HERCULES

Sustainable futures for Europe's HERitage in CULtural landscapES: Tools for understanding, managing, and protecting landscape functions and values

GA no. 603447

D2.1 Innovative interdisciplinary protocol for under-standing long-term landscape dynamics, based on the perspectives of historical ecology, landscape biography, and complex systems theory

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Executive summary

The first deliverable of Work Package 2 (D 2.1) of the HERCULES project contains the outlines of a protocol for studying the long-term changes in cultural landscapes. It is intended as a *first design* of such a protocol, as it has to be tested and refined further in the process of conducting three regional case studies and inter-regional comparisons within the HERCULES project. The protocol defines an innovative methodological procedure for understanding the long-term development and transformation of cultural landscapes, drawing on recent insights from geography, landscape archaeology, (historical) ecology, anthropology and information science. The procedure will be informed by the definitions and the conceptual framework developed in HERCULES work package 1.

The protocol text subsequently deals with the following topics and issues:

1. A short description of its main *aim* and its relationship to the work being done in other work packages of the HERCULES project (Section 1);
2. An *overview of the major concepts and approaches* in archaeological and historical landscape research in both North America and Europe and the major issues raised in landscape history over the past decades (Section 2). This also defines the necessity of developing an integrated approach to long-term changes in cultural landscapes (Section 3);
3. A set of *premises* for understanding long-term changes in cultural landscapes (Section 4), as well as a number of *operational principles* for translating these premises to concrete starting points, procedures, methods and techniques in individual or comparative landscape projects (section 5). These premises and operational principles are based on the methodological buildings blocks of the protocol: *historical ecology, landscape biography and complex systems theory*.
4. Starting points for integrating landscape history with the current theory and practice of *geodesign* (Section 6);
5. Design of an *infrastructural facility* for retrieving and linking archaeological, historical and ecological data and geo-information (SDI) to support the interdisciplinary study of landscape change (Section 7).
6. An exploration of concepts and techniques in *dynamic modeling* that can help better and more consistently understand the long-term processes that have been operating (or still are) in cultural landscapes, including outlines and examples of a comparative *case study approach* (Section 8).

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Abbreviations

ABM	Agent-based modelling
AD	Anno Domini
BC	Before Christ
CS	Complex Systems
DEM	Digital Elevation Model
GI-literacy	Geospatial Information Literacy
GIS	Geographic Information System
HE	Historical Ecology
LB	Landscape Biographies
LiDar	Light Detection and Ranging or Laser Imaging Detection and Ranging
LUS	Land Use Scanner
SDI	Spatial Data Infrastructure
WP	Work Package

1 Introduction

This report describes the outlines for a Protocol for understanding long-term changes in cultural landscapes, which is the first deliverable (D2.1) of work package 2 of the HERCULES project.

HERCULES strives for the empowerment of public and private actors to protect, manage, and plan for sustainable landscapes of significant cultural, historical, and archaeological value at local, national, and on Pan-European scales. By applying and developing innovative technologies and tools for assessing and mapping cultural landscapes, HERCULES will:

a. Synthesize existing knowledge on the drivers, patterns, and outcomes of persistence and change in cultural landscapes.
b. Close knowledge gaps regarding the dynamics and values of cultural landscapes.
c. Generate tools for landscape observation and modeling in order to understand values of and threats to cultural landscapes in Europe.
d. Develop a strong vision of pathways towards protecting heritage in cultural landscapes, especially for landscapes of high historical and archaeological value.
e. Provide policy makers and practitioners with a cutting-edge Knowledge Hub to guide decision-making for the benefit of cultural landscapes with significant archaeological / historical components

In achieving these goals, the HERCULES project responds to the European Landscape Convention's call for trans-disciplinary research and involves important actors with stakes in cultural landscapes across all project stages.

Within the HERCULES project, work package 2 (from now on WP2) focuses on the study of long-term landscape change. The principal aim of WP2 is to enhance methodologies to collect data and to create knowledge about the long-term dimension of cultural landscape change. Its specific objectives are:

1. To define an innovative methodological procedure for understanding the long-term development and transformation of cultural landscapes, drawing on recent insights from geography, landscape archaeology, (historical) ecology, anthropology and information science. The procedure will be informed by the definitions and the conceptual framework developed in WP1.
2. To develop and test an infrastructural facility for retrieving and linking archaeological, historical and ecological data and geo-information (SDI) to support the interdisciplinary study of landscape change.
3. To develop models for analyzing long-term trends in landscape history in the case study sites.

In WP2, the cultural landscape will be conceived of as being both a socially constituted and meaningful whole and a dynamic system that enables people to adapt to changing climatic and environmental conditions. Starting from this broad definition, and informed by the definitions and the conceptual framework in WP1, WP2 explores the methodological potential of historical ecological and biographical approaches to cultural landscapes (Crumley 1994, 2015; Kolen, Hermans & Renes 2014; Meyer & Crumley 2011; Roymans et al. 2009). In this way, WP2 also aims at an understanding of the long-term background to the short-term changes and current transformations in the European cultural landscapes that will be studied in WP3 and WP4.

In order to assess the long-term interactions between social and natural drivers more accurately and systematically, the concepts of historical ecology (HE) and landscape biographies (LB) will be integrated with a complex systems (CS) approach.

Thus, in T.2.1, a sound interdisciplinary protocol for understanding long-term dynamics in cultural landscapes will be developed by a core team of HERCULES researchers from UU, VU, TU, and Leiden University. This will be done in consultation with experienced theoreticians and landscape researchers with diverse disciplinary backgrounds, as well as with the core team of WP3, which also explores the possibilities of dynamic modeling for understanding short-term and current changes in the landscape. The protocol will be tested and applied in some of the HERCULES study landscapes, more particularly in the river delta landscape (including the Holocene peat area) of the central and western Netherlands (Waterland), the Uppland area in Sweden and Kodavere/Vooremaa in eastern Estonia. The technical aspects of the testing, which involve the dynamic models and Spatial Data Infrastructure (SDI), will be done in close cooperation with WP7.

2 Rationale: the ongoing divide in landscape research

It is important to understand something of the history of landscape research before introducing the premises and operational principles of an integrated long-term approach. In recent decades the long-term study of landscapes has seen rapid international growth. While archaeological theory and practice has been at the forefront, the disciplines of geography, anthropology, history, ecology, and philosophy have also made important contributions. Our approach draws from both European and North American archaeological traditions, which together reflect the contributions of other key disciplines.

Beginning in the 1970s, European and North American landscape studies were often divided between more social science and humanities-oriented constructivist approaches (taking landscape as a social construct) and more natural science-based essentialist approaches (seeing landscape as an external natural phenomenon), which prevented landscape researchers from developing truly interdisciplinary perspectives. Particularly in Europe, the more essentialist approaches primarily aim at objectified knowledge of landscape as an external phenomenon, either in terms of processes and systems or in terms of morphologies (field divisions, built structures, infrastructure, etc.). In the 1970s the old holistic landscape approaches of cultural geography (e.g. Sauer) and local history (e.g. Hoskins) had gradually given way for ever more advanced theories and models for spatial analysis and cross-cultural comparison that followed the quantitative and statistical paradigm that was developed within the ‘new’ human geography and the ‘new’ processual archaeology. The new approaches were, however, not only essentialist, but also markedly reductionist, treating humans as little more than anonymous particles and statistical factors.

By the end of the 1970s European reactions appeared, first within ‘humanistic’ geography and, from the early 1980s, within the ‘new’ cultural geography. The ‘humanists’ (Meinig 1979) defended the message that landscape was ‘in the eye of the beholder’ and, hence, visions of landscape always showed the subjective fascinations, interests and ambitions of the perceiver. This last point was followed some years later in the new cultural geography developed by Cosgrove and Daniels, who were strongly inspired by the humanistic geography and iconographical approaches in history (Cosgrove & Daniels 1988; Cosgrove 1984). In the early 1990s, research in the Anglo-Saxon academic world seemed to have moved increasingly towards the study of landscapes as social and symbolic constructions. This perspective was also adopted by hermeneutic and interpretative ('post-processual') landscape archaeology, notably in the UK. On the other hand, large numbers of regional landscape studies, partly related to planning, still described and mapped landscapes in the traditional way of the 'local history approach' and landscape morphology. The gap between these different worlds of research seemed unbridgeable and kept growing, hence the frustrations about over-theorizing in geographical and archaeological landscape research (see Fleming 2007 and Johnson 2007 for an example of the controversy).

In the United States and Canada, response to processual archaeology was enthusiastic in some influential circles, but also generated strong resistance. This response took a variety of forms, including but not limited to gender archaeology (feminist, queer theory), political archaeology (issues of class and power), mortuary studies (the body), historical archaeology (combining physical remains and documents), the archaeology of agency (individual and group identity and decision making), and an explicitly cultural re-engagement with environment and ecology. Contract archaeologists, reflecting their own growing importance and diminished interest in theoretical battles, adopted a pragmatic approach to heritage management and historical/environmental conservation. One could argue that in North America, landscape archaeology drew on these lively initiatives and had become, in its own right, a response to processual archaeology by the end of the 1980s.

To conclude, there is a continuing divide between more essentialist and naturalistic approaches to landscape on the one hand and more constructivist and 'culturalist' approaches on the other, both in postwar European and–to a lesser extent–North American research. However, whereas in Europe landscape archaeology responded to processual archaeology by re-engaging humanistic geography, history and phenomenology, landscape archaeology in North America developed within the Boasian framework of anthropology that was influenced by history, ecology, and environmental archaeology.

3 Towards an integrated approach

In 1996, The Danish-American geographer Kenneth Olwig tried to synthesize the essentialist and constructivist traditions, based on a thorough investigation of the origins of the landscape concept, by re-introducing the 'substantive' nature of landscape (Olwig 2002; Olwig 1996). Although such a synthesis of paradigms, if possible at all (as many researchers oppose the idea of paradigms itself), is not an explicit goal of the integrated long-term approach to be developed in WP2, there is certainly a link between WP2 and Olwig's endeavor. WP2 too aims at developing an integrated approach to the study of landscapes, combining the long-term perspective of archaeology and history with recent insights from cultural ecology, anthropology and geography. To achieve this goal, elements of recent 'landscape biography', 'historical ecology' and 'complex systems theory' will be used as theoretical building blocks. Landscape biography and historical ecology are among the prominent emerging approaches to the study of long- term landscape history, and are now being combined and integrated with a complex systems approach to human-land and human-nature interactions.

Landscape biography studies the long-term transformations in landscapes, preferably from prehistory to the present, viewing landscape at each point in time as a complex interplay between social and economic developments, culturally specific perceptions of the environment, the history of institutions and political formations, and ecological dynamics (Roymans et al. 2009; Kolen et al. 2014). As a historical research strategy, it expresses a strong sense of the multi-layered nature of landscapes. It acknowledges the non-linear and path-dependent character of cultural landscapes and the active role that landscapes play in the life histories and social memory of people (cf. Ingold 2000). This means that landscapes are not only seen as the (interim) outcomes of drivers, but in themselves are considered drivers for social, economic and climate change as well. From a social perspective, prominent focus is given in landscape biographies to the identity constructions of communities and the role played here by landscape.

Historical ecology, which emerged in the US within the Boasian paradigm, developed a practical framework of concepts and methods for studying the past and future of the relationship between people and their environment (Balée 1998; Balée & Erickson 2006; Crumley 1994, 2012; Hornborg & Crumley 2007; Meyer & Crumley 2011). While historical ecology may be applied to spatial and temporal frames at any resolution, it finds particularly rich sources of data at the ‘landscape’ scale, where human activity and cognition interact with biophysical systems, and where archaeological, historical, ethnographic, environmental, and other records are plentiful. The term historical ecology draws attention to a definition of ecology that includes humans as a component of all ecosystems and to a definition of history that goes beyond the written record to encompass both the history of the Earth system and the social and physical past of our species. Historical ecology provides tools to construct an evidence-validated, open-ended narrative of the evolution and transformation of specific landscapes, based on records of human activity and changing environments at many scales. Historical ecology offers insights, models, and ideas for a sustainable future of contemporary landscapes based upon this comprehensive understanding of their past.

Complex systems are self-organising and exhibit what are known as ‘emergent properties’, which cannot be deduced from the individual natural or cultural components of the system. Agent-based perspectives on complex systems (cf. Van der Leeuw and McGlade 1997; Bentley and Maschner 2003) combine the principles of complex systems theory with the concept of interacting agents. Agent-based modelling (ABM) allows the study of whether developments inevitably lead in a certain direction (path dependence), and whether different scenarios will produce similar outcomes (equifinality). By this, it is very suitable for exploring long-term developments in cultural landscapes, allowing the testing of different hypotheses of the development of the cultural heritage embedded in these landscapes. As ABM also leads to insights on how micro-scale processes give rise to macro-scale phenomena, it is of great interest to landscape archaeology, where we can usually only observe the macro-scale results of micro-scale actions in the past. Several archaeological studies have used ABM for this purpose (Kohler et al. 2007; Wilkinson et al. 2007).

Together, these frameworks encompass the range of variation that is currently found in international landscape studies. While the frameworks largely overlap, landscape biographic approaches focus on the regional scale of analysis and are more explicitly phenomenological and aimed at heritage studies, while historical ecological approaches are multi-scalar and are more comprehensive and explicitly empirical. Both frameworks embrace the stakeholders, planners, and managers of landscapes. For the first time, WP2 aims at integrating the so far separate concepts of landscape biographies and historical ecology with a complex systems-based perspective on cultural landscapes. With spatial dynamic models specifically designed for the needs of interdisciplinary study of landscape change, HERCULES intends to provide landscape researchers with new tools to understand long- term developments in cultural landscapes by more effectively linking archaeological, historical, ecological and social data.

4 Understanding long-term changes in cultural landscapes: premises

By integrating landscape biography, historical ecology and complex systems theory, WP2 wishes to realize a trans-temporal approach to landscape, treating epochs, periods, and other temporal divisions as ripe for research and not firewalls that protect temporal specialties. Such a trans-temporal approach has several advantages. Particularly important for planning and heritage, the coupled human/environment system can be analyzed with regard to effective management strategies under specific (local, regional) cultural and environmental conditions and the results used to formulate future scenarios.

Thus a major issue is how to practically envision future landscapes. Many archaeologists, geographers, architects and heritage managers are employed to plan and manage entire towns or regions, taking into account the complexity of changing environments. In addition to the trans-temporal approach, WP2 wishes to contribute to overall approaches for HERCULES by including future management aspects and by enhancing the role of long-term thinking and analysis in geodesign, urban planning, landscape design, and stakeholder involvement.

Moreover, traditional historic landscape assessments are poorly matched with the needs of planners, policy makers and public interest groups. Such knowledge communities actively contribute to the further development of landscapes and regions, including their heritage (Fairclough & Grau Moller 2008; Janssen et al. 2014; Kolen et al. 2014). We wish to introduce these important knowledge communities to new possibilities for understanding complex interactive processes over the long term by clarifying the powerful roles of narrative, social memory, and practical experience (from the past and the present) in collaboration and design.

In order to tackle these challenges, an integrated and multidisciplinary approach to long-term changes in cultural landscapes should start from the following 15 premises, or at least from a combination of a significant number thereof:

> **[4.1] The Earth system and human societies are, together, the most complex system we know.** Complex systems (also called complex adaptive systems, abbreviated CAS) are densely connected networks with several features that set them apart from simpler systems such as internal combustion engines. The behavior of some elements in CAS cannot be predicted (termed non-linearity), but they emerge in the course of time.
>
> **[4.2] A complex systems approach offers a useful focus for the study of biophysical systems that include humans** which, now that the Anthropocene has arrived, are

everywhere on Earth. The goal of 'long-term studies' is to combine knowledge of past human societies with knowledge of past biophysical conditions and use their analysis to model sustainable future possibilities for heritage management.

[4.3] Much of what we know about such systems cannot be based on extrapolation from present conditions. Yet these CAS are remarkably historical: initial conditions of the system are a strong predictor of later states. Past decisions shape and constrain subsequent ones and small differences are disproportionately the cause of later circumstances. This is called *path dependence*. Thus physical infrastructure, social practices, and other conditions can impede necessary system-wide change.

[4.4] Diversity plays a critical role in ensuring resilience to systemic shocks, not just of living organisms but also of thought and practice and how, together, these have shaped landscapes over time.

[4.5] A region's linked human and environmental history contains information about how it responds to extremes. For example, knowledge of past climate extremes allows managers to anticipate changes in the region (e.g., ground water levels, the impact on particular species, or clever innovations people found in the past).

[4.6] Knowledge of past management strategies can help avoid earlier mistakes or, in the case of good results to a particular strategy, offer viable alternatives to a similar contemporary challenge. These 'old-and-new' solutions stimulate 'tinkering' to arrive at hybrid innovations and stimulate sustainable current development. They have many advantages: use of low-cost, low-impact, locally available materials, a local and motivated work force, and a source of local pride which strengthens community.

[4.7] Knowing a system's history can be seen as using completed experiments undertaken in the laboratory of the past. All (pre)historic techniques are not sustainable, but it is true that their persistence is, at least in part, witness to their utility.

[4.8] Landscape change is affected by forces at all spatial scales, from local to global.

[4.9] Landscapes have their own temporalities and rhythms, in relation to but distinctive from individual and community life cycles. The past is also always present in the landscape of 'today'. All landscapes incorporate "the powerful fact that life must be lived amidst that which was made before" (Meinig, 1979: 44).

[4.10] The holistic form of historical ecology (Crumley 2015) that we employ is theoretically and methodically strong, embracing the contribution of many different knowledge communities and types of data, working with diverse stakeholders, and to project future scenarios for regions.

[4.11] An explicit research question of landscape biography is to investigate the power of existing landscapes on people and their spatial practices, as well as the dynamic way in which people have dealt with their environment through time.

[4.12] Landscape biography highlights the importance of social memory and the means to construct "a chronicle of life and dwelling" (Ingold 2000: 189). To engage today with past landscapes we must be able to tell stories that re-connect heritage visitors to the thoughts and emotions of previous inhabitants. Additionally, landscape biography can make people aware of similarities and differences (otherness) in the perceptions, emotions and thoughts of people, both in the past and in the present. In this way, heritage landscapes can be promoted as tools of tolerance, openness and pluralism.

[4.13] Historical ecology and landscape biography both study long-term transformations in landscapes from prehistory to the present, viewing landscape as a dynamic and complex interplay between social and economic developments, culturally specific perceptions of the environment, the history of institutions and political formations, and ecological dynamics (Crumley 1994, 2015; Kolen et al. 2014; Meyer & Crumley 2011; Roymans et al. 2009). It is important to realize that the disciplines contributing to this exercise, like landscape archaeology, historical geography, historical anthropology and palaeo-ecology, explore quite different datasets (see 7.2 below) covering different time-intervals and aspects of landscape change. These datasets and the methods used to analyze and interpret them must be related and integrated in systematic ways in order to synthesize long-term changes.

[4.14] Together, historical ecology and landscape biography can link social memories to the long term, connecting the micro-histories of places to broad-scale developments, and integrating experience and process. One of the routes to this end is by the study of how, in different mnemonic, religious and social systems, memories, values and ideas concretely interact with the material world (e.g. Küchler 2002).

[4.15] Thus landscape biography and historical ecology view landscapes as palimpsests that are transformed continuously, both through conscious interaction by people with the material past in the environment and through less conscious forms of agency. This illustrates that landscapes cannot simply be seen as the outcomes of drivers, but that landscapes themselves are also drivers of social, political and economic change.

Together historical ecology and landscape biography satisfy Goals 1A and 1B: historical ecology, landscape biography, and databases/modelling activities satisfy Goal 1C. Final results of WP2 activity will satisfy Goals 1D and 1E.

Taking the above set of premises as its methodological starting point, this protocol will not produce a single paradigm but rather offers a toolbox of concepts and competencies (cf. de Kleijn et al. 2014; Kolen et al. 2014; Meyer & Crumley 2011; Crumley 2015). At the same time, the premises can be chosen as explicit theoretical guidelines for research projects that tackle long-term changes in cultural landscapes.

5 Operational principles

A set of 10 operational principles (in addition to the conceptual tools outlined above) guide our research design (Meyer and Crumley 2011:122). These principles include:

[5.1] A commitment to begin with a research design constructed by all collaborating scholars and evaluated/supported by relevant stakeholders who jointly decide central questions, elucidate desired outcomes, and plan the data gathering, data merging, and interpretive phases of the project;

[5.2] A commitment to work with both quantitative and qualitative empirical data (see also 6.1);

[5.3] A commitment to integrate both academic and non-academic knowledge (see 7) in a fashion, which privileges neither and attempts to translate each to the other;

[5.4] A commitment to employ data collected using 'best practice' protocols for each relevant discipline when available;

[5.5] A willingness to keep independent from one another these various lines of evidence until such time as discipline-based data gathering is considered sufficient, but also to keep researchers themselves in constant dialogue;

[5.6] A willingness to see conclusions about the history of a region constantly modified or reversed by new, evidence-based interpretation;

[5.7] A recognition that changes in knowledge about a region tend to have material (and thus historical) effects in the region;

[5.8] A recognition that evidential gaps (both spatial and temporal) raise questions about the appropriate extent of extrapolation, leading to questions of scale and reliability;

[5.9] A recognition that designers' decisions about temporal and spatial parameters must be tied both to desired outcomes and to available information about historical and on-going processes of change; and

[5.10] A recognition that while 'baselines' are very important, they have the potential to introduce errors into later interpretations.

6 Geodesign

6.1 Landscape history and spatial planning

Gunn (in Crumley 1994) convincingly explains that landscapes do not just survive, but must be maintained. He emphasizes the importance and role of what he calls 'capturing': the long-term transmission of cultural information about the environment, in addition to the short-term intergenerational exchange of information, knowledge and memories. This starting point is of crucial importance, both for the reconstruction of long-term processes of landscape change as well as for the developing strategies for valuing and transmitting heritage in the present and the (near) future.

Since the 1980s, a growing interaction can be observed between landscape history and heritage on the one hand, and spatial planning and design on the other. Spatial planners are more receptive to past designs and practices and help to anchor history and heritage more firmly in the present and future. This has resulted in a number of successful initiatives to integrate historical knowledge and material heritage in (urban) landscape interventions, including the Internationale Bauausstellung (International Building Exhibition) Emscher Park in Germany's Ruhrgebiet, aimed at strengthening the identity of the place and strengthening its social and economic vitality while at the same time finding new purposes for remnants from the past (Raines 2011). In other countries as well, such as the United Kingdom, Denmark, the Netherlands and Italy, valuable landscapes and other forms of cultural heritage are used as tools in revitalising rural areas and urbanized regions (Braae 2003; Fairclough & Grau Moller 2008; Janssen et al. 2014; Tietjen et al. 2007). These shifts in public appreciation request new approaches that link knowledge of the past to actual themes such as sustainable development, social identification and quality of life.

These new approaches should also help overcome a series of fundamental problems, including the persistence of traditional forms of disciplinary knowledge production and one-sided information flows, and the absence of procedures for collaboration between heritage specialists, planning professionals and local stakeholders. Furthermore, a review of the early heritage based planning collaborations (such as Dutch Belvedere) highlights that the circumstances in which these could flourish are no longer present. Governments across Europe are reducing their involvement in spatial planning; the financial and socio-economic downturn is undermining property development; and many regions in Europe are facing demographic shrinkage instead of growth. Publically commissioned, large scale property development is a thing of the past; transformation and rezoning of existing structures, led by public-private initiatives is the way forward (Janssen et al. 2014).

In sum, effective procedures, tools and services must be developed to facilitate a fruitful integration of long-term landscape perspectives in planning and design practice under these new circumstances.

6.2 Geodesign, geospatial technologies and long-term landscape dynamics

Planning and design frameworks like Geodesign can be adapted to create a suitable work flow for planning and design sensitive to the long-term character of processes and the historical foundations of societal values. Geodesign, as formulated by Steinitz (2012), seeks to structure the planning and design process according to a series of steps, which should be taken in an iterative manner (see figure 1). In the process, it aims to foster a fruitful integration of local knowledge and values (‘people of the place’) and expert knowledge (‘geographical sciences’) with the creativity of the landscape architect (‘design professionals’), facilitated by geospatial tools (‘information technologies’). So far, geodesign has been primarily informed by quantitative knowledge of short-term processes. But, recent technological innovations in GIS, Spatial Data Infrastructures and linked data make that an increasing range of data formats can be integrated and visualized in ways accessible to the participants in Geodesign.

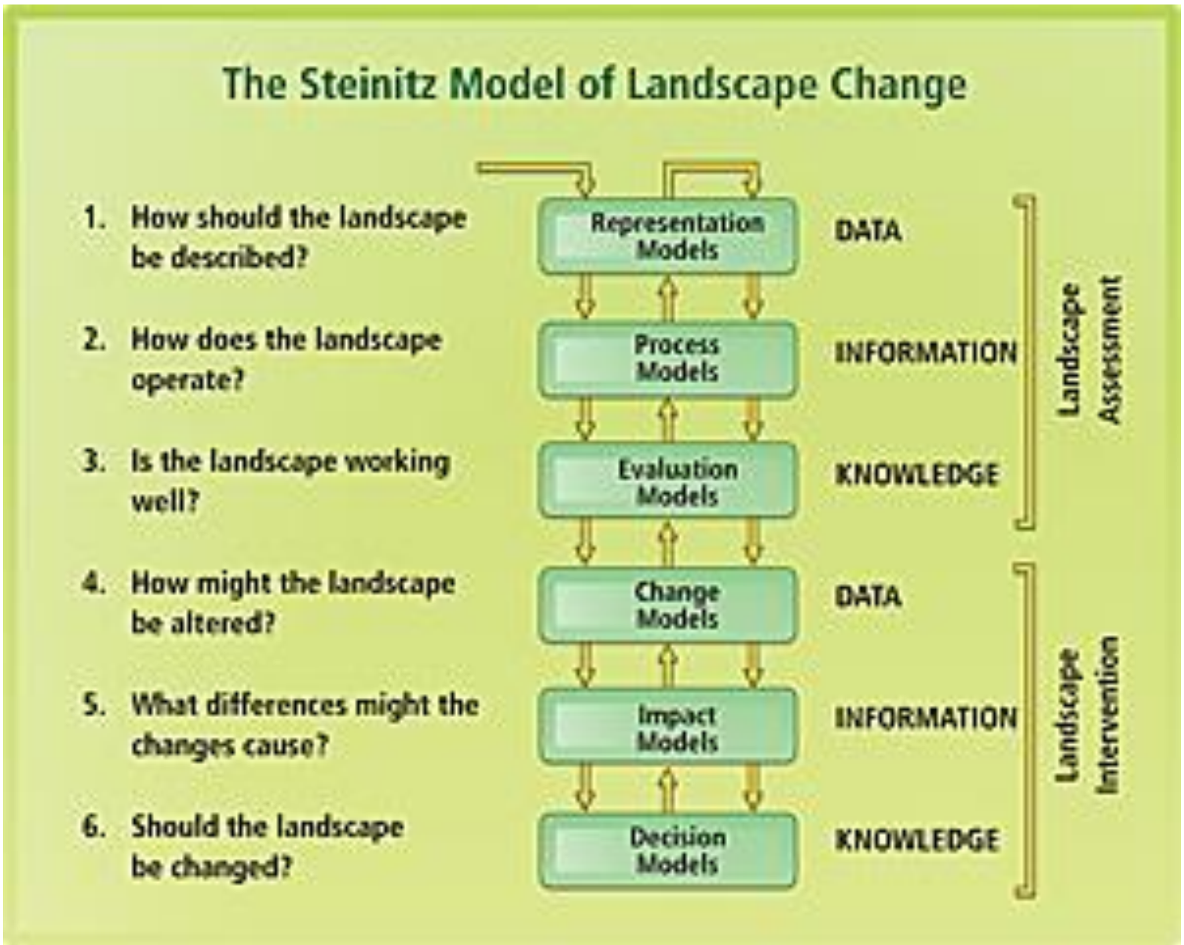

Fig. 1: The Geodesign framework (Steinitz 2012) (http://www.esri.com/news/arcnews/summer09articles/gis-designing-our-future.html)

Based on these technologies, tools can be developed capable of further bridging the gap between landscape research, heritage and planning (Burgers et al. 2014; de Kleijn et al. 2014). Biographical and historical-ecological approaches of landscape can contribute to this, without uncritically justifying all changes that are proposed by politicians, planners and designers. The aim must be to bring insights in historical processes, environmental heritage and social memory to the relevant actors, so that old landscapes can be transformed from vulnerable landscapes into socially vital and resilient landscapes. A framework for the study of long-term changes in landscapes should fulfill this goal by systematically exploring what information could be fruitfully introduced at each stage of the planning and design process.

For all the reasons given above, this protocol puts explicit emphasis on the long-term perspective in the maintenance and transformation of cultural heritage landscapes. Those practicing long-term landscape analyses should support this by conducting their studies also with the interests of heritage and landscape management in mind. Two of the WP2 study landscapes, Vooremaa and the Dutch Delta, will be the subject of workshops as part of WP8. In the case of Vooremaa, the aim will be to examine with heritage mangers how the long-term perspective on the region created by WP2 research can inform their strategies for the future. In the case of the Dutch Delta, the workshops will focus on a complex planning intervention, examining how a long-term perspective on the various systems involved – including land use, transportation networks and leisure – can inform a better decision. In this latter case, Geodesign will be used as a framework of reference to systematically assess, at which stage(s) of the process, knowledge of the long-term has the most added value.

The long-term reconstructions and short-term reconstructions of work packages 2 and 3 within Hercules can provide valuable input for the landscape assessment steps within the Geodesign framework. The models outlined for reconstructing long-term dynamics in section 8 can illuminate both the structure of the current landscape and those processes with a long past that are still ongoing. To enable knowledge exchange about landscape characteristics and processes with those practicing spatial planning and heritage management, an information infrastructure must be in place. This infrastructure is further outlined in section 7.

Such a knowledge exchange makes certain demands on the kinds of spatial modelling conducted as well as the manner in which the data is stored and disseminated with the aid of an SDI. These issues will be further examined next in the protocol.

7 Towards a Spatial Data Infrastructure[1]

7.1 Introduction

The availability of digital tools and data to study long-term changes in the landscape has, over the last decade, grown tremendously. Landscape scholars and landscape practitioners are more and more digitally skilled and the use of Geospatial technologies has grown significantly. Landscape research is nowadays unthinkable without the use of Geographic Information Systems (GIS) software to analyze, and Spatial Data Infrastructures to systematically store and share digital spatial information. The framework proposed here promotes the integration of data and perspectives produced by academics and Land Management practitioners.

7.2 Data categories for long-term landscape studies

Given their explicit multidisciplinary aim, studies of the long-term history of landscapes and ecosystems make use of datasets from various sources. Optimally, these will include a combination of the following data.

- Data and information that (can) inform landscape researchers and stakeholders (spatial planners, landowners, heritage managers, local interest groups etc.) about the **natural characteristics** and **physical properties** of the landscape, both past and present, like geological and soil data, soil maps, digital elevation maps, palaeo-geographical maps, botanical data, data on climate and climate change, etc.;
- Data and information that (can) inform landscape researchers and stakeholders **about social economic land use** and **land use systems**, both past and present, like archival sources, cartographical databases, archaeological databases (e.g. large-scale vectorised excavation plans and survey databases), specific soil data and botanical data, databases for historical landscape features, monuments and historical urban structures, etc.;

[1] Based on De Kleijn et al. 2014

- Data and information that (can) inform landscape researchers and stakeholders about the **political (territorial)** and **religious aspects** of past landscapes, like archaeological databases (burial sites, ritual depositions), archival sources (monasteries, parishes, manorial estates, etc.), cartographical databases (historical maps), databases for specific monuments and religious architecture (like churches), etc.;
- Data and information that (can) inform landscape researchers and stakeholders **about past experiences** and **meanings of landscape**, like databases for field and place names, oral history databases, cartographical databases (historical maps), visual databases for landscape painting and historical photography, etc.

7.3 Spatial Data Infrastructure

It has been acknowledged recently that in order to explore and combine multidisciplinary datasets optimally these kinds of data could best be organized by means of a so-called Spatial Data Infrastructure or SDI (De Kleijn et al. 2014). The core function of an SDI is to enable users to share geospatial information beyond the level of a single institute or organization. This need is generally found in landscape research. In understanding what an SDI encompasses we make a distinction between the user objectives, technological components, Geospatial Information (GI)-literacy, content and governance (De Kleijn et al. 2014). The combination of the GI-literacy and the objectives determine the extent to which the technological components need to be developed and the content to which access is needed.

At the core of an SDI lies the technical infrastructure in which services, varying from data viewing services to download and more complex processing services. On top of these services applications can be built with which users, with different objectives and GI-literacy levels, can perform their tasks. The applications through which the services can be accessed vary from web viewers for users to view and validate data, to dedicated GIS software with which modelling experts can perform complex analyses (e.g. ArcMap, Quantum GIS, GeoDMS, MapINFO, etc.).

For governance of an SDI three aspects can be distinguished. First, a party coordinative institute has to take the on leadership and ensure long-term viability and educate where necessary users how to use the tools. Second, the users' requirements for functionality and content have to be closely looked at in order to ensure that their needs are translated to (technical) requirements for the SDI and the applications that are implemented on top of it. Third, considering the content, the management of who can use what information for which purposes is also a fundamental part of SDI governance. Although the current trend is to publish data in the public domain as open data, to which the HERCULES project also strives to, some data cannot be put in the public domain due to privacy issues and restrictions of the data providers.

7.4 A SDI for the study of long-term landscape change

The study of long-term landscape change would benefit considerably from improved availability of data about the history and heritage of the landscape and functionalities with which the data can be processed and shared through an SDI. In the process of studying long-term landscape change, five areas in which an SDI has the potency to play an important role can be distinguished.

- First, an SDI offers functionalities to integrate digital spatial data (also from different repositories e.g. different universities, governmental institutes etc.) in structured way enabling users to work systematically.
- Second, an SDI offers functionalities to communicate historical and heritage spatial data to various stakeholders ranging from history and heritage experts to the people of the place for purposes of validation.
- Third, an SDI offers functionalities to process and/ or download data into specialist software with which complex long-term landscape change models can be developed and executed.
- Fourth, an SDI offers functionalities to share the models and the outcomes of long-term landscape change models dynamically, allowing changes to the data to automatically update the model.
- Fifth, an SDI offers functionalities to disseminate the research results as services which can be part of the Knowledge Hub developed in HERCULES or existing local heritage management data infrastructures.

The areas/themes identified above, except for the fifth, are not to be seen as separate phases, which follow up on each other, but are to be approached as stages through which long-term landscape modelling goes through in several iterations.

A schematic overview of the SDI is shown in figure 2. It shows how the data servers are related to the clients and shows how the SDI aids long-term landscape change modelling. It also shows how the SDI components are related and how the SDI interacts and can be integrated with HERCULES' Knowledge Hub developed in WP 7. The spatial modelers work foremost with professional GIS software, whereas the past oriented and future oriented landscape professionals and the people of the place provide feedback through workshops using decision support tools. These last-mentioned groups are also providing feedback making use of custom-made data viewers. Finally the project outcomes and results will be transferred to the HERCULES knowledge hub, providing insights in best practices for future landscape research.

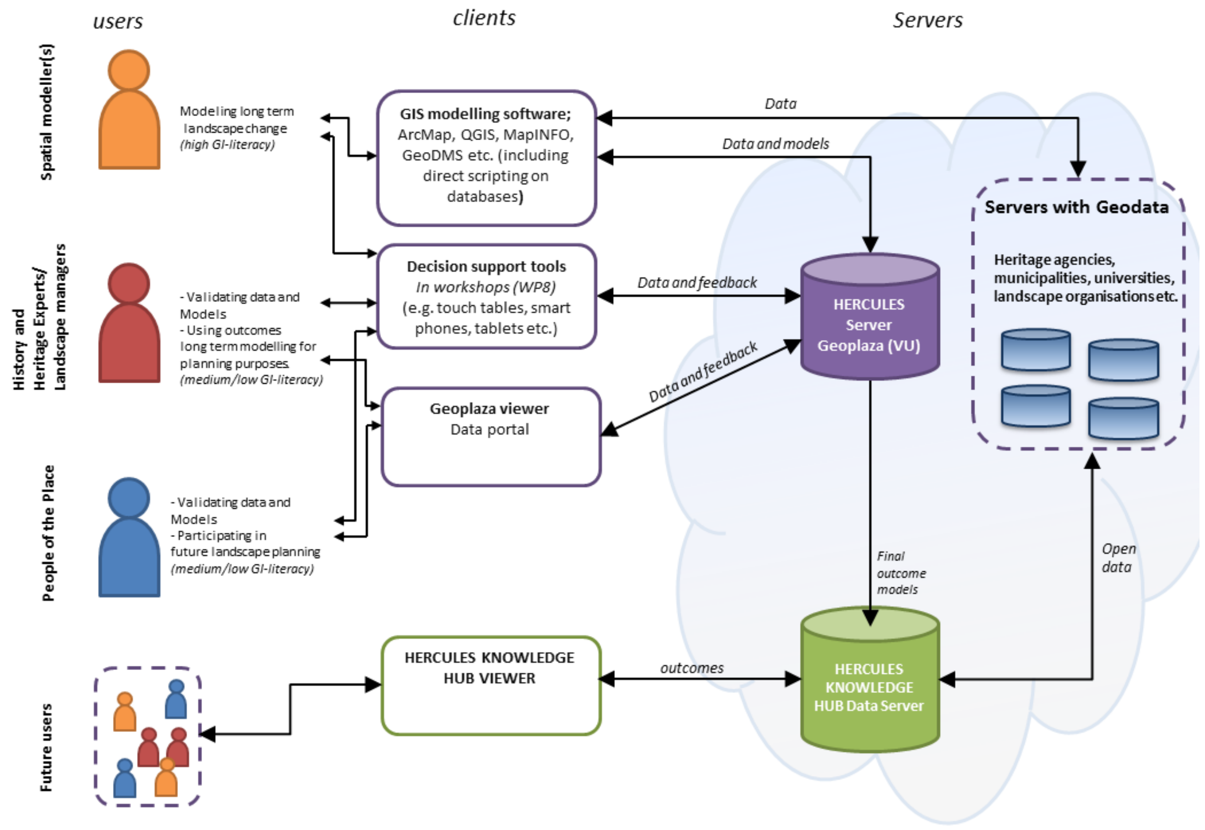

Fig. 2: Schematic overview Spatial Data Infrastructure

8 Dynamic Modelling

8.1 Introduction

As stated above, the SDI is essential for giving stakeholders access to relevant spatial information and validate outcomes of spatial models about the past and current landscape. However, in itself, it will provide nothing more than a framework to accommodate the management and visualization and exchange of spatial data sets. Current approaches to mapping and visualizing landscapes of the past can be described as predominantly static: typically, they only offer snapshots of archaeological or historical periods, showing the places where people settled and used the landscape, as well as the landscape setting itself (notably in the form of palaeo-geographical, or better said palaeo-geomorphological reconstructions). Predictive models (which are essentially statistical extrapolations) are then applied to predict the possible distribution of archaeological remains (see e.g. Kamermans, Van Leusen, & Verhagen, 2009; Verhagen & Whitley, 2012). In this approach, time periods are lumped, and the dynamics of landscape transformation are obscured, tacitly assuming that in each and every period people was experiencing the landscape as a tabula rasa.

Approaches to overcome this static approach to reconstructing and visualizing past landscapes are becoming more and more common in archaeological scientific research. Notably, techniques like Agent-Based Modelling (e.g. Kohler et al., 2007; Wilkinson et al., 2007) and Dynamical Systems Modelling have great potential for better understanding the observed patterns of settlement and land use, and the processes that led to these patterns (cf. Bentley & Maschner, 2003; McGlade & van der Leeuw, 2013). Such models are designed as heuristic tools, for example to build scenarios of population development and to develop more sophisticated theories of human (spatial) behavior from that; but the outcomes should not primarily be seen and used as accurate predictions of for example past land use. It can therefore be doubted whether these models, in their current state of application, would be of much use to heritage professionals. From their point of view, information needs to be accurate and usable, rather than obscure and ambiguous.

For these reasons, WP2 will not adopt ABM as a core modelling technique, despite its high potential for academic analysis. The outcomes would not, at this stage, be able to inform heritage policy, and hence not serve the overall aims of HERCULES. WP2 will therefore adopt and further enhance models that are able to close the gap between static mapping aimed at heritage professionals and dynamical modelling designed for academic research by developing models that will on the one hand include the understanding that settlement and land use are dynamic and path-dependent phenomena; and on the other hand come up with predictions and mappings that will make sense in a heritage context.

8.2 Adopting a case-study approach

Within WP2 the concrete possibilities of dynamic modeling will be explored by adopting a case study approach. This will be done for three different areas, each being representative for more widespread environmental and climatic conditions within Europe: Atlantic (the Dutch river area), Boreal (the Uppland area, Sweden) and continental European conditions (Kodavere and Vooremaa, Estonia). A Mediterranean area (Puglia, Italy) will be used for comparison. All case studies, most notably the Dutch and Swedish ones, will start from the premises defined in Section 4 and follow the operational principles of Section 5. For each of the three main study regions a somewhat different modelling framework will be adopted to achieve this aim. Therefore, we will briefly introduce each of the case study landscapes below.

<u>A. The Dutch river area</u>

Parts of the Dutch river landscape were occupied already during the Mesolithic and Neolithic. Initially, land use will have been limited to the stream ridges of the rivers and the adjacent parts of back swamps, as well as on Pleistocene river dunes and their surroundings. In the Middle and Late Bronze Age significant sections of the stream ridges were transformed into true rural landscapes, with scattered (and roaming) farmyards with associated burial mounds, gardens, field systems and roads. This rural landscape was part of a mosaic environment with forests, wetlands and more open cultivated areas. In the Roman Period, the study region formed the Northwestern part of the Roman frontier on the continent. By then, land use had been intensified considerably, creating a more open landscape with an increased human impact on the water system.

In about 1000 AD, the inhabitants of the river villages in the study region began building embankments along major rivers like the Rhine and Meuse. Along with the villages themselves, fields and gardens occupied the highest parts of the banks, while the slopes down to the flood basins behind the banks were used as communal meadows and pastureland. In the period from 800 to 1250 AD, towns in the Dutch river area expanded significantly and there was growing demand for agricultural products. To satisfy this demand, the agricultural land area had to be extended to the low-lying peat areas and river basins. But before these areas could be drained and reclaimed, embankments had to be built along the river courses and any obstructing ones had to be dammed. Several centuries later, the still remaining open spaces between the village embankments were closed off and long, uninterrupted dikes were built. This process was completed in most parts of the Dutch delta by about 1300 AD. Inside the dikes, where in winter especially the river water was sometimes dammed up to a significant extent, river forelands were created.

Thus over the course of five centuries, from 1000 to 1500 AD, the Dutch delta changed dramatically. It was transformed from an open delta where the rivers had free reign and where large areas were taken up by fens and marshes to a tightly ordered agricultural territory under human control. With their far-reaching interventions such as dike building, the inhabitants of the Dutch river landscapes unconsciously reset the environmental agenda for themselves. In the long run, their reshaping of wetlands and stream valleys had unexpected repercussions, like dike breaches and large-scale floods.

In the Dutch river delta, the so-called Land Use Scanner (LUS) will be deployed to model land use changes (Hilferink & Rietveld 1998; Koomen et al. 2011). This modeling framework was originally designed for predicting land use development in the near future, based on information about the current situation and the hypothesized development of future land use demand. The allocation methods applied in LUS are the logit based model to determine probabilities and a discrete allocation method to generate an allocation that is optimal given the suitability of different plots within the region. The LUS models are based on the understanding that land use is primarily influenced by socio-economic developments. This concept can also be applied with relative ease to situations in the past. A major advantage of this approach is that it shifts the pervading focus in archaeology from local settlement sites to various landscape scales as the object of interest. It also looks at the landscape from the angle of its use, rather than from the dominant, geomorphologically-based point of view aiming at predicting the landscape's suitability for settlement – which is of course only one aspect of what people did in the past.

The LUS is particularly suitable for the Dutch river delta, given the very extensive data available on settlement distribution and paleo geographic reconstructions for the area over long periods of time.

B. The Uppland area (Sweden)

The formation of regions takes place through interaction with natural boundaries such as ecological and topographical reference points. Since the regressive shoreline displacement in Uppland, like elsewhere in Sweden, changed the landscape and offered new land for occupation, it is necessary to examine how the topography influenced the choice of locations and the appearance and shape of regions.

A strategy to reconstruct regional landscape change is to take the physical characteristics of the landscape into account, such as the presence of fresh water. Proximity to fresh water is important in the choice of settlement locations. Streams, lakes and rivers not only provide food and water but are also means of communication. Rivers can connect communities into smaller regional groups, so-called river-based communities (Jordan 2003). Another such natural connective element is a water catchment area. A water catchment area constitutes the area from which all run-off water comes together in a point or in a stream. A watershed is the boundary between two such areas. Typically, a watershed is a height where the rain falls on two different sides forming two different water catchment areas. This method has been used frequently in studies concerning physical geography and to some extent in the study of prehistoric regions where it has been argued that water catchments have influenced the development of territories and administrative regions (Löwenborg 2007; von Hackwitz 2012; Wijkander 1983).

For these reasons, the Uppland case focuses on the modeling of shoreline dynamics in relation to isostatic land rise. The model used here is based on a shoreline method from archaeological sites combined with an isolation method built on analyses to determine when lakes were isolated from the sea. The benefit of using a regression equation is that the method considers both the isostatic uplift and the eustatic variations. This means that the shoreline reconstructions will be more accurately calculated, especially for larger areas, as the uplift is uneven between different land areas. Further, the shoreline can be modelled from any given BP value which means that a site can be put in its specific time context in terms of shoreline displacement as long as there is a valid BP value (Sund 2010). The regression equation used here was originally developed by Jan Risberg et al. (2007) and further developed by Camilla Sund for the area of Eastern Central Sweden (Sund 2010). The accuracy of Sund's model is comparable with that of Risberg (Risberg et al. 2007), but with the advantage of generating a contemporary shoreline over a larger area (Sund 2010:27). The applied model is generic and well suited to create a model for the area of Uppland as a whole. Local deviations might occur as topographic thresholds could later have been eroded, making it difficult to accurately model the shoreline in detail at every point, but overall the model would be fairly accurate and relevant for the analyses proposed here.

Additionally, water catchments can be calculated from a digital elevation model (DEM) using a set of hydrological functions in a GIS (Geographical Information System). Relevant pour points are selected, considering the modelled shoreline, and from the pour points drainage basins can be calculated to identify the upland area that is hydrologically joint at the pour point. The pour point would also act as an important social node in the landscape, connecting everyone using the upstream watercourses, and thus forming a natural region that would be easily recognized. If there is a pronounced isostatic land rise in the area this will affect both shorelines, thus making different pour points relevant at different periods. In areas with level terrain this might also cause the inland boundaries of the watersheds to shift as the land surface is tilting. It is therefore necessary to use a DEM that has been modified to the relevant time period using a method like the one described above. Also the quality of the DEM is important, where poor quality of the DEM might make it impossible to use for hydrological modelling. In the Uppland study area, a high resolution DEM has been produced by the Swedish Cadastral Agency (Lanmäteriet) using LiDAR technology. Since the DEM also has been edited to account for bridges this makes the data very suitable for hydrological analysis.

Using the shore line and watershed modelling together with the digital database from the National Heritage Board (Fornsök) the aim is to model the development of social relations through regions and regionalism in the area, in order to better understand the long term land use of the area starting with the early Neolithic (ca 4000 BC) and ending with the Viking Age (ca 1050 AD). The analyses are being conducted in GIS software.

C. The Kodavere and Vooremaa area (Estonia)

Kodavere and Vooremaa are neighboring regions in the southeastern Estonian lakeside landscape. The theoretical part of this case study relies on principles that are similar to the Uppland case study. Water bodies in this area form an extensive communication network, which was and still is being used for food procurement, transport, and trade. Occupation and land use focused on the western shore of Lake Peipsi, which is on the one hand a lake, but on the other hand has many similarities with a sea (i.e. the Baltic Sea) (Karro 2012). Moreover, the lake is part of a larger lake system including Peipsi and Pskov that has been documented as part of a trade route system that covered an enormous area stretching from Scandinavia to Byzantine (Mägi, in press).

The method deployed for analyzing landscape changes throughout the Iron Age (500 BC – 1200 AD) correlates geological information about the lakeshore with archaeological data, historical maps and cultural historical information (like historical narratives about places and landscapes). The dynamics of shorelines is reflected in geographical shifts of human settlement as well. Water levels in the lakes went up gradually, but the land still rises faster in the southern part of the study area. This implies that the present-day situation in the northern part may roughly be indicative of the situation in the past in the southern part. Lake Peipsi has seven visible shoreline terraces dating from different periods since its formation after the last Ice Age, of which the 38 meter asl shoreline most strongly correlates with historical and present-day settlement patterns. Folklore and historical photographs give some hints about the traditional land cover (19th and the beginning of the 20th century) that was drastically changed during the Soviet period.

For the Vooremaa region a historical GIS is applied. Detailed historical maps are geo-referenced and vectorized into layers based on land use information (e.g. arable, pasture, meadow, forest, swamp, fallow) and settlement features (e.g. farms, manors, mills, taverns, churches, roads, administrative boundaries). Additionally, a database with relevant attribute data (information about land use) is used. The layers based on historical maps can then be integrated with known archaeological sites, which will result in a series of detailed maps representing pre-industrial landscape changes.

This provides us with a coherent sequence of about 350 years of land-use, indicating land use functions in terms of arable land, pastures and meadows, forests, swamps and bogs. Much of the wetland in Estonia was not drained until the beginning of the 20th century, which is why historical maps and archaeological information are a good source for detecting suitable arable land cultivated before the mechanization of agriculture. The model may also help to understand why some sites developed into centers of power and –subsequently- into important places of local identity ‘surrounded’ by local narratives and beliefs. Historical land-use data combined with contemporary soil maps and adequate digital elevation models in the historical GIS also provides a good platform for elementary predictive modelling, which could be effectively used in preventive heritage management.

References

Balée, W. L. (1998). *Advances in historical ecology*. New York: Columbia University Press.

Balée, W. L., & Erickson, C. L. (2006). *Time and complexity in historical ecology: studies in the neotropical lowlands*. New York: Columbia University Press.

Bentley, R. A., & Maschner, H. D. (2003). Complex systems and archaeology: Empirical and theoretical applications. Salt Lake City: University of Utah Press.

Braae, E. (2003). *Konvertering af ruinøse industrilandskaber*. Arkitektskolen Aarhus, Aarhus School of Architecture.

Burgers, G.-J., De Kleijn, M., & Van Manen, N. (2014). Urban landscape archaeology, Geodesign and the city of Rome. In: *Geodesign by Integrating Design and Geospatial Sciences.* D. Lee, E. Dias, & H. J. Scholten (eds.). Berlin: Springer.

Cosgrove, D., & Daniels, S. (1988). *The iconography of landscape: essays on the symbolic representation, design and use of past environments*. Cambridge: Cambridge University Press.

Cosgrove, D. E. (1984). *Social formation and symbolic landscape*. Madison: University of Wisconsin Press.

Crumley, C. L. ed. (1994). *Historical ecology: cultural knowledge and changing landscapes*. Santa Fe: SAR Press.

Crumley, C. L. (2012). A heterarchy of knowledges: tools for the study of landscape histories and futures. In: *Resilience and the Cultural Landscape: Understanding and Managing Change in Human-Shaped Environments*, T. Plieninger & C. Bieling (eds.). Cambridge: Cambridge University Press, pp. 303–314.

Crumley, C. L. (2015). New Paths into the Anthropocene. In: *Oxford Handbook of Historical Ecology and Applied Archaeology*, C. Isendahl & D. Stump (eds.). Oxford: Oxford University Press.

De Kleijn, M., van Manen, N., Kolen, J., & Scholten, H. (2014). Towards a User-centric SDI Framework for Historical and Heritage European Landscape Research. *International Journal of Spatial Data Infrastructures Research*, *9*, 1–35.

Fairclough, G., & Grau Moller, P. (2008). Landscape as Heritage–The Management and Protection of Landscape in Europe, a summary by the Action COST A27 LANDMARKS. *Geographica Bernensia: Berne*, *79*.

Fleming, A. (2007). Don’t bin your boots. *Landscapes* 8: 85–99.

Hilferink, M., & Rietveld, P. (1998). *Land Use Scanner.* An integrated GIS based model for long term projections of land use in urban and rural areas. Research paper retrieved from http://www.macaulay.ac.uk/elpenproject/pdf/finaltext.pdf

Hornborg, A., & Crumley, C. L. (2007). *The World System and the Earth System: global socioenvironmental change and sustainability since the Neolithic*. Walnut Creek CA: Left Coast Press.

Ingold, T. (2000). *Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. Oxford: Routledge.

Janssen, J., Luiten, E., Renes, H., & Rouwendal, J. (2014). Heritage planning and spatial development in the Netherlands: changing policies and perspectives. *International*

Journal of Heritage Studies 20: 1–21.

Johnson, M. (2007). Don't Bin Your Brain! *Landscapes* 8: 126–128.

Jordan, P. (2003). *Material culture and sacred landscape: the anthropology of the Siberian Khanty*. Walnut Creek CA: Altamira Press.

Kamermans, H., Van Leusen, M., & Verhagen, P., eds. (2009). *Archaeological Prediction and Risk Assessment: Alternatives to Current Practice.* Leiden: Leiden University Press ASLU, 17, 162.

Karro, K. (2012). Lakeside and maritime landscapes: Cases of Kodavere settlement district (Eastern Estonia) and Pöide settlement district (Saaremaa). *Lietuvos Archeologija* 253–270.

Kohler, T. A., et al. (2007). Settlement ecodynamics in the prehispanic central Mesa Verde region. In: *The Model-Based Archaeology of Socionatural Systems*, T. Kohler & S. van der Leeuw (eds.). Santa Fe: SAR Press, pp. 61–104.

Kolen, J., Hermans, R., & Renes, H. (2014). *Landscape biographies: geographical, historical and archaeological perspectives on the production and transmission of landscapes*.Amsterdam University Press, Amsterdam.

Koomen, E., Hilferink, M., & Borsboom-van Beurden, J. (2011). Introducing land use scanner. In: *Land-use modelling in planning practice,* E. Koomen, J. Borsboom-van Beurden (eds.). Dordrecht: Springer, pp. 3–21.

Küchler, S. (2002). *Malanggan: art, memory and sacrifice.* London: Bloomsbury Academic.

Löwenborg, D. (2007). Watersheds as a Method for Reconstructing Regions and Territories in GIS. In: *Digital Discovery:Exploring new frontiers in human heritage.* Proceedings of the 34th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Fargo, United States (April 2006), Budapest, pp. 143–149.

McGlade, J., & van der Leeuw, S. E. (2013). *Time, process and structured transformation in archaeology*. Oxford: Routledge.

Meinig, D. W. (1979). The beholding eye: Ten versions of the same scene. In: *The Interpretation of Ordinary Landscapes: Geographical Essays,* D.W. Meinig (eds.). Oxford: Oxford University Press, pp. 33–48.

Meyer, W. J., & Crumley, C. L. (2011). Historical ecology: using what works to cross the divide. In: *Atlantic Europe in the First Millennium BC: Crossing the Divide*, T. Moore & L. Armada (eds.). Oxford: Oxford University Press, pp.109–134.

Olwig, K. (2002). *Landscape, nature, and the body politic: from Britain's renaissance to America's new world*. Madison: University of Wisconsin Press.

Olwig, K. R. (1996). Recovering the substantive nature of landscape. *Annals of the Association of American Geographers*, 86: 630–653.

Raines, A. B. (2011). Wandel durch (Industrie) Kultur [Change through (industrial) culture]: conservation and renewal in the Ruhrgebiet. *Planning Perspectives* 26: 183–207.

Risberg, J., Alm, G., Björck, N., & Guinard, M. (2007). Synkrona paleokustlinjer 7000-4000 kal. BP i mellersta och norra Uppland.

Roymans, N., Gerritsen, F., Van der Heijden, C., Bosma, K., & Kolen, J. (2009). Landscape biography as research strategy: The case of the South Netherlands project. *Landscape Research* 34: 337–359.

Steinitz, C. (2012). *A framework for Geodesign: changing geography by design*. Redlands CA: ESRI Press.

Sund, C. (2010). Palegrafiska förändringar i östra Svealand de senaste 7000 åren. *NKA* 16.

Tietjen, A., Riesto, S., & Skov, P. (2007). *Forankring i forandring: Christiania og bevaring som ressource i byomdannelse*.

Verhagen, P., & Whitley, T. G. (2012). Integrating archaeological theory and predictive modeling: a live report from the scene. *Journal of Archaeological Method and Theory* 19: 49–100.

Von Hackwitz, K. (2012). The Creation of Regions: An Alternative Approach to Swedish Middle Neolithic Boundaries and Cultures. *Norwegian Archaeological Review* 45: 52–75.

Wijkander, K. (1983). *Kungshögar och sockenbildning: studier i Södermanlands administrativa indelning under vikingatid och tidig medeltid*.

Wilkinson, T. J., Christiansen, J., Ur, J., Widell, M. & Altaweel, M. (2007). Urbanism within a dynamic environment: Modelling Bronze Age communities in Upper Mesopotamia. *American Anthropologist* 109: 52–68.