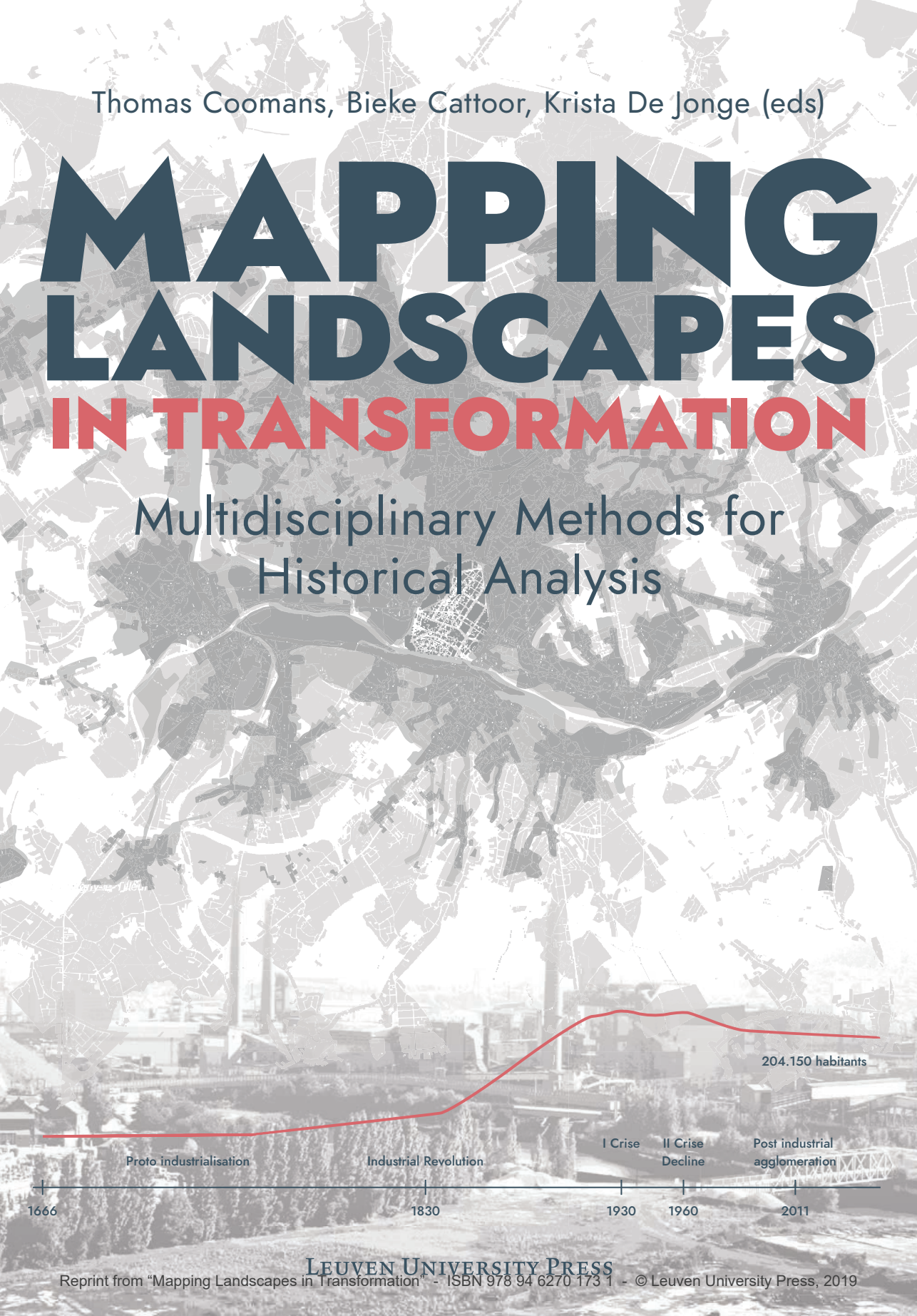
Thomas Coomans, Bieke Cattoor, Krista De Jonge (eds)

MAPPING LANDSCAPES IN TRANSFORMATION

Multidisciplinary Methods for Historical Analysis



Leuven University Press

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Edited by

Thomas Coomans, Bieke Cattoor, and Krista De Jonge

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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.

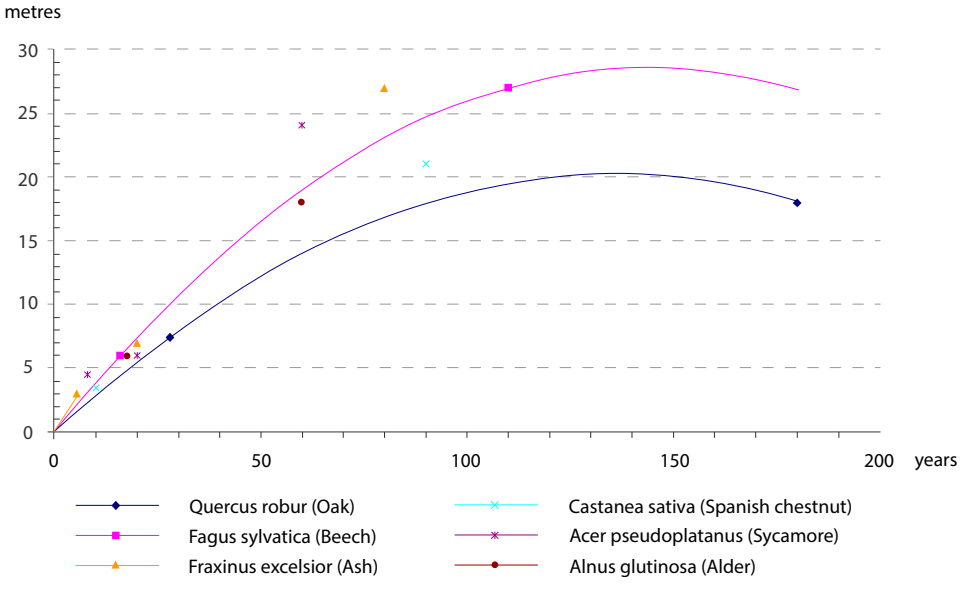

Fig. 2: Distribution of measured growth in height over time for different tree species augmented with a logarithmic plot of the growth curves of beech and oak (analysis by Steffen Nijhuis. Data derived from: Colvin 1972; Ruyten 2006).

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

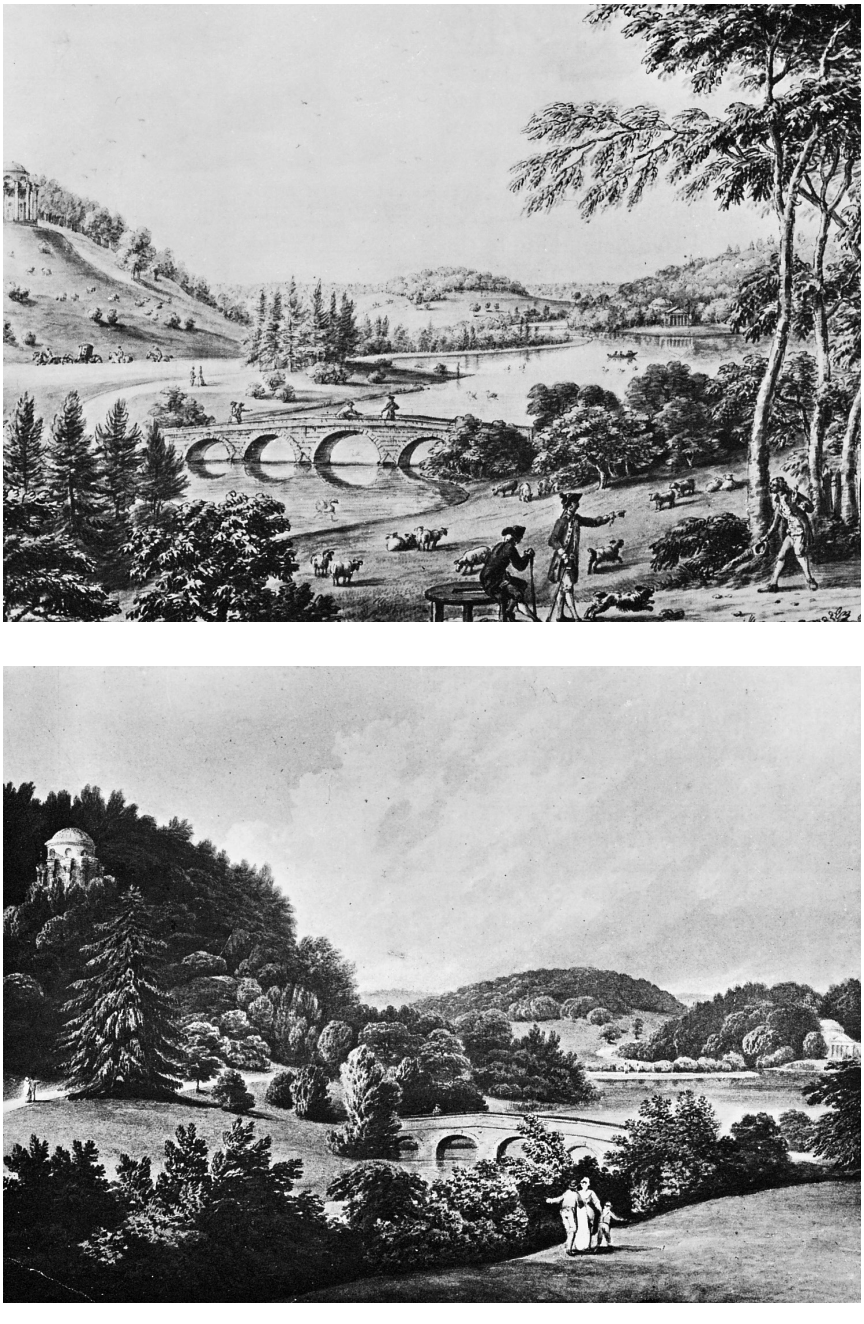

Fig. 3: The spatial densification of the Valley Garden exemplified by comparing the views of Bampfylde, 1770 (top) and Nicholson, 1813 (bottom). The effect of forestation efforts is visible on the ridges at the South bank of the Great Lake (images from: Woodbridge 2002).

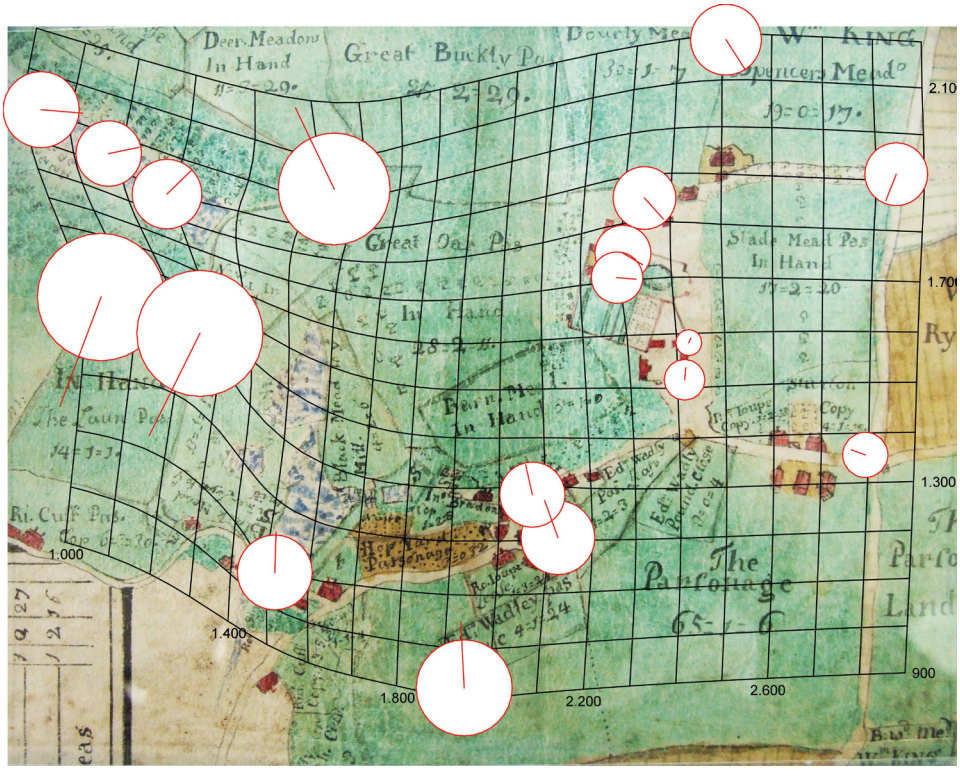

Fig. 4: Cartometric analysis of the 1722 map represented as distortion grid with a cell size of 100 metres. The map has a very low planimetric accuracy (RMSE 5.2 metres), with large local variances, particularly in the valley. The vectors show the direction of distortion and the circles indicate the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

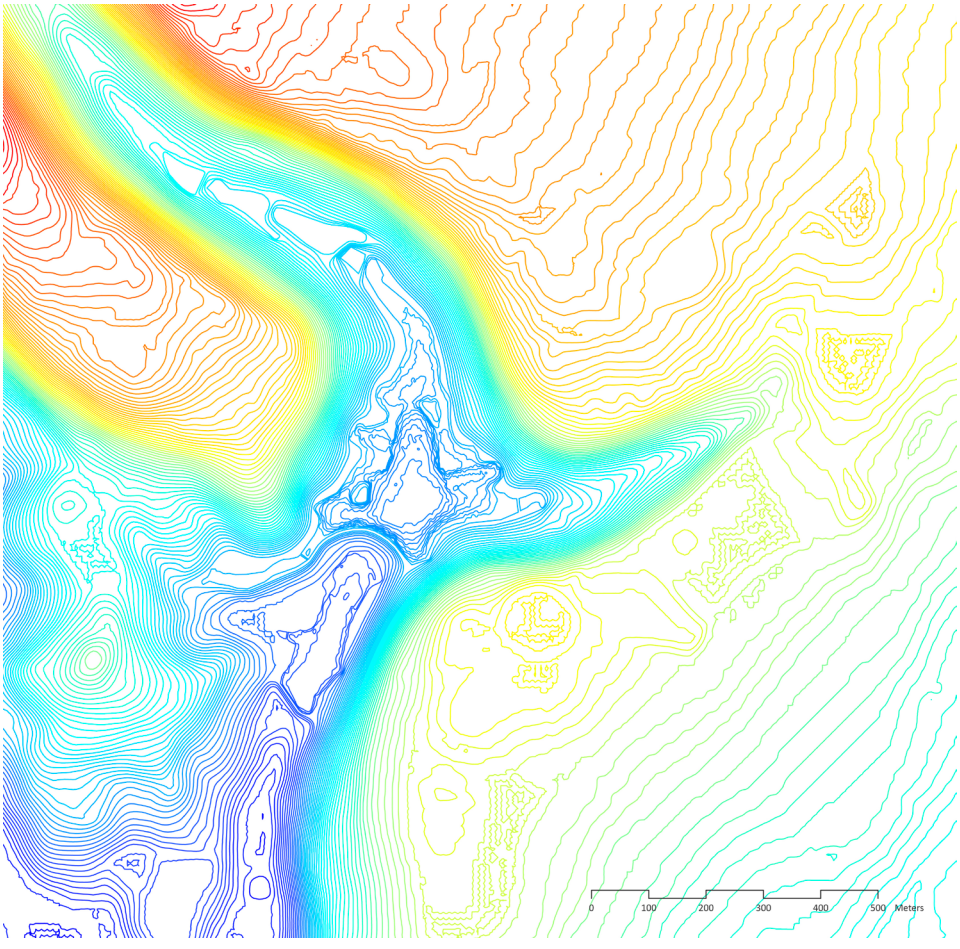

Fig. 5: Bathymetric data of the lakes at Stourhead landscape garden. The relief in the water body is geo-referenced, vectorised and merged with a contour map derived from point vector data of terrain heights (map: Steffen Nijhuis & Michiel Pouderoijen).

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

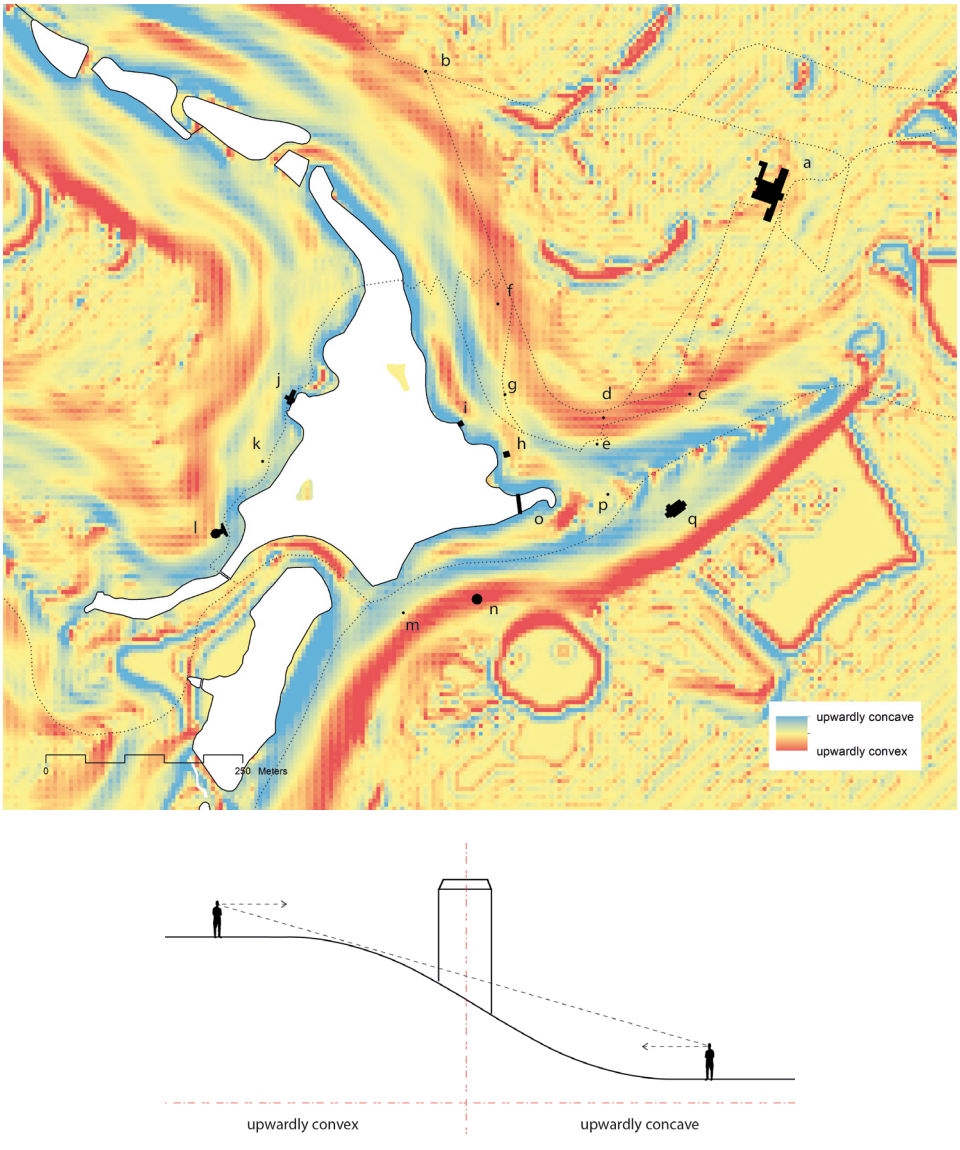

Fig. 6: Correlation between architectural features in the Valley Garden 1785 with upward curvature of the slopes (Stourhead t1). Most architectural features take advantage of the valley's curvature dramatising and ensuring exposure by their placement: Stourhead House (a), Obelisk (b), Statue of Apollo (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.

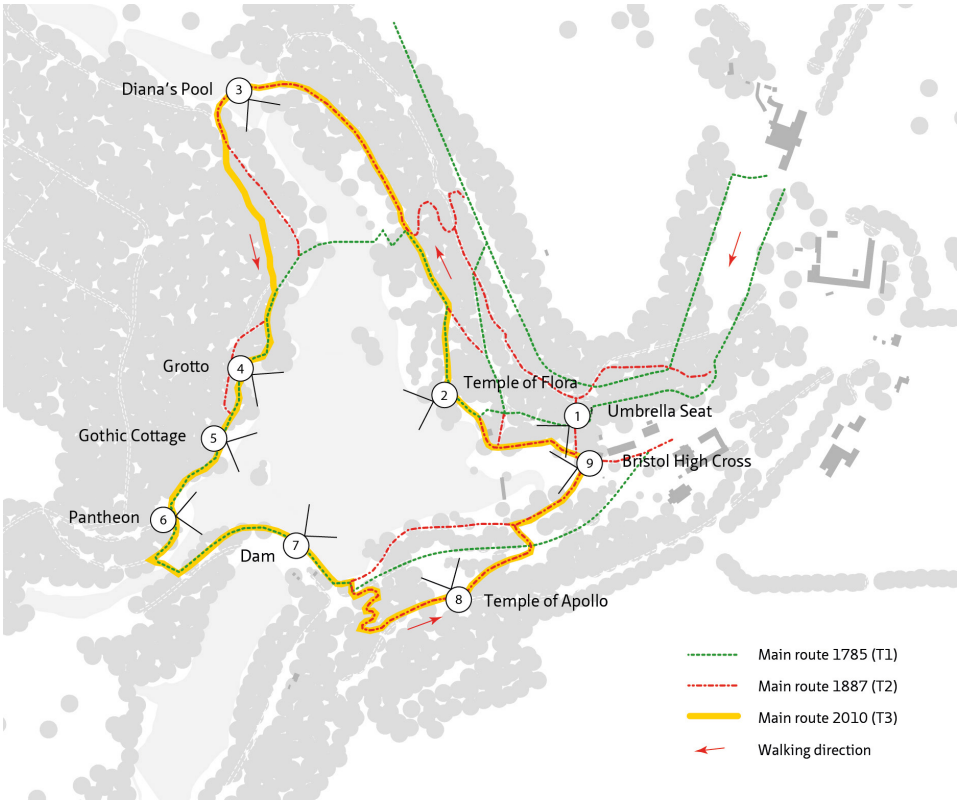

Fig. 7: Important viewpoints related to the pictorial circuit of Stourhead landscape garden throughout the ages.

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**].

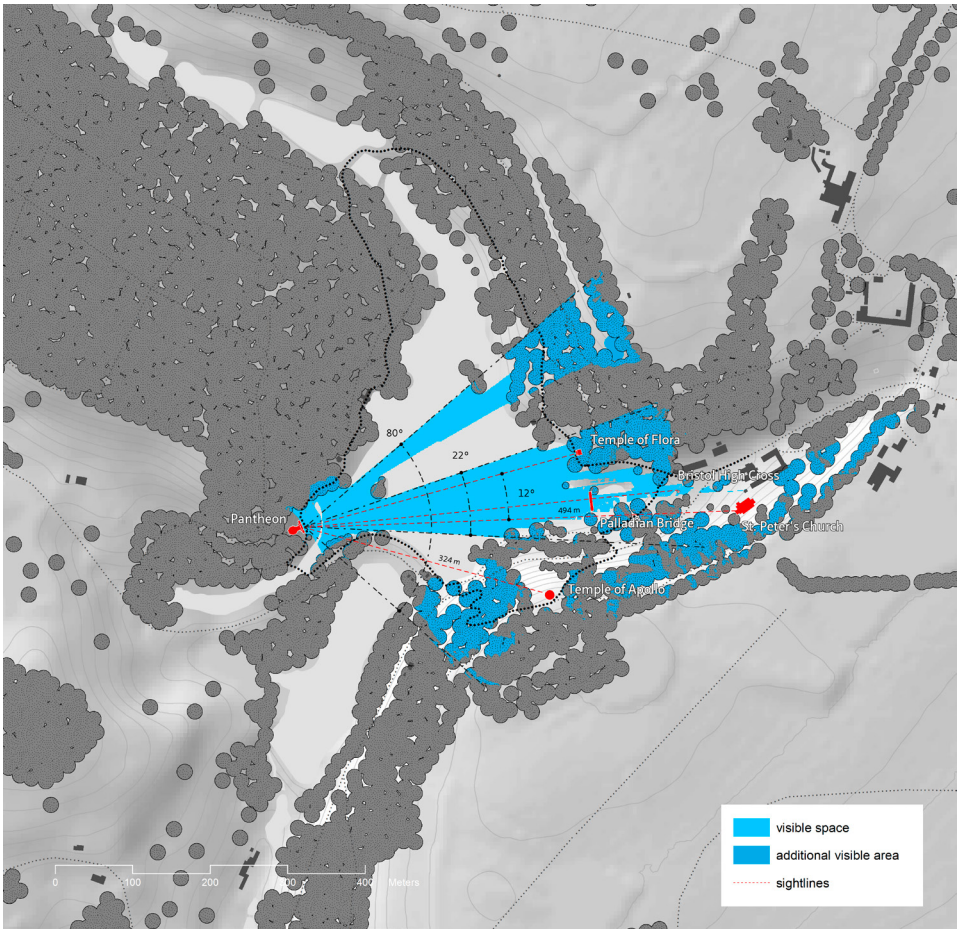

Fig. 8: Visibility analysis from the Pantheon (viewpoint 6), Stourhead 2010.

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

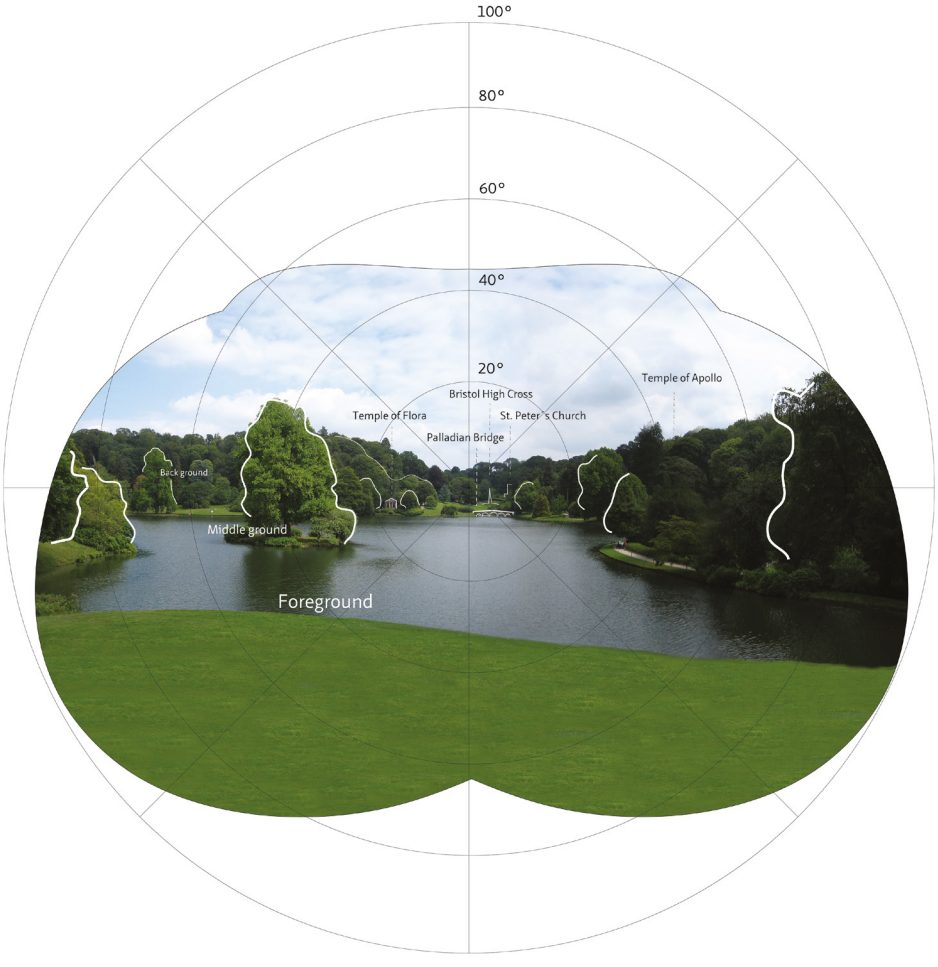

Fig. 9: The field of view gazing straight ahead from the Pantheon at eye-level, Stourhead 2010. The Temple of Flora, the Palladian Bridge, Bristol High Cross, and St. Peter's Church are important foci in this view. The Temple of Apollo was also an important focal point in this view but is now overgrown.

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

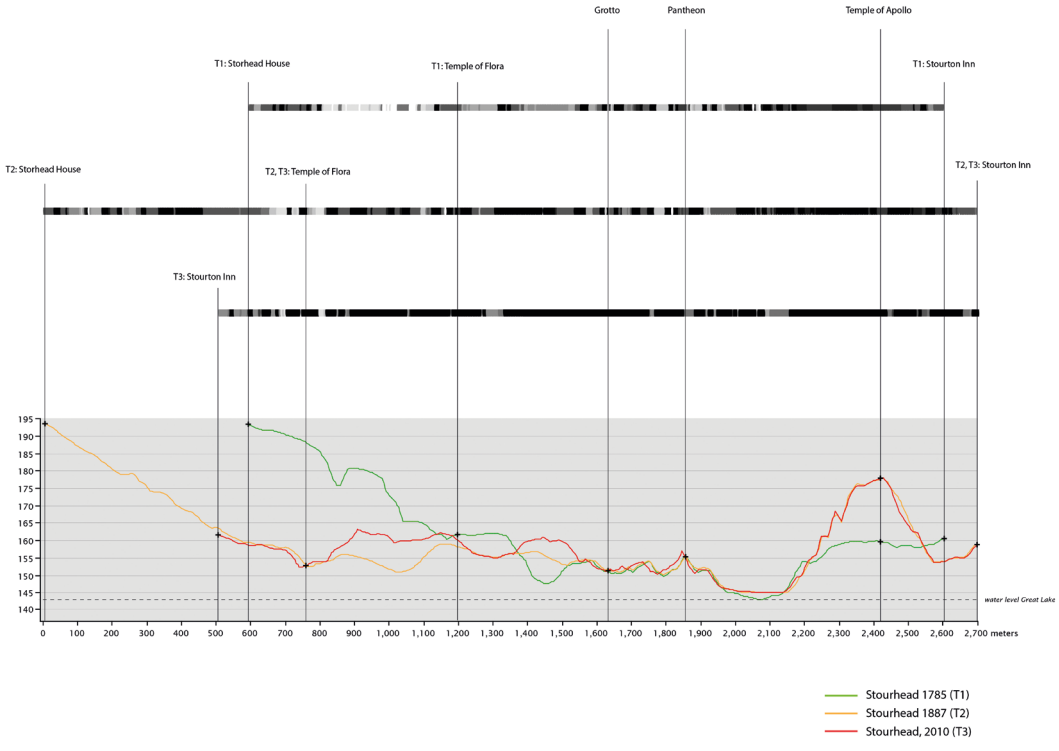

Fig. 10: Comparison of light-shade experience along the main routes in Stourhead 1785, 1887 and 2010.

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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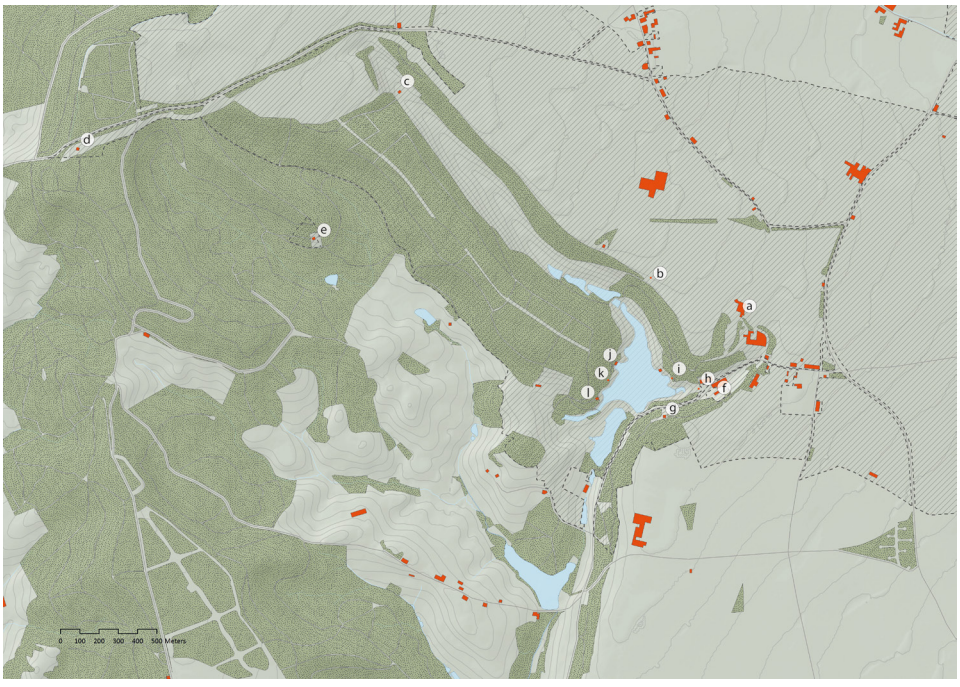
Maps

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.

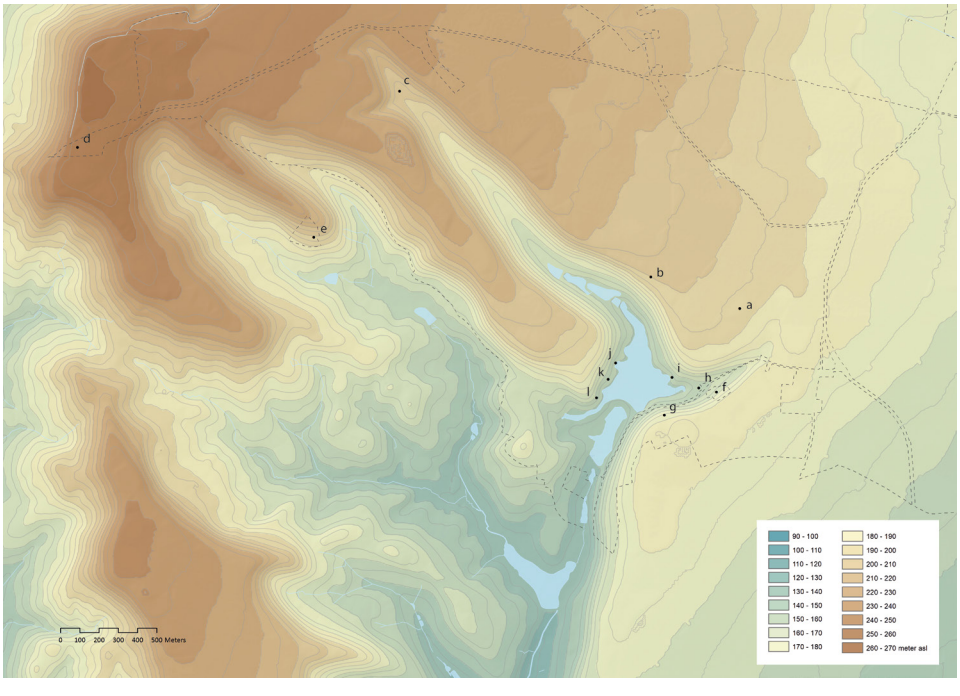
Map series 1: Terrain conditions as prerequisite

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.

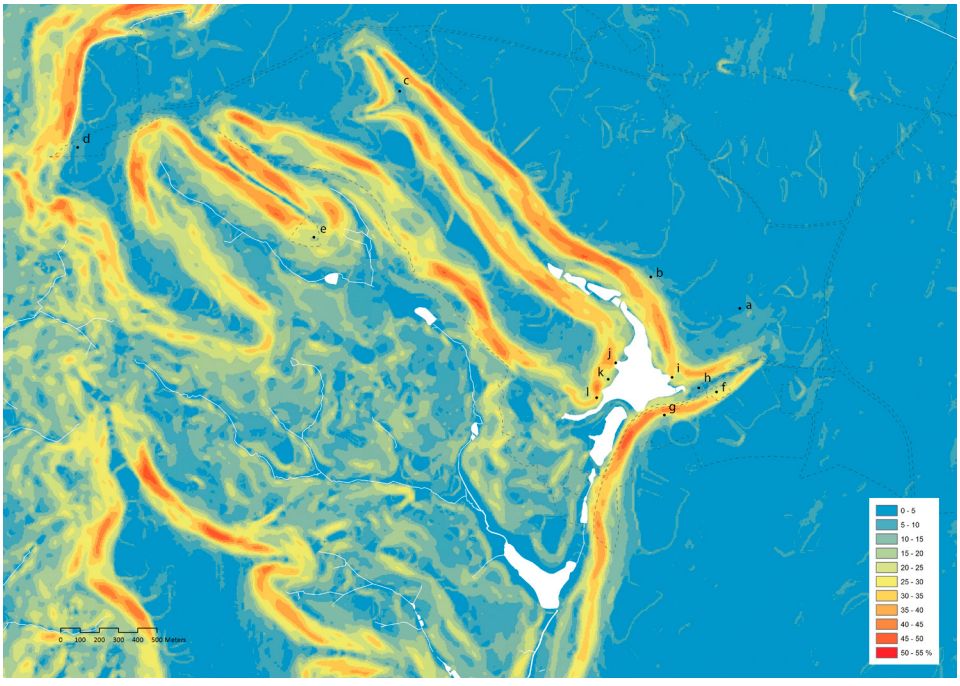


Map Series 1, Map 1: Steffen Nijhuis, *Stourhead Landscape Garden with the Locations of Important Features*.

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*.



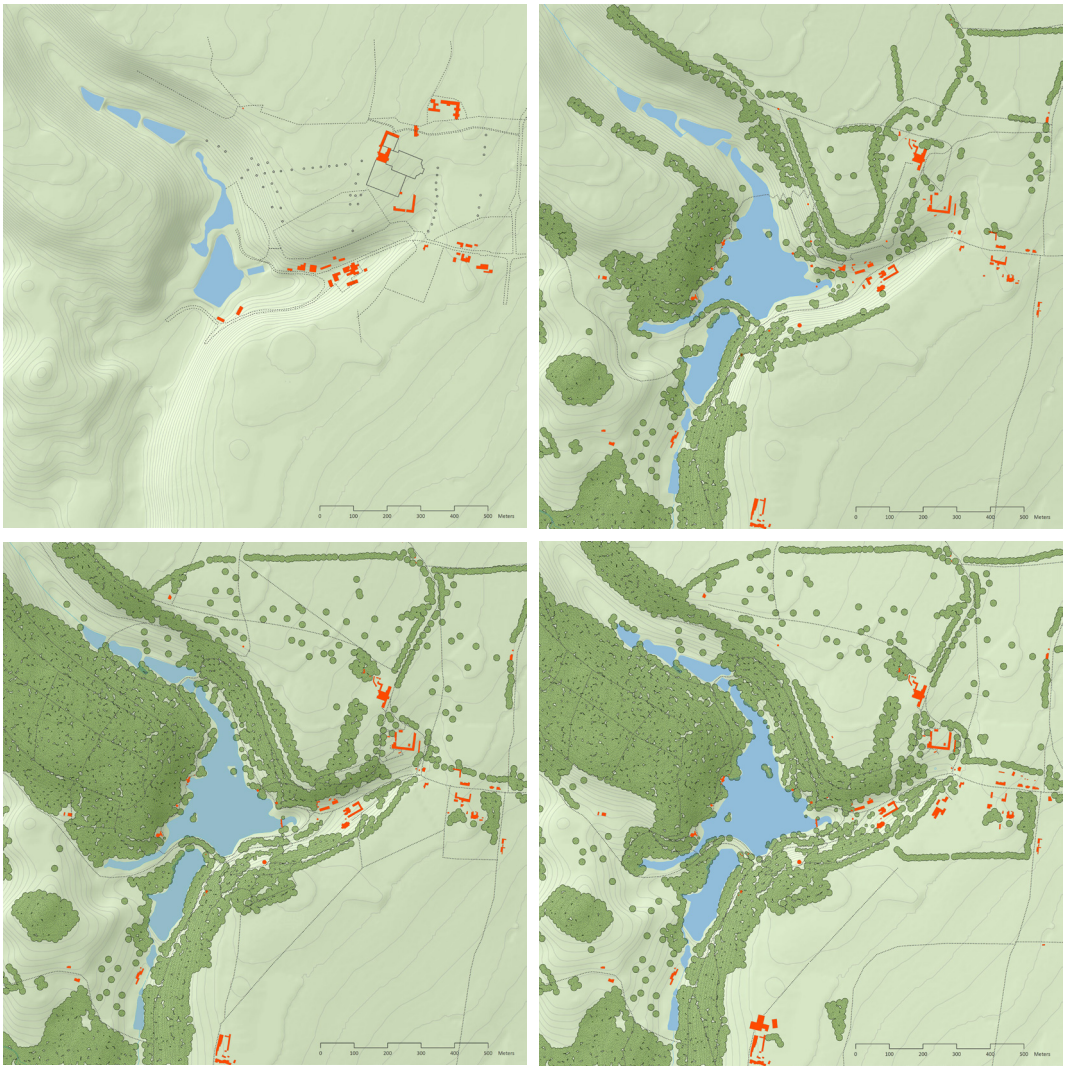
Map Series 1, Map 3: Steffen Nijhuis, *Stourhead Slopes*.

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

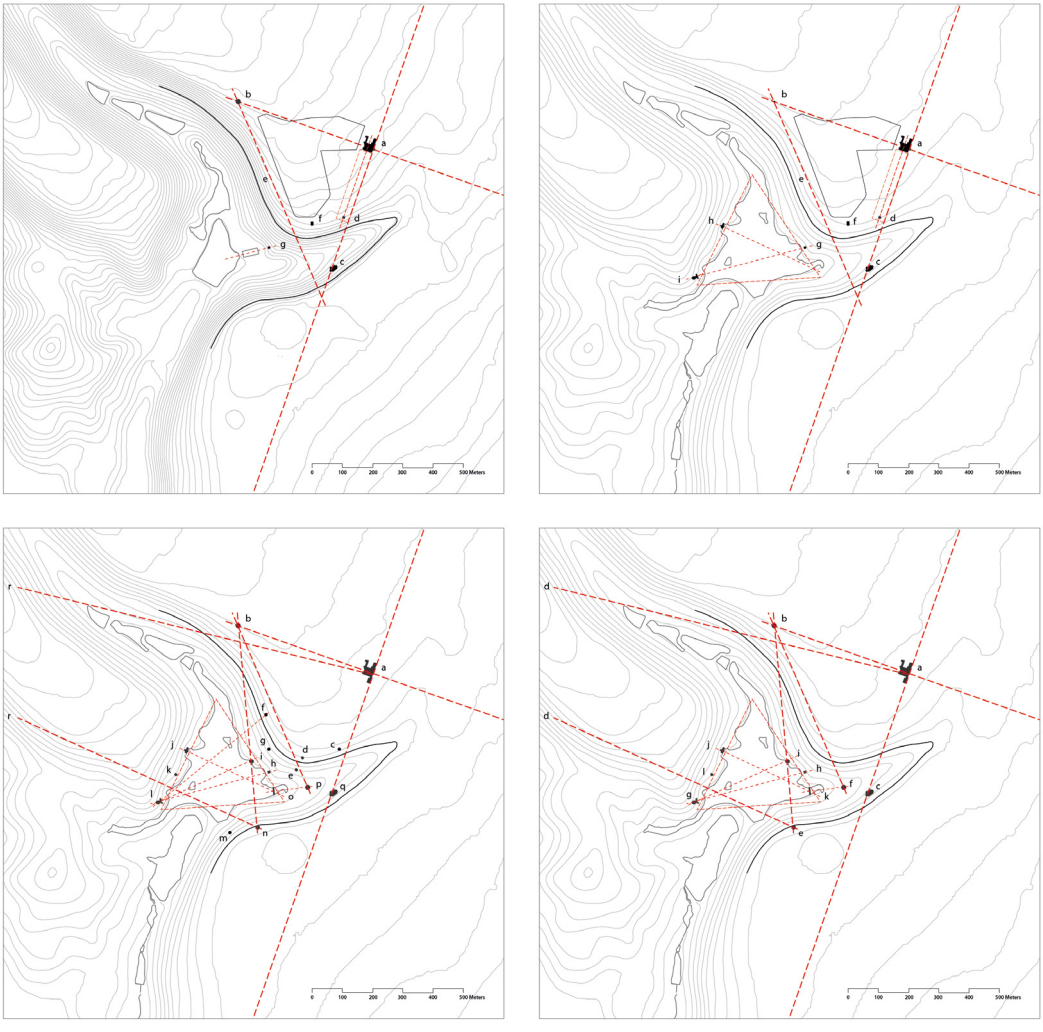
Based on BGS 1:50,000 soil database.

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.



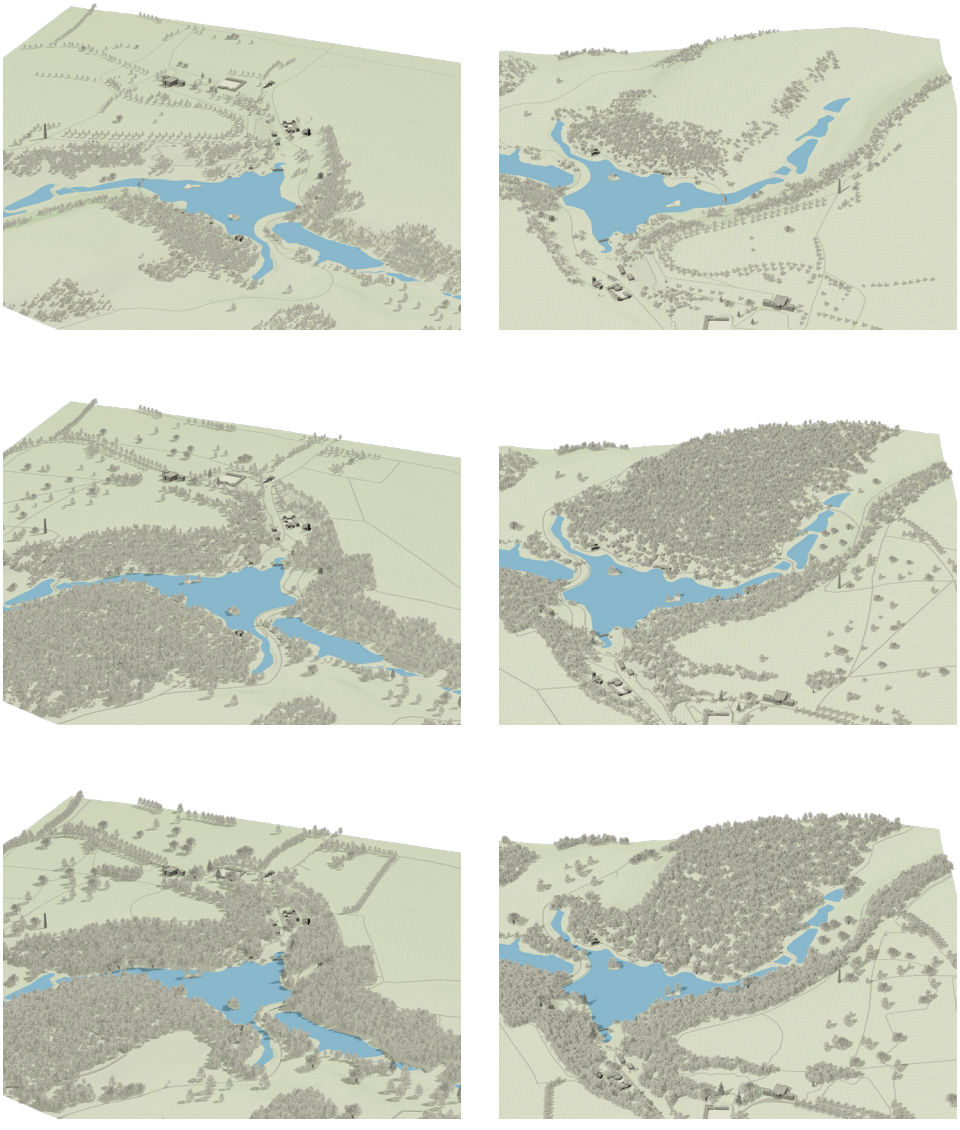
Map Series 2, Map 1: Steffen Nijhuis, *Evolution of Stourhead 1722, 1785, 1887 & 2010.*



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

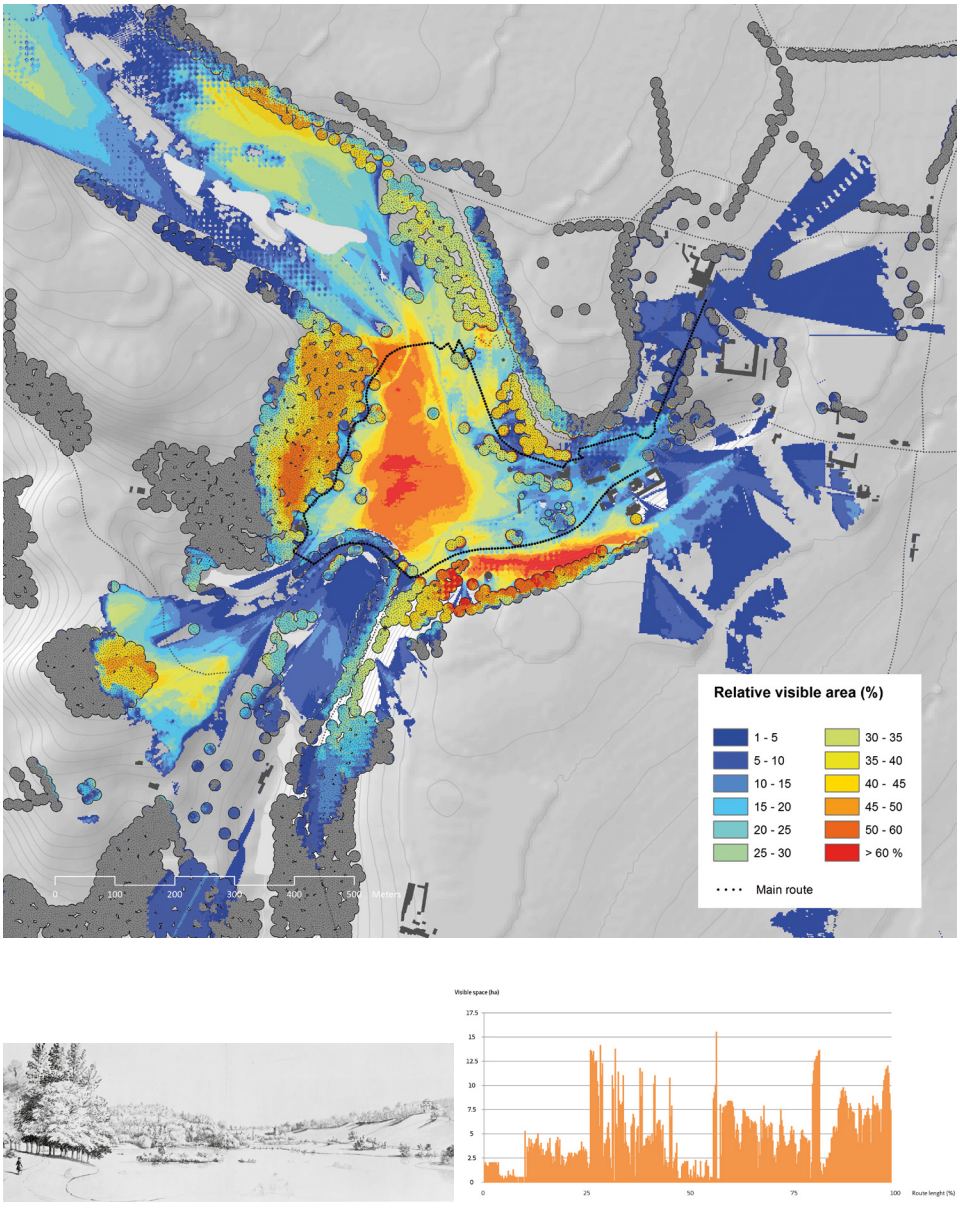
The successive development of the corporeal form of Stourhead landscape garden started with the articulation of the spatial relationship between the plateau and the valley by planting masses and creating transitional spaces with architectural features on the edges of the plateau and the slopes of the 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.



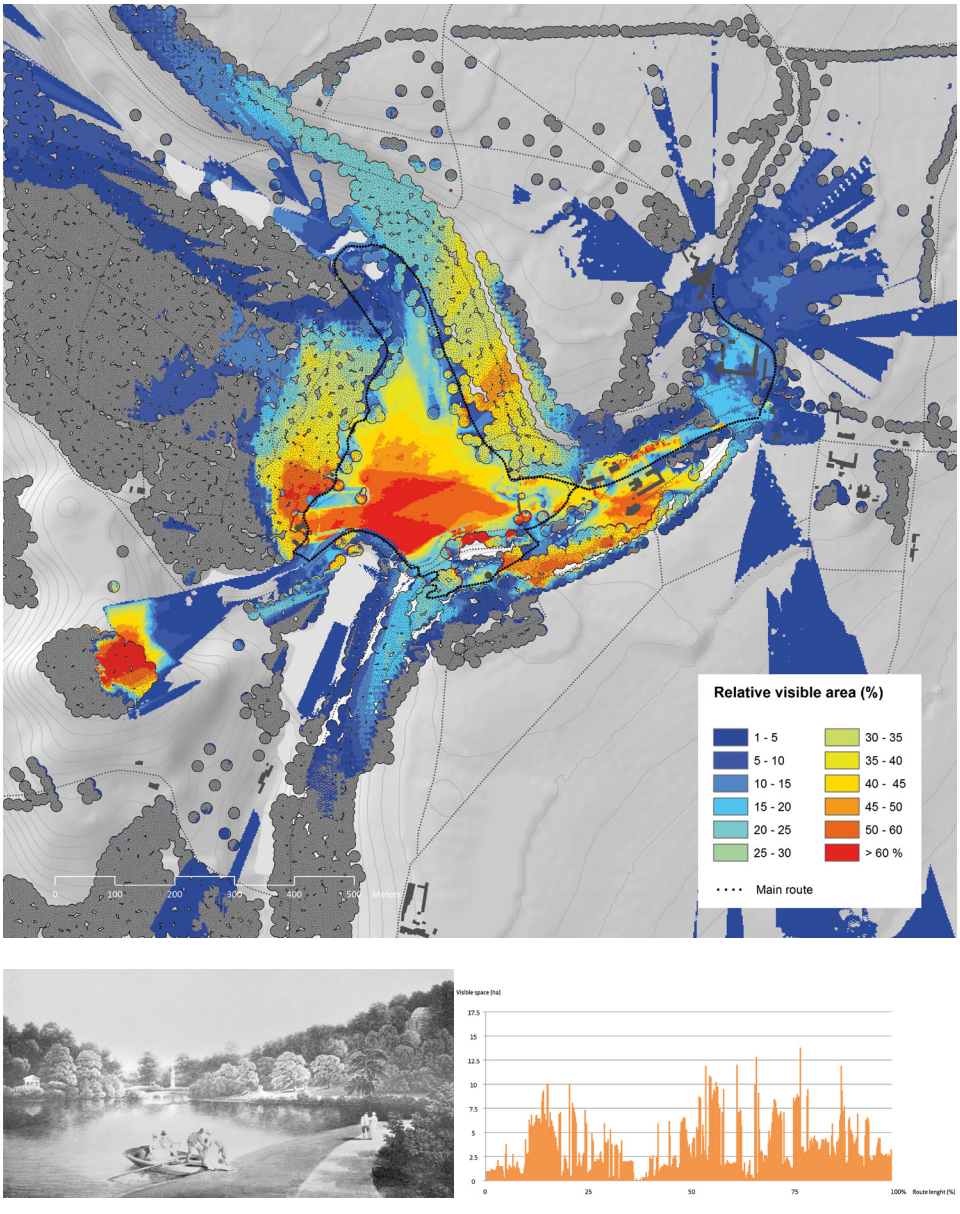
Map Series 3, Map 1, Steffen Nijhuis, *Evolution of the Three-Dimensional Composition Stourhead 1785, 1887 & 2010;* Left: *Views from the south.* Right: *Views from the northeast.*

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

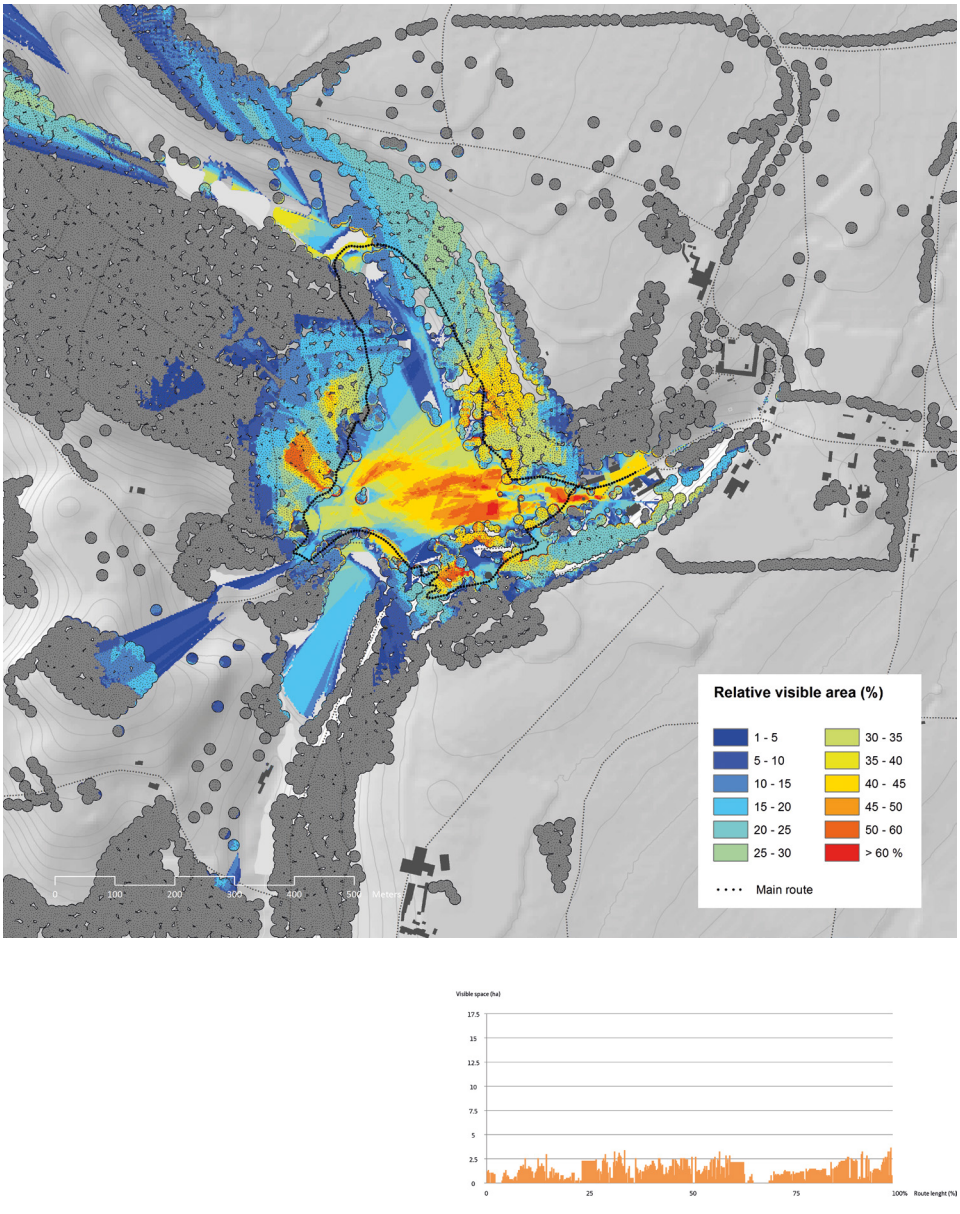
Visual connections are important to the visible form of the landscape architectonic composition of Stourhead landscape garden. Sightlines virtually organise and connect the features on opposite sides of the lake. Here, portrayal blends with the landscape at hand. The relationship between the house and 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*.



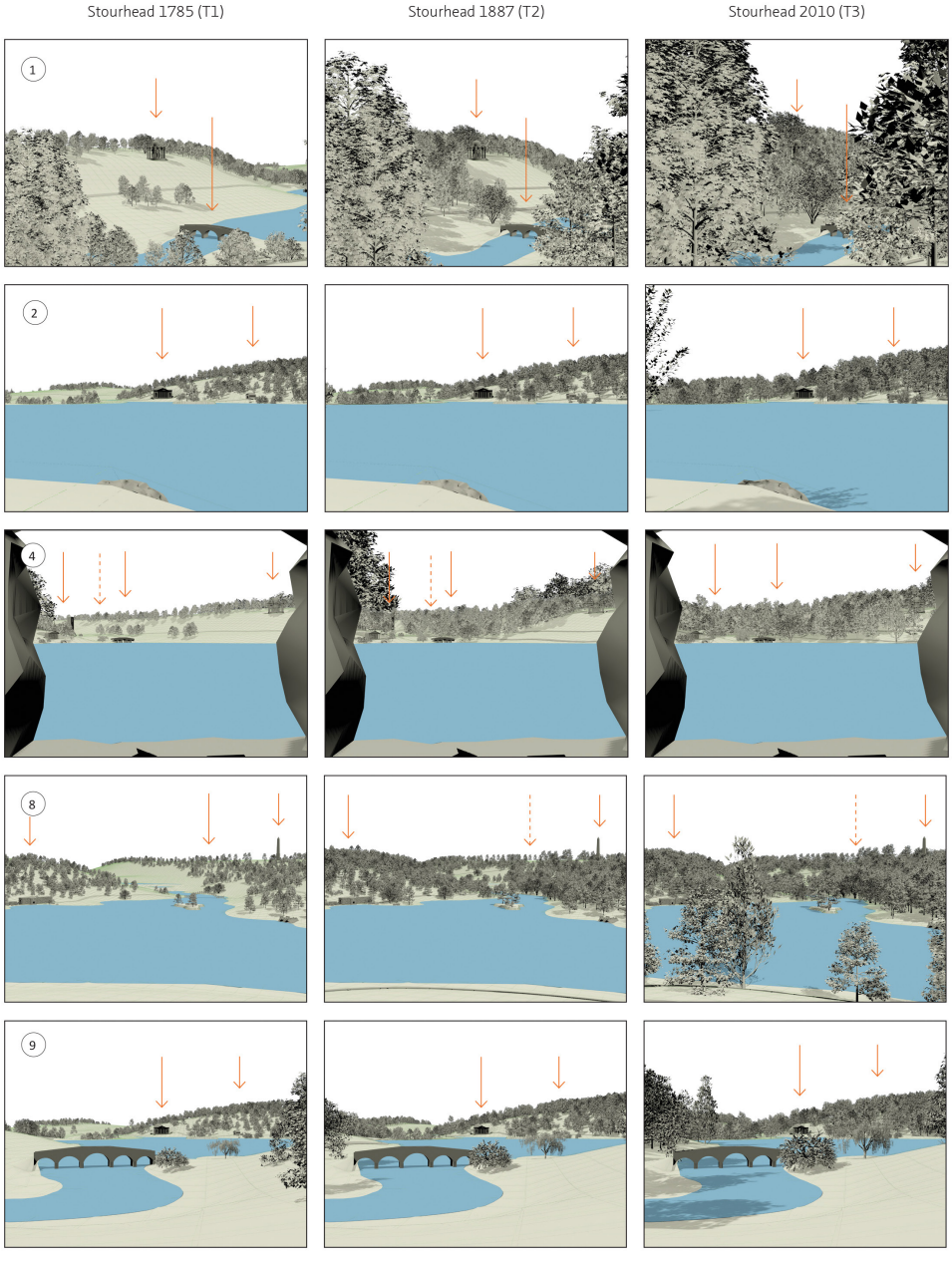
Map Series 4, Map 2, Top: Steffen Nijhuis, *Relative Visibility at Eye-Level Following the Main Routes of Stourhead in 1887*; Bottom left: F. Nicholson, [*View of the Valley garden*], *around 1813*; Bottom right: Steffen Nijhuis, *Comparison of the Amount of Visible Space Following the Main Routes of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

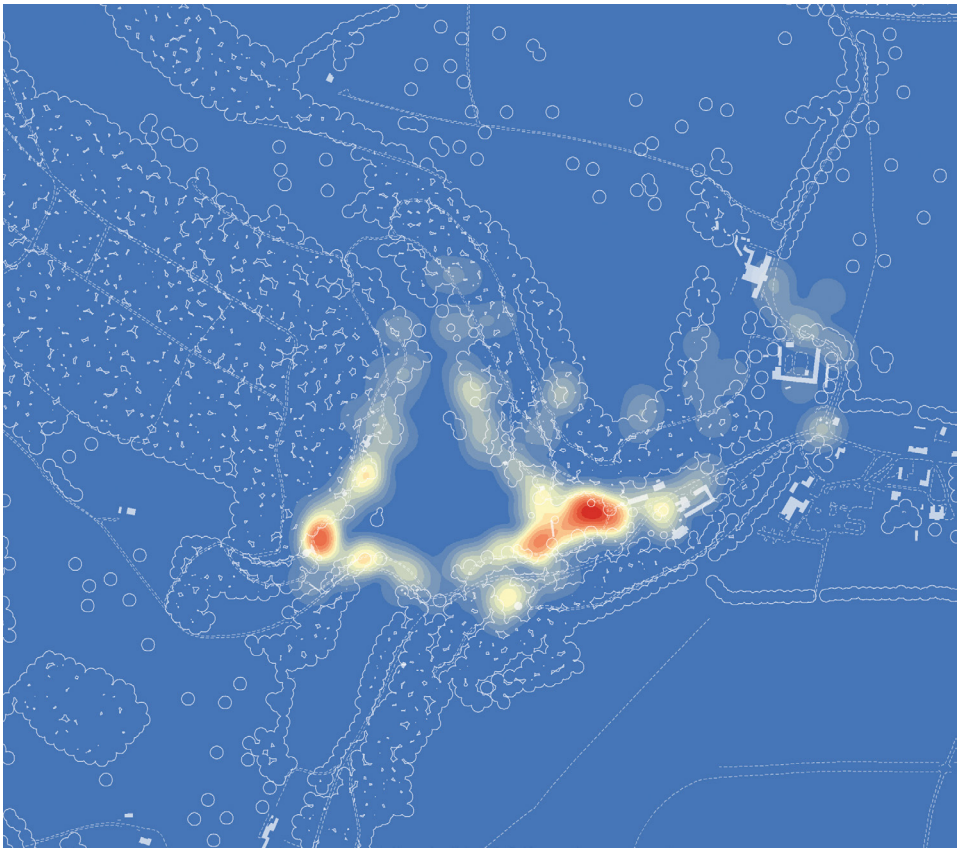
Map series 5: The quality is in the richness of meaning

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.



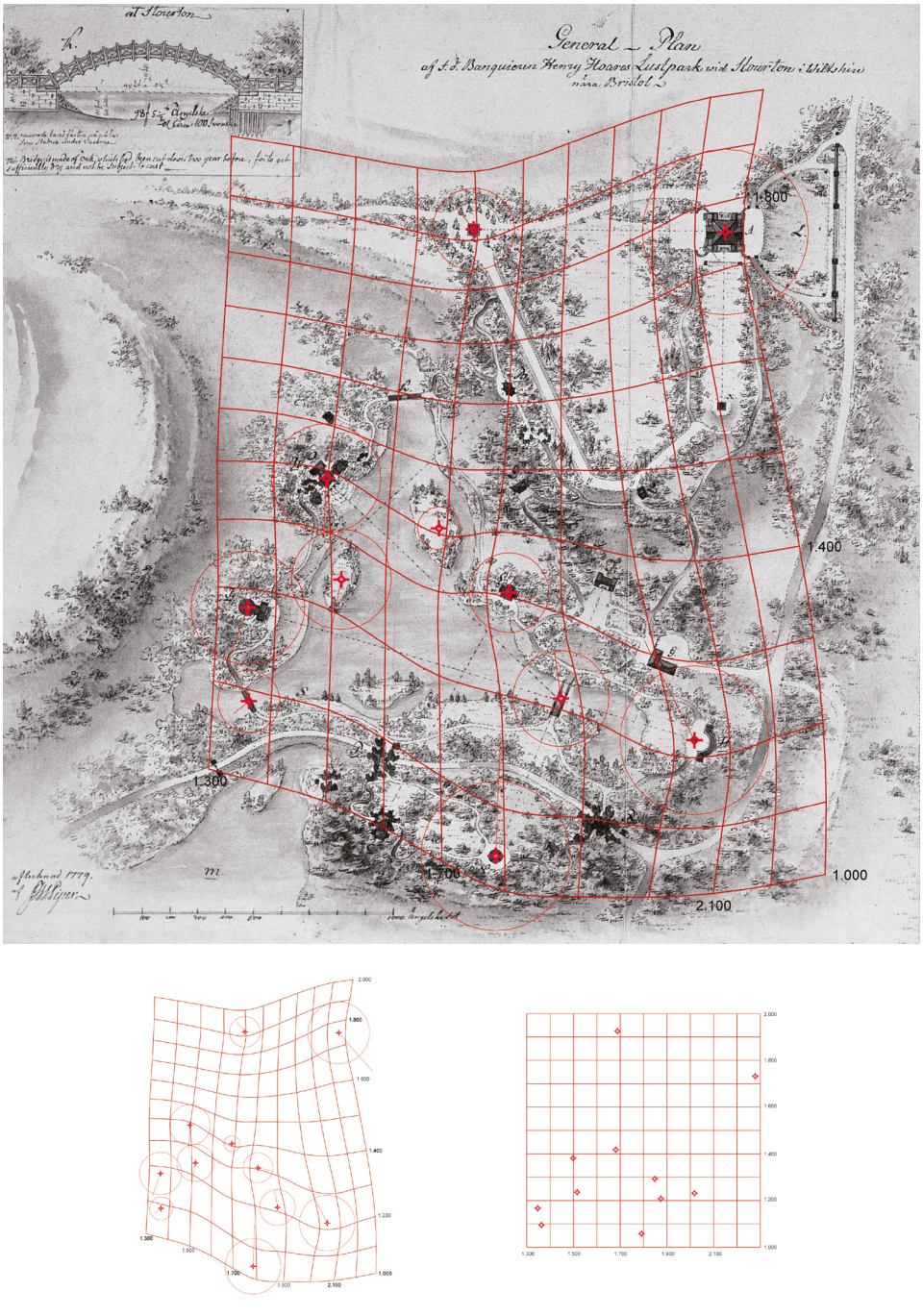
Map Series 5, Map 1: Steffen Nijhuis, *Development of the Views with the Architectural Features as Focal Points.*

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.*

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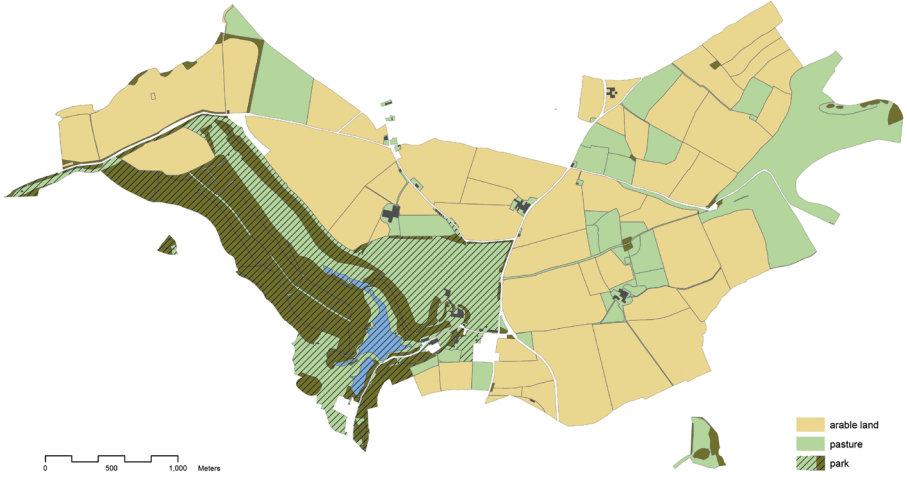

Map Series 6, Map 2: Steffen Nijhuis, *Land Use at Stourhead in 2010.*

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.