, the ambivalence of photography between the act of recording a disappearing reality and the implicit sanctioning of the processes which cause

that very disappearing, remains open: '[f]rom the start, photographers not only set themselves the task of recording a disappearing world but were so employed by those hastening its disappearance' (Sontag 2005: 59). Warning that 'an image-world is replacing the real one', Sontag concludes with the need for an ecology of images if 'there can be a better way for the real world to include the one of images' (Sontag 2005: 120 and 141).

Could an ordering system, a digital memory theatre based on photography, make even a small contribution towards responsibly using and relevantly ordering the ever-growing clouds of past and present photographic imagery? This chapter suggests that an open-ended, dynamic relatedness between maps and photographs — centred each time on one photograph as *punctum,* the interest-catcher, then contextualised through *studium* using maps, as well as other pictures and data — can cross-fertilise the intertwined histories of landscape photography and railway landscape. It can provide a friendly yet structured approach that could benefit historic research, planning, teaching, but also public-awareness raising. Finally, exploring the multi-scale railway territories by dynamically relating the historic documents to models of the present-day environment occasions a more in-depth understanding of the railway's potential of generating, but also of *re*-generating the landscape.

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Maps

Introduction

The five graphics presented in this chapter illustrate a system of interconnected geo-located data that uses the photographic image as a portal towards beginning a multi-layered investigation of change in the railway landscape, or as a nexus around which diverse types of historic documents may revolve and confront each other. The database is structured into five main image galleries and several sub-galleries. Diverting Roland Barthes' twin notions — *studium* and *punctum* — we consider the topographic photograph or the topographic postcard as the eye-catcher, the *punctum* that touches us, stirs our interest and the subsequent *studium,* i.e. exploring landscape history by bringing in other sources (Barthes 1993: 25-42). The database is destined not only to present research results, but also as an instrument for on-going, collaborative research.

Diagrammatically, each of the five graphics is structured in four rows as follows:

G (main galley)

P (*punctum* image and its identity card)

sub-galleries		
D diachronic place survey	**T** type declinations	**L** along the line

IM (*studium* image map)

The proposed framework consists in five main image galleries (first row of each image), grouping railway photography according to five species. **G** [Map 1] G1: reception buildings viewed from the city side; [Map 2] G2: views of station yards; [Map 3] G3: tramways or railway lines in the street; [Map 4] G4: railways in industrial sites; [Map 5] G5: railways in the countryside. All images included in galleries are geo-located in Google Earth and can be accessed either as mapped images or by browsing one of the five thematic galleries. As an image is clicked on — the *punctum* image, **P** (second row) — the photo is displayed in full size, along with a set of attached data: (a) a small schematic map of the Transylvanian railway network showing the location and the geographic coordinates in WGS84; (b) the image 'identity card'; (c) three icons linking to three sub-galleries

related to the image under discussion. To each image of the five main galleries three sub-galleries correspond (third row): **D** diachronic place survey — changes of the same spot, in time; **T**: type declinations — similar space, elsewhere; **L**: along the line — same topic explored along the rest of the same railway line. As a sub-gallery icon is chosen, one is presented with an image-map collage of thematically related images, **IM** (lower group of images). By clicking any of the image map sectors, the corresponding document pops up enlarged: (i) if it is a text or table, it can be read and it may link to other related items; (ii) if it is a photograph, the same set of attached data as for the *punctum* image is displayed (see above); (iii) if it is a map or plan, one is directed to a calibrated map overlapped with the corresponding area in Google Earth.

Unless stated differently, all photographs are postcards from the collections of the Cluj County Library (BJC) or of the Cluj Central University Library (BCU).

Map 1: Cristina Purcar, *Reception Buildings Viewed from the City Side*. [From left to right: Brad c.1950, Braşov c.1900, Arad c.1910, Cluj c.1910, Oradea c.1910. **P**: Arad. The railway station. Reception building. Arch. Lajos Szantay. South-west façade. Undated antebellum postcard, after 1910. **D**: Arad before 1910. Arad c.1960. **T**: Timişoara; mapped locations of the other first class reception buildings of the early twentieth century in Transylvania. **L**: Alba Iulia reception building, endpoint of the railway from Arad, the First Transylvanian Railway line, open in 1868. Façade towards lines; façade towards the city. ACFR Timişoara. **IM**, upper row, left to right: Arad, first station; reception building, open 1858; south-west façade; north view. Arad, first station; reception building, open 1858; south-west façade; south view. lower row, left to right: Arad, cadastre map of the railway station insertion in the existing urban fabric in 1858. ACFR Timişoara. Arad, development of the urban structure after the railway advent: 1858; before WWI; interwar period; c.2000 (Purcar 2009b). City plan before WWI. Arad History Museum. Interwar and 1960s reception building views].

During the nineteenth and early twentieth centuries, railway stations were perceived as status symbols of their towns. Not only were they the main entrances thereto, but they also replicated, in a minor scale, the essential urban functions such as public service, commerce, industry, and housing. Synecdochically identifying the settlement with its foremost modernity asset, publishing images of a town's railway station in the form of postcards was a matter of pride, as late as the 1960s-70s, emphasis being placed as much on the square organisation as on the building itself.

The railway arrived in Arad from Budapest (via Szolnok) in 1858. Positioned obliquely at the crossroads that gave the town its commercial and strategic importance, the station plot was inserted with an eye on the line's subsequent eastward prolongation. The railway station was situated remotely from the town's increasingly dense historic core, on the other side of the water canal, being therefore more part of the rural realm than part of the town proper. However, its siting at a major country road crossing turned this marginal station into the symbolic and visual northern entrance to the city. The railway line started being incorporated into the urban fabric by the end of the nineteenth century, where the so-called 'new quarter' developed by filling the empty area left between station and town; as the station was a terminus between 1858 and 1868, the new quarter could easily expand beyond the tracks as well. During the twentieth century, Arad grew constantly, mainly due to its intensive industrialisation. Industrial and (railway) worker residential areas developed — always depending on each other — on both sides of the tracks, during both the interwar and socialist periods. The replacement of the original reception building by a much larger one in brick at the turn of the twentieth century is symptomatic of this development. The apparent-brick Neo-Renaissance-style edifice celebrates industrialisation as progress, a contemporary Renaissance, replacing the Gothic-Romanticist-style initial building. During the 1960s-1970s, increased density and some commercial functions were introduced by the insertion of middle and high rise apartment blocks, in the attempt to produce a public space with more centre-like qualities. Captured by each succeeding period postcards, the station square atmosphere is rendered such as to suggest dynamism and prosperity, with the reception building always assuming the lion's share therein. Indeed, the other fronts of the square are almost never looked at. Landscape, as constructed collective image of the environment, is thus defined selectively, highlighting some parts while eluding others.

Map 1: Reception Buildings Viewed from the City Side.

Map 2: Cristina Purcar, *Tracks inside Stations: the Railway Yards*. [From left to right: Cluj before WWI. Tușnad interwar. Petroșani c1920s. Oradea before WWI. Brașov interwar. **P**: Petroșani. The railway station. South view. Undated interwar postcard. BCU Cluj. **D**: Petroșani, station square, view from east. c1960s. **T**: Kassa, in Hungary. **L**: Arad before 1910; Arad before WWI. **IM**, *upper row, left to right*: trajectory and end stations of the First Transylvanian Railway (FTR) — trunk line Arad—Alba Iulia, branch line Simeria—Petroșani. Mapped station class hierarchy. *Lower row, left to right*: cadastre plans of station classes along the FTR. ACFR Timișoara and OJC Cluj. Postcard images of main FTR stations: Arad, Simeria, Alba Iulia, Petroșani. Schematic façades of the FTR station facilities: water reservoirs with housing annexes, goods warehouses with housing, reception buildings].

Inner views of station yards are another widespread species of early railway photography: often commissioned by the railway companies to document the extension and endowment of stations, they can also be the subjects of postcards. The view is usually biased towards the reception building and waiting platforms, often a steaming locomotive or train carriages as eye-catchers. Also, an all-embracing, higher viewpoint is often employed, in order to facilitate the descriptive, inventorying mood of these images.

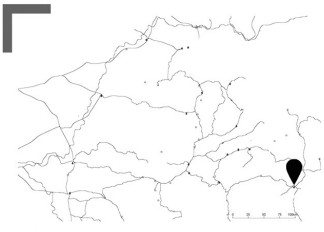
Buildings and installations required by the railway ensemble were generally conceived according to type projects. Given that type projects were employed for the most representative edifices — the reception buildings — they would naturally be employed for the technical premises as well. If 'objective' representations, such as the cadastral plans, reflect these types of projects indiscriminately, the interior landscape of railway yards is only captured selectively by photography. From the five-class station hierarchy along the First Transylvanian Railway, only the first two classes, end-point stations and junction-point stations (red and magenta dots respectively on IM map) can be documented through historic postcards or military photography. When the small halt of Cetatea Bolii is exceptionally photographed (Map 5, IM, left column, middle), rather than highlighting the railway built structures proper, as the other images of this 'family' do, this is due to the spot's rocky character and the desire to show the victory-over-nature of the railway construction endeavour that literally had to cut through mountains. In Map 2, the *punctum* image shows the railway station in Petroșani shortly after WW1, with the turntable and locomotive sheds in the right foreground and with the water reservoir and administrative buildings on the left. Far left, the reception building and its canopy can also be glimpsed. Such wide-angle views encompass the railway station's yard in its entire span, proudly attempting to capture the assets of the railway, especially in a town that actually owed its rapid growth to the railway advent in 1870 and the consequent boom of coal mining in the area.

Map 2: Tracks inside Stations: the Railway Yards.

Map 3: Cristina Purcar, *Street Lines: Historic Tramways*. [From left to right: Cluj, main square. Sibiu, Gen. Magheru str. Brașov, Lungă str. Oradea, main square. Timișoara. **P**: Brașov. Lungă str. Undated postcard, BCU Cluj. **D**: Brașov, Lungă str. City plan c.1915. Brașov, Lungă str. Undated, interwar postcard. **T**: Sibiu, city centre tramway views. **L**: Brașov, tram station 'Promenade', undated postcard, before WWI. Brașov, tramline in the main square, interwar photo. **IM** Map: Brașov. magenta line: trunk railway lines, northwards to Cluj (open 1873), southwards to Predeal and Bucharest (open 1879). yellow: vicinal lines. red: tramline, open in 1892, at its longest, before 1922. black: 1960s rearrangements of the trunk lines and marshalling yard. Photos: view of the Brașov tram hotspots, before WW1. 1: Bartolomeu church and railway station. 2: Panoramic view from north with the Customs Gate of Brașov fortified area, before 1892. 3: Panoramic view from north, after the Customs Gate demolition, to make room for traffic, especially the steam tram. 4: north front of the central square, with the turning point of the steam tram. 5: the tram station 'Promenade' opposite the financial palace, the present town hall. 6: Noua suburb, highlighting the tramline. 7: reception building of the tram station in Noua suburb, open in 1907. 8: tram in the village Dârste. 9: aerial view of Dârste village with industries and industrial railway branch highlighted].

Around 1900, in parallel with the development of the main railway network, local railway lines, tramways, were open in the more important Transylvanian towns, in order to connect the centre with the industrialising suburbs and with the rapidly expanding residential areas, often former villages included during the same period within the municipal boundaries of the mother-town. Despite the fact that in some tramline shots the tram and/or the line do not always seem to be the main protagonists, it is the tramline streets, rather than other streets, which tend to be depicted more frequently – these were the town's hotlines just as the tram stops were its hotspots.

In Brașov, a major south-eastern Transylvanian city, the tramline [Map 3, red line on the aerial photo] was open in 1892. At its longest before 1922, it connected the northern suburb, the former village of Bartolomeu with the town's centre and the southern suburb Săcele. Mapping the historic postcard locations on the tramway's route, several focal areas are highlighted. In Bartolomeu, the vicinal railway station (yellow line), also the tramway's starting point, is captured behind the mediaeval church, the actual emblem of the place (1). Views of the Long Street (*Strada Lungă,* 2), connecting the Bartolomeu suburb to Brasov's historic core, display a pericentral streetscape, with fronts of uneven height and façades alternating then fashionable neo-classicist and eclectic façades, with the rural-type houses characteristic of the Transylvanian rural baroque of the seventeenth and eighteenth centuries (far on the right front). The image is typical for the late-nineteenth century growth phase, when the town flourished thanks to industry and trade, the pericentral urban fabric undergoing densification (continuous street fronts and added floors) and 'embellishment' according to the time's taste. A much-photographed spot was the Customs Gate north of the historic core (3-3) where the early nineteenth century neo-classical gate, having replaced the mediaeval one, was demolished at the advent of the tramway in order to prevent it from hindering the traffic flow.



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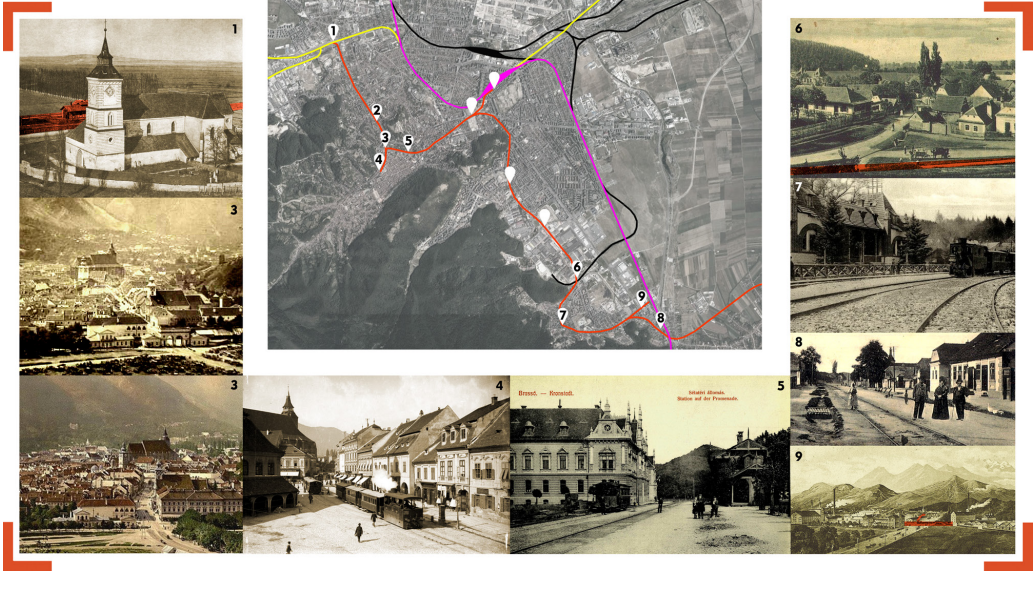
BRASOV (Brasso, Kronstadt).
Tramway in Strada Lungă (Ulita Lunga, Langegasse, Hosszu-utca).
Undated BW postcard, 9,5x14,5 cm.
BCU Cluj. Digital Library. Available online: http://dspace.bcucluj.ro/handle/123456789/40448, 22.10.2017.



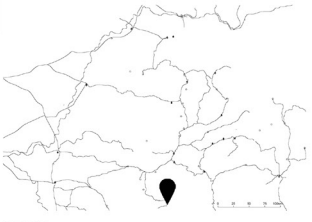
Map 3: Street Lines: Historic Tramways.

At the very heart of the city views of the tramway's stop in the city-hall square (4) show the loop allowing for the steam locomotive to return. The importance of the tram for the *Belle Époque* city is also denoted by the frequent postcard depictions of the Promenade station with its café terrace aligning with the public garden (5). Tellingly, although the Financial Palace, contemporary with the tramline, always plays an important role in images of this area (5, left) the postcard is not named after it, but rather after the tramline's station. Further southward 'along the line', the rural city outskirts (6, 8) are captured as traversed by the tramline heading to the industrial developments of Dârste (9). Facilitated by the tramline, the improved integration between town and suburbs led to the development of new quarters, such as *Noua* (The New One), with its Secession style tram station (7), frequently illustrated in postcards as a status symbol.

Map 4: Cristina Purcar, *Tracks, Mineshafts, Furnaces: Railways in Industrial Sites*. [From left to right: Hunedoara steel work before WWI. Petroșani electric plant and coal sorting station before WWI. Petroșani coal sorting station before the Găvojdia blast furnace, c.1890. Turda cellulose factory before WWI. **P**: Petroșani coal mines sorting station. Interwar postcard. **D**: Petroșani, lower miner-housing colony. Petroșani coal sorting station. Interwar postcards. **T**: Petroșani panoramic view and lower miner colony, interwar postcards. **L**: Hunedoara steel works and castle. **IM**: Petroșani. 6. View of the lower colony from the west. 1. Railway station with reception building seen from south-east. 7. Interwar housing colony, east of the railway line. Maps: *left*: Petroșani, urban growth schemes. *up*: c.1900; down: c.2000. *right*: Petroșani urban pattern before WWII (Purcar 2009b)].

A consistent corpus of late nineteenth-century railway photography consists of views of industrial sites, wherein tracks are always included. These were intended to document the assets of state and private companies as a matter of pride and as a token of the state's or company's modernity and prosperity. Cultivating monumentality and orderliness, the images would also have acted as incentives for shareholders' trust and investment. The powerful, dynamic compositions, foregrounding the neat verticals, horizontals, and diagonals of the industrial buildings and installations are often seconded by the softly blurred, undulating lines of the natural surroundings.

'Appeared as out of magic', as the famous French geographer Élisée Reclus noted after his visit in 1873 (Reclus 1876: 368), Petroșani developed rapidly from a hitherto remote and unknown archaic region of south-west Transylvania into a vivid industrial town, due the advent of railways and the coal-mining boom. From a hamlet of isolated shepherd households scattered on the hills, the mining town formed itself along the Jiu Valley, on both sides of the railway line and station. The latter was not only the catalyst of that urbanisation process, but also, literally, the centre of the emerging urban fabric, its structuring north-south spine. [Map4, IM] In Petroșani, the main coal mining society and worker-housing landlord was also a major shareholder in the society which concessioned the construction of the First Transylvanian Railway Simeria-Petroșani branch.



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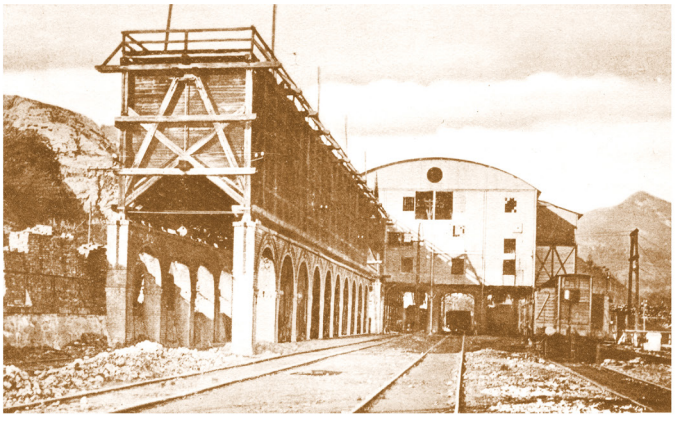
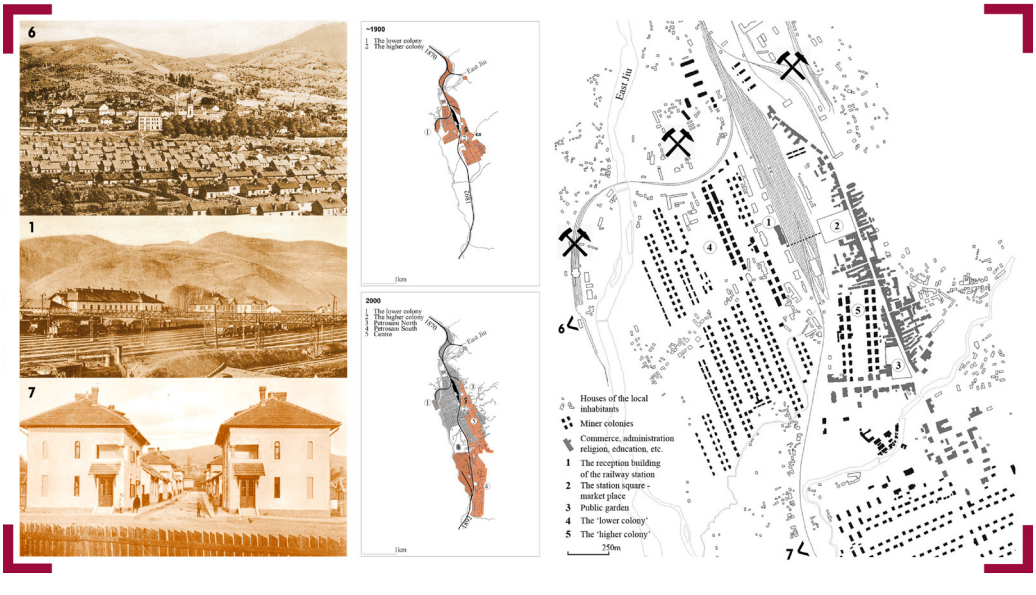


PETROSANI
The state mines sorting station.
Undated interwar postcard. BCU Cluj.



Map 4: Tracks, Mineshafts, Furnaces: Railways in Industrial Sites.

This led to the particular situation that the more representative part of the town developed east of the railway station, where land was available for smaller public and private investment, since the west side was already occupied by the first miner colony and station buildings. Atypically thus, the station's reception building is segregated from what became the town centre by the wide railway trench of the station, the only link being a footbridge (1). While the diachronic place survey (IM) shows the development of this peculiar urban structure cartographically, historic photography captures its landscape through three characteristic types of images: industries, always integrating the railway lines (P); the colonies with their uniform grid patterns (6 – foreground: nineteenth-century miner colony, 7 – Interwar clerk colony); public spaces and representative buildings such as churches, schools, and hospitals (6 – background). As in the previous case studies, landscape construction via photography proves a highly selective operation: while the railway is only present in views of industrial premises and of the station itself, to make the colonies appear more friendly as domestic places, the railway is usually omitted from the image frame, even if, in order to capture the view, the photographer needs to stand among the tracks (7 – the wooden fence delineates the railway plot).

Map 5: Cristina Purcar, *"The Machine in the Garden": Railways in the Countryside*. [From left to right: Stana, Oradea-Cluj railway line, earthworks. Photo by Ferenc Veress, c.1870s (Köpeczi 2001). Brănișca railway bridge near Deva, undated postcard before WWI. Oravița railway viaduct. Interwar postcard. Tunnel on the Oravița-Anina railway line. Interwar postcard. **P**: Railway bridge over the river Mureș on the First Transylvanian Railway (FTR) trunk line, opened in 1868. South view. Undated postcard, before WWI. **D**: Bridge over river Mureș on the FTR (Köpeczi 2001). **T**: Unidentified place. Arad. Bridge over river Mureș. Undated postcard, 1970s. **L**: Lipova. Panoramic view of the FTR along river Mureș. Undated photo. **IM**: photos, up to down: Petroșani, locomotive shed at the northern end of the town. Interwar card. Cetatea Bolii, on the FTR branch line, Simeria-Petroșani. Hand-coloured postcard, before WWI. Centre and below right: front-page and images from French geographer Élisée Reclus' *Récit de voyage to Transylvania's mining regions* (Reclus 1874); all drawings illustrating Reclus' text were made after the original photos of Ferenc Veress].

In *The Machine in the Garden* (…), noticing the long-lasting vitality of the pastoral myth in the American culture, in spite of, or perhaps just because of the force of industrialisation, Leo Marx explains this by the fact that 'the pastoral ideal has been incorporated in a powerful metaphor of contradiction' through its encounter with the 'counterforce' represented by industrialisation (Marx 1979; Purcar 2009a). A large family of railway photography, consisting of track (and train) views within a natural or agricultural context — more often than not focusing on engineering art works such as trenches, tunnels, bridges, viaducts — can be read as illustrations of Marx's 'metaphor of contradiction'. Railway construction images, but also monuments or other remarkable sites viewed from the train were created, published, and collected as symbols of progress and of civilisation's taming of nature.

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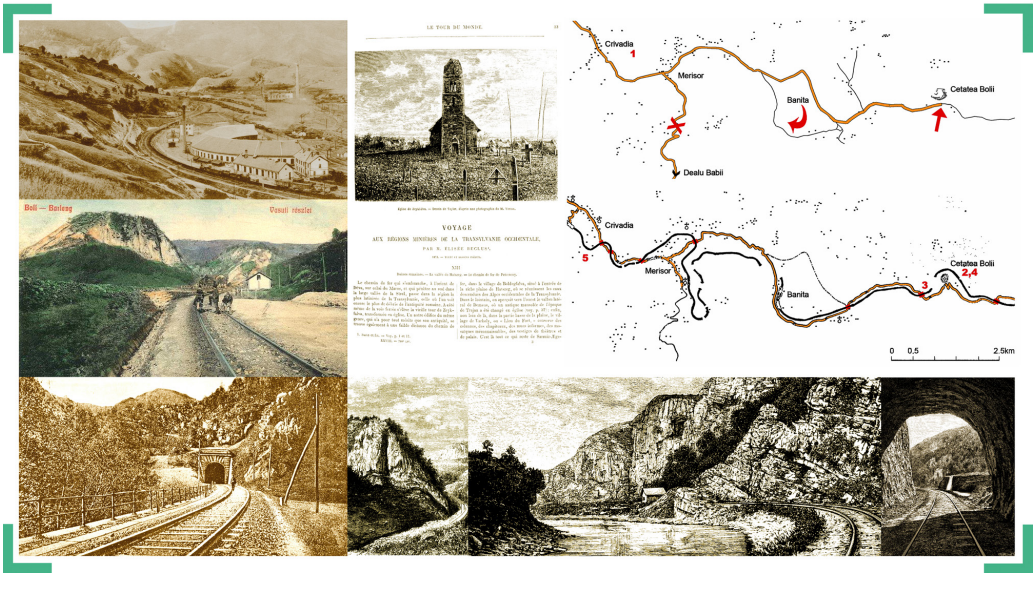
BRANISCA
Railway bridge over the river Mures on the First Transylvanian Railway trunk line Arad – Alba Iulia (1868). South view. Undated postcard, before WWI.



Map 5: "The Machine in the Garden": Railways in the Countryside.

Through the countryside, the most remarkable views perceived by travellers along the railway route almost always include powerful images of the railway itself as well. The railway itinerary establishes new spatial relationships with and between the pre-existing 'visual events' of the route, offering new vantage points and introducing new boundaries within the natural terrain. At the same time, the geomorphology of the traversed places together with the track route configuration (determined by the railway design rationale, based on efficiency and economy), combine to create a series of different landscape character sequences, an unintentional landscape design project. As self-coherent territorial-scale architecture, the railway project engendered simultaneously, albeit not purposefully, a coherent *mise-en-scène* of the traversed places, relating similarly to places of similar landscape character: speeding up along strait-cut stretches as a largo appeared; slowing down along sinuous sections as the river valley narrowed and the terrain became steeper; emphasising exceptional natural spots by exceptional railway landmarks such as cuttings, tunnels, viaducts, or bridges. Along the First Transylvanian Railway (FTR) trunk and branch lines [Map 5], several such examples of remarkable landscape-generating encounters between railway features and the traversed places can be highlighted: the spectacular tunnel and trench at the Cetatea Bolii cliff near the homonymous picturesque cave (IM, left column, middle and below); the Strei church, one of the oldest stone churches in Transylvania, that became a landmark of the railway journey along the FTR branch line because, unlike the country road, the railway passed very close to it (IM, upper row); the shifting of the main road to Petroșani in favour of a route doubling the railway and the spectacular sinuosity of the route between Crivadia and Cetatea Bolii (IM, maps) described by French geographer Élisée Reclus in his travel account (IM, center) as 'an alpine railroad with numerous and magnificent works of art' [*un chemin de fer alpin, aux nombreux et magnifiques travaux d'art*] whereby a new landscape appears at each following curve' [*à chacune des courbes qui se succèdent se présente un paysage nouveau*] (Reclus 1874).

Part two
FOCUS

7.
Mapping Archaeological Landscapes in Transformation
A Chaîne-Opératoire Approach

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Ralf Vandam (University of Leuven)
Frank Vermeulen (Ghent University)

Inevitably, archaeology has had something to do with landscapes, ever since the early days of the discipline. In every stage of its development, encompassing or smallish, this relationship has been (de/re-)constructed and (pre/re/post-) conceived. Since the 1990s, the idea of landscape has once again become prominent in archaeology, serving often as an interface between the physical and the conceptual, the spatial and the social, the real and the image, the natural and the cultural (David and Thomas 2016). Archaeological landscapes, however, have served less as an interactive field between these sets of concepts — that typically oppose one another in modernist thinking — functioning more as a common boundary between them. Specifically, remote sensing, photogrammetry, surveying, cartography, and GIS-based methods (mainly cost-distance and visibility analysis) have broadly constituted the empirical and positivist approach to archaeological landscapes, concentrating on the natural and physical aspects (Bevan and Conolly 2004; Hritz 2014; Sevara et al. 2017). Others introduced interpretive and phenomenological approaches as part of which the focus is very much on human agency and cognition, and symbolic meanings ascribed to the landscape (Edmonds 1999; Tilley 1994, Tilley 2004, Tilley 2008). In the 1990s and early 2000s, the limited interaction between these two domains has often been in the form of heated discussions regarding what constitutes the best way to study

archaeological landscapes (Barrett and Ko 2009; Brück 2005; Fleming 2006). Within the last decade, however, many landscape studies in archaeology have aimed at mediating the relationship between these qualitative and quantitative realms (Fitzjohn 2007; Gillings 2015; Llobera 2012; Graves McEwan and Millican 2012).

Mainly due to this intermediate position, not only in archaeology but also in other fields (Bender 2006; Morin 2009), the attribution of meaning to the 'landscape' concept has often been put aside as complex and ambiguous. In recent, post-representational studies, the dualistic approaches to landscapes (and hence their intermediate position between the above-mentioned realms) are often fruitfully critiqued and the term is taken to encompass both sides. In the case of the separation between representation and referent, Robert Layton and Peter J. Ucko (1999: 1) define landscape as referring 'both to an environment, generally one shaped by human action, and to a representation … which signifies the meanings attributed to such a setting' (Layton and Ucko 1999: 1; see also: Cosgrove 1984; Daniels and Cosgrove 1988; Dubow 2009). Similarly, the geographer Veronica della Dora states that the referent and representation in landscape studies are to be taken as 'laminated together, just like the windowpane and the landscape in the famous Magritte paintings' (della Dora 2009: 335; see also Olwig 2005). Notably, the approach to landscapes in such post-representational lines of thought comes very close to Jean Baudrillard's influential ideas on reality in which the difference between a referent and its ubiquitous representations disappears in simulation in favour of a hyperreal (Baudrillard 1981).

This complex understanding of landscape, as simultaneously and intricately constituted by what is traditionally referred to as physical and social space or the reality and the image, no doubt renders the study of landscape cartography a crucial part of landscape studies. Yet, even though the 'physical' and 'social' landscapes are major study areas in archaeology, landscape maps and the practices of mapping landscapes have received relatively limited attention (see, however, Gillings et al. 2019). While landscape cartography and GIS have been a substantial topic of concern in phenomenological archaeology, the approach in that context has been predominantly rejectionist where maps and GIS have been considered as inherently modernist media objectifying the landscape (e.g. Thomas 2001: 169; Tilley 2004: 218).

Fig. 1. Aerial view on the flat coastline near Porto Recanati (Marche, Italy) with the limestone massif of the Monte Conero in the distance. The remains of the Roman town site of *Potentia* lie buried under the fields in the forefront, just behind the coastal strip (photo Frank Vermeulen, 2006).

In the rest of this chapter our aim is to approach landscape cartography in archaeology in a new light shaped by the concept of *chaîne opératoire*. The approach is used mainly in practice-based studies of materials within archaeology and anthropology, as we explain in the next section. Through *chaîne opératoire*, technical processes, or performances of making and using 'things' are conceptualised as being shaped by cognitive and pre-cognitive (i.e. pre-conscious), culturally marked choices. As such, the *chaîne opératoire* approach suits the recent ambitions of critical cartography which aims to move its concerns from the 'map object' to the mapping processes (Perkins 2009), and move beyond an unfruitful fragmentation of such processes into modernist oppositions (Del Casino and Hannah 2006).

Subsequent to the introduction of the *chaîne opératoire* concept, choices about cartographic tools and map content and use are presented below in the case of two archaeological projects, namely the Potenza Valley Survey (PVS) and the Sagalassos Archaeological Research Project (SARP). The PVS studies human occupation and changing complexity between the early first millennium before

Fig. 2. View on the area of the Upper Agora at the archaeological site of Sagalassos, South-west Turkey (Photo credits to Bruno Vandermeulen and Danny Veys).

our era and the end of Antiquity in the valley of the river Potenza (Marche region, central Adriatic Italy) (Fig. 1). SARP focuses on the nature and logic of change in the long-term social-ecological development of the study region surrounding and including the archaeological site of Sagalassos (South-west Turkey), between Middle Palaeolithic times and yesteryear (Fig. 2).

The concept of *chaîne opératoire*

Chaîne opératoire is a type of anthropological sequence model which is practice-based and presents technical processes as a web of embodied actions (see Schlanger 2005 for an overview). It serves to move 'typological concerns from objects to processes' and, like other sequence models — Marcel Mauss' *enchaînements organiques* — it presents 'a way of relating formally diverse materials to a single process' (Bleed 2001: 117). Studies based on *chaîne opératoire* take as their starting point the insight that 'observing someone digging a hole, or carving a sculpture, is fundamentally different from analysing the digging-stick, the hole, its width and depth' (Coupaye 2009: 438).

In simple terms, *chaîne opératoire* refers to a framework of considering all processes leading to the creation of an 'opus' as well as leading from that 'thing'. The processes as well as the 'things' result from human beings (individuals and/or groups) making choices. These choices are actually the most central element to document in *chaîne opératoire*, rather than the processes (functions of choices) or 'things' (results from choice), as the choices are mostly meaningful (Caple 2006). The meaningfulness does not always need to represent High Culture, but can also be operational/mechanistic in nature, especially when making the 'thing'. But all of the choices, no matter at which level, are cognitive, socially and culturally marked — resulting in commodities, no longer 'things' — and therefore represent past human behaviour. As a result, the consideration of *chaîne opératoire* is not limited to the choices made in creating commodities, but also related to their use and discard. Objects forming part of household contexts will be constituted, function, and valued in different ways compared to commodities sustaining public or ritual functions. Even if votives are to be set aside in sanctuaries, for instance, this can never result in discard as the commodities need to stay in possession of the deity within the area of the sacred precinct. In this way, a *chaîne opératoire*-type of insights can also help in understanding the formation processes of the archaeological record and, as a matter of fact, the transformations of archaeological landscapes and their mapping.

Chaîne opératoire and cartographic choices in the PVS and SARP

Crafting maps in archaeological projects are often long *chaînes opératoires* that involve various actions interlinked with one another. These *chaînes opératoires* can also be drastically different from each other, depending on the choices made regarding the cartographic tools and what needs to be mapped. For instance, producing hand-drawn paper maps of a Neolithic house will involve a whole set of knowledges and cartographic skills different from the three-dimensional laser scanning of a Roman theatre. Specifically, while the first will involve taking measurements with tape measures in great precision (up to a centimetre) and sketching on paper, the second requires a command of where best to place 'target points' while dealing with large structures, and how to operate the terrestrial laser scanner and process the collected point cloud. Given this key role of the choices on cartographic tools and content in shaping the *chaîne opératoire* of archaeological mapping, we turn to these sets of choices in the Potenza Valley Survey (PVS) and the Sagalassos Archaeological Research Project (SARP) in the rest of the chapter.

Choices of cartographic tools

Making archaeological maps today is almost exclusively a digital and, in most cases, a geographical information systems (GIS)-based endeavour. This persistent choice for digital tools in archaeological landscape mapping is largely shaped by a 'disciplinary agency' (Pickering 1995: 115), which constitutes a force to consider GIS-based practices to be indispensable in integrating large quantities of geospatial information and generating related knowledge of past human activity. The cases of the PVS and SARP present no exceptions, with GIS technology being used extensively to map archaeological features. What made GIS a favourable choice in both projects has also been the know-how, soft- and hardware available at the time of the respective map-making endeavours, even though not necessarily available in the initial phases of the projects.

Despite its ubiquity, though, GIS is no ordinary tool for archaeological mapping. The technology in the archaeological study of landscapes very often plays the role of connecting abstract theories about past human behaviour with observed archaeological phenomena (often referred to as 'archaeological record': Barrett 2001; Patrik 1985). Here, the archaeological record serves as an empirical proxy for past human behaviour while it is considered to have altered over time through 'site formation processes' (Schiffer 1987). Within this epistemological framework, where the past is represented by archaeological finds, GIS allows 'users to formulate models, or representations, of potential past experiences, attitudes, behaviours, processes, and patterns' which is considered by archaeological practitioners as heuristically useful (Brouwer Burg 2017: 116).

Map 1 is a GIS-map of the archaeological site of Sagalassos that forms an example of such a heuristically useful representation that incorporates the (past) humanscape with the (present) natural landscape. One of the aims in producing the map is to bridge the gap between archaeological hypotheses on ancient Sagalassos and empirical information collected at the site in recent decades. The map comprises architectural drawings overlaid on a digital elevation model. The elevation information used to create the digital model was collected mostly with total and global positioning systems during fieldwork, while gaps in the elevation dataset were filled using the freely available global digital elevation model GTOPO30; information on architectural remains were recorded by architects. **Map 2** is another example that similarly brings the past and present together, this time in the environs of Sagalassos, namely at the archaeological site of Düzen Tepe located at less than two kilometres to the south-west of Sagalassos (Vanhaverbeke et al. 2010). This map is created with GIS using information collected from satellite imagery,

intensive archaeological and topographical surveying, existing topographical maps, and geophysical research.

A similar GIS-based mapping practice bridging the past and present is presented in **Map 3** of the Roman colonial town of Potentia, located ca. 1 kilometre south of the present-day mouth of the river Potenza. Specifically, while historical sources and small-scale excavations since the second half of the twentieth century provided first insights into the general development of this ancient settlement, very little was known of the site's internal structure and its relation to the wider landscape context. Oblique aerial, vertical aerial, and satellite imagery revealed crop and soil marks of the town's street network, walls, and buildings. In combination with legacy data and field walking results, the remote sensing data provided diachronic density maps of archaeological materials, which allowed a more detailed appreciation of the site's general chronological development, functional zoning, and spatial evolution between the early second century BCE and the later sixth-seventh centuries CE (Vermeulen et al. 2006). While this approach revealed archaeological traces for most of the urban and suburban areas, the western and southern parts of the town and its immediate hinterland were lacking archaeological indications. **Map 3** presents the efforts to fill these gaps in the archaeological narrative of Potentia and connects the town with its wider environment through geoarchaeological (mapping of the microtopography, geomorphological augering, electrical resistivity profiling) and remote sensing (active, oblique aerial photography, geophysical surveying) applications.

Choices of content and use

Mapping is both an epistemological and ontological process in the sense that 'it is both a way of thinking about the world, offering a framework for knowledge, and a set of assertions about the world itself' (Kitchin et al. 2009: 1). Perhaps this is more the case for Western scientific cartography — in comparison to indigenous and other non-Western mapping traditions — which is the predominant cartographic tradition in today's landscape archaeology. This is because in Western scientific cartography, maps typically serve as authoritative tools preoccupied with objective and accurate mimesis of the mapped places (Turnbull 1996). If archaeological landscape maps are in fact taken as mirroring the landscapes unproblematically, the choices about their content become all the more important. As unproblematic copies of the landscapes, they constitute strong arguments, or at least powerful statements, about mapped archaeological landscapes rather than being mere descriptions of them (Corner 1999; Wood 2010).

This is exactly the case for the maps in **Map 4** presenting mainly the settlement history of the Potenza river valley. The maps, showing results of a complex methodological workflow, are not merely a mirror of the Potenza river valley but essentially an epistemological and ontological statement that defines the changing settlement patterns through time as a crucial aspect of the valley. Specifically, **Map 4a** shows the three sample zones of the PVS Project together with annotated main modern town locations. These sample zones are a product of multi-scalar landscape research in the project where the field methodologies (landscape-based, artefact-based, and remote sensing-based) are applied on scales ranging from the wider regional scale to the level of these three sample zones along the ca. 80 kilometre-long course of the river Potenza (roughly coinciding with the upper, middle, and lower sections of the valley) and to the scale of the individual site. The maps in **Map 4b-f** represent transforming settlement patterns from the Iron Age into Late Antiquity. The complex methodology that led to these five maps involves archaeological line walking and associated surface artefact analysis. Limitations of this surface record are dealt with by geoarchaeological and remote sensing case studies focusing on the preservation and detection potential of the archaeological record (e.g., erosion and sedimentation), landscape exploitation, landscape dynamics, and human-landscape relation of the detected human occupation sites (Taelman et al. 2017; Vermeulen et al. 2017). Recurrent site visits with higher resolution artefact collections, intensive active aerial and geophysical prospections, and targeted excavations are among the most important strategies employed to deal with traditional biases and the restricted view imposed by selection and sampling in the Potenza Valley. The results of the intensive fieldwork allow us better to understand the surface records and to re-evaluate the general landscape and settlement history of the region (Taelman et al. 2017; Van Limbergen et al. 2017), and visualising these results on maps which prescribe the Potenza river valley as an arena for transforming human settlement patterns.

Map 5 is yet another representation of transformation of the Potenza river valley: a representation of the changing environmental conditions of the southern suburban area of the lost town of *Potentia* and the ancient bed of the river Potenza. The composite image with many cartographic elements is created using aerial photography and LiDAR imagery. Inset 1 shows crop marks of the ancient river Potenza demonstrating an abandoned deltaic river channel with bifurcating channels. Topographic correlation of the ancient riverbeds indicates a gradual southward migration of the active delta channels. Inset 2 shows the location of the Roman bridge of *Casa dell'Arco*, the preserved arches of the Roman bridge in the walls of the eighteenth-century farm, the soil profile with a typical fluvial upward

fining and the corresponding radiocarbon dates. Similar to the case of settlement patterns, the contents of this map are part of an ontological project that involves defining Potenza Valley's past, this time in terms of changing environmental conditions.

Importantly, choices about map content will not only put forward arguments about the mapped places but also will have consequences for the use context. That is, users place maps in a new set of relations and make it part of a novel set of practices which bring in new cartographic tensions and opportunities. This has been the case for the old site plan of Sagalassos crafted in the 1990s [**Map 6**] by cartographers who paid most attention to the *hic et nunc* of how the site presented itself, for orientation and reference purposes (Van Rompaey and Depuydt 1997). Of extant archaeological remains, such as the Theatre, only the contours were included in the map, but not the details of the still visible architectural parts of the buildings. Here, the cartographers aimed at considering the ruin as part of the topography and landscape, rather than of a once-upon-a-time town. In the same way, the excavated remains were not mapped in detail, with the natural topography dominating the visual aspect of the resulting map. Deemed an adequate cartographic representation of Sagalassos by the cartographers themselves, this map faced tensions when archaeologists who wanted to use it for publications needed more architectural detail. In other words, when the map was placed in a new set of relations by archaeologists and their user choices, the need for a more detailed version became obvious. As a result, of the unpublished, original 1:500 map with contour intervals of 1 metre, a detailed version at 1:2000 was derived for publication purposes, including a higher degree of interpretation of the 'archaeological' urban fabric. This new map constitutes yet another powerful statement about the mapped place, rendering the architectural remains at Sagalassos more of a fundamental characteristic of the site in comparison to the original 1:500 map.

Conclusion

The *chaîne opératoire* approach can serve as a way to study landscape mappings in terms of the choices that shape them. Concentrating on pre-cognitive, culturally marked cartographic choices that form archaeological landscape mapping is one way of coming to terms with the fact that maps are performative. Performativity in this context refers to the idea that there is no pre-given territory that serves as a reference for the map. Instead maps and mapped places are repetitively created through cartographic choices and associated practices (Hacıgüzeller 2017).

The *chaîne opératoire* approach then is a way of addressing archaeological landscapes as social constructs. It is a way to emphasise that we both make our worlds and live in them. From this point of view, archaeological landscape studies do not need to focus on physical landscape or social landscape conceptualised as separate. In fact, archaeological landscape cartography from a *chaîne opératoire* approach makes it bluntly clear that there is no sense in using such modernist distinctions since the cartographic choices we come to discuss through the *chaîne opératoire* approach clearly rely on a complex set of relations that defy these distinctions.

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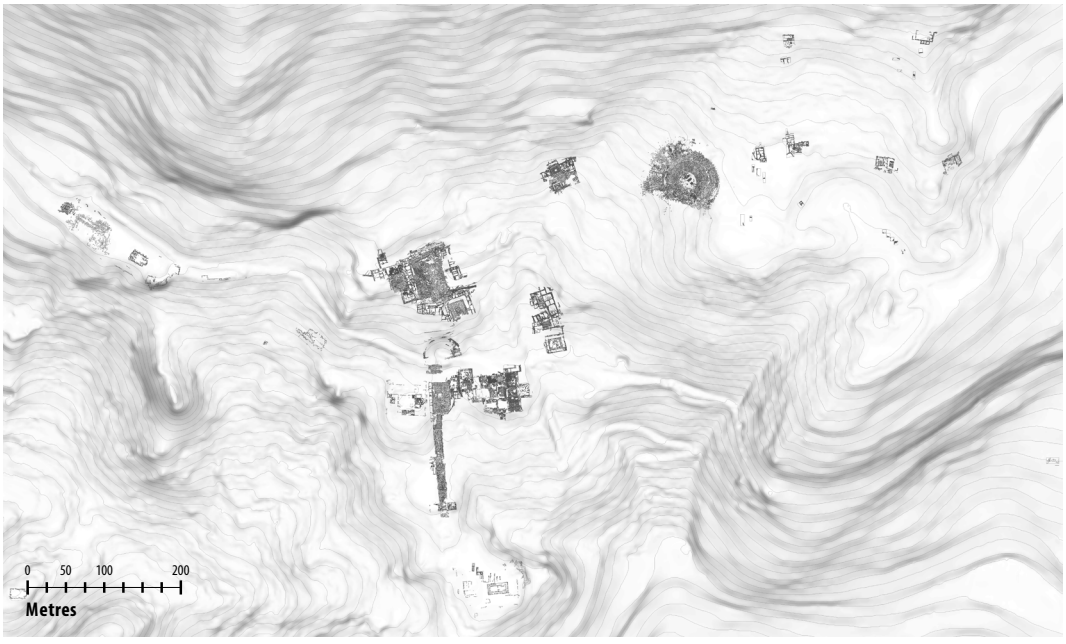
Maps

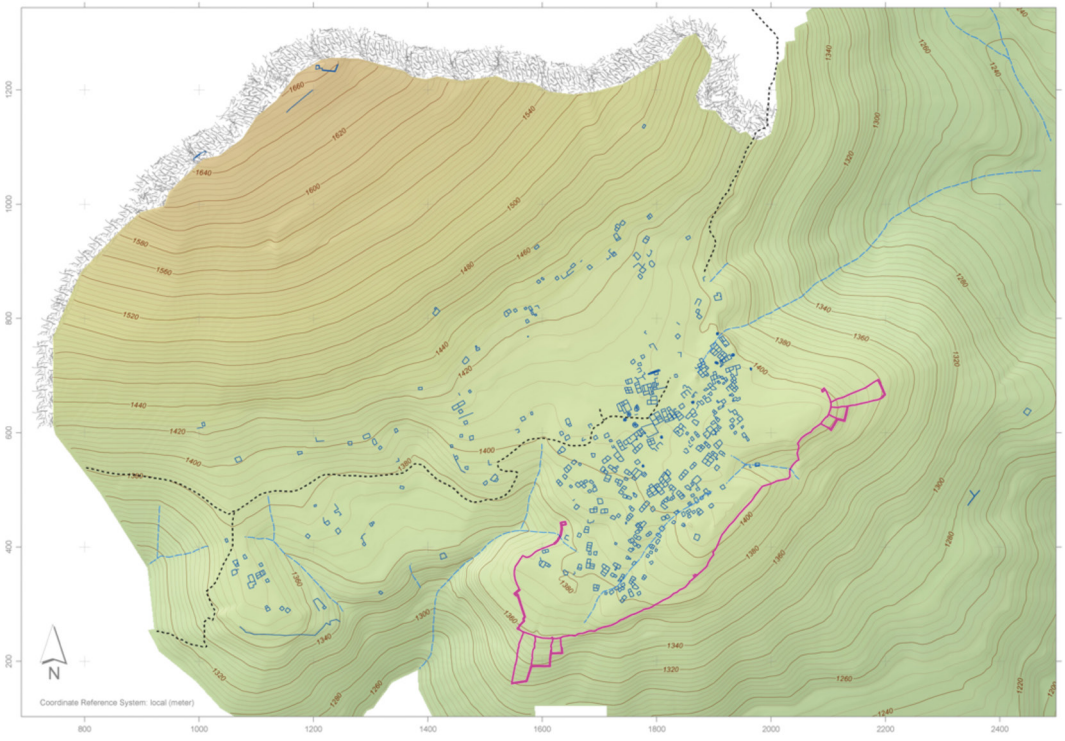
Introduction

Long-running projects such as the Potenza Valley Survey (PVS) and the Sagalassos Archaeological Research Project (SARP) typically evolve in research questions, but also in the technologies applied in the various steps of the research, including the management, analysis, and representation of spatio-temporal data. In the initial years of the PVS, map-making was based on a GIS approach that combined ESRI's ArcView 3.x (later replaced by various versions of the ArcGIS suite) and Microsoft Access. The maps presented here are a product of this particular set of tools. Currently, the PVS spatial data are being migrated to an open-source and cross-platform data infrastructure based mainly on PostgreSQL, R (The R Project for Statistical Computing) and QGIS, and at the web publishing front, Arches web application and CIDOC CRM semantic ontology (see www.potenzavalleyproject.ugent.be). This migration, in combination with the documentation of source codes and scripts, for the purpose of data management, analysis, and visualisation of spatial information enhances the reproducibility and verifiability of the map-making process, and promotes the reuse and extension of the methodology. In SARP geospatial data management and display in cartographic format evolved from the use of simple data tables and computer aided drawing (CAD) software [Map 6], to that of a combined approach where AutoCAD, ArcGIS 9.x and 10.x, QGIS and PostgreSQL are employed together [Map 1] and [Map 2]. Typically CAD software is vector-based and does not allow the use of raster data structure. A combination of vector and raster data using GIS software, as in [Map 1] and [Map 2] here, on the other hand, powerfully brings together detailed vector drawings of architectural remains with raster datasets such as hillshades and digital elevation models.



Map 1: Sagalassos Archaeological Research Project, map coordinated by Piraye Hacıgüzeller (2018), *Map of the Archaeological Site of Sagalassos*.

A map of the archaeological site of Sagalassos (SW Turkey) recently created using geographical information systems technology. The map has shortcomings similar to the one produced by Prof. Frans Depuydt and his team. It presents Sagalassos as an immutable landscape through a snapshot of the ancient settlement which never existed. The snapshot combines actual topography with a selection of excavated (and at times backfilled) architectural remains during different fieldwork seasons. As such, these remains were never exposed in the combination presented on the map. However, the map remains a visually powerful rendition of Sagalassos produced through the application of tried-and-tested techniques common to geospatial research as well as a desire to push the boundaries within digital humanities. Specifically, the map was produced by incorporating freely available digital elevation models with the existing contour map of Sagalassos through meticulous manual editing. Subsequently highly detailed architectural drawings in computer aided design (CAD) format were integrated into the topography created. The map was created to serve as a detailed architectural interface for the newly built integrated geospatial database system of Sagalassos. The system aspires to employ innovative spatial ontologies for digital geohumanities research.

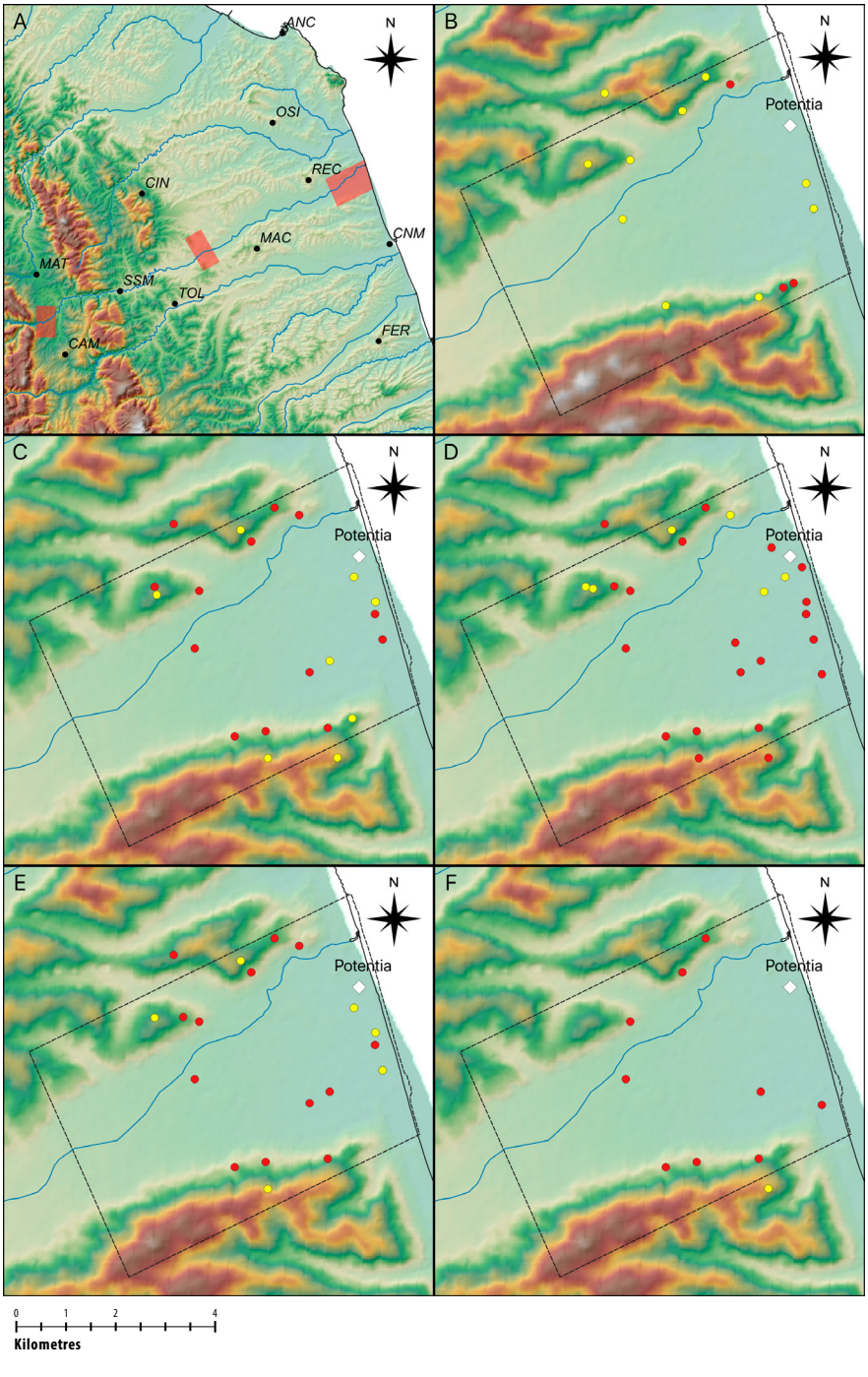


Map 2: Sagalassos Archaeological Research Project, map coordinated by Hannelore Vanhaverbeke (2010), *Map of the Archaeological Site of Düzen Tepe*.

The map of the archaeological site of Düzen Tepe (SW Turkey), produced by Dr. Hannelore Vanhaverbeke and her team. The site of Düzen Tepe is difficult to read. Not only is agriculture and pastoralism still performed on large parts of the site, making it into an active, utilised landscape, but the nature of the archaeology is also difficult to read. The settlement itself dated to late Achaemenid and early Hellenistic times. In this way, the site is earlier than the introduction and development of the concept of polis in the region in middle Hellenistic times. With the polis of Sagalassos, monumental urban architecture was to be introduced. This quite visible urban armature was missing at Düzen Tepe, however, as this site was situated within another period and associated with another type of social complexity and organising daily life on the ground. Additionally, the site was abandoned by middle Hellenistic times, allowing cultural and natural processes of depletion and degradation to take over. As a result, the archaeology of Düzen Tepe is best characterised as ephemeral on the ground. Considering its acknowledged historical importance, however, a truly concerted effort at mapping revealed an interesting reading of the archaeological site, based on the application of satellite image study, intensive archaeological surveying, topographical mapping, and geophysical surveying.

Map 3: Devi Taelman (2018), *Urban and Suburban Setting of the Roman Colonial Town of Potentia*.

Urban and suburban setting of the Roman colonial town of *Potentia* (184 BCE and abandoned in the early Middle Ages). A multi-method approach (artefact survey, vertical aerial and satellite imagery, and geophysical survey), in combination with legacy data, has allowed a more detailed appreciation of the site's chronology, functional zoning and spatial evolution between the early second century BCE and the late sixth–seventh centuries CE. The N-S oriented *cardo maximus* coinciding with the Roman coastal road and the E-W oriented *decumanus maximus* coinciding with the final stretch of the road linking *Potentia* to the *Via Flaminia* form the town's main axes. The intra-mural urban area consisted of a regularly subdivided network of streets and housing blocks of different sizes. Extra-mural activity was mostly attested as funerary zones and sectors of economic activity (pottery production, market gardening…). A. Orthorectified oblique aerial imagery and satellite imagery showing clear crop marks of the town's urban and suburban street network. B. Results of the magnetometer survey showing the internal urban structure, including street grid, public monuments, and housing structures. C. Interpretation of the main components of the Early Imperial town plan set against the microtopography derived from LiDAR data. The microtopography reveals the elongated beach ridge on top of which ancient *Potentia* was built that was eroded in its southern part during Late Medieval times due to river activity.



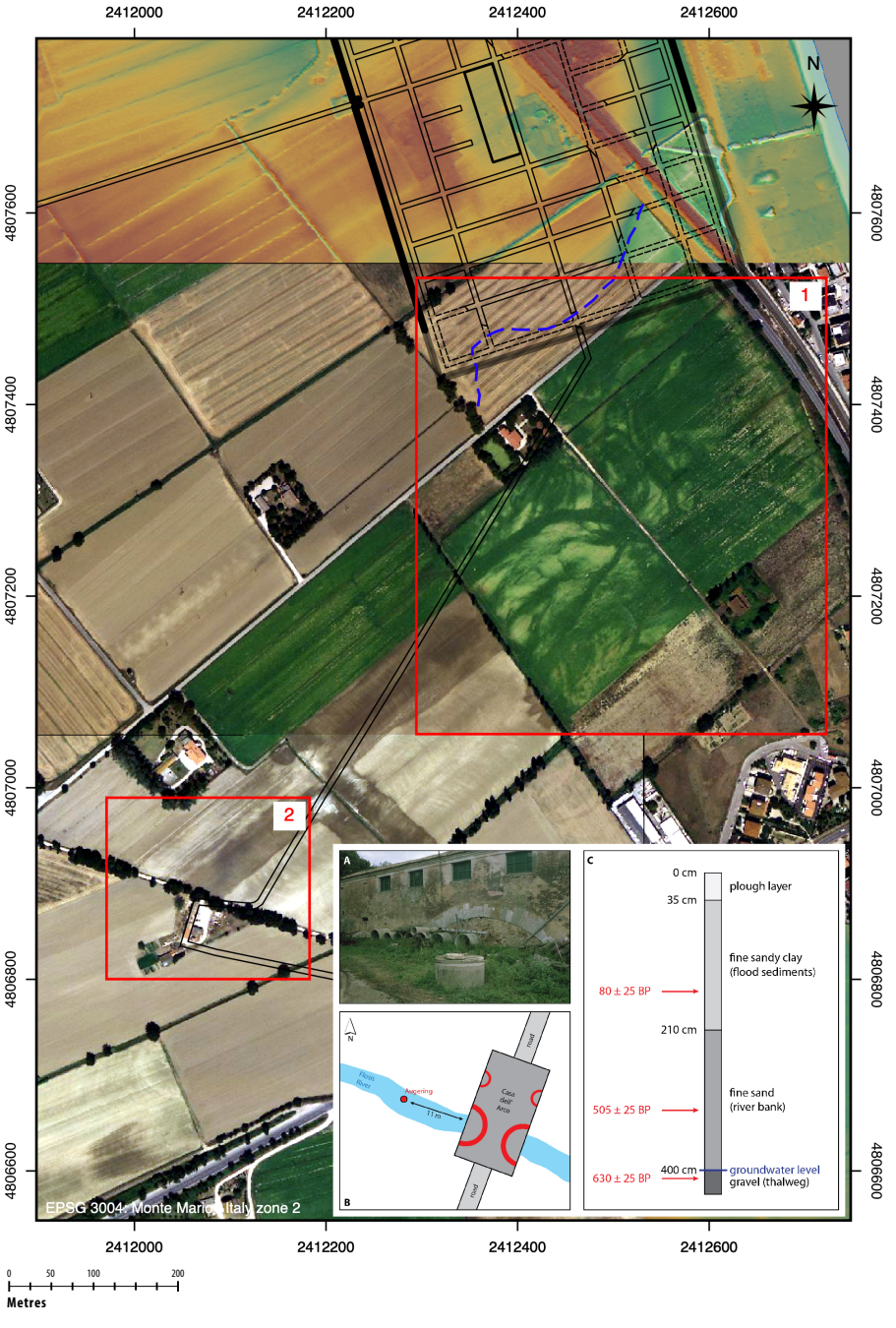
Map 4: General Landscape Setting of the Potenza Valley Survey.

Map 4: Devi Taelman (2018), *General Landscape Setting of the Potenza Valley Survey*.

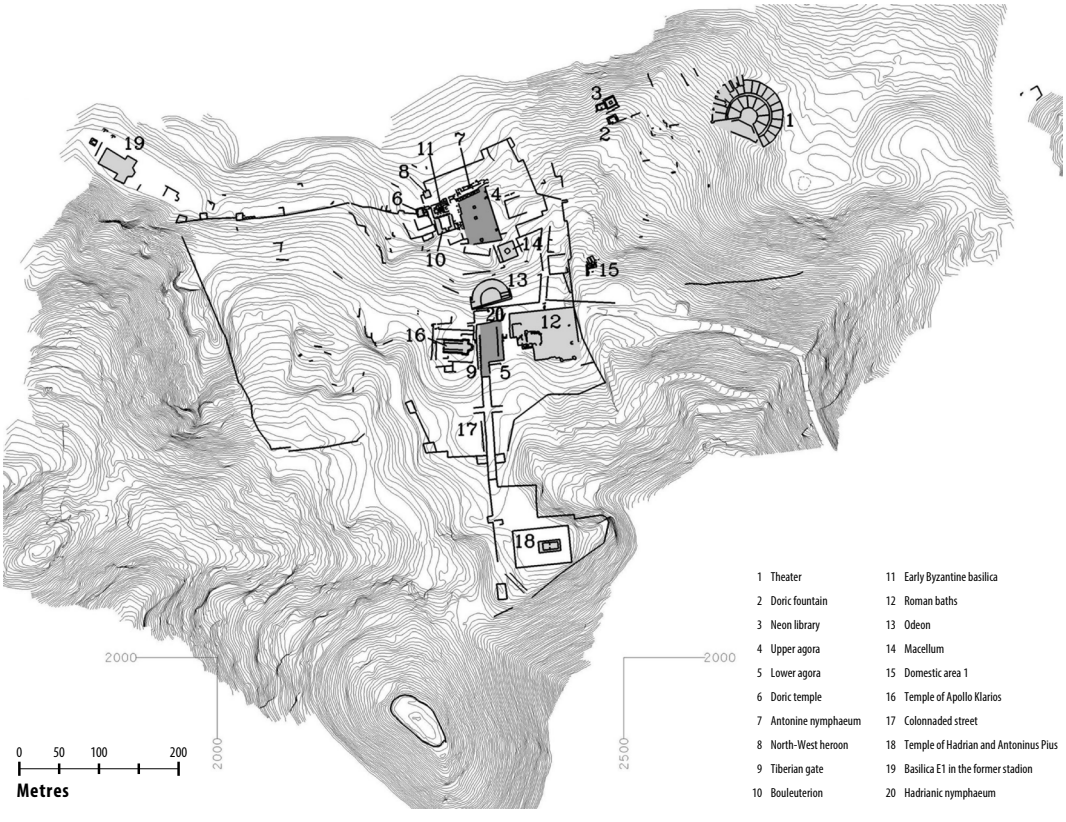
General landscape setting of the Potenza Valley Survey (PVS). The project focuses on the human occupation between the early first millennium before our era (c. 900 BCE) and the end of Antiquity (c. 600 CE) in the valley of the river Potenza (Marche region, central Adriatic Italy). Field work is applied on scales ranging from the wider regional scale to the level of three sample zones along the c. 80-kilometre-long course of the river Potenza, roughly coinciding with the upper, middle. and lower sections of the valley, and to the scale of the individual site. A: Overview of the three sample zones along the river Potenza selected for intensive artefact survey in the PVS project and indications of the main modern towns. B-D: Changing settlement patterns in the lower valley section of the river Potenza between Iron Age and Late Antiquity (red = certain sites, yellow = possible sites). B: Iron Age; C: Republican period in relation to the Roman colonial town of *Potentia*; D: Early Imperial period in relation to the Roman colonial town of *Potentia*; E: Middle Imperial period in relation to the Roman colonial town of *Potentia*; F: Late Antique occupation in relation to the Roman colonial town of *Potentia*.

Map 5: Devi Taelman (2018), *Landscape Setting of the Southern Suburban Area of the Lost Town of Potentia and the Ancient Bed of the River Potenza*.

Landscape setting of the southern suburban area of the lost town of *Potentia* and the ancient bed of the river Potenza, mapped with the combined use of aerial photography and LiDAR imagery. Inset 1 shows crop marks of the ancient river Potenza, demonstrating an abandoned deltaic river channel with bifurcating channels. Topographic correlation of the ancient riverbeds indicates a gradual southward migration of the active delta channels. At the latest in 1453–1635 cal CE the river abruptly migrated to the north, partly eroding the Potentia beach ridge and the southern part of the Roman town. Inset 2 shows the location the Roman bridge of *Casa dell'Arco*, the preserved arches of the Roman bridge in the walls of the eighteenth-century farm, the soil profile with a typical fluvial upward fining, and the corresponding radiocarbon dates. The fluvial upward fining points towards a migrating meandering river. Radiocarbon dates indicate that the Roman channel remained in use until the late medieval period. The final date illustrates that the alluvial plain was still subject to regular floods until the late nineteenth century or early twentieth century.



Map 5: Landscape Setting of the Southern Suburban Area of the Lost Town of Potentia and the Ancient Bed of Rhe river Potenza.



Map 6: Sagalassos Archaeological Research Project, coordinated by F. Depuydt (Van Rompaey A. & F. Depuydt 1997), *1:20 000 Map of the Archaeological Site of Sagalassos*.

The 1:20 000 map of the archaeological site of Sagalassos (South-west Turkey), produced by Prof. Frans Depuydt and his team. The scaled version of the map accentuates the urban framework of the ancient city, but freezes it in the rendering of the actual landscape contours of the site as well as in time. In this way, no chronological depth or interpretation is considered, displaying graphically a snapshot understanding of the importance of mainly the urban monumental core zone. Although providing a strong visual synopsis of the urbanscape, it remains difficult to unpack this map. It not only stacks stages of its diachronic development, but also presents a topography that never existed from integrating actual landscapes and contours with a reconstructed archaeology. Terraces must have been a very common feature at ancient Sagalassos, for instance, sustaining the development of the built framework for a community on an undulating and at times even steep terrain. Such elements would have had an impact on circulation and communication, and in this way formed an essential element of the urban landscape. This interface is lacking from the map, as the available information on the archaeology of terraces is insufficient. As a result, the map is the result of a set of rational decisions, and these need to be considered in order to fully comprehend the map.

8.

A High-Resolution Multi-Scalar Approach for Micro-Mapping Historical Landscapes in Transition

A Case Study in Texas, USA

Arlo McKee (University of Texas at Dallas / Texas Historical Commission)
May Yuan (University of Texas at Dallas)

The European Landscape Convention (ELC) defines landscape as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (Council of Europe 2000: article 1). The ELC calls for states to introduce landscape in the law 'as an essential component of people's surroundings, an expression of the diversity of their shared cultural and natural heritage and a foundation of their identity' (Council of Europe 2000: article 5a). As such, a landscape reflects a history of environmental, social, and cultural engagements, and it inscribes material records of human activities in places over time (David and Thomas 2008).

Cartography and Geographic Information Systems (GIS) methods have commonly been used for regional mapping because the spatial resolution of most geospatial data is too coarse to catch local details. However, what remains from the changing engagements and related material records throughout landscape transitions can be subtle and demand attention to micro features at sites. High-resolution data collection techniques and multi-scalar data analytics are necessary to support micro-mapping local details and contextualising the local details with historical documents and maps to understand the transition of a landscape. A historical Caddo mound (M.S. Roberts site) is used here to demonstrate the high-resolution, multi-scalar approach.

In this chapter, we develop a general, multi-scalar approach for understanding the historical landscape in transitions within a small stream valley in East Texas. Although many of the tools we use for identifying site locations and researching historic records are commonplace in historic and archaeological studies, the novelty of our work resides in the integration of new rapid and high-resolution data collection techniques to help identify some of the local preservation concerns of historical and cultural resources in the region. Specifically, we discuss the collection of 3D photogrammetric mapping data at a relatively unknown Caddo mound, M.S. Roberts site. Archaeological sites in Texas are highly correlated with the current population distributions, and the remote location of the M.S. Roberts site contributes to its lack of public awareness [**Map 1**]. We combine the 3D photogrammetric data with historical documents and maps to estimate both natural and anthropogenic threats of erosion over the past century.

The site and archeological landscape

The M.S. Roberts site was recorded as an archaeological site in 1931 by J.E. Pearce and A.T. Jackson from the Department of Anthropology at the University of Texas at Austin. The site was reported to Pierce by a local informant, Jeff D. Reagan, who had heard about a nearby 'Indian mound' and rumours that the landowner, Mr. Roberts, had intentions of levelling the mound to fill in the adjacent borrow pit from which the earthen mound fill was obtained. In October 1931, both Pearce and Jackson visited the property and recorded the site as a 'domiciliary mound with a surrounding village' (Fig. 1a). They excavated two trenches in the mound. Since their efforts did not recover artifacts other than what they found walking the ploughed field, the Texas Archaeological Research Laboratory (TARL) only retained a short letter report and associated communication, including a sketch map showing the location of the borrow pit, excavations, and field roads in relation to distances to the nearby stream. The sketch map indicated the mound dimensions as a slightly oblong 24 m x 20 m area at 1.7 m above the natural terrace vaguely georeferenced to somewhere in the Caddo Creek watershed. In the early 2010s, a highway expansion project evoked a renewed interest in the M.S. Roberts site by both professional and avocational archaeologists, as well as the current landowners of the site. In the summer of 2015 (Fig. 1b), we started the collection and production of a high-resolution topographic map and orthophotography of the site in conjunction with the new archaeological excavations (Perttula et al. 2016).

Fig. 1a: Pearce and Jackson (1931) Photograph of Pearce Standing on the Mound [Courtesy of the Texas Archeological Research Laboratory].

Fig. 1b: Mark Walters (2015) Photograph of the Mound at M.S. Roberts Site.

The new archaeological excavations uncovered a ceramic assemblage dated to A.D. 1400-1680, or perhaps as early as A.D. 1320 (Perttula et al. 2016). This period spanned the latter part of the Middle Caddo and the entire Frankston phase in the upper Neches River valley (Perttula 2012). During this time, Caddo communities were scattered along stream valleys in a dispersed settlement system that might have stretched several miles. Caddo villages, hamlets, and farmsteads supported horticultural and agricultural farming of maize, squash, and other crops. While documents were lacking for Caddo settlements in the upper Neches River valley, Caddo settlements could be gleaned from the often reproduced Terán Map (Fig. 2) that depicts one such Caddo community along the Red River Valley as observed by the Spanish expedition of 1691-92 (Texas Beyond History 2003). Many of these communities had a mound centre where ceremonies, rituals, and burials of important persons in the community took place.

Fig. 2: Domingo Terán de los Rios (ca 1692), *'Terán Map' of Upper Nasoni settlement on Red River* [Courtesy of Texas Beyond History, the J.P. Bryan Map Collection].
The Terán map showing settlements of a historical Caddo community along the Red River produced as a result of the 1691-92 exploration of eastern Texas led by Domingo Terán de los Rios, the first Governor of Spanish Texas. The map shows a village which is considered part of the Cadohadacho alliance, with small farmsteads or extended family compounds separated by hedges or rows of trees or bushes. Although the Terán Map shows a compact village setting, a Caddo community might actually be distributed along several miles of the Red River.

Caddo Creek is a low-order stream that flows south-east into the Neches River. There are 44 prehistorical archaeological sites within the Caddo Creek watershed. Although many of the sites have not been radiometrically dated, the spatial pattern of these sites with Middle-Late Caddo artifacts fits well with a dispersed Caddo community centred on the Caddo Creek [**Map 2**]. In fact, Perttula and Walters (2016) pose the idea that this watershed represents one of only seven known distinct Late Caddo communities in East Texas. Although few sites have been confidently dated as exclusively Historic Caddo (post-1680), both reduction of populations and changes in land use resulted in two major changes to the settlement landscape: (1) clustering late-period archaeological sites closer to the larger confluence with the Neches River and (2) abandoning most of the upper reaches of the Caddo Creek watershed. By 1730, the Caddo likely entirely abandoned the area, but at least one Caddo community was known to be near the nearby community of Poynor [**Map 1d**] in the 1830s. At the end of the Cherokee War in 1839, in which the Republic of Texas' President Mirabeau B. Lamar (1798-1859) successfully ordered the expulsion of the Indians in East Texas, the Caddo were again driven from the region and the Caddo Creek watershed transitioned to rural agricultural land (Everett 1990).

One set of aerial photographs from the Tobin Aerial Archive from 1933 postdates Pearce and Jackson's initial site recording visit [**Map 3**]. These images allow easy identification of the borrow pit as a dark patch of vegetation near the northern end of a rectangular agricultural field. Two dark linear patches extend from the borrow pit to the north-west and south-east, which may have been artificial channels diverting water across the field while the land was being used for cotton. Additionally, extensive erosional rills are visible west and south-west of the mound and borrow pit that mark the edge of the flat terrain, while to the north-west there are clear artificial terraces to prevent further erosion. The fence lines partitioning the site into north and south fields were removed at some point between 1933 and 1966, but the fence east of the mound has been maintained in the same place until today. Additional gullying south of the borrow pit is apparent on the 1966 aerial photography, and by 1996 the gulley was formalised as a small pond along with the establishment of the lake west of the site. Although the mound itself is hardly visible in the aerial photographs, the borrow pit is identifiable because it is accentuated by the channels extending from the feature and typically darker vegetation. Beginning with the 1996 imagery, north-south oriented plough marks are visible in many subsequent images, and many of the subtle low-lying areas appear to have been filled. Imagery taken in the early 2000s shows the area under residential construction with signposts marking the property into ten residential plots. The extensive erosion and gullying to the south and west, in combination with the establishment of modern property boundaries and consistent landscape maintenance, has certainly affected the preservation and character of the Caddo archaeological site. We have explored the site characteristics in greater detail through high-resolution drone mapping of the property.

Drone micro-mapping

Drone-based photogrammetric micro-mapping has been proven to be an incredibly efficient method to produce datasets that are not easily obtainable by other methods (Nex and Remondino 2014). As an automated data collector, a drone allows a camera with an intervalometer to collect images at an overlap of 80 % both between image shots and transects. The drone mapping of the M.S. Roberts site was conducted with a commercially available DJI Phantom quadcopter equipped with a 16 MP Canon digital camera. Within two hours of field time, we collected over 1,000 photographs of the 20-acre site area at a camera height that allowed for less than 1 cm per pixel resolution. These images were processed in Agisoft Photoscan Pro with a technique named Structure-from-Motion Multi

Stereo-View (SfM-MSV) to align the set of images in an arbitrary 3D space and generate both a point cloud and solid model representing the ground surface and other visible objects (Carrivick et al. 2016; Smith et al. 2016). Horizontal and vertical control was established by placing aerial targets adjacent to the corner stakes of a 20 metre grid for geophysical data collection (McKinnon et al. 2017) and recording those ground points with a differentially-corrected GPS receiver. These GPS locations were identified on individual image in the 3D scene to apply scale and verify the accuracy of the dataset. This processing resulted in both a 1 cm orthorectified image and a 5 cm digital elevation model of the site.

Delineation of the site mound and borrow pit features was conducted in ArcGIS using the high-resolution digital elevation model (DEM) derived from the drone imagery. Although Pierce noted that the borrow pit was located near the mound, his field map of the site omitted this feature and instead mapped the mound in relation to the placement of his excavations. Nevertheless, the high-resolution dataset from drone imagery allows identification of the mound and borrow pit features in a semi-automatic fashion with relative elevations above and below the average terrace surface. We first removed the spatial trend of the data using a second-order Global Polynomial Interpolation, which also removed additional artificial curvature produced from the Agisoft Photoscan processing. High-frequency changes in local vegetation were removed by passing the DEM through a first-order Local Polynomial function with a filter radius of 1 metre. With much of the terrace then being represented by a relative elevation of zero metre, a simple threshold was applied to delineate the mound and borrow pit areas above or below the arbitrary terrace surface, respectively. Although these methods work well for a relatively small site area, such as the M.S. Roberts site, we have found that other methods, such as Topographic Position Indexing (TPI), are well-suited for aiding in the delineation of prehistoric cultural features in a variety of more complex settings (De Reu et al. 2013; Heilen 2015). The primary difference with TPI analysis from the polynomial smoothing we employed at M.S. Roberts is that with TPI both relative elevations and standard deviations are included in the analysis to aid in the delineation of features of different sizes. Given the relatively discrete features and relatively large sizes of the features compared to the 5 cm pixel size, the local polynomial filtering generated a sufficiently smooth surface relative to the average terrace height such that the more involved analyses were not needed.

This delineation of the mound revealed a slightly oblong feature that had a maximum height of 91 cm above the relative terrace surface and a general length and width of 43.5 metres by 26.6 metres. The borrow pit was defined as a clearly

isolated depression beginning about 50 cm below the terrace surface, though the depression grades to the remaining terrace gradually and is not clearly defined in the data between 0-50 cm below the surface. The DEM processing resulted in a relatively flat terrace surface at an arbitrary zero-metre mark as the base height, and the archaeological features were expressed as elevation differences above and below the base height. Henceforth, calculations of the volume of the mound and missing volume of the borrow pit were straightforward. We clipped the DEM to contain only the archaeological features and the positive and negative cell values above or below the base height, and used the number of cells, and cell size for volume calculations (cf. Chang 2009). We estimated the volumes of the mound and borrow pit as 313.68 and 270.82 cubic metres, respectively, with approximately 86 per cent of the estimated mound fill being represented in the borrow pit area [**Map 4**]. The gradual slope, especially near the edge of the borrow pit, made it difficult to delineate the exact feature boundary. Nevertheless, the calculated volumes of both the mound and borrow pit closely resembled each other. This correlation suggested that nearly all the fill comprising the mound was excavated from the borrow area.

The mound dimensions and shape in the drone data appeared to be elongated in the north-south direction compared to what was initially recorded by Pearce and Jackson in 1933. To understand these differences better, we use the current mount apex as a tie point to overlay the historic map and high-resolution 3D data from drone imagery. Although Pearce and Jackson reported the length, width, and height of the mound, they did not georeference the features on a topographic map. Consequently, we needed to generate a new digital elevation model by fitting a normal curve to the mound at a height of 1.7 metres and matching the 24 metre by 20 metre length and width to approximate the surface that may have been present when they recorded the site. By matching the apex of the 1933 mound map with the current site data, we estimated the volume of soil loss that had occurred throughout most of the twentieth century. Other studies of mound erosion used sediment flux diffusion models to depict the amount of degradation that occurred to areas where soil creep was the dominant mass wasting process (O'Neal 2005). Although those earlier studies utilised a two-dimensional sediment flux, we developed the following algorithm and implemented a python script to estimate soil loss in a 3D model by calculating the curvature in each time step.[1]

1. The python scripts are available at https://www.dropbox.com/sh/dc20u8076ttxwnq/AABni3Xa1_QdeDWzTVjlcGj1a?dl=0

The initial formulation of the sediment flux model to characterise soil creep on slopes was provided by Nash (1984) and later Pierce and Colman (1986) as $\frac{\partial y}{\partial t} = c \frac{\partial^2 y}{\partial x^2}$, where $\frac{\partial y}{\partial t}$ is the change in the surface at a given time step, c is the sediment flux, and $\frac{\partial^2 y}{\partial x^2}$ is the gradient of the slope. Using ESRI's arcpy python library, our script iterates through any number of years given a starting DEM. Operationally, this is performed by:

1. Starting with an initial DEM (T_o)
2. Calculating Curvature at T_o ($Curv_o$)
3. Multiplying $Curv_o$ by the sediment flux to calculate the initial Flux Raster (F_o)
4. Calculating the DEM (T_1) by subtracting F_o from T_o
5. Repeating steps 1–4 for as many time steps as needed using the new DEM(T_i) for starting inputs at each step

Based on the difference in height over an 85-year period, we estimated that the mound lost soil at a rate of 0.0035 m^3/year. This was determined by matching the 1931 reported height of the mound to the height as observed in the drone data [**Map 5**]. By modelling erosion in this way, it became apparent that natural soil creep could not have been the only factor in the mound's erosion because the modern shape is too elongated to the south and south-east compared to what was reported. To account for this directional elongation an additional aspect calculation was added to each time step. For each time, the aspect of the initial DEM was calculated and classified according to general compass directions. A scalar value was then applied to the south, south-east, and south-west directions to match the modern observed shape of the mound. More than triple additional soil flux was added to each erosion step for the southern directions to account for both the current shape and volume distribution. Our interpretation is that modern agricultural practices and the establishment of a permanent fence have led the tendency to plough consistently in the north-south direction, which in turn has resulted in the elongation of the mound. Since active ploughing has not occurred recently, it is likely that further degradation has been minimised, however.

Conclusions

This study presented the use and integration of historical mapping with modern drone-based data collection to help one understand transitions within a rural landscape, using a historical site in East Texas, USA, as an example.

Transitions in the landscape were rarely abrupt and often reflected human-environment interactions. In this case study, we demonstrated ways to unearth past natural processes acting on the landscape and human processes on land preservation. To help elucidate many of these processes we took a multi-scalar approach, with roots in both qualitative human geography and quantitative physical geography. While the word limit of the chapter prohibited discussions on the findings from the associated archaeological excavation, the historical human aspects of the landscape change, combined with the excavated archaeological artifacts, drew insights into the historical changes that resulted in the expulsion of a once thriving agrarian Caddo settlement with a solitary ceremonial centre. Both historic American settlements in the area changed the character of the M.S. Roberts site from what was probably the community focal point during the Late Caddo period to sparsely populated agricultural land.

The landscape transitions continue. Recent urban population growth and the development of the immediate site area for suburban residences invoked archaeological studies at various sites in the region, and hence enriched our understanding of the historical landscape change. Meanwhile, while regulations would promote landscape preservation at sites, regional landscape transitions will never cease. Drone-based micro-mapping of historical landscape with historical documents and mapping helps to relate local and regional landscape transitions to reveal the underlying environmental and human processes that contributed to the change.

In tandem with, and in part resulting from, agricultural land use practices, geomorphic processes reshaped the character of the M.S. Roberts site. Our approach of collecting high-resolution site-level remote sensing data on the site characterised how the site features had changed throughout the twentieth century. Erosion modeling of archaeological mounds was not a new approach. What the drone-based micro-mapping approach added was the ability to calculate volume and the rate of erosion. It was shown to be extremely useful to understand what rates of degradation were expected and how this might affect our understanding of the original form, work involved with construction, and maintenance of these types of features in other settings (Bell et al. 1996; O'Neal 2005). In a quick comparison to the case of O'Neal's work at the Hopewell site in Ohio, a sediment flux of 0.0005 m^2/yr was observed over a period of 1800 years. Given that the Hopewell earthworks was constructed from clayey soil and the mound at the M.S. Roberts site was a sandy fill, it was expected that a higher rate of erosion would occur at M.S. Roberts. However, it was surprising to learn from this study that the mound

had suffered from over seven times more degradation at M.S. Roberts than was observed at the Hopewell site. Furthermore, the changing shape of the mound would suggest that this was most likely due to twentieth-century ploughing practices at the site. While we developed the drone-based mapping in the case study, the quantitative modelling analysis developed for studying this site would be applicable to other sites in the region to help understand the transitions of other archaeological landscape features which would likely continue over the next century.

Acknowledgments

We are indebted to the current landowners of the M. S. Roberts site, Jim and Denise Renfroe. Without their permission and encouragement, we could not have conducted these investigations. We are also grateful to Dr. Timothy K. Perttula for his support and openness with research collaboration on this site and others.

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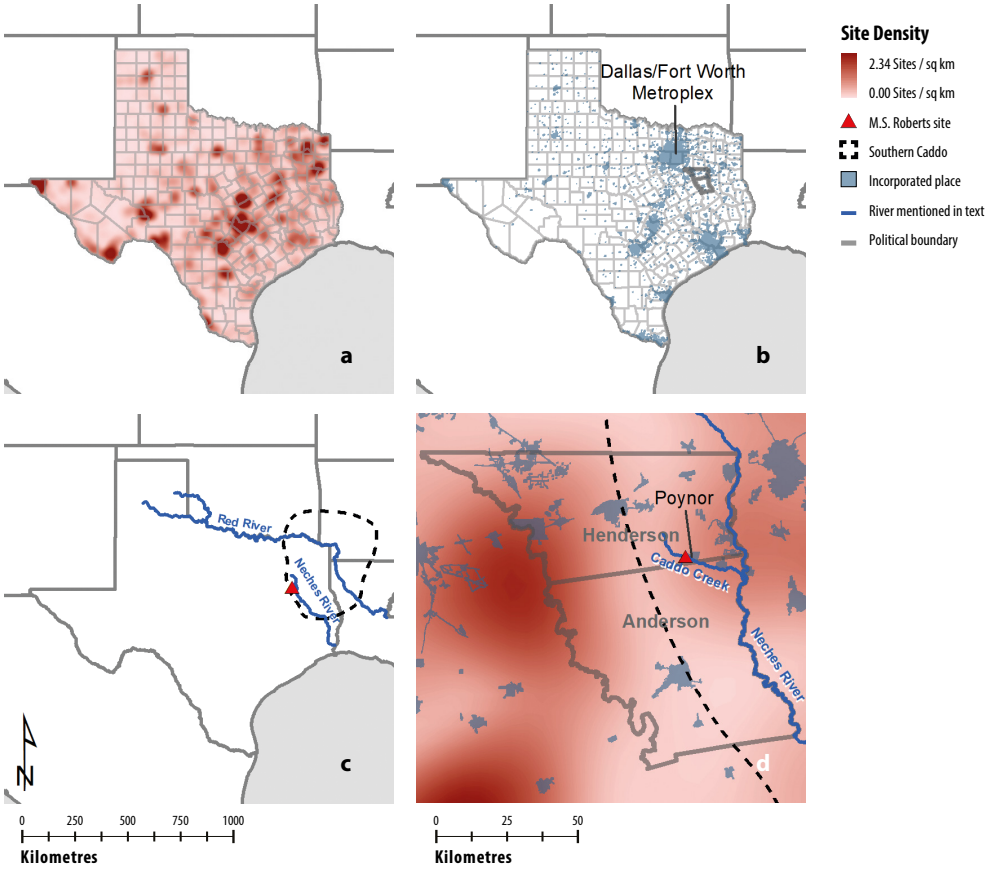
Maps

Introduction

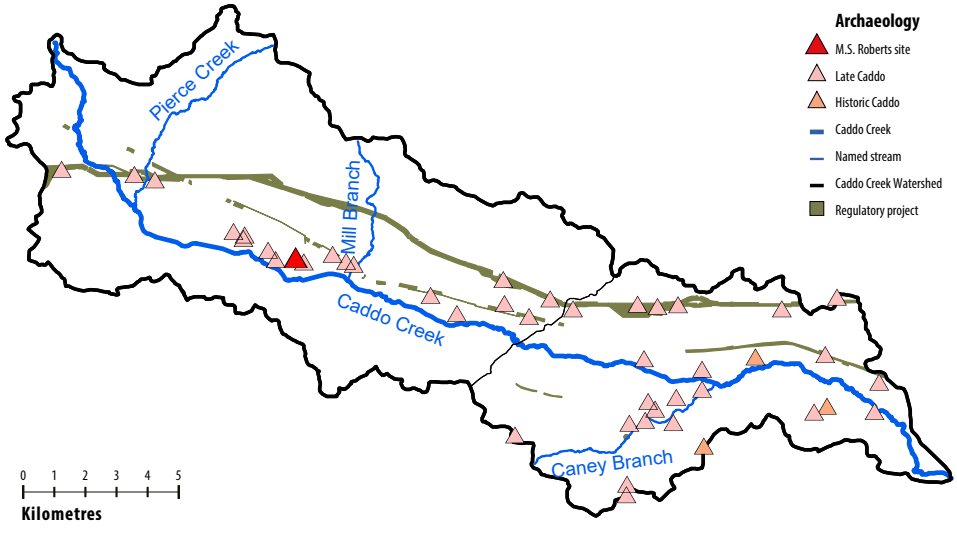
This study examined the transitions of a historical landscape at the M.S. Roberts site in East Texas. A ceramic assemblage excavated from the archaeological site placed this site to AD 1400-1680, a later part of the Middle Caddo and the entire Frankston phase in the upper Neches River Valley. A historical sketch map highlighted the spatial distribution of Caddo villages, hamlets, and farmsteads along the upper Neches River. The site would be a part of the settlements on the sketch map. Based on information from historical documents at the Texas Archaeological Research Laboratory, we created a GIS map to contextualise this site spatially along with other Caddo settlements in the Caddo Creek watershed. Through aerial photo interpretation, we zoomed into the M.S. Roberts site and identified landscape features in 1933, 1966, 1996, and 2015 and cross examined the changes in the landscape features across the four images. We then used drone photogrammetry techniques to develop a 3D model of the site at a spatial resolution of less than 1 cm. The micro-mapping approach provided us with the high-resolution data necessary to calculate changes in landscape features at the site. Specifically, we developed algorithms and python scripts to calculate the volumes of a mound and a pit and the soil loss rate.[2]

2. The scripts are available at https://www.dropbox.com/sh/dc20u8076ttxwnq/AABni3Xa1_QdeDWzTVjlcGj1a?dl=0)



Map 1: Arlo McKee (2018), *The Texas Archaeological Sites Atlas*. a: *Density of Recorded Archaeological Sites in Texas, USA;* b: *Population Density in Texas, USA;* c: *Geographic Location of the M.S. Roberts Site;* d: *Zoom-in View of the of the M.S. Roberts Site Showing Density of Recorded Archaeological Sites, Population Density and Main Geographic Features*.

The Texas Historical Commission and the Texas Archeological Research Laboratory maintain a GIS database with location information of archaeological sites in Texas with restricted access via a WebGIS, named The Texas Archaeological Sites Atlas (a.k.a. *Atlas*). Currently, there are over 80,000 sites recorded in the state. Submissions of new sites approximate at 1,000 per year. The *Atlas* is ideally suited to identifying archaeological sites or areas that may be threatened by landscape transition from increasing population.

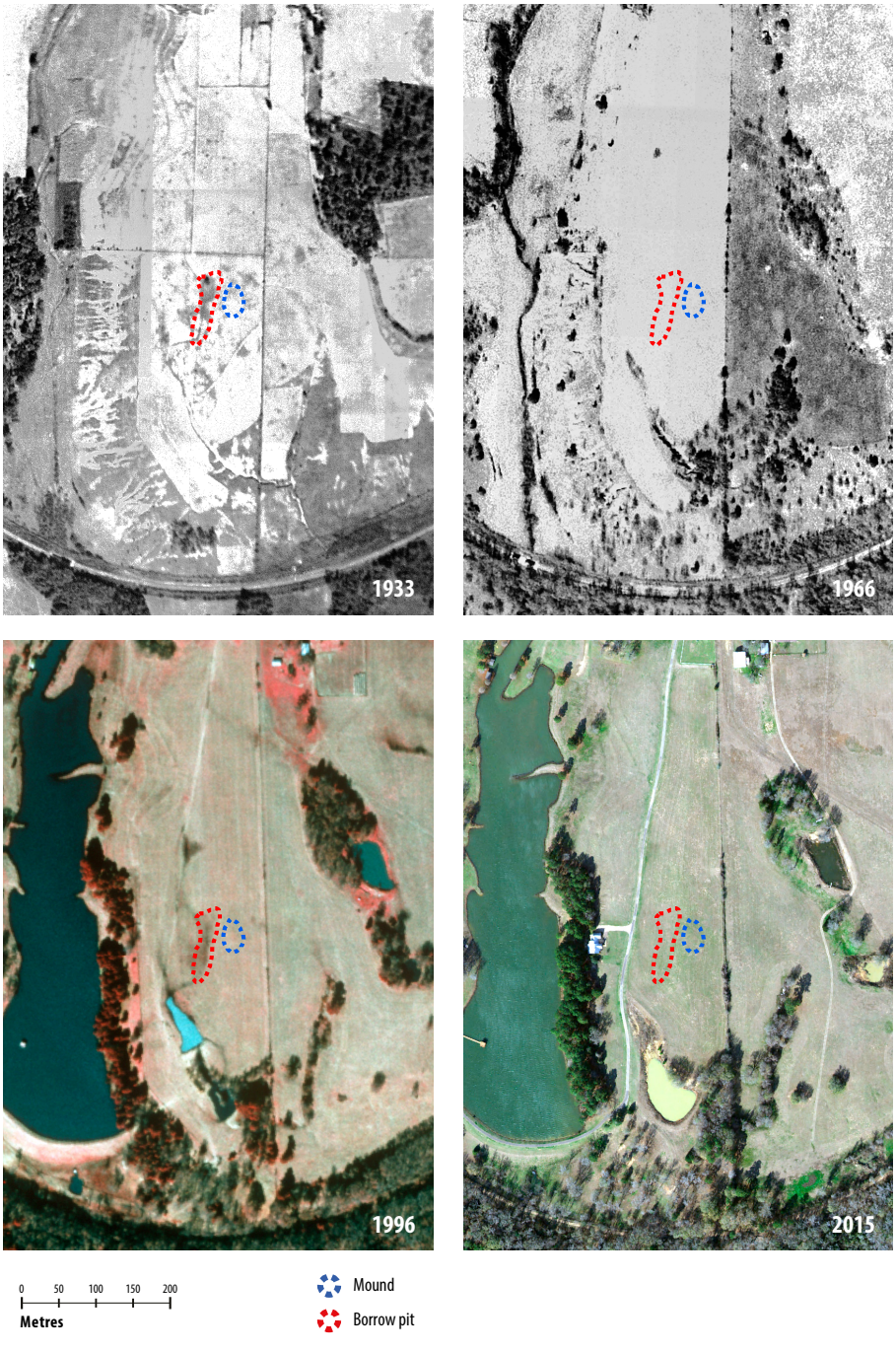


Map 2: Arlo McKee (2018), *Archaeology in the Caddo Creek Watershed*.

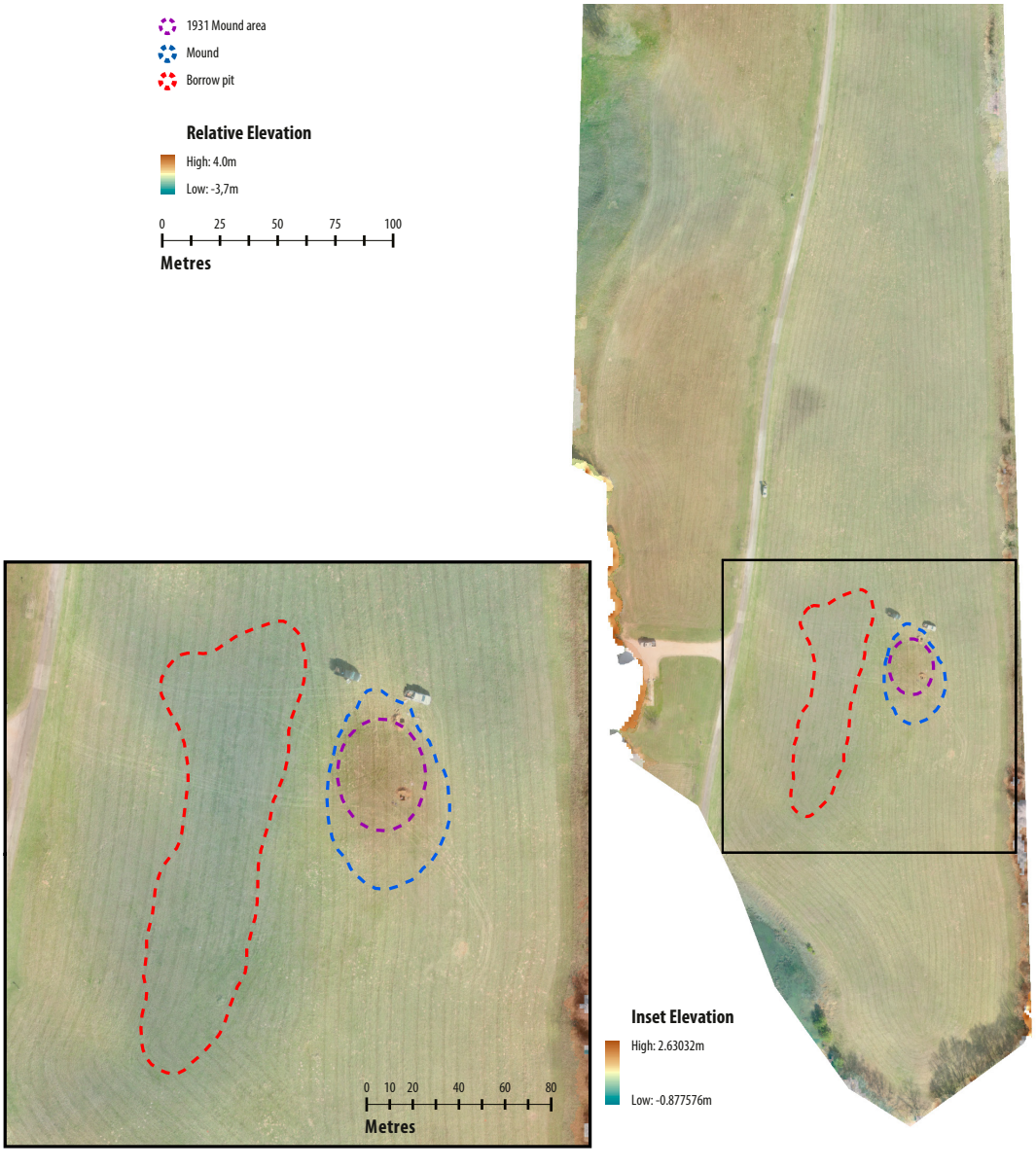
The GIS map was created using archaeological sites from Atlas to contextualise the M.S. Roberts Site geographically in relation to other prehistoric sites in the Caddo Creek watershed. While the distribution of sites is more dispersed than the Terán map, the Caddo Sites within this watershed resembles a loose clustering of small communities or hamlets that would have been connected by a common mound ceremonial center (the M. S. Roberts Sites). In this way, the dispersed Late Caddo site distribution resembles what was depicted on the Terán map, with Historic Caddo Sites tending to be located closer to the trunk stream to the east.

Map 3: Arlo McKee (2018), *Historic Aerial Photographs of the M. S. Roberts Site Area* [1933 and 1966 aerial images courtesy of Tobin Archives, 1996 and 2015 aerial images courtesy of TNRIS].

Historic and modern aerials of the M.S. Roberts site show fence pattern changes, agricultural use, channelised disturbance through the borrow pit, and the transition to a manicured and platted land ready for suburban residential development.

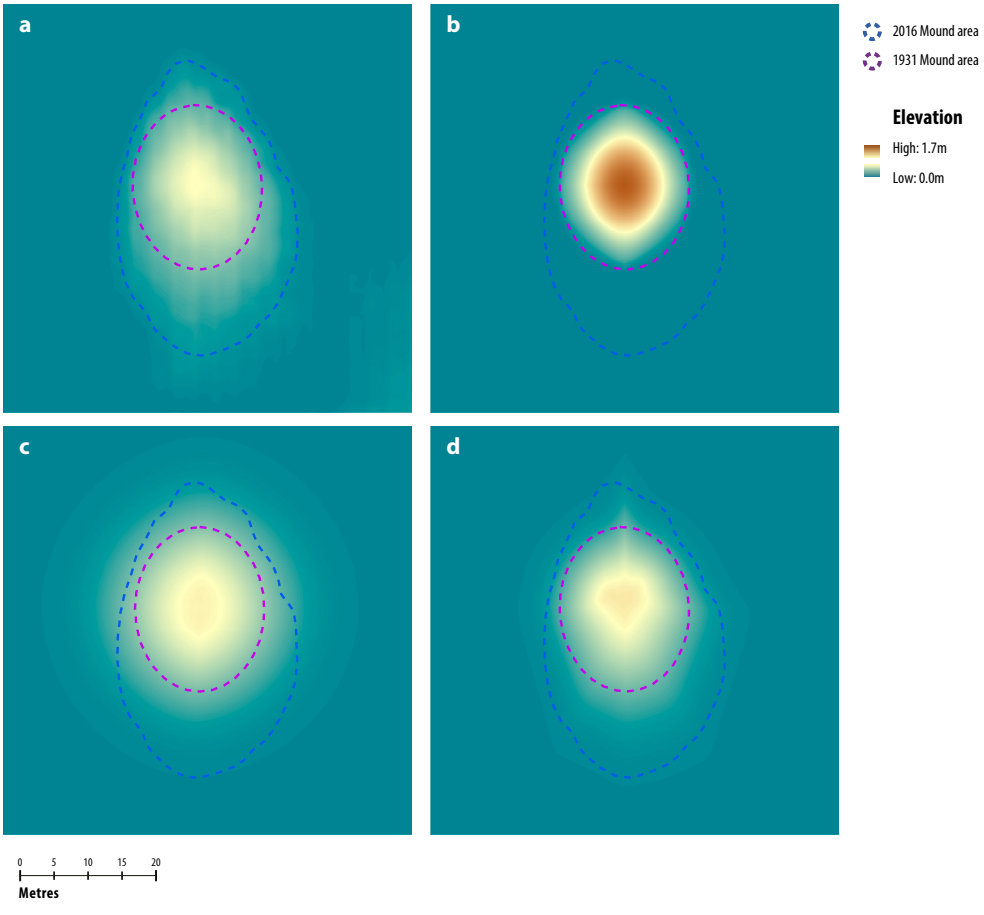


Map 3: Historic Aerial Photographs of the M. S. Roberts Site Area.



Map 4: Arlo McKee (2018), *Digital Elevation Model of the M.S. Roberts Site.*

Using drone-based photogrammetric techniques, we created a high-resolution (< 1 cm) digital elevation model (DEM) of the M.S. Roberts site to identify a mound, a borrow pit, and other natural features.



Map 5: Arlo McKee (2018), *Soil Erosion Modeling of the M.S. Roberts Site*.

We developed a soil erosion model and estimated the soil loss rate at 0.0035m³/year. Results of the erosion modelling show a: the 2016 drone surveyed mound height; b: the DEM estimated from the 1931 dimensions; c: the final erosion model result with uniform erosion in all directions; d: the final aspect-dependent erosion model result.

9.

Pixels or Parcels?

Parcel-Based Historical GIS and Digital Thematic Deconstruction as Tools for Studying Urban Development

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Very often, scholars aiming at mapping spatial arrangements and developments of the urban past choose nineteenth-century cadastral maps as the starting point for their analysis. These maps were for instance the main sources for the so-called regressive town plan analysis, a research method developed by the geographer Michael R.G. Conzen in his seminal study on the growth of Alnwick, Northumberland (Conzen 1960). The method has its origins in the structuralist approach that affected the historical and geographical sciences in the 1960s and 1970s, was refined afterwards by scholars of the Urban Morphology Research Group at the University of Birmingham, and influenced the still ongoing European Historical Towns Atlases project (Simms 2015). From the 1990s onwards, town plan analysis got a digital afterlife with the emerging of geographical information systems and their implementation in historical geography, urban morphology, landscape studies, building history, and archaeology. Today, various urban historical GIS projects still start from the parcel-based approach, as they also use the nineteenth-century cadastral maps as base layers. The French *Alpage* project is built up from the digitisation, geo-referencing, and vectorisation of the so-called *plans d'îlots Vasserot*, drawn in the period 1810-1836 (Noizet 2008-2009; Chareille et al. 2013; Raveaux et al. 2013). In the Low Countries, the Dutch *Hisgis.nl* website is built upon the cadastral maps from 1832, while the Bruges *Kaartenhuisbrugge* project uses the initial cadastral maps (*primitieve plans*) made in 1811, 1831, and 1835 as base layers (D'Hondt 2009) [**Map 1**].

For the creation of historical GIS applications these nineteenth-century cadastral maps have three important strengths: (1) they are geometrically accurate; (2) they

provide an account of the topographical objects and spatial patterns that existed before nineteenth- and twentieth-century urbanisation and industrialisation hugely transformed the cityscapes; and (3) they can quite easily be geo-referenced and warped on present-day cadastral and topographical maps. Yet, one might ask if both these nineteenth-century cadastral maps and the historical GIS applications that are built upon them are also relevant and useful when it comes to visualise and understand landscape transformation. In order to answer this question, I have assessed some of the renowned historical GIS platforms for Paris, Bruges, Antwerp, and some Dutch cities and towns: Alpage *AnaLyse diachronique de l'espace Parisien* (http://mapd.sig.huma-num.fr/alpage_public/flash/) [**Map 2**], the *Kaartenhuisbrugge* and *MAGIS Brugge* projects (http://www.kaartenhuisbrugge.be/Huis/ and http://magis.kaartenhuisbrugge.be/), the *GIStorical Antwerp* project (https://www.uantwerpen.be/en/projects/gistorical-antwerp/), and the Dutch *Hisgis.nl* website (http://www.hisgis.nl).

In the first section, I will discuss some methodological issues, seen from the perspective of a map and urban historian. It is definitely not my aim to reject the usefulness of these applications or to disregard the huge efforts the project staff has invested in them, but merely to reflect upon their values for studying historical landscape transformation in general and urban development in particular. In the second and third sections I will plead for the integration of this 'traditional' parcel-based historical GIS with the digital analysis of older maps and provide a small example of work in progress.

Parcel-based historical GIS applications: some major methodological issues

It goes without saying that the creation of online historical GIS systems and applications requires a lot of time, energy and funding and that project leaders and map developers face various technological issues during the developing process (e.g. Gregory and Ell 2007; Antrop et al. 2015). In addition to these technological challenges several heuristic issues emerge. Some of them have been discussed intensely before, e.g. the integration of imprecise, incomplete and/or fuzzy historical data in the rigid GIS data model (Bodenhamer et al. 2010; Bodenhamer 2015: 10 and 18). The protection and accessibility of the mass of data are other issues: most historical GIS platforms do not give direct access to the underlying databases and metadata and only offer the opportunity to explore edited map products and search engines for specific enquiries. By contrast, the objectiveness and accuracy of historical GIS systems are less distrusted. One of the reasons

might be that both the producers and users too often reduce map accuracy to geometric accuracy solely. Yet, already in 1980 M.J. Blakemore and J.B. Harley urged scholars also to take topographic and chronometric accuracy into account when it comes to study, interpret and use old maps. While chronometric accuracy concerns 'the methods by which early maps are dated and related to accepted time scales within different map cultures', topographic accuracy deals with 'the quantity and quality of the information in a map about landscape objects' (Blakemore and Harley 1980: 55 and 68).

Just like any other cartographic product, nineteenth-century cadastral maps resulted from a selection process, including both intentional and unintentional choices, and from the conscious or unconscious visions on landscape, territory, and society adopted by commissioning parties and map-makers of the time. The cadastral maps have been produced for fiscal and administrative purposes, which undoubtedly impacted on the map-making practices and the shape and lay-out of the final products. According to Katalin Szende (2013: 189), 'the more relevance a feature had for the primary aims of cadastral mapping, that is, for fiscal and administrative ends, the more attention it would have received from the cartographers'. Since the primary purpose of the surveys was to collect data for taxation assessments, the areas of the taxable units were measured and mapped precisely, while other topographic features such as watercourses, public buildings, and the (remains of) defence systems were less important. In some countries the cadastral maps — which initially were purely institutional products — have been commercialised afterwards, e.g. the so-called 'Popp maps' in nineteenth-century Belgium (Vrielinck 2018). Commercial editors sold reduced copies of the maps, which means that their chronometric and topographic accuracy were reduced compared to the original material.

It seems that scholars using nineteenth-century cadastral maps and historical GIS applications that are built upon them generally do not pay much attention to these issues, and just take advantage of the maps' high geometric accuracy for reconstructing the layout of building plots, parcel limits, and landscape patterns. Anne Kelly Knowles (2008: 2) considers historical GIS systems to be superb tools 'for mapping and geographically analysing census data, social surveys, and other kinds of systematically collected information linked to known geographical units and locations'. Although she also pointed to the use of GIS 'to visualize past landscapes and the changing morphologies of built environments over time', the question remains whether parcel-based historical GIS really is a suitable tool for studying, reconstructing, and visualising landscape transformation, which

inherently starts from and depends on incomplete and heterogenic sets of data. Actually, several historical GISs are temporal-historical systems: they take the nineteenth-century cadastral maps as their starting point, but also tend to visualise older landscape features and spatial patterns and/or link historical data to the base maps (Heere 2008: 115). In other words, these temporal-historical GIS applications add time-depth to the nineteenth-century maps. Georectified Popp-maps of Bruges are for instance used to visualise, analyse, and explain social change in the city between 1300 and 1700, to cite just this very recent example (Deneweth et al. 2017).

It was certainly not the intention of the nineteenth-century mapmakers, commercial editors and governmental institutions that commissioned the cadastral maps to produce 'historical maps', i.e. maps that portray facts derived from the critical interpretation of source materials concerning cultural and physical elements which did not exist when the map was made' (Wallis and Robinson 1987: 107). The maps were not produced as sources for academic research or educational purposes. They simply provide an account of older landscape features and morphological patterns because 'the plan and fabric of the town, representing as they do the static investment of past labour and capital, offer great resistance to change' (Conzen 1980: 6), a phenomenon commonly known as 'spatial inertia'. Notably field and parcel limits and street plans often resist landscape transformation through the times. Although not always visible to the naked eye, these relics structurally remain present in orthogonal (cadastral, topographical) maps and aerial views too. But how do we measure the time-depth of these inert landscape features? This can be achieved only by studying object per object, pattern per pattern: 'it requires special attention to ascertain to which period exactly these features date back, and to place them consistently in a context of their own time', to quote Katalin Szende (2013: 189) again. Hence, the time-depth of a mapped landscape object should certainly not be extrapolated to the whole map.

Finally, most historical GIS applications focus too much, or even solely, on parcels and buildings. The nineteenth-century cadastral maps particularly represent real estate property, while streets, roads, waterways, and other topographic features were just mapped in order to provide spatial context. In contrast to older urban maps, the representation of small landscape features, temporary items, or movables is completely lacking. Hence, the cadastral maps offer a very still and almost sterile representation of the urban landscape, consisting of empty roads and streets, which omits the representation of street furniture, means of transport, waste, animals, people, movables, the hinterland, etc. The same applies to

the historical GIS applications that are built upon them: the main focus is on properties, parcels, and private houses, while public spaces are often neglected [Map 3]. Neither the maps nor the historical GIS applications give an impression of perspectives, skylines and altitudes, hot spots and places of desolation, openness and closures, etc. Yet, when it comes to reconstructing and mapping landscape transformation, these aspects should be taken into account too.

Digital thematic deconstruction: an alternative application with complementary perspectives

The heuristic issues mentioned above should of course not restrain us from building and using historical GIS applications, on the contrary. It is however necessary to keep on reflecting about the strengths and weaknesses of the applications and trying to approve them, preferably by matching the desires from producers and consumers as far as possible. Most publications (books, articles, manuals, reports, etc.) on the subject are written by the producers of these systems (e.g. Noizet et al. 2013), so it might be a good idea that users also publically share their comments. From the producers' perspective, a very simple step might be to provide users with a short note on the accuracy levels and various degrees of time-depth of the base maps used for the applications.

A more advanced yet technologically challenging and time-consuming suggestion would be to evolve from the present-day static historical GIS applications to digital motion maps, showing evolutions of landscape and building patterns through time. In anticipation of this step, scholars are currently experimenting with so-called deep maps, i.e. maps that are 'not confined to the tangible or material, but include the discursive and ideological dimensions of place, the dreams, hopes, and fears of residents'. Being a platform, process, and product at the same time, deep mapping implies the creation of multimedia environments 'embedded with tools to bring data into an explicit and direct relationship with space and time' or, in in short, of 'a new creative space that is visual, structurally open, genuinely multimedia and multi-layered' (Bodenhamer et al. 2015: 3-4). But except for some recent small steps in the GIStorical Antwerp project (Janssens and Jongepier 2015), deep mapping has not yet been introduced in the urban historical GIS systems of the Low Countries.

A network of French urban archaeologists and geographers has chosen a radical alternative, the so-called 'chrono-chorématique', which implies a schematic and abstract modelling of 'urban trajectories' through the times, based on 'chorèmes'

or schematic representations of spatial objects. (Boissavit-Camus et al. 2005; Djament-Tran and Grataloup 2010) Unfortunately, it seems that this approach has not yet found its way to the scholars and research networks outside France, and it remains unclear how it can be integrated into historical GIS.

Another innovation might be to extend and link the traditional parcel-based historical GIS applications with the so-called 'digital thematic deconstruction' of pre-nineteenth-century topographical maps and bird's-eye views. To a certain extent, the focus on the nineteenth-century material has restrained scholars — both landscape historians and urban morphologists — and map developers from taking advantage of the qualities of older maps. These maps often tend to have a figurative nature and are therefore considered less precise, highly symbolic or quite imaginative. It is not surprising, then, that they are merely used as 'nice pictures', visualising or illustrating verbal arguments (Burke 2001: 9-10). But despite their geometric imperfections and sometimes imaginative nature, old maps have important qualities too: many of them show spatial objects, (parts of) landscapes, and territories which are not or only partly visible in the nineteenth-century parcel maps.

Especially the old topographical maps, which mostly have a figurative and pictorial nature, set out 'to convey the shape and pattern of landscape, showing a tiny portion of the earth's surface as it lies within one's own direct experience' (Harvey, 1980: 9). Despite their — sometimes very striking — subjectivity, most early modern urban maps are stuffed with landscape elements represented with quite a high level of topographic accuracy. See for instance Jacopo de' Barbari's impressive bird's-eye perspective of Venice from 1500 which combines a high degree of topographic accuracy with a symbolic and moralising perspective on city and society (Schulz 1978; Howard 1997). Moreover, old topographical maps have been produced in earlier periods, closer to the landscapes and landscape change scholars aim to reconstruct and map. Compared to the nineteenth-century cadastral maps, their chronometric accuracy is much higher.

Digital thematic deconstruction is a method of digital map analysis which is particularly suitable for studying, analysing, and unlocking such pre-nineteenth-century, figurative cartographic and iconographic documents (Vannieuwenhuyze and Vernackt 2014). Briefly speaking, it requires the systematic digital redrawing of an old map which is subsequently saved as vector data through a GIS. A rasterised high resolution scan of the old map serves as the base layer for creating a whole new set of adjoining polygons ('tiling'), which are categorised as clearly

defined topographic typologies and sub-typologies (e.g. 'street', 'house', 'moat', 'gate', 'bridge', 'tree', etc.). As such, a thematic categorisation of all map objects is realised and stored in the accompanying topological database [**Map 4**]. It is a golden rule not to add extra cartographic content, for instance by duplicating parts of the image or correcting mistakes. In the first place the map 'speaks for itself'; secondly, the cartographic elements are categorised (the basic level of interpretation), while subsequently a whole range of supplementary attributes can be added to the database (the second level of interpretation).

Digital thematic deconstruction thus offers the opportunity to convert a static image (the 'nice picture') into a dynamic file and research tool, which can subsequently be used for different inquiries and applications on the web, tablet, or smartphone (Vernackt et al. 2014) [**Map 5**]. One of the main benefits is that it becomes possible to digitally re-edit old maps following everyone's own desires, in other words to turn an early modern figurative map into a historical thematic map [**Map 6**]. In particular, it helps to visualise those landscape objects and patterns which are not necessarily visible with the naked eye. These and other relevant data help archaeologists, landscape scientists, building historians, and urban morphologists to study and explain the morphology and evolution of past landscapes and spatial arrangements.

The future: integrated approaches and systems

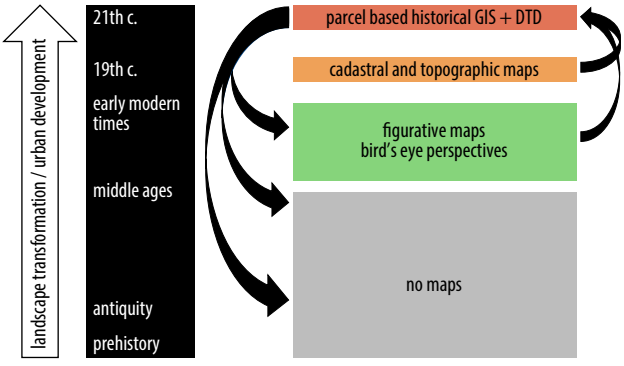
Digital thematic deconstruction using GIS is not that different from regressive town plan analysis and parcel-based historical GIS applications. Both approaches indeed imply the digitisation and vectorisation of a specific type of old maps through the creation of a set of thematically defined layers and storing attributes in a linked topological database. Yet, there are some important differences too. Digital thematic deconstruction does not need a geo-referenced map as base layer: while the geometrically accurate nineteenth-century cadastral maps can easily be warped on present-day parcel and topographical maps, it is mostly futile to geo-reference early modern figurative maps and bird's-eye views, since they witness too many spatial distortions. Geo-referencing hugely deforms the original map/image, which would mean that it becomes 'unreadable' and thus unusable for digital analysis of its topographic and figurative content. The power of these maps actually lies in the three-dimensional representation of the landscape, which most nineteenth-century (and more recent) orthogonal cadastral maps lack.

Another big difference is the extent of the digitisation: while parcel-based historical GIS applications primarily focus on buildings, parcels, and real estate, digital thematic deconstruction takes the entire map into account, including the public spaces, various types of small landscape elements, and 'useless data', such as people, animals, mythological creations, and movables, natural phenomena like shadows and smoke, decorative motifs, legends, cartouches or even 'distortion' (missing parts, damage, blank spaces). In addition, dismantling the map not only means dismantling the mapped landscape, but also questioning the use of the landscape and the map-maker's (and/or commissioner's) visions and perspectives on it. In other words, the method not only allows the isolation of every single cartographic or iconographic detail from the map, but also provides insight into the production process and its complex composition. Both the map and the mapped landscape are analytically and critically approached, which in turn warns users not to take the representation for granted.

It is not my intention to call for a replacement of parcel-based historical GIS by digital thematic deconstruction applications. Admittedly, digital thematic deconstruction has some disadvantages too. First, it is an even more intensive and time-consuming operation to digitise an entire pre-nineteenth-century map manually. Due to their figurative, three-dimensional nature, most of the map elements have complex and irregular shapes, which contrasts with the rather regular and 'simple' shapes of parcels and building plots on the cadastral maps. For the moment it is not yet possible to do the digitisation automatically, e.g. by some kind of image recognition algorithm, but it is expected that technological advances will allow one to do this in future. A second disadvantage concerns the scale and extent of figurative maps: in general, highly detailed figurative maps have a large scale and size (e.g. 109 x 107,5 cm for Cornelis Anthonisz' bird's-eye perspective of Amsterdam from 1544; 177 x 100 cm for Marcus Gerards' copper engraving of Bruges from 1562). A complete digitisation and vectorisation leads to the creation of very large datasets, which are not always easy to handle and use. Finally, just like parcel-based historical GIS applications, the digital thematic deconstruction itself does not allow one to visualise landscape transformation, since it also offers a static representation of the mapped landscape.

Visualising and studying landscape change can, however, be realised by combining both approaches, since they are quite complementary. Therefore, I would like to plead for an integration and juxtaposition of traditional parcel-based historical GIS with the digital thematic deconstruction of one or more maps of the same city, town, or area. Such an integrated system and approach offers the opportunity to combine

the strengths of both applications: the geometric accuracy of the cadastral maps and the figurative power and reduced time-depth of the early modern topographical maps (Table 1). At the University of Amsterdam, students are currently digitising and linking historical data to some of the old bird's-eye perspectives of the city (e.g. Cornelis Anthonisz' woodcut from 1544 and Balthasar Florisz van Berckenrode's engraving from 1625) and to the nineteenth-century cadastral maps, with the aim of studying the socio-economic transformation and the spatial layout and development of the city more thoroughly. In the near future, it will be tested whether it is possible to build and to bring online an integrated digital system which juxtaposes the data and allows the cross-fertilisation of the results of the different inquiries.



	geometric accuracy	chronometric accuracy	topographic accuracy	figurative value	time-depth
19th century cadastral maps	high	good	good	low	good
parcel based historical GIS	high	low	good	low	good
early modern figurative maps	low	good	very good	high	very good
DTD	low	low	very good	high	very good

Tables 1a and 1b: Schematic overviews of an integrated system combining parcel-based historical GIS based on nineteenth-century cadastral maps and digital thematic deconstruction of pre-nineteenth-century topographical and figurative maps, with the strengths of both applications (© Bram Vannieuwenhuyze).

Such an endeavour costs a lot of time and energy. For the moment, the work is still in progress, so it is not yet possible to show and discuss real results. I confine myself to one small case, based on the fourfold digital map analysis of a single

building block in Amsterdam (Prins Hendrikkade, Damrak, Haringpakkerssteeg and Hasselaerssteeg): the digital thematic deconstruction of Cornelis Antonisz's bird's-eye view from 1544, a heat map showing the variation in rental prices in 1562 plotted on the nineteenth-century cadastral map, the digital thematic deconstruction of Balthasar Floris van Berckenrode's bird's-eye view from 1625, and a screenshot from the HisGIS.nl website which offers data on buildings, parcels, occupants or owners, professions, and taxes with the cadastral map from 1832 as base layer (http://www.hisgis.nl/hisgis/gewesten/amsterdam/kaart1830/amsterdam1832; accessed 13 April 2018) [**Map 7a-d**]. Comparing the results of the digital analyses allows one to draw conclusions or to make hypotheses about the evolution of this particular part of the urban landscape, notably the change of parcel limits, building density, and the urban skyline, evolutions in occupations and socio-economic functions, social segregation, etc.

Let us for instance briefly examine if there was a correlation between rental values, presented on the heat map, the occupational data of 1832 stored in the HisGIS.nl database and the architectural characteristics of the urban sixteenth- and seventeenth-century fabric. Both bird's-eye views show large and tall houses inside the building block and alongside the Hasselaerssteeg (on the right side of both images), which seems to contrast with the relatively average rental values and with the small rectangular parcels on the nineteenth-century cadastral map. It is likely that the parcels have been split up at a given time, while the large buildings must have been destroyed and replaced by smaller housing units. The high rental prices alongside the Prins Hendrikkade, highlighted in red on the heat map, can be explained by the presence of wood storing facilities, as is suggested by Cornelis Anthonisz's map. There is no trace of the wood trade in the cadastral data for 1832, since only two ironmongers, a tobacco trader, and a *procureur* are registered in the HisGIS.nl database. The wood trade had probably left the area, leaving space for new activities and building projects. Some of the former open spaces no longer existed in the nineteenth century. At the Damrak, the red spot on the heat map seems to correspond with the large house with the bell gable drawn by Cornelis Anthonisz, which was probably inhabited by a wealthy family. In 1832 this house was occupied by a fruiterer.

Of course, figurative and cadastral maps never tell the whole story, especially if they originate from different periods and were created for different purposes. Additional historical, cartographical, iconographical, and archaeological data must be added in order to check the tentative hypotheses stated above and complete the analysis. What matters here, however, is to stress that juxtaposing the old

maps and integrating the various HisGIS data will open the path for approaching the evolution of the cityscape and socio-economic trends in a new way, especially if larger areas (entire neighbourhoods or whole cities) are taken into consideration. Nevertheless, it will be a huge challenge to design such an integrated system so that users can visualise, interpret, and use the results of their inquiries properly. Among other things, the distinct orientation, the various scales, and the connectivity of the maps need special attention. In a very ideal situation, such a system shall also be supplemented with other visual schemes like the 'chrono-chorématique' or deep mapping applications. The future will tell if such integrated systems will be achievable, viable, and relevant.

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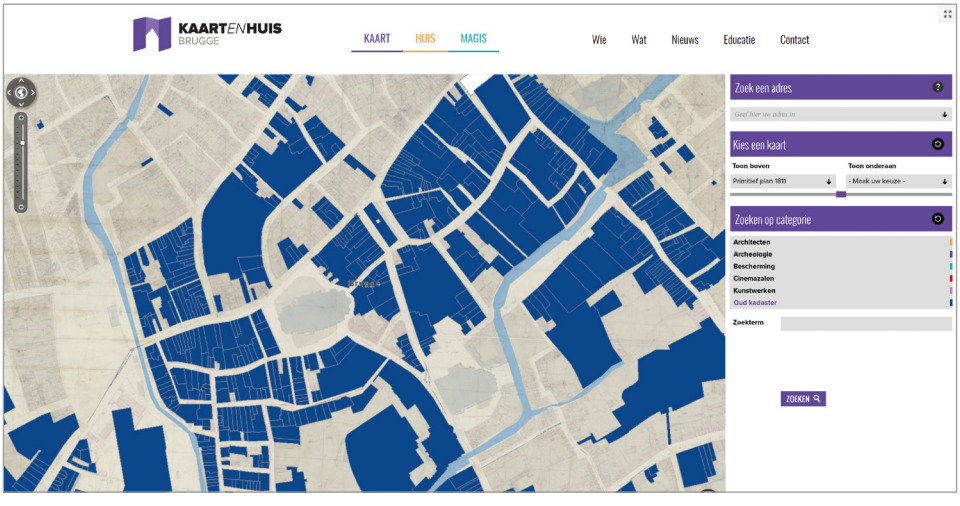
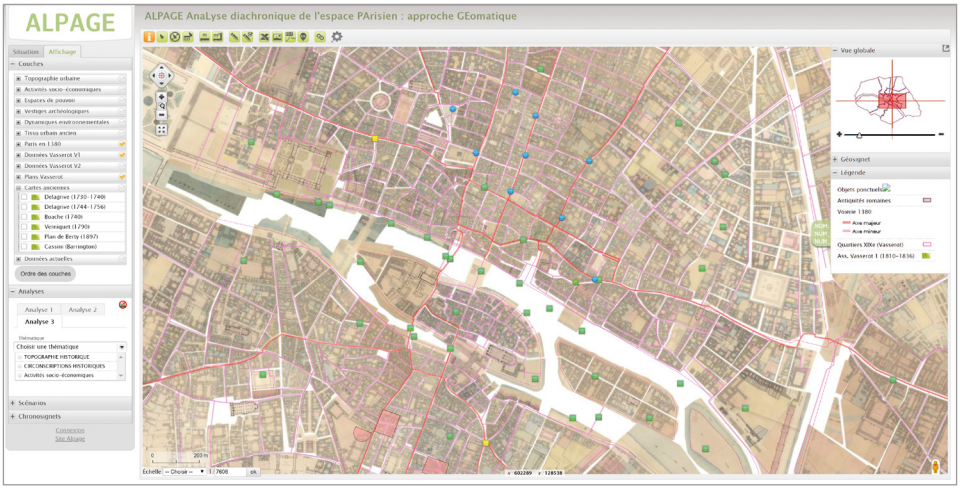
Maps



Map 1: *Primitieve Plan Bruges 1811* [Oud Kadaster], in *KaartenHuisBrugge* [online], available from <http://www.kaartenhuisbrugge.be/Huis> [13 April 2018].

Screenshot of the *KaartenHuisBrugge* website for Bruges, with a zoom on the area around the Saint-Salvator cathedral. The initial cadastral map (*primitieve plan*) from 1811 serves as the base and background layer, on top of which layers presenting data on architects, archaeological findings, protected sites and buildings, cinemas, pieces of art, and property histories can be visualised. By clicking on one of the dark blue polygons, a new window with the property history (*Oud kadaster*) of the parcel pops up. It is also possible to use the search engine on the right side.



Map 2: *Plans d'Îlots Vasserot & Landscape Objects Paris 1380*, in ALPAGE AnaLyse diachronique de l'espace PArisien [online], available from <http://mapd.sig.huma-num.fr/alpage_public/flash/> [13 April 2018].

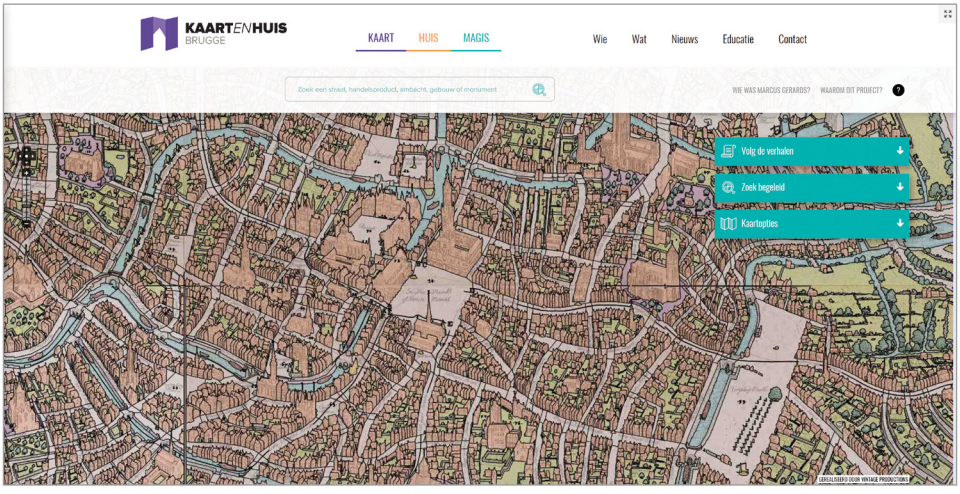
The Paris Alpage website offers the opportunity to export edited maps and diagram legends of the city's old topography, plotted on one of the geo-referenced old or new maps of the city. In the example above, the nineteenth-century *plans d'îlots Vasserot* with the different *quartiers* serve as the background layer for the visualisation of a range of linear and punctual landscape objects that existed in Paris in 1380, e.g. major and secondary roads and streets (red and pink lines), fountains (small blue dots), sites or *lieux* (small green squares), street crosses (small yellow squares), and some Roman antiquities (pink polygons).

Map 3: *Antwerp Vectorized 1834 Cadastre*, in *Gistorical Antwerp* [online], available from <http://www.hisgis.nl/hisgis/gewesten/antwerp/antwerpenkaarten> [13 April 2018].

Screenshot of the *GIStorical Antwerp* project website presenting the results of the digitisation and vectorisation of all parcels in the city-centre of Antwerp based on the cadastral map of 1834. The diagram legend on the right side explains which colour is used for which type of building. The first tab in the menu left above (*Ga naar*) offers the opportunity to search for and navigate to particular streets, while the second and third tabs (*Kaartlagen* and *Achtergrond*) allow one to add layers with additional data (e.g. distribution of professions, former house numbering, other old maps, actual aerial view).

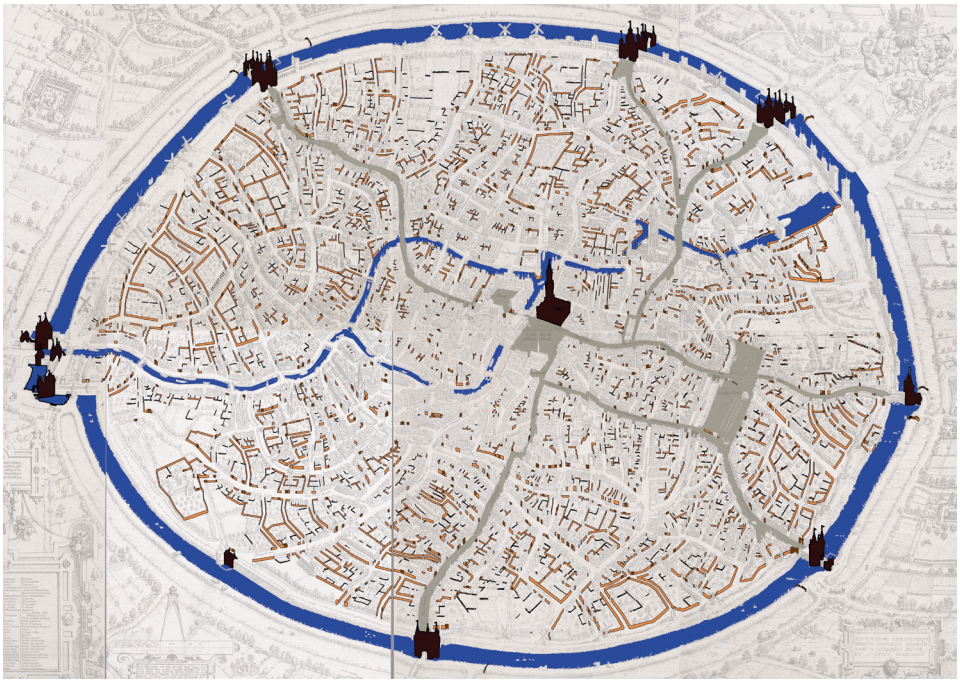
Map 4: Elien Vernackt, *Digital Thematic Deconstruction of Marcus Gerards' Engraved Map of Bruges from 1562*.

Digital thematic deconstruction of Marcus Gerards' engraved map of Bruges from 1562 using QGIS (Bruges Museum). The map objects of the bird's-eye view are redrawn as polygons, saved as vector data, and attributed a particular typology (e.g. house, church, street, bridge, tree, fence, etc.).



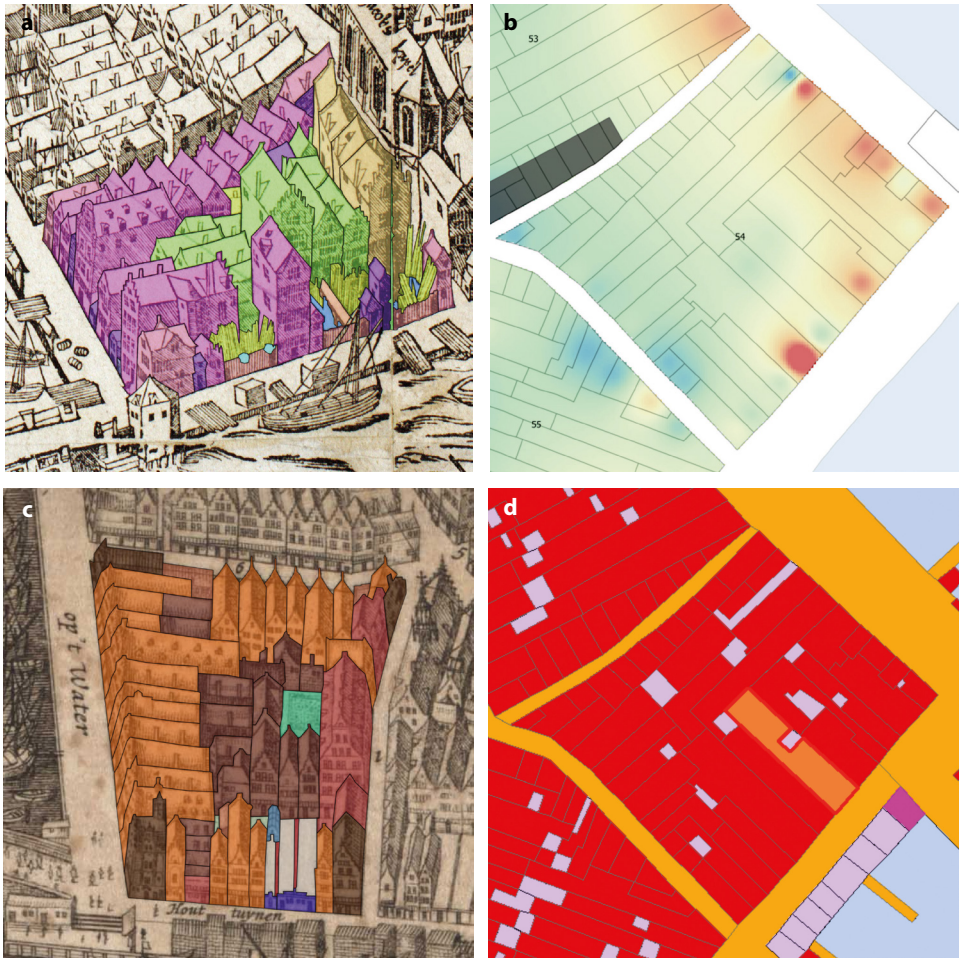
Map 5: *Marcus Gerard (1562) Map of Bruges*, in: MAGIS Brugge, *Kaartenhuisbrugge* [online], available from <http://magis.kaartenhuisbrugge.be/> [13 April 2018].

Screenshot of the *MAGIS Brugge* ('Magic Bruges') website, added to the *Kaartenhuisbrugge* platform. Visitors can manually explore the base map, Marcus Gerards' engraved bird's-eye perspective of the city and its surroundings from 1562, by dragging the image and zooming in and out. Colours have been added to distinguish the main different types of landscape objects (buildings, water, street network, open spaces, fauna). By clicking on those objects, a window with historical background and references pops up. Two search engines offer the opportunity to make general inquiries in the database (blank search field above) or to be guided along some of the main themes of Bruges' history (*Volg de verhalen* and *Zoek begeleid*).



Map 6: Ward Leloup and Bram Vannieuwenhuyze, *Historical Thematic Map Based on the Digital Thematic Deconstruction of Marcus Gerards' Bird's-eye Perspective of Bruges from 1562* [Courtesy of Bruges Museum – Caldenberga].

Historical thematic map, based on the digital thematic deconstruction of Marcus Gerards' bird's-eye perspective of Bruges from 1562. On the map the different types of parcel limits (fences, walls, hedgerows) of the Bruges' city-centre are highlighted. It sheds light on the fragmentary nature of early modern urban space and on the enclosure of large fields in the city's periphery.



Map 7: Juxtaposition of the results of the fourfold digital map analysis for a single building block in Amsterdam. a: Bram Vannieuwenhuyze, *Digital Thematic Reconstruction of Cornelis Antonisz' Bird's-eye Perspective of Amsterdam from 1544*. b: Gabri van Tussenbroek, *Heat Map of Rental Prices from 1562 Plotted on the Cadastral Map from 1832*. c: Bram Vannieuwenhuyze, *Digital Thematic Deconstruction of Balthasar Floris van Berckenrode's Bird's-eye Perspective of Amsterdam from 1625*. d: Geo-referenced and Vectorized Cadastral Map from 1832, from: *HisGIS* [online] <http://www.hisgis.nl/hisgis/gewesten/amsterdam/kaart1830/amsterdam1832> [13 April 2018].

a: digital thematic deconstruction of Cornelis Antonisz's bird's-eye perspective of Amsterdam from 1544. b: heat map of rental prices from 1562 plotted on the cadastral map from 1832. c: digital thematic deconstruction of Balthasar Floris van Berckenrode's bird's-eye perspective of Amsterdam from 1625. d: screenshot of the parcel-based HisGIS.nl website, showing the geo-referenced and vectorized cadastral map from 1832 with data on buildings, parcels, occupants or owners, professions, and taxes in the underlying database.

10.
The Secularisation of Urban Space
Mapping the Afterlife of Religious Houses in Brussels, Antwerp and Bruges

Reinout Klaarenbeek (University of Leuven)

This research aims to investigate the visual and material urban transformations after the suppression of the monasteries and convents in three Belgian towns — Brussels, Antwerp, and Bruges — between 1773-96 and 1860 (Coomans and Klaarenbeek 2014).[1] These towns had a large presence of religious houses: after a first wave of foundation of abbeys from the high Middle Ages, the urbanised Southern Low Countries — more or less the territory of present Belgium — attracted mendicant friaries and nunneries, hospital convents, charterhouses and beguinages in the thirteenth century (Coomans 2018). From the late sixteenth century onwards, a wave of new foundations including the Society of Jesus (Jesuits) resulted from the Catholic Counter-Reformation that was counterbalancing the neighbouring reformed Dutch Republic. At the end of the eighteenth century, the concentration of urban religious houses in the Southern Low Countries exceeded thirty per large town, owning no less than 13-15% of the *intra-muros* urban space.

During the second half of the eighteenth century, religious houses were the target of increasing criticism from the state authorities: they denounced the supranational organisational structures of the religious orders and societies as unwanted interference with state matters. Moreover, the religious properties escaped taxation

1. The research project *Redeveloping the City: urban transformation and 'heritigisation' after the secularization of religious houses in Belgian towns at the dawn of the modern age (1773/96-1860)* is funded by FWO Flanders Research Foundation, no. G.0B0912N. Promotors: Prof. Th. Coomans (KU Leuven, Departement of Architecture), Prof. J. De Maeyer (KU Leuven, KADOC), Prof. I. Bertels (University of Antwerp) and Prof. T. Verschaffel (KU Leuven, KULAK).

and were thought to hinder productivity and the proper functioning of the real property market. Finally, contemplative male and female orders lacked societal interest (Schepper 1942; Laenen 1996). All the religious houses in the Southern Low Countries were supressed in three successive batches. First, the Society of Jesus was suppressed by Empress Maria Theresa of Austria in 1773. Second, all the contemplative 'useless' communities were suppressed in 1784-85 by order of the 'enlightened monarch', Emperor Joseph II of Austria. Third, after the French Revolution had conquered the Southern Low Countries, all remaining abbeys, monasteries, convents, beguinages, and other religious houses were abolished in 1796.

The French state confiscated all the real-property belongings of the supressed religious houses and selected the best ones for its own purposes to accommodate military barracks, workshops, and storehouses. Other former religious complexes responded to the increasing need for educational, judicial, and administrative buildings. Since the number of former religious houses largely exceeded the needs of the state, part of the buildings was conceded to urban authorities. The latter converted religious complexes to accommodate care and educational functions (Antoine 2009), while others were erased to provide space for new urban and architectural developments in the densifying centres (Van de Vijver 2007). Around 1800, all the remaining former religious buildings had been sold on a great scale in public auctions, providing the state with income to finance ongoing wars. The fate of the secularised convents was just as diverging as the intentions of their new owning private individuals or companies.

The 'afterlife' of the former religious complexes until *ca.* 1860 is at the very centre of my research. The first step describes and visualises the afterlife: which complexes survived, how were the ensembles divided into parcels and allotted to various owners, which (successive) new functions were attributed to which buildings? The second step aims to find out which mechanisms can explain this afterlife in the context of the transformation of the ancient regime city towards the modern city? During the first half of the nineteenth century, the notion of heritage was nearly absent — in contrast to the current challenge of adaptive reuse of redundant churches. This research subject embarks on a rather unexplored field, mainly as a result of the disinterest of historians in materiality (Bodinier and Teyssier 2000) and of the preference of art historians for well documented architectural and urban masterpieces.

The implementation of a historical GIS is a highly appropriate methodological tool for this research, considering its capacity to visualise and analyse both space

and time and handling large datasets. A total number of 100 former religious complexes were included in the system, comprising all suppressed abbeys, monasteries, convents, charterhouses, and beguinages of Brussels, Antwerp, and Bruges. This contribution shows a practical example of the implementation of the GIS and describes its challenges and benefits. After having defined the spatial units, the sources, and drawing process, and having visualised the urban changes, I will explain how the database was designed and how the sources were implemented.

Defining the spatial units

Every historical GIS requires, for the matter of topographic coherence, a historical reference map to which all other layers adjust, referred to as a 'base map'. Most historical GIS projects in Belgium use the oldest or 'primitive' cadastral plans as base maps. These primitive plans were drawn up following the accurate methods and guidelines of the French *Recueil méthodique*, using the metric system (Zoete 1979). This high degree of standardisation allows one to use the primitive plans comparatively between cities, despite the fact that these plans were created between 1811 and 1834 and involved numerous surveyors. The processing of the primitive cadastral plans into a digital 'base map' will not be elaborated on here, beyond mentioning that it involved scanning, geo-referencing on the current topography, and, finally, vectorising (Gregory 2002; Knowles 2002).

The next step in creating the historical GIS comprised the reconstruction of the ground plans of the religious houses. Indeed, before anything could be said about the transformation of the buildings, a *zero measurement* was needed: a reconstructed ground plan showing the spatial arrangement at the moment of the suppression. The definitions of this spatial arrangement that were represented in the GIS as vector layers were based on religious houses as an *architectural type* (Coomans 2018: 41-83). The common spatial characteristics of the religious houses include:

1. The enclosure (polygons). Perhaps the most determining architectural aim of a religious house was to separate the life of the community from its (urban) surroundings. The enclosure forms a boundary of the domain and separates this space from adjacent public and private properties. Neither its *materialisation* (freestanding walls, blind or only very occasionally penetrated outer walls of buildings facing adjacent public or private properties, etc.), its *use* or *perception* (variations between orders, time of day, etc.), nor adjacent properties in the form of rented houses were included in this boundary.

2. The gates (points). Even for religious houses with the strictest enclosure as for contemplative nuns, connections between inside and outside were needed. This was achieved in gates in walls or buildings, which included main gates in carefully designed urban settings as well as simple back doors to the gardens.
3. The footprint of the buildings within the enclosure (polygons), including all the buildings regardless their function.
4. Basic functional zones (polygons). All enclosures, regardless of their origins and order, could be divided into three most basic functional zones: the church or chapel, the buildings of the community, and the garden. Despite the fact that religious houses had more architectural and spatial elements in common (sacristy, chapter house, dormitory, refectory, kitchen, parlours, library, etc.), it was decided not to descend to the level of buildings because the unequal sources do not allow themselves to be systematic. Also for this zone, aspects of *use, perception,* and *materialisation* are not included in the definition.

This set of four spatial definitions reduced the religious complexes to their most basic urban characteristic, regardless of their identity, origin, gender, mission, history, etc. The inevitable loss of information through the use of aggregated units is considered a necessary and reasoned concession to lever the analysis beyond individual religious houses to a comparative analysis. The defining took place in an iterative process with the sources available, which ultimately, determined the boundaries of the data categories.

The sources and the drawing process

The era of the secularisation of the religious houses in the Southern Low Countries coincided with significant improvements in the domain of cartography: maps lost increasingly their symbolic connotations through rationalisation (Boutier 2005). Within this context, an outstanding corpus of cartography comprised ground plans of individual religious houses. Anticipating sale, subdivision, or reuse, state-appointed surveyors and architects measured the sites and drew large-scale ground plans (around 1:500 – 1:1.000). These plans appeared in the years following the suppression (1773, 1784-85 and 1796), displaying the state of the complexes at the moment of their secularisation. Georeferencing these maps on the base map revealed their high geometric accuracy. It is mainly thanks to the availability of this outstanding corpus of cartography that most religious houses could be reconstructed.

The source *par excellence* for research into monastic architecture in the Southern Low Countries are the printed bird-eye views from the books of Antonius

Sanderus (1586-1664) and Jacques Le Roy (1633-1719) (Fig. 1). These bird's-eye views depict the (predominantly prestigious male) religious houses and are a product of the regained confidence of the counter-reformed Catholic Church. Art-historical literature duly points to the symbolic aspects of these representations, which urges us to consider deviations such as an over-dimensioning of the church, decreasingly accurate dimensioning towards the edges of the image, false suggestions of symmetry, erroneous reliance on older images or unexecuted plans, omission of information, etc. (Coomans 1988). Nevertheless, the volumes and enclosure boundaries depicted in the bird's-eye views can — through their form, relative positioning, and dimensions — be identified on the primitive cadastral plans. In these cases it seems perfectly justified to assume that both refer to the same building and, consequently, to assign the cadastral footprints to the reconstruction map. More problematic are the cases when the available bird's-eye views show drastically changed urban situations with little or no points of reference with the primitive cadastral plans.

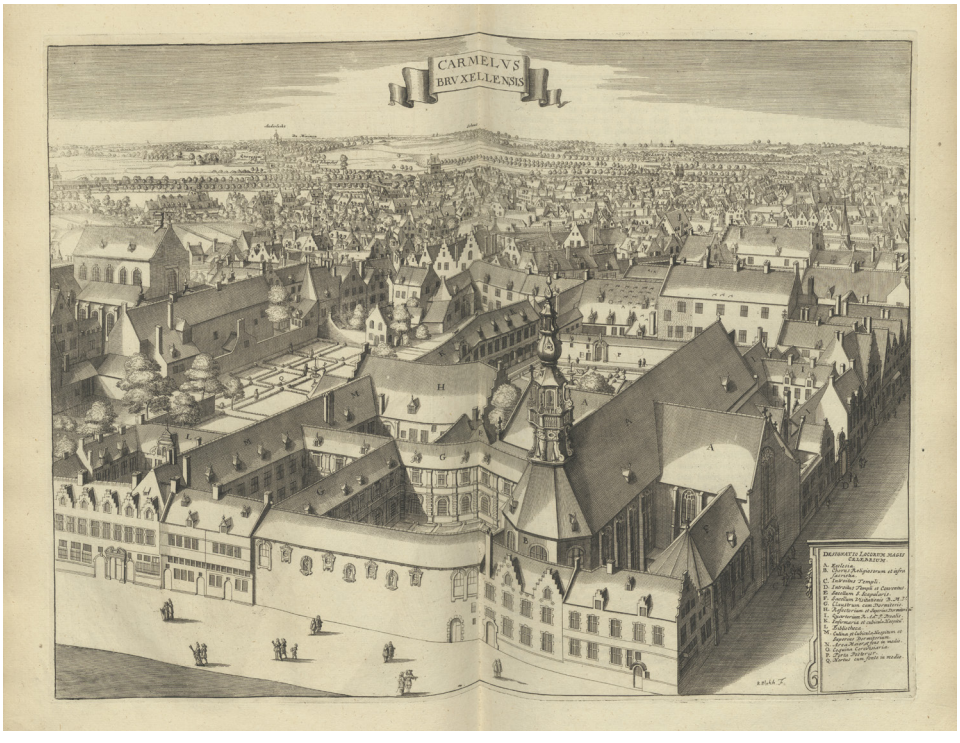


Fig. 1: Reinier Blockhuizen (ca 1650), the Carmelite friary in Brussels depicted in bird's-eye view [Le Roy (1727). *Groot Kerkelyk Toneel des Hertogdoms van Brabant*, 80-81: digitised by Utrecht University, MAG: MAZ 731].

This bird's-eye view depicts the Carmelite friary in its full splendour. Its most prominent feature are the large church with a finely decorated bell tower and the square cloister directly to the left. Further, a conglomeration of buildings is organised around courtyards and gardens. A legend in the right corner specifies the functions of these buildings, which include: parlours, guestrooms, a refectory, kitchens, a chapter house,a library, an infirmary, a brewery, etc.

The reliability of this bird's-eye view that dates to about 150 years before the time of the friary's suppression was tested through a comparison with other cartographic sources. The bird's-eye view turned out to be very similar to the detailed surveys of the friary that were drawn up in 1798 (not depicted). The combination of a bird's-eye view and a detailed survey from 1798 resulted in a reliable reconstruction of the ground plan of the Carmelite friary in GIS.

When an individual ground plan as well as a bird's-eye view is missing, reconstructions could exclusively be based on the primitive cadastral plans to which a *retrogressive* value was attributed. Considering that suppression preceded the cadastral enterprise by only two or three decades, it seems a fair assumption that spatial characteristics of the former religious houses are still, to a varying degree, identifiable on the primitive cadastral plans. Religious houses that are mapped in individual ground plans and depicted on bird's-eye views confirm this assumption. This is not equally true for all four defined spatial characteristics: the enclosures (groups of significant larger parcels) and to a lesser extent the buildings grouped around courtyards turned out to have fairly reliable indicators. Obviously, this retrogressive analysis of projecting information backwards with scarce or even a complete lack of testifying cartographic or iconographic evidence results in a lower reliability of the reconstruction and presents a risk of biasing continuity when compared to the 1834 situation.

The process of drawing the reconstruction maps, in conclusion, involved a historical triangulation of cartographic and iconographic sources. Insofar as time and sources allowed, the sources mentioned above were complemented by additional evidence such as city-maps, photos, drawings, paintings, and field visits. The resulting maps — inclined to suggest a rather unjust objectivity and indisputability — were in need of references to uncertainties in 65% of the cases); 2) a bird's-eye perspective (10%); 3) a detailed urban city map (10%); 4) a retrogressive projection (15%). Furthermore, insecure spatial elements obtained solely through retrogressive analysis were depicted in dotted lines.

Visualising change through superposition

Aspects of the evolution of the religious house could be revealed by confronting the reconstruction layer (1773-96) with cadastral layers of the same area at different times. For this purpose, in addition to the primitive cadastral plans (1811-34), a third time layer was added to the historical GIS. This layer was created by updating the base map (formed by the cadastral plans from 1811-34) to the cadastral situation around 1860. For this purpose, the city plans published by Philippe Christian Popp (1805-79) were used, which were derived directly from the so-called 'mutation sketches', the cadastral system for registering changes in parcel boundaries and buildings (Vrielinck 2018). As such, the layer of 1860 was, both geographically and temporarily, to a large extent compatible with the first two time-layers.

A comparison of the three consecutive maps offered useful means for studying the transformation of the former religious houses. The maps reflect the results of spatial solutions concerning the redistribution and reorganisation of the properties of the former religious houses [**Maps 3a** and **3c**]. Furthermore, the maps reveal the evolution of the footprints of the buildings, which allowed a detailed visualisation of the gradual disappearance of the built substance of the religious houses. To enhance the readability of this evolution of buildings, so-called 'transformation maps' were created that depict the evolution in one sight [**Maps 3b** and **3d**]. With the help of the registers, the parcels on the former religious houses could be further populated with owners and uses [**Map 4** and **Map 5**].

The reliance of this method on the cadastral plans is perhaps both its strength and its weakness. On the one hand, cadastral plans provide research into the nineteenth- century spatial urban history with a very solid cartographic backbone. On the other hand, cadastral plans — suggesting objectivity through uniformity and rationalisation — are subject to source critics, as is any other historical source. With regard to the reliability of the cadastral plans, corruption, under-capacity of the services, or lack of skilled employees could cause incorrect or delayed processing. Furthermore, the scope of the afterlife is limited to the cadastral categories related to land taxation (parcels and buildings), omitting topographical aspects such as fencing, elevation, circulation, and architecture. Ideally, the maps serve as a subject of discussion and as a basis for further refinement, complementation, and possible correction through comprehensive case studies.

The design of a database

A second track of this study consisted of a functional analysis. To this end, the main characteristics of the afterlife of the 100 religious houses were registered in a database, the design of which needed to address both space and time. With regard to space, the level of data-gathering was formed by the functional zones, which included the church, community buildings, and the garden of each former religious house. Consequently, for each zone a 'timeline' was constructed: a subsequent range of time-slots — each defined by a begin- and end-year — covered the period from the suppression to 1860. For each time-slot a set of three variables became apparent:

1. Preservation. The diverging degree of preservation is expressed in three attributes: a) 'reuse', the preservation of building(s) and scale; b) scale, a dissolution of buildings but preservation of scale; c) subdivision, a dissolution of both buildings and scale.
2. Function. Based on definitions of existing heritage thesauri, seven main categories were formulated: military, education, industry, care, religious, parish church, and redevelopment.
3. Actor. Distinction between: state, city, private, and religious.

To illustrate the main layout of the database, Table 1 presents a simplified extract that relates to the afterlife of the Dominican friary in Antwerp.

The implications of using the *zones* as the main level of data-gathering are very similar to the spatial characteristics. The spatial aggregation resulting from the database's inability to register on a finer spatial scale is considered a necessary and reasoned concession, to lever the analysis beyond the individual religious houses to a comparative analysis. The defining took place in an iterative process with the sources at our disposal.

The sources and their implementation

The input for the database mostly relied on existing research. In particular, the accounts on urban history dating from the second half of the nineteenth century — products of the first waves of scientific historical research — proved to be very instructive sources on the afterlife of the religious houses (Stynen 1998: 73-117). Indeed, urban chroniclers such as Alexandre Henne and Alphonse Wauters for Brussels (Henne and Wauters 1848) and Augustine Thys for Antwerp (Thys 1893) supply the database with ample information. Cartographic evidence

Table 1: Afterlife of the Dominican friary in Antwerp.

SPACE: ZONE	TIME: TIMESLOT	VARIABLES: PRESERVATION	FUNCTION	ACTOR	SOURCE
CHURCH	1796-1802	reuse	unknown	state	absent in sale records, scenario and actor deduced from period 1803-1860
	1803-1860	reuse	parish church	city	Thys, 1893: 129; confirmed by cadastral maps
FRIARY	1796-1802	reuse	unknown	state	assumed, see church
	1803-1812	reuse	military barrack	state	Thys, 1893: 130
	1813-1818	reuse	military barrack	city	Thys, 1893: 130
	1819-1861	reuse	parish church	city	used for parish church cadastral 1830 — military still present on urban maps Jouan (1855)
GARDEN	1796-1850	reuse	unknown	unknown	some division on cadastral maps
	1851-1860	subdivision	new street	city/ private	Thys, 1893: 130

such as cadastral maps, the accompanying registers, and urban maps comprised cross-sectional evidence. Additionally, despite the fact that monographs on religious houses and archival repositories tend to stop at the suppression, some of them give some interesting clues about the afterlife of buildings. Finally, a number of surviving and 'heritagised' religious houses were dedicated to more substantial (building) historical research.

The most serious disadvantage of applying these different sources into a single database with predefined categories is perhaps the risk of 'decontextualisation'. A critical use of the sources and persistently providing references to the origin of the data do not entirely take away the fact that the juxtaposition of sources can be problematic. Yet, the alternative of going back to the original sources themselves was impossible in the context of this research project: after the suppression, the

historic evidence became scattered over a wide range of archives (state, urban, clerical, and private) and the extensive sample-size itself would be too large to perform such a comprehensive analysis.

Another aspect that needs to be addressed is gaps in information: for some time periods no or only very scarce evidence could be found. These gaps are registered as 'unknown'. Yet, in order to boost the analysable sample, using hypotheses filled these gaps. About the church of the Dominican friary in Antwerp (Table 1), no evidence was found prior to 1802. However, the fact that the church became a parish church proves that: 1) the building was in the earlier time still existing and 'reused' (preservation) in one way or another (function: 'unknown'); 2) in all likelihood the church had not been sold and still belonged to the state (actor). Eventually, the afterlife between 1773/1796-1860 of each of the three categories (preservation, function and actor) could be determined for over 70%, providing a critical mass for analysis of the data.

The database offered a tool for statistical analysis in itself, as in relation to their location. Querying allowed one to focus the analysis in many directions, whether it was by (combinations of) grouping functions, actors, preservation, or the religious houses' characteristics (gender, era of foundation, year of suppression). Through the use of identical identifiers of the enclosures and zones in both the database and the GIS-tables, the information about afterlife could be mapped [**Map 6**]. By relating them to layers containing characteristics of the historic towns, such as building blocks, rivers, former urban walls, and gates, implicit locational choices could be revealed. Cautious interpretation and verification of the sources (if available) were needed, since geographic fallacy — an overestimating of the role of space — is not inconceivable.

Conclusion

This contribution has addressed the benefits and the issues of using GIS in visualising and explaining the afterlife of secularised religious houses in urban contexts in transformation. In this research, GIS allowed one to lift the research into the afterlife of religious houses — until now the exclusive domain of case studies — to a new, urban, scale. As was pointed out throughout this contribution, research at this level implied the definition of comparable spatial and database units at the price of spatial aggregation and generalisation. These inevitable shortcomings were responded to by a clear defining, a critical use of the sources, and, above all, traceability of the sources. With regard to the sources, this study presents

an example of a full use of the cadastral mapping system in GIS. The cadastral maps were used not only for creating cross-sections, but also for retrogressive analysis, transformation mapping through time, and intra-urban comparisons. The cartographic essay illustrates the GIS and anticipates some results, starting from the Carmelite friary in Brussels.

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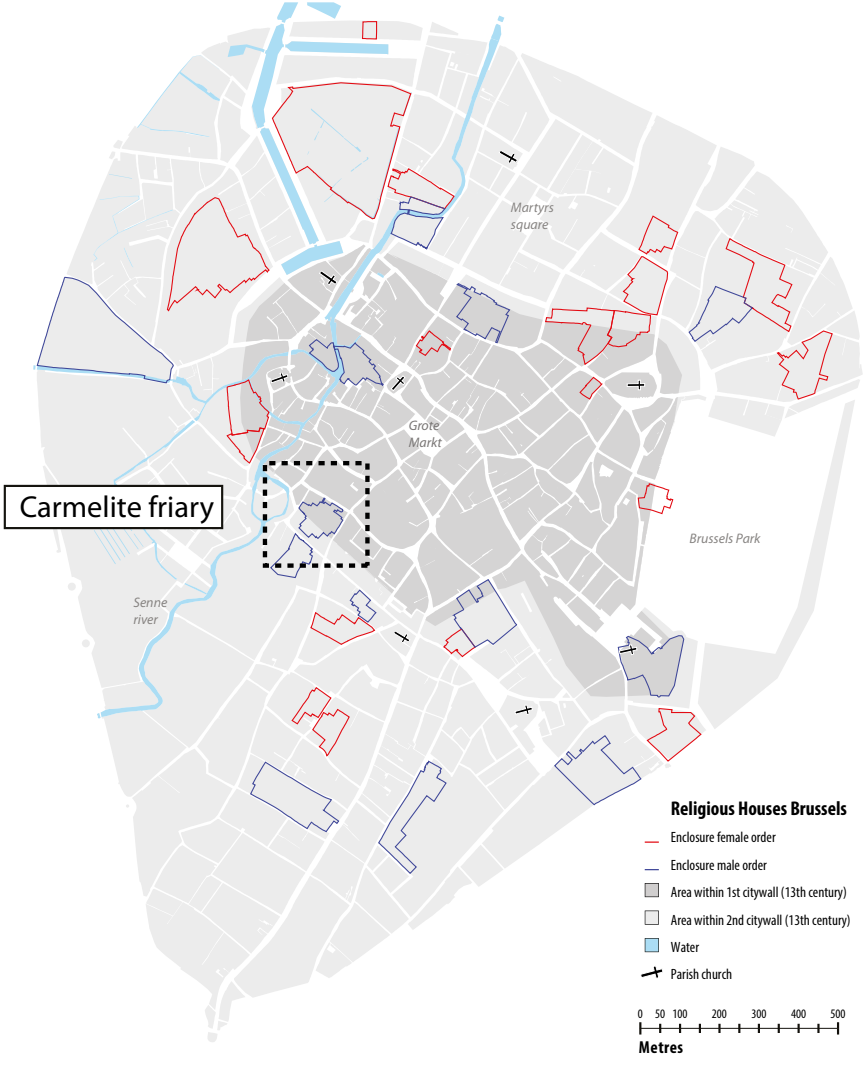
Maps

Introduction to the case study

Flocks of tourists stroll around the famous Brussels attraction *Manneken Pis*. The other side of the street used to be the location of an urban monastery from 1249 to the end of the eighteenth century. The Carmelite friary belonged to one of the major mendicant orders in the Middle Ages. Shifting relations between state and church led to its suppression in 1796. After the religious complex was sold in a public auction, new streets were established through the grounds of the former friary and the buildings were gradually replaced by new houses. Today, no remains of the former friary are visible in the urban landscape.

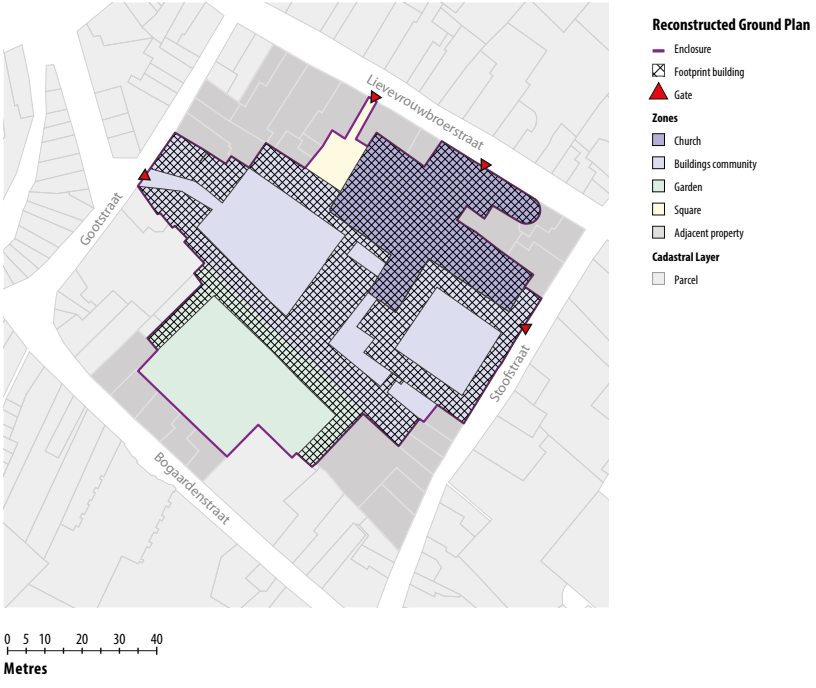
The Carmelite friary is one of the hundred religious houses in Brussels, Antwerp, and Bruges that were suppressed at the end of the eighteenth century. This research sets out, first, to describe and visualise the 'afterlife' of these suppressed religious complexes. Which former religious complexes survived, how were the ensembles divided into parcels of various owners, which new functions were attributed to which religious houses? Secondly, the research aims to find out which mechanisms can explain this afterlife in the context of the transformation of towns from the end of the ancient regime city towards the industrialised society. In contrast to present-day challenges of finding adaptive reuses for an increasingly number of unused religious buildings, the notion of heritage was nearly absent.

At the core of my methodological approach is the implementation of a historical GIS. The GIS proved to be a vital method of conducting a comparative synthesis on the urban level. Using iconographic, cartographic, and, more specially, cadastral plans allowed us to elucidate the evolution of the secularisation of urban space. The following maps of the Carmelite friary of Brussels, illustrate this methodology.



Map 1: Reinout Klaarenbeek (2018), *Location of the Carmelite Friary and the other Suppressed Religious Houses in Brussels.*

The Carmelite friary was founded in 1249 within the first city wall of Brussels (early thirteenth century). Land at the periphery of the town was typical for the settlement of religious houses. The Carmelites' location in the lower part of Brussels is in line with a major distinction of the local monastic landscape: nearly all the medieval religious houses were situated in the western lower part of the valley of the Zenne river, while the seventeenth-century religious houses almost exclusively occupied the higher eastern part of the city. Following the expansion of Brussels and the construction of a second wall in 1357-1373, the Carmelite friary gained a central location.

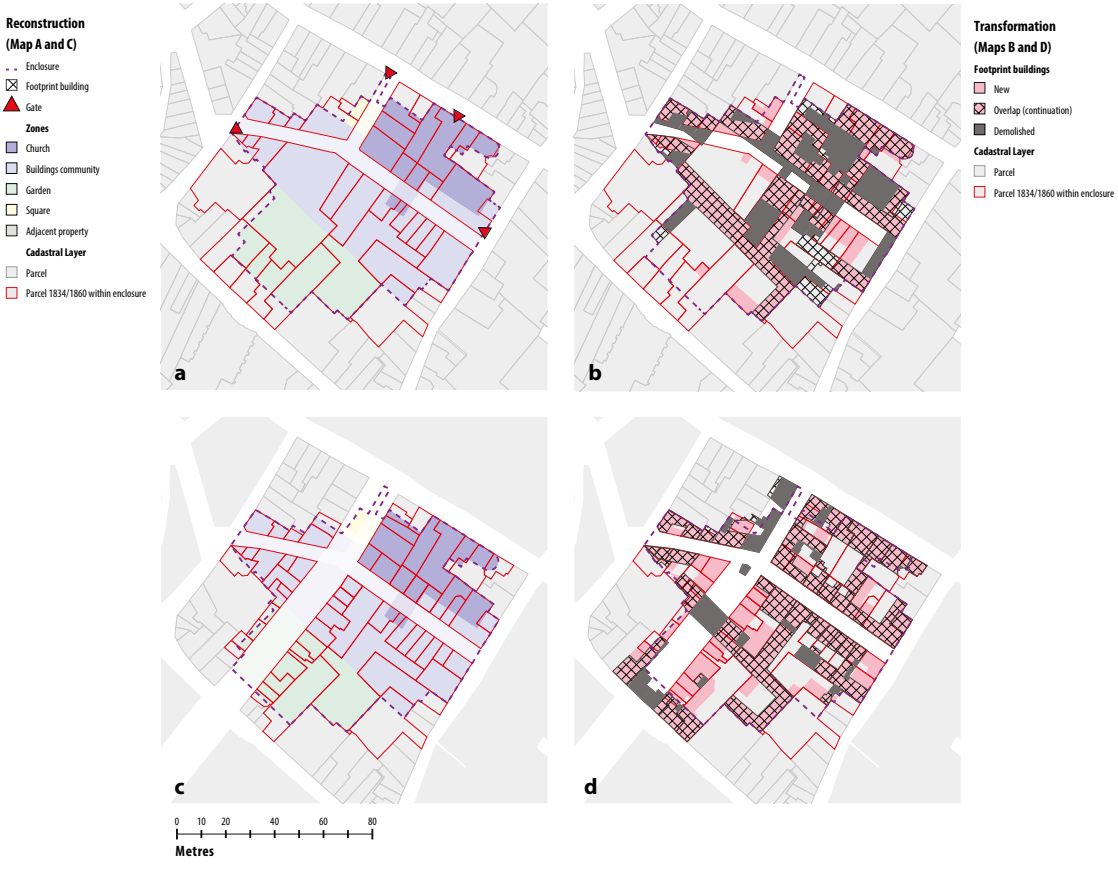


Map 2: Reinout Klaarenbeek (2018), *Reconstruction of the Ground Plan of the Carmelite Friary in Brussels before its Secularisation in 1796*.

Before anything could be said about the transformation of the building complex, a *zero measurement* was needed: a reconstructed ground plan representing the spatial arrangement at the time of suppression. For this reason the available cartographic and iconographic sources were related (georeferenced if possible) to the base map, which was composed of the oldest or 'primitive' cadastral plans from around 1811-34.

The mapping was based on four spatial definitions that reduced the religious houses — regardless of the religious orders' origin, gender, or mission — to their most basic urban characteristics:

- The enclosure (purple line) forms a boundary of the domain of the community, and separates this from adjacent public and private properties. The friars also owned houses outside the enclosure (dark grey) that were rented and were a source of income.
- The gates (red triangles) form the connections between the enclosure and the public sphere.
- Three zones presenting the basic functions of the friary: the church (dark purple) with chapels and sacristy; the buildings of the community (light purple); the garden (green).
- The footprint of the buildings (cross-hatching) is independent of the zones. By the alternation between built and unbuilt space, the organisation of space through courtyards becomes visible.



Map 3: Reinout Klaarenbeek (2018), *Transformation Maps of the Site of the Former Carmelite Friary in Brussels*.

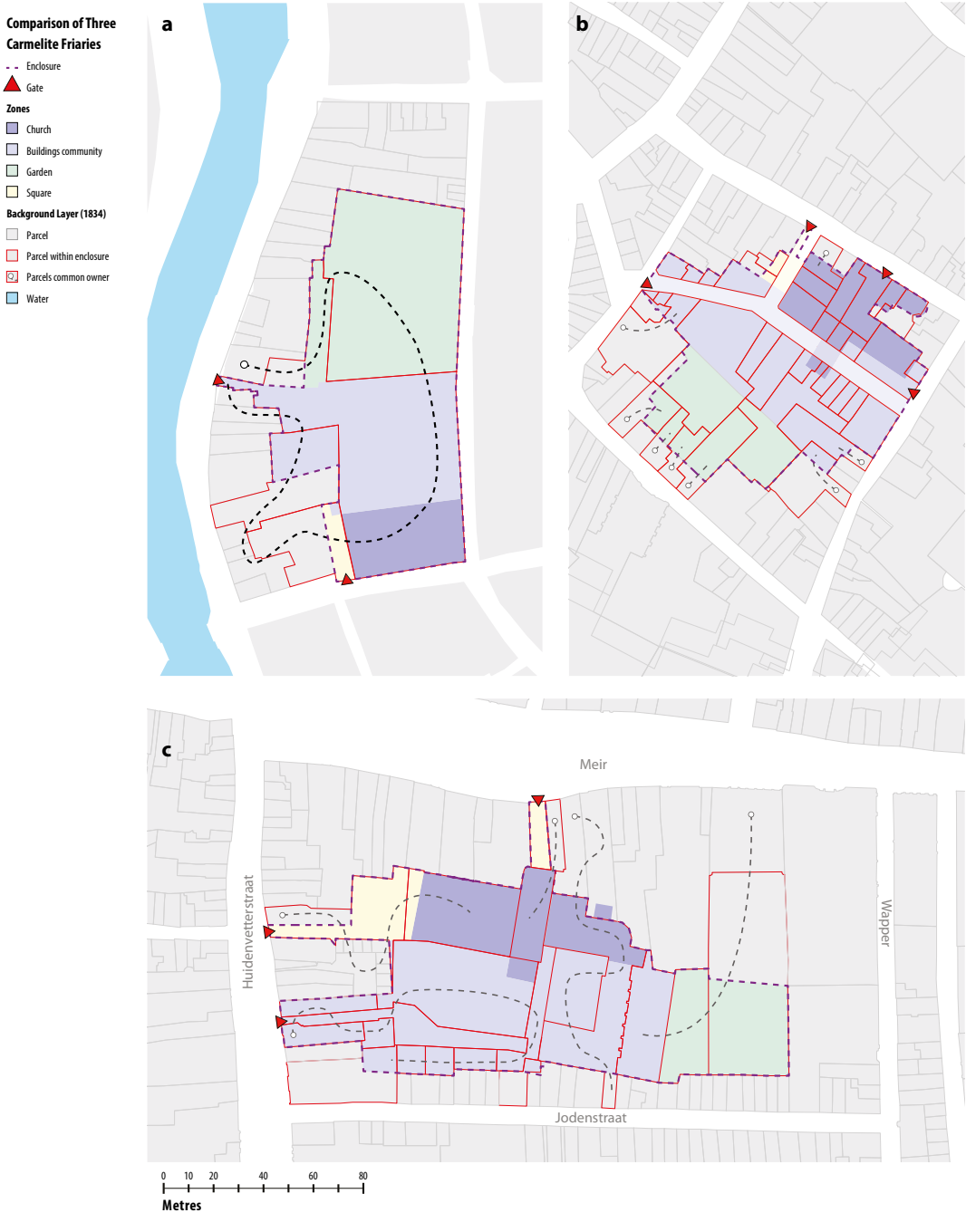
The evolution of the buildings and the parcels of the friary is shown, by overlaying the reconstructed ground plan with layers of cadastral maps from 1834 and 1860. Map a contains the layer with the parcel boundaries of 1834, that is projected on top of the layer of the reconstructed ground plan (without the buildings). It shows the far reaching division of the terrain into small parcels created along new streets. The location of the new streets drew very much on the structure of the supressed friary: the eastern and the northern branches of the new streets were plotted against the (demolished) church. Map b contains the buildings in three categories: demolished after 1796 (black), built after 1796 (pink), and existing buildings/new buildings on former demolished buildings (cross-hatched pink). Map B was obtained by 'overlaying' the buildings of the reconstructed ground plan with the primitive cadastral plans from 1834. It reveals that most parts of the friary were replaced by new housing. Map c contains a layer with parcel boundaries of 1860, that is projected on the layer of the reconstructed ground plan. It reveals the construction of a new, wide, street. Map d contains the evolution of the built areas between 1834 and 1860, obtained by the same overlay process as described in Map b. The new street implied both demolition of houses and construction of new houses alongside the new street.

Map 4: Reinout Klaarenbeek (2018), *Spatial Logics of Reallotment of the Carmelites Friary in Brussels: Directions and Access to Water.*

The logic of reallotment of the terrain of the former Carmelite friary is further explored by creating thematic maps and combining the maps with additional map layers.

Map a depicts parcels in 1834 within the former enclosure. Arrowed lines indicate the direction of the parcels. Partly, existing parcels were extended, especially at the location of the former garden (dark arrows). New parcels were rather rational, rectangular in different sizes (yellow). The parcels created form the existing streets and turn out to be slightly more dominant (grey arrows). Two parcels deviate from the other parcels, by both their size and form (Map a, n°1 and n°2). The first represents a large urban house, which was most probably situated in the former library wing of the friary. The second represents a dead-end street: a small passage leads to a backyard where small houses were created in the remnants of the former friary buildings.

Map b represents the underground water infrastructure of the friary, as mentioined a historical map. The map points to the significance of the accessibility of water: both large parcels had access to wells.



Map 5: Comparison of the Carmelite Friaries' Development in Brussels, Bruges and Antwerp.

Map 5: Reinout Klaarenbeek (2018), *Comparison of the Carmelite Friaries' Development in Brussels, Bruges and Antwerp*.

The Carmelite friary's evolution in Brussels (a) could be compared to that of those in Antwerp (c) and Bruges (b). The use of GIS allowed, above graphic software, the convenient creation of comparative maps with corresponding legends, orientation, and scale.

Map b contains the layer with the parcel boundaries of 1834 that is projected on top of the layer of the reconstructed ground plan. Like the Carmelite friary in Brussels, the friary in Bruges was largely demolished after it got into private hands. However, whereas the former was extensively divided into many parcels, the latter was split up into only three large parcels, owned by a single person (indicated by the dotted line). The difference is illustrative of the different dynamics on the real-property markets between the cities in the early nineteenth century.

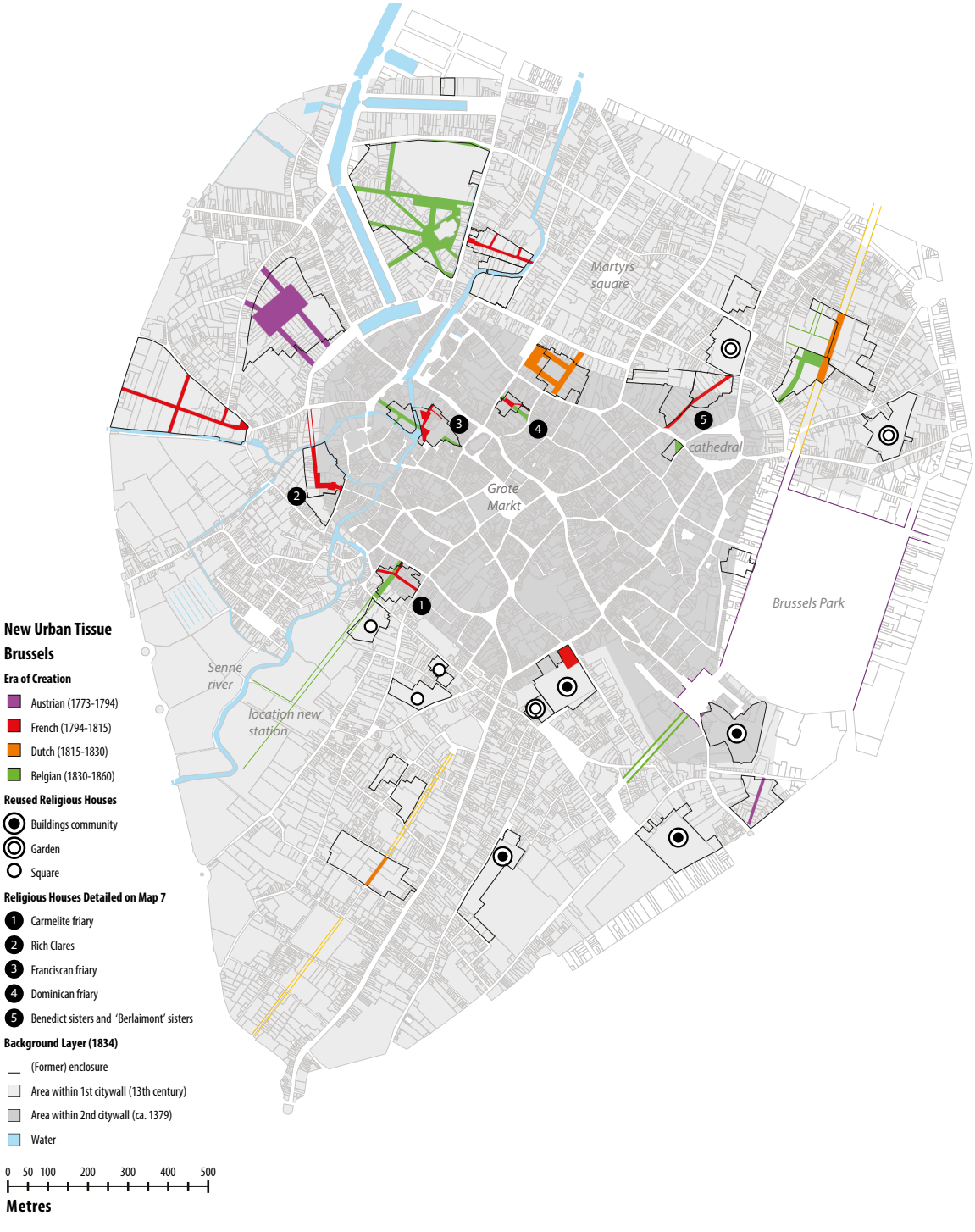
Map c, the Carmelite friary in Antwerp (founded 1498), was, like the Carmelite friary in Brussels, split into a considerable number of parcels. By contrast, the parcels were reached by the existing streets. For one part, the parcels were connected to the street west of the former friary. For another part, they were added to the gardens of the prestigious houses at the street to the north (Meir). Remarkably, the nave, the transept, and the choir of the former church were split into different parcels and belonged to different owners.

Map 6: Reinout Klaarenbeek (2018), *New Streets on the Sites of Former Religious Houses in Brussels*.

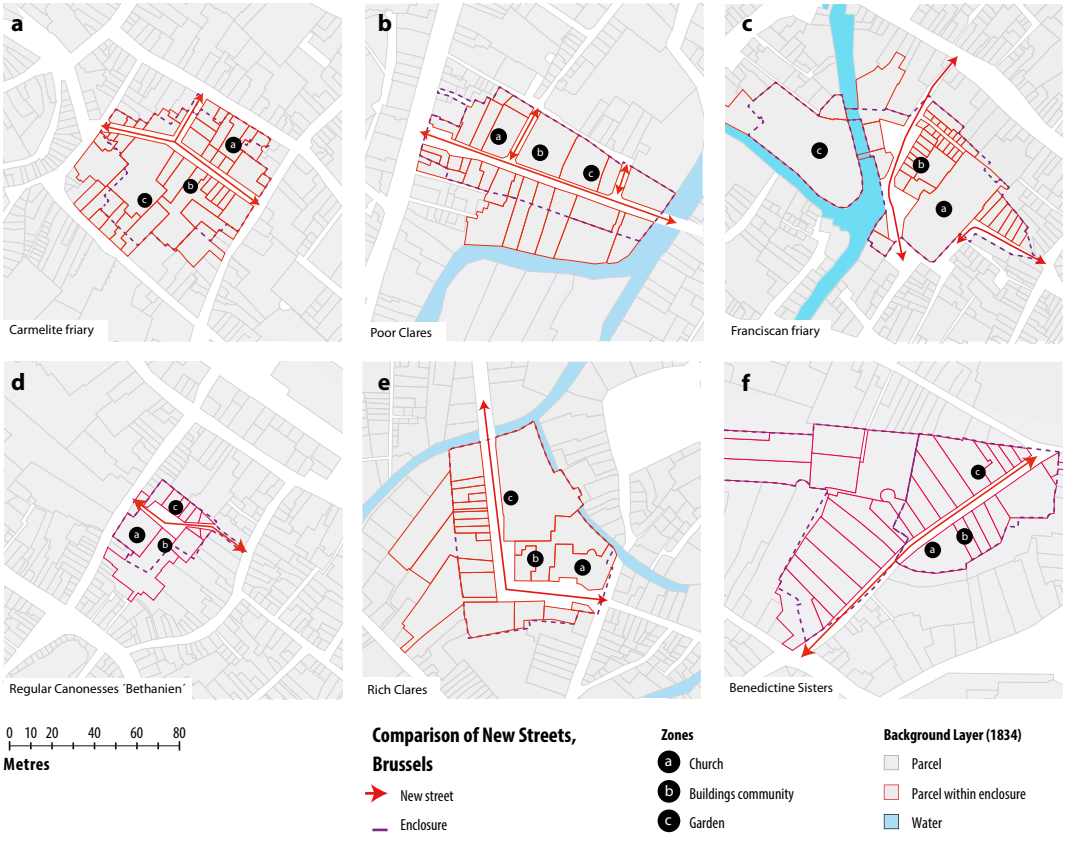
The creation of new streets proved to be characteristic for Brussels. The database of 'afterlife' indicates that Brussels counted eighteen former religious houses with one or more new streets. In Antwerp, with eight cases, the number was significant lower, whereas in Bruges the phenomenon was absent. The new streets — through corresponding identifiers — could be plotted on a city map, to study the scenario in a wider urban context.

Placing the new streets (coloured by their time of creation) in a larger urban setting basically reveals two patterns:

- A clear east-west distinction. At the west side, the availability of large religious houses played a crucial role in three major urban projects. At the east side, reuse by military and other state functions prevailed. This east-west distinction subscribed to a division of 'high Brussels' with the palace and most aristocratic residences, and 'low Brussels' in the Senne valley.
- A distinction between the area within and outside the oldest centre. Within the area of Brussels' first city wall, all the religious houses were subject to subdivision and new streets. Notably in the French time (1794-1815) street building peaked.



Map 6: New Streets on the Sites of Former Religious Houses in Brussels.



Map 7: Reinout Klaarenbeek (2018), *Comparison of New Streets on the Sites of Former Religious Houses in Brussels*.

The new street through the Carmelite friary (a) can be compared to other former religious houses where new streets were created. This allows one further to differentiate between different street building projects and urban results. On map a, the new streets do not connect to existing streets and are relatively small. This finding seems to suggest a dominance of real-property development, rather than improving traffic. The convent of the Poor Clares (b) is comparable, although the east-west junction could be considered as an improvement to the traffic. The Franciscan friary (c) is illustrative of the ad hoc creation of a new public space. On the location of the demolished church a new indoor butter market was created. To achieve better access to this new facility, existing alleys and the open space within the friary's enclosure were turned into public space. The small convent of contemplative Regular Canonesses (d) was turned into an open market. The convents of the Rich Clares (e) and the Benedictine Sisters (f) are examples of combined traffic and real-property development. Interestingly, the new street on Map e was laid out in such a way that monastic buildings were preserved. The church was turned into a parish in 1805.

11.
Mapping Through Space and Time
The Itinerary of Charles of Croÿ

Sanne Maekelberg (University of Leuven)

According to Immanuel Kant geography is the study of space, while history is the study of time (1781/2004). Pushing this classic dictum a bit further, a map is a representation of space which does not show time or changes over time. However, human movement in space as well as in time has attracted the attention of geographers for decades and the examples of social geography are legion. In this chapter, we will look into one individual's reach and constraints in space and time. Charles of Croÿ was, as the fourth Duke of Aarschot, one of the highest ranking noblemen in the Low Countries at the time. He had important functions at court and held several governorships of strategic provinces during his lifetime. The function of governor was an important military position that entailed presence in the territory and defending the borders from external attacks, in the case of Hainaut especially from France. Through a visualisation of the itinerary of his life, we can distinguish patterns linked with his functions and responsibilities as well as with specific events in his private life. Through the composed itinerary a correlation is sought with the network of residences, serving Charles of Croÿ and his nomadic lifestyle. According to Paravicini and Kruse, length and frequency of stay are paramount in defining which residence is 'important' and which is not (Paravicini 2002), an analysis that we want to apply to Charles of Croÿ. The perennial question is which residence is more important in the residential system and why.

The sources

The reconstruction of Charles of Croÿ's itinerary is based on two important sources: his own memoirs and a collection of his letters.

Charles of Croÿ briefly described his own life in his *mémoires autographes*, which he wrote himself in 1605. These memoirs were published in 1845 by the baron de Reiffenberg and are an important source concerning the life of Charles of Croÿ (de Reiffenberg 1845). However essential to gain insight into his mind and thinking, they are unfortunately not detailed enough to reconstruct his itinerary, since they only give a year-by-year outline of his activities. In that sense, they differ from the itineraries reconstructed by Paravicini for the Burgundian dukes in the fifteenth century, which are based on the day-to-day accounts of consumables at the court.

A second, more extensive source gives more insight into his whereabouts. The *lettres missives* conserved in Brussels at the State Archives of Belgium constitute a collection of correspondence containing 912 letters, written from 1580 to 1612. Most of these letters were not actually penned by Charles of Croÿ himself but by a secretary. In accordance with the customs of that time, each letter bears the signature of Charles of Croÿ, in his own hand, together with the location and date of sending. This information makes it possible to retrace the duke's movements.

The use of historic correspondence to research spatial patterns and relations is not new. Several projects work on the question 'how to solve a problem like correspondence?' (Cultures of Knowledge). The University of Oxford created an open source catalogue and archive of letters, making them available to researchers worldwide (Cultures of Knowledge 2009). This initiative was based on the fact that the collection of letters created by one person is often scattered across different archives located all over the world, making it extremely difficult to master for one researcher. Applied examples are the 'Mapping the Republic of Letters' project of the University of Stanford, which focuses on the visualisation of complexity in spatial, temporal, and biographical information (Mapping the Republic of Letters 2015). A number of case studies demonstrate the information that can be deduced from these letters, ranging from travel to publication data. Since 2013 the Huygh-ens Institute has been working on a project entitled 'Circulation of Knowledge and Learned Practices in the seventeenth-century Dutch Republic' (Circulation of Knowledge 2013). Through the *ePistolarium* linked to this project visualisations of social networks, established by the analysis of more than 20.000 letters, are made possible. Here a virtual research environment, the database of letters and metadata, can produce dynamic visualisations based on several filters.

All of these examples have a strong focus on networks, as letters establish a con-nection between sender and receiver. As the letters we examined were mostly addressed by Charles of Croÿ to the consecutive governors of the Low Countries,

Fig. 1. Adrien de Montigny, The castle of Chimay, 1597. Dülmen, Herzog von Croy'sche Verwaltung, Hs. 38: 'Album of Croÿ – Croÿ properties in Hainaut', fol. 5 (digitised by KU Leuven Libraries).

and especially Archduke Albrecht of Austria and the Infanta Isabella of Spain, a network analysis of this collection would not add much to our research. We decided to focus on the biographical information that could be deduced from these letters, since we aim to study the role of the ducal residences in the itinerary of Charles of Croÿ (Fig. 1).

Spatiotemporal approach using QGIS

Based on these sixteenth-century sources we created our own dataset. While the spatial-geographic information from the autobiography was a bit harder to decode, the extraction of information from the letters was pretty straightforward. The resulting dataset consists of the location, which is the name of a town or village, and an accompanying date. To make this information legible for GIS software, the location was expressed in geographic coordinates [Table 1]. GIS enables very accurate locations, however the historic evidence that we have does not. Wherever possible, we used the coordinates of the residence where Charles of Croÿ stayed, but more often the centre of the city mentioned in the letter was used.

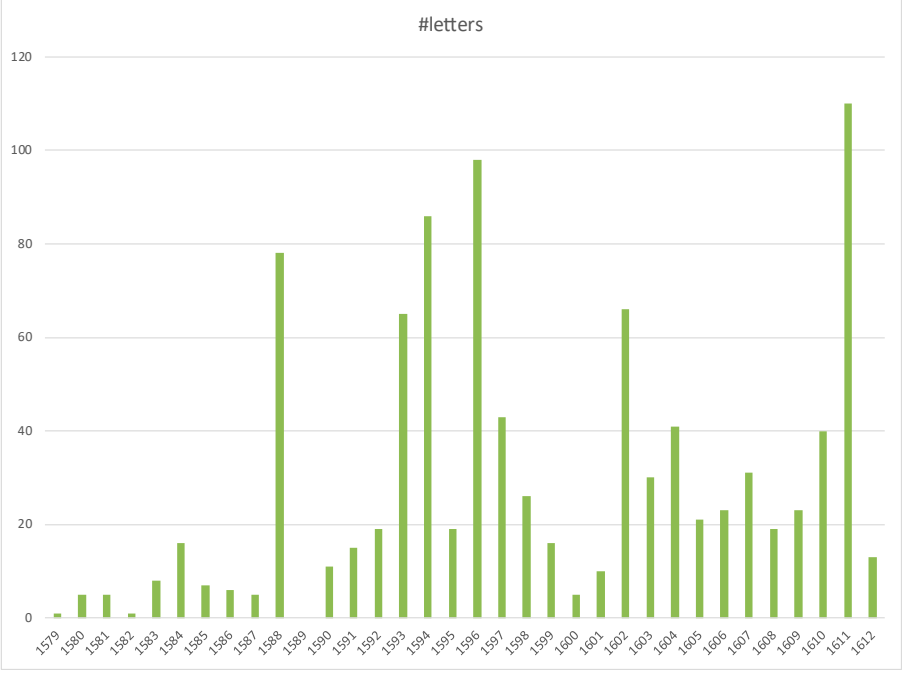
One of the other characteristics of historic sources, however, is that they are not systematic nor fully preserved/found. The same goes for the source material we used. The letters collected in the State Archives in Brussels cover 32 years with 912 letters. Even though the collection is extensive, it is not nearly large enough to cover 32 years of travels and duties. Thus, there are important gaps in the continuity of the source material that must be considered and shown in the visualisation [Table 2].

The geographic aspects are one layer of the information, but the dataset also includes time. Using the Time Mapper plugin for QGIS the time dimension can be added, after converting the time data to the Gregorian timeframe. Dates from before 1582 are expressed in the Julian timeframe, leading to a discrepancy in the data. This is solved by converting the Julian times to the current Gregorian timeframe, which is also recognised by most GIS software. Now the gaps in our data really become visible. We can cover the entire life of Charles of Croÿ with a three-hour movie, but obviously for long stretches on end no information is available. The gaps can, however, be reduced to a minimum by including all the additional source material and literature on the life of the fourth Duke of Aarschot. Most importantly, the dataset was completed with all the documents that we could find that were also signed and dated by Charles of Croÿ. These comprise the numerous descriptions, pre-cadastral maps, plans, contracts, and specifications concerning his properties and domains, all personally revised by him.

Table 1: Dataset of the itinerary.

	Day	Month	Year	field_4 ▲	field_5	X-co	Y-co
2539	26	11	1611	1611-11-26	Comines	50.76534399…	3.006975000…
2540	26	11	1611	1611-11-26	Bruxelles	50.84209299…	4.359360000…
2541	27	11	1611	1611-11-27	Lille	50.63988400…	3.061823000…
2542	27	11	1611	1611-11-27	Lille	50.63988400…	3.061823000…
2543	28	11	1611	1611-11-28	Ippre	50.85115600…	2.886246000…
2544	28	11	1611	1611-11-28	Ippre	50.85115600…	2.886246000…
2545	28	11	1611	1611-11-28	Lille	50.63988400…	3.061823000…
2546	29	11	1611	1611-11-29	Dixmude	51.03347300…	2.864942000…
2547	30	11	1611	1611-11-30	Bruges	51.20880700…	3.224119000…

Table 2: Number of letters according to year.



In addition we can make up some hypotheses concerning the whereabouts of Charles during the gap periods. For example, his autobiography mentions that he studied in Leuven, so we assume that he stays there for several years. If he is said to participate in a battle, we can hypothesise on his journey, but still the lacunae remain significant, as demonstrated by the movie. This linear visualisation allows

to identify some of the important functions of Charles of Croÿ. For example his appointment as governor is always followed by an exploratory tour of the respective province, but it is impossible to deduce personal patterns linked with his own preferences.

As base map to display the information deduced from the composite biography we used a map of the Low Countries. In the sixteenth century the Low Countries consisted of 17 provinces, roughly corresponding with present-day Belgium, Luxembourg, The Netherlands, and Northern France. By 1600, a pivotal time for our analysis, the Northern Low Countries (approximately The Netherlands) had virtually split off from the Southern Netherlands. Despite the fact that until the Peace of Westphalia (1648) the boundaries would remain subject to constant change due to the continuous military conflicts, we use a static map for the nine Southern provinces under Spanish rule, based on contemporary sources (Jongepier 2014) [**Map 2**]. Underlying the provinces we use the little-known 'Vrients' map from 1602 showing the Low Countries during the reign of Archduke Albrecht and the Infanta Isabella (1598-1621) (Vrients 1602). This map — consisting of twelve sheets glued together — is oriented towards the west [**Map 1**], but after meticulous geo-referencing it can be made to match the seventeen provinces.

Web-based presentation

The biography of Charles of Croÿ can be visualised using several online tools. A first approach was developed using StoryMap JS, a free online tool that allows one to tell stories based on the locations in which they occurred. The sites linked to the itinerary of Charles of Croÿ can be easily visualised on a map of the present-day borders and state lines. However, these borders have little to no significance with regard to the political situation in the sixteenth century. To implement the contemporary map with the borders of the seventeen provinces, the underlying layer should be a pixel-dense file of this map, i.e. an image. The advantage of using this tool is that you can tell the story of one lifetime through a semi-interactive tool, while the locations can be combined with a certain level of narrative information on the whereabouts of the duke. However, it is essentially a linear approach, which moves through the life of Charles of Croÿ in a forward direction and which does not allow one to emphasise certain locations or information. Furthermore a lot of the locations in the itinerary are often repeated, as Charles visits certain locations on several occasions during his lifetime, which makes the StoryMap JS visualisation rather complex. The tool seems more suited to creating travel visualisations or tours around a certain territory.

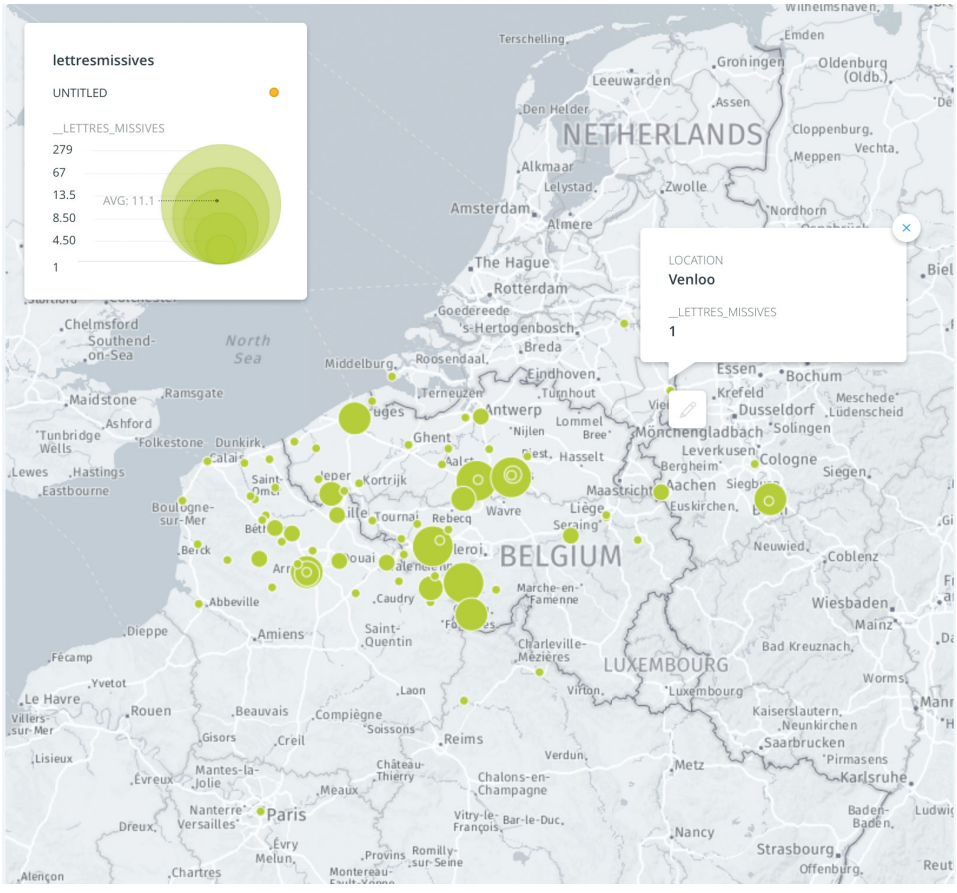


Fig. 2: Sanne Maekelberg (2017), *Relative Time Spent at Different Locations during Charles of Croÿ's lifetime*, made with CartoDB.

The challenge of illustrating changes over time is solved here using web-based interactive maps, made with CartoDB. Unlike printed maps, these allow the viewer to browse through certain time periods and to go back and forth, contrary to the linear movement of the guided animation (made using QGIS) and the approach using StoryMap JS. Essentially developed for modern-day applications, this tool can also be transformed to fit historic research. The composed dataset used in QGIS can be directly imported into CartoDB, and after geo-referencing you immediately get the locations plotted on a present-day map. Using the built-in options for visualisation you can easily achieve a map showing the 'importance' (that is, the relative time spent based on the number of letters) of the different locations by the size of the spheres (Fig. 2) [Map 3]. Here, too, additional information

can be added in a pop-up window, such as the location, the number of letters and even the reason for the presence of the duke, which is narrative information. CartoDB also allows one to take the time-factor into consideration by adding a timeline to the visualisation. Despite the limitations of the open source software that was used, a coherent visualisation with browsing options was possible.

Discerning personal patterns

This analysis gives a general overview and a visualisation of Charles of Croÿ's lifetime. However, keeping in mind our general aim of reconstructing his network of residences, we are looking for patterns such as seasonal migration which will allow us to make more sense of his itinerary in relation to his residential network. An approach using static superimposed maps provides a solution. After dividing and superimposing the maps according to season we get some interesting results. During Spring (March–June), Charles of Croÿ distinctly preferred to stay in Beaumont and in Heverlee, both residences with important hunting facilities. This actually matches the archdukes' preference for going hunting in the Spring. Brussels, on the other hand, is most visited during Autumn and Winter, which is understandable if we consider that the city was probably uncomfortably hot, not to say unhealthy, during the Summer. Despite the incompleteness of the sources, some seasonal migration can thus be discerned, with a hunting season in the Spring and the avoidance of the main court residence city during the Summer [**Map 4**].

The same conceptualisation is used to cover the 'seasons' of the life of Charles of Croÿ, divided according to his functions. Again we see some distinctive patterns, linked with the different periods in his life. In the period 1580-84 the focal point is in Flanders, which seems self-evident when considering his governorship of the province. During the following time periods, Flanders completely disappears from the itinerary. Also his appointment as governor of Hainaut is clearly visible, with a major increase in his stays in Mons, capital of the province, from 1595 onwards. However, we also see a parallel tendency to retire towards Beaumont and Heverlee. At the same time the number of letters increases, probably meaning that Charles spent less time in the close vicinity of the court (making letters more necessary) [**Map 5**].

As shown by these strategic maps, a nobleman of the highest rank such as Charles of Croÿ had, to some extent, the luxury of his own migrational patterns, free from the obligatory attendance at court. Charles does not follow the distinctive seasonal

migration of the archdukes to their country residence in Mariemont, where they spent long periods every Spring and Autumn, as shown by an analysis of their correspondence (Demeester 1978). On the other hand, Charles of Croÿ remained at their beck and call, as shown by the summons to Brussels on several occasions. Even when he retired, from 1605 on, he continued travelling in the service of the archdukes.

From the information in the source material we can also deduce some of the travels that Charles of Croÿ undertook in his lifetime. Two examples are especially informative. In 1580, at the beginning of his career, Charles undertook the journey from Aachen to Antwerp to join the Revolt together with his wife Marie de Brimeu, as he had Protestant sympathies at the time. By mapping out this journey it becomes clear that he obviously did not take the shortest possible route, clearly avoiding the territories controlled by Alexander Farnese, moving from the principalty of Liège (which was a separate state at the time) through France and continuing by boat to Antwerp [**Map 6**].

The second journey is dated 1611 when, aged 51 and at the end of his career (and life), Charles undertook a last trip through the provinces of Flanders, Artois, and Hainaut [**Map 7**]. During this two-week journey he visited one town a day. Considering his age and health issues, as Charles of Croÿ was known to have gout which caused painful inflammations in his hands and feet, this journey cannot have been an easy undertaking. We can deduce, however, an average daily travel distance equal to thirty kilometres, which is approximately the distance between Heverlee and Brussels, and Beaumont and Mons, respectively. This proximity to important political capitals also helps to explain the crucial role of the residences of Heverlee and Beaumont as favourite places of retreat of Charles of Croÿ.

Conclusion

There is certainly an added value in using GIS to work on historic data. Due to the lack of sources, it is hard to discern patterns using the linear representation covering the entire lifetime of Charles of Croÿ. However, the creation of strategic superimposed maps does throw new light on the movement habits of this high nobleman. In order to make it accessible and comprehensible to a larger audience, the representation needs to include a certain level of interactivity. This is achieved by the implementation of a web-based representation, which allows one to toggle between time periods and locations.

We can conclude that by using GIS to query the available data, we saw things that we had not seen before, which makes this approach an undeniable gain with respect to the classic methods. The visualisations revealed an obvious centre of gravity in the province of Hainaut when it comes to the duke's presence. Because of the results of this research we decided to focus on Heverlee, Brussels, Beaumont, and Comines, as they emerge as the primary places of residence not linked with the military duties of the duke. The use of this method highlights the different uses of the residences — military, hunting, and proximity to the court — which was the base of the selection of case-studies for further research.

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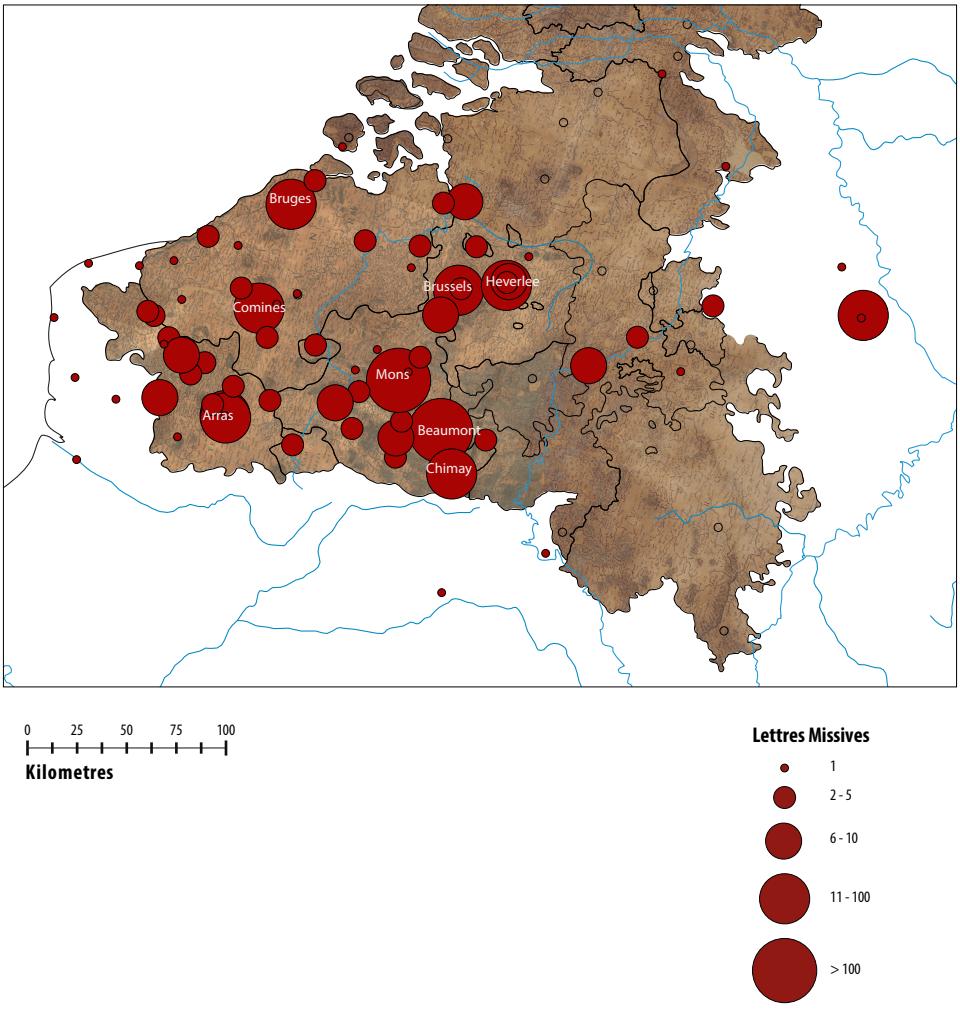
Maps

Map 1: Vrients, J. B. (1602), *Nova et emendate totius belgi sive inferioris germaniae cum adiacentibus et finitimis regionibus geographica description antverpiae apus ioannem baptistam vrients anno a christo nato MDCII* [© City Archive Furnes (Veurne)].

'Vrients' map from 1602 showing the Low Countries during the reign of Archduke Albert and the Infanta Isabella. The map — consisting of twelve sheets glued together — is oriented towards the west.

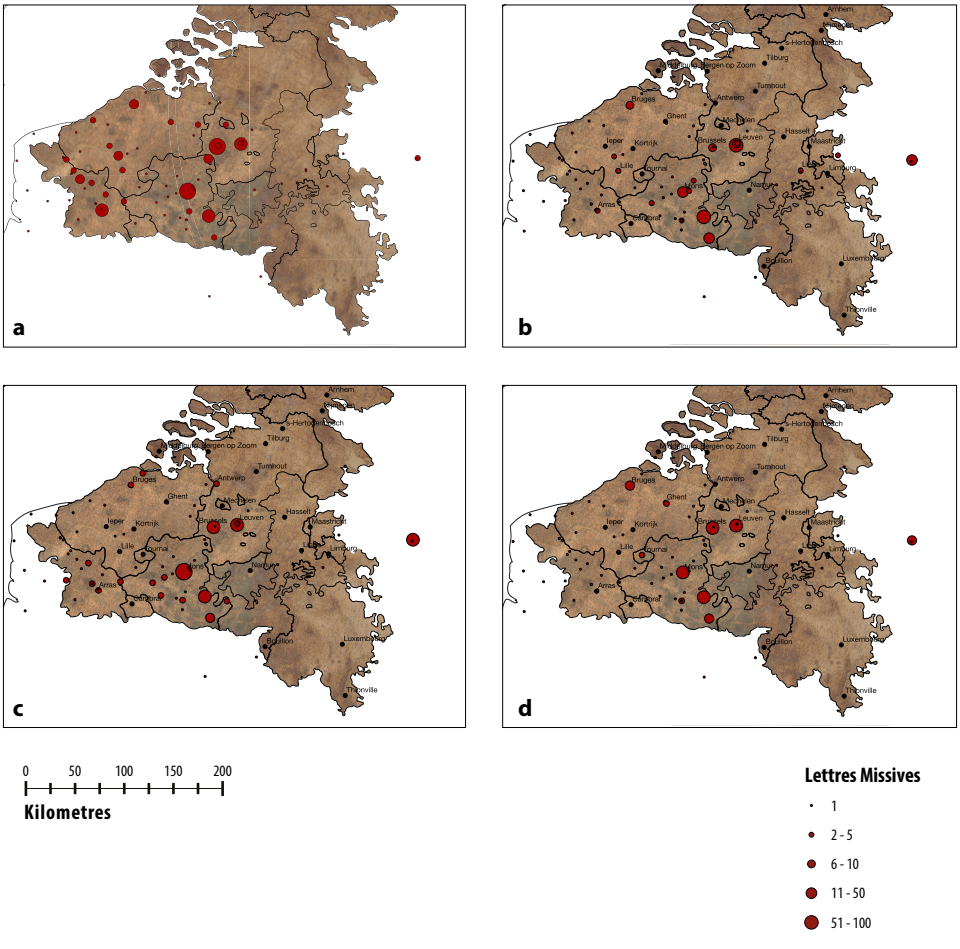
Map 2: Sanne Maekelberg (2017), *The 17 Provinces of the Low Countries around 1600* [Combination of the 'Vrients' map © Stadsarchief Veurne, with a reconstruction of the Low Countries © I. Jongepier/GIStorical Antwerp – University of Antwerp/Hercules Foundation].

Map of the Low Countries around 1600, displaying the 17 provinces, roughly corresponding with present-day Belgium, Luxembourg, The Netherlands, and Northern France. Despite the fact that until the Peace of Westphalia (1648) the boundaries would remain subject to constant change due to continuous military conflicts, we use a static map for the nine Southern provinces under Spanish rule.



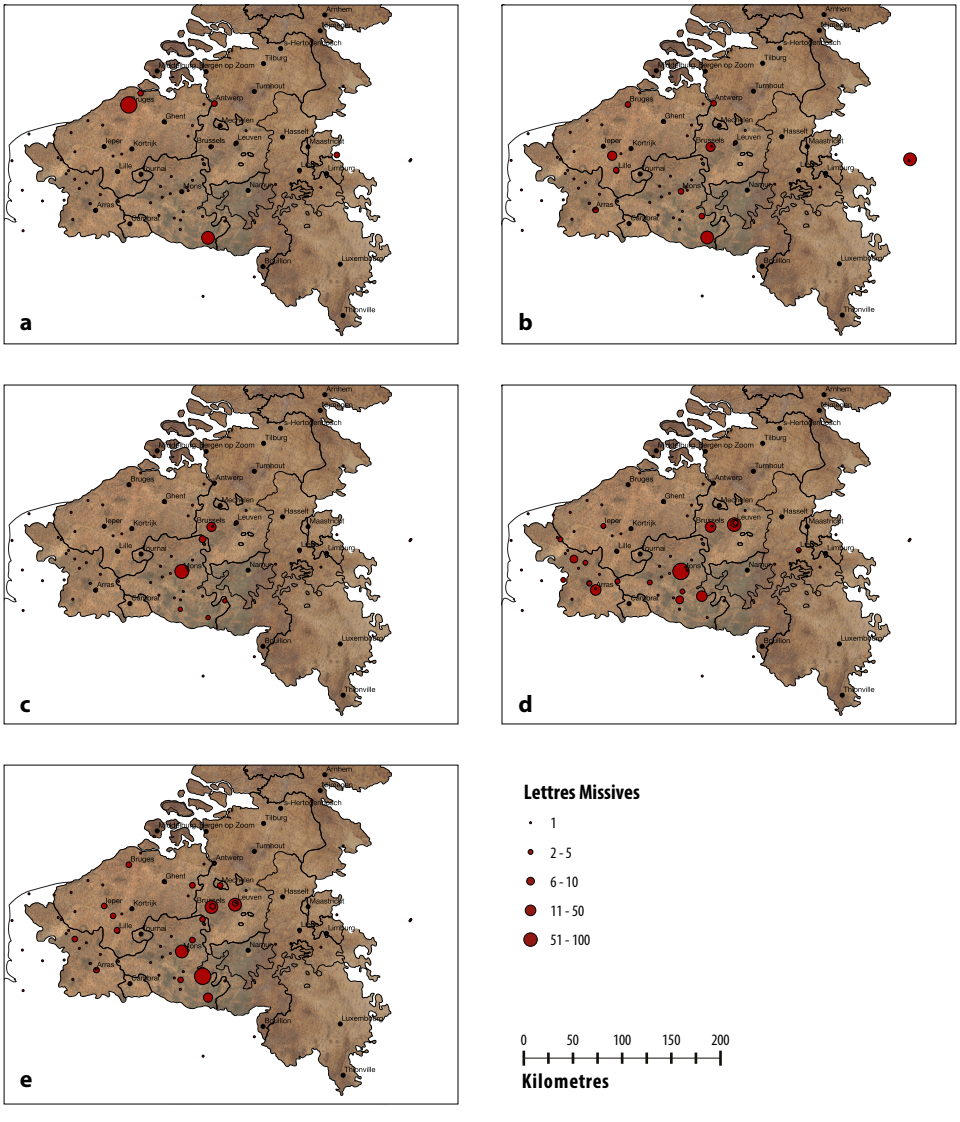
Map 3: Sanne Maekelberg (2018), *Relative Time Spent at Different Locations during Charles of Croÿ's lifetime*.

Map elaborated on the basis of CartoDB analysis [Fig. 2], showing the relative importance — that is, the relative time spent in based on the number of letters — of the different locations



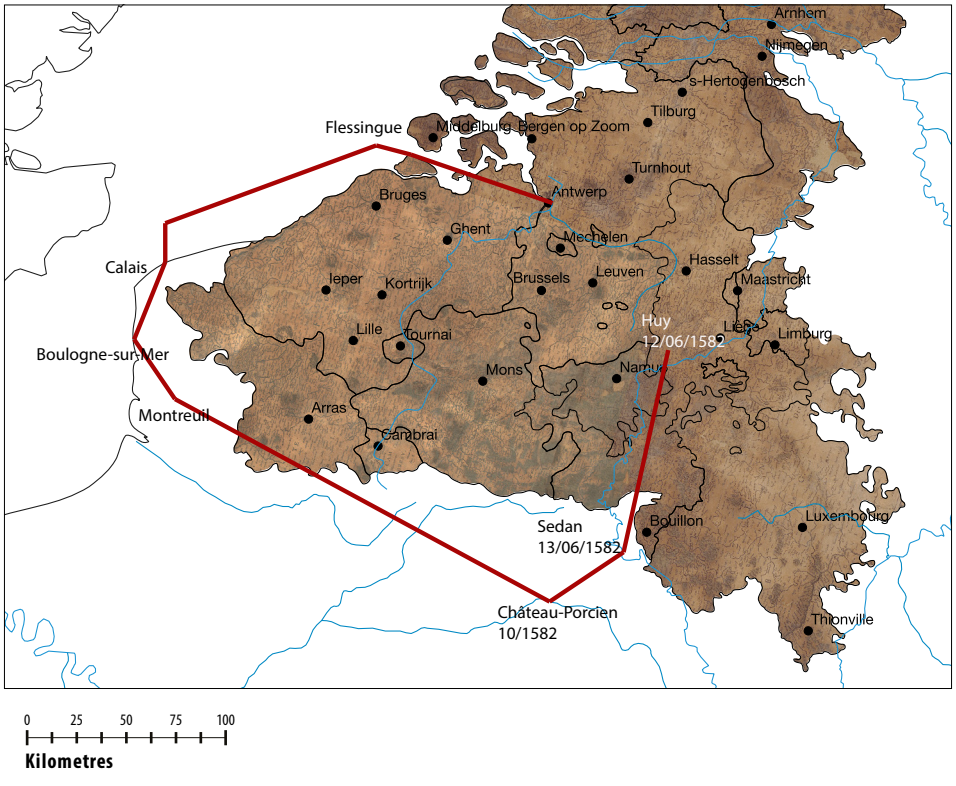
Map 4: Sanne Maekelberg (2018), *Superimposed Residencies of Charles of Croÿ.* a: fall residencies; b: spring residencies; c: summer residencies; d: winter residencies.

Static super-imposed maps, divided according to season, show the seasonal migration of Charles of Croÿ. During Spring, he distinctly preferred to stay in Beaumont and Heverlee, both residences with important hunting facilities.



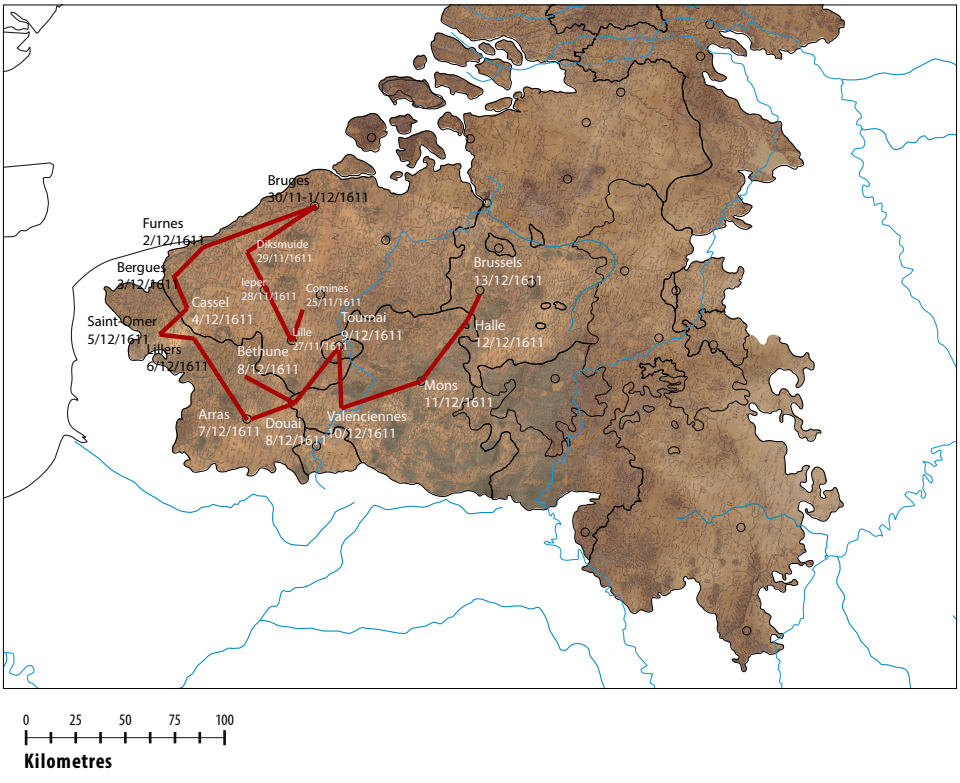
Map 5: Sanne Maekelberg (2018), *Superimposed Map of Charles of Croÿ's Residencies*. a: 1580–1584; b: 1585–1592; c: 1593–1595; d: 1596–1605; e: 1606–1612.

Static superimposed maps of the 'seasons' of the life of Charles of Croÿ show distinctive patterns linked with his functions. In 1580-84 the focal point is Flanders, as he is governor of the province. His appointment as governor of Hainaut is clearly visible, with a major increase in his stays in Mons from 1595. By the end of his life he retired to Beaumont. Charles of Croÿ had, to some extent, the luxury of his own migrational patterns, free from obligatory attendance at court.



Map 6: Sanne Maekelberg (2018), *Charles of Croÿ's Journey from Liège to Antwerp in 1582*.

In 1582 Charles of Croÿ undertook the journey from Liège to Antwerp to join the Revolt together with his wife Marie de Brimeu. The map of this journey shows that he obviously did not take the shortest possible route, clearly avoiding the territories controlled by Alexander Farnese, moving from the province of Liège through France and continuing by boat to Antwerp.



Map 7: Sanne Maekelberg (2018), *Charles of Croÿ's Journey through the Provinces of Flanders, Artois and Hainaut in 1611.*

Journey of 1611 through the provinces of Flanders, Artois, and Hainaut. From this journey an average daily travel distance equal to 30 kilometres can be deduced. This equals approximately the distance between Heverlee and Brussels, and Beaumont and Mons. This proximity to important political capitals helps to explain the crucial role of the Heverlee and Beaumont residences as favourite places of retreat of Charles of Croÿ.

12.
Landscape Appreciation in the English Lake District
A GIS Approach

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There is a well-established tradition of historical geographers using geographical information systems (GIS) to study historic landscapes and, particularly, landscape transformation (see Cunfer 2005; Donahue 2007; Walford 2018). Such studies tend to be based on quantitative sources and social science paradigms. This tendency is unsurprising, as the GIS data model is well suited to structuring analyses of quantitative sources with attribute data in tabular form linked to spatial data representing precisely located points, lines, or polygons. This chapter presents a new approach to the study of how landscapes were perceived in the past and how this changed over time. Implementing this approach requires a very different integration of GIS from the one used in previous studies because the sources involved are not quantitative: they are texts containing qualitative descriptions and, as such, need to be analysed using a mix of approaches that combine spatial analysis with close reading.

To explore the potential of using GIS to research changing perceptions of historic landscapes we draw on the Corpus of Lake District Writing (CLDW). This is a collection of eighty digitised texts written about the English Lake District between 1622 and 1900. The Lake District is one of the most written about rural landscapes in the world (Fig. 1). Most famously, it was the home of William Wordsworth and his contemporary Lake Poets; however, it has also been described by many lesser-known writers, as well as being the subject of many guidebooks, journals, and travelogues. The CLDW holds a collection of both famous and less-canonical

Fig. 1. Coledale Fells, seen from Crosthwaite, English Lake District (photo Christopher Donaldson).

works.[1] The challenge this chapter explores is two-fold: first, how to convert the texts in the CLDW into a form suitable for importing into GIS; second, how to analyse these texts in an appropriate manner for literary and geographical study. This chapter reports on an approach that meets these challenges through a case study that examines three words commonly associated with the landscapes of the Lake District: beautiful, majestic, and sublime.

From text to GIS database

The CLDW contains approximately 1.5 million words of text marked up with a light XML (eXtensible Markup Language) encoding to identify features such as paragraph breaks and to incorporate basic metadata. The challenge is how to convert this unstructured textual format into a data model suitable for importing into a vector GIS, which requires data in tabular form linked to coordinate-based locations. Performing this conversion involves a two-stage process known as

1. For a full list of titles in the corpus: see http://www.lancaster.ac.uk/fass/projects/spatialhum.wordpress/?page_id=64

geoparsing (Grover et al. 2010). In the first stage, automated named entity recognition (NER) techniques are used to identify words suspected of being place-names. In the second, these words are matched to a place-name gazetteer, and, where a match exists, the coordinate data the gazetteer provides are assigned to the relevant word. These coordinate data are allocated through additional XML tags that are added to the texts. Conducting this process in an entirely automated manner was found not to be satisfactory for the complex place-names found in the CLDW (see Butler et al. 2017). The process was enhanced using concordance geoparsing — where a small subset of the text is geoparsed, the results are checked, and any corrections fed into processing subsequent subsets (Rupp et al. 2014) — and a considerable amount of manual checking.

Geoparsing the CLDW led to the identification of nearly 40,000 place-names: 2.6% of the total word tokens in the corpus. Linguists count items of punctuation as tokens in addition to words. Of these place-names, 96% are in the UK and 88% are in and around the Lake District. The remainder are frequently places in mountainous parts of North America or Europe that texts in the CLDW compare to locations in the Lakes, or places mentioned in a similarly associative manner. Interestingly, only 60% of the place-names identified are found within the modern Lake District National Park. This suggests that today's National Park is smaller than the area historically associated with the Lake District.

Map 1 offers a visual summary of the results of geoparsing the CLDW. Here, all of the place-names found in and around the Lake District have been located using the coordinates allocated to them in the geoparsed XML. Rather than use a dot-map, which is difficult for the human eye to interpret (particularly when there may be multiple dots at the same location), the map uses a technique called density smoothing to simplify the pattern. The map shows the density of place names near to each location. 'Near' is defined objectively (Fotheringham et al. 2000: 149): to allow comparisons, density on all of the maps in this chapter has been normalised using z-scores. A z-score of 0.0 is the mean density for the dataset; 1.0 is one standard deviation above the mean, and so on. **Map 1** shows that there is a very clear and clustered pattern to the place-names mentioned in the CLDW. There are major clusters of places mentioned in and around the larger settlements, including Lancaster, Kendal, Penrith, Bowness, Ambleside, Grasmere, and Keswick. There are also pronounced clusters near the major mountains and lakes. In sum, **Map 1** demonstrates that the place-names mentioned most often in the CLDW are located around the principal settlements and landmarks in the centre and east of the region. It is striking, though, that significant areas of this landscape are far

less frequently mentioned by the texts in our corpus. However, representing these clusters is somewhat problematic since large areas such as lakes are represented using a point; the point on the east bank of Windermere, for instance, gives little indication of precisely to where on this large body of water the text is referring.

Map 1 demonstrates that geoparsing can be used to convert a text into a GIS; it also affirms that GIS-generated maps can be used to summarise the patterns of place-naming in a text corpus. That said, **Map 1** tells us nothing about what the texts in the corpus say about these locations. To explore this aspect of the corpus we used a concept taken from corpus linguistics: co-occurrence. Linguists argue that two words appearing near each other in a text are likely to be related (Adolphs 2006: 56-59; McEnery and Hardie 2012: 122-123). To operationalise this principle with place-names we have developed the concept of the place-name co-occurrence (PNC). A PNC occurs when a place-name is found within a set number of word tokens of a particular search-term. In this case, we used a measure of ten word tokens. Take, for example, the following extracts from the CLDW:

> …on the pinnacle of 'the mighty **Helvellyn**'. How sublime an elevation! How glorious a panorama! (Baines, 1829)
> 'The scenery about **Buttermere** is truly sublime and august. On a promontory to the east of the lake…' (Anon, 1804)

In each case, the place-name is highlighted in bold and the search-term, 'sublime', is underlined. In instances like these, the fact that the place-name is within ten tokens of the search-term is taken as indicating that they are associated with one another. Thus, Helvellyn and Buttermere are both (correctly) identified as being described as sublime. Both, in other words, are classed as PNCs of sublime.

Consider, however, the following further extract:

> '–still presenting the same appearance of sublime confusion – of the mountains of **Blackcomb**, **Scaw fell**, Coniston Old Man, Helvellyn, Fairfield, Hill Bell…' (MacKay 1846)

This third example illustrates two ways place-name co-occurrence relationships can be more complicated than the first two examples suggest. Blackcombe and Scawfell[2] are both place-names that lie within ten word tokens of 'sublime'. As a

2. Note the non-conventional spelling of these formations in the quotation.

result, the clause quoted is the source of not one, but two PNCs: one for Blackcombe and one for Scawfell. The remaining place-names in the quotation (Coniston Old Man, Helvellyn, Fairfield, and Hill Bell) lie outside the ten-word-token span; they are thus erroneously not considered to be associated with 'sublime' and so do not create PNCs. One needs to be mindful of the possibility of such errors when analysing PNCs. Still, in spite of such potential limitations, employing the concept of PNC does allow us to associate place-names with search-terms and thus investigate what places are being associated with particular themes of interest.

Beautiful, majestic, and sublime places in the Lake District

Using PNCs enables us to produce maps such as **Map 2a**, which shows the locations of the PNCs for all instances of the search-term 'beautiful' in the CLDW. The word beautiful occurs 1,233 times in the corpus, creating 485 PNCs. This amounts to 39.4 PNCs per 100 instances, suggesting that 'beautiful' is strongly associated with place-names. There is a clear geographical pattern to these PNCs, with clusters around Windermere, Ambleside, and Grasmere in the south, and Keswick and Derwentwater in the north. This pattern is potentially somewhat problematic, however. **Map 1** showed that there is a clear pattern to place-naming in the corpus; consequently, the pattern shown in **Map 2a** could simply identify places that are associated with 'beautiful' because those places are often mentioned in the CLDW overall. To determine whether this is the case, we implemented advanced spatial analysis techniques, particularly Martin Kulldorff's Spatial Scan Statistic (Kulldorff 1997). Kulldorff's Statistic allowed us to identify places that were more closely associated with the search-term than would be expected given the background geography of all the place-names mentioned in the corpus.

Map 2b displays the results of using Kulldorff's Spatial Scan Statistic to identify areas that have more PNCs with 'beautiful' than would be expected based on the underlying place-name geography shown in **Map 1**. These clusters are termed hotspots. Kulldorff's Spatial Scan Statistic also identifies those areas which have fewer PNCs than would be expected; these are termed cold spots. Thus, **Map 2b** shows that the area around Grasmere is a hotspot as well as being a density cluster in **Map 2a**. This suggests that Grasmere is both a frequently mentioned location and, moreover, one that is described as 'beautiful' more often than would be expected. The area around Keswick is also a hotspot in **Map 2b**, but it is noticeable that this is further west than the density cluster shown in **Map 2a**. A third hotspot is found in the southern part of the Lake District, in the area covering the Cartmel Peninsula and High Furness. This is an area that has a low density of

place-name instances [Map 1] and of 'beautiful' PNCs [Map 2a], which suggests that, although it is not an area mentioned frequently in the CLDW, when it is mentioned it is often described as 'beautiful'. Map 2b also shows two cold spots. The large one in the north-east corner of the map can probably be ignored, as this is an area well outside what would normally be thought of as the Lake District. The smaller one in the west, however, is the Western Fells, which include Scawfell Pike, the highest mountain in the Lake District. This finding suggests that this area is not often described as beautiful in the corpus; rather, this region inspired somewhat grander language.

Indeed, the area around Scawfell is more associated with the word 'sublime', as Map 3 shows. 'Sublime' occurs 270 times in the corpus and has 87 PNCs: 32.2 PNCs per 100 instances. This percentage suggests that sublime is a little less strongly associated with named places than the other two terms. The density pattern in Map 3a shows a strongly clustered pattern with clusters around Keswick, Ullswater, Windermere, Coniston, and the Western Fells (including Scawfell). Most of these are major tourist sites. The Western Fells, however, were less frequently visited and are mentioned less often in the corpus. The fact that the only hotspot for 'sublime' is located at these fells [Map 3b] indicates the emotional effect the mountains had on the writers in the CLDW. As with Map 2b, the cold spot to the east of the map can be ignored as it is beyond the Lake District.

Map 4 shows two similar maps for the term 'majestic'. 'Majestic' is a far less common word than 'beautiful' or 'sublime' in the CLDW, wherein it occurs only 173 times. However, it forms 79 PNCs (45.7 PNCs per 100 instances), which makes it more commonly associated with named places than 'beautiful'. The patterns shown in Map 4 are very different from those in Maps 2 and 3. These patterns are concentrated in two major density clusters, one around the mountain Skiddaw in the north, and a less pronounced one around the point representing the River Duddon in the south. These are both hotspots as well as density clusters; there are no cold spots.

Map 5 draws these three patterns together on two single maps. Map 5a shows the density clusters with z-scores above 2.58 for all three search-terms. What is clear from the pattern is how different the geographies associated with the three search-terms are. The only place where all three terms overlap, a tiny sliver between the Keswick cluster and the Skiddaw cluster, can be dismissed as an edge effect. The only major overlaps are between 'beautiful' and 'sublime', which cluster together in Keswick and Windermere. There is also a more limited

overlap between 'beautiful' and 'majestic' centred on Skiddaw, but there is no overlap between 'majestic' and 'sublime'. **Map 5b** shows that for hotspots this pattern of no overlap is even more pronounced: none of the hotspots overlap at all. However, the Western Fells provide a hotspot for 'sublime' and — although not shown — a cold spot for 'beautiful', suggesting a marked contrast between the two terms.

Figure 2 shows that, as well as spatial variation in how the words are used, there is also temporal variation. The corpus can be divided into four period groupings: the Early Modern period, the 'long' eighteenth century, the Romantic period and the Victorian era. Figure 2a shows the percentage of instances of the three search-terms that occur in each grouping. These percentages are influenced by the fact that the corpus contains more texts from the Romantic period and the Victorian era than the other two groupings. Accordingly, Figure 2b compares each of the three terms to what would be expected if its use were proportional to the number of words in each period grouping. The Early Modern period has been left off this graph as it represents a much smaller portion of the corpus. This chart shows not only that 'majestic' was most used in the Romantic period texts in the corpus, but also that the word is much less seldom used either before or afterwards. 'Sublime' was also most used in works from the Romantic period, but the use of the term appears to have decreased during the Victorian era. The use of 'beautiful', by contrast, appears to have remained broadly constant across all three periods.

Exploring transformation in landscape representation involves evaluating change over space and time simultaneously. In order to do this, we have used the three period groupings from Figure 2: the 'long' eighteenth century, the Romantic period, and the Victorian era. We can then apply a technique called Spatial Segregation Analysis (Rowlingson 2015; Diggle et al. 2005) to assess how patterns of instances vary between periods. Spatial segregation analysis is a technique that compares point patterns, in this case PNCs from different periods, and identifies parts of the map that have statistically significantly more points from one set of points than the other. It also provides a global summary statistic that identifies whether the two patterns are statistically significantly different from each other across the entire map area.

Map 6a offers an example of the application of this method. Here, we compare the PNCs of 'beautiful' from the 'long' eighteenth century with those from the Romantic period. The global statistic for this is $p=0.07$, which suggests that overall

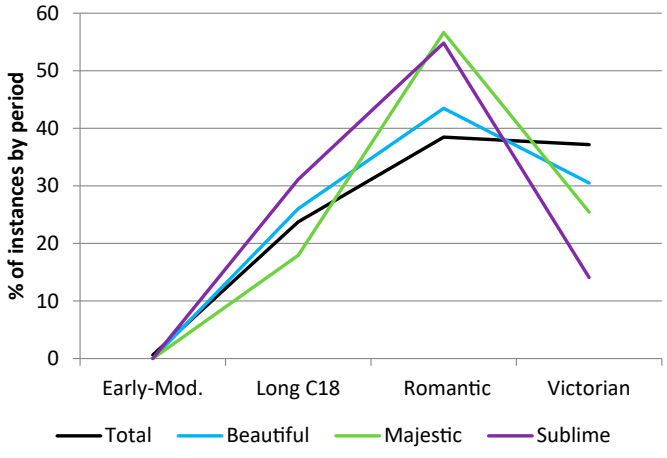

Fig. 2a. Word use by period showing overall percentages of instances occurring in each period.

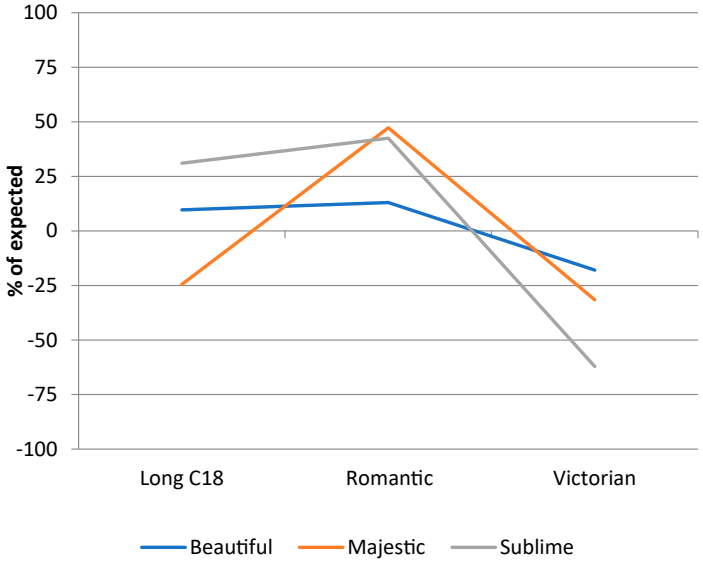

Fig. 2b. Word use by period showing overall percentages normalised by overall word count in each period.

In general these diagrams show that the usage of all three terms declines in the Victorian era although this is least pronounced for 'beautiful'. 'Majestic' was relatively uncommon in the 'long' eighteenth century, but became popular in the Romantic era before dropping out of use again. 'Sublime' was popular until the Victorian era.

the differences between the distributions in the two groupings are not significantly different. Map 6a implies that this is a slight over-simplification as the area around Grasmere has more PNCs of 'beautiful' in the Romantic era than it did in the 'long' eighteenth century. Further to the west, the area around Ravenglass and Eskdale also has significantly more beautiful PNCs in the Romantic period, although this is largely because there are none in the 'long' eighteenth century. Map 6b, which compares the Romantic period and Victorian era, suggests that this development was part of a growing trend. This map shows significantly more 'beautiful' PNCs in the Victorian era, particularly in the area west of Coniston Water. This suggests that this previously neglected area was increasingly described as 'beautiful' as time went on. At the same time, areas around Keswick and Derwent Water and Ullswater have significantly more 'beautiful' PNCs in the Romantic era, suggesting that these traditionally popular landscapes became less associated with 'beautiful' as time went on. The global statistic for the comparison between the Romantic and Victorian eras is p=0.01, meaning that these patterns are significantly different from each other and suggesting that the rate of change in the use of this word increases over time.

Map 7 shows the same technique applied to 'sublime' PNCs. Interestingly, the two patterns are similar to those for 'beautiful' shown in [Map 6]. The contrast between the 'long' eighteenth century and the Romantic era is not statistically significant globally (p=0.09) while the comparison between the Romantic period and Victorian era is significant (p=0.01). Locally, the pattern again shows a move towards the southern and western Lake District over time although the emphasis on Grasmere disappears. The analysis for 'majestic' has not been mapped because the pattern is too concentrated on Skiddaw and the Duddon Valley, with the Duddon emerging as a PNC only really in the Victorian era.

Overall, the spatial segregation analysis suggests that there is an increasing tendency over time to describe landscapes in the south and west of the Lake District as both 'beautiful' and 'sublime'. Following up this finding further using Kulldorff analysis, however, does not suggest that this is because there appear to be new clusters of PNCs in these areas when compared to the background geographies. Instead, it appears to be the case that, over time, the south and west of the Lake District received more attention within the corpus. This trend probably reflects the fact that these localities began to be more frequently visited, especially following the completion of railways to locations such as Windermere and Coniston during the Victorian era. Such developments can be seen to have worked in

tandem with changing cultural values to transform how the Lake District was visited and perceived.

Place-centred reading

The above analyses all present abstract summaries from a large corpus of historic texts. These summaries identify and describe aggregate geographical and temporal patterns within those texts. The patterns found should, in turn, be thought of as a question to the researcher: e.g. why is this pattern as it is? The ability to perform such descriptive analyses is a feature of most maps and diagrams produced by GIS analyses. The use of qualitative textual sources, though, enables us to address those questions with reference to the material from which the patterns arise. By focusing on the text around any given PNC we can begin to understand more precisely the nature of the relationship that underlies the observed search-term and place-name co-occurrences. In other words, we can move from macro (or 'distant') reading approaches (Jockers 2013; Moretti 2013) to more conventional — in literary studies, at least — close readings of the parts of the text that the macro-approaches identified as significant.

As noted above, 'majestic' presents perhaps the most striking pattern of our three search-terms, as its PNCs are highly clustered in two distinct areas, Skiddaw and the Duddon. Identifying places in the text where these place-names are found within ten word tokens of the word 'majestic' can either be done by looking at the PNCs themselves or by using corpus software such as AntConc (Anthony 2005) or CQPweb (Hardie 2012), which provides more contextual text. This investigation reveals that Skiddaw, a mountain that towers above the tourist town of Keswick, is most commonly described as 'majestic' in guidebooks from the Romantic era. It is difficult to determine if there was a particular text that established this trend; it appears to be common throughout the CLDW, and the word 'majestic' is used as a descriptor in many contexts. The Duddon PNC presents an interesting contrast. In his *The River Duddon: A Series of Sonnets*, William Wordsworth (1820: 32) writes 'now expands majestic **Duddon**, over smooth flat sands'. This is the first time that the Duddon is described as 'majestic' in the corpus, and five of the other six texts that describe the Duddon as 'majestic' use exactly this quotation.

The major hotspot for 'sublime' is in the Western Fells [**Map 4**], an area that can be seen from a distance in much of the Lake District but that was, and remains, relatively inaccessible. In stark contrast to 'majestic', close reading reveals that 'sublime' tends to be used to describe these mountains as a group; for example:

'on the west the mountains of *Red Pike*, **High Stile**, and **High Crag** rise precipitously to a sublime elevation' (Baines 1829); and 'that sublime group of mountains, **Yewbarrow**, **Pillar**, **Great Gable**, **Kirkfell**, *Lingmell*, and *Scawfell*' (Waugh 1861).[3] Thus, 'sublime' seems to be used quite specifically to refer to groups of mountains in the distance, rather than individual summits. This application of the word was maintained during the Victorian era, even as the use of 'sublime' appears to have decreased. For example, Mackay (1846) refers to 'the sublime chain extending from **Coniston** to **Ennerdale**', a phrase that is repeated by a number of subsequent writers.

The usage of 'beautiful' is more difficult to pin down. The most obvious question driven by **Map 2b** is why the Southern Lakes are shown to be a 'beautiful' hotspot. Referring back to the corpus reveals that this finding is perhaps misleading. In 1860, Edwin Waugh published a guidebook entitled *Over the Sands to the Lakes*, which frequently uses the word 'beautiful' to describe places in this part of the Lake District. In 1861, Waugh went on to publish a collection entitled *Rambles in the Lake Country*, wherein he reproduced his earlier text as a chapter. The hotspot displayed in **Map 2b** is thus a result of these two texts, combined with the sparsity of other writing about this area. Beyond this, however, it seems clear that 'beautiful' is often used to describe well-visited parts of the Lakes at relatively low elevations, particularly near Grasmere and Keswick, and that this use of the word persists over time. By contrast, 'beautiful' is not used to describe high, remote, 'sublime' landscapes such as the Western Fells.

Conclusions

In this chapter we have shown how three words that are historically used to describe the Lake District — majestic, sublime, and beautiful — are actually employed in distinctive ways to describe different places and different types of landscapes. We are also able to explore if and how the use of these words in the corpus changed over time. 'Majestic' is used for a small number of places in quite specific ways, and in one case (e.g. the River Duddon) we are able to show that Wordsworth's use of this word resulted in many subsequent writers describing it in this way. 'Sublime' tends to be used to describe mountain ranges as lists of peaks. It was particularly associated with the Western Fells, but as the term became less popular it also

3. Italics refer to words that are place-names that lie outside the ten-word span and are thus (wrongly) excluded from defining the PNC.

began to be increasingly used in other similar areas. 'Beautiful' is the most widely used word but seems to have a fairly specific association with low-lying, popular parts of the Lake District.

The implications of this chapter are broader than the examples we have used here. They demonstrate that, in addition to traditional quantitative and cartographic sources, we can now use GIS-led methodologies to explore how landscapes and environments are represented. More than this, we can discover how the perceptions of those landscapes, and the language used to describe them, transformed over time.

Acknowledgements

Research for this chapter was carried out as part of the project *Geospatial Innovations in the Digital Humanities: A Deep Map of the English Lake District*, funded by the Leverhulme Trust (RPG-2015-230).

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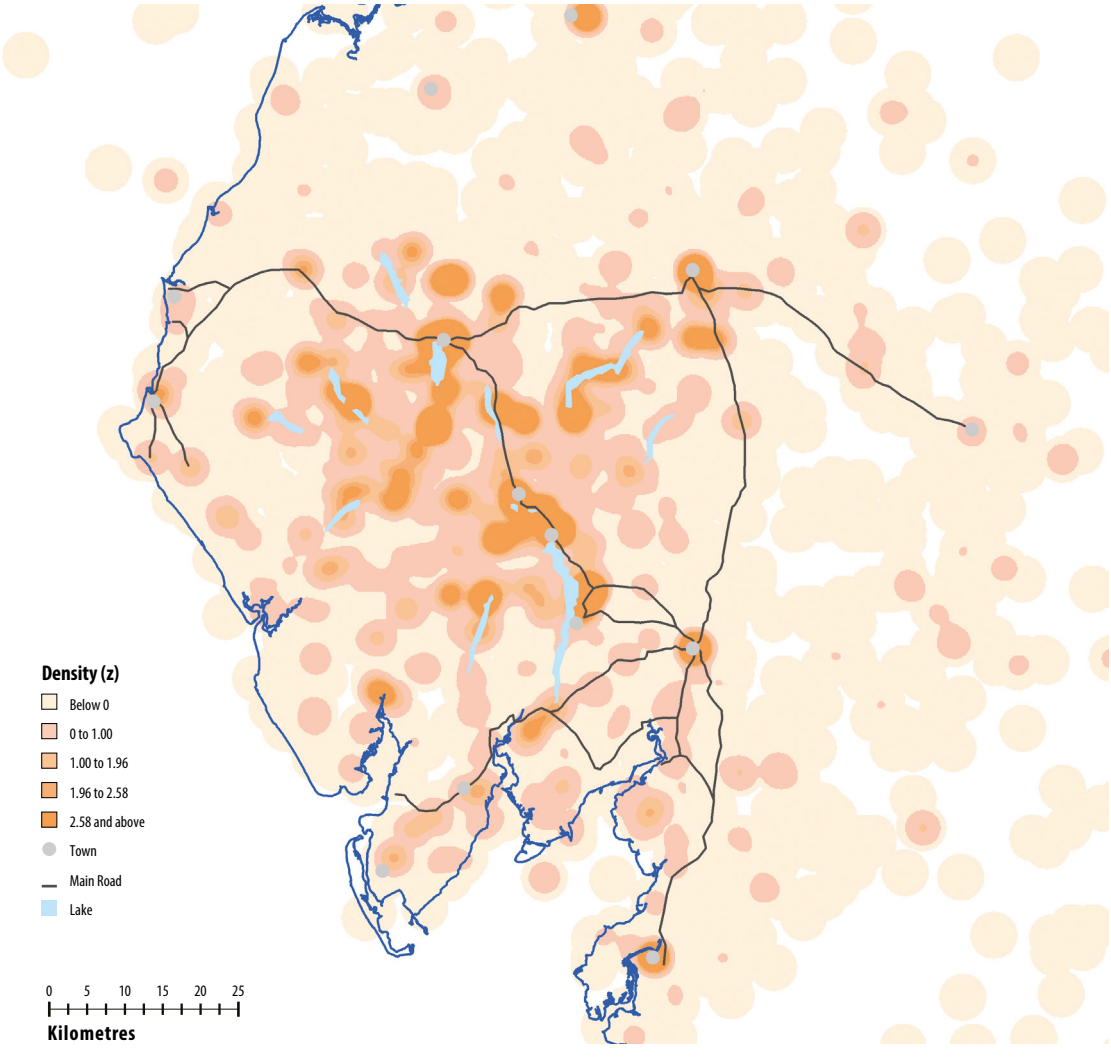
Maps

Map 1: *Place-names Mentioned in the Corpus of Lake District Writings in the North-west of England.*

The map started as a point map of the locations of all of the place-names within the Corpus of Lake District writing. These points were density smoothed to highlight the places that are named most frequently in the corpus (shown in dark shading) and contrast these with areas that are rarely mentioned (shown in yellow). The map identifies major clusters in and around the larger settlements, including Lancaster, Kendal, Penrith, Bowness, Ambleside, Grasmere, and Keswick. There are also pronounced clusters near the major mountains (particularly Skiddaw, Helvellyn, Scawfell, the Old Man of Coniston) and lakes (Windermere, Coniston Water, Ullswater, and Derwent Water).



Map 1: Place-names Mentioned in the Corpus of Lake District Writings in the North-west of England.

Map 2a: *Density Smoothed Map of PNCs for 'Beautiful'.*
Map 2b: *Kulldorff Spatial Scan Statistic Map of PNCs for 'Beautiful'.*

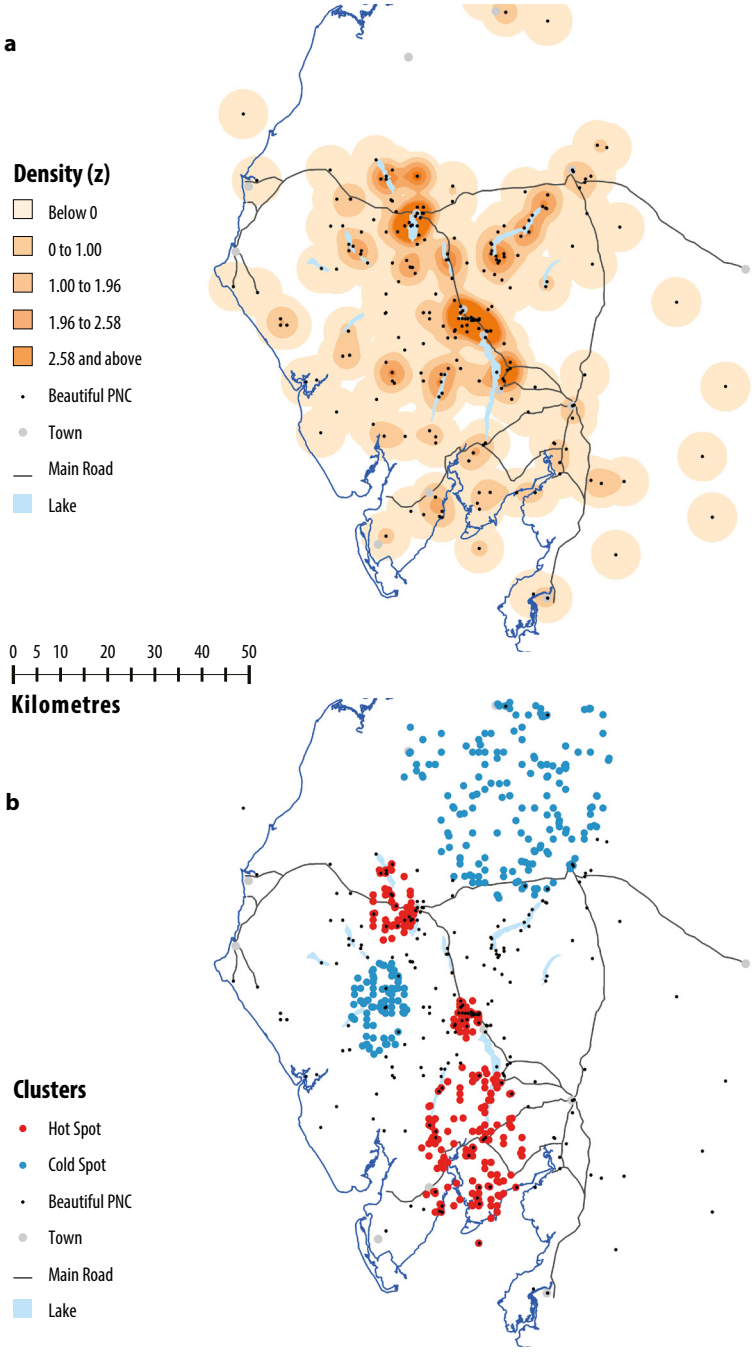
Place-name co-occurrences (PNCs) are found when a place-name appears within 10 words of the search-term, in this case the word 'beautiful'. The resulting pattern is then density smoothed to create the pattern shown in Map 2a. This shows that the places described as 'beautiful' are clustered in and around Keswick and Derwent Water in the north-west, Grasmere and Ambleside on the road south from Keswick, and Windermere further south again. This pattern could, however, be a result of the fact that people are writing about these places more than other places. To test for this, Map 2b uses Kulldorff's Spatial Scan Statistic to identify places where there are more 'beautiful' PNCs than would be expected given the overall distribution of place-names shown in Map 1 (termed hot spots), and fewer than would be expected (cold spots). This shows that Grasmere is a hotspot and so is the area to the west of Keswick and Derwent Water. The Grizedale Forest area, in the south of the Lake District, is also a hotspot, suggesting that although this area is not discussed often, when it is it is frequently described as 'beautiful.' The area around the Western Fells is a cold spot, meaning that it is not described as 'beautiful' as often as would be expected.

Map 3a: *Density Smoothed Map of PNCs for 'Sublime'.*
Map 3b: *Kulldorff Spatial Scan Statistic Map of PNCs for 'Sublime'.*

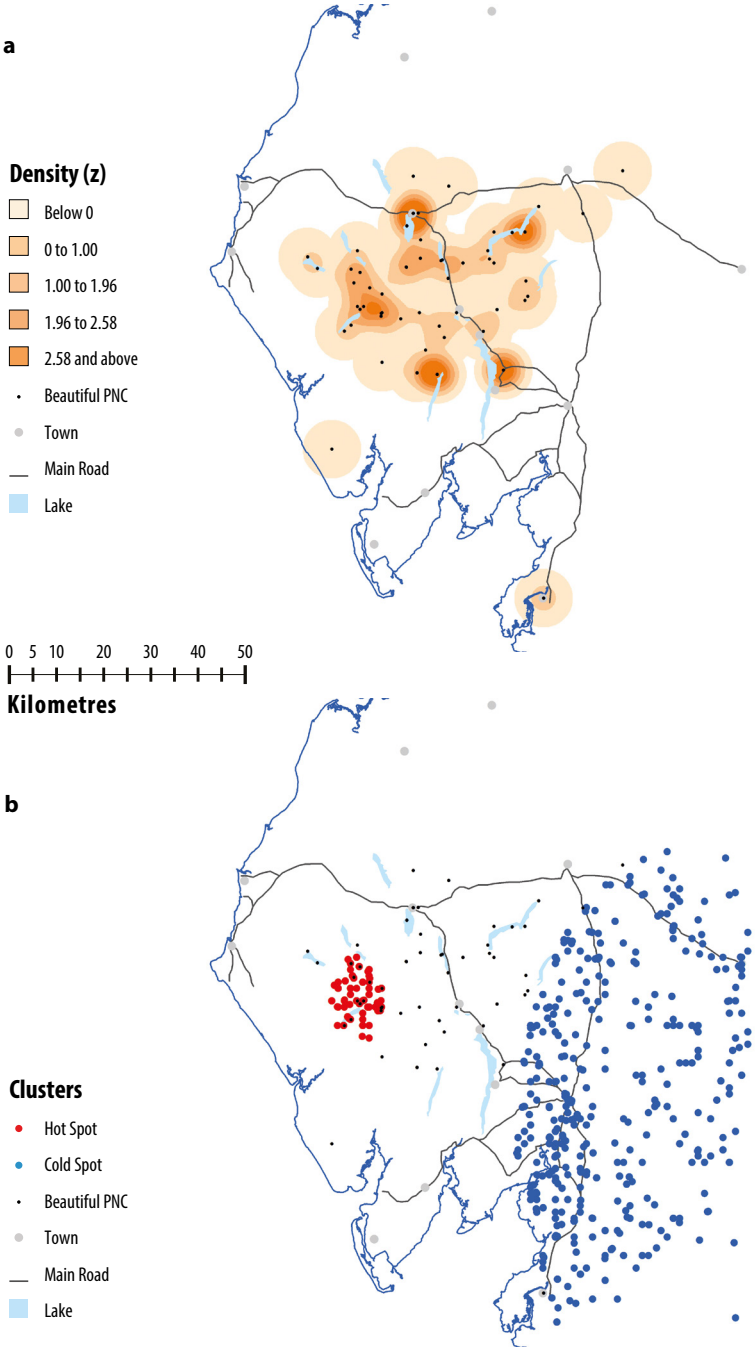
These maps were created in the same way as the maps in Map 2. They show density clusters around Keswick, Ullswater, Windermere, Coniston, and Scawfell. The Kulldorff map shows that only the Western Fells around Scawfell are a hotspot.

Map 4a: *Density Smoothed Map of PNCs for 'Majestic'.*
Map 4b: *Kulldorff Spatial Scan Statistic Map of PNCs for 'Majestic'.*

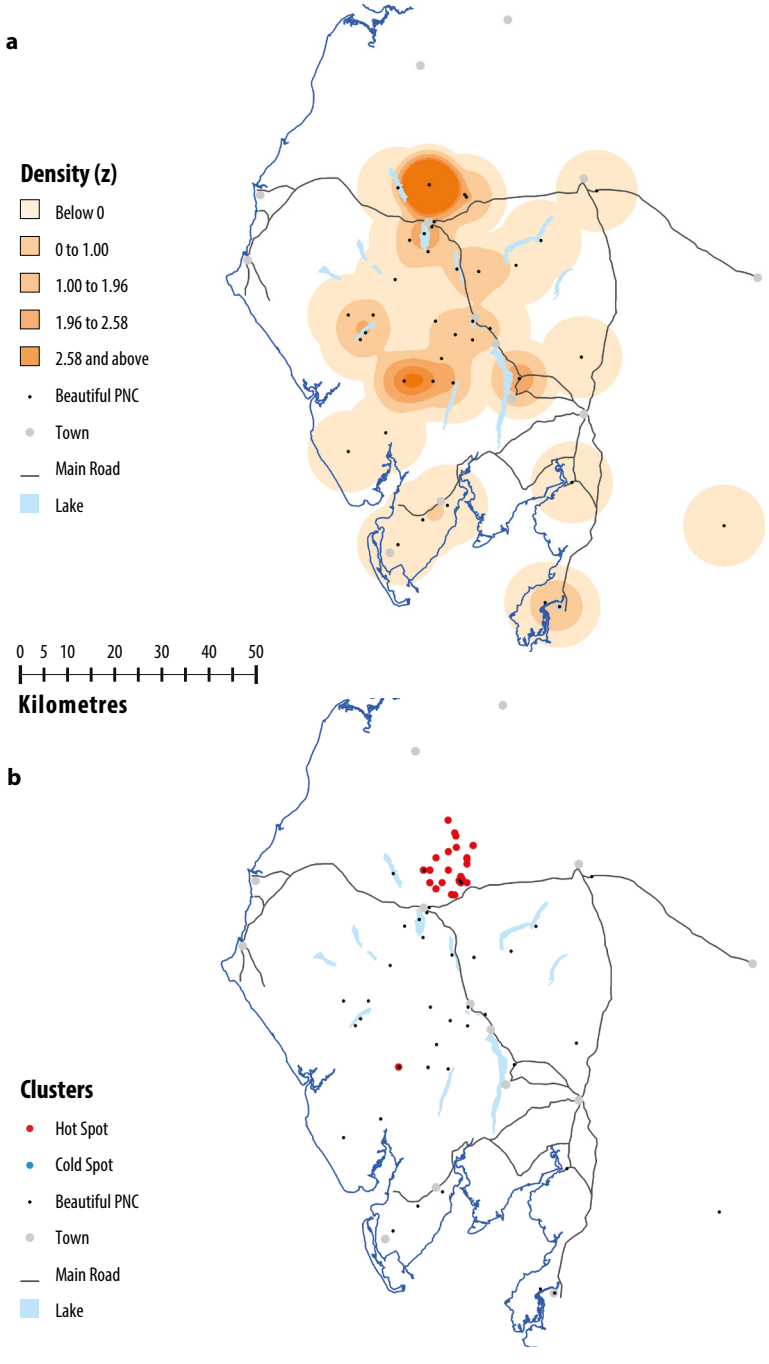
In this case, the density clusters and Kulldorff hot spots are found in two similar locations, namely Skiddaw in the north and the Duddon Valley south of there.



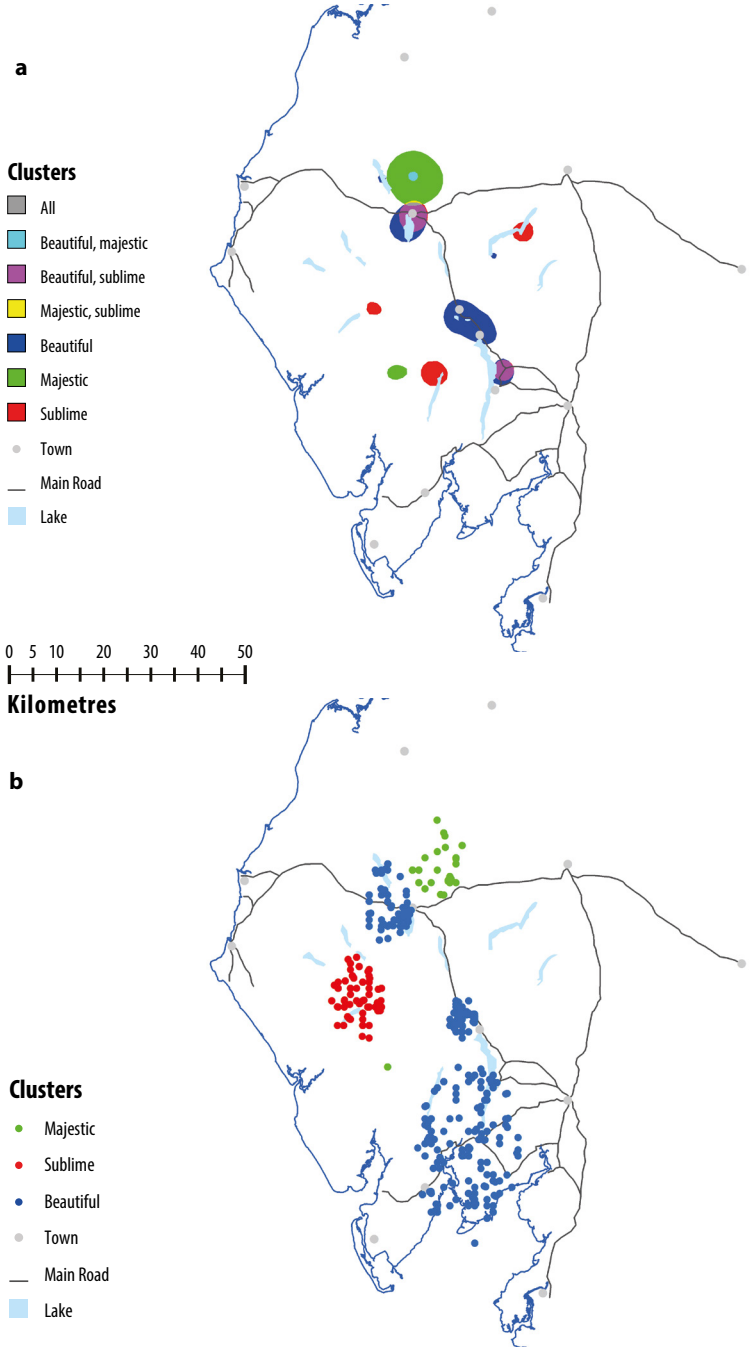
Map 2: Map of PNCs for 'Beautiful'. a: Density Smoothed Map; b: Kulldorff Spatial Scan Statistic Map.



Map 3: Map of PNCs for 'Sublime'. a: Density Smoothed Map; b: Kulldorff Spatial Scan Statistic Map.



Map 4: Map of PNCs for 'Majestic'. a: Density Smoothed Map; b: Kulldorff Spatial Scan Statistic Map.



Map 5: Map of PNCs for 'Beautiful', 'Sublime' and 'Majestic'; a: Density Smoothed Map; b: Kulldorff Spatial Scan Statistic Map.

Map 5a: *Density Smoothed Map of PNCs for 'Beautiful', 'Sublime' and 'Majestic'.*
Map 5b: *Kulldorff Spatial Scan Statistic Map of PNCs for 'Beautiful', 'Sublime' and 'Majestic'.*

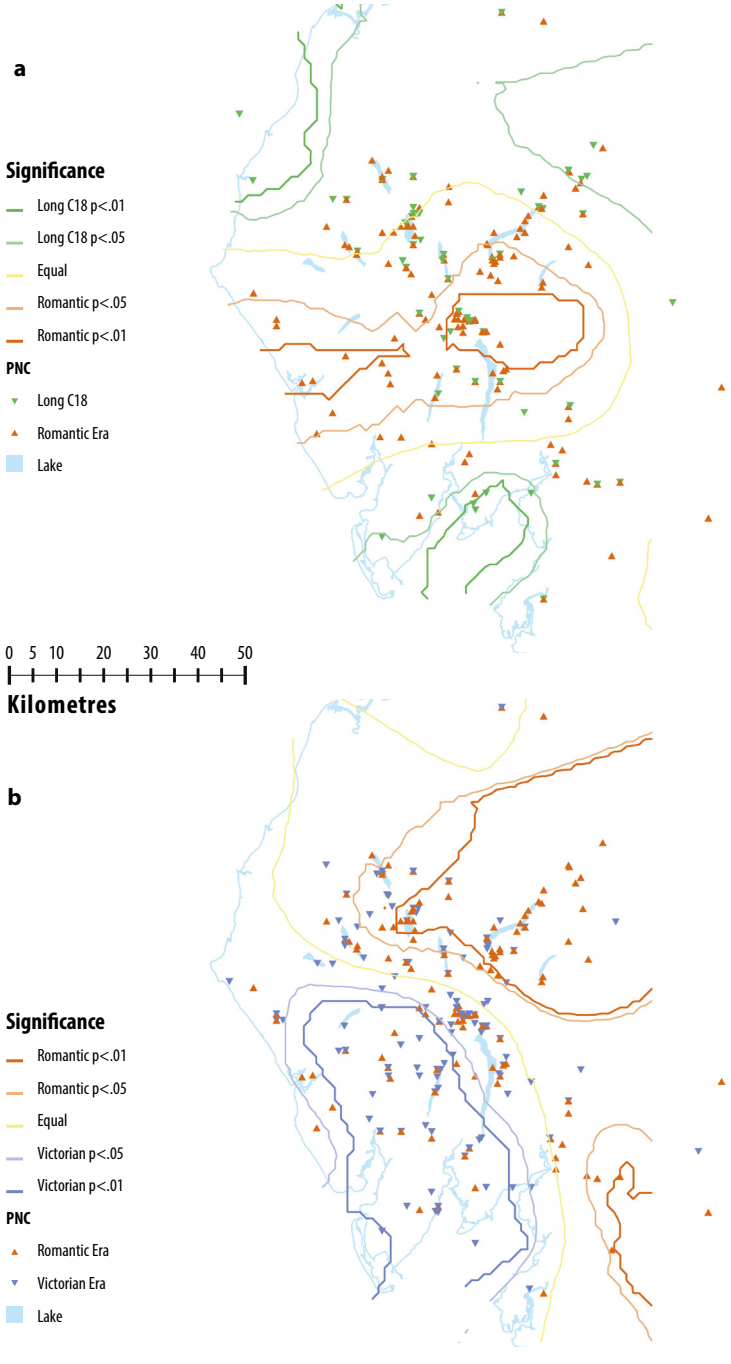
Comparing the patterns of all three search-terms using density smoothing and Kulldorff Spatial Scan Statistic. The density smoothed map [Map 5a] defines clusters as areas with a z-score of over 2.58, while the Kulldorff map [Map 5b] uses statistically significant hot spots. The two maps show that there are very few overlaps between the places described using the three search terms. 'Beautiful' and 'sublime' do have density clusters around Keswick/Derwent Water and Windermere, but these are the only major areas of overlap. There is no overlap on the Kulldorff hotspots.

Map 6a: *Spatial Segregation Analysis Comparing PNCs for 'Beautiful' for the 'Long' Eighteenth Century and the Romantic Eras.*
Map 6b: *Spatial Segregation Analysis comparing PNCs for 'Beautiful' for the Romantic and Victorian Eras.*

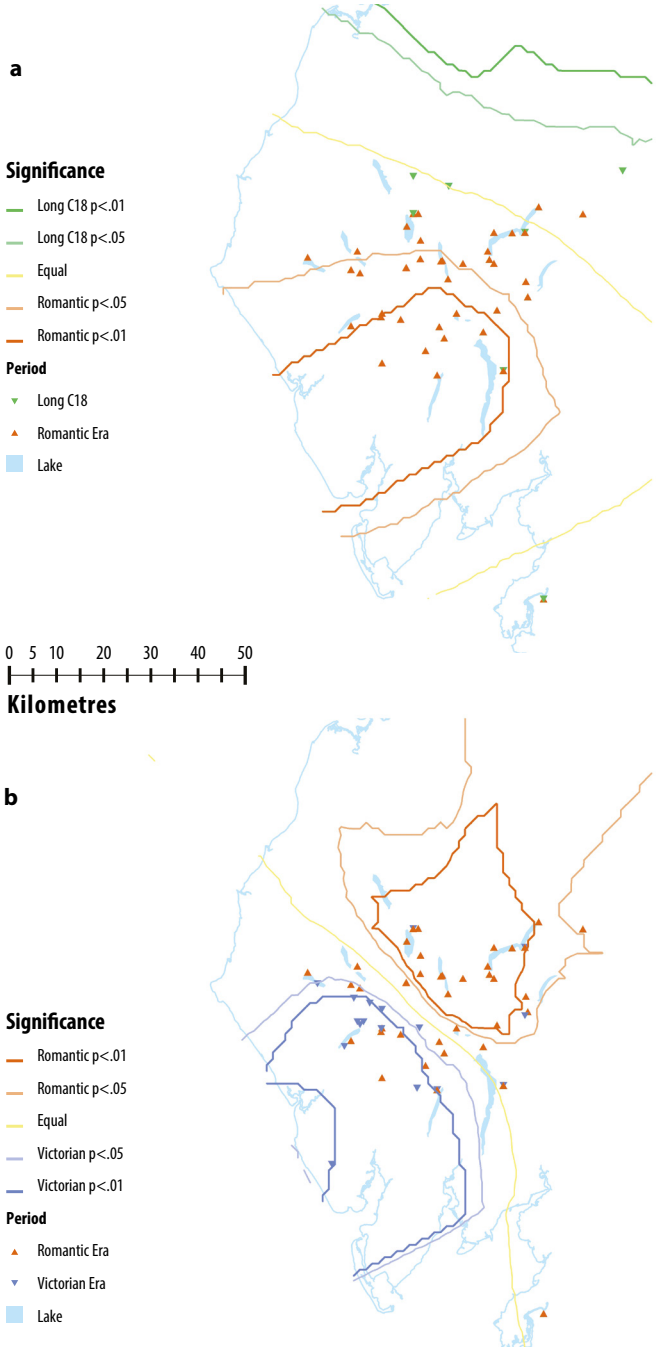
Spatial Segregation Analysis comparing PNCs for 'beautiful' for the 'long' eighteenth century and the Romantic era [Map 6a], and the Romantic and Victorian eras [Map 6b]. The techniques identify areas that have statistically significantly more PNCs from one period than the other and highlights them using contour lines. The maps suggest that Grasmere became increasingly associated with 'beautiful' in the Romantic era and that there was a more general rise in describing places in the southern and western parts of the Lake District as 'beautiful' over time.

Map 7a: *Spatial Segregation Analysis Comparing PNCs for 'Sublime' for the 'Long' Eighteenth Century and the Romantic Eras.*
Map 7b: *Spatial Segregation Analysis Comparing PNCs for 'Sublime' for the Romantic and Victorian Eras.*

Spatial Segregation Analysis comparing PNCs for 'sublime' for (a) the 'long' eighteenth century and the Romantic era, and (b) the Romantic and Victorian eras. These maps also show a move to the south and west over time.



Map 6: Spatial Segregation Analysis Comparing PNCs for 'Beautiful'. a: For the 'Long' Eighteenth Century and the Romantic Era; b: For the Romantic and Victorian Eras.



Map 7: Spatial Segregation Analysis Comparing PNCs for 'Sublime'. a: For the 'Long' Eighteenth Century and the Romantic Eras; b: For the Romantic and Victorian Eeras.

13.
Digital Humanities and GIS for Chinese Architecture
A Methodological Experiment

Chang-Xue Shu (University of Leuven)

How can one use a non-architectural source to build a new history of architecture? The study makes use of a corpus of Chinese local gazetteers (*Difangzhi*, lit. 'local history') to take up the methodological challenge. The source comprises 3,999 volumes dating from the tenth to the twentieth centuries covering all the populated area of China, and has been facilitated with a digital infrastructure.

This chapter is structured as follows: Sections I and II question some unacknowledged fractures and bias in the established histories of Chinese architecture, and open the issues in context. In Sections III and IV, the chapter proposes a new strategic approach to Chinese architecture with original questions and hypothesis. Section V elucidates how the new data were extracted, particularly the methods used in this study for mining and processing large-scale data thanks to digital humanities and geographic information system (GIS). Sections VI and VII report a ground-breaking result on Chinese architecture with two arguments.

The chapter embodies five innovative aspects: (1) using non-architectural sources to build architectural history; (2) bridging the long divided histories of the ancient and modern architecture of China; (3) focusing on the often ignored aspects of materiality in Chinese architecture, especially the mineral building materials; (4) applying cutting-edge datasets and tools from digital humanities into architecture, and providing critical viewpoints for either field. (5) The findings support two original arguments I come up with, showing both continuity and transformation of Chinese architecture in the *longue durée* of centuries; novel questions were generated too. The article is an introductory report for the project entitled 'Mineral Building Materials in China. Rediscovering Built Environments in the Large Datasets of Difangzhi, 10–20th Centuries.'

A fracture in the historiography of Chinese architecture

Scholarly studies on Chinese architecture[1] present a clear division between subjects of ancient and modern times. This generates a fracture if one looks into the considerable timberwork-led narratives about ancient Chinese architecture (Liang et al. 2001; Liu 2003: 3; Zhang and Guo 1985: 57-58; Pan 2009; Chang 2016; Fu and Steinhardt 2017) and the masonry- and concrete-led narratives about the modern types (Wang and Fujimori 1992; Zheng 1999; Lai et al. 2016). The situation has partially resulted from the ideas of Chinese architectural historians of the first generation, typically in Liang Si-Cheng's words from the 1930s: 'The Chinese builder never cultivate a real knowledge of brick and stone as primary structural media for ordinary use. … Masonry structures, therefore, occupy a position in no sense comparable to that in European architecture' (Liang et al. 2001: 451-452).

Western masonry structure, however, became the earliest and primary construction method used in building novel, modern types of architecture in China from the mid-nineteenth century onwards. This fact has been explicitly shown in source materials and the most recent studies addressing China's move towards modern architecture (Shu 2018; Shu and Coomans 2020; Shu et al. 2017; Shu 2015a; Shu 2015b; Shu 2013; Shu, Van Balen and Elsen, 2018). The western masonry works were built of mostly certain sorts of building materials made from mineral substances — typically brick, tile, stone, lime, earth, and concrete in the language of architects and engineers. The modern construction was conducted nearly exclusively by Chinese workers and builders with appropriate supervision from new architects and engineers, either foreign or Chinese. How could the Chinese workers and builders who 'never cultivate a real knowledge of brick and stone as primary structural media for ordinary use' effectively adapt to and become skilled in western masonry systems built in brick, stone and binding material of all sorts? In other words, why did masonry structure (not steel structure, for instance) become the first and successful step when China moved to western models of construction, followed by concrete structure that can be considered as a second success in China's modern architecture history? There must be some issues unaddressed.

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1. In this study 'architecture' covers all the technique aspects of construction in addition to aesthetic viewpoint. Activities include but are not limited to: infrastructure, foundations and substructures, hydraulic works, production and use of building materials. A reference is given to Vitruvius' *The Ten Books on Architecture* (Vitruvio and Barbaro 1567; Vitruvius et al. 1914).

An unreliable source for architecture

Questioning this fracture and bias between the histories of Chinese architecture, I explore sources that are not conventional for architectural study. The bigger aim is to experiment with cross-boundary methods and to generate novel (forms of) knowledge of architecture. Chinese local gazetteers (*Difangzhi* 地方志, lit. 'local history', LG in abbr.) have been consulted as the first step, since the whole corpus of this sort of source covers all the populated areas of China and a long-term period from the tenth to the twentieth centuries.

The reliability of *Difangzhi*, however, has often been suspected in terms of architectural study. It is a sort of documentation written and compiled by the local gentry and elite officials, who basically were literati and scholars, not construction practitioners. Records in Difangzhi, although when it comes with construction topics, are very different from technical and monographic literature. The latter is in expert language filled with practitioners' jargon and they have been systematically studied by historians of Chinese architecture since the twentieth century, while the former is a compilers' (re-)interpretation of events and activities, and often does not provide solid or reliable information about dates, forms or technique details that historians of architecture have mostly cared about. The historians' scholarly concentration has remained too narrow in particular (often monumental) works, architects, typologies or architectonics to build the histories of Chinese architecture. What they found in fieldwork does not always match what was recorded in *Difangzhi*, or is even not mentioned in *Difangzhi* at all.

The account below from Wilma Fairbank represents the typical ways in which Chinese local gazetteers have been used since the first generation of Chinese architectural historians and their ideas about it—'guidebooks' yet 'not necessarily reliable.' One can read, too, the approaches historians of Chinese architecture adopted to collect information and build the history since the very beginning.

> 'Before undertaking such expeditions, the Liangs learned to map out their routes on the basis of local gazetteers. These scholarly compilations of local history noted the ancient temples, pagodas, and other monuments in which each district took pride. But the dates were not necessarily reliable, and often buildings that sounded like treasures and inspired long side trips were discovered to have been drastically altered or demolished. Nevertheless, these guidebooks provided the means of surveying wide areas, eventually whole provinces, without missing whatever important structures had survived. Of course, certain individual discoveries resulted from pursuing rumours,

word-of-mouth suggestions, even obscure monuments praised in traditional folksongs. In the 1930s the field of Chinese architectural history was truly open to the excitement of unprecedented finds' (Liang, Fairbank and Liang 2001: 26).

Turning the unreliable to reliable: from material evidence to knowledge of architecture

Architectures have always been transformed, destroyed or reconstructed over time, regarding either form or material. The written *Difangzhi* records of architecture from earlier periods do not necessarily correspond with the architectural remains one found in the field in later times. This does not mean that the *Difangzhi* records are not reliable, since the material evidence might disappear or be transformed in one way or another. The continuity and consistency of *Difangzhi*, instead, have ensured the transmission, dissemination and inheritance of architectural knowledge through Chinese literati. In other words, *Difangzhi* is a solid source about the architectural knowledge of Chinese literati.

This study, therefore, distinguishes between material evidence of architecture and histories of architecture. It considers the textual data from *Difangzhi* a collective, autonomous corpus of codified knowledge linked to elite literati and scholars, and differentiates it from the embodied knowledge retrieved from field and laboratory work (observation and experiment), or directly from craftsmen, practitioners and experts, which historians of Chinese architecture mostly rely on. In this sense, *Difangzhi* becomes a primary source of the knowledge of architecture. The smaller aim is to uncover a hidden history of Chinese architecture and the relevant building materials used in the *longue durée*, as well as certain (if any) unknown historical structure(s) of material culture.

These questions prompt the inquiry: how about the relations between the traditional elite yet non-expert knowledge of architecture as far as recorded in *Difangzhi* and the modern specialised knowledge built up by modern historians and ended up in a scholarly discipline of Chinese architecture? Secondly, how did the historical structure evolve into the nineteenth and twentieth centuries when intensive changes happened? Did it represent a decisive factor for the onset of the way the modern forms, ideas, and practice emerged? And thirdly, how is the elite knowledge re-conceived and reused today?

Old source in new digital shapes

The recently developed digital-GIS infrastructures of *Difangzhi* provide possibilities to answer these questions. New tools have turned *Difangzhi* into an exceptional novel source.

A Chinese local gazetteer book (or *Difangzhi* book) was compiled for a particular prefecture or province defined by administrative boundaries. For the purpose of government, it contains information of all sorts that was considered significant to the local society under official administration of the prefecture or province. The contents, consistently structured by themes, cover local landscape, customs, products, construction activities and others. The source per se is remarkable in terms of its large spatio-temporal coverage and good continuity. It has been well studied and elucidated in recent publications in either the Chinese or the English language (Liu et al. 2010; Dennis 2015).

As far as I can see, contents related to architecture are largely and continuously recorded in *Difangzhi*. However they have not yet been studied in a systematic manner. Building materials often appear in the sections and context of construction such as city fortification, hydraulic works, schools, temples and tombs (建置, 城池, 關營, 學校類), material specialty and local expertise (物產, 實業類), and moral, societal or political achievement linked to local peoples and models (藝文類等), covering broad time and space. They as a whole form a collective mental map of Chinese literati in conceiving architecture.

About 8,000 volumes of *Difangzhi* survive today, physically dispersed. This study uses a subset of 3,999 volumes as source material (~50% of existing LGs), which have been turned into collated and digitalized datasets. The corpus of the 3999 volumes has been facilitated with a work-in-progress infrastructure developed by the Max Planck Institute for the History of Science in Berlin (MPIWG) — the Local Gazetteers Research Tools (LoGaRT). The study takes full advantage of it. Each local gazetteer book, including all of its contents, is associated with geographic coordinates that refer to the local administrative capital according to the administrative level the book covers. Generic metadata are available too, including book year, dynasty, reign period, administrative typology, author, book edition and edition year. LoGaRT serve full text mining and geographical analysis to aid the metadata. Functions within LoGaRT have been explained in recent publications (Chen et al. 2017; Chen 2016; Chen et al. 2016).[2]

2. About LoGaRT, see: https://www.mpiwg-berlin.mpg.de/research/projects/logart-local-gazetteers-research-tools.

The two attributes of time — 'book year' and 'edition year' — have different meanings. Book year represents the year a local gazetteer book was compiled, and edition year represents the year the book was (re)printed. Calculating the dataset of 3999 volumes with the R software, 3750 volumes (94%) have the same book year and edition year, which means they are first edition books; 249 volumes (6%) have different book year and edition year, which means they are reprints. The book year data are related to the Chinese literati who absorbed and recorded the practical knowledge of architecture while the edition year data are associated with the books that aided in circulating the knowledge through publication and replication. Both agencies favoured the dissemination of the architectural knowledge.

The corpus used in the study contains volumes dating from the tenth to the twentieth centuries. The early centuries are represented by only a few volumes. From ca.1450, the corpus exhibits remarkable growth in quantity, with drops in the reign periods (*Nianhao* 年號) that were politically weak or short. Breaking down the 3,999 source gazetteers by dynasty (*Chaodai* 朝代), 1% are from the three Tang (618-907), Song (960-1279) and Yuan (1279-1368) dynasties, 13% are from the Ming Dynasty (1368-1644), a majority 68% are from the Qing Dynasty (1644-1912), and 18% are from the period of the Republic of China (1912-49). Uneven distribution of gazetteers also appears in reign periods within a dynasty. For instance, the Jiajing (嘉靖 1522-66, 5%) and Wanli (萬曆 1573-1620, 4%) reigns within the Ming Dynasty, and the Kangxi (康熙 1662-1722, 13%), Qianlong (乾隆 1736-95, 17%), and Guangxu (光緒 1875-1908, 14%) reigns within the Qing Dynasty contain relatively more volumes of local gazetteers than other reign periods [**Map 1**].

Digital humanities and GIS can do more

What do recent digital humanities tell us and what do they not?

Recent digital humanities have dealt with methodological reflections concerning data extracting, processing, and reading in different quantitative scales and disciplinary contexts (Berry and Fagerjord 2017; Gold and Klein 2016; Moretti 2015; Jockers 2013; Moretti 2013; Burdick et al. 2012; Southall, Mostern and Berman 2011; Moretti 2000). Culturomics well represents the digital text-search approach (Koplenig 2017; Blevins 2014; Leetaru 2011; Michel et al. 2011). Historians of China studies, like most digital historians, have largely invested in digital mapping based on GIS, themes apart from architecture (Southall, Mostern and Berman

2016; Berman 2015; Southall, Mostern and Berman 2011; Bol 2007).[3] Most recently, architectural historians have started to use digital methods too (Galletti 2017; Jaskot and Van der Graaff 2017), and their source materials remain in relatively small quantities compared to those in Culturometics studies. These developments are all encouraging.

Looking into older disciplinary contexts, the new digital developments actually have connotations different from one another, though they are under the same umbrella of 'digital methods'. Digital historians have experienced digital mapping as a 'spatial turn' (Robertson, 2016: 294) with increasing attention to space, while architectural historians seem more excited about the broader scales of sites that digital methods could generate. In part, this reflects the fact that architectural and urban historians have nearly always dealt with space-related topics and mapping has long been a basic tool and approach for research, not to mention other digital tools for 3D modelling and image analysis. In this very study of architecture, not only are the spatial dimensions (all the populated regions of China) untraditionally big, but the temporal scale (from the tenth to twentieth centuries) is also exceptionally long among extant studies of all the fields mentioned above. This *longue durée* approach raises new challenges in text mining first of all.

The Chinese language went through complex linguistic changes and variations from the tenth to the twentieth centuries and from one place to another. It depends on local dialects, habits and styles of writing in different social groups, generating generic linguistic features and phenomena like so called 古今字, 通假字, 異體字, 俗字, 異文. For instance, brick, as a type of building material, could be signified by various Chinese characters and phrases such as 磚, 塼, 甎, 陶磚, 陶塼, 陶甎, 磚石, 塼石, 甎石; they all appear in the LG text. The changing Chinese language generates more complex — and often ambiguous — instances. The LoGaRT, following a Culturomics approach, uses key word(s) or phrase(s) to explore relevant contents. The text mining thus has to rest on precise yet fragmental words or phrases. Meanwhile, authors and compilers of *Difangzhi* often did not use technical terms or jargon belonging to the lexicon of practitioners and experts, but had a different vocabulary. Therefore, in order to extract appropriate new data, the first and key step is defining appropriate words and phrases for text mining.

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3. For more platforms and infrastructures see: CHGIS: https://sites.fas.harvard.edu/~chgis/. Electronic Cultural Atlas Initiative: http://www.ecai.org/. DocuSky: http://docusky.org.tw/DocuSky/ds-01.home.html.

Building materials is a focus of this study outside of recognised historical structures or themes that gave apparent shapes to the local gazetteers. New digital tools were intended to uncover invisible ideas and historical structures hidden in the text. For this, the study requires meaningful data pertinent to building material instead of searching general linguistic terms superficially linked to that. It must examine the associated meanings of all the hit results and remove irrelevant contents. By the time the research was conducted, computers were not yet able to read this high-level knowledge independently. LoGaRT-generated mappings are often too abstract. Further contextualisation and in-depth analysis are very necessary.

A hybrid methodology was thus adopted. The standpoint agreed with 'digital history 1.5' (Fridlund 2018). A loop-round, semi-automatic mode was developed for the text mining and data processing, given the detail below. Distant and close reading, macro- and micro-analysis, qualitative and quantitative, analytical and synthetic methods were all employed in an integrated manner. In reading the spatio-temporal distribution of the architectural knowledge, GIS mapping was used as a tool to process and analyse data, like the view of the Harvard CHGIS project (Bol 2007: 6).

A loop-round working flow

The loop-round method was designed in order to mine the text as comprehensively as possible. A preliminary keyword-based search shows that resulting hits came from highly diverse sections and contexts in LG books. Moreover, the linguistic complexity and potential of OCR (optical character recognition) errors make it impossible to conduct a simple, schematic data extraction. Therefore, instant disambiguation was conducted. LoGaRT, GIS and RegEx tools were used in combination to assist text mining. The text mining was organised by themes of mineral building material. Each keyword search was followed by immediate review and contextualisation, both textual and geographical, and the aim was to identify and disambiguate the computer-resulted hits. Each search was controlled within the quantitative scale of fewer than 10,000 pages, which made the workload of context review practical. Further aided by GIS tools, the resulting intermediate data were processed into refined data in appropriate forms. The loop-round manner especially helped to avoid filtering out alternative terms and phrases that might be pertinent to the topics (Fig. 1).

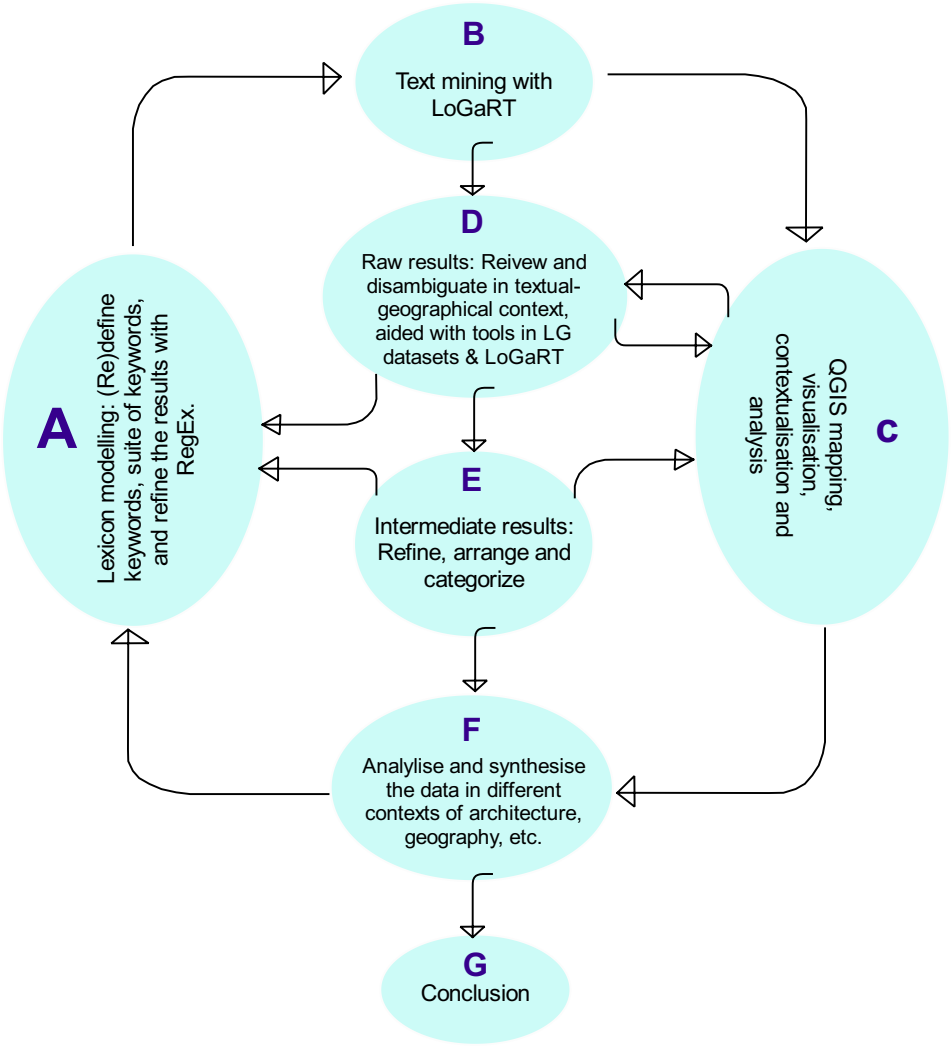

Fig. 1: The method: how the data were extracted from the Chinese local gazetteers.

Concerning the context that structured the Chinese local gazetteers, these two questions have always been taken into account: (1) In which sections did local gazetteer compilers place such information? (2) When and how did their descriptions vary — such as details, terminology, etc.? (Chen et al. 2017: 54). Answers to these questions may help us to understand circulation and evolution of the local knowledge.

Keywords modelling

Chinese keywords have been defined and modelled in the following steps:

1. Preparing a preliminary vocabulary from architectural literature, denoting the building materials used in China. The preliminary vocabulary was built on both architectonic terms from classic books of Chinese architecture and non-architectonic terms collated from non-expert sources (*Ying shan ling* 2006; Li 1103; Yun 1734; Dai 1755; Wang 2000; Wen 2008; Liu 2010; Fu, Steinhardt and Harrer 2017: 348-374). They cover the Chinese terms denoting brick, tile, stone, lime, natural earth and clay, traditional concrete (lime concrete), modern cement, and modern (reinforced) concrete, as well as the use of them in architecture.
2. Reshape the architectural terms within the LG text and context. The aim was to adapt the preliminary vocabulary into contextualised vocabulary for mining LG contents as efficiently as possible. This is because: (1) as mentioned earlier, the *Difangzhi* vocabulary of architecture is different from architectonic terms built by experts and practitioners, see examples below. (2) Presumably, the LG corpus contains potential textual patterns in the documentation of building materials, and recognising any textual patterns might help the text mining in one way or another.

In reshaping the preliminary vocabulary of architecture into an adapted vocabulary based on the difangzhi text, I conducted searching trials in the loop-round manner and repeatedly. Both simple (single) and advanced keyword modelling methods were used. Single keyword searching was followed by advanced keyword searching. Advanced keywords were modelled by using 'and' and 'or' combinations of sets of keywords (keyword suites), and search algorithms (RegEx) for keyword pattern defining. RegEx was efficient in detecting the potential textual pattern, refining searched results and remodelling keywords. Keywords and search algorithms were adjusted, remodelled, and combined on a case-by-case basis. In the end, a new vocabulary resulted, consisting of single keywords, keyword suites, and search algorithms that were adapted to the *Difangzhi* text.

The resulting vocabulary exhibited significant differences from the previous vocabulary based on architectural literature. For instance, in *Difangzhi*, artificially burnt brick and natural building stone were often customarily combined in one term as *zhuan-shi* (lit. brick-stone, with written variations in the Chinese character *zhuan*). The combination suggests that *Difangzhi* compilers and authors considered that brick and stone had very similar functions in construction.

Monographs of architecture, instead, consider them as two distinct sorts of material requiring different construction techniques from ancient to modern times. This distinction shows the abstract and collective features of the *Difangzhi* source. A similar example is *zhuan-wa* (lit. brick-tile, with written variations in *zhuan*), indicating that brick and roof tile shared similar methods of fabrication. Another example is 大木作 (*da-mu-zuo*), translated as 'large-scale wooden structures' (Fu, Steinhardt and Harrer 2017: 352). For historians of Chinese architecture, it was a basic term mostly used to denote the major and principal wooden structure of traditional Chinese architecture. In the corpus of LG, however simple keyword searching of 大木作 hit 19 results only with the book years covering a long period of 1482-1936. In contrast, keyword searching of "木樑 木梁" (*mu-liang*, lit. wooden beam) hit 989 results covering 1268-1949 [**Map 2**]. The close reading in context reveals that *mu-liang* often connotes the meaning of a horizontal timberwork system instead of individual beams. It is better translated as 'wooden beam structure.' Such examples clearly expose the different vocabularies between non-expert intellectuals and expert practitioners. Moreover, it should be kept in mind that the architectural terms in LG do not necessarily correspond to the terms or accurate meanings used by architectural experts, or the terms we use to categorise building materials today.

Table 1 shows some of the finally defined keywords and the architectural uses connoted or denoted by the keywords. Table 2 reports the resulting hit numbers of pertinent contents (measured by page), after checking each hit's context through steps [A], [B], [C], and [D] as explained in the flowchart (Fig. 1).

Geographic analysis and comparative reading: adding-up and breaking-down

In the GIS mappings, point markers were always read together with provincial and prefectural administrative boundaries [**Map 3b**]. This is a compromise because of geographical uncertainty or just lack of precise data. The LoGaRT relates a local gazetteer book to point coordinates data (longitude and latitude) of its administrative capital, which is a 'georeferenced location' (Berman 2004). Thus not all the GIS points represent the precise places where the searched activities actually happened. Instead, a GIS point means that the knowledge of the activity once reached the marked place while the activity might happen in another place under the same administrative region (often) or even faraway (sometimes). Therefore, all the GIS points are considered as a reduced yet accurate spatial representations of knowledge, rather than precise locations of activity.

Functions in LoGaRT and QGIS infrastructure was utilised as the tool to analyse and process data. The purpose is to look for latent relations and patterns significant for the research questions. For instance, my text mining defined three major categories of stonework: '砌以石 building-in-stone' (indicating the action), '石料 stone-material' (the materiality), '石匠 stone-mason/-masonry' (the labour) respectively (see the textual context in Tables 1 and 2). I examined and disambiguated the contents hit by these keywords, and input the intermediate results into QGIS. The 'Histogram' function in QGIS helped to visualise how the hit contents of stonework were distributed in timeline; longer and shorter breaks facilitated distant and close reading in comparison [**Map 3a**].

Meanwhile, the intermediate results were placed in classified layers by metadata such as book year, dynasty, reign period and administrative level. The data strata were added up in different combinations and/or broken down in varied divisions. For example, I added up the above mentioned three categories representing stonework, and then broke down the merged data by book year at equal intervals of 50 years. Each stratum of the 50-year data was overlaid cumulatively, so as to observe the step-by-step evolution in space [**Map 3b**]. Similar analyses were conducted within each category of 'building-in-stone', 'stone-material', and 'stone-mason/-masonry' [**Map 4a** and **Map 4b**]. The method successfully assisted in tracing geographical routes through which the knowledge was transmitted, developed and spread. Adding-up and breaking-down of data strata were always combined with comparative reading in a visual manner. These integrated methods proved to be powerful in my findings on Chinese architecture.

The advanced phase was to detect latent relationships between different building materials, construction activities, and the raw sources. Different thematic categories — such as 'building-in-stone', 'replacing-wood-with-stone', and 'mineral mountain' — were compared to one another with data strata in different combinations. Geographic context was always inspected, for building materials largely relied on geographical and geological resources. In the in-depth mapping, not only were political and cultural context introduced but also geographic and geological maps. Thanks to the vector mapping (and the vector format e-publication), large-scale distant reading and close reading are both feasible.

Relative frequency

The numbers of LG volumes appear quite uneven in different periods [**Map 1**]. This frames the quantitative scales of searchable data. In a defined category,

the more volumes of gazetteers, the more keyword-leading hits are inclined to be generated. Absolute numbers of hits are not sufficient for one to look up the changes in architecture. Therefore, an index 'I' was introduced to denote relative frequency of the records concerned. It is calculated by dividing the number of hit records in a statistical category by the total number of LG books in that category. For instance, in a thematic search of 'building-in-stone' (砌以石), the hits appear on 1,170 pages covering the period 1225-1949 (book year). Amongst them, two pages are from 23 books of the Song Dynasty, zero page from 11 books of the Yuan Dynasty, 149 pages from 510 books of the Ming Dynasty, 834 pages from 2,733 books of the Qing and 185 pages from 721 books of the Republic era; thus, the frequency value I of each dynasty is 8.7×10^{-2} (Song), 0 (Yuan), 29.2×10^{-2} (Ming), 30.5×10^{-2} (Qing) and 25.7×10^{-2} (Republic era), respectively. The records of 'building-in-stone' peak in the Qing dynasty in either absolute numbers or relative frequency. If breaking down the 1,170 hits by reign period, different I values of frequency will be generated, too. These parameters represent how frequent and intensive stone construction was recorded in LG in a particular dynasty or reign period. The diagram below represents the relative frequency of stonework as recorded in the local gazetteers, covering the results from 'building-in-stone', 'stone-material', and 'stone-mason/-masonry' cumulatively. It exhibits a sudden drop at the turn from the Ming to the Qing dynasty [**Map 5a**].

$I = NP/NB$

I: Index indicating the frequency of a thematic topic recorded in a defined category.
NP: number of pages hit by keyword-based text mining in the corpus of the defined category.
NB: total number of LG books in that category.

A discovery: replacing wood with stone and brick

This study opens a novel issue of 'replacing wooden structure with stone and brick' in ancient Chinese architecture, which earlier scholarship has not yet discussed.

I started text mining with keywords linked to timberwork. The purpose was to avoid ignoring wooden construction and prevent the isolation of this study of mineral building material. Surprisingly, the resulting contents are intensively concerned about the decay, deterioration, and collapse of wooden material and structure, and often telling of the fact that the timberwork was substituted by stone and/or brick masonry for better solidarity and greater durability. For instance, 34% results (119 out of 352) hit by the keyword for 'wooden column' (木柱) actually

talk about poor durability of the wooden structure and replacing wooden columns with stone and brick columns and walls. Similarly, in the contents hit by the keywords for 'wooden-beam structure' (木樑 木梁), about 30% (280+ out of 989) talk about replacing the wooden structure with stone masonry for similar reasons. Table 3 lists some representative examples with short textual context, and they are all direct quotations from the LG text.

Further extensive text mining extracted 3,493 pages (out of the 3,999 LG volumes) that contain records of the reconstruction and replacement of wooden structures with stone and brick materials, covering the period from 1201 to 1949. The records often appear in the context of building city walls and fortification, roads, schools, temples, bridges and other hydraulic works like ferry ports, culverts, banks, dykes and dams; they were arranged under the thematic section names of 'Construction', 'Ferry and Bridge', 'Irrigation', 'Embankment and Weir', 'City and Fortification', 'School', 'Landscape and Geography', and 'Metal-Stone' (Table 3). As in mapping, the records were mostly located along rivers [**Map 7**]. The highest quantity and frequency of the activities appear in the Qing dynasty (1644-1911), and it is in the Qing dynasty too that the widest and most intensive spatial distribution appears [**Map 5b**, **Map 6**, **Map 8**]. Jiangnan, a cultural-geographical region of East China, evidently maintained a mass of records throughout the Ming and Qing dynasties, covering Zhejiang, southern Jiangsu, the eastern and southern parts of Anhui and the northern part of Jiangxi provinces as shown in **Map 7** and **Map 8**. In the Qing dynasty, breaking down the data by reign period and exhibiting them in a cumulative manner revealed the gradual growth and spread of the records in space [**Map 8**]. Through the analytical mappings [**Map 8**], it is clear that it was as early as during the Kangxi period (1662-1722) that the spatial structure of this replacing-wood-with-brick-and-stone activity took place.

The relative frequency, as represented in **Map 5b**, exhibits two high phases: one in the middle-Ming period covering 1465-1521 (成化, 弘治, 正德), which is surprising, and the other in the Qing periods covering 1796-1911. Neat increment appears in the Ming periods of 1522-1644 and throughout most periods of the Qing covering 1644-1875, yet with a disruptive fracture in between. The disruption may be explained as a consequence of the political revolution from the Ming to the Qing dynasty. The relative frequencies of the Song and Yuan dynasties are shown in hachures instead of bold bars because the LG books and the results from the Song (15 hits) and the Yuan (5 hits) are too few to be significant, comparing to the greater number of data in later periods. Concerning the relative frequency, the

trend of stonework is compatible with that of replacing wood with brick and stone [**Maps 5a, 5b**].

Opposite records of 'replacing stone with wood' were extensively searched too. In total 115 results were collated, which is many fewer than the 3,493 results of 'replacing wood with stone' in contrast (3% of the latter). The records of 'replacing stone with wood' cover a period of 1512-1949 in the Ming, Qing and Republic eras, and mostly are in the context of bridge construction, restoration and reconstruction. According to the records, bridges were repeatedly rebuilt in either stone or wood after serious damage, and stone was often the choice if conditions permitted. The reasons for changing from stone to wood can be cited as: (1) stone and its labour were too expensive while wood and its labour were relatively economical and more feasible; (2) interest in antique taste or ideological thoughts;[4] and (3) stone blocks were recycled for another urgent project.[5]

New arguments and questions

The results reveal — accurately and to its fullest possible extent — firm evidence of a historical geography of Chinese architecture 'replacing wood with brick and stone'. Architectonically, the material replacement meant that masonry structure developed widely in Ming and Qing China. The increasing use of brick in Ming and Qing China has been well recognised by Chinese architectural historians too (Liu 2003; Zhang and Guo 1985; Pan 2009), whose works rested on the synthesis of fieldwork instead.

The bigger picture the study reveals sustains two clear-cut arguments. One is to repair the earlier specified 'fracture' between ancient and modern Chinese architecture in the historiography. I argue that historical experiences of brick and stone masonry represent a decisive factor for the onset of the way China went on to develop modern architecture, in either ideas or practice, at a time when intensive changes happened in the nineteenth and twentieth centuries. I suggest keeping a

4. "順治初太守李公正茂惟設木橋名曰利涉固有深意　康熙癸卯始易木為石以期久遠　議者謂形家言天門閉塞不利人文非自古設渡之意　復廢石橋易以木." see: 江寧新志 (35137), 江蘇南京, 清乾隆, 1748, 卷第六　建置志, p. 354, and 江南通志 (16882), 江蘇, 清乾隆, 1796, 卷二十五　輿地志　關津一, p. 2775.
5. "在城南明德都元時建木橋建屋於上後增以石明初因修城用石毀橋取石易以木今日久圮." in 萬州志 (36814), 海南, 清道光, 1828, 卷四　建置　津梁, p. 288.

holistic sense of historical milieu in close reading tangible material evidence and writing histories of Chinese architecture no matter whether in ancient or modern times.

Secondly, I argue that the increasing trends of brick and stone in Ming and Qing influenced the wooden roofing construction of Chinese architecture at the same time. Chinese architecture was characterised by its large roofs with far-reaching, curved eaves, and this has been very well recognised. From middle to late Imperial China the large roof system (representatively Tang and Song architecture) transformed into a relatively smaller size and shorter eaves (representatively Qing architecture), accompanied by changes in construction techniques. Architectural historians have long studied the technique changes in all details, and considered the transformation a big issue in need of explanation (Lin 1932; Han 1988). Liu Zhi-Ping, probably for the first time in 1957, expressed the idea that the far-reaching eaves were used to help prevent earthen and wooden walls from deterioration caused by rain, and that the technical solution was later developed into aesthetic taste (Liu 2000: 58).[6] Liu's idea has been quite well recognised by Chinese architectural historians. But very few scholarly studies have been undertaken to discuss the two points. Earthen structures are indeed sensitive to excessive moisture in all its forms—rain, standing water, snow, high and continual relative humidity (Avrami et al. 2008; Warren 1999; Alessandrini et al. 1990). Compared to earthen walls, brick and stone masonries were less vulnerable to moisture in general. Therefore, it is reasonable to say that the largely increased use of brick or stone in walling tended to promote the shrinking size of the wooden roof structure from middle to late Imperial China. The results of the study support such a hypothesis.

New questions are raised. Why was the activity of replacing wood with stone and brick so frequently recorded in mid-Ming periods of 1465-1521 (成化，弘治，正德) [**Map 5b**]? Why in the Qing dynasty was this architectural activity developed so widely in space and intensively in time with stable and continuous growth? What were the reasons? Did the trend of brick and stone form a new culture of architecture? What were the technical sources of the widespread masonry construction as recorded in *Difangzhi*? Liu (1985: 30) and Chang (1993) wrote about Islamic and Western influences in Imperial China's masonry works by studying

6. '中国建筑特点之一，即是常用出檐结构. […] 出檐大时雨水不易淋湿墙壁. 因为中国建筑多用版筑土墙或夹泥墙或木板墙，墙角下很容易被雨水浸坏，所以出檐是愈大愈好 […] 因为大大方方毫不掩饰，毫不做作的出檐，所以也就感觉出檐并不难看，久而久之，成了共同的习惯. 一般房屋如不出檐，或檐短，便觉得局促不美了.'

particular types of architecture and the architectonics. In addition to that, what other exterior sources and interior mechanism could result in the present discovery on such a large scale?

The source material the study relies on is far from complete. However this does not affect the critical phenomena it has exposed. In future, a more complete corpus of the Local Gazetteers would only add examples and details to the issue. The remaining research results about brick, stone, lime, earth and concrete, which has not yet been discussed in this article, will be discussed in a second article; the resultant lexicon in Tables 1 and 2 has cast a light over that.

Keyword-based text mining is a limited method. What lies outside the hit results is in need of further exploration and contextualisation. The loop-round searching mode and lexicon-defining method could be useful for digging up other sorts of Chinese sources, should the source be well collated into full text searchable datasets.

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Tables

Table 1: Keywords modelling for the text mining using LoGaRT.

No.	**English Translation**	**Resulting lexicon used for text mining** (different keywords are separated by comma)	**Annotating the contents**
[1]	Replacing wooden column with brick and stone	易木為石以期久遠，去木柱改砌以磚石，以石柱易木柱，以石易木柱，去木柱鼎建石竇，木柱有朽壞時後之人易之以石墩，去木柱改砌以磚石，舊用木柱且朽今易用石，星門舊以木柱元至正二年令麗思中易之以石，易捲蓬木柱以石易蓬以甎瓦，斲石以易木柱，易木柱以石，易木柱為石，木柱歲久易圮致煩屢修[…]鼎新重建易木以石可垂永久，以木柱易以磚柱，前後二殿俱五間七架易以石柱，重建木柱歲久仍頹雍正十二年奉部議估修以磚爲柱，皆木柱官寺劉壽易之石，易木柱爲石垛，斗門木柱易壞伐石代之，乾隆元年頭門燬本坊衆姓重修易木柱以石墻，昔之木柱悉易以石凡朽者更之，因木柱易朽易以石，大為拆改兩廡沿階木柱換用石柱襯瓦竹篾及周圍坭墻易之以磚，將向之木柱傾斜者轉而為石柱，…	*Mu-zhu*: Lit. wooden column. In the LG text it denotes the vertical load-bearing system transferring loads to the base in Chinese architecture.
[2]	Replacing wooden-beam or -column structure with stone	以石易木梁，九仙橋初名合沙橋舊為木梁宋景德間郡守袁逢吉始易以石，遂誓修石梁，舊為木梁國朝天順五年知府滿本愚易之以石，大泮橋 初為木梁正統五年姚福德始易以石，永樂間重建木梁正統間改建石梁，國朝大順六年又重建陽春橋[…]正統三年巡撫侍郎周忱知縣項任改建石梁，通濟橋[…]初架木梁成化十年知府周正命民汪用本等募衆伐石券，易木梁以石，木梁易朽欲易以石，木柱有朽壞時後之人易之以石墩浮橋不如木柱之安木梁不如石敷之固而斲石之費比之竪木奚啻倍，…	*Mu-liang*: Lit. wooden beam. It means horizontal structural system consisting of wooden beams, transferring loads from top down to the vertical load-bearing system.

No.	English Translation	Resulting lexicon used for text mining (different keywords are separated by comma)	Annotating the contents
[3]	Replacing wood with brick and stone	易木為石，易木以石，改木為石，易用石，易之以石，易以石，易之石，改砌以磚石，易木梁以石，石柱易木柱，以石易木，易捲蓬木柱以石，石以易木，易以石柱，易木柱為石，易木柱以石墻，易木柱以石，木柱換用石柱，將向之木柱傾斜者轉而為石柱，易木柱爲石墩，易殿柱以石，改木柱為石垛，易木柱為石垛，木柱易壞伐石代之，易木柱為石墩，盡易木梁而石之，…	The hit contents appear in the context of foundation, basement, stylobate, masonry wall, hydraulic work, arch, culvert, bridge, embankment, road pavement, etc. Reasons as told in the text: better solidarity and longer durability.
[4]	Reconstructing with brick and stone	易以磚石，易以塼石，易以甎石，易之以磚石，易之磚石，用磚石重建，甎石重甃，益以磚石，用磚石重築，易為磚石，加甎石重甃，改用甎石重修，以磚石改砌，修葺易以磚石，…	Reasons as told in the text: better solidarity and longer durability.
[5]	Replacing stone with wood	石亭易以木坊，石梁易以木，後易以木，今易以木，而易以木，廢石而易以木，廢石橋易以木，石燬復易以木，更易以木，石橋易以木，石梁燬者易以木，易以木板，圮易以木，石圯易以木，石燬易木，石圯易木，以木易石，…	
[6]	Brick-tile	陶磚，陶塼，陶甎，磚瓦，塼瓦，甎瓦	Uses in roof, wall, foundation, etc.
[7]	Brick-tile making place	磚窯，塼窯，甎窯，磚瓦窯，塼瓦窯，甎瓦窯，磚廠，塼廠，甎廠，磚瓦廠，塼瓦廠，甎瓦廠	Production of brick and tile
[8]	Brick-tile and the making	陶磚，陶塼，陶甎，磚瓦，塼瓦，甎瓦，磚窯，塼窯，甎窯，磚瓦窯，塼瓦窯，甎瓦窯，磚廠，塼廠，甎廠，磚瓦廠，塼瓦廠，甎瓦廠	Use and production of brick and tile, indicating all the relevant activities inclusively

No.	English Translation	Resulting lexicon used for text mining (different keywords are separated by comma)	Annotating the contents
[9]	Brick-stone	磚石，塼石，甎石	The LG records are mostly about:1) methods of construction; 2) reconstruction with stone and brick; 3) extraction, preparation, purchase and transportation of the materials.
[10]	Stone-mason/-masonry (the labor)	石匠	Labor of stone mason, or the works of stone masonry
[11]	Stone-material (the materiality)	石料	Material-based LG records, often related to the production, purchase, transportation and storage of stone materials in addition to its use.
[12]	Building-in-stone (the action)	砌以石（補砌以石，甃砌以石，增砌以石，包砌以石，改砌以石，築砌以石，etc.）	Uses of stone, emphasis on the action of building in stone
[13]	Stone works ([10]+[11]+[12])	砌以石，石料，石匠	All the hit contents related to stonework
[14]	Lime	石灰，礦灰，堊灰，希灰，石堊，石堊燒，石鍛，鍛石，鍛石，煆石，礦子灰，白灰	
[15]	Lime-kiln	灰窰，灰窯，灰窑，石灰窰，石灰窯，石灰窑	
[16]	Limestone-quarry	石灰山，石灰嶺，石灰陂，石灰堆，石灰礦，灰礦	

No.	English Translation	Resulting lexicon used for text mining (different keywords are separated by comma)	Annotating the contents
[17]	Oyster-lime	蜃灰，蠣灰，蠣蚌灰，蠣房，古賁灰，且炭亦灰	65% of the results (148 out of 229) were identified as contents speaking about using oyster-lime as binder. The rest is largely linked to food or medical uses.

Table 2: Crucial results hit by the keywords.

Category of keywords	Time span (book year based)	Counts of pages hit by keywords (irrelevant contents removed)						Most in the Section Names of
		Total	Song 960-1279	Yuan 1279-1368	Ming 1368-1644	Qing 1644-1912	Republic time 1912-49	
[1] Replacing wood column with brick and stone	1229-1949	119	1	0	10	94	14	藝文(or 文徵), 學校(or 學宮), 建置 (or 營建), 津梁(or 橋樑, 水利), 寺觀(or 壇廟), 金石, …
[2] Replacing wooden-beam or column structure with stone	1229-1949	393	2	0	31	284	76	建置, 建設, 津梁, 學校, 營建, 城池, 藝文, 文徵, 輿地, 山川, 橋渡, 橋梁, 水利, …
[3] Replacing wood with brick and stone	1201-1949	3493	15	5	384	2516	573	城池, 水利, 橋梁, 橋渡, 津梁, 建置, 地理考

Category of keywords	**Time span** (book year based)	**Counts of pages hit by keywords** (irrelevant contents removed)						**Most in the Section Names of**
		Total	Song 960-1279	Yuan 1279-1368	Ming 1368-1644	Qing 1644-1912	Republic time 1912-49	
[4] Reconstructing with brick and stone	1274-1949	288	1	1	43	200	43	建置: 城池, 橋樑, 閘壩, 堰塘, 壇廟, …
[5] Replacing stone with wood		115	0	0	6	94	15	橋樑
[6] Brick-tile	1201-1949	2824	6	2	232	1576	1008	寺觀, 藝文志, 兵防, 城池, 建置, 城市, 關營, … (highly diverse)
[7] Brick-tile making place	1464-1949	95	0	0	9	46	40	人物傳, 疆域志(橋樑, 村莊), 山川(水), 列傳, 實業
[8] Brick-tile and the making	1201-1949	2909	6	2	238	1621	1042	寺觀, 藝文, 兵防, 城池, 建置, 城市, 關營, …
[9] Brick-stone	1201-1949	5502	10	6	714	3702	1070	城池, 水工, 城郭, 建置, …
[10] Stone-mason/ masonry (the labor)	1379-1949	1048	0	0	69	587	392	金石志
[11] Stone-material (the materiality)	1516-1949	465	0	0	15	252	198	建置, 海塘, …

Category of keywords	**Time span** (book year based)	**Counts of pages hit by keywords** (irrelevant contents removed)						**Most in the Section Names of**
		Total	Song 960-1279	Yuan 1279-1368	Ming 1368-1644	Qing 1644-1912	Republic time 1912-49	
[12] Building-in-stone (the action)	1225-1949	1170	2	0	149	834	185	建置，營建，城池，兵防，水利，橋樑，橋渡，漕運，梁津，古跡，…
[13] Stone works (=[10]+[11]+[12])	1225-1949	2683	2	0	233	1673	775	
[14] Lime	1068-1949	6007	14	7	367	3091	2528	地理考，實業，地質志，物產，輿地
[15] Lime-kiln	1455-1949	830	0	0	23	377	430	疆域，物產，礦產，建置(or建設志)，城池，關營(or關隘，城堡考)，兵防(or 兵食)，山川，輿地，關梁，河渠，…
[16] Lime-stone-quarry	1265-1949	359	1	0	46	223	89	方輿，山川，輿地部，疆域，…
[17] Oyster-lime	1253-1949	229	1	2	21	150	55	建置，田賦，堤防，物產

Table 3: Hit results of replacing wooden structure with brick and stone.

Hit by keywords	**Time**	**under the Section Names of**	**Contents**
木柱 (wooden column) 木樑 木梁 (wooden-beam structure)	1229-1949	建置, 建設, 營建 (construction); 津梁, 關梁, 橋樑, 橋渡 (ferry and bridge); 水利 (irrigation); 堤堰 (embankment and weir); 城池 (city and fortification); 學校 (school); 藝文, 文徵 (art and literature); 山川, 輿地 (landscape and geography); 金石 (records of metal and stone); etc. …	30% of the hit results (393 out of 1325) are about replacing wood with stone
Citing some examples in context (different quotations are divided by full stop): 去木柱改砌以磚石. 以石柱易木柱. 以石易木柱. 易木柱為石墩. 木柱有朽壞時後之人易之以石墩. 舊用木柱且朽今易用石. 斲石以易木柱. 易木柱以石. 易木柱爲石墩. 舊用木柱者悉易以石. 易殿柱以石. 易木柱而結石塾. 重建改木柱為石堶. 易木柱為石堶. 易木梁以石. 盡易木梁而石之. 木柱者水蠹浸剥易腐乃命石工購石砥柱悉以石. 正德八年僉事李志剛去木柱改砌以磚石. 重建長橋撤去木柱鼎建石竇六十二楹每竇用鐵鐕八條. 星門舊以木柱元至正二年令麗思中易之以石. 隆慶四年知縣黃一龍又總修之并易捲蓬木柱以石易蓬以甎瓦. 木柱歲久易圮致煩屢修崇戊辰知縣楊之屏鼎新重建易木以石可垂永久. 以木柱易以磚柱. 重建前後二殿俱五間七架易以石柱後殿始立. 重建木柱歲久仍頹雍正十二年奉部議估修以磚爲柱. 櫺星門向置木柱屢修屢圮甲寅夏公捐金創建石柱學宮煥然一新. 創始皆木柱官寺劉壽易之石. 櫺星門一座明萬曆十九年知縣楊繼韶建久圮康熙二十年王基鞏重修奈木柱易朽雍正十二年邑原武罔訓導胡藝琦捐易以石. 易木柱爲石堶. 東湖斗門木柱易壞伐石代之. 乾隆元年頭門燬本坊衆姓重修易木柱以石墻. 尊經閣木柱蟻蝕坍塌知縣姜山捐俸重建易以磚牆. 昔之木柱悉易以石凡朽者更之毀者造之. 因木柱易朽易以石. 大為拆改兩廡沿階木柱換用石柱襯瓦竹篾及周圍坭墻易之以磚. 將向之木柱傾斜者轉而為石柱. 康熙二十六年知縣王廷諴重修聯兩廳為一中起高脊四十六年大殿木柱蟻蝕知縣吳廷芝易石柱.吳江有長橋[…]舊本木柱[…]元季易以石橋爲洞門一百五處迄今二百餘年. 迎恩橋[…]竪木爲柱而架梁其上[…]柱有朽壞時後人易之以石墩[…]木梁不如石墩之固而斲石之費比之竪木奚啻百倍.重建前後二殿俱五間七架易以石柱.風雨之處舊用木柱今易以石柱可歷久弗壞也. 改建木柱之梁以爲石橋. 先年俱用木柱[…]易圮三十年知縣陳朝策週圍易以磚砌.大興東湖水利以斗門木柱易壞伐石代之. 撤去木柱仿照滻灞橋之工咸易以石柱厚培堅築以期經久. 殿中四木柱近座二年久蟻蛀民國二十三年甲戌改用石柱. …		

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Maps

An introduction to the mapping section

This mapping section presents the study in a visual way, with detailed explanations of the source material, the methods, and the results. They can be considered as supplementary yet independent material for the textual sections. Maps 1-5a set out, step by step, the generic methods used for the study. Maps 5b, 6a, 6b, 7 and 8 deal with a critical phenomenon from the results. EXCEL, Spreadsheet, R, and QGIS were utilised to aid the LoGaRT in analysis and visualisation.

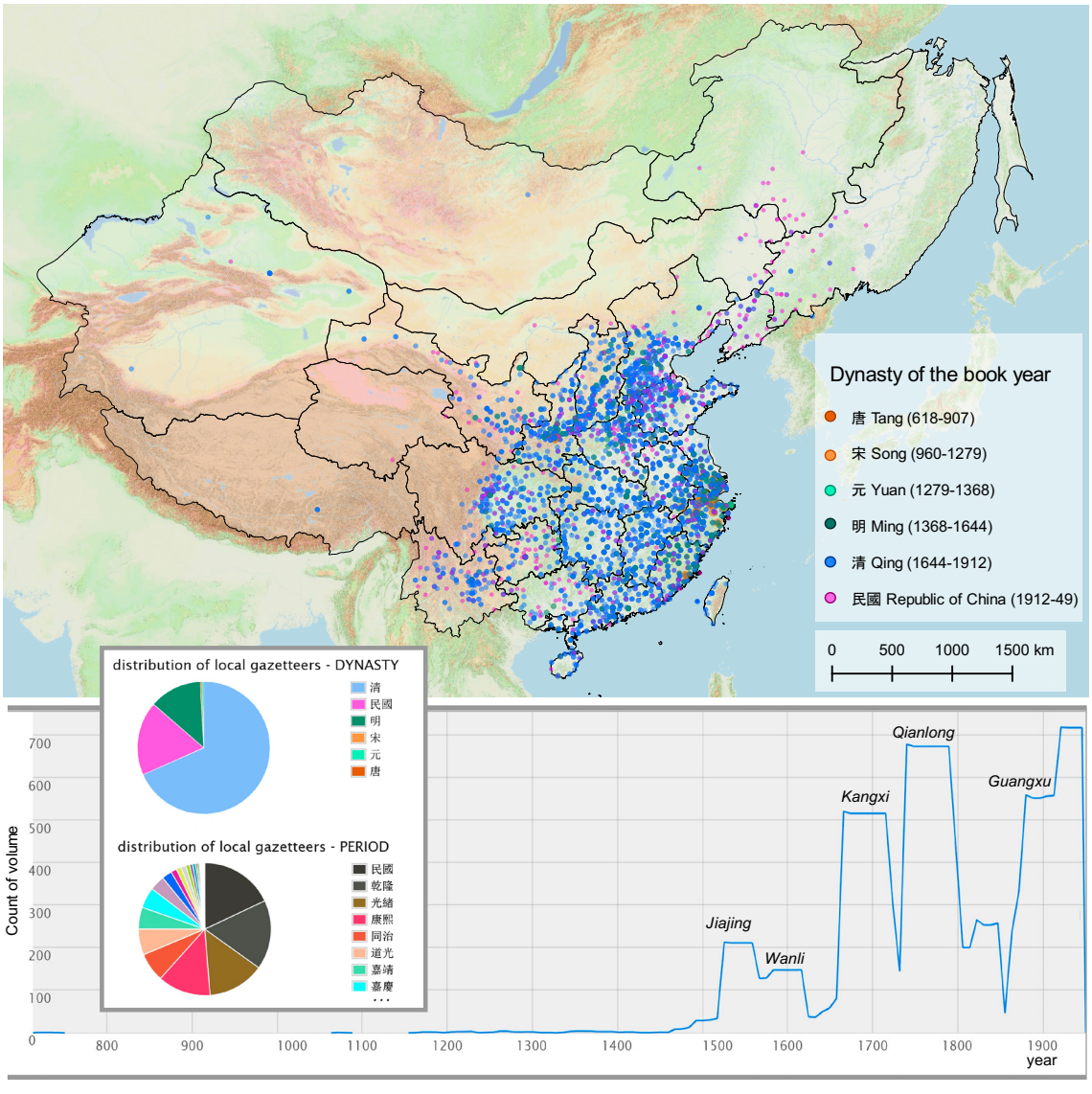
In visualisation, the 1820 administrative boundaries (CHGIS, 2016) were adopted consistently in favour of comparative reading. The factual territory and administrative boundaries of China were changing all the time. The study always contextualises the data with their contemporaneous administrative boundaries. Moreover, although 6% of the 3999 source books have different 'book year' and 'edition year' and the study has a concern in it, this section systematically adopts 'book year' data to establish the mapping analyses related to temporal processes, unless 'edition year' is specified like in Map 6b.

Map 1: Chang-Xue Shu (2018), *The Source: Spatio-Temporal Distribution of the 3999 Volumes of Chinese Local Gazetteers* (Difangzhi).

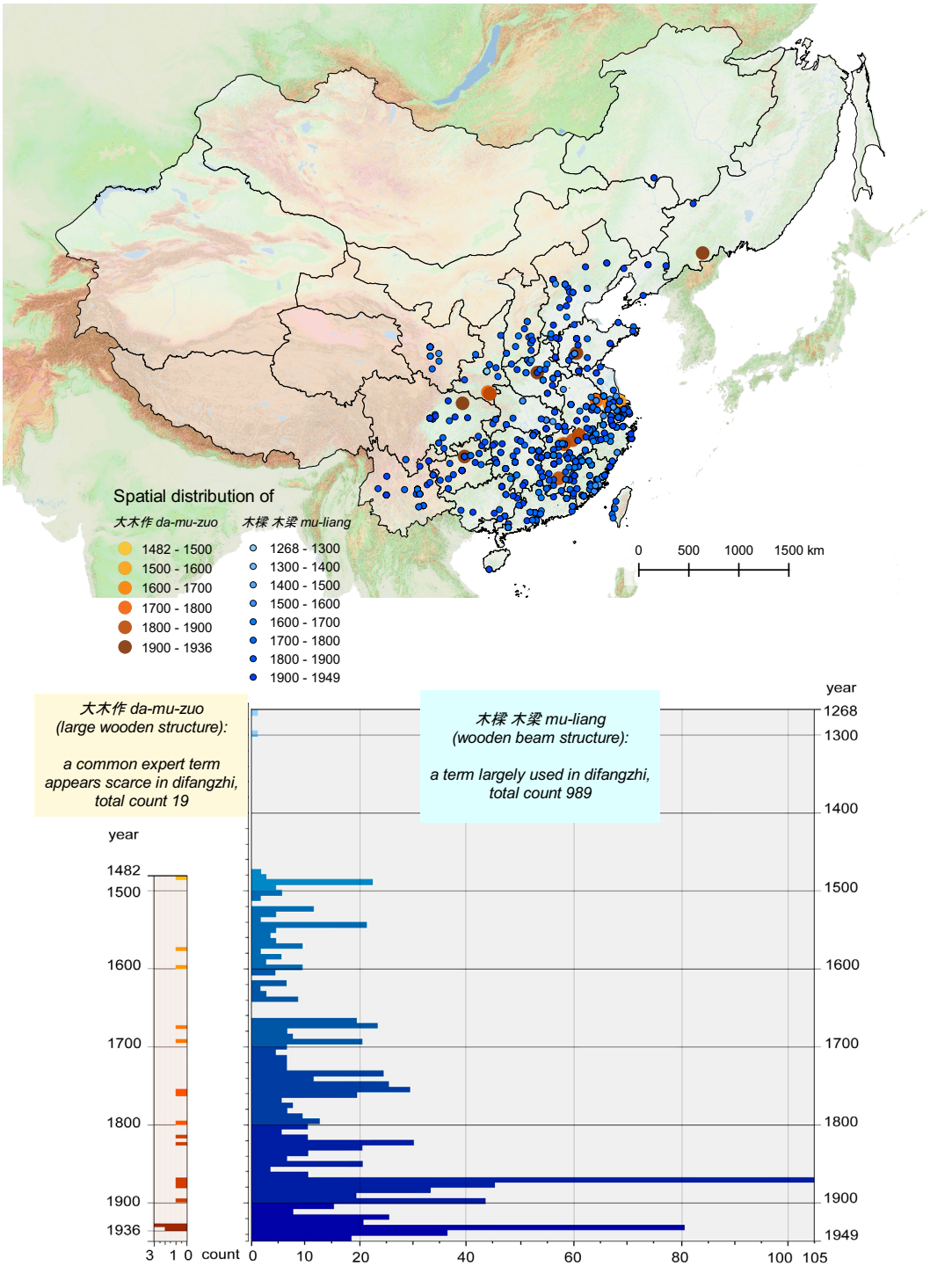
The map (top) shows that the source covers all the populated regions of China. The diagram and the pie charts (bottom) visualise a very uneven distribution of the local gazetteers in time. Although they cover the tenth to the twentieth centuries, the major part comes after the second half of the fifteenth century, that is, in Ming, Qing, and Republic times. It is obvious that politically stable and long reigns of Imperial China guaranteed that rising quantities of local gazetteers would be produced. This corresponds with the nature of *Difangzhi* — a sort of documentation written and compiled by the local gentry and elite officials, and it was closely related to local governing and administrative functions.

Map 2: Chang-Xue Shu (2018), *Starting with Keywords Modelling: Contrasting results of 'da-mu-zuo' and 'mu-liang', showing the Chinese local gazetteer has its vocabulary of architecture distinct from the experts'*.

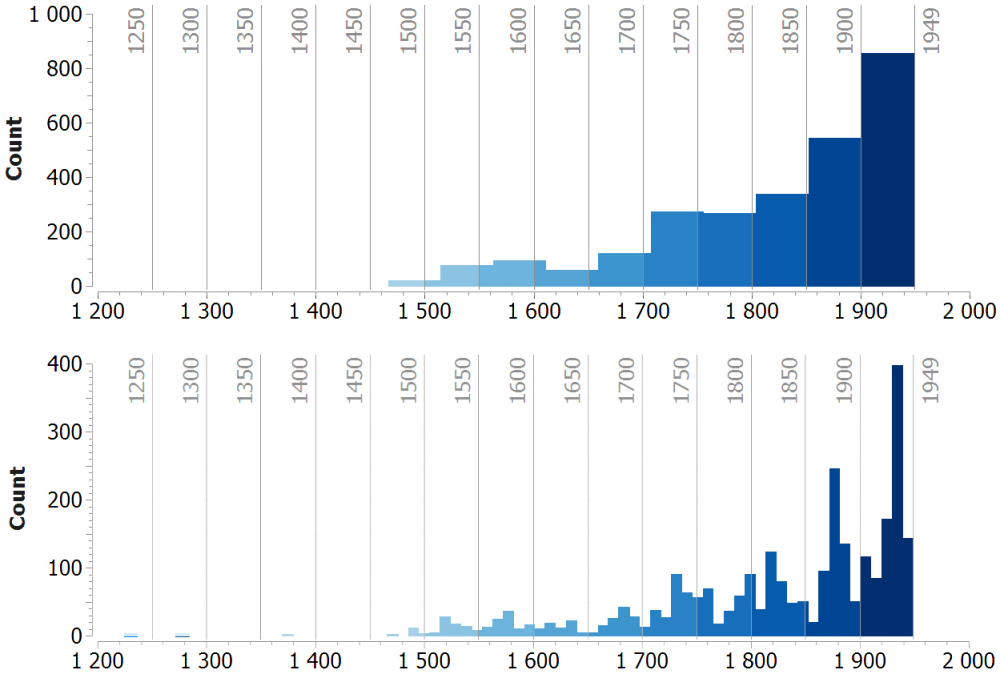
Chinese local gazetteers contain a latent lexicon of architecture distinct from the architectural experts' language in either ancient or modern times. As an example, this mapping shows the contrasting results of '*da-mu-zuo* 大木作' (lit. large scale wooden structure) and '*mu-liang* 木樑 木梁' (lit. wooden beam) in spatio-temporal dimensions after text-mining the *Difangzhi* source. The former is a basic technique term of Chinese architecture while it appears surprisingly scarce in the Chinese local gazetteers in spatio-temporal dimensions. The latter, instead, hit considerable results about wooden structure. The in-depth review of the hit contents in context reveals that 'mu-liang' not only denotes the apparent meaning of wooden beam (an ingredient of structure), but also connotes the horizontal timberwork system.



Map 1: The Source: Spatio-Temporal Distribution of the 3999 Volumes of Chinese Local Gazetteers (Difangzhi)



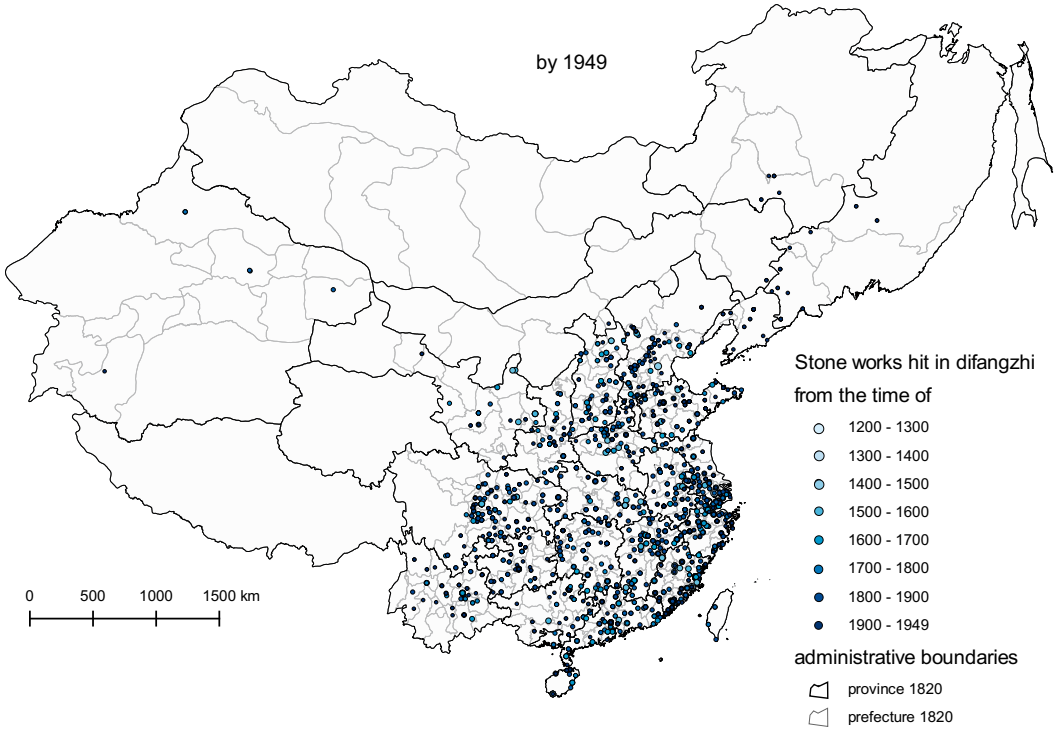
Map 2: Starting with Keywords Modelling: Contrasting results of 'da-mu-zuo' and 'mu-liang', showing the Chinese local gazetteer has its vocabulary of architecture distinct from the experts'.



Map 3a: Chang-Xue Shu (2018), *Reading the Raw Results with Histograms*.

Take the thematic topic of stonework for instance. After review and disambiguation, all the hit contents pertinent to stonework were added up; EXCEL and QGIS were used as tools. Then the assembled results were automatically calculated into quantitative histograms in the QGIS. The histograms could tell how frequently stonework activities were written up in the corpus of Chinese local gazetteers.

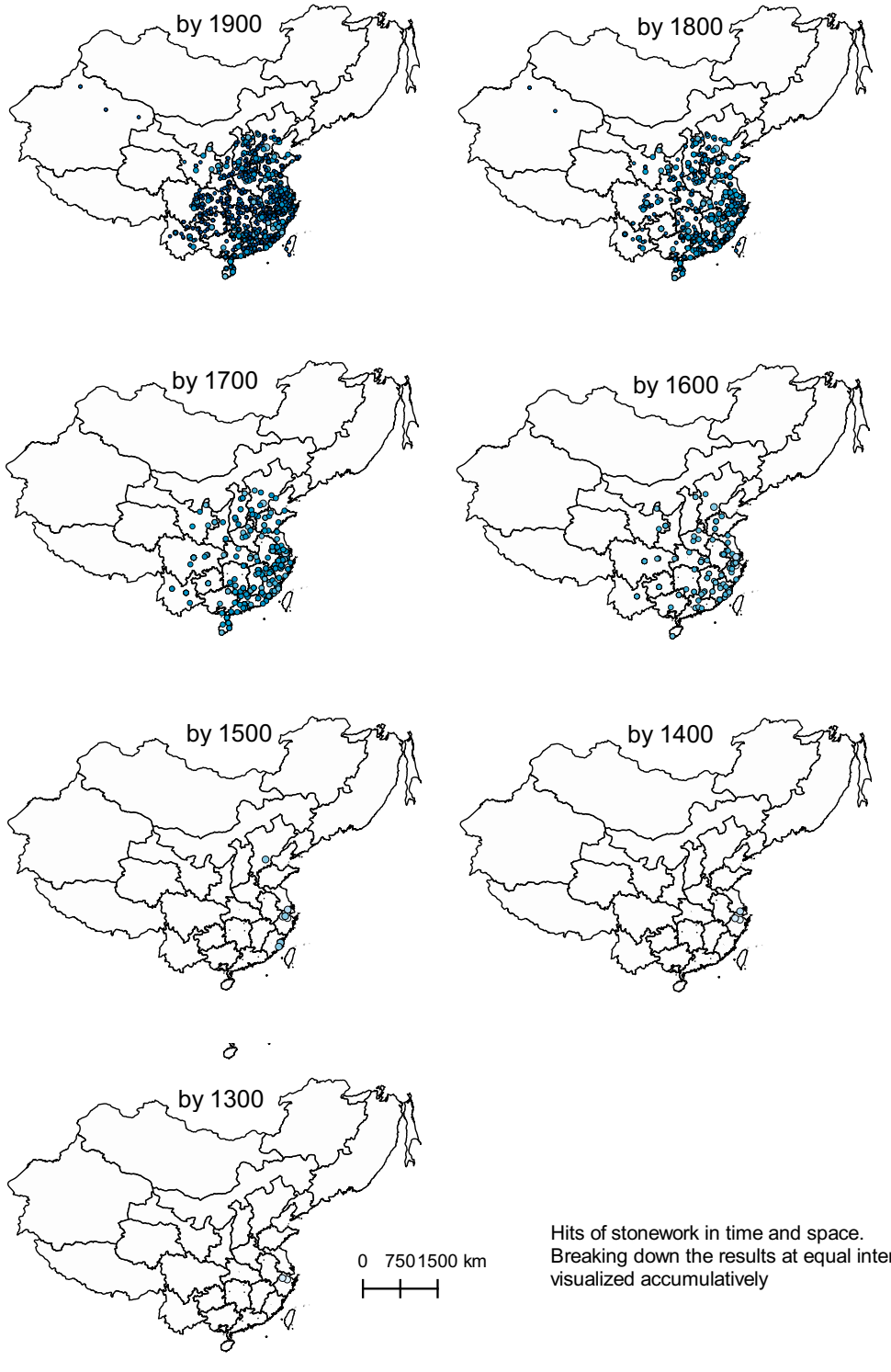
In this mapping, two histograms result from the same results counted at different points in time. The diagram at the top dealing with longer intervals (50 years) visualises the general trend that requires 'distant reading' (Moretti 2013), while the one at the bottom with shorter intervals (10 years) requires 'close reading' comparatively.



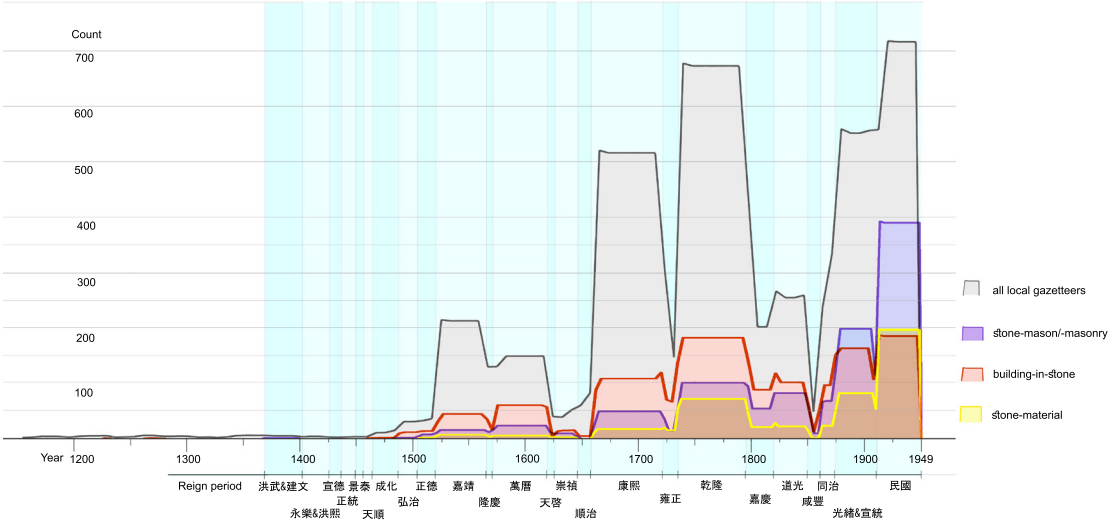
Map 3b: Chang-Xue Shu (2018), *Analysing and Synthesising the Hidden Historical Structures in space*.

Following 3a, the assembled results of stonework were broken down at equal intervals (e.g. 50 or 25 years) and the changes were observed step by step in geography. The maps in 3b show the process in part (at intervals of 100 years). The changes are visualised in a cumulative manner.

The mapping reveals a changing historical structure of the intellectual knowledge of stonework in space. It proves that a spatial structure was well established from 1600 to 1700 at the latest. It also visualises how greatly the spatial structure was developed in the Qing dynasty (1644-1911) and in the Republic era (1912-49).



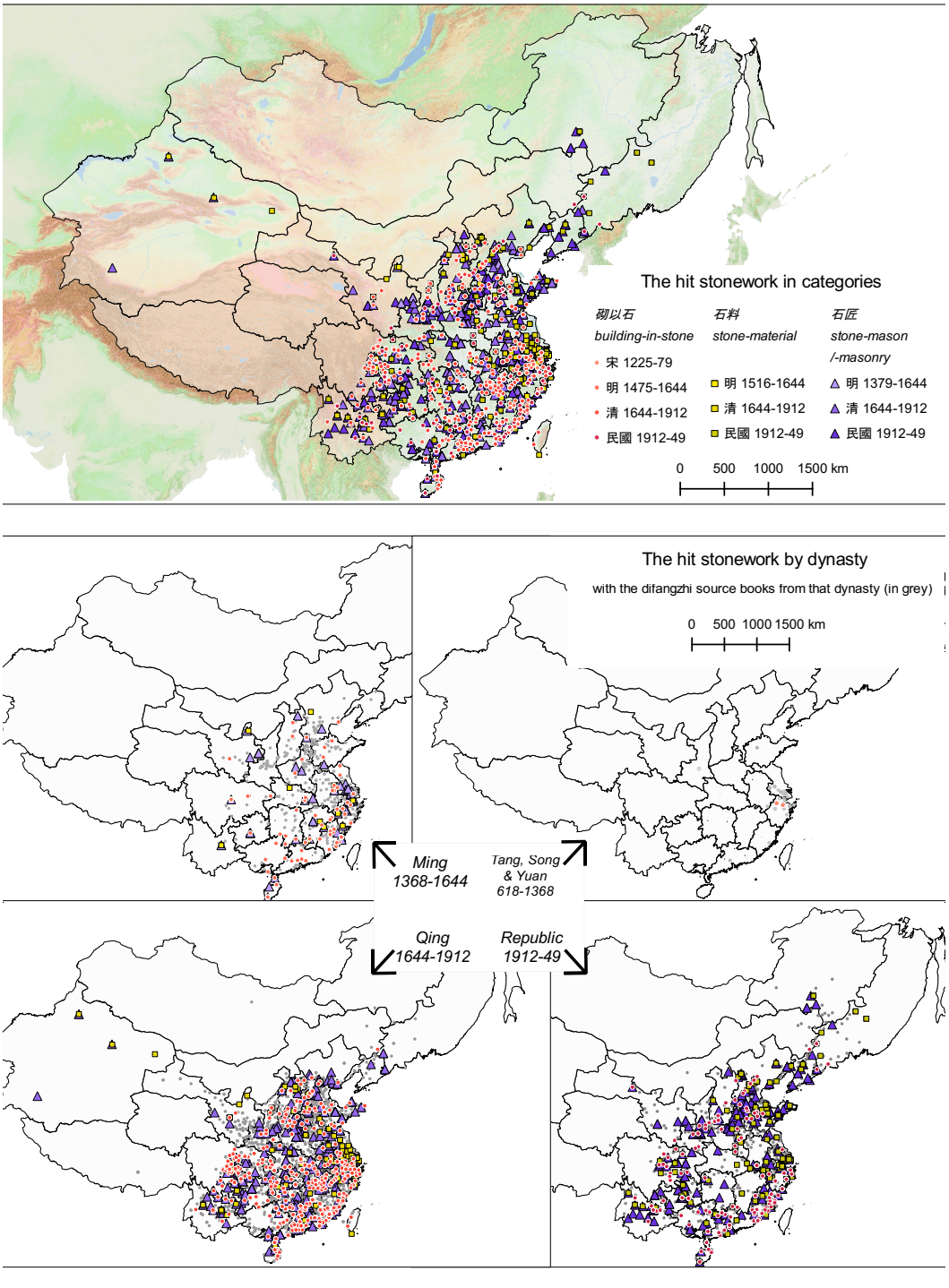
Hits of stonework in time and space.
Breaking down the results at equal intervals, visualized accumulatively



Map 4a: Chang-Xue Shu (2018), *Quanti-Qualitative Analysis through Line-Chart Mapping*.

The hit results of stonework contain three principal categories: 'building-in-stone' (emphasising on the action or activity), 'stone-material' (materiality), 'stone-mason/masonry' (linked to the labour). Each of the categories generates a line chart representing the results of that category in quantity-time correlation, and the quantity was counted by page. The three line graphs, together with the quantity-time graph of the *Difangzhi* source (the dark grey line graph counted by volume), were layered along the same timeline. It was supplemented with another timeline graph marking Chinese reign periods (*chaodai* 朝代) of the Ming and Qing dynasties (rendered in two shades of light green alternatingly).

In this line-chart mapping, similar trends in rises and drops are apparent between the line graphs, with differences visible too. It shows that the absolute count of the hits in a particular period are framed by the volumes of the *Difangzhi* source in that period. Therefore, it is very necessary to introduce an index of 'relative frequency' to represent the intensity and density of a topic which was recorded by Chinese literati in *Difangzhi* in a defined period. Still, the mapping shows that 'building-in-stone' increased remarkably in the Qianlong period (1735-96, see the red line graph), and 'stone-mason/masonry' rose even more rapidly in the Republic period (1912-49, the purple line graph).



Map 4b: Geographical Distribution of Stonework in Thematic Categories and in Dynasties.

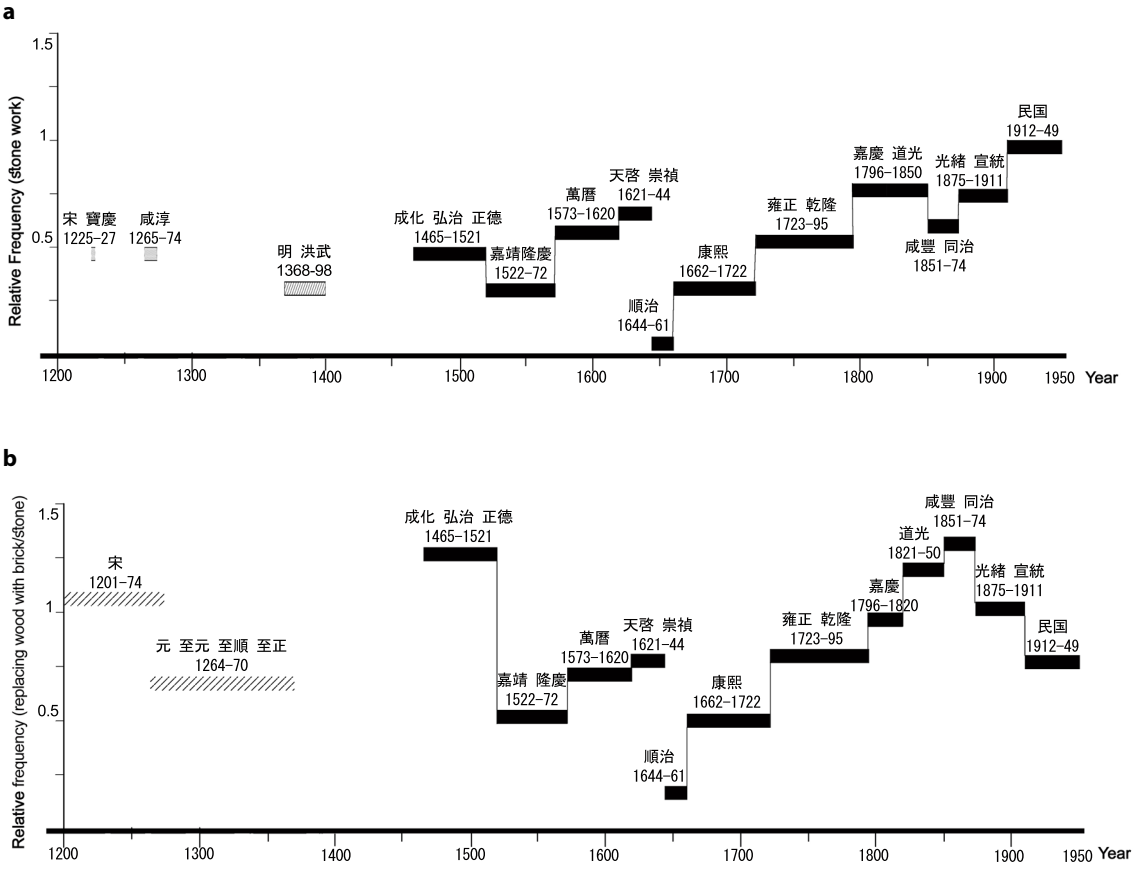
Map 4b: Chang-Xue Shu (2018), *Geographical Distribution of Stonework in Thematic Categories and in Dynasties*.

This mapping broke down the hit results of stonework by thematic category and dynasty respectively. The mapping at the top is a general presentation of the assembled results. It proves the wide geographical scale the Chinese practice and knowledge of stonework had reached by 1949. At the bottom, the mapping by dynasty shows several geographical structures of the knowledge. A geographical structure was formed in the Ming dynasty (1368-1644) at the latest. The structure developed and evolved differently in the Qing dynasty (1644-1911) and in the Republic period (1911-49), with distinct characters in either era. The most intensive development occurred during the Qing dynasty, and it appears continuous with the structure in the Ming (see the two maps at the left-bottom). In the Qing dynasty, moreover, the records of stonework extended over the regions in the northwest (via Hexi Corridor) and southwest (largely in Sichuan, Yunan and Guizhou). After the first half of the twentieth century, the development formed a Ơ-shape structure: few records are from regions of Central China yet remarkable traces are found over the northeast (see the map of Republic time in the right-bottom).

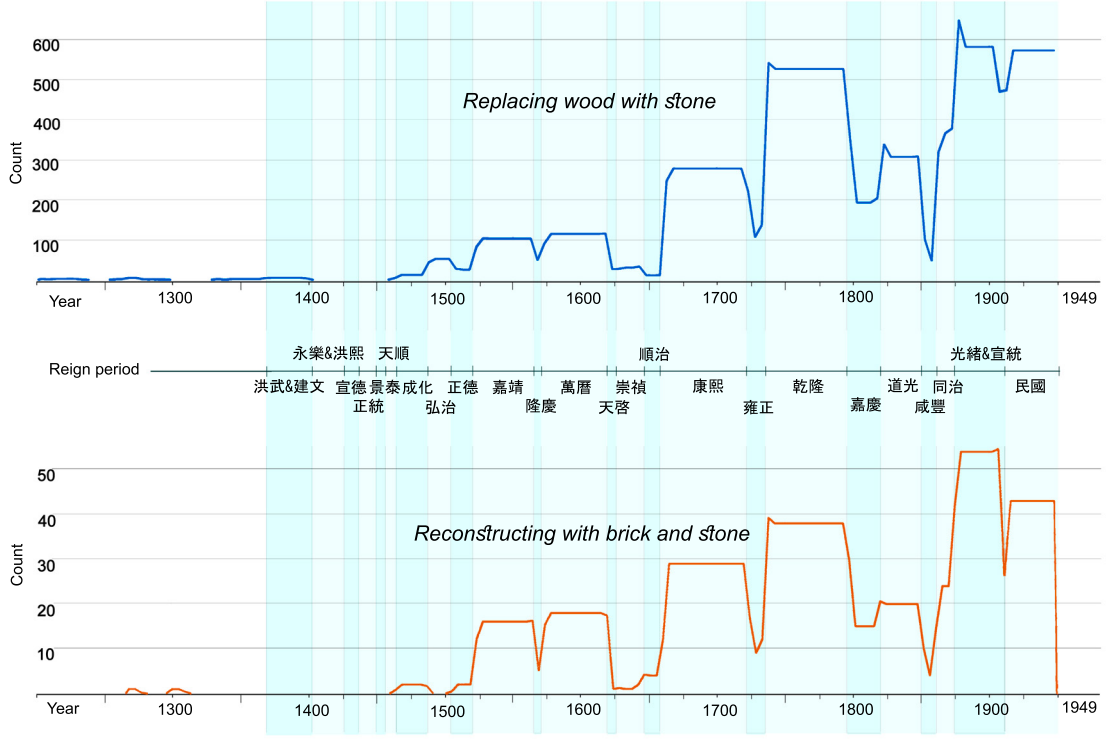
Maps 5a and 5b: Chang-Xue Shu (2018), *The Relative Frequency in Reign Periods*. The results of stonework (5a) and replacing wood with brick and/or stone (5b).

An index of 'relative frequency' was introduced and calculated, concerning the facts shown in 4a — quantitative limits of the source books unavoidably impact the hit results, and all the trends are closely linked to reign periods. The mapping of 'relative frequency' correlated four parameters: the counts of the source book (by volume), the counts of hit results (by page), metadata of 'book year', and reign periods. The index of relative frequencies in different reign periods was calculated. They were then transformed into a line-graph, where each horizontal line segment represents how intensive and dense the hit records are in that significant period.

The mapping of 5a dealt with the hit results of stonework, and 5b the hit results of 'replacing wood with brick and stone.' 5a and 5b are compatible in the following three aspects. (1) Both exhibit a sudden drop (or disruption) at the change from the Ming to the Qing dynasty, which may be explained as a consequence of the political replacement. (2) Both show stable increases in the periods of 1522-1644 and from 1644 to the end of the twentieth century respectively. (3) Both exhibit a high phase covering the three middle-Ming periods of 1465-1521 (成化，弘治，正德). However, 5b has very distinct trends: (4) The increase in 1465-1521 is exceptionally high compared to that shown in 5a; the reasons need explanation. (5) the relative frequency in 5b drops off after 1875, which is not exhibited in the case of stonework in 5a; this implies that new building material became available, or simply that the traditional activity of 'replacing wood with brick and stone' became less concerned by *Difangzhi* compilers.

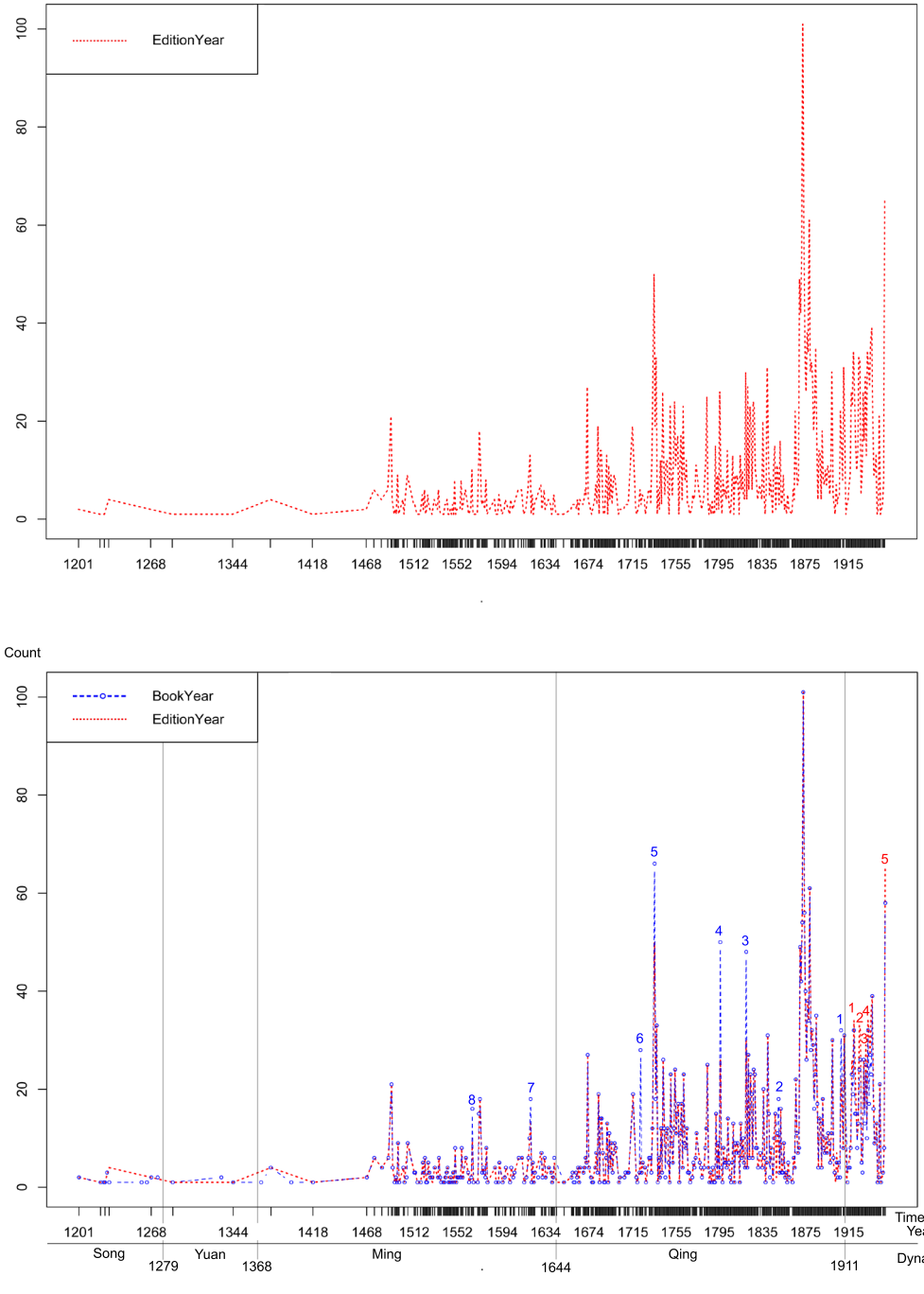


Maps 5: The Relative Frequency in Reign Periods. The results of stonework (5a) and replacing wood with brick and/or stone (5b).



Map 6a: Chang-Xue Shu (2018), *A Critical Result: Replacing and Reconstructing (Wood) with Brick and Stone*.

The following Maps 6, 7 and 8 provide the most critical evidence of the historical fact of using mineral building materials: 'replacing wood with brick and stone'. Earlier scholarship has not yet discussed the phenomenon of replacement from wood to masonry structure (stone or brick masonry) in Chinese architecture. Map 6a consists of two count-year diagrams, showing the thematic results of 'replacing wood with stone' and 'reconstructing with brick and stone' respectively. The trends in these two charts are quite similar and compatible.



Map 6b: Circulating the Knowledge via the Chinese Literati and the Local Gazetteer Books. A closer reading of the hit results of 'replacing wood with stone' in count-year diagram.

Map 6b: Chang-Xue Shu (2018), *Circulating the Knowledge via the Chinese Literati and the Local Gazetteer Books. A closer reading of the hit results of 'replacing wood with stone' in count-year diagram*.

The Chinese literati and the local gazetteer books constitute two kinds of agency promoting the circulation of architectural information. In the datasets collated through LoGaRT, one should understand the attribute 'book year' as the time the Chinese literati officially documented the practical knowledge or events of architecture and the attribute 'edition year' the time the practical information was (re-)circulated and disseminated. Map 6b shows these two modes of knowledge circulation. The two charts, 'count – book year' (blue) and 'count – edition year' (red), thus visualise two long-term structures of circulating the practical knowledge of architecture. The mapping of 6b used R — a software environment for statistical computing and graphics.

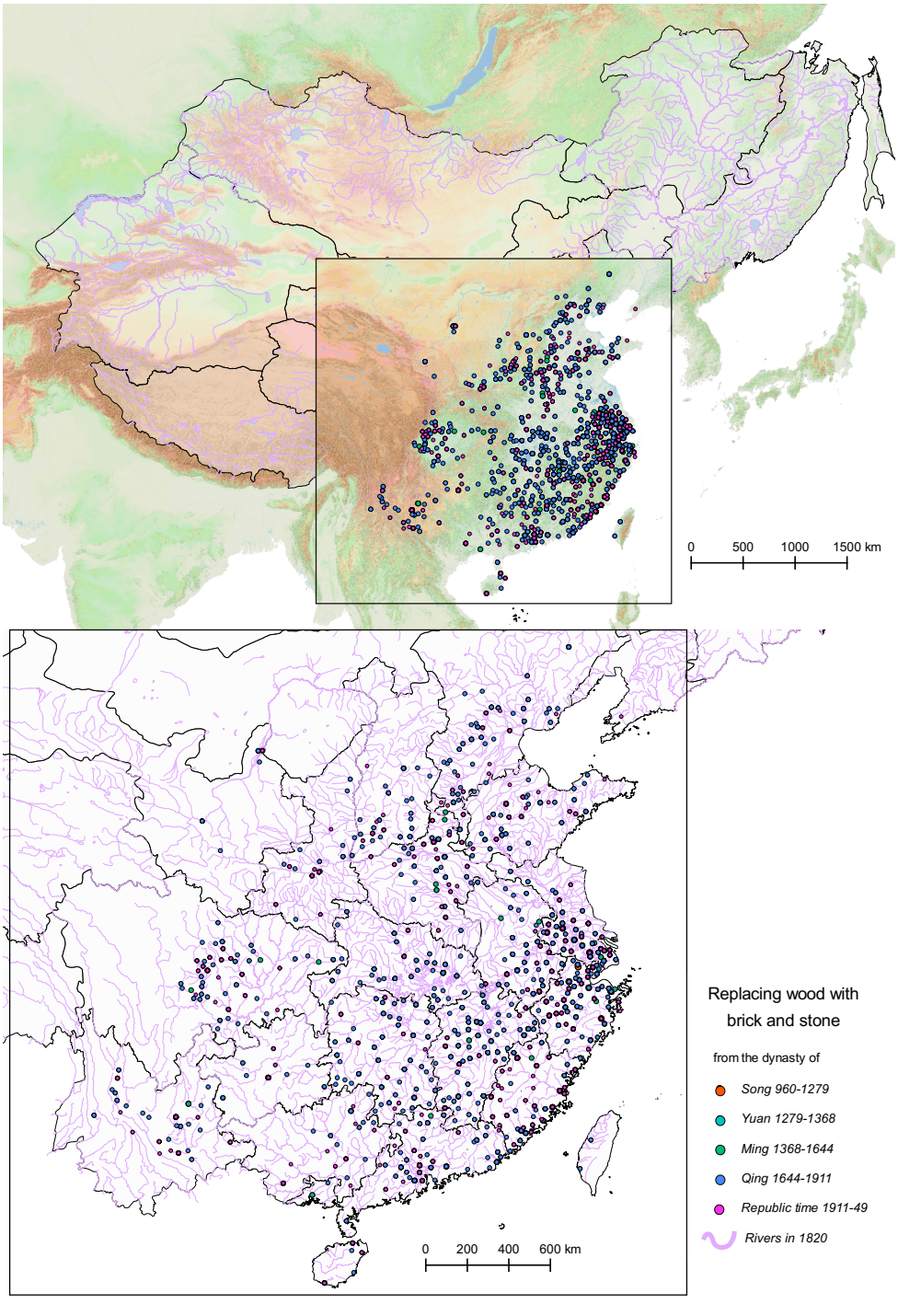
The blue and red charts were built on the same hit results of 'replacing wood with stone'. Overlapping the two line charts (6b-bottom), one can see their co-occurrence and difference. To make the difference more visible, I marked the significantly higher peaks in the blue line chart with bluish Arabic numerals and the higher peaks in the red line chart with reddish numerals. In comparison, it suffices to say that the practitioners' knowledge of 'replacing wood with stone' was remarkably absorbed by the Chinese literati in late-Ming and Qing eras (esp. 1566-1850), and the practical knowledge were increasingly (re-)circulated in the Republic era (1911-49).

The same method of R visualisation was applied to the dataset of the whole 3999 source books. The resulting visualisation confirms that the local gazetteers were largely compiled in Ming and Qing dynasties and even increasingly (re-)printed in the Republic era (1911-49), which is compatible with what 6b shows.

Please note that Map 6b resulted from the same EXCEL dataset that the 6a-top diagram rested on, but the 6a-top was processed by LoGaRT.

Map 7: Chang-Xue Shu (2018), *Replacing Wood with Brick and Stone*. Mapping all the pertinent results from 1201 to 1949 in terrain (top) and contextualising them in the 1820 river system (bottom).

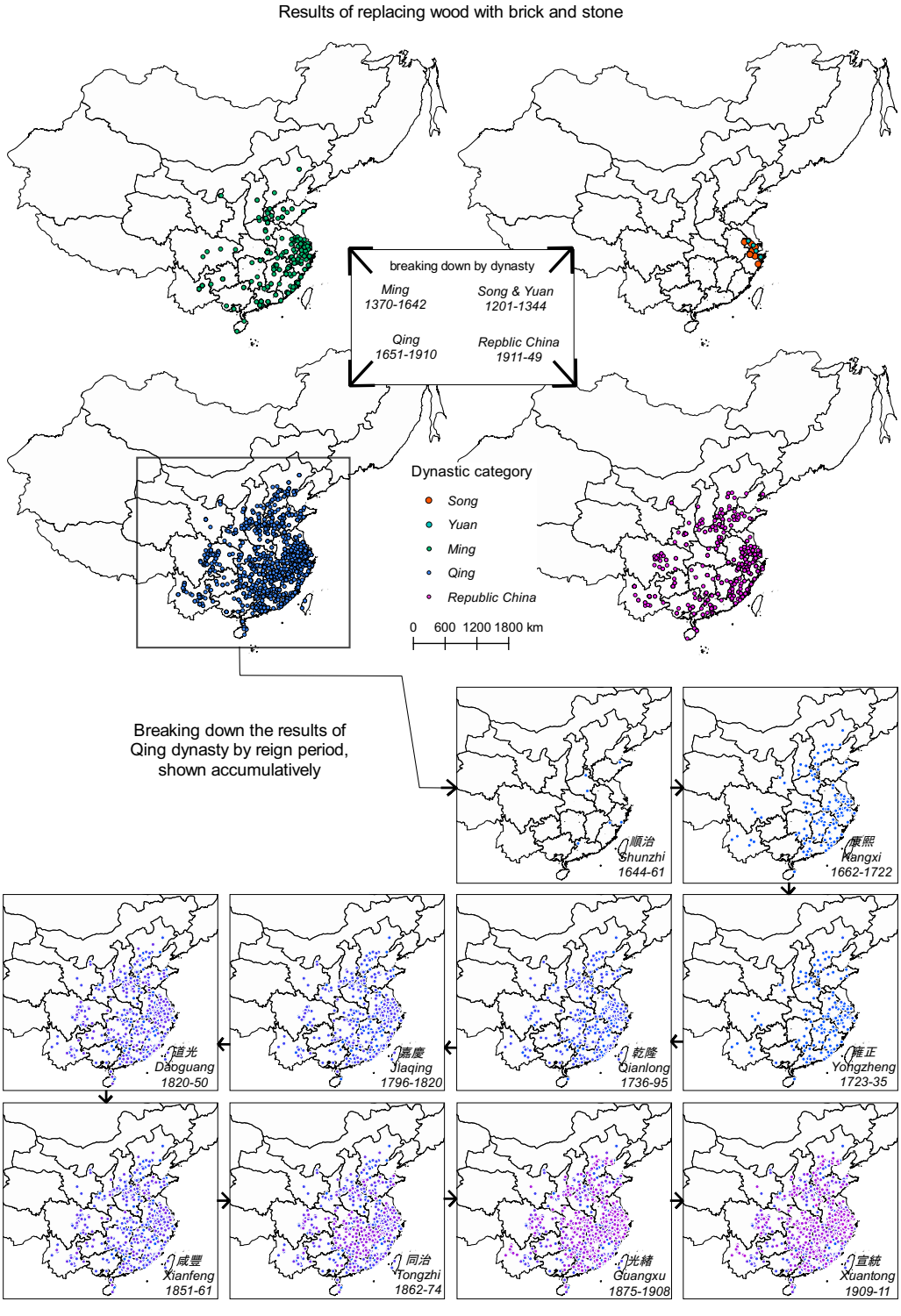
This mapping shows that most of the records of replacing wood with brick and stone were apparently located along rivers. The mapping corresponds with the fact that the contents are largely recorded in the local gazetteers in the context of building city walls, fortification, roads, schools, temples, bridges and other hydraulic works like ferry ports, culverts, banks, dykes and dams; they were arranged under the thematic section names of 'construction', 'ferry and bridge', 'irrigation', 'embankment and weir', 'city and fortification', 'school', 'landscape and geography', and 'metal-stone'.



Map 7: Replacing Wood with Brick and Stone. Mapping all the pertinent results from 1201 to 1949 in terrain (top) and contextualising them in the 1820 river system (bottom).

Map 8: Chang-Xue Shu (2018), *Replacing Wood with Brick and Stone*. Analytical GIS mapping, by breaking down the results in dynasties, non-cumulatively (top) and breaking down the results of the Qing dynasty by reign period, cumulatively (bottom).

The most and most frequent occurrences of the activity appear in the Qing dynasty, and it is in the Qing dynasty too that the widest and most intensive spatial distribution appears [see Map 5b, Map 6, Map 8-top]. This analytical mapping in Map 8-bottom proves that by the end of the Kangxi period (1662-1722) at the latest the spatial structure of this replacing-wood-with-brick-and-stone activity had formed.



Map 8: Replacing Wood with Brick and Stone.

POSTFACE

Mapping Historical Landscapes in Transformation

An Overview

John Bintliff (Leiden University / The University of Edinburgh)

In this postface overview of this edited volume, I have been asked firstly to highlight key themes; secondly to elaborate on them from my own experience of approaches to townscape and landscape research; and thirdly to identify areas that were not so prominent in these collected papers but deserve inclusion in a holistic overview of current research in these fields.

Social interaction

We are treated to an insightful chapter analysing mobility in a regional historical environment by Sanne Maekelberg with the sixteenth- early seventeenth-century travels of Duke Charles of Croÿ. His letters reveal political structures, his changing career, aspects of contemporary strategic conditions, and the world of leisure.

Let me try to widen the field to embed this into other approaches to social Interaction in the urban and rural environment.

Anthropologists have demonstrated the importance of face-to-face communities with an upper limit of around 150 people (Dunbar 1996). Many historical rural societies use village fission to preserve this form of society. It requires constant out-marriage to survive (Bintliff 1999). Even in modern urban societies this 'Dunbar' threshold persists; the average number of Facebook contacts is 175!

If a village rises to 500-600 or more inhabitants, it can become mostly in-marrying. Social stability now requires some kind of horizontal or vertical social stratification. On a global level these corporate communities tend to show emergent

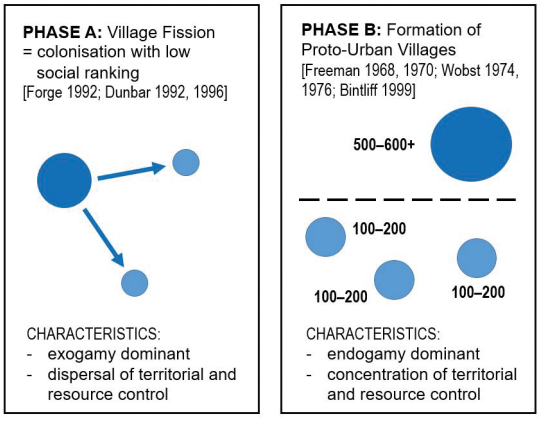


Fig. 1: A model for the transformation from a face-to-face settlement to one largely endogamous and ripe for the development of a corporate community. Numbers refer to population range of settlements (from Bintliff 1999: fig. 4.10).

properties of an urban or even city-state character (Bintliff 1999) (Fig. 1). Wendy Davies (1988) documented this process amongst the Early Medieval villages of Brittany.

It was the historical geographer Ernst Kirsten (1956) who demonstrated that the typical city state or *polis* of ancient Greece had usually arisen in this fashion, calling it a *Dorfstaat*. Eberhard Ruschenbusch (1985) took this further statistically with his calculations for the population and territory range for this '*Normalpolis*': of the 700-800 minimum city-states of the Classical Aegean for which data are available — 80% have populations of 2000-4000 people and maximal territories of 5-6 km radius, thus a mere one hour walk to the city-state borders. Importantly frequently 70-80% of citizens lived in the Polis centre (Bintliff 1997), since territory size was so small, allowing an unprecedented degree of citizen political involvement.

The transition from village to city life brings dramatic cultural changes. Winfried Schmitz (2004) outlines convincingly how the Greek villager Hesiod (ca. 700 BC) represents at the dawn of European literature, in his poem on a farmer's year, the *Works and Days* (Ἔργα καὶ Ἡμέραι), a form of communal peasant morality embedded in a limited range of expected behaviour enforced by group verbal and physical action, and a belief in punishment or blessing by the gods. This is already contrasted with town morals. Modernising societies (as Classical Athens most famously would become), have diverse opinions and lifestyles and open discourse,

so here the old members of society cannot compete, whereas traditional village societies rely on norms handed down across the generations.

Luis Bettencourt's (2013) global analysis of modern urban behaviour likewise found that while the number of our close contacts may stay similar to the Dunbar threshold, we engage with a far wider spatial network and with people of far more varied lifestyles, roles and ideas.

Social network analysis

Sanne Maekelberg's study of historical correspondence also introduces the current vogue for Social Network Studies (Kadushin 2012). This rapidly expanding field, which began in Sociology, but has since expanded throughout the Humanities, focusses on the importance of studying patterns of relationships that connect social actors, using quantitative and graphic approaches.

However, as Hans Beck (pers. com.) reminds us, we must invert the telescope to document how individual settlements, indeed individuals, participate in these wider interactions, with the next house, the next village, the nearest town, out to ever more distant regions, rather than assume that the existence of chains of links to ever-widening communities absorbs most of the thoughts and practices of human agents.

Lieve Donnellan (2016) has carried out such a sophisticated exercise, through a statistical analysis of the grave goods and burial customs of the Iron Age cemetery on the island of Pithekoussai off the coast of Tuscany, supposedly a massive urban entrepôt manned by Greek and Phoenician traders. Her Network Analysis (Fig. 2) clearly showed that the dominant community present was actually the indigenous Tyrrhenian protohistoric population, alongside a smaller immigrant community, but one which was gradually adopting elements of Greek and Phoenician culture.

Space syntax

In a keynote lecture to the preceding conference (not published in this volume), May Yuan introduced the concept of analysing social space in the built environment. Probably the most advanced research programmes in this field are those carried out within the framework of space syntax through the work of Bill Hillier and his followers in University College, London (Hiller and Hanson 1984; Hillier 1996).

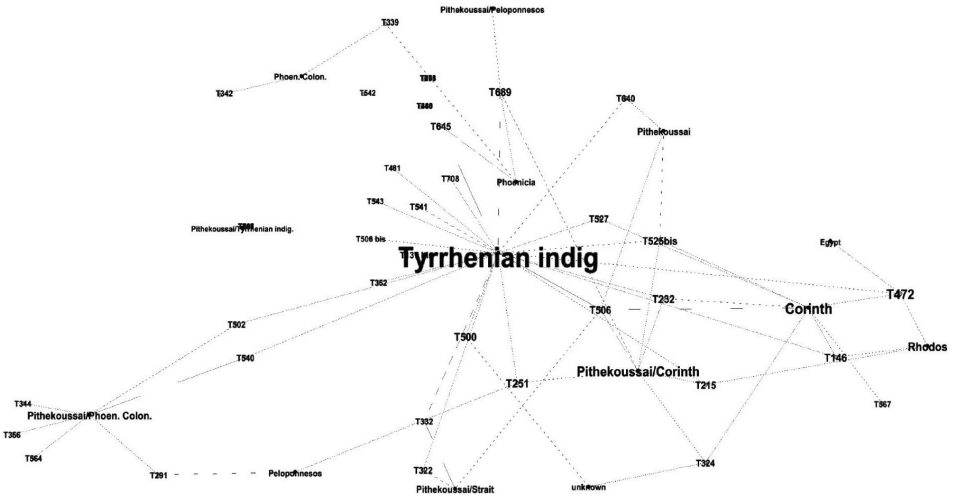


Fig. 2: Network Analysis of the grave goods and burial customs of the Iron Age cemetery on the island of Pithekoussai, Tuscany (Lieve Donnellan, 2016: 139).

Hanna Stöger's (2011) space syntax study of an apartment plot in ancient Ostia, the port of Rome, begins with access graphs. Natural paths of movement can be computer simulated with repetitive avatar agents (Fig. 3).

She adds a visibility analysis through the block. Her wider conclusions link the concept that people make the built environment to the complementary concept, buildings make people. This was a city neighbourhood at the height of its productivity, which was a good survivor in its original planned form over several centuries, because of its spatial structure, since this prevented 'gentrification' which occurred with most other housing blocks (*insulae*). For example a 'two-line logic' pulls people from the street space into the inner space of the *insula*, creating successful interaction inside the *insula*. It was also embedded in a diverse active larger neighbourhood.

Marlous Craane (2013) has analysed the historical development and regional rise of the town of 's-Hertogenbosch in the Netherlands using urban and regional space syntax approaches. Her analysis follows the hierarchy of streets in the historic town ranked by ease of movement, and she also relates the town to the road and waterway routes in its region, ranked by degrees of connectivity and ease of movement.

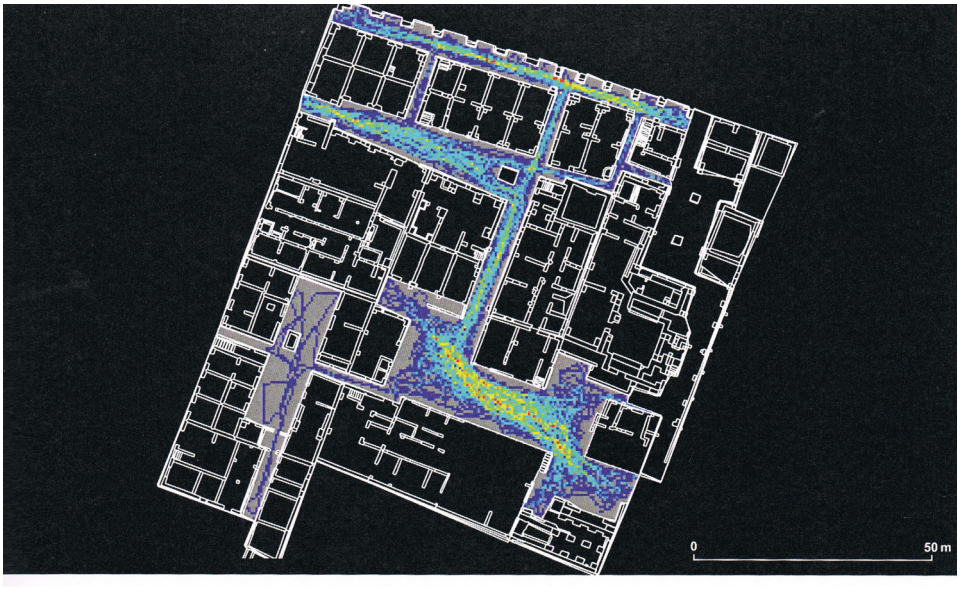


Fig. 3: Natural paths of movement of space syntax in an apartment plot in ancient Ostia (Hanna Stöger, 2011: 195).

Urbanism, central places and the organisation of landscapes

Jeroen Poblome, Frank Vermeulen and their associates have elaborated on the scalar analysis of the structuring of human settlements in town and country in ancient Italy and Turkey, from agents to state-sponsored initiatives, deploying complex multi-scalar GIS reconstructions. Arlo McKee and May Yuan use varied layers of GIS data to present a historic native site in Texas, to illuminate issues of preservation and public awareness of a major monument in their midst. Bieke Cattoor has challenged the modes of mapping modern interventions in the built environment of South-West Flanders. This is in many respects a deteriorating environment, and to counter this she uses maps illustrating the region's development over time across the nineteenth to twenty-first centuries, but also innovatively maps options to offer alternative and more positive futures.

Although no longer popular with geographers after their Post-Modern turn, the empirical study of urban hierarchies remains a very lively issue for those of us trying to understand the city patterns of Antiquity and the pre-Modern world in general. Key questions are: how many cities, where are they, how large, what exactly is their functional role, and how do they interact with one another?

Geographers have long charted the empirical range of influence for traditional villages, regional market towns and cities: thus the market town sphere of attraction or 'human catchment' was commonly 2-3 hours' radius or 10-15 kilometres (Bush and Bracey 1955).

These issues are central to the recently completed ERC project at Leiden University (*Empire of 2000 Cities*) in which all the towns of the Roman Empire have been catalogued and analysed. Norman Pounds' (1974) classic distribution map of official towns in the European parts of the Roman Empire already raised issues with the apparently distorted urban cover. Tønnes Bekker-Nielsen's (1989) urban classification by intercity distance for the Roman Western Provinces showed that towns in his classes A and B were close enough (comparable to Greek polis intercity distances) to fit well into classic marketing radii. But clearly in large areas of the Empire where intercity distances were far larger (his classes C to E), unofficial central places were needed to service local rural populations. Martin Millett's (1995) study of Roman small towns in East Anglia identified such a phenomenon in Roman Britain, of numerous unofficial small towns that must have arisen as 'emergent phenomena' in response to rural demand.

A similar landscape restructuring is seen in Roman Sicily (Bintliff, in press). The Greek period island has a regular network of cities. Roman conquest was followed by a dramatic loss of cities with new towns on the coasts, leaving the hinterland of the island almost bereft of official towns for the rest of Antiquity. In their place developed a series of unofficial central places in close relationship to wealthy estates, probably founded by landowning magnates to service their dependent workforces.

A typical Classical Greek town in the Aegean has: 70-80% urban, 20-30% rural share of the population. A typical Roman town in Italy has: 20-30% urban, 70-80% rural share of the population. We are currently working on the concept that in some Mediterranean landscapes Romanisation meant streamlining towns to more widely-spaced (and at times fewer) urban foci of elite landowners and regional servicing, especially linked to interregional trade. We see this as a form of economic rationalisation linked to a commercialising economy.

Contemporary geographers are deeply suspicious of quantitative, rule-seeking approaches such as space syntax, reminiscent of the passé New Geography, but the subdiscipline is based on empirical studies and incorporates phenomenological perspectives. Even less popular is research into the interaction between cities in an urban network, symbolised by the famous or infamous and also puzzling observations produced by charting city sizes against their hierarchical rank, to

observe agreement or deviations from the Rank-Size Rule. In an ideal urban system following this model, cities when ranked by size would map onto a logarithmic series, or power law, in which the second-largest town would be half the size of the first, and so on. The commonest explanation for such a pattern would be a complete integration of the individual economies of each town into the entire urban system.

This curious model would not be taken so seriously were it not to agree with many Early Modern city systems, wholly or partially, for example the United States since the later nineteenth century. France Guérin-Pace (1995) illustrates the common deviation, for the cities of France over the same time-period where, Paris apart, all cities show an excellent fit to a straight line correlation size versus rank, unchanged for 160 years.

The Leiden Roman Urbanism Project has big data to experiment with on ancient urban hierarchy. Real Roman city data, such as those exhaustively collected for example for the towns of Roman Gaul by Frida Pellegrino (forthcoming), show that the top cities, rather like the single primate city Paris in the nineteenth century AD, are in a group of their own, with several rather equal regional centres. The medium- sized towns show signs of fitting their own rank size line, but to tend to bulge out against the ideal trend, then the smallest towns do not conform to any rule. In fact not only is the same picture obtainable from the entire Roman Empire of official towns (Fig. 4), but nearly all Pre-Modern urban systems look like this graph. The convexity in the middle-rank cities is interpreted as showing that there are many modular towns of similar size forming regional central places for rural communities, while the group of largest cities, also of comparable scale to each other, may represent the top level of several regional pyramids of city hierarchy.

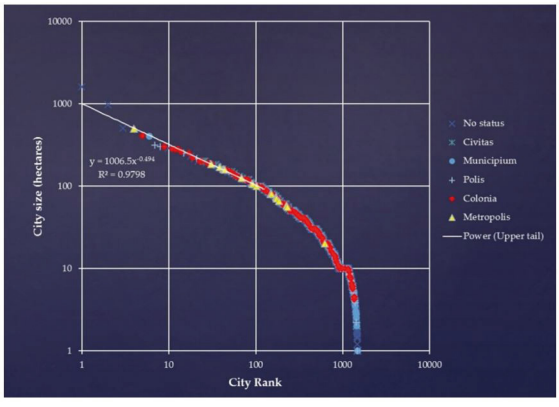


Fig. 4: Rank-Size analysis for the cities of the High Roman Empire (Pellegrino, in press).

Importantly, if we now compare Luuk de Ligt's (2012) study from Northern Italy ca. 1600 AD, nearly all towns except the smallest begin to fit the rank-size line, but two top-ranking towns dominate the graph (Venice and Milan). The general trend from convexity to a power-law, as just mentioned, has often been considered as an example of the invisible hand of economics, with every town constantly controlled in size by its relationship with all the other towns in a network. Paul Krugman (1996) later argued that it marks instead the 'random' variation between town location and resources, historical factors: each town is an independent unit competing for resources and socio-political advantages. The ecological model of Frontier (1976) and de Ligt's Italian cities study more plausibly reverts to the original formulation, by arguing that a mature urban 'ecosystem' sees the emergence of trophic levels with diversity and complexity tied by feedback. Larger towns prey on smaller in a network that has tightened over the last 2000 years.

The structural transformation of cities and regional communications

In Reinout Klaarenbeek's chapter on the afterlife, and often creative reuse, of former convent spaces in several cities of Belgium, we gain insight into historical processes of urban change at the agent and institutional level. From a situation at the end of the eighteenth century when up to 15% of urban space was filled with religious houses, political initiatives dissolved almost all of them by 1860. Urban plots were studied by Klaarenbeek across time in their use of space, with historic maps, archives, pictures and the tools of GIS revealing the progressive remodelling for new purposes of these urban landscapes. Cristina Purcar enriches her analysis of the expanding and innovative railway network in Romania with significant heterogeneous voices and viewpoints, based on photographs, maps and archival accounts. The railway system altered the physical and mental world of the country and its inhabitants, while the maps and photos both aim to promote modernisation and at the same time document the disappearance of a traditional world. Bieke Cattoor deconstructs the creation of new roads and suburbs in Flanders through the introduction of conflicting narratives and the collapse of time. Jill Desimini likewise asks us to release our spatial vision from single cartographic realism to heterogeneous and dynamic alternatives. Standard topographic maps are far from experienced reality, offering carefully selected elements of the landscape deemed significant to map-makers. Google Maps do permit user-modification but remain mediated by restrictions imposed by the media giant. Open Street Map allows users to add data relevant to them, more clearly a communal enterprise. Bram Vannieuwenhuyze

presents us with a potentially fruitful merger of parcel-based urban topographic analysis and the earlier visual representations of towns in the Low Countries. The concept of 'deep mapping' adds aspects of personal experience to cadastral maps, which were usually made for taxation purposes. This new approach deploys archival and visual records to explore households and individuals, wealth levels and occupations, which via GIS can be stacked over each other into interpretive layers for urban plots and whole districts of historic towns. Likewise Cecilia Furlan shows how 'thick mapping' integrates oral history, photos and paintings into the otherwise neutral mapping of time-sequenced changes in the industrial landscape of Charleroi — from its creation to the current post-industrial wastelands.

From at least the Renaissance era in Europe documentary and visual records have allowed us to see the dialectic between the different scales of Braudelian history: the short, medium and long term but also the interactions between individuals, communities and a wider world (Braudel 1972).

In the next figure we see an image of Broad Street, Ludlow in England by Samuel Scott, 1765. Firstly, this is a genuine record of a specific street in a specific town at a specific point in time. The artist lives in this street and moreover the people shown are recognisable historical individuals of his close acquaintance. With the help of archival records we can flesh out their names and lives. So at one level we are looking into the lives and social interactions of unique agents in a defined moment in time, the world of individuals, events and year-defined places. So much for the emic level. But the urban-historian Mark Girouard uses this snapshot to

Fig. 5: Samuel Scott (1765), View of Broad Street, Ludlow, detail (from Girouard, 1990: Fig. 123).

encapsulate a medium-term historical process, the dramatic transformation of English and other contemporary West European towns towards a 'gentry' society dominated by the landed elite — 'polite society', contrasted to what can be shown for preceding centuries. At the etic level then we are observing the culmination of economic and social processes which go back at least to the fourteenth century AD (Britnell 2009).

Urban change and class

This topic did not feature very directly in our conference, with the exception of Karl Beelen's case study in India. In his thoughtful chapter a challenge is made to official maps which display and promote state and local government planning, emphasising modernisation developments and approved forms of settlement. In contrast a new genre of mapping, created with poorer local community members whose unofficial coastal settlements and traditional ways of life are threatened by these developments over their heads, gives an alternative voice to neglected sectors of society. Indeed particularly following classic studies such as David Harvey's *Social Justice and the City* (2009), this topic should be a central theme for our discussion.

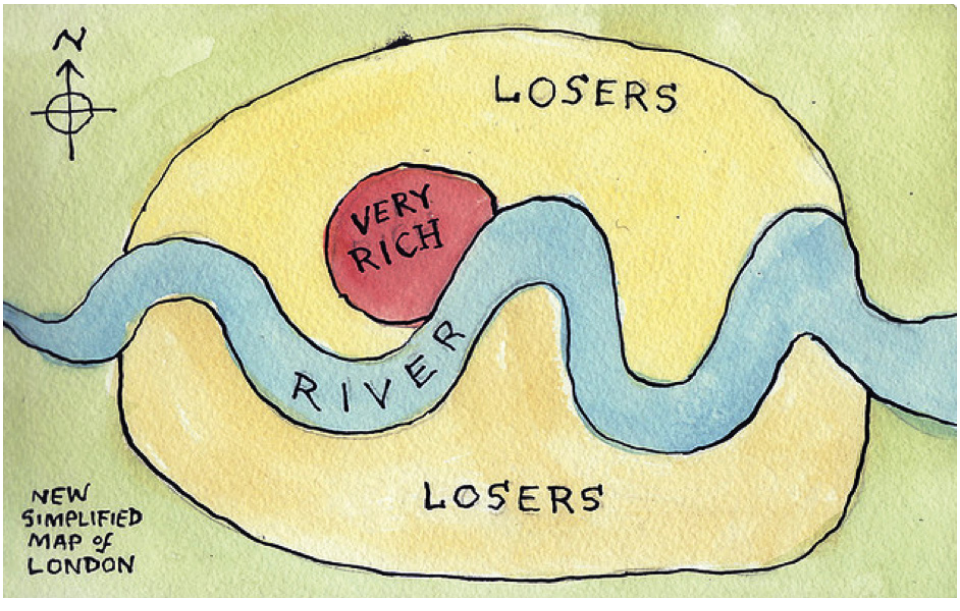


Fig. 6: New simplified map of London drawn from memory. Author Anon (http://www.revue-urbanites.fr/entretien-reparer-des-marches-defaillants-et-apres-la-regeneration-urbaine-par-projet-a-londres-avec-martine-drozdz/).

Social Issues are more relevant than ever in European city studies, and my next illustration, a satirical cartoon on class and housing in London (Fig. 6) is not a foolish exaggeration, when a United Nations survey recently found that one in five children in the United Kingdom live in poverty.

In a sophisticated and wide-ranging study, the urban geographer Erwin Sabelberg (1983) has shown how the role of the elite house (*palazzo*) as a form of Renaissance and Baroque self-presentation differed fundamentally between northern and southern Italy, and this has led to dramatically contrasted townscapes in the modern era.

Palazzi in Florence or Siena in the historic centre are still largely in the hands of the elite, and a high percentage of such families were in power before 1800. Also banks and other institutions of culture and government like to use the palazzi, since they breathe high status. Sicilian palazzi in contrast have been converted into cheap apartments and restaurants. In Tuscany the Renaissance house, a base for industry, commerce and banking, contained and exhibited to the public the means which *made* its resident elite, and this remains the function of palazzi today. In contrast in Sicily the Renaissance and Baroque house merely *expressed* the status of its elite residents whose wealth always lay elsewhere, in great rural estates, and it has been easier to abandon — more than once — unfashionable houses for newer styles built in other parts of the city.

In this context we should mention the classic pioneer study of a contested townscape, the anthropologist Michael Herzfeld's (1991) study of the conflict between the heritage community and the living occupants of the Venetian town of Rethymno in Crete, placed into a wider framework in his recent paper 'Heritage and the Right to the City' (2015).

Deceptions of mapping and townscape views

In Bram Vannieuwenhuyze's chapter we learn of the perils of bias inscribed in newer and earlier historic maps, but also how to rescue information from them using juxtaposition with empirical data and through learning the cultural norms of past map makers. Karl Beelen unravels the divergent forms in which urban bypasses in India can be presented and read in positive and negative ways. Bieke Cattoor challenges the dominant mode of portraying human landscape and townscape interventions as simplistic statements of progressive acts of improvement. Chang-Xue Shu very fruitfully deconstructs official versions of architectural

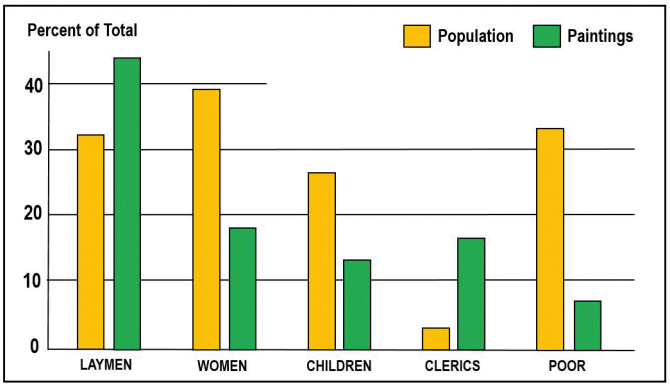


Fig. 7: Comparison of the social structure of the eighteenth-century Modena population in official records an in contemporary street scenes (Nicassio 1991: Fig. 11).

history in China, by exploiting the neglected but prolific archive of local history gazetteers, dating from the tenth to the twentieth century. A bias to certain forms of progressive construction in official histories misreads architectural realities when data-mining and GIS allow more accurate records with grass-roots observations.

My favourite and clever example of a study in the bias of visual representation of past towns is by Susan Nicassio (1991) for a series of supposedly representative contemporary townscapes of eighteenth-century Modena. The underrepresentation of women, children and the poor is clear when compared with contemporary census records (Fig. 7).

Phenomenologies of landscape

A very lively field in Human Geography, and more recently in Archaeology, is that of Landscape Phenomenology, in which a tactile approach contrasts with that of the positivistic mapper of a structured landscape. Ian Gregory in his contribution to this volume captures the ways in which literary descriptions of the Lake District record changing mentalities towards its physical and economic geography, and the varied ways in which writers encounter its constituent districts.

GIS techniques allow exploration of the 'Phenomenology of Landscape': the way past inhabitants saw their world. An example application is that by Phil Howard (2007), part of a survey of an ancient city and its landscape in Greece, the town of Thespiai. We asked, what could you see from the Thespiai city wall of the countryside settlements? Could rural inhabitants see the town they were

citizens of? Surprisingly rural farms and the city were rarely intervisible. The farms were rather located in advantageous positions as the centre of small estates.

Phenomenology as an approach to landscape has been taken to the extreme in what many have considered to be a 'sacred text' of Post-Modern landscape archaeology, the volume by Chris Tilley entitled *A Phenomenology of Landscape* (1994): 'space does not and cannot exist, apart from the events and activities within which it is implicated. Space is socially produced' (*Phenomenology*: 10). I have a passing regret for the occupants of the pre-human Earth. No space for dinosaurs. In a practical application of such ideas, the archaeologists Barbara Bender, Chris Tilley and friends, from the Institute of Archaeology in Central London went to South-West England to prehistoric settlement sites, with the aim of re-enacting the Bronze Age viewpoint on the countryside through an imaginary doorway held up by Bender (Bender, Hamilton et al. 1997).

The excursions of urban academics into the contemporary countryside are coloured by such romantic visions of a pre-modern world where rural life is sensuous, mystical — and unable to make a livelihood. The vast empty spaces produced by modern farming technologies contribute to this unrealistic urban fantasy (Bintliff 2013).

Phenomenologies of townscapes and of globalisation

Bieke Cattoor asks us to fragment and deconstruct the large-scale maps of contemporary and historic built environments in Flanders into humanly-accessible segments of complex, layered, micro-spatial worlds where experience on the ground does not follow the official planning narratives. Reinout Klaarenbeek shows us how the post-medieval towns of Belgium had a townscape dominated by the spires of religious institutions.

In Hellenistic and Roman cities there develops a recognisable 'iconoscape', or 'cité des images', where instead of modern advertising billboards the ancient citizen was constantly confronted with the serried ranks of honorific statues portraying the urban elite (van Nijf, 2011). We need not assume that the public always walked in awe of these watchful powerful. In Oslo the elevated bronze statue of a late eighteenth- early twentieth-century local worthy (Fig. 8) has repeatedly been the object of subversive comment…

Fig. 8: Graffiti adorn a Norwegian worthy in central Oslo (http://www.ekosystem.org/photo/932176).

Neural networks

This theme was not discussed in the current collection of papers, yet it forms a natural complementarity with the importance in most of these chapters of combining the formal mapping of landscape and townscape features with experiential dimensions at the human scale. The billions of memory cells in the brain (neurons) create networks of association, mirroring what we observe in the outer world. What we later observe in the world stimulates these inner unconscious structures to influence our actions and ideas heavily. Each person is unique due to their personal history, but we behave guided by the inner self that experience has made us (Greenfield 2015). We largely think and act *the way the outer world has made us.*

Thus, growing up in a highly dynamic, globalising society such as seventeenth-century urban Holland would have moulded one sort of awareness of the sphere of human action and a specific set of awarenesses of social norms and freedoms (Bintliff 2005).

Heritage and the integration of the cartographic and the experiential approaches

Steffen Nijhuis has addressed the innovative potential of landscape architecture, the teasing apart of layers of action that created contemporary heritage sites over time, such as the famous rural estate gardens at Stourhead in England, both to comprehend

the process of creation and also to inform current strategies of maintenance and preservation. His use of GIS to plot and visualise the regular transformation of this artificial Classical landscape included effective use of viewsheds to elucidate the visual experience visitors were offered at key points of their navigation of this formal park.

Probably the central theme that unites so many papers at this meeting, as I have recently several times pointed out, has been that of integrating the Cartographic and the Experiential modes of studying the spatial patterning of human culture. This theme is part of Cristina Purcar's contribution on railway photography in Rumania, in Ian Gregory's analysis of literary modes in the Lake District, in Cecilia Furlan's study of the industrial landscape of Charleroi, in Jill Desimini's chapter on contrasted layers in alternative cartographies, and in Bieke Cattoor's deconstruction of planning initiatives in Flanders.

Closely related to this field are Virtual Reality reconstructions: they form a major innovative, yet at the same time a controversial, tool. We have developed a digital restored ancient Greek city, that of Koroneia, within my own archaeological project in Central Greece. The virtual reality model is navigable and can be explored on a laptop or also smart phone. We hope to make it available in local schools this year. Another example would be a VR navigable reconstruction of the University of Ghent project in the Roman town of Ammaia in Portugal (Fig. 9), directed by Frank Vermeulen (Corsi 2016).

Fig. 9: Michael Klein (2015), VR navigable reconstruction of the Roman town of Ammaia in Portugal, "Radiography of the Past" project (copyright: 7Reasons/Ghent University).

There is major debate within the VR community about the transparency of reconstructions, especially immersive experiences, but recent protocols demand that VR townscapes allow the (usually considerable) layers of speculative rebuilding to be revealed against the surviving evidence.

Conclusion

Key points for future discussion and elaboration which emerge from the papers in this volume are:

- Social interactions,
- Urbanism, central places and the organisation of landscapes,
- The structural transformations of cities and regional communications,
- Urban change and class,
- Deceptions of mapping and townscape views,
- Phenomenologies of landscape,
- Heritage and the integration of the cartographic and the experiential approaches.

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The development of historical geographical information systems (HGIS) and other methods from the digital humanities have revolutionised historical research on cultural landscapes. Additionally, the opening up of increasingly diverse collections of source material, often incomplete and difficult to interpret, has led to methodologically innovative experiments. One of today's major challenges, however, concerns the concepts and tools to be deployed for mapping processes of transformation—that is, interpreting and imagining the relational complexity of urban and rural landscapes, both in space and in time, at micro- and macro-scale.

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