Storied lines
Using historical documentation to characterize archaeological connectivity

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Nothing can hold on unless it puts out a line, and unless that line can tangle with others.

- Tim Ingold, Life of Lines.

For Gerby and halfpaw.
# Table of Contents

Abstract ........................................................................................................ iv
Abbreviations ............................................................................................... vi
Sammanfattning på svenska ...................................................................... vii
Acknowledgement ....................................................................................... viii
1. Introduction .............................................................................................. 1
2. Landscape survey in Iceland .................................................................... 3
   2.1 Ísleif – an archaeo-historical SMR .................................................... 5
3. Materials: expanding the farm schema with historical sources ............... 9
   3.1 Source criticism .................................................................................. 11
      3.1.1 Verifiability ................................................................................. 12
      3.1.2 Diachronicity ............................................................................ 13
4. Methods: archaeoinformatics and cyberinfrastructure ........................... 15
   4.1 Database choices ............................................................................... 15
   4.2 The schema ...................................................................................... 16
   4.3 The frontend ...................................................................................... 20
5. Theoretical perspectives: relational approaches .................................. 23
   5.1 Network analysis ............................................................................... 23
   5.2 Assemblage theory ........................................................................... 29
6. Delimitations of the thesis ...................................................................... 34
   6.1 The thesis and archaeological network science .................................. 34
   6.2 The thesis and archaeo-historical research in Iceland ........................ 34
7. Creation of individual articles ................................................................ 37
   7.1 Paper 1: Setting the scene. ................................................................. 37
   7.2 Paper 2: Networks, assemblages and CIDOC-CRM. ......................... 39
   7.3 Paper 3: Episcopal economics: Skálholt as a system of provisions .......... 40
   7.4 Paper 4: Case study 2: resource networks. ........................................ 41
8. Conclusions .............................................................................................. 42
References .................................................................................................... 45
Individual articles. ....................................................................................... 52
# Table of Figures

**Figure 1**: surveyed sites in Ísleif by county. .................................................. 5  
**Figure 2**: surveyed sites in Ísleif. ................................................................. 6  
**Figure 3**: a screenshot of the original farmstead table. .............................. 7  
**Figure 4**: a typical page in the 1847 Johnsen land census. ......................... 10  
**Figure 5**: a typical page in the JÁM census. .................................................. 11  
**Figure 6**: as every record in JÁM is listed by date, it is possible to reconstruct the surveyor's journey. ................................................................. 13  
**Figure 7**: a distribution of farmstead descriptions containing the word ‘goat’............................................................................................................. 17  
**Figure 8**: the database schema. The overlaid boxes show the type of data stored. ........................................................................................................... 18  
**Figure 9**: a distribution of the terms ‘in living memory’ (manna minni) and ‘in the old days’ (að fornu). ................................................................. 20  
**Figure 10**: a Google Analytics screenshot showing statistics for visitors to jardabok.com. ............................................................. 22  
**Figure 11**: JÁM survey by year, organized by commune. ............................. 24  
**Figure 12**: rivers of things: a visualization of rent flows............................. 31  
**Figure 13**: a map showing farmstead valuation.......................................... 38  
**Figure 14**: a screenshot of the search functionality on jardabok.com. .... 43
Abstract

As the title suggests, this thesis applies historical documentation as a connective tissue to link together the main conceptual classes in Iceland’s largest SMR, Ísleif. These are the roughly 6000 historic farmsteads used as a classification scheme in Johnsen’s 1847 land census Jarðatal Johnsens. This thesis has three main components. It is primarily an infrastructural work, and most of the time spent on the thesis went into building the underlying database, made in a way to be accessible to a wide audience and integrated with related research infrastructures already in place and in development. Secondly, it is a methodological work, as the highly detailed inter-site relationships encoded in the infrastructure allowed me to model highly contextual networks, which in turn enabled me to develop new methods for modelling archaeo-historical networks by using the computational ontology CIDOC-CRM. Finally, the historiographical component of the thesis investigates the role of networks of interactions between farmsteads in early 18th century Iceland, and more specifically the role of resource claim networks in land use during the post-Reformation and earlier periods.
Abbreviations

ANT – Actor-Network-Theory

API – Application Programming Interface

AT – Assemblage Theory

CIDOC-CRM International Committee of Documentation’s Conceptual Reference Model

DI – Diplomatarium Islandicum

GIS – Geographical Information Systems

JÁM – Jarðabók Árna Magnússonar & Páls Vídalín

JJ – Jarðatal Johnsens

NoSQL – Not Only Structured Query Language

OCR – Optical Character Recognition

PDF – Portable Document Format

RDBMS – Relational Database Management System

SNA – Social Network Analysis

SQL – Structured Query Language
Sammanfattning på svenska

Som titeln antyder tillämpar denna avhandling historisk dokumentation som en bindväv för att koppla ihop de viktigaste begreppsklasserna i Islands största SMR, Ísleif. Dessa är de ungefär 6000 historiska gårdarna som använts som klassificeringsschema i Johnsens 1847 jordbog Jarðatal Johnsens. Denna avhandling har tre huvudkomponenter. Det är främst ett infrastrukturellt arbete, och det mesta av tiden som använts för avhandlingen gick till att bygga den underliggande databasen, gjord på ett sätt att vara tillgänglig för en bred publik och integrerad med relaterad forskningsinfrastruktur som redan finns på plats och under utveckling. För det andra är det ett metodiskt arbete, eftersom de mycket detaljerade relationer mellan webbplatser kodade i infrastrukturen tillät mig att modellera mycket kontextuella nätverk, vilket i sin tur gjorde det möjligt för mig att utveckla nya metoder för att modellera arkeo-historiska nätverk med hjälp av den beräknande ontologin CIDOC-CRM. Slutligen undersöker den historiografiska komponenten i avhandlingen rollen för nätverk av interaktioner mellan gårdar i början av 1700-talet Island, och mer specifikt rollen som resursanspråkningsnätverk i markanvändning under efterreformationen och tidigare perioder.
I’m thankful to many people who helped and inspired me during the writing of this thesis. First and foremost, I would like to thank Phil Buckland for many fruitful discussions throughout the past five years. I would like to thank Johan Linderholm, Claudia Sciuto, Sofi Östman, Samuel Ericson and other colleagues at Umea University; likewise Adolf Friðriksson, Orri Vésteinsson, Birna Lárusdóttir, Elín Hreiðarsdóttir and other colleagues at Fornleifastofnun Íslands; Tom McGovern, Anthony Newton, Megan Hicks, Ramona Harrison and other colleagues at NABO; Rachel Opitz, Oscar Aldred, Gavin Lucas, Carl Knappett and many others in the field; my parents Arnfríður Gísladóttir and Páll Gíslason. Most of all I’d like to thank my wife, Gerby, for the enduring and unfailing support.
1. Introduction

The objectives for this thesis began to form through discussions early on during the doctoral programme. I had joined from an institute in Iceland that had generated a large amount of data but had very little capabilities to analyse it synthetically. I knew I wanted to use my PhD project to improve the capacity to do large scale research on Icelandic historical and archaeological data, but it took a while to decide on how I would approach that.

I decided to rework the largest scale tier of archaeological survey data in Iceland, namely the table containing historical information for farmsteads. I will describe in detail what this table contains, and the changes I made for the thesis project, but for now I would like to stress that the thesis builds on existing infrastructure to facilitate research not just for myself, but for the community of scholars interested in Iceland’s past.

This thesis has three main components. It is primarily an infrastructural work, and most of the time spent on the thesis went into building the underlying database, made in a way to be accessible to a wide audience and integrated with related research infrastructures already in place and in development. Secondly, it is a methodological work, as the highly detailed inter-site relationships encoded in the infrastructure allowed me to model highly contextual networks, which in turn enabled me to develop new methods for modelling archaeo-historical networks by using the computational ontology CIDOC-CRM. Finally, the historiographical component of the thesis investigates the role of networks of interactions between farmsteads in early 18th century
Iceland, and more specifically the role of resource claim networks in land use during the post-Reformation and earlier periods. Two of the four articles focus on the methodological work of the thesis; the other two on exploring the historical networks identified in the data. The infrastructural component is only discussed obliquely in the four included articles, and for that reason the introductory text is dedicated to a large degree to discussing the capacity building aspects of the thesis.
2. Landscape survey in Iceland

I am positioning my project in the tradition of landscape survey. By landscape survey I mean the non-invasive\textsuperscript{1} study of landscapes with a view to understanding anthropogenic drivers of change, and the recording of visible anthropogenic features and evidence of impact on the environment. There are a few reasons for this. Firstly, landscape survey is somewhat problematic in the context of archaeological knowledge production. It is one of the oldest forms of archaeological investigations, and arguably every country has some form of site register (SMR), which is to say datasets of surveyed features in the landscape (often called earthworks, or archaeo-topographies; Fradley, 2018). In Iceland, we know of over 100,000 sites, whereas barely 1000 have been excavated. SMRs make much less of an impact on archaeological research than one would think given these numbers.

SMRs work best when studying features that have a very clear function when surveyed, particularly when considering the landscape context of these features. If sites are not well-identified, the diagnostic value of the SMR decreases significantly. While there are many Icelandic sites that are relatively easy to interpret based on morphology and location in the landscape, these are general interpretations which risk missing important specifics about the site in question. Site registers include thousands of sites that are simply called ‘ruins’ or ‘features’; this is because it is very difficult in many cases to say anything more specific with certainty.

\footnote{Though one could include minimally invasive techniques such as coring.}
It is furthermore very difficult to assess the age of a site from the surface. Where architectural traditions are well understood and characterised by change, this becomes much easier, although risks perpetuating generalized frameworks of site seriation that may not hold up to scrutiny. In Iceland, where turf house construction methods were hardly standardised it is very difficult to date a surveyed feature, especially those that look pre-19th century. For this reason, site surveyors in Iceland rarely try to estimate the age of sites, often leading to SMRs with a very flat temporality.

Excavation is an archaeologist’s primary method for establishing time depth and function, but the reality is that most of the 100,000 sites known in Iceland will not be excavated in my lifetime. As my thesis includes the building of a cyberinfrastructural resource enabling spatial and temporal research across the country, I needed some sort of proxy for excavations that could establish time depth and function. I settled on pushing my focus heavily into historical documentation, as the digitization of historical resources in Iceland has only recently begun. *Jarðabók Árna Magnússonar og Páls Vídalín* (hereafter JÁM, see section 2) was the natural choice for this purpose. It is a remarkable document and there are probably very few instances of a land census this detailed for an entire country – at least I have not heard of one! My first article includes a description of the source and my interpretation of it (Pálsson, 2018), but I will expand on that overview below.

Before that, however, I will discuss Iceland’s most detailed SMR, known as Ísleif (Friðriksson & Vésteinsson, 1998).
2.1 Ísleif – an archaeo-historical SMR.

Comprehensive site-based survey in Iceland effectively started in the mid-1990s at the initiative of Fornleifastofnun Íslands. Deeming the contemporary sites and monuments record, numbering under 400 sites, to be an inadequate register of Iceland’s heritage assets, the institute developed a new SMR – Ísleif (Friðriksson & Vésteinsson, 1998). The structure of the database is bipartite, with one table containing farmsteads listed in an 1847 land census (Johnsen, 1847), and the second table containing surveyed sites. As of late 2018, Ísleif contains approximately 6000 farm units and 100,000 sites, a third of which have geographical coordinates.

![Figure 1: surveyed sites in Ísleif by county.](image)

Compared to other Nordic site registers, such as the Norwegian Askeladden or the Swedish FMS, Ísleif is striking for its focus on historical context and recordings of oral history. Ísleif surveyors
rely on an integrated methodology for site detection, including aerial reconnaissance, documentary research, field walking and interviewing local informants. It is, for this reason, not simply an archaeological site database but an *ethno-archaeo-historical* one. It contains sites that might be considered oddities in a site survey system, such as places mentioned in historic documents (but not located). In addition, the database contains dozens of sites that could be called intangible, such as places associated with folk tales or places thought to be the dwellings of supernatural creatures.

![Map of sites in Ísleif](image)

**Figure 2:** surveyed sites in Ísleif.

This broader focus on historical context and local belief and memory is innovative in the context of archaeological site survey. Ísleif, however, is not an innovative technical resource. It has diverged only moderately from its mid-1990s origins as a flat table
Access database. Both parts of the schema were in dire need of a redevelopment; for my PhD, however, I decided against contending with the site database. My reasoning for this choice mostly came down to current usage of the two parts of the Ísleif SMR. The farmstead table is rarely updated or expanded, staying true to its origins as a digitization of the 1847 land census; conversely, the site table is updated almost daily as new sites are recorded and surveyed. Designing a new relational schema for this information was likely to lead to issues, and so I decided to focus my efforts on the landscape-scale farmstead table.

Figure 3: a screenshot of the original farmstead table. The field names translate as: county; commune; parish; farm name; farm number; notes; homefield modifications; survey history; boundaries; place names; primary key. Note the many empty fields.

Descriptions in the farmstead table are held in large text fields with very little breakdown of the text based on its content. The amount of text per site, or per lögðýli is also highly variable, with certain key pieces of information missing from certain farms while present for other farms. For instance, farm valuations are known for practically every lögðýli farm unit in the country, whereas the information is only sporadically recorded in Ísleif, as part of text descriptions stored in an undifferentiated field for information about a farm’s
history. Finally, the wording of comparable information for different farms is not consistent, which makes even text searches through long descriptions of questionable value.

The redesign of the table into a proper normalised schema needs to be discussed from two perspectives. Firstly, I reviewed the extant historical sources to understand how farms have historically been described. Following on from that, I developed a relational schema aimed at capturing these descriptions. Describing these processes comprise sections 3 and 4, respectively.
3. Materials: expanding the farm schema with historical sources

As noted above, the original Ísleif farmstead table was based on Johnsen’s 1847 land census. It is an obvious choice for a straightforward register of historic farmsteads as it is both simple in structure and thorough in scope. Figure 4 shows a typical page from this volume, listing name, type of ownership, value, rent, livestock rental and occupant information for every farm. The figure shows both the strength and the weakness of using Johnsen as a model for farmstead data. Its simple structure is easily converted into a spreadsheet, but the mid-19th century surveyors understood the extreme constraint this structure imposed on the complexity of farmstead data. Roughly half the page consists of footnotes, covering various information that the simple ‘schema’ can’t fit. This includes uncertainty about some of the information listed for farmsteads, discussion about divisions between farmsteads, information from earlier land census documents, recent changes in ownership, and so on. In other words, the simple structure of the census is betrayed by the high degree of messiness needed to encompass the complex character of the data the census has compiled.
Figure 4: a typical page in the 1847 Johnsen land census. Note the large number of information contained in footnotes.

Compare this to the earlier land survey Jarðabók Árna Magnússonar og Páls Vídalín (hereafter JÁM), compiled between 1702-1714. It is stupendously thorough in comparison to other surveys done in Iceland. JÁM can be described as an Enlightenment-era database. The entries are ordered consistently by paragraph, every description is dated to the day, the descriptive vocabulary appears quite constrained, and the authors do their best to pack every bit of information into their ‘schema’ – which is to say the roughly 4200 farmsteads populating Iceland’s 18th century landscape.
Figure 5: a typical page in the JÁM census. In contrast to the later Johnsen census, JÁM is both more detailed and better structured.

My NAR paper (Paper 1) has an overview of how the census came about and how it is structured, so I won’t repeat myself here (but see section 6.1, below). It is important to discuss the transformation from printed volume to database, however. As this is a lengthy subject, it deserves its own section (see section 4).

3.1 Source criticism

JÁM has certain drawbacks as a source that must be considered in the digitization process. I will discuss these under two separate headings: verifiability and diachronicity.
3.1.1 Verifiability

Much of the information in JÁM is not reproduced anywhere else, and so it is important to consider whether it is reliable information. We do have the methodological brief written by the surveyors in 1702, shortly before the work began (Magnússon, 1916, p. 21). Árni Magnússon and Páll Vídalín divided the responsibility between them and relied on several assistants to complete the census (Magnússon & Vídalín, 1990 XIII, p. 13). Páll undertook much of the fieldwork, while Árni, based in Skálholt, administered the project and handled correspondence with the Crown. The surveyors appeared to understand the possibility that farmers might misrepresent the capacities of their farmsteads, and their response was to gather the whole community of farmers together at one farm, usually the parish church or a high status farm, and to have farmers answer questions openly, in front of their neighbours (for more on this, see Guðmundsson, 1993). This had the effect of ensuring that any disputes were heard and noted, and that certain information could be corroborated or improved by communal memory (referred to as manna minni by the surveyors). In other words, while only a fraction of the information in the census can be cross checked with other sources, the surveyors had a cross-checking system that was inherent to the way they gathered the data.
Figure 6: as every record in JÁM is listed by date, it is possible to reconstruct the surveyor's journey.

3.1.2 Diachronicity

The second major issue with JÁM is that it took thirteen years to compile. The methodology used remained relatively consistent from 1702-1714, with a notable exception of the early work in the northern counties of Dalasýsla, Húnavatnssýsla and the southern Vestmannaeyjar islands. Details for those are more scant, and it is clear that it took a number of months for the methodology to mature. In addition, there was a major outbreak of smallpox in 1707-1709, which led to a population drop of anywhere between a quarter and a third of Iceland’s population. In other words, Iceland changes fundamentally halfway through the survey process. This is very important to keep in mind when doing any kind of comparative analysis, but luckily every farmstead survey is dated
to the day, and this time stamp is recorded in the database. I found it to be an opportunity for diachronic research, as it is possible to analyse the short-term effects of the population collapse by comparing the areas surveyed before, during and after the epidemic. The paper describing this analysis is forthcoming in *Scandinavian Journal of History*, but it is not part of the thesis.
4. Methods: archaeoinformatics and cyberinfrastructure

4.1 Database choices

Modelling information requires a cascading array of choices, and one of the earliest is choosing the database platform. A few years ago, the choice would have mostly boiled down to which SQL-based database technology to use, but new formats have emerged recently to challenge the hegemony of SQL as a data store. The two challengers worth noting are NoSQL and graph databases. NoSQL\(^2\) stands for ‘Not Only Structured Query Language’ and clearly derives its name from the more established SQL database technology. NoSQL databases such as MongoDB have gained a following for their flexibility in analysing unstructured data. It is particularly effective at handling rapidly growing text-based datasets such as social media posts as it does not require a normalized schema to hold data.

Graph databases\(^3\) use graph structures for semantic queries and data modelling. They are more suited to model complex data than SQL, as graph models have a richer set of tools to explicitly articulate the relationships between different parts of a data structure. Popular examples of graph databases include Neo4J, Oracle Graph and Amazon Neptune.

\(^2\) [https://en.wikipedia.org/wiki/NoSQL](https://en.wikipedia.org/wiki/NoSQL)

\(^3\) [https://en.wikipedia.org/wiki/Graph_database](https://en.wikipedia.org/wiki/Graph_database)
As the historic land census registers are well-structured legacy datasets, I never considered using NoSQL. I did consider graph databases, but ultimately decided on SQL as it is the more established technology, and in particular, it is better at handling spatial data. There is a clear front runner in the SQL database space for handling spatial data: PostgreSQL. PostgreSQL is an open source, free database technology which has a very large user base and a rapid development cycle. In addition, the open geospatial data community OsGeo has developed an extension to PostgreSQL called PostGIS, which adds a large set of functions and tools aimed at modelling, generating, manipulating and analysing spatial data. It has come to replace many of the functions formerly handled by GIS suites using shapefiles, such as ArcGIS. I decided to base my platform at Humlab in Umea, where I was given server space to deploy a PostgreSQL instance, along with other useful tools such as a Geoserver and a few front-ends exposing the underlying PostgreSQL data.

4.2 The schema

I developed a schema for the land census, organized on four principles. The core principle is the event, which is to say that any information ingested into the database is treated as an event describing any aspect of the data. The second and third principles are the farm as social unit, and the farm as a set of features in the landscape. This means that a good deal of the data relates to a social phenomenon (the name of the farm, its valuation, various owners

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4 [https://www.postgresql.org/](https://www.postgresql.org/).
through time), whereas another batch refers to its material affordances (geolocation, morphology, preservation conditions).

The fourth and final principle is the safety net. If I ever refer to a historical document, I try my best to include it verbatim in my database. I have scanned some 7000 pages of documents, OCR'ed it, and error-checked it so that any analysis I do can be linked directly with the source material. This allows a search of the spatially enabled text and has proven a powerful tool to rapidly expose patterns in the data (see figure 7 for an example of this).

**Figure 7**: a distribution of farmstead descriptions containing the word ‘goat’, mapped against historical place names referring to goats. This distribution map show that a georeferenced textual database can show patterns in the text that would take a significant time if done manually.

Figure 8 shows the schema, annotated to show its functionality.
Such a complex schema may appear to be rather over the top. But considering potential complexity of even a single sentence describing a single ‘datum’ feature of a farmstead shows why this is necessary. Let’s take rental payment descriptions as an example. Here’s an example of a descriptions of increasing complexity:

1. Rent 120 ells.
2. Rent 120 ells. Paid in wool and fish.
3. Rent 120 ells. Paid in wool and fish to the owner, at a nearby farm.
4. Rent 60 ells, when last occupied. Some remember that it was 120 ells some years before then. Paid in wool and fish to the owner, at a nearby farm.
5. Rent 120 ells. Paid during the spring to Stafholt, or sometimes to Alþingi. For the first few years (of Sigurður Björnsson’s overseeing period) it was occasionally paid with livestock in the autumn to Hvítárvellir, where Sigurður lived at the time. … Proceeds from rented livestock paid in butter to Stafholt or to Hvammur in Norðurárdalur, or to a location within the county specified by Sigurður (Magnússon & Vídalín 1913-1943 VIII, p. 24).

The first two versions can be properly modelled using a flat table or a simple relational schema. But the penultimate example includes different conditions through time, and the final example includes conditional statements that require added measures. Rent changes can be recorded as events, linked to the historic documents describing the change. Sometimes these are time stamped, but time in JÁM is rarely calendrical. It is more often based on social memory, and this is reflected in the temporal system in the database. The time periods are:

1. Now
2. Recently
3. In living memory
4. Before living memory
Figure 9: a distribution of the terms ‘in living memory’ (manna minni) and ‘in the old days’ (að forn).  

The database also uses a calendrical time stamp system where appropriate, such as to log survey events, date historic documents and time stamp events described in the census with known dates. The variable ways in which time is recounted in JÁM, along with the conditional character of much of the information, calls for a corresponding complexity in the schema.

4.3 The frontend

With the background infrastructural work completed at approximately the mid-point of the thesis project, I received funding to build an API to allow public users access to the data, as well as a web-GIS interface. This funding came through my
participation as a data provider in the NSF-funded project DataArc, a cyberinfrastructural project aimed at enabling transdisciplinary research using a heterogeneous set of data sources about the North Atlantic (see Pálsson & Opitz, 2019).

The application programming interface (API) is a RESTful web service written in Python. It serves data to two endpoints currently; the DataArc repository and the thesis project homepage www.jardabok.com. The API can also be queried using a web browser at the url, and the project has a Github page, where the code is freely available to download.

The Jarðabók homepage has proven relatively impactful, even with very little advertisement. The page has had 260 visits over the past 90 days at the time of writing, or almost 3 visits per day. Figure 10 shows the geographical spread of these sessions, showing that roughly half of the traffic comes from Iceland, with traffic from the USA and UK distant second and third. Interestingly though, the site is visited from all over the world. The site allows users to search the entire text, read individual farmstead descriptions, explore the networks I have modelled, and download the original land census volumes as PDFs. As the project is part of ongoing, funded cyberinfrastructural projects like DataArc and ARIADNEplus, I am hopeful that I will be able to secure more funding in the future to further develop the frontend for user-friendly accessibility.

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8 https://github.com/humlab/icelandic_farms_as_network.
9 23.7.2019.
**Figure 10**: a Google Analytics screenshot showing statistics for visitors to jardabok.com over the past 90 days. In total, there were 260 visits to the site in that period.
5. Theoretical perspectives: relational approaches

5.1 Network analysis

I chose network analysis as my main analytical framework in my thesis, as much of the data in JÁM has a relational element, and network analysis is a good way to approach such data. Network analysis has been employed in archaeology for over 50 years, but it has enjoyed a major rise in popularity recently. As Peeples and Brughmans (2017) point out, there have been more archaeological network studies published in the past five years than in the previous fifty. The origin of the term network in Western thinking has been mapped to the 16th century (Parrochia, 2005), but network analysis is considered to be rooted in a branch of mathematics called graph theory (Barnes & Harary, 1983; Harary, 1960; van Steen, 2010). Graph theory defines a network as a set of nodes (also called points or vertices) representing the smallest units of analysis, and a set of edges (also referred to as lines or ties) between these vertices representing their relationships. Networks can be characterised in several ways based on their properties, and many researchers have suggested a set of definitions for the type of nodes and edges (e.g. Borgatti et al., 2009). Networks can be as small as a handful of nodes and edges to millions of connected nodes.
In a pair of recent overview articles, Brughmans (2010, 2013) reviews the applications of network analysis in archaeology, describing the influences that graph theory, social network analysis and complexity theory had on the discipline beginning principally in the 1970s (Brughmans, 2013, p. 633). He notes that the popularity of network approaches waned in the preceding decades before a resurgence of interest in recent years (2010). Brughmans goes on to note that archaeological applications of networks perspective are very heterogeneous, each adopting their network methodology and terminology from a largely different set of authors (2010, p. 278). Ambiguity and heterogeneity in the use of network as a concept is by no means exclusive to archaeology, however. As Knox, Savage & Harvey observe (2006, p. 114) “network ideas are remarkably poorly networked among themselves.” This is in part due to the

*Figure 11: JÁM survey by year, organized by commune.*
flexibility of the term network, and the breadth of contexts in which it is used. A network can be defined in as general a sense as “a set of items ... with connections between them” (Newman, 2010, p. 169). Networks can be geographic, representing the connections between places in space, or relational, mapping the connections between nodes without reference to their spatial location. No wonder, then, that the applications vary greatly.

At the centre of this methodological heterogeneity is the difference between what Brughmans (2010, p. 298) refers to as qualitative and quantitative approaches to network analysis. As the categorical designation suggests, quantitative approaches employ mathematical and statistical tools to analyse data structured into networks. Quantitative approaches have been shown to be effective at analysing networks that are well understood mathematically, even in the context of very complex networks (Barabási, 2003); network approaches are not short of drawbacks, however. Emirbayer and Goodwin (1994) argue that network approaches share a fundamentally structural bias that introduces both rigidity and passivity that is at odds with the social interaction under study.

Representing the world as a set of points connected by a set of links runs counter to lived experience of the world, argues Ingold; he instead sees the world as a mass of intersecting lines: a meshwork rather than a network (Ingold, 2008, p. 82). This critique is shared by many of those whose approaches Brughmans refers to as qualitative. These approaches do not attempt to quantify the networks under study, foregrounding instead the fluidity and dynamism of social relations and space as a social construct based on theoretical approaches associated with the so-called spatial turn.
(e.g. Lefebvre, 1991; Massey, 2005; Tuan, 2001; Whatmore, 2002). Sheller, for instance, states that “rather than mathematically precise network analytical approaches to describing social worlds, I argue that a messier imagery of liquid social dynamics will enable a better understanding of the complexity of these mobile social interactions” (Sheller, 2004, p. 41). Others draw on Deleuze and Guattari’s (1987) classic work on rhizomatic relations as a foundation for network thinking, comparing their notion of ‘striated space’ with rigid networks and ‘smooth space’ with the fluidity of lived experience (e.g. Lee & Brown, 1994; White, 2008). A particularly influential qualitative network approach is actor-network-theory (ANT). According to ANT, humans and things coexist symmetrically in socio-material interactions (e.g. Law, 2003; White, 2008); both people and things can be actants in social relations, and the agency driving these social relations is distributed across complex networks of humans and non-humans (Latour, 2005).

The approaches mentioned in the preceding paragraph have a similar approach to conceptualizing the observed world as relational; that is, that meaning is produced not just by people, animals and objects but also by the relations between them. Furthermore, the extent of these relations are often considered too complex to be mapped out in full. The point of these studies, then, is not to run quantitative analyses of fully-mapped networks, but to focus on certain identified relations in the network and to make hypotheses based on those relations in the context of network thinking; that is, that agents act in certain ways based on the relationships they have to other agents/actants in the network (Latour, 2005).
Knappett’s work (e.g. Knappett, 2011; Knappett, 2013), however, provides strong arguments for the suitability of combining approaches from both the quantitative and qualitative traditions of network thinking. To begin with, he responds to Ingold’s (2008, p. 82) criticism by arguing that “there is no need to oppose meshworks (arrays of intersecting lines) and networks; they can be considered as experiential and analytical dimensions respectively (Knappett, 2013, p. 40). Specifically, he sees high potential in the combination of ANT and Social Network Analysis (SNA). Knappett argues (2011, p. 9) that, “from ANT we have an effective means for thinking through the distributed nature of socio-technologies and materiality ... and from SNA we acquire an explicit methodology for characterizing connections.”

Sindbæk has argued that network analysis is particularly suitable for the study of exchange and communication in the archaeological record (Sinbæk, 2007a & 2007b). He cites Watts & Strogatz (1998) and Barabási’s work (e.g. 1999) to problematize the two ways in which long distance interactions have been modelled in archaeology, either assuming what Sindbæk calls down the line interactions, where goods diffuse from an origin through a set of random exchanges, and assumptions based on Christaller’s central place model (Christaller & Baskin, 1966), whereby place to place interactions follow strict rules of hierarchy and a progression toward a radial structure of well-connected centres and subsidiary peripheries. Sindbæk takes issue with the former as the study of well-understood networks show that exchanges always rely on particularly well-connected nodes. He takes issue with the latter as central place perspectives do not take historical formation processes into account. Networks are assumed to progress toward the most
stable and efficient configurations, whereas network studies have shown that formation processes imbue certain nodes with degrees of connectivity that endure as the network grows and changes (Barabási, 2003, p. 91). In particular, Sindbæk suggests that so-called weak ties (Granovetter, 1973), which connect separate communities in unpredictable ways, can aid in interpreting signs of exchange in the material record.

Historical network analysis has gathered considerable momentum in recent years, Düring has gathered an extensive bibliography of the field, and he and his colleagues provide a brief outline of the field in the introduction of the inaugural issue of the Journal of Historical Network Analysis (Rollinger, Stark, Düring, & Gramsch-Stehfest, 2017). The issue, in addition to a recent review article of network methods in history (Lemercier, 2015) provide an outline of the current state of network perspectives in historical research. Historians have adopted network methods for similar reasons to those of archaeologists and face similar issues in doing so. As for the former, historians use network science to provide formal approaches to understanding complexity, to traverse scales, and due to its affinity with relational thinking (see Lemercier, 2015; Prignano, Morer, & Diaz-Guilera, 2017). Much like archaeologists, historians face issues adopting methods developed outside the historical disciplines to their subject matter. In particular, historians stress the importance of source criticism when using formal network analytical techniques on fragmentary data (e.g. Düring, 2016).

Both archaeologists and historians predominately draw on Social Network Analysis (or SNA; Borgatti, Everett, & Johnson, 2017) for
the methodological language and tools to interpret and study networks (Mills, 2017; Shankar, Eschenfelder, & Shankar, 2017). While the methods were developed in social sciences studying primarily contemporary networks between people, archaeologists in have extended the scope of SNA to consider the different topologies of historical, spatial and material networks (Mills, 2017).

Network analysis, in summary, brings numerous advantages to the study of archaeology. It is a relational approach that focuses on interaction, enabling, according to Knappett (2013, p. 57), “more dynamic and fluid accounts of human socio-material assemblages.” Secondly, network analysis considers both individual and group contexts, thereby making it particularly suitable for integrating archaeological studies at multiple scales. Thirdly, as Knappett argues it can integrate social and physical space; in other words, topology and geometry (ibid., p. 57). Finally, networks allow for highly variable nodes and links, accommodating the combination of various sources of agency, such as artefacts, places and people.

5.2 Assemblage theory

Network analysis is a flexible and robust approach to relational data, but it felt necessary to bring in another theoretical perspective aimed at analysing relations in data. I chose assemblage theory for its robust framework of terms that are eminently applicable to network perspectives. The theoretical framework has recently become quite popular in archaeology (e.g. Hamilakis & Jones, 2017; Jervis, 2018; Lucas, 2017; Pitt, 2019). It is derived from the writings of Deleuze & Guattari (1987; see also Deleuze, 1994), but
significantly elaborated by DeLanda (2006, 2016). DeLanda attributes properties to assemblages that concur, in broad principles, with the so-called qualitative network approaches, although he does so with hardly any reference to network analysis, not referring at all to important qualitative network thinkers like Ingold and Latour. Shared tenets include the ability to traverse scales while retaining core ontological properties of interaction; the insight that networks/assemblages are both practiced and immanent while being fully individuated entities with their own causal influences, and that these entities can become component parts of larger networks/assemblages (see DeLanda, 2016, p. 19-21).

Assemblage theory addresses what Delanda refers to as micro-reductive and macro-reductive approaches. Micro-reductionism assumes that a whole can be reduced to the sum of its parts, and that all agency is ultimately attributable to the individuated agents in a social system, while macro-reductionism attributes agency primarily to systems. To overcome these, Delandadan assemblages interact and nest together in sets of interactions (Delanda 2016 p. 82). These assemblages, nested across various scales, exhibit both ascending and descending causal relations, so that the “properties of a whole are produced by the ongoing interactions between its parts, while the whole, once it is stabilised, reacts back to its parts” (ibid, p. 83). The term for these interactions is emergent properties, a term used to similar effects in complexity science (Holland 2012).
Figure 12: rivers of things: a visualization of rent flows in the northern Húnavatnssýsla county from tenants to owners, and finally to the trade harbour at Skagi.
Delanda (2016, p. 1) defines an assemblage as a *whole made up of heterogeneous parts*. In other words, assemblages are temporary phenomena composed of entities and their relations, often used to describe social entities. Assemblages are scalable entities that can join to form larger assemblages, and their internal consistency can be described using a pair of distinctions. The first is the distinction between relations of interiority and exteriority, which is contingent on the character of the assemblage. For instance, an archaeological institution and its members might have relations of interiority describing the relations between component parts of any one archaeologist and relations of exteriority to describe the relations between the archaeologists, whereas a network of archaeological institutions would treat all of those as interior relations, and the links between institutions as exterior relations. In other words, an interior relation in one assemblage may be treated as an exterior relation in another.

The second pair of terms is that of territorialisation and deterritorialization, which are Deleuzo-Guattarian concepts (cf. Deleuze & Guattari 1987). These describe the “degree to which the components of the assemblage have been subjected to a process of homogenisation, and the extent to which its defining boundaries have been delineated and made impermeable” (Delanda 2016, 3). In other words, territorialisation is not (necessarily) a spatial process, but the degree to which an assemblage is ontologically cohesive.

The preceding sections give a brief overview of the tenets of network analysis and recent applications in archaeology. These two frameworks have rarely been used together, and I touch on this in some detail in Paper 2 (*Cutting the network, knotting the line,*
submitted to The Journal of Archaeological Method and Theory). I will pick up on the discussion in the section devoted to that article, below.
6. Delimitations of the thesis

6.1 The thesis and archaeological network science
Two of the four papers (1 and 2) are oriented towards the network community. I see the major contribution of my thesis to network thinking in archaeology is my work in addressing some of the issues laid out in my first article, published in *The Norwegian Archaeological Review* (see below). Namely, how do we move from networks modelling dyadic relations with no mechanism to network models that anticipate the emergence of additional dyadic and triadic relations? My contribution is the use of detailed historical sources to establish general ways in which networks get cut and re-articulated as prescriptive relations turn into material and human flows. Secondly, I show that the use of highly developed cyberinfrastructures, including creative uses of computational ontologies, can help bridge the gap between so-called quantitative and qualitative approaches. This is the main objective with my second article.

6.2 The thesis and archaeo-historical research in Iceland
Despite the relative lack of network based historic research in Iceland, the island provides a very suitable region to develop network perspectives on the past. The island was settled late in the 9th century, and while there is little indication that early settlers produced texts, they certainly came from text-producing regions. Iceland is well known for its sagas, literary works written mostly in the 13th century and regularly copied throughout the middle ages. Property deeds and church records survive as far back as the 12th century, collected in the mid-19th century codex Diplomatarium
Islandicum (1857). Text produced by Icelanders themselves are augmented by two corpora primarily written by outsiders. The first is are Norwegian and Danish records written about the island – a colony of Norway and later Denmark from 1264. In addition, dozens of travelogues detail journeys across Iceland by visitors primarily from neighbouring Scandinavia and the British Isles, many of whom giving valuable perspectives on everyday life on the island (Horrebow, 1758; Morris, 1911; Ólafsson & Pálsson, 1974). In addition, an island environment affords clear boundaries to limit a case study; nevertheless, the size of the island and its community, as well as its connections to neighbouring islands throughout its history provide enough material for analyses at the regional and supra-regional scale.

My goal with articles 3 and 4 is primarily to investigate the roles of inter-farmstead networks in post-reformation Iceland. Article 3 is a collaborative effort where my role is analysing the historic power centre Skálholt from a country-wide perspective, where I use the network perspective to discuss the way it operated at such a large scale. Article 4 is a case study centring on resource claims in JÁM. I chose resource claims as they show that land use often operated significantly differently from expectations based on thinking of farmsteads as atomic, semi self-sufficient entities.

In sum, two of the four articles are concerned with methodological development within archaeological network research. The other two are based on case studies where I think through some of the enactments of historically documented networks, as well as suggesting fresh insights into how land was used by foregrounding
the role of resource claims and large networks of obligations and centralised land management.
7. Creation of individual articles

7.1 Paper 1: Setting the scene.

I wanted the first paper to give an overview of the data, the project and my thinking. There are many unexplored themes and loose ends, but it is to be expected given the scope of the work and the fact that it is only 10,000 words. The article surveys the land census and goes through how I’ve constructed a schema based on the census structure. I could barely discuss actual findings, but the reviewers understood what I was attempting to do and accepted it. The first article, published in *Norwegian Archaeological Review*, touches on the elements I explore in later articles. For instance, the networks presented there are not explored in any detail. These include property, resource claim and obligation networks. All three have thousands of links and need multiple articles to fully explore. It is also very important to stress their interdependence. This leads to some issues when writing an article-based thesis, which is why this article is so important to provide the basis, and the discussion about interdependence. It enables me to focus on specifics in subsequent articles.
Figure 13: a map showing farmstead valuation.

Another issue is the use of network analysis in archaeology. I allude to several ways in which SNA and other formal network analytical approaches would fail to anticipate the complexity in JÁM, but again, I don’t go into any detail about this, but pick up the thread in article 2.

Status: Published in The Norwegian Archaeological Review.
Length: c. 10,000 words
Contribution: 100%.
7.2 Paper 2: Networks, assemblages and CIDOC-CRM.

As much as I like the network as an approach to interaction, I have run into issues trying to use formal network analysis. My data are quite different from the ones used in SNA approaches in archaeology. It is detailed, but it does not scale up into large networks spanning the whole island. The only way to do that is to combine several networks, and while I think this has a lot of potential, it produces a multi-modal network assemblage that will be very hard to analyse with the kind of formal network analytical techniques provided by SNA or other toolkits. Furthermore, the most interesting thing about my networks is how they lead to emergent properties that begin to influence the way edges link together. I’m more interested in exploring quantitative methods to anticipate these emergent properties (using agent-based modelling maybe, or some homebrewed methods!), using assemblage theory as a theoretical beacon.

That leads to the second paper. Assemblage theory and network analysis are both popular in current archaeological thinking, but they have tended to be discussed and applied separately. This paper begins with a comparison of the two, moving on to discussing the use of the computational ontology CIDOC-CRM and computational functions to refine and articulate networks, which is something I’ve been calling my network lineology.

It is still under review. I hope it will be well received, as I believe there are significant advances to be made in developing new methods for network modelling. So far, refined ontologies have barely been brought to bear on the way we model archaeological networks, and I hope this article will inspire others to experiment
with CIDOC, or other standard ontologies, when constructing their networks.

**Status:** submitted to *The Journal of Archaeological Method and Theory.*

**Length:** c. 6000 words

### 7.3 Paper 3: Episcopal economics: Skálholt as a system of provisions

It was very important to tie my work into current archaeological research. Ideally, I wanted to be able to ground truth some of my observations from the land census with excavation data. To that end I contacted Gavin Lucas to work on a paper looking at Skálholt, the see of Iceland’s southern bishopric, and a well-known site archaeologically. We later expanded the group to include historian Árni Daniel Júlíusson and archaeologist Birna Lárusdóttir. The paper considers Skálholt as a system of provision for everyone associated with the bishopric and its hundreds of tenant farmers. It was accepted by the *Scandinavian Journal of History* for publication. Gavin, Birna and I wrote sections examining Skálholt at three different scales – as a single farm, as a centre controlling its immediate surroundings, and as a node in a network stretching across three quarters of the country. I took the third scale – the national overview – and worked my data into the framework for the paper, which was the System of Provisions approach (Fine, *et al.*, 2018). I still base my analysis primarily on modelling the data as networks, however.

**Status:** Published in *The Scandinavian Journal of History*

**Length:** c. 11.000 words
Contribution: 25% of the text, and all the images. The paper is divided into four sections, with final, concluding remarks


I wanted the fourth article to explore one of the networks presented in the first paper in greater detail. I chose to focus on the resource networks (is. itak) because of their implications for understanding how farmsteads interacted with respect to using the land, and the fact that these have hardly been studied at all. Again, even looking at these without any time depth proved to be probably too much material for a single article. The current submission categorises the claims into a few categories organized by different scales, while showing that these are inextricably related – the word I use in the article is enchained, as a reference to chaines operatoires.

Status: Published in Human Ecology
Length: c. 6.000 words
Contribution: 100%
8. Conclusions

As this thesis is focused on building a lasting infrastructure that benefits not just my own research, but the wider community, an appropriate question at this stage is what is possible, now that this infrastructure is in place? How has this thesis changed the potential for archaeological and historical research in Iceland? Let me begin by stating how much work went into reading over and encoding the data. After the automated text recognition procedure, I read over the entire text to fix character recognition errors and have the character recognition errors down to less than 0.1% of the text currently. I then encoded over 8000 relations between farmsteads, and georeferenced every one of them. I also georeferenced every tenant farm in northern Iceland, done by poring over maps and archaeological survey reports. Due to that work, it is now possible to search the whole JÁM text, something that has not been possible since its publication, over 100 years ago. It is also possible to analyse this text spatially, by showing search results as a point distribution of where certain terms and phrases occur (see Figure 14). As the text and associated analyses are hosted in a spatial PostGIS database, it is also possible to bring to bear any spatial analytical toolkit in a geographical information system, like ArcGIS or QGIS. PostGIS has built-in connectivity to statistical packages like R and Stata, as well as network analytical toolkits such as Gephi, which increases the capacity for dynamic analysis. The API built to serve the data to the web further increases data availability. This opens the door for future research combining qualitative, close readings of the text and related archaeo-historical material with a quantitative analysis of the PhD database contents.
Figure 14: a screenshot of the search functionality on jardabok.com, showing the distribution of the term 'kolgjörð' or 'charcoal making' in the text, parsed by farmstead.

I have also made the JÁM infrastructure part of larger projects. While this arguably served as a distraction during the dissertation, it means that now that it is nearing completion, the data are not only available to large groups of researchers, but also annotated with metadata and encoded using the computational ontology CIDOC-CRM. That makes the data readable and linked to other datasets. The two examples most relevant here are the NSF-funded project DataArc,\(^{10}\) where the database is connected to other data sources about the North Atlantic, and the Institute of Archeaology, Iceland’s\(^{11}\) survey and archaeological data.

It is too early to say how much the infrastructure will be used in the future, but it has supplied me with a number of research questions that I am currently developing into papers post-PhD. I hope the

\(^{10}\) [www.data-arc.org](http://www.data-arc.org)

\(^{11}\) [www.fornleif.is](http://www.fornleif.is)
continued visits to the website, almost 3 per day on average over the past 90 days, is a sign that it is becoming a well known and key resource for anyone researching Iceland’s past.
References


Individual articles.