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The function of open fields

Agriculture in early modern Sweden

Kristofer Jupiter

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Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development
Uppsala

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Cover: Digitised and rectified map of Kleva village 1749.
(Kristofer Jupiter)

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Abstract

This thesis examines the spatial arrangement of holdings and villages in early modern open fields, the dominating system in large parts of Europe for nearly a millennium. Open fields is characterised by the spatial division of holdings, scattered and intermingled in one or more fields. The thesis examines the practical aspects of open field farming and the function of scattered holdings, and the aim is to study how scattered holdings were integrated into farming practice and the larger institutional and communal arrangement of open fields the mixed farming system. Open fields in southwest Sweden are analysed empirically on farm, village and inter-village level using historical maps. Methodologically, maps are combined with written sources for spatial and temporal analysis and estimates of time consumption in cultivation and transportation. Furthermore, it analyses the distribution of plots in two different field systems and discusses the efficiency of small-scale production and area-productivity in open fields, and cooperation between villages and reconstructions and analysis of fence-organisations.

This thesis shows that scattered and intermingled holdings facilitated an efficient management of time, work and space. The open fields allowed for spatial and temporal sequence of work and diversification crops. What ultimately defines an open field is both the openness of a physical landscape, fence or unfenced and, more so, the requirement of the cooperation between its participants and synchronisation of key activities of farming.

Keywords: Open field, Historical geography, Time-geography, Agriculture, Spatial analysis, GIS, Agrarian History

Author's address: Kristofer Jupiter, SLU, Department of Urban and Rural Development, Division of Agrarian History, P.O. Box 7012, 750 07 Uppsala, Sweden.

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Abstract

Denna avhandling undersöker den rumsliga organisationen av gårdar och byar i det tidigmoderna open fields systemet som dominerande stora delar av Europa i nästan ett millenium. Open fields kännetecknas av tegskiftad jord, med ägoblandning i ett eller flera gärden. Avhandlingen undersöker tegskiftet utifrån ett praktiskt och funktionellt perspektiv. Det övergripande syfte är att undersöka på vilket sätt tegskiftet var integrerat i det praktiska arbetet och i den institutionella och den gemensamma organisationen? Tegskiftet analyseras på olika skalnivåer, från den enskilda gården till bynivån och slutligen mellan byarna i form av hägnadslag. Empiriskt analyseras det Västsvenska tegskiftet utifrån historiska kartor som kombineras med andra källor för rumsliga och tidsliga analyser av transporter och åkerbruket. Undersökningen analyserar tegskiftet i två olika trädessystem och behandlar frågan om effektivitet och area-produktivitet i småskaligt åkerbruk. Vidare undersöks hägnadernas roll i det tidigmoderna jordbruket och genom rekonstruktioner av hägnadslag analyseras samverkan mellan byar rumsligt och funktionellt.

Avhandlingen visar hur den rumsliga organisationen integrerades i det praktiska arbetet och möjliggjorde för en rumslig och tidslig sekvens av arbetet samt för ett diversifierat utsäde. Tegskiftets rumsliga organisation medgav för en effektiv hantering av tid, rum och arbete. Vad som slutligen definierar *open fields* är både öppenheten i ett fysiskt landskapsutsnitt, hägnat eller ohägnat, men huvudsakligen, kravet på samarbete mellan dess deltagare och synkronisering av jordbrukets olika sysslor.

Keywords: Open fields, tegskifte, historisk geografi, tidsgeografi, jordbruk, rumsliga analyser, GIS, Agrarhistoria

Author's address: Kristofer Jupiter, SLU, Department of Urban and Rural Development, Division of Agrarian History, P.O. Box 7012, 750 07 Uppsala, Sweden.

Preface

In 2008, after I had defended my master's degree essay, I was asked whether I had ever considered doctoral studies. Until then, the idea of a Ph.D. had not really crossed my mind. Later that year Anders Wästfelt, my current supervisor asked me if I was interested in a job for three months. Even though the sales pitch was less than convincing, that three months of this type of monotonous work would be a stretch. The job was to register historical maps in GIS in the project *Nationalutgåvan av de Äldre Geometriska Kartorna* (2004–2010) at the National Archives. I was offered the job and before I knew it, the three months turned into nearly 10 years after continued work in subsequent projects, *Yngre Geometriska Kartor* (2011–2014) and *TORA* (2015–2019). Obviously I was familiar with historical maps from my undergraduate education in human geography, but working this close to the sources was something else.

During the years that I worked on these projects, I studied thousands of maps in detail to set coordinates for settlements by identifying locations of villages, farmsteads, mills, bridges and churches, among others. Working with these sources for a long time and examining each map closely was, on the one hand, painstaking and repetitive work – enough to make you go insane. At the same time intriguing and a unique opportunity to gain both general and detailed knowledge of historical maps and Sweden's early modern agricultural landscape. To the best of my knowledge, I do not believe that I have gone insane.

The work in map projects really inspired me and the idea of a Ph.D. seemed less farfetched. The monotonous work suited me quite well after all, and led me to studying the open fields. The large scale maps of unsystematic open fields of Västergötland and Falbygden caught my interest. The meticulous surveys showing the division of individual holding in open fields in great detail offered an opportunity to add another piece to the puzzle of the open fields.

The initial idea to compare various types of open fields and spatial organisations of holdings throughout Sweden was abandoned relatively quickly, and the question of why holdings were scattered and intermingled steered the examination towards the spatial organisation and practical and functional aspects of open field farming. Regardless of my experiences and acquired knowledge, without funding, this thesis would not have been possible.

I am very grateful to Handelsbankens Research Foundation and Jan Wallander and Tom Hedelius Stiftelser for financing this doctoral project. Furthermore, I would also like to thank The Royal Swedish Academy of Letters, History and Antiquities and Riksbankens Jubileumsfond for financing the Rumsliga kartanalyser project, that was as part of the TORA-project at the National Archives. I am also grateful to Brandförsäkringsverkets stiftelse för bebyggelsehistorisk forsking, from which I received a stipend.

There are a number of people that I want to thank and that in various degree and ways have been important during these last five years. First I want thank my head supervisor Anders Wästfelt for your commitment, positivity and curiosity. You were my supervisor when wrote my candidate essay and in a way you never quit that job. The fact is that you are the one that really got me interested in research and made me believe that it was possible. So thank you for inspiring me to start and continue asking questions. To my assistant supervisors Jesper Larsson and Johanna Widenberg, thank you both for your valuable insights, good advice and for pushing me on and not least reading and commenting on my texts. I want to thank Olof Karsvall for all the discussions and always, sharp remarks and analyses. Clas Tollin, thank you for hiring me. Working in the map projects was very educational and thank you for always take time to listen to my questions. Catarina Karlsson, thank you for your valuable input on ploughing and time estimations, without it I would have been lost. Thanks to all my past and present colleagues at the division of Agrarian history for the discussions over coffee, in seminars and lunch.

It is ironic, that I, being a master at procrastination, have written a thesis about efficient time management. It has been a challenge to say the least. Without you Sara, Sixten, Beata and Sven, this would not have been possible. Thank you for your endurance and for believing in me and putting up with me throughout this project and for all those times I have been physically present but somewhere else in my thoughts. I can´t thank you enough, Love you.

Stockholm, August 5, 2020
Kristofer Jupiter

Dedication

Till Sara, Sixten, Beata och Sven

Du vet redan tillräckligt. Det gör jag också. Det är inte kunskap vi saknar. Vad som saknas är modet att förstå vad vi vet och dra slutsatser
Sven Lindqvist

Contents

List of publications

This thesis is based on the work in the following papers, referred to by Roman numerals in the text:

I Jupiter* Kristofer (2020). The function of open field farming – Managing time work and space. *Landscape History*, vol 41:1, pp. 69–98.

II Jupiter* Kristofer, Wästfelt Anders (2020). Function and spatiality – efficiency and adaptation in open field farming. (Manuscript).

III Karsvall* Olof, Jupiter Kristofer, Wästfelt Anders (2020). Fenced open fields in mixed-farming systems: Spatial organisation and cooperation in southern Sweden during the seventeenth century. *Journal of Historical Geography* (Resubmitted manuscript).

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* Corresponding author.

The contribution to the papers included in this thesis are as follows.

I I am the sole author of this paper.

II The analysis and writing has been a cooperation between both authors. I conducted all of the data collection and empirical processing. The manuscript will be sent to the *Agricultural History Review journal*.

III I am a co-author of this paper. The analysis has been an equal cooperation between the three authors. I conducted all of the data collection and empirical processing.

List of figures

1 Introduction

This thesis studies the spatial organisation of scattered and intermingled holdings that characterised European villages and hamlets for the last millennium up to the present day – in what is generally referred to as *open fields*. Agriculture in open field villages is characterised by a mixed farming system, the combination of grain production and animal husbandry were the animals produced manure needed for fertilising the arable but also for food and as draught animals. The consequence is the need for a spatial division of land use in arable land, meadows and pastures.

Sources form the basis of historical research, and maps are fundamental for analysing spatial phenomenon and land division, such as open fields. When studying a large number of maps and reading voluminous research on the subject, open fields are just as much about consistency as they are about variety. Field-systems, spatial patterns of scattering, topographical and geological conditions show local variations and differences, but the basic 'solution' and spatial organisation of farming is characterised by consistency. There is a common theme of manually driven farming and it is generally carried out in small units, in small, arable plots. This is true in the Swedish and European context but also in a global perspective. The conundrum of open fields is: why does small-scale farming necessarily have to be organised with intermingled holdings? This thesis stresses the importance of the functional aspects of small-scale farming to understand the logic of the open fields.

From the time of the enclosure movement in England, the reorganisation in the storskifte and the subsequent consolidation in the enskifte and laga skifte in Sweden, the question of why peasants scattered their holdings in open fields has been of interest of contemporary agriculturalists and later researchers in different disciplines. Various explanations for this seemingly irrational arrangement have been put forward. Whether peasants did not know better, 'the dumb peasant model' (Dahlman 1980 p. 38) or because of

institutional arrangements in, inheritance praxis, shareholding, property rights or the lack of markets for insurance, the general assumption has been that open fields and scattering were inefficient for the sole purpose of arable production. Research has been done in different countries and regions, and various types of open field systems have been analysed. Yet, the debate is still ongoing.

The term open fields refers to, on the one hand, the physical layout of holdings and fields with intermingled or scattered plots. On the other hand, the term refers to the open field system, which is the common denominator in a wide variety of regional and local types of open field systems characterised by various spatial arrangements that are organised in different field systems with no or various degrees of common regulation of resources, pastures on the stubble and fallow – and for communal pastures on outlying land.

In a Swedish context research on historical agriculture, the development of settlements and agrarian landscapes, studies of various regional field patterns and field-systems from late Iron Age, through the early and high Middle Ages, and up to the early modern period by geographers, economists, historians, and archaeologist have a long tradition. This study focuses on the specific phenomenon of scattering (sw. *tegskifte*). Obviously, the local, regional examples and variations and their respective history and characteristics are important; however, they all scattered their holdings, with the exception of the minority of systems based on consolidated holdings (*särägosystem*) (Karsvall 2016 p. 81). This is what makes the puzzle of the open fields so interesting, still relevant and an ongoing debate, even though some suggest that the cause of scattering has been solved. However, this thesis argues that to understand why open fields were established and persisted for so long, we must understand its function and farming practice for the individual farm. The analysis of scattering starts with individual farms and individual plots.

Different interpretations of the cause of scattering and the origin of open field villages have been put forward in research. Scattering has been interpreted as an intentional spatial solution to reduce risk (McCloskey 1972, 1975), diversification and temporal management (Fenoaltea 1976, 1988); the result of shareholding; and something that would ensure an equitable distribution of holdings (Vinogradoff 1892; Maitland 1897). Furthermore, scattering has been viewed as an 'unwanted' or at least not intended effect of subdivision resulting from land colonisation, co-aration (joint ploughing) and/or partible inheritance (Seebohm 1883; Maitland 1897; Thirsk 1964). Scattering has also been explained as an arrangement to create stable institutions and organisation and its efficiency is not its capabilities to

generate output but to ensure stable institutions in the management of large-scale extensive grazing (Dahlman 1980). Robert Dodgshon makes a well-founded point regarding the character of the debate surrounding open fields and states 'that the debate over them [open fields] has not been a progressive one, with each contribution adding to, or refining, a single line of argument. Instead, one has had a plethora of independent viewpoints put forward, each one tending to add uniquely to the debate' (Dodgshon 1980 p. 1).

There is something incomprehensible about scattered holdings in open fields, and the presumption that scattered holdings per definition are inefficient for arable production was promoted by 18th-century contemporary writers who were highly sceptical to the old ways and dismissed this concept as primitive and inefficient (Heckscher 1957 p. 32; Fenoaltea 1988 p. 174). This view of open fields as inefficient affected subsequent research, and the key to the puzzle of open fields is to understand why farmers choose to organise farming in such a tedious and inefficient manner.

The approach of this thesis is to focus on the common feature/element of open fields – scattered and intermingled holdings. Writers on enclosures stressed privatisation and property rights, oppose the communal property regime in open fields, as an important factor of the rise in productivity. However, open fields – at least in the Swedish context – involve communal arrangements, communal grazing of outlying lands and communal grazing over the fallow and stubble. The outlying land (utmark) was not physically divided into shares but was a common pooled resource (CPR) (Larsson 2014 pp. 40–1), whereas the infields were strictly divided into individually owned and worked plots. Open fields represented a strictly individual system relying on the individuals rights but also their responsibility towards the collective, and was thus subjected to communal regulation.

Even with a large volume of publications and interpretations on open fields, the debate is ongoing, and pieces to the puzzle still need to be added.

2 Aim and research questions

Open fields are spatial arrangements that are part of the practical utilisation of resources for the main purpose of producing output. Arable production stands at the heart of open fields and generally also includes animal husbandry in mixed farming systems, which is the case for large parts of Europe north of the Alps. Arable production is intensive and requires nutrients to produce an output that exceeds the input. In mixed farming systems, animal husbandry is fully integrated into the system to restore nutrients to the soil by spreading manure and draught animals. In addition to the use of manure for fertilisation, the use of fallowing parts of arable also allows the soil to rest. Thereby, the mixed farming system requires both hay production and pastures to balance arable production. Varying land use has both spatial and temporal implications with different chores in different areas at different times. In addition to time, the delimiting factor in manual farming is the scale of production, and the acreage of individual farms stipulates the intensity at which it could be worked. Time, scale and labour are important variables for understanding open field farming and, thereby, its practical aspects. Farming practice and how scattered holdings are integrated in farming practice are essential to understand the logic and/or the rationale behind open fields. The open fields or the division of arable land into small plots are not restricted to villages. The practice in manual farming and the organisation of arable land in several small plots also occur in single farms[1], pointing towards the functional aspects and scale of farming practice.

[1] Numerous examples exist of single farms were the arable is divided into several smaller plots in the large-scale maps available in the *GEORG* database and the topographical register at the National archives and *TORA* The farms of *Esbjörnstorp* (P3:213) in Paper 3 represent an example of two farms – one with continuous cropping and one practising a three-field system with the arable land divided into spatially partitioned plots.

A distinction has to be emphasised. Open fields are both the physical, functional organisation of space and an institutional arrangement of property in mixed farming systems. As an overarching term, open fields hold both aspects, and both have to be considered to understand open fields. The term open fields refers to the physical arrangement, the spatial phenomenon or feature of scattering (intermingled holdings) with unfenced plots, whereas the term common fields refers to the overarching organisation and regulation of the communal organisation of work in the arable and meadows in one or more open fields, as well as access to outlying pastures and woodlands (Bailey 2010 p.156; Fenoaltea 1988 p. 171). These terms have sometimes been used synonymously in research. The inconsistent/varying use of key terminology complicates things, which has much to do with language and the translation of the terminology of national and regional *types* of open fields.

2.1 Aim

The aim of this thesis is to study the practical aspects and the function of scattered holdings in the arable land and how this contributes to understanding the logic of the open fields.

Furthermore the aim is to analyse how the practice and spatiality of open fields were closely integrated in the larger institutional and communal arrangement that characterises open fields in the mixed farming system.

2.2 Research questions

To achieve the aim of this thesis, three specific research questions are asked. The three papers (chapter 7) correspond to the research questions. Open fields have been studied for a long time in research but the focus has not been on the detailed, practical aspects of farming. To understand the logic/rationale of the spatial arrangement of open fields, a spatial analysis will contribute valuable insights. Furthermore, to analyse how farming practice was integrated in the spatial layout of holdings, we need to understand how farming was actually carried out. By estimating the time spent on cultivating the arable and the transportation costs of individual farms, the functional logic behind the complex spatial arrangement in open field villages will be analysed, as will how fragmented holdings were integrated in farming practice of open fields. How arable work was carried

out, what chores were involved, what crops were used, and how numerous plots were utilised in cropping and the time required for transport are central questions of an analysis of the time and geographical management of work and space in open fields.

The first question is as follows.

1. What was the purpose of fragmented holdings in open fields, and how was the spatial organisation integrated in farming practices?

Farming in open fields was small-scaled and to resolve the spatial characteristics of individual holdings require a detailed analysis and reliable spatial sources. However, the management of individual arable plots in open fields is simultaneously integrated in a broader spatial and practical context in different fields, in larger fence-organisations in cooperation with other villages and in the management of extensive communal grazing. To analyse scattering in the broader context in which villages functioned, open field systems must be studied at different scales and in different field systems.

The second question is as follows.

2. Was the spatial division of holdings equitable and does the empirical evidence support the concept that scattering in unsystematic systems reduced risks?

In research on unsystematic open fields, the equitability of the distribution of individual holdings has not been examined, and the validity of explanations such as risk aversion is debatable. Paper 2 compares the inner diversification of holdings in unsystematic one- and three-field systems. The aim of Paper 2 is to compare these different systems on the basis of the yield capacity of individual plots and their size and spatial distribution. Furthermore, spatial and practical adaptation and efficiency in different field systems are analysed, and the function of open field farming in general is discussed.

The third question is as follows.

3. What role did fences play in the open-fields and what constitutes the common denominator of open-fields?

Scattered holdings in open fields were a physical feature of the institutional arrangement that encapsulated common fencing, pastures over the stubble and fallow and access and management of outlying resources (e.g., pastures, wood, fuel and fishing). However, the institutional and communal arrangements of the open field system extended beyond the village or hamlet, and

villages were or could be spatially interlinked and in cooperation with neighbouring villages in what is called *fence-organisations* (Paper 3). In this way, a wider scale is needed to understand the institutional context wherein individual farms and villages functioned. By comparing fence-organisations in two regions – one characterised by the one-field system with continuous cropping and one using a three-field system (regular fallow) – qualitative and quantitative analyses of the spatial and organisational implications of mixed farming in different systems are possible, which have implications for the basic definition of open fields.

All studies and results will be discussed in the light of previous theories and findings on the open fields from other European contexts.

2.3 Scope/delimitations

Some clarifications need to be made about the scope of this thesis. The study of open fields in most historical research inevitably requires narrowing down the selection of what is to be examined spatially, temporally and empirically. The analysis performed and conclusions presented in this thesis rely empirically on historical maps from the 17th, 18th and 19th centuries of villages in the southwest parts of Sweden. In addition to written sources, cadastres (*jordeböcker*), tax registers (*mantalslängder*) agricultural reference books and parish descriptions are used in combination with the maps that are primary sources. Temporally, open fields are studied in a broad scope and are not restricted to the 17th and 18th centuries. The analysis of open fields is restricted to arable land and fence organisations. Furthermore, the empirical focus is on what is referred to as the unsystematic scattering that characterises open fields in southwest Sweden. Thus, the aim of this thesis is not to categorise and analyse various regional forms and patterns throughout Sweden. Studies on agrarian history tend to be restricted to nations or regions. There are obvious reasons for that kind of restriction, besides the fact that Swedish researchers in most cases grew up somewhere in Sweden and are familiar with the historical, regional and local traditions. Language is important, not the least. However, given the prevalence of open fields in large part of Europe and the similarities regarding key features, regional and national examples are relevant and can bring insight on open fields in a broader international discussion.

This is not a longitudinal study of open field systems in the studied villages; instead, this study focuses on the division of arable land and how the spatial configuration of farms and villages relates to farming practice, time-geographical aspects of manually driven farming and the efficiency/

inefficiency of open fields. Furthermore, the analysis is based on empirical evidence. The results are discussed in a broader context, previous research and explanations to the open fields. In this sense, the analysis is contemporary (to the sources), and this study is delimited to the function of scattered holdings in early modern agriculture.

2.4 Layout of this thesis

The layout of this thesis is as follows. After the introduction and aims, an overview of previous research on the subject is presented. The overview consists of a summary of selected relevant research found for this study. Research on the open fields is voluminous, and the intention is not to provide a complete summary of the entire field of research. The overview is followed by chapter 4, in which the theoretical context and approach of this thesis are presented and discussed. Chapter 5 presents the study area of Skaraborg County. Chapter 6 is divided into two sections. The first section presents the sources, and the second section presents the methodology used in the different papers. Chapter 7 provides a summary of the three papers that form the empirical foundation of this thesis. In the final chapter, the research questions are answered and discussed. The chapter ends with a synthesis, and the conclusions are discussed in a broader scientific context.

3 Open fields – an overview

Open fields have caught the interest of researchers in various disciplines, and a large number of publications specifically or indirectly involve open fields. Research on open fields has, as Hans Renes (2010 p. 65) notes, been based on a local and regional perspective that has led to 'monocausal explanations and simplistic conclusions, and studies on the varying contexts and geographies in which open fields occur and a broader European perspective are needed'. Grigg (1974) argues along these lines as well:

> Many Europeans find it difficult to regard their farming systems as part of one major system; indeed European geographers have traditionally emphasised not only differences between countries, but between pays within one country. But on a world scale the farming of northern Europe has considerable homogeneity. (Grigg 1974 p. 152)

In Europe, north of the Alps, from the British Isles in the west and Russia in the east, agriculture was dominated by two systems, mixed farming and dairying, from the seventh century. Grigg's comment draws attention to an important distinction that must be made. The term open field refers to both the historic farming system that dominated in Europe and the institutional arrangement of fragmented holdings and communal regulation. The focus on local and regional examples has led to the identification and classification of different *types* of open fields with the common feature of scattered holdings. The argument here is not that detailed local studies are the wrong way to go, on the contrary, detailed studies on how these systems were spatially organised and functioned are fundamental, but at the same time, it is problematic to provide general explanations based on one type of open field, which in many cases is the *regular common fields* of England. Many of the most widely spread explanations to scattering is based on the English example, even though a majority of villages throughout Europe would not

comply with the definition of the regular common fields. This is not to say that the voluminous research on English open fields is misdirected or irrelevant, far from it, but much is to be gained by comparing these results and conclusions with other contexts and sources.

The question of why peasants scattered their holdings is a puzzle. Different explanations have been put forward. There is an obvious problem with the question because there is no way of knowing how peasants actually perceived the problem. We simply cannot know and are left to present plausible theories as to *why* and *how* holdings were scattered and intermixed in open fields.

The aim of this chapter is to present and discuss some of the central models of explanations for scattering. However, the goal is not to present a complete bibliographic overview of the origin of open fields, merely an introduction to some of the central ideas and works; instead, the focus is on explanations that primarily consider the *function* of open fields. In addition to theories on function, this chapter also includes a summary of the research on the Swedish example. Furthermore, the aim here is to discuss key terminology and definitions to be clear about how the terms in this thesis are used and defined.

Research on open fields in Europe is voluminous, and several comprehensive bibliographical overviews exist on the subject, such as Helmfrid ([1963] 2000); Dodgshon (1980); Sporrong (1985); Fenoaltea (1988); and Renes (2010). Mats Widgren summarised the European debate on the origin of open fields into three overarching lines or interpretations: *the ethnological, the materialistic/evolutionary* and *the social* (Widgren 1997 p. 12). These interpretations overlap and are not of primary interest themselves; however, together they form a simplified framework wherefrom different theories and hypothesises stem. In the context of this overview, the 'last' phase should perhaps include both the *social* and *rationale* aspects of human behaviour.

3.1 Early work

3.1.1 Ethnicity, Equity and Plough-teams

The German geographer August Meitzen published his work on settlement and agriculture (*Siedlung und Agrarwesen der Westgermanen und Ostgermanen, der Kelten, Romer, Finnen und Slawen*) in 1891, and its main thesis was that the structure of European settlements was based on ethnicity in different parts of Europe and represented the idea that village formation

had been more or less static since the transition from nomadic tribes to sedentary agriculture. Meitzen's deterministic approach of large-scale maps from the 18th and 19th centuries was used to analyse the agrarian landscape(s) and inspired subsequent research on the subject. According to Helmfrid, a fundamental mistake of Meitzen was that he interpreted settlement structures in the 18th and 19th centuries as being pristine and unchanged over time (Helmfrid [1963] 2000 p. 15). Meitzen's ethno deterministic approach inspired other German and French geographers and historians. Despite later criticism raised of his interpretations, the basic argument was considered valid by subsequent researchers. In Germany, regional studies and fieldwork chronologically form the basis of the different types of settlements. Meitzen's sharply delineated regions of types of settlements started to be dissolved and became more fluent and diverse. Helmfrid ([1963] 2000 pp. 15–6) emphasises, for example, Robert Grandmann (1926) and Otto Schlüter (1952), in the continuing work on the evolution of settlements in which the occurrence of different types of settlements is, to a large extent, random.

One of the first to write about the open fields in England and the specific feature of scattering was Seebohm (1883) in his book, *The English Village Community*. Seebohm suggested that scattering in open fields was the result of co-aration (joint ploughing), in which each villager contributed an ox to a plough team and each holdings' plot/strip was cleared one at a time. One plot and one holding at a time created an intermixed sequence of plots, and each plot was the equivalent of a day's work (1883 pp. 117–125). Furthermore, Seebohm argues that the procedure was systematic and that a repeated sequence in the manner in which plots were allocated. A neighbour's plots would appear in the same location in relation to another neighbour's plots, throughout the field(s) (1883 pp. 110–13). Seebohm based his theory on 10th-century Welsh law and argued that the system had its origin in the Roman period. The argument of co-aration was criticised by contemporary writers. Vinogradoff (1892) argues that scattering was the result of shareholding. Equal shares of both good and poor quality, and each holdings' share was proportional to its rights and duties towards the community, communal ownership and equalised individual rights (1892 pp. 235–38). Vinogradoff argues that intermixture in open fields withstood the private ownership that was necessary to break/tear down the system. Private ownership/property made enclosures possible. Maitland (1897) agreed with Vinogradoff regarding shareholdings but emphasised that the fundamental cause of scattering was that of egalitarianism and asked 'who laid out those fields?' The obvious answer is that they were laid out by men who would sacrifice economy and efficiency at the shrine of equality (Maitland 1897:337).

An evolutionary interpretation

In England, Meitzen's work also inspired the American Howard Gray (see also Renes 2010 p. 44) and his work on English field systems (Gray 1915). Gray argued that the origin of the two- and three-field systems was that of Anglo-Saxon immigration and that 'the fact that the midland system was that of the Germans in their home land and was thus more than any other essentially Teutonic' (Gray 1915 p. 415), in line with Meitzen's concept of the ethnic origin of various settlements and field patterns. However, Gray identified and reconstructed regional field systems and rejected the idea of the two- and three-field system, which was prevalent throughout England and considered the archetypical field system, was restricted to the Midlands (Gray 1915 p. 403). Furthermore, he also saw partible inheritance as a driver to create complex patterns, such as the two- and three-field system (Dodgshon 1980 p. 14).

In the 1930s and 1940s, new theories and methodologies empirically questioned Meitzen and subsequent researchers. W. Müller-Wille (1944) and G. Niemeier (1944) presented theories that interpreted settlement structures and field patterns as a result of evolutionary development by identifying a chronological pattern of fields and strips using a retrospective analysis of large-scale maps to identify older elements. Sparsely distributed farms in connection to an arable called the *Esch* and consisting of intermixed long narrow strips, that was an old element dating back to the 9th century. This type of division in arable land was called *Langstreifenflur.* A subsequent development was block-shaped arable parcels and pastures for extensive used surrounding the centrally placed arable. (Helmfrid [1963] 2000 pp. 16–7).

In France, Marc Bloch ([1931] 1966) synthesised the agrarian landscape of France and divided it into three provinces or regional types based on the spatial characteristics of farms and villages: the Mediterranean region with unfenced block-shaped plots in irregular open fields; the Atlantic Bocage-region with dispersed settlements and blocks-shaped parcels separated with hedges; and the Middle-European characterised by the 'classic' open field with large villages with intermingled holdings and crop rotations in a three-field system with communal grazing on outlying lands and fallow fields (Ibid. pp. 21–56). Bloch emphasised the continuous change in spatial organisation and rural life in general and the need to avoid the 'common error' of drawing a direct correlation between 18th-century sources and the Neolithic Age. Furthermore, he stressed the role of technological change, the heavy wheel plough with patterns in regular open fields and the ard in irregular systems but also the social context and the role of the village community and organisation in the establishment and maintaining these systems (Ibid. pp. 150–80).

Charles and Cristabel Orwin (1938) argued that the development of the three-field regular common field system of the Midlands was the final stage in a linear institutional development (Bailey 2010 p. 156). In line with Seebohm, the Orwins saw that piecemeal land reclamation contributed to scattering but considered joint ploughing (co-aration) as the main driver (Dodgshon 1981 p. 137). Thirsk (1964 p. 3) argued that the 'fully-fledged' common-field system was reached through the four essential elements: intermingled holdings in arable and meadows; common pastures over the stubble and fallow; common pastures on outlying land; and, finally, the communal regulation of activities by the village assembly. A deterministic idea in the evolutionary interpretation is that there is a natural progression and development from the primitive towards the advanced. Thirsk's article, *The Common Fields* (1964), introduced new ideas of dynamic changes and the development of agrarian landscapes and settlements in England. Thirsk's article broke with the previous interpretations of the common fields as a creation of Saxons and suggested that the elements that determine fully-fledged common fields – scattering, common regulation of grazing and crop rotation – were not established from the start but were the result of evolutionary development over time. According to Thirsk, the origin of open fields was the result of piecemeal reclamation and partible inheritance under population pressure (1964 pp. 12, 24–5), and Thirsk dated the common fields to the 12th to mid-13th centuries. This dating has since been questioned, and the common field system emerged by the 10th century (Lewis, Mitchell-Fox, Dyer 1997 pp. 13–17), which undermined the role of population pressure because population pressure was moderate at that time (Bailey 2010 p. 163). In this view, scattering of holdings is a consequence rather than a function – something that was actually intended.

In contrast to Thirsk, Bruce Campbell links the transition from open fields to common fields to a decline in population rather than a population increase and argues that little evidence exists that supports that population growth was the driver for common rights and regulations (Campbell 1981 p. 123). He does not refute that population growth could increase scattering through subdivision but argues that intensification by establishing regular common fields with more efficient use of resources and labour enables common grazing and minimises supervision (Campbell 1981 p. 124). Furthermore, Campbell questions the concept of common fields being a structural innovation: 'organised peasant communities beg the essential question whether such communities existed prior to the creation of the common-field system' (1981 p. 119). He argues that these communities might as well have been the effect of the transition.

The Swedish geographer Gunnar Lindgren (1939) interpreted the three-field system of *Falbygden* in the county of Västergötland with highly fragmented holdings as the result of the transition from the one-field system (continuous cropping/irregular open fields) directly to the three-field system. To ensure that each holding participated in each of the three fields, the larger blocks were split into three, of which two were exchanged with other plots. Lindgren argues that this transition also involved a reallocation of settlement and the creation of nucleated villages (1939 p. 149). However, Lindgren does not provide an explanation to the cause of scattering in the one-field villages that preceded the three-field system.

Morphology and the retrogressive approaches

An important step in studies of open fields was the work by Anne-Liese Krenzlin, which introduced retrogressive analysis to reconstruct medieval systems using large-scale cadastral maps (Krenzlin 1959; 1961). The retrogressive method makes use of a younger, more comprehensive source material to complement older and more fragmental sources to reconstruct an older situation (Karsvall 2013). Krenzlin represented an evolutionary view and saw settlement structures as the result of a long and complex development in which the highest level of development was the three-field system. In some areas, the three-field system was never established because the prerequisites did not allow for it. Krenzlin represents a view that the peasant farmers drove development, that the deciding factor in settlement and field patterns was the economy and that fragmentation and the field system were the cause of the communal village organisation and not the other way around, as suggested in previous research (Widgren 1997 pp. 13-4).

In 1950, an interdisciplinary approach involving historians, archaeologists and geographers in using aerial photography combined with written material in the study of field systems started, and O.G.S. Crawford was one of the pioneers in the field (Renes 2010 p. 47). The physical landscape as both the object and a source was also a feature or an approach in Swedish research in which the retrogressive approach and morphogenetic studies influenced researchers. Helmfrid (1962) used large-scale maps, field studies and written and archaeological evidence to analyse the medieval origins of the systematic open fields (*solskifte*) of southeast Sweden. For the province of Öland, Göransson (1971) used medieval sources and historical maps to study the solskifte. Göransson refutes the idea that systematic scattering in the solskifte was introduced top-down by the nobility, whom he argued preferred consolidated rather than dispersed holdings.

In Swedish research, the cause of scattering has not been the main focus, as was its origin. However, the idea of the mouldboard plough was quickly refuted by Göransson because the ard dominates the solskifte region; furthermore, joint ploughing was not practised. He connects its establishment of the land assessment unit expressed in *attungar*, and thereby links its origin to the military organisation. The question as to why holdings were distributed in numerous scattered unfenced plots remains unanswered (Göransson 1958 p. 128).

The geographer David Hannerberg (1955) developed a *metrological* method that examined historical measures and measuring systems used in land and tax assessments that formed the basis of land division in systematic, regular open fields (solskifte). The method is a mathematical approach and implies the systematic origin of patterns – that field patterns can be traced and measured in maps and the physical landscape. It is an evolutionary and retrogressive approach in which the chronological layers of rural landscapes can be deciphered by spatial analysis and measurement (Hannerberg 1976 p. 23). Folke Dovring's retrogressive approach, the *casuistic* (*kasuistisk*) method inspired by Marc Bloch, examines the 'historical levels of settlements' (Ibid pp. 13, 16) by looking back in time using several younger sources related to a specific case/village to examine its specific character and history. However, Dovring (1953 p. 401) noted the risk of finding systems – seeing what is not in the sources when analysing the origin and development of settlements. Detailed examinations of villages are necessary to make broader generalisations of the origin and development of settlements and agriculture in regions.

Sporrong (1985) concludes that the regulated systematic system – the solskifte in the region of Mälardalen – had a relatively late date and was preceded by an open field system with block-shaped parcels (*Blockåkersystem*), which were prevalent up until the late medieval period (Sporrong 1985, p. 196). Sporrong identifies a reorganisation of the cultivated landscape that took place in the 12th century with geometrically regulated tofts and the interconnection of land and toft using 14C –analysis, field evidence, metrological and retrogressive analysis by examining deserted arable fields. The two-field system is dated before 1100 A.D. (Sporrong 1985 p. 196).

Sporrong focuses on development and landscape changes and argues that the foundation in agrarian society was the village and the farm, privately owned and cultivated arable land (in combination with the dominating animal husbandry). The mixed of older forms of collective and communal ownership and organisation and the reinforced privatisation within the open fields is a paradox in which different values from different stages of development

coexist. Despite feudalisation and the associated system of tenants in the early middle ages, practically and technologically little changed, and agrarian society was characterised by its continuity (1985 p. 197).

The geographer Mats Widgren's retrogressive analysis of unsystematic open field systems in Bohuslän in southwest Sweden using 18th-century maps and medieval written sources analysed open field villages from the 14th century onwards. Widgren analyses the subdivision mechanisms, and identifies four factors that affected fragmentation and argues that the specific system or praxis for partible inheritance and ownership was the main driver for subdivision. The *skyldeiesystemet* involves the existence of small shares of individual holdings. These shares were small and were not cultivated in severalty, but the right to the farm was held by one individual farmer. The owner(s) of shares could be the church, the crown or freeholders, who had the right to the rents from tenants. Heirs inherited their shares and the rights to rents (*landskyld*) from those who had the rights to the farm, generally the first-born son. The system led to extensive subdivisions, but regulations sought to uphold the 'initial' holding – the farm (1997 pp. 34–6).

In their study of partible inheritance in the county of Dalarna, Sporrong and Wennersten (1995) show its social and practical application and the spatial implication of holdings in open fields. In contrast to Bohuslän, subdivisions were counteracted, and each plot of a holding was not split between heirs. Instead, plots were divided among heirs. New farms/holdings were established, but marriage strategies, as well as exchange and buying of land, were part of it. The physical layout was basically intact, whereas ownership changed continuously (Sporrong & Wennersten 1995 pp. 71–2).

3.1.2 Institutions, risk and diversification

From the 1970s, new theories on the cause of scattering were put forward. Dodgshon (1980), McCloskey (1975, 1976), Dahlman (1980) and Fenoaltea (1976, 1988) examined open fields from the social aspects of communal organisation and institutional arrangements, the importance of property rights and the economic and behavioural perspectives – the rationale of *homo economicus*.

Community and institutions

Dodgshon (1980; 1981) stresses the importance of cooperation, community and gradual development and change at different stages. The singular interpretation that scattering had one specific cause is refuted, and Dodgshon argues the need to 'specifying what was going on at other stages' and not

focus on a specific stage (Dodgshon 1981 p. 139). The two interpretations that he finds appealing are that of shareholding and piecemeal colonisation, and he argues that 'both could conceivably act as a precursor for the other: shareholding could foster the systematic sharing of land during phases of expansion just as easily as the latter could engender a spirit of shareholding' (1981 p. 140). According to Dodgshon, the relationship between landholders is central and the 'interjacency of their property' and raises the question as to why peasant farmers entered into the relationship in the first place (1981 p. 140). The interpretation here is that Dodgshon's argument is that piecemeal colonisation would fragment holdings and create interjacency, a social bond that develops a sense of community, it would require or actually create (at least) a physical shareholding based on equity and/or to ensure risk aversion. There are similarities between Krenzlin and Dodghson in gradual development and change and that settlements were not static and created at a certain point in time. However, the development is not deterministic, 'The relationship which subdivided fields express, therefore, possibly evolved out of circumstances before being cemented by choice. It was not necessarily one which farming communities were somehow born to' (1981 p. 143).

Carl Dahlman's (1980) explanation of open fields was motivated by economies of scale. The combination of small-scale, intensive arable cultivation and extensive large-scale grazing was created, in which scattering in the arable would prevent the strategic behaviour of individual landholders. Dahlman's theory is based on a theoretical model of the common field, and with it, the associated features of two- or three-fields, scattered and intermingled holdings and so forth. One piece of the puzzle is communal grazing. According to Dahlman, the key is to reduce transaction costs. If outlying pastures (waste) were held privately/consolidated, then individual landholders had to agree with their neighbours that they all would throw their lands open to accommodate large-scale grazing. To achieve this – a 'chain of transactions' for all to agree – each owner had to compensate the others and himself (Dahlman 1980 p. 117). Grazing in common with a single herdsman hired for the entire village herd was more efficient than an individual arrangement (Ibid. p. 113). Regarding scattering of the arable, Dahlman considers it inefficient for the sole purpose of arable production (Ibid. p. 140), but scattering in of the arable in a three-field system reduced transaction costs and ensured that withdrawal from large-scale grazing was 'radically reduced'. Individual grazing on fallow plots became more costly primarily because of the cost to 'fence off all the little strips from his neighbours' instead of a communal arrangement (Ibid. pp. 124–5). Thus, according to Dahlman, the basic function of scattering is that it created

incentives to participate in the communal regulation of grazing, and scattering facilitated stable institutional arrangements when the bargaining power of individuals was reduced. Dahlman's 'universal' explanation is, first, not empirically founded and, second and more important, restricted to a model of regular common fields and does not consider the many various types of open fields that spatially, functionally and institutionally differ (in various degree) from common fields. Furthermore, according to Dahlman, scattering was the last element to be added to the system and, in a sense, a necessary evil.

Open fields and behaviour towards risk

Prior to Dahlman, the economist Deidre McCloskey presented her theories on scattering in open fields in a number of articles and book chapters. McCloskey stressed that 'the origin of open fields is less important than their reasons for persisting over many centuries; that the economics of property rights is the key to their costs and their demise; that their benefits were those of insurance' (McCloskey 1991 p. 344). McCloskeys explanation is that scattering reduced risk by spatially scatter holdings in various soil conditions, slopes, dry and wet areas, exposure to sun and wind, and others. Different areas are sensitive in different ways to weather. Thereby, scattering secures at least some yield in variable weather conditions (McCloskey 1975 pp. 114–5). Because futures markets and markets for loans were poorly developed and insurance against unpredictable outputs was not available, scattering functioned as an insurance and reduced the risk (McCloskey 1976 pp. 18–9). McCloskey focuses on the persistence of open fields instead of the initial causes. She argues that the classical explanations of scattering in the historiography of the open fields as a result of, for example, co-aration, partible inheritance, egalitarianism and land-colonisation, are insufficient to explain the persistence of open fields. McCloskey argues that *risk aversion* is the only explanation that withstands scrutiny (McCloskey 1976 pp. 117–8). As with Dahlman, McCloskey concludes that scattering was inefficient and decreased productivity but also caused other inefficiencies, including neighbourhood effects, such as common grazing, and that communal cropping created conflicts and division. McCloskey argues based on rents that productivity in open fields was 13% lower compared with enclosed farms, and the efficiency of open fields in 'their prime' would have been even lower than in open fields that were about to be enclosed (McCloskey 1975 pp. 87–8).

However, the increase in rents on enclosed farms as an expression of increased productivity is a disputed correlation. Allen (1992) contends the

relation and argues that open and common fields were as efficient, even more efficient than privately held land (Allen 1992 pp. 130–49). Clark (1998) argues that other factors – not increased productivity – explain higher rents because of general rent inflation between 1760 and 1815 and the freed burden of tithes (Clark 1998 pp. 77–8).

In the literature, many of the inefficiencies of scattering were rejected by McCloskey. She argues that the cost of transportation was trivial because plots were located close together and/or were small enough that up to four plots could work together in a day. Jointly ploughing arable land – even scattered plots – is the equivalent of a single consolidated holding (McCloskey 1975 pp. 78–9). The main losses, she argues, were those of negative neighbourhood effects, spreading of disease amongst the cattle in communal grazing arrangements; restrictions imposed by communal rules and practices; and discouraging potential talent, knowledge and ideas (Ibid pp. 78–83).

McCloskey makes an important distinction or selection in her examination, 'why did open fields persist from the twelfth to the nineteenth century in some places in England and disappear in the seventeenth and eighteenth centuries in most?' (McCloskey 1976, pp. 57–8). This distinction is based on the late date of enclosure of regular common field systems in the Midlands, whereas other types of irregular open field systems were enclosed at an earlier stage. McCloskey argues that the reasons for the implementation of an enclosure are key to understanding the logic of open fields and that it is correlated to the cause(s) of its dismissal: 'The inefficiencies of the open field system have presented historians with a puzzle: Why did it persist? The puzzle is relevant here because one must know the reason for its persistence to understand its dissolution in enclosure' (McCloskey 1975 p. 88). That is a fair argument; however, according to McCloskey, its persistence is that of risk aversion in the lack of proper markets for insurance. When such markets were available and possibilities existed for storage, peasants were enclosed in the pursuit of profit through higher efficiency. However, the causes of their dissolution are not necessarily synonymous with their capability to persist.

McCloskey's hypothesis has gained widespread acceptance but has also been criticised. Several key issues have been put forward that challenge the generality and applicability of the model. By restricting her study to the particular form of the Midland system, the generality of her analysis to other types of open field systems in other parts of Europe that do not meet the specific spatial and regulatory characteristics of regular common fields is questionable. She concludes that Midland clay soils were sensitive to weather and, thereby, required a higher degree of scattering to minimise risk,

as opposed to irregular open field systems on free-draining soils in southeast England[2] (Ibid p. 118). Hence, McCloskey argues that there are ecological factors to both the degree of scattering and the persistence of common fields and that they would be enclosed later. Another issue is the question of market integration and differing spatial arrangements. Yelling (1982 p. 411) refutes McCloskey's argument that integration in the London market explains the irregular systems in southeast England, whereas the lack of market integration explains the late enclosure and the persistence of the common fields of the Midlands. The integration of the 'diverse economy of London' offered stable markets for crops and allowed peasants to 'diversify their personal portfolios … outside agriculture' and that it is 'not surprising to find their land enclosed early – if indeed, they were ever open' (McCloskey 1975 p. 118). Another criticism of the risk model is that avoiding risks only works for the individual holding and not the village as a whole, and the landholder does not gain any protection against risks (Ibid p. 412). Campbell stresses the correlation between strong lordship and regular common fields and the weak correlation with irregular systems (Campbell 1981 p. 128), which further contradicts the risk theory.

Temporal and spatial diversification

Although McCloskey identifies risk aversion as the function that made the common field persist despite a loss of productivity, the economist Stefano Fenoaltea contests this assumption and argues that scattering in fact maximised productivity, and '[i]t did so because the diversification achieved by the scattering of strips allowed the optimal allocation of labor to the land with minimal incentives to shirk' (Fenoaltea 1988 p. 190). The climate in Europe north of the Alps is the key to understanding the spatial characteristics of open fields and had temporal consequences on farming practice. Heterogeneous soil conditions, drainage and exposure to the elements affected the timing of the central chores of ploughing and harvesting, and to achieve the best results, different parts of the arable were ready for preparation at different times and 'productivity depends critically on the careful allocation of labor over space as well as over time' (Ibid. p.

[2] Yelling (1982 p. 411) argues that the distinction between the midlands and the southeast is insufficient and, in fact, incorrect. The midlands did not entirely consist of clay, and the southeast regions did not entirely consist of free-draining sands. With reference to Postgate (1973), Yelling argues that common fields on free-draining sands in the east (Breckland) were enclosed later than the common field villages on clay. M.R. Postgate in Baker and Butlin (Eds.) *Studies of field systems in the British isles*, pp 281–324.

191). The hypothesis of spatial and temporal allocation in open fields was presented by Charles Parain[3], and Fenoaltea and combines Parain's model with the work of North and Thomas (1971)[4] to provide theoretical support for the model (Ibid. p. 190). Fenoaltea's theoretical approach is that of new institutional economics and that 'a model of the common fields is logically acceptable if it is compatible with rational behaviour and economic efficiency' (Ibid p. 172).

Fenoaltea argues that in addition to the efficient utilisation of space, scattering also amended the landlord's adequate supervision. If the manor managed its land as a single, large farm, then labour transaction costs were high and the risk of shirking imposed a cost of supervision because employed workers do not profit from their own work and, instead, shirk. A division of small farms with scattered holdings ensures minimal loss of effort because each farm also worked for itself and supervised its hired workers. However, spatially homogeneous holdings did not provide an optimal allocation of work to areas best cultivated at a certain time. The 'superior solution' to ensure both supervision and optimal practice is a systematic division of holdings. In a systematic division of holdings, each small farm constitutes a proportionate share or 'a microcosm of the entire arable', and the village as a whole allocated work to particular areas and soils and, 'thus, minimizes labor-market transactions and maximizes the productivity' (Ibid pp. 191–2). Fenoaltea is not specific on any type of open field system, and the hypothesis is suggested as a universal solution. However, the concept of systematic diversification in manorial systems points to regular common fields. The lack of empirical evidence has apparent implications on the reliability of his argument. The only empirical evidence put forward is with reference to a statistical study by F. Pryor (1988). Pryor conducted a statistical analysis based on a global census of agriculture in 1960[5] and concluded that statistical evidence exists that provides some support for the correlation between

[3] Charles Parain presented the hypothesis in his chapter, "The Evolution of Agricultural Technique" in M. M. Postan (ed) *The Cambridge Economic History of Europe from the Decline of the Roman Empire*. Cambridge University Press, 1966, pp. 125–179.

[4] North and Thomas provided Fenoaltea with the theoretical framework and analysis of transaction costs in manorial systems. Douglass C. North and Robert P. Thomas, "The Rise and Fall of the Manorial System: A Theoretical Model," *Journal of Economic History* 31, no. 4 (Dec. 1971): pp. 777–803.

[5] Pryor examined the degree of land scattering using statistical data from around 1960 from 35 nations on the degree of scattering and the number of parcels divided by the number of holdings in each nation. The ratio is regressed using a number of proxies, including labour scheduling (frost-free days), tenancy, risk, inheritance, egalitarianism and major crops. Overall, the study showed little evidence for either Fenoaltea's labour scheduling or McCloskey's risk hypothesis.

scattering and the scheduling of work on farms with short seasons. However, he concluded that 'the degree of explanatory power is not very impressive' (Ibid. p. 307). Pryor´s study finds little support for other variables, such as risk, partible inheritance or equity (Ibid. pp. 313–6). In Fenoaltea's article (1976), *Risk, Transaction Costs, and the Organization of Medieval Agriculture*, he examines McCloskey's risk hypothesis and concludes that risk aversion affected behaviour and peasants sought to reduce risk but that this explanation is insufficient for scattering and risk aversion is linked to consumption rather than the spatial organisation of production. In his article, *Transaction Costs, Whig History, and the Common Fields* (1988), the critical examination of the suggested causes of scattering is expanded and includes most of the presented explanations regarding the English case. Fenoaltea propose to 'dismiss them *en masse* as logically and empirically untenable' and that the solution was apparent if not for 'ideological blinders'. In fact, scattering in open fields was desired to achieve agricultural efficiency, according to Fenoaltea, but the weight of history and the inefficiencies of open fields propagated by 18th-century agrarian reformists influenced modern researchers. The view of scattering as inefficient resulted in various explanations that motivated irrational organisation (Fenoaltea 1988 p. 171).

Beyond the Middle Ages – proto-open fields

In addition to the 'classic' studies on open fields that generally focused on medieval open fields or later periods when open fields were on the brink of dissolution and consolidation, contributions have been made to unveil the origin of open fields and the preceding arrangements. Studies on the origin and preceding systems mainly rely on archaeological evidence and, to some extent, written sources and place names.

David Hall (1995 p. 130) dates the English 'strip fields' to the end of the Middle Saxon period (A.D. 400–850), approximately the eighth or ninth century. In his study of Northamptonshire, Hall refutes partible inheritance as a cause of early open fields and stresses that population pressure and reducing waste through land reclamation necessitate fallow to ensure grazing. Thus, according to Hall, there are practical causes, and managing a single area of fallow for communal grazing is easier to control than individual consolidated areas (Ibid pp. 138–9). However, in the Roman period, English landscapes were under cultivation, and the first Saxon settlers engaged in 'primitive agriculture' on rich soils along river valleys. The Saxon and pre-Saxon settlements generally do not correlate with the late Saxon and medieval sites and villages, and evidence exists of these earlier sites 'underneath or on the edge' of present settlements or deserted medieval

villages (Ibid. pp. 129–31). Shreds from handmade Saxon-period pottery provide important evidence for identifying pre-open field settlements (Hall 2014 p. 134).

Susan Oosthuizen (2005) identifies a system of long furlongs across a prehistoric Iron Age land division dated to the 8th or 9th century that functioned as additional grassland for common grazing and was part of a system with intensive arable cultivation in which these furlongs on the edge provided nutrients to arable fields when sheep were folded on arable land. Oosthuizen interprets these furlongs as being part of an infield/outfield system in which these outfields/furlongs were less intensively manured and periods of cultivation were interrupted by long periods of fallow (Ibid p. 182–5). The interpretation is that the layout of these furlongs is not part of the 'classic open fields' arrangement, and the combination of some characteristics of open fields with elements that differ from it suggests a 'proto-open field arrangement' (Ibid. p. 186).

In a study of fossil fields in southwest Sweden, the geographer Mats Widgren (1990) presents evidence of pre-medieval strip field systems dated to the B.C. 500 to A.D. 200 period. This study combines archaeology, morphological and metrological examinations of maps and field studies that indicate Iron-age strip fields. Widgren argues that, based on the field evidence, it is 'difficult to explain these fields in any other way than as a land division between landholders in a farming community, *i.e.,* subdivided fields in the medieval sense' (Widgren 1990 p. 16). With reference to Fenoaltea's argument (1988) that the costs associated with scattering in open fields relative to private holdings are insignificant or non-existent and that to adapt to varying soil condition, allocating work to different areas was efficient and maximised productivity, the spatial fragmentation of plots has its own rationality and function. (Widgren 1990 p. 16). The findings and interpretation challenge both Dahlman's (1980) theoretical model and the concept of the typical elements that compose the common field village and McCloskey's conclusion that the persistence of open fields was that of risk aversion in the absence of markets for insurance and grains. Widgren argues that 'if subdivided fields thus have a rationality of their own, regardless of the other types of property rights and farming systems with which they are found, it is natural to see subdivision as an element which has come and gone over time' (Widgren 1990 p. 16). However, there are obvious uncertainties in the distinction between working parcels or tenure parcels and whether 'these fields were subdivided property in a community of peasants' (Ibid. p. 16). To draw conclusions about property and tenure based on archaeological evidence in geometrical forms is precarious. Nevertheless, Widgren's study

points to the importance of function in interpreting the small-scale characteristics of both open field systems and preceding arrangements. Scattered and intermingled holdings are generally associated with villages and communities, but the division of arable land into several small parcels is also prevalent in many single farms (see the example of Esbjörnstorp in Paper 3) and hamlets/villages based on consolidated holdings that are not necessarily intermingled.

Numerous studies on the subject in different disciplines and research traditions examine open fields in different historical periods and geographical settings. Despite the regional and national varieties in spatial organisation, the common denominators – division in several small plots and/or cooperation among neighbours – are characteristic of agriculture in Northern Europe during the last millennia.

This thesis stresses the importance of relating the function of scattered holdings and practice in open field farming, how spatially dispersed holdings were utilised and the implications that were potentially created and resolved. Furthermore, the historical contexts in which open fields are studied and the theoretical perspective applied influence our interpretations and understanding of the logic of open fields.

Another aspect of previous research concerns the question of language, terminology and definitions. The following section further discusses these aspects and how key terminology has been used and defined in research.

3.2 Definitions and terminology

The aim of this chapter is to present how key terminology is defined and used in this thesis. Research on agrarian history involves a large set of terms. Varying local and/or regional terms can have the same definition, which can cause confusion within a nation and further misinterpretations in translating them into English. A common language – a lingua franca of science – is, on the other hand, a good thing and enables comparisons and a broader debate instead of looking inwards at national conditions and peculiarities. However, the English case regarding terminology is no different than in other countries, and the debate over terminology and definitions is not a new one.

3.2.1 Open and common fields

Farming in pre-enclosure Europe is characterised by small-scale arable production, spatially organised in several intermingled plots. Obviously, institutional arrangements exist that were based on farming in severalty

(spatially); however, the vast majority of villages in Europe north of the Alps was organised in what is most often referred to as open fields. Thus, the term open field is used, on the one hand, as a generic term for various types of spatial arrangements and field patterns and, on the other hand, to describe the specific physical division of holdings in numerous unfenced plots scattered and intermingled over the arable and meadows. In this definition, open fields concern form and represent a 'landscape feature', that describes 'the morphology of fields' (Bailey 2010 p. 156). The definition of open fields as solely a physical division of holdings separate from any communal regulation has its limitations.

In the English context, a distinction exists between open fields and common fields on the basis of the degree of communal regulations of agricultural activities. Open fields have generally referred to the system before the enclosures, and these fields were not necessarily literally open but delimited by hedges, fences, ditches or dry-stone walls (Adams 1976 p. 79). Joan Thirsk (1964 p. 3) introduced the term common field that distinguished open fields and was composed of four elements: 1. The division of arable land and meadows into a number of unfenced plots scattered and intermingled with neighbouring holdings; 2. common pastures on the fallow and after harvest in the arable and meadow fields; 3. common pastures and rights to other resources in the outlying land for landholders; and 4. activities regulated by the village assembly and manorial courts or a township (Thirsk 1964 p. 3). Thirsk's definition therefore requires a regular field system, that is, a two- or three-field system that excludes any one-field system with continuous cropping and irregular fallow.

In the fully fledged regular common field, with a strong communal regulation regarding field rotation (fallow), with strict communal organisation of cropping rotations and grazing and access to outlying resources by the village assembly. Although the regular common fields have a strong communal regulation, the open fields or irregular open fields have been characterised by weak regulations with little or no communal regulation and a low degree of scattering combined with piecemeal enclosures (Bailey 2009 p. 16; 2010 p. 159). The validity of that argument (outside the British isle) is debatable. The same terminology is used in other contexts with different meanings. The use of the term common is problematic and indicates less communal arrangements in open fields despite the fact that one of the central features of open fields – scattering in the arable is the spatial outcome of a communal arrangement and the use of fallow and cooperation between neighbouring villages. There is varying complexity in different types of systems, but it is important to be clear about what we mean by open and

common fields. This thesis further discusses the relationship between these terms and that most villages were communally organised and utilised different spaces in common, but not all villages were open.

In another aspect, regular or irregular not only refers to a fallow system and regulation but also to field patterns and layouts of holdings. Whereas regular systems suggest an ordered or repeated sequence of plots in each furlong – characteristic of the sun-division system – irregular systems lack any ordered structure and appear seemingly random in the spatial distribution of holdings (Roberts & Wrathmell 2002 p. 2). This is consistent with the terminology used in the Swedish case and, in this thesis, the terms systematic and unsystematic are used regarding the spatial layout of holdings.

However, the terms open fields and common fields have been used interchangeably without any distinction of their meaning (Bailey 2010 p. 156). Confusion exists over what is to be classified as open fields in different contexts where, on the one hand, this term has been used for large systems with continuous unfenced open landscapes with no physical boundaries between villages or holdings and, on the other hand, also refers to fenced systems with mixed farming, different field systems and visually closed landscapes. In her often cited article (1975), The Persistence of English Common Fields, the term common field is used 34 times and the term open field is used 100 times. Her definition of the 'textbook version of the open field system' – a rotation of wheat–barley fallow in the three great fields – was of holdings that were scattered, and each farm held equal parts in the three fields (Ibid p. 76). Although McCloskey identifies that the division of holdings in the three fields was not necessarily equal among peasants, the terms are used synonymously.

Three discussions

In research, there are at least three general discussions about open fields. One discussion concerns institutional aspects – the combination of individual ownership and common cultivation/usage in open field farming. The principle of letting arable land, which was individually owned but communally regulated, was used for a common pasture after harvest – the functional aspect in common field systems (Renes 2010 pp. 40, 60).

A second discussion focuses specifically on the fragmentation of holdings, the scattering of plots and the origin of open fields. The discussion focuses on the morphology of fields, combining archaeology, field studies and historical geography and a retrogressive methodology, and the use of historical maps in the analysis (i.e., Beresford 1955; Helmfrid 1961; Sporrong 1985; Widgren 1997; Roberts & Wrathmell 2002). The morpho-

genesis of field patterns has been of interest in the Swedish case. The origin of the physical layout of arable land in open fields, which could take systematic and unsystematic forms in their layout, has been debated for a long time, with few results regarding the actual cause(s) but valuable insights and knowledge about the continuity of open fields.

A third discussion captures open fields as a visual open landscape targeting arable fields, which may have physical boundaries (hedges, fences, ditches, dry-stone walls) but, in most cases, lack them (Dyer et al. 2018 pp. 37–41). Therefore, open and common fields could be understood as overlapping concepts, even if open fields – according to Renes (2010 p. 60) – is a broader term that also includes the visual aspect of open arable landscapes and the physical layout of individual holdings.

In a Swedish context fences were in general permanent, though temporary fences were put up for cultivation on the fallow field (SuSaml nos 111). In countries such as Sweden, fences were a common and distinctive element of the landscape, at least until the nineteenth century. The fences, which were usually made of wood or stone walls in certain areas, could serve as property boundaries, but they primarily aimed to keep the grazing animals away from cultivated fields. Moreover, fences were not used to separate and enclose one's own land. Rather, they were a common resource that several settlements and farmers shared (free farmers owning the land or tenants).

Lindgren (1939) could show that the farmers had coordinated their fences in a way that promoted cooperation between villages/hamlets by synchronisation in the arable land and animal grazing on the fields after harvesting.

In other words, how agriculture was organised in large parts of northern Europe cannot be understood without regard to fences. Fences appear to be a key component in the open-field regarding an agrarian system based on cooperation. The cooperation between settlements by the reduction of fences separating them is in the Swedish medieval law referred to as *hägnadslag*.

In this thesis the term *fence-organisation* is used for these spatial arrangements[6]. By reducing all or some of the inner fences farming activities, within the larger interconnected field, required synchronisation from its participants.

The discussion regarding terminology is not new. In 1968, a conference was arranged to generate a discussion on agrarian features and terms (Butlin

[6] The Country law of Sweden, MEL = *Magnus Erikssons landslag*, Stockholm, see Holmbäck & Wessén (1962), BB VII, VIII, XIII, 101–106. The law uses the term *värnalaghi (værnlaghi)*, by Schylter interpreted as, one who has land within the same fenced field as another, see C. J. Schylter. *Ordbok till Samlingen af Sweriges Gamla Lagar*, Lund, 1877.

1969 p. 142). One of the papers presented was A.R.H. Baker's Some terminological problems in studies of British field systems (1969), which argues the importance of the 'construction and adaptation of a uniform terminology' to reach broad conclusions. In imprecise terminology, the 'diversity of British field systems, both in space and time', which is the case in Europe at large, risks fallacy in comparisons when discussing different systems (p. 136). Baker suggested the term sub-divided fields instead of open fields because it is confusing when open fields were enclosed with physical boundaries (fences, ditches, hedges, dry-stone walls). Regarding the term common fields, Baker argues that it presents fewer problems but that the use of open and common fields synonymously is problematic and adds to the confusion (Ibid. p. 140).

All of the good arguments and intentions had little impact on research. Dodgshon (1980) complies with Baker and Butlins' subsequent suggestions (Baker & Butlin 1973). However, whether this clarifies or contributes to the confusion is debatable. Dodgshon (1980) criticises McCloskey for using the term open fields for what 'others would prefer to call simply sub-divided fields' (Ibid. p. 22). Dodgshon prefers the terms sub-divided fields and field systems because the generic terms open and common fields were insufficient, given that villages took different forms and could not be defined as either open or common fields (Dodgshon 1980 p. 21). Dodgshon uses the term sub-divided fields synonymously with scattering, intermingled or intermixed holdings and what is commonly referred to as open fields. However, the term sub-divided fields points to the process of the subdivision of holdings through the splitting of plots/parcels through inheritance or transactions for half or part of a holding (individual plots or a share of the total). Sub-division thereby refers to the subdivision of an already scattered holding, which is how the term is used throughout this thesis.

The term field system is also confusing because Dodgshon uses it as an overarching term for the system, from early forms of communal farming to villages with a 'communally regulated system of cropping or rights of common grazing over arable after harvest' (Dodgshon 1980 p. 1), and this term is used synonymously with open or common fields. The field system, at least in a Swedish context, refers to a system of fallow and a number of (open) fields in one-, two- or three-field systems.

However, many times, well-founded insights and suggestions to establish a more precise use of key terminology seem to have had little impact. Today, open fields and common fields are still the 'basic' terms used in research.

This thesis emphasises that the open field is defined as an open area of arable land and/or meadow either delimited by a physical boundary or not,

wherein an assembly of cultivators of at least two farms cooperate in the use of resources within a defined area.

In this definition, an open field does not necessarily require intermingled holdings, which are traditionally viewed as the common denominator of open fields. Emphasis is on cooperation and collective solutions in a system based on individual ownership and not least the individual's responsibility towards the common good. Cooperation does not necessarily involve regulated crop rotations or regular fallow but at least requires peasants to respect the boundaries between holdings plots and to some degree synchronisation of the time for sowing and harvest. The mere upholding of boundaries of holdings required an institutional arrangement for their maintenance regardless of the degree of regulation in farming practice.

In this way, a fenced arable field (or meadow) in a village of two farms in southwest Sweden is considered an open field, as is a large unfenced area consisting of a number of villages and numerous farms involved on agricultural plains in the Netherlands. The occurrence of intermingled holdings is only one aspect of cooperation and communal organisation in both arable work and grazing and is still required regardless of intermingled holdings. The number of plots and their spatial distribution changes movement over space but not the need for cooperation.

Fences or boundaries are rarely mentioned in classical works on open fields, even though boundaries were important aspect of open field farming. In the Swedish case, fences (mainly wooden fences) are by far more frequently mentioned in medieval laws than, for example, arable land, which indicates their importance, and the regulation is an essential part of Swedish open and common fields. The institutional arrangement of fences is similar to that of the division of land, and fences within the village were divided into sections, and each farm was responsible for a number of sections. This division ensured that those who neglected their part of the fences could be held responsible if animals entered and trampled the arable field. In the Swedish case, the available sources are very good, and the important role of fences in the Swedish mixed farming system is apparent in large-scale maps.

In the Swedish context, the emphasis has been put on the physical division of individual plots – the manner in which plots were distributed (e.g., Göransson 1954, 1961; Sporrong 1985; Widgren 1997). The manner in which plots were distributed is not related to the overall organisation of farming but has more to do with the origin of these types of structures. It is obvious that different systems or principles in different parts of Sweden resulted in physical differences in land division; however, in general, there was one system throughout Sweden (with some regional differences regarding the

main focus on arable production or animal husbandry) characterised as an infield system (sw. inägosystem) with a fenced infield with individual ownership and cultivation and common outlying lands (utmark) for pastures, fuel, building materials etc. The term infield system should not be confused with the infield-outfield system (Dodgshon 1980 pp. 83). The infield system was a mixed farming system, even though with a variety of field systems (regular and irregular fallow). The manner in which is important, but scattering is often a feature in most open fields – but not in all.

Plot and parcel are used synonymously throughout to describe the smallest unit (sw. Teg). However, the registration of plots in maps is generally done at the cadastral level and, in some cases, hides any underlying subdivision. Thus, there is a distinction of functional plots (brukningsteg) and ownership/property plots (ägoteg), which is further discussed in Paper 1. In this thesis, farm/farmer and peasant/peasant farm (bonde, gård/brukningsenhet) refer to the farming unit, generally a family farm either as a freeholder or tenant and does not include smallholders or crofters. In the Swedish context, the term bonde is more diverse and refers to a social category or class, and the majority relied on working the land on their farms even though that was not always the case (Gadd 2000 pp. 51).

4 Theoretical approaches on open fields

In this chapter, the theoretical basis and broader scientific perspective used in this thesis are discussed. This thesis is predominately empirically driven, however, some theoretical models is applied. The theoretical underpinning and context of the empirical evidence are imperative for analysis and to draw valid conclusions. All of the studies are based on fundamental theoretical and geographical considerations regarding time, space and the practical aspects of farming and the basic historical perspective – the purpose of everyday farming at the farm level.

Time and space are fundamental variables in agriculture, and time is an axiom regardless of the theory if we exclude physics. Time cannot be expanded and is the most limiting variable in farming. Space relates to time when the scale of farming increases, and an increase in arable land requires more time if there is no change in the workforce and/or changes in technique and technology. In contrast, the purpose of farming has to do with human behaviour and needs, and economic and social rationale in agriculture depends on the context and is not a constant. Theories on economic and social science have implications for our understanding of the function and purpose of open field farming and its spatial layout.

4.1 Time, space and scale – a time-geographical approach

The basic question asked by geographers is, why does it look the way it does in a particular place/landscape? There are a variety of causes of local, regional and national differences and how landscapes and settlements, among others, take different shapes and forms that have to do with culture and customs/traditions, as well as the physical landscape. In this section – and in this thesis, for that matter – the focus is on similarities and funda-

mental circumstances that, regardless of location, are general. Scattering in open fields is such a feature/phenomenon that was prevalent in large parts of Europe. In preindustrial as well as modern agriculture in general, the temporal and spatial characteristics and constrictions that arable production pose on farmers have to be managed. The scale of operations changes with technological development; however, in principle, the same rules apply throughout history, and arable production depends on farmers to carry out the best practices for preparing soils and sowing the right crop at the right time in the most suitable area.

In this thesis, time-geography is the underlying approach to an analysis of open fields and is primarily used in Paper 1 through a detailed analysis of work and transportation. In all studies, a time-geographical perspective is applied to understand the spatial configuration of open fields in relation to agricultural practice in general.

Time-geography, a space/time-trajectory model, was formulated and developed by the geographer Torsten Hägerstrand (1985, 2009) and is not a theory in itself but rather an 'ontological contribution preceding formation of theory' (Hägerstrand 1985 p. 195). Theoretically, the model is based on Karl Popper's and John Eccles' three worlds that separate the physical world of artefacts and nonorganic and biological matter in world 1 and subjective knowledge, thoughts and memories in World 2. World 3 is composed of the culture created by humans and human minds, art, mathematical theorems, myths and poetry, among others. Hägerstrand argues that there is no well-ordered perspective to manage the complexity of the world and to treat society, nature and technology as a whole (Ibid pp. 193–4).

Society, nature, and technology are spliced together in the no-man's land that extends between the realms of scientific and humanistic thought and between theory and practice. A patent specification never mentions the human being who is going to communicate with the proposed machine. It never considers who is going to make a profit or who is going to lose a job. On the other hand, historians and even economists mostly take technology as given or deal with it in crude aggregate terms. We have no sociology or ecology of men and things considered together. (Hägerstrand 1985 p. 193)

This argument reflects a broad scientific approach that is not the goal here and is not how the time-geographical model is used in this thesis. However, the broad onset attempts to make sense of the world and society by studying the spatial and temporal aspects of human activity and movement and the various constraints that, put simply, regulate what is possible for an individual or population. The time-geographical approach provides concepts to analyse processes in time-space. In time-geography, place (landscape,

region) is conceptualised based on five key-terms: populations, paths/ trajectories, projects, pockets of local order and prisms. In this thesis, the concepts of projects and prisms are used and are relevant to analysing open field farming. Projects are activities performed in different environments, and some require coordination (coupling) between individual and/or materials. A region or area in which projects reoccur, such as a village or field where ploughing or harvesting occurs, is called a pocket of local order. These landscapes and pockets of local order require institutional arrangements and rules regarding ownership, and access rights secure that the purpose of the projects can be fulfilled. The prism or what is also called the return principle dictates the space wherein the various projects occur. Humans are locally based and need a place to sleep and eat. Daily chores or activities and physical movement are restricted by the speed at which an individual can move to and from the home and defines the 'prism' (Hägerstrand 1985). The village infield (arable land and meadows) and the outlying pastures and woodlands form the 'open field prism' wherein activities or projects are carried out.

Work involves movement, places and time (spent), and the most obvious constraint is that humans cannot physically be in two places at the same time. Furthermore, the ability to carry out one's activities is limited by other constraints that depend on decisions made at an earlier time, as well as on social and organisational obligations, structures, locations and access to resources (Ellegård 1999 p. 167). The time-geographical approach is used to study activities performed by individuals at the micro-level and how individuals make use of available resources and fulfil those activities. By 'tracking' everyday activities and how time-space implications or configurations affect these activities, an individual's movements in time and space can be mapped. The village and the open fields form the prism, and individual plots are several small pockets of local order.

The time-geographical approach has not been applied in all studies, but the conceptualisations of space-time variables in landscapes and society are useful in thinking about manually driven agriculture. There is also an ecological aspect to time-space that has to do with the phenology of crops. Different crops have different growing periods and prosper in different type of soils. Paper 1 shows how farming practice is organised in a time-space sequence in which different crops are sown at different times throughout arable fields. Furthermore, Paper 1 shows that scattered holdings are correlated with practice but depend on the scale of individual plots. As plots decrease in size because of subdivisions, the spatial configuration becomes

costly and less efficient because of increased transportations in relation to labour input.

Activities involved in open field farming (on a family basis) are confined in space and time, and the puzzle of open fields is in how their spatial configuration facilitated good management of time and space and, if you will, offered an efficient mode of production. This thesis argues that a time-geographical approach is necessary to understand the fundamental variables of farming in general and the spatiality of open fields in particular.

The time-geographical model is not a specific historical approach, even though the 'realities', constrictions and possibilities in time-space are universal regardless of time (when). There is an underlying ambition of a complete and fundamental understanding of the contexts of society and nature that form the world (Hägerstrand 2009 pp. 18–36). To understand populations (humans, animals and the material world), their various trajectories and projects in prisms and pockets of local order at different scales empirically require vast amounts of data, even if we consider areas and regions. Historical records are generally fragmented and incomplete. Yet, the basic rules of time, space, nature and resources are constant and, although spatial arrangements and technology have changed over time, the historic farmer had to manage these variables.

In many ways, time-geography concerns the physical aspects of farming; however, our understanding of the rationale of spatial configurations makes it necessary to comprehend the basic purpose of activity/farming. This is further discussed in the following sections.

4.2 Purpose and rationale

This section focuses on the theoretical underpinnings in the study of changes in agriculture, spatially and practically. Many prominent scholars and explanations of open fields have been developed by economic historians. To some extent, the focus has primarily been on scattering in open fields, but many times the approach has been through the lens of enclosures and the agricultural revolution, focusing on an increase in outputs after the dissolution of open fields. From the enclosures and onwards, agricultural outputs increased dramatically and, through this perspective, open field farming might seem inefficient, assuming that the purpose was to maximise productivity and surplus production. However, this thesis argues that, on the basis of the individual family farm, such an assumption can lead to misconceptions and erroneous conclusions about the function of open field farming.

4.2.1 Historical perspective

The aim of this section is to highlight the importance of the historical perspective and how historical contexts and human behaviour and rationale are theoretically perceived and interpreted. The question of the purpose and function of scattering in open fields has been approached from different/ various theoretical and historical perspectives and, consequently, with varying empirical and methodological approaches. The argument is that our historical perspective influences the interpretation of what is studied and, to some extent, is based on assumptions about human behaviour and an economic rationale. This thesis stresses the importance of analysing open fields based on contemporary sources when the open field systems were in use and the retrogressive potential of younger sources in offering clues to earlier situations and conditions.

In historical research, scholars seek to fill in the gaps not covered by the sources to understand distant realities and practices, and the gaps can be significant. In an attempt to fill in the unknowns for which historical records are scarce or lacking can be precarious, and circumstantial evidence can lead to over-interpreting sources and jumping to conclusions (Myrdal 2012 p. 16). This relates more to the way that sources are used methodologically, but a retrospective or retrogressive approach has theoretical implications and concerns regarding how we approach history, how it affects our interpretations and how it depends on our historical perspective.

The retrogressive approach uses younger sources, more complete records or the physical landscape, in addition to older and incomplete sources, to explain and analyse the village, landscape or system at an earlier point in time (Karsvall 2013 p. 412). In contrast, the retrospective approach is characterised by an explanation of the present landscape or a landscape at a particular point in time by looking forward from an earlier point in time to identify the mechanisms that can explain the present or studied landscape and why it looks the way it does (Widgren 2000 p. 3). These approaches are closely associated with methodology and represent different perspectives on history and historical research. Retrospective studies are associated with a critique of sources in traditional Swedish historical research were one of the requirements is the spatial and temporal closeness of sources in relation to what is studied (Myrdal 2012 p. 17). Critiques of the retrogressive approach argue that a tendency exists to exaggerate continuity and stability over time (Karsvall 2013 p. 432).

As previously stated, studies on the cause and function of open fields have been approached from the perspective of enclosures, looking back into history, from a modern or at least early-modern departure, through which

interpretations of historical practice and changes in previous arrangements (open fields) are found and explained based on economics and rational human behaviour. McCloskey argues for the need to understand the relationship between open fields and enclosures and how the 'persistence of communal agriculture […] must be related logically to the reasons for its eventual dissolution' (McCloskey 1975 pp. 73–4). The logic is that farming in open fields was upheld as long as it was economically efficient and that there must be some other variable or rationale compensates for the loss of productivity – in McCloskey's case, it was risk aversion. Dahlman (1980) suggests that stable institutions and common grazing over the fallow are the main benefits that promoted open fields, despite the inefficiencies of scattered holdings. The logic is that there are secondary effects that counterbalanced the inefficiencies – not that scattering in itself was a means of efficient farming. Researchers have asked the question of why villages were organised in (various types of) open fields, assuming they were inefficient. Others have made the contrary argument and have suggested that they were as efficient as, or even more efficient than, enclosed farms (Allen 1992). A legitimate question is, what do we mean by efficiency? Farming produces output in the form of corn. To measure efficiency is to measure the yield of corn per acre produced. Other factors, such as biodiversity, sustainability, optimal farm size, the number of people employed (or not employed) or those whose livelihoods are supported by farming and taxation, all affect measurements of efficiency (Bray 2008 pp. 324–5). Social aspects and rationale are other factors to consider. The actual yields were definitely important for self-sufficiency, and other factors can weigh in on how and why farming was organised in open fields.

Approaching open fields relative to farming in enclosures is, in some sense, a theoretical retrogressive approach. There is a risk of interpreting open fields as a 'primitive' form of agriculture that would have maximised productivity and surpluses if possible because that would be the natural order of things. This can lead to a retrogressive fallacy, the tendency of over-interpretation and the exaggeration of the continuity of economic rationale and (general) purpose of farming.

In contrast to neoclassical economic theory and perspective, Alexander Chayanov's theories offer a different perspective on the peasant economy and are discussed in the following section.

4.2.2 Chayanov and the Labour–Consumer Balance

This thesis stresses the importance of analysing the spatial configuration and practice in open fields within the context(s) in which they were established. In 1966, the Russian economist Alexander Chayanov's work, The theory of peasant economy (1923), was first published in English. The work was introduced to a broader community of economists and researchers and was both well received and criticised (Shanin 1986 p. 1). This is not a thesis on economics; however, the economics of everyday life and certainly of historic agriculture are of importance in understanding the spatial organisation in open fields, and vice versa. Chayanov is not concerned with the spatial characteristics of open field farming, but his focus on the scale and operational logic of self-sufficient farming has relevance for open fields. His work is empirically based on detailed statistical records of the state program launched in 1861 that continued for more than four decades (Thorner 1986 pp. xi–xii).

Chayanov's theory on the peasant economy refutes the interpretation and concepts of family farms' rationale and economic behaviour in classic and neoclassic economics as businesses and capitalistic enterprises based on hired workers to earn profits. Instead, Chayanov argues that 90% of farms in early 20th-century Russia did not have hired labour (Thorner 1986 p. xiii). Furthermore, he argues that a family farm cannot be viewed as an enterprise and defines the family farm as 'a farm normally run by a family without hired outside wage labor, sometimes in part engaging in nonagricultural crafts and trades' (Chayanov 1986 p. 272).

Chayanov's theory and analysis promote a definition of family farms in which production and incentives are not driven by capitalist factors and rationale that seek to maximise profits in a system dominated by capitalism (Chayanov [1924] 1986 pp. 1–3). The quantitative interrelationship of the four main factors of production according to classical and neoclassical economics are profit, wages, rents and interests. According to Chayanov, it would be impossible to quantify any profit and to calculate the gross annual output, '[i]f one brick drops out of this system, the whole building collapses' (Chayanov 1986 [1924] pp. 3–6). Instead, Chayanov argues that these categories cannot be applied in an economy in which the price category is absent and in an economic system that only serves to satisfy the needs of the farm. It is a 'natural economy' in which the family farm is both the production unit, the consumer unit and economic activity provide for the needs of every unit and '[t]herefore, budgeting here is to a high degree qualitative: for each family need, there has to be provided in each economic unit the qualitatively corresponding product in natura'. (Ibid p. 4) In Chayanov's

opinion, the absence of wages in family farms' economies require a different economic theory because the economic structure is fundamentally different when the driver(s) of production is intimately linked to the labour input and the basic needs to ensure self-sufficiency. Chayanov refers to this relation as the labor–consumer balance or the consumer-worker ratio (Thorner 1986 p. xv; Chayanov 1986 [1925] pp. 58−9).

The balance between satisfying the family's needs and the drudgery of labour is fundamental in Chayanov's argument and is the central concept in his economic theory. The approach is from below, from the operational level of farms, and considers not only agricultural production but also crafts and trades – all of which are aspects of the 'peasant family economy'. At the end of the agricultural year, the family farm receives the result of the labour of cultivation after being exchanged on the market, which makes the gross product. The net product or the 'labour product' is what remains after rents and other expenses for restoring the farm's assets: seeds, equipment repairs, material, fodder, number of livestock and others are deducted to retain the same result the following year. The labour product is divided between household members for consumption and any remaining capital used for investments in the farm and, if possible, for savings (Chayanov 1986 [1924] p. 5).

Labour and consumption are the two basic aspects of the family labour product. The first important aspect of consumption is to secure the needs for consumption. The second is the drudgery required to achieve it. Chayanov argues that an increase in production through hard labour corresponds negatively to its significance for consumption. To endure, the balance between work and consumption is characterised by a disequilibrium. The subjective valuation of the drudgery of labour is lower than the significance of satisfying the needs for consumption and, if an equilibrium is reached, hard work is pointless because the increase cannot be endured (Ibid p. 6). However, the outputs of farming can be increased, and closeness to markets and natural conditions are important. Otherwise, most peasant families can either extend working hours or intensify labour, which Chayanov called the degree of self-exploitation, and the increased labour input is tolerable as long as the income per labour unit does not decrease (Ibid pp. 7−8).

Chayanov's labour–consumer balance has been criticised for not having been substantiated in the empirical data mainly for not including – or rather assuming – easy access of family farms to farming inputs besides labour, such as fertilisers, equipment and credits. Furthermore, the analytical relevance of Chayanov's labour–consumer balance is for contemporary agriculture has been questioned because other variables such as demographic change, the role

of state policies, international trade and technological developments is not included. In contrast, his theories have been applied in historical studies on agriculture and 'stone age economics' (Shanin 1986 pp. 2–3).

In the context of open field farming, this thesis argues that Chayanov's theory on operational logic brings valuable insights into the rationale and economic behaviour related to historical agriculture in general and self-sufficient farming in particular. Thinking about the individual farm in the open field village in the 17th or 14th century or even further back in history, the purpose of farming is of importance. With regards to Chayanov, this is not to assume that there was no market integration or that farms did not strive to increased yields and efficiency. However, farming was in general small-scaled and carried out on a family basis. Here, Chayanov's emphasis on the scale, the size and the production of farms provides important perspectives in understanding scattering in open fields and the efficiency/inefficiency of individual farms and the system as a whole.

4.2.3 Scale and efficiency

In Chayanov's theory, the degree of self-exploitation increases when the scale of operations or the intensification of labour increases but the increased outputs is not balanced with the work input. The balance between work and consumption relates to efficiency in the sense that it is inefficient to put in more work if the needs of the family have already been met and energy is lost if profits are negligible. Efficiency stands in the centre of the open field debate and causes to the persistence of scattering in open fields despite their assumed inefficiency for arable production. Perhaps the question we should be asking is not which spatial arrangement produces the most grain per area unit but what is considered to be efficient in a certain place at a certain point in time. As Chayanov suggests, we have to take into account that increased production is not necessarily sought after or worthwhile.

Increased outputs must not necessarily relate to scale and intensification even though the mere transition from scattered holdings in open fields to enclosed land held in privacy has been suggested to raise outputs. The mechanism behind the effects of farming in large consolidated plots rather than in several small plots has been attributed to a reduction in fallows (Turner 1986 pp. 687–8), suggesting that the effects of enclosure are related to new knowledge and practice rather than physical change.

In economic studies of contemporary agriculture, a discussion exists on the inverse relationship. The inverse relationship relates to the correlation between productivity and scale for area productivity that is higher in

small(er) farms than in large(r) farms (Barret & Bevis 2019 p. 2). Studies on the inverse relationship have been criticised as an illusory, statistical creation and the result of measurement errors or omitted variables; however, this criticism has been refuted and proven unsubstantiated by Barrett and Bevis (2019). In addition to the inverse relationship are edge effects, which are the perimeter-area ratios at which the productivity of a plot is higher in the peripheral areas than in the centre (Barchia & Cooper 1996). Regarding the shape of the plots, the perimeter-area ratio is important. Consequently, a long, narrow plot gives more 'edges', and a higher percentage of peripheral areas and less internal areas, whereas a square- or triangular-shaped plot generates the opposite. The plot size is also important for edge effects, and a larger size decreases the perimeter-area ratio (Figs. A13 and A14 in Barret & Bevis 2019 p. 82). There is a strong correlation between edge effects and an inverse relationship, and biophysical causes have been observed, such as sunlight, drainage and soil nutrients, to be more plentiful at edges and are important for crop growth. The behavioural factors are more difficult to derive but are suggested to be 'plot awareness' – farmers tend the visible areas on edges more carefully than the central areas of plots (Barret & Bevis 2019 pp. 12–13, 56). In contrast to these findings, Federico (2009 pp. 137–42) argues that the theoretical and empirical evidence of a 'specific type of farm … is structurally superior to others' and suggests that the advantages and disadvantages depend on local conditions.

It is not suggested that the open field farmer was aware of these 'spatial effects' that would be a retrogressive over-interpretation. However, these theories highlight the central aspects of open fields, the question of their efficiency/inefficiency and the function of scattered holdings in several small and dispersed plots. Furthermore, the biophysical causes proven true in contemporary farming are likely valid regardless of time. Spatial configuration and efficiency/inefficiency are discussed in Paper 2. There are practical and time-geographical constraints and possibilities that dictate farming – in present and historical agriculture. What is changing over time is knowledge, technique and technology. Although we find divisions in arable land in several small plots on single farms (Paper 3) that point to the importance of understanding farming practices, generally, scattered holdings appear within villages and hamlets in a mix of individual responsibilities and communal organisation in different institutional arrangements. The institutional aspects are of equal importance for understanding the open fields.

4.2.4 Institutions, commons and property

The communal arrangements of common land were members of a village, or a hamlet had rights to resources not subjected to individual properties, such as pastures, woods, heathland, peat and others, which are important components in medieval and early modern European agriculture (de Moor et al. 2002 p. 15). The 'commons' is often associated with uncultivated or temporarily cultivated outlying land, generally referred to as commons, which is used synonymously with allmänning in the Swedish context (Larsson 2009 p. 24). Much of the research on commons and institutions concerned extensive resources. The theoretical work by North (1990), de Moor (2012; 2015) and, in particular, Ostrom (1990) describes how these communal systems and arrangements functioned and the importance of institutions. Elinor Ostrom's extensive empirical work on commons in various places throughout the world shows that commons did not necessarily lead to the overuse of resources. In contrast to Hardin (1968), she showed their functionality and stability. Ostrom's design principles on common-pool resources (CPR) stipulate the requirements or rules that have to be fulfilled to create stable communal arrangements (Ostrom 1990 pp. 88–102). In a sense, her work is meta-historic and makes use of previous historical research on the studied cases to analyse the stability of the CPRs. Her studies do not concern open fields but other communal arrangements on irrigation, woodlands, fisheries and others. However, Tine de Moor (2009) have applied Ostrom's theoretical work in an analysis of historical communal arrangements in Flanders.

Commons and the institutional organisation(s) that accompany them are fundamental to understanding and analysing open fields. The open fields – the infields composed of arable land – and meadowland and pastures were thrown open for communal grazing when not cultivated. Smith (2000) refers to open fields with private rights and ownership as semi-commons (p. 132). Dahlman (1980) emphasises the function of scattered holdings in open fields as a physical arrangement strengthened the stability of institutions managing large-scale and extensive grazing (in outlying lands). Intermixed holdings in the arable function to ensure cooperation and counteract anyone withdrawing from the grazing arrangement. The term common fields indicates the degree of regulations of communal arrangements of grazing the fallow and the access to outlying resources, while open fields are characterised by weak or irregular communal regulations (Bailey 2010 p. 159).

Paper 3 focuses on communal arrangements between villages by analysing the fence systems and how the responsibility to build and uphold fences was related to owning land. Similarly, because arable land was

divided in a number of plots, the fences were divided in a number of sections for which each farm was responsible. Thus, communal organisation was not only about rights to grazing the fallow and outlying pastures and woodlands but also individual responsibility for the collective.

The communal arrangements that occur at different scales in and between villages are of great importance to understanding open fields. The institutional complexity of open field farming has practical, spatial and temporal implications and relies on well-defined individual responsibility and ownership and strong communal regulation.

5 Study area

Historical studies are always restricted and confined to the selected sources, which potentially provide insights into a specific problem. Restricting a study to a certain area is inevitable, and choosing a specific area is to actively disregard other areas. This is certainly true for open fields with various spatial characteristics and specific national and regional types of open field systems throughout Europe north of the Alps that are predominantly organised in mixed farming systems.

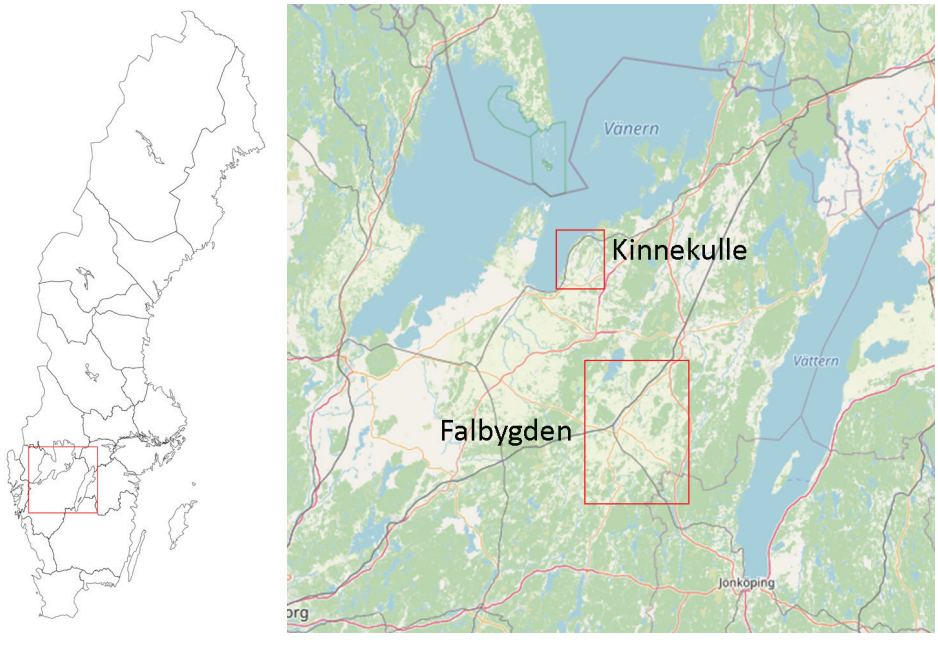

Figure 1 & 2. Overview of study area. OpenStreetMap 2020.

The studied open fields are located in the county of Skaraborg (Västergötland) in southwest Sweden (see Figure 1 and 2). The main area is in one of the central agricultural regions in Sweden called Falbygden, close to the small town of Falköping. The prefix *fal-* points to the landscape type called *falan*, a hilly open terrain categorised as a forestless high plain (Lundahl 1970) with the characteristic table-mountains (Sporrong 1996 p. 44). The Villages and hamlets on Falbygden were mapped in a land survey in the 1640s with almost complete coverage. The studies in Papers 2 and 3 concern villages in Falbygden. Paper 1 examines a village located approximately 45 kilometres northwest of Falbygden on the lower plateau of the table-mountain of *Kinnekulle* and the village of Kleva. The main reason for this study, outside of Falbygden, is the available sources.

Skaraborg County is a region with establishment of settlements and agriculture in the Neolithic period (Axelsson 2010 p. 81) and is a central region in Swedish agrarian history (Lindgren 1939; Gadd 1983). Skaraborg County is characterised by varying geographical conditions, field systems and agricultural specialisation. The western and northern parts is dominated by the open plains while Falbygden in the central, is characterised as a undulating, highland plain with forests in the east and south.

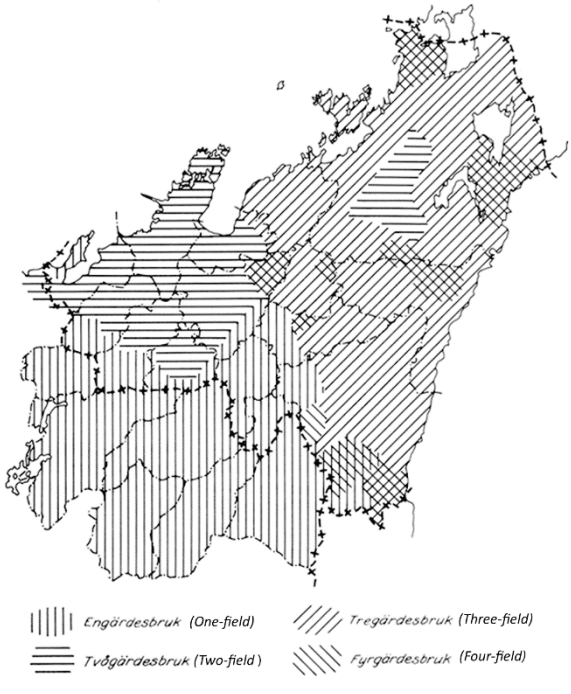

Figure 3. Distribution of field systems in Skaraborg County and parts of Älvsborg County c. 1780 according to Gadd 1983 p. 207. The map is based on information from County and Parish descriptions from 1750s and 1780s. (Translation of terminology have been added)

On the grain producing open plains in the west the two-field system dominates, while the one-field system was predominant in the south and southwest. In the east and north the three-field system was common, with enclaves of two-field systems (northern parts) and four-fields in the woodlands (see Figure 3).

Falbygden, which also included parts of Älvsborgs County in the south, is divided between one-field system in west and south, and the three-field system in the east. This division follows the fault that runs from north to south. There are no natural-geographical or geological differences between these two areas, which can explain the predominance of these two systems (Gadd 2018 p. 65). The division in different field systems is studied in Papers 2 and 3.

Skaraborg deviates in many ways from the rest of Sweden and east Sweden in particular. Villages are in general, considerably larger compared to southeast Sweden[7]. On the countryside, a larger share of the population were peasants that owned land and the number of landless and crofter were fewer, as is the presence of noblemen compared to the east in early 19th century, however the origin of these differences are likely to be old (Herlitz 1974 pp. 31–3). Besides social and demographic aspects there are other differences in that set Skaraborg apart from eastern Sweden relates to tax systems and spatial organisation of holdings in open fields.

The way holdings was spatially arranged separates Skaraborg and western Sweden from the east. Whereas open fields in in the west are characterised by an unsystematic scattering of holdings, the open fields of eastern Sweden are characterised by a systematic division – the solskifte (sun-division). The medieval tax system in the eastern region (solskifte region[8]) was based on the performances of the collective and, thereby, connected to the military organisation of the *ledung*. The introduction of the solskifte has also been associated with the dissolution of the *ledung* and the introduction of the *markland* in the latter part of the 13th century, and taxes were based on land (Lindquist 1968 p. 113). Instead, taxes in Västergötland were based on individuals and the individual farm and were more correlated with a feudal

[7] Large villages in not exclusive for Skaraborg in a national perspective. Settlements on the open plains of Skåne and in the County of Dalarna and Norrbotten, villages of similar size as i Skarabogr is characteristic.

[8] The solskifte region includes the counties of Uppland, Västmanland, Sörmland, Närke, and Östergötland; northwest parts of Småland; and the island of Öland (Göransson 1958 p. 103). The region is not homogenous and the prevalence of a sundivision is debated, and its occurrence varies. Collective taxes are mostly associated with Uppland and the Mälar region, whereas Östergötland exhibits more complexity with elements of both tax systems (Lindqvist 1993 p. 26).

organisation (Ibid. p. 26). In the region of the solskifte, land was assessed based on the *attung* and *markland*, and there was no real assessment of land in Västergötland. This is a short and simplified summary of medieval taxes, but the existence of systematic and unsystematic open fields is important.

The agrarian landscape of Sweden is characterised by regional differences with varying settlement structures, from predominantly single farms and hamlets to large villages; different field systems and systematic and unsystematic divisions of holdings.

Various reasons exist as to why the study area was selected, foremost because unsystematic open fields with an irregular spatial distribution of holdings have not been explained and have not been studied nearly as much as systematic open fields – the solskifte (sun-division) of southeast Sweden. Important research has been performed (see chapter 3), but the question of why holdings were spatially arranged as we see in the geometrical maps has not been answered. The explanations of scattering in open fields by English and American researchers have mainly been based on the regular common fields of the English Midlands. A system with regular fallow organised in a two- or three-field system with a systematic distribution of holdings is similar to the Swedish solskifte system. However, regular common fields are not the dominating or most common 'type' of open field system in Europe. In Sweden, unsystematic, irregular systems were in the majority.

Unsystematic open fields have not been thoroughly examined regarding spatial division of holdings, and the empirical possibility to do so is exceptionally good in Skaraborg (as is presented in greater detail in chapter 6). Gunnar Lindgren´s thesis *Falbygden och dess närmaste omgivning vid 1600-talets mitt: en kulturgeografisk studie* (1939) is an important study, however there are questions unanswered and those that might have to need revision. The possibilities today, to examine the rich source of information on spatial division of holding in detail, that the historical maps provide, and to combine this spatial information with other sources that relate to the same village/hamlet is a reason to why this region is studied.

Figure 4 & 5. Comparison of unsystematic and systematic field systems. The two examples illustrate the differences between the two. To the left, a detail of Segerstad village (1644−47), Segerstad parish, Skaraborgs County. To the right, a detail of Stora Berga village (1692), Klockrike parish, Östergötlands County. (Sources: D18:31; P2:50 Riksarkivet)

6 Sources and methods

In this chapter, the different source materials and how they have been methodically analysed and utilised is presented. In the first part, the sources are discussed. In the second part, how these sources have been used in the three papers is presented.

Most villages and hamlets in Sweden were mapped at least once and, in many cases, two or three times in the geometrical surveys in the first half of the 17th century, in the 18th century, during the agricultural reform of the storskifte (from 1749, and at the time of the enclosure reforms of enskifte (from 1803) and laga skifte (from 1827). Maps were produced for various reasons – surveys, disputes/conflicts regarding boundaries, sales and separation of holdings. From the start, in the early 17th century and onwards, the practice of surveying developed and surveyors improved over time, producing more accurate and detailed maps.

In addition to maps, other written sources have been used in combination with the maps, such as parish descriptions (sockenbeskrivningar), tax registers (mantalslängder) and cadastres (kronans jordeböcker). Furthermore, the results from experimental research (Gebresenbet et al. 1997; Karlsson 2015) and agricultural reference books have also been used in time estimations of farming practice (Paper 1).

The sources and methods used to retract information and analyse these sources are presented in greater detail in the following sections.

6.1 Sources

The 17th-century large-scale Swedish survey maps are invaluable source materials when studying historical land use, settlement structure and spatial organisation of holdings prior to the reorganisations in the 18th and 19th centuries. Internationally, Swedish survey maps are a wholly unique body of

source material, and nowhere else can such an abundance of cartographic material be found for this period (Baigent 1990). Maps from two surveys from different periods produced for different purposes form the empirical basis on which the three studies are based: the large-scale maps from the first half of the 17th century, the so-called *older geometrical maps* and maps produced in the *storskifte*. The idea of a radical redistribution and dissolution of villages formulated in the 'Instruction for Land Surveyors' 1749 (Helmfrid 1961 p. 115) was implemented in the 18th and 19th centuries.

The large-scale historic maps are generally spatially reliable and became increasingly accurate over time. However, a crucial aspect of the Swedish land survey maps is the 'administrative level' on which they were done. Generally, the maps depict the *cadastral level* (tax unite) of holdings, meaning that the surveyed holdings could correlate to the *functional level* (i.e., a single peasant farm). However, that was not always the case, and cadastral holdings could have been subdivided into two or more individual/independent holdings. Subdividingsions of farms was not allowed by law (Kristoffers landslag) through an ordinance in 1459, but subdivisions still occurred (Granér 2002 p. 73). Subdivisions into smaller holdings were unwanted because their ability to pay taxes was reduced. In the proclamation of 1684, restrictions on subdivisions were eased, and in 1747, subdivisions of smaller farms were allowed by royal decree (Ibid. pp. 74–6). The *mantalslängder* is an important source for aggregating the actual number of individual farms.

6.1.1 Large-scale maps – 17th and 18th century

In the first half of the 17th century, an ambitious survey project was initiated that, for more than 20 years, produced large-scale maps of approximately one-third of the Swedish kingdom (see Figure 6). During the 1630–1655 half of Sweden's villages, hamlets and single farms were mapped in a nationwide systematic survey – from Pajala village in the far north to the southern tip of the island of Öland. The result is a unique source material, a systematic survey of Sweden consisting of approximately 12 000 large-scale maps of open fields prior to the consolidation of farms in the 18th and 19th centuries. Two major projects have made the majority of 17th century geometrical maps accessible through two databases[9].

[9] GEORG maps from the first survey 1630–1655, and KARL from the 1680–1700 period (https://riksarkivet.se/geometriska). The databases are also available online in TORA (Topografiskt Register på RiksArkivet), provided by the Swedish National Archives. TORA is a historical register based on historical settlement units that refer to villages, hamlets and farms in medieval and early

In 1628, the Swedish *lantmäteriet* (Swedish land survey) was established, and the mathematician and surveyor Anders Bure (1571–1646) was appointed to lead the state organisation. The tasks were formulated through ten-point instructions, mostly regarding the economic character of the mapping of lakes, potential waterways, and harbours, making inventories of forests and marshes, surveying towns and others (Tollin 2007 p. 51). The third point stipulated that each province should be surveyed and that maps (*landtaflor och afritningar*) should be made of arable land, meadows and outlying woodlands and pastures of villages, hamlets and single farms (Figure 6).

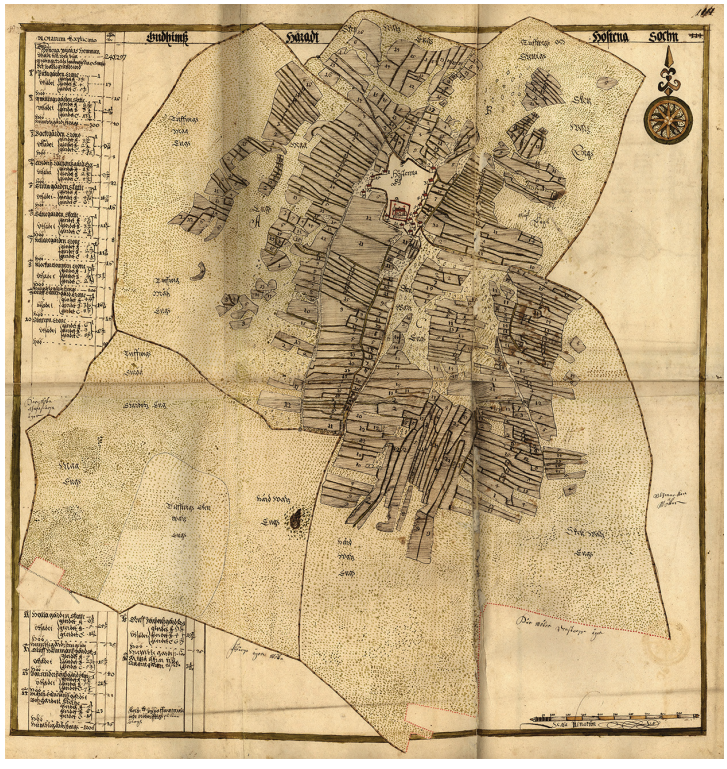

Figure 6. Högstena village 1644–47, Högstena parish, Gudhems hundred, Skaraborgs County. The village is organised in a three-field system, with a fourth meadow field, which is common in the three-field region on Falbygden. Every plot in the arable is specified with a number that correspond to the farm that they belong to. The map is done in a scale of 1:3333. (Source: P2:114, Riksarkivet)

modern Sweden. TORA currently covers approximately fifty per cent of all settlements in 17th century Sweden. The databases are both statistical and spatial and include exact coordinates for villages (e.g. farms, mills) and detailed statistical data from all maps at the farm level. All of the text was transcribed.

Furthermore, the instruction states that surveyors should submit suggestions for improvements (Ekstrand 1901 p. 2). Bure was instructed to employ and train surveyor. Initially, six surveyors were trained, and additional surveyors were trained over the course of the project (Höglund 2017 pp. 48–9). Initially, the surveyors were supposed to focus on freeholders farms (*skattehemman*) and tenants to the crown (*kronohemman*); however, farms belonging to the nobility (*frälsehemman*) were not supposed to be mapped unless they were part of a village or if the landholder wanted it. However, in the 1634 instructions, all villages and farms were supposed to be surveyed (Tollin 2007 p. 52). Still, the outcome varied and, in many cases, tenants under nobility were included. In other cases (even after 1634), they were left out, resulting in a number of 'partial' surveys, such as in the village of Borgunda (TORA/Georg P2:133–134). In 1644, the surveyor Johan Botvidsson only measured the plots belonging to 13 of the 31 holdings, resulting in an incomplete map of the village (Figure 7).

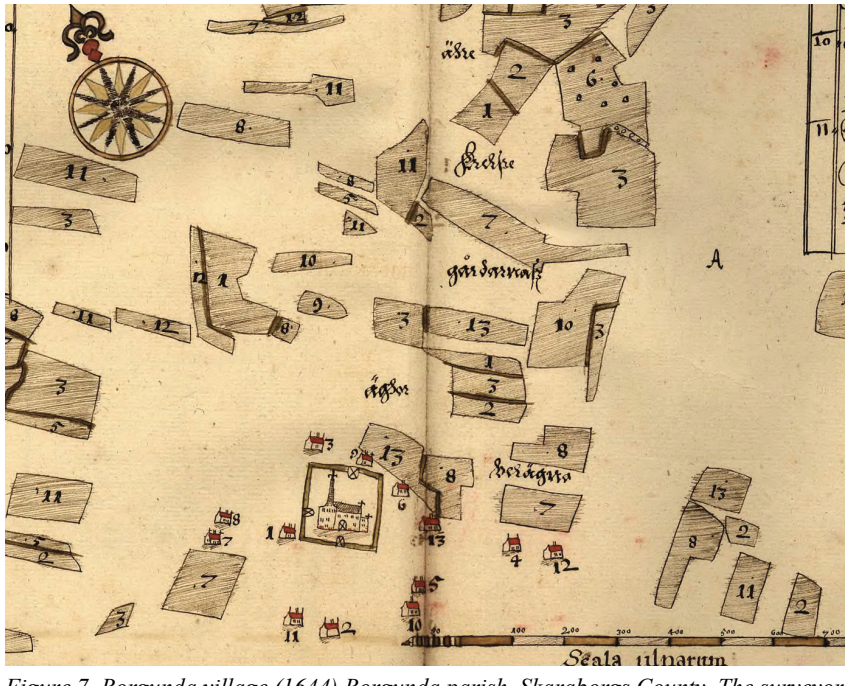

*Figure 7. Borgunda village (1644) Borgunda parish, Skaraborgs County. The surveyor Johan gyllenstig botvidsson only surveyed 13 out of 31 holdings in the village. Only arms that were tenants under the crown (*krono*) or freeholders (*skatte*) was measured while farms belonging to the nobility (*frälse*) are left out. Borgunda is organised in a three-field system and the three fields are depict on separate pages. (P2:133-134 Riksarkivet)*

However, the reason the land survey project was initiated at the beginning of the 17th century is not entirely clear. It has been assumed that the survey was carried out for tax purposes to completely revise land taxes. Tollin (2007, 2020) shows that such an explanation is unlikely for a number of reasons. Land measurements and surveys (without making maps) have been made since the Middle Ages (size and quality), and taxes on land have been registered in the cadastres since the 1530s. Land measurements were carried out parallel to the map surveys in the early 17th century. During that time, new taxes were not based on land and tolls were impost on goods[10]. For tax purposes, the geometrical survey seemed excessive and costly (Tollin 2007 pp. 52-4). Staffan Helmfrid argues that the most remarkable thing about the (oldest) geometrical maps is that they were actually made. He also correlates the huge undertaking as an expression of the kingdom's expansive ambition rather than as an improvement in taxation (1959 p. 229). The survey was an ambitious project and resulted in a unique systematic survey of settlements in the first half of the 17th century.

The large-scale maps from the province of Västergörland and the county of Skaraborg, and more precisely Falbygden, have primarily been used in studies. The parishes in this region were almost completely covered by surveyor Johan Botvidsson (Gyllensting) between 1636 and 1647. Älvsborg was surveyed by Kettil Classon (Felterus) during 1644–1648. The southern parts of Falbygden administratively belonged to the county of Älvsborg, and in total, approximately 1600 maps were produced[11]. The maps from Västergötland were made at a larger scale of 1:3333; in general, maps were produced at a scale of 1:5000 or 1:4000. The reason for the larger scale was likely the lack of a land assessment unit, as in the region of the systematic open fields of solskifte[12]. The spatial division of holdings throughout the

[10] Tollin 2007 p. 53; tolls were put on mills (*Kvarntullen*) and on various gods brought into town markets (*Lilla Tullen*). The *Älvsborgs andra lösen* (1613), a temporary tax over six years, meant that taxes were placed on individual wealth, including money, precious metals and livestock.

[11] The province of Västergötland includes the counties of *Skaraborg*, *Älvsborg* and, administratively, *Falbygden* belonged to both counties.

[12] See Ericsson (2012) and Karsvall (2016). The size of the holdings and their share of the village were assessed in *Öresland* and *Attungar*, and farms' shares were expressed in *byamål*. The *byamål* were generally expressed in ells and/or rods (sw *alnar* och/eller *stänger*). In the *solskifte*, the width and, thereby, the size of each plot was proportionate to each farm share of the village/hamlet, and the location in each furlong and field appears in a repeated sequence throughout the infield. The physical location of farmsteads on the toft is correlated with the location of each plot belonging to farms plots in each furlong. Therefore, there was no need to measure and delineate every plot because the size of each farm was calculated based on the total size of the village's arable land and meadows. Scattering in solskifte is, in a Swedish context, referred to as *regelbundet* (regular),

region was unsystematic, and as a consequence, the surveyor measured each and every plot throughout the arable to estimate farm size and each farm was marked with a number and every plot belonging to the farm was marked with the same number. Although the meadow plots were not measured/delineated in the maps, the meadow land was divided in the same manner as arable land. Plots (both arable and meadows) owned by a farm in another village were the exception and were marked with a red dotted line. The larger scale in maps from Västergötland was related to the need to measure each plot in order to assess the size of the holdings. Settlements were large, and many plots were small, and the larger scale probably made surveying easier.

The geometrical maps provide detailed information and various information on early modern agriculture. The maps show the location of the settlements using a house symbol that represents the actual buildings. The size of the cultivated fields was measured (in *tunnland*[13]), and the surveyor made notes (text on the map) of the type of soils (e.g., clay, sandy). If the soils were stone rich, larger stones and mounds of stones are marked. The meadows were measured in yields of hay (*lass*), and the quality and type of meadows (wet or dry meadows) were assessed. Vegetation is marked, and various trees and bushes are in both text and symbols. Fences are delineated as stylised wooden fences (*hankgärdesgård*) that were the most common technique, dry-stone walls are marked to resemble a stone wall and boundaries are marked with a red dotted line. Fences could also represent a border between the settlements. Because the fences were meticulously delineated, the maps provide information on the field system and fence systems (lack of a fence between villages/hamlets, Paper 3). Mills, hops, kitchen gardens and fruit gardens were also mapped (see Figure 8). The infield (*inägomarken*) was surveyed, and the outlying land (*utmark*) was only assessed in the text description.

whereas the unsystematic field pattern in Västergötland (and other parts of Sweden) was *oregelbundet* (irregular) because of the lack of apparent patterns and seemingly random distribution of plots.

[13] 1 tunnland = 4936 m^2 = 0,49 ha. 1 tunnland equal approximately 1.2 acres.

Figure 8. a. permanent facilities for fishing and a watermill. Detail of the map of Ullfors (1640–41), Uppland.County b. Hopgardens in Möne village (1644–45) Älvsborgs County. The Notarum Explicatio specifies 3700 hop poles in the village. c. Detail of meadows in Brunnhem (1644-47), Skaraborgs County. The surveyors specifies the meadow as dry (*sw. hårdvallsäng*) with sparse oak forest with a few larger trees, which is specified with symbols. (Source: a. A3-149–150 b, O2:36–37, c. P2:89–90 Riksarkivet)

Each map includes text, *Notarum Explicatio*, which specifies the quantitative and qualitative information of the farm size and yields of hay, the number of farms, their type (tenants under the crown or nobility, freeholders) and the mansus (*mantal*). For land estimation, the value of the property is estimated in *markland*, and the farm's share in the village (*byamål*, in those cases that were practised) is specified in ells and/or rods (see note 5). Access to and the quality of outlying land (*utmark*) are also stated, including pastures, fuel, building materials and fishing waters. In addition to the valuable information on scattering, the geometrical maps are valuable sources for various disciplines in the study of agrarian history and landscapes.

The detailed surveys of villages and hamlets and the spatial organisation of fragmented holdings in unsystematic open fields offer possibilities for an analysis of early modern agriculture, especially spatial analysis. Moreover,

the number of maps produced in a relatively short period by the same surveyor in a region enabled a statistical analysis of entire regions and on a national level as well. This source material has been used on different scales, both at a detailed level of individual plots and farms and for larger areas consisting of several different settlements. Large-scale maps have been used as a primary source in numerous studies (i.e., Lindgren 1939; Helmfrid, 1962; Göransson 1971; Vestbö-Franzén 2004; Jansson 1998; Tollin 1999; and others).

6.1.2 Storskifte maps – 18th and 19th century

The first survey (oldest geometrical maps) ended in the 1650s. Subsequently, mainly small-scale geographical maps were produced. Some large-scale maps were produced, such as in the newly concurred county of Skåne (Scania), and the surveyor Nils Eriksson two hundreds (Oxie and Skytt) in 1660. The end of the geometrical survey coincides with Karl X Gustav's reduction (1655) that basically involved the retraction of one-fourth of the donated estates to the crown (Höglund 2017 pp. 55–63). Starting in the 1680s, the reduction resulted in a large number of maps[14] (Database KARL). Maps were also produced for other reasons, such as conflicts regarding boundaries and taxation. Surveys were also initiated in the concurred provinces, such as Vorpommern, Gotland and Livland. From this time, maps were produced with a purpose and were used in courts as legal documents in various conflicts; surveys could be commissioned by courts (Jansson 2009 p. 226).

In mid-17th century Sweden, with inspiration from England for the idea of land reorganisation, the storskifte was presented for the first time in 1749 (Helmfrid 1961 p. 115). The storskifte was misleadingly used as being synonymous with an enclosure, which is not entirely correct. However, there are similarities, especially the ambition to break up the common organisation of the village and promote privatisation – to hold land in a single consolidated plot. The storskifte initially had little impact, and it was not until the formal regulation in 1757 that the implementation of the reform became more frequent. The act of 1757 was less radical than the previous one and allowed the retention of the village organisation and holdings divided into 3-4 plots; however, this was generally not the case, and the reduction of plots 'tended to be a generally slight reduction of parcels'

[14] In the *Yngre geometriska kartor 1680–1700* (KARL) project, the majority of the geometrical maps produced during the c. 6500 period were digitised, each village set with coordinate, statistic data registered in a database and all text in the maps was transcribed.

(Helmfrid 1961 pp. 118–121). There was a reluctance to accept the storskifte, and farmers preferred a division into several plots because of soil quality. In the three-field system in Skåne, surveyors were unable to find a solution of fewer than 12–15 plots/farm or several times more 'because there were variations in soil quality, title rights and distance to the village centre' (Pred 1985 p. 346).

The storskifte was carried out over a period of approximately 70 years. After 1830, reorganisations according to the storskifte were rare. During the storskifte, numerous maps were produced, and the quality of the surveys improved over the 100 years since the start of the Swedish land survey. The manner in which maps were drawn varied depending on the style surveyor and when the survey was performed. The maps were mostly made at a scale of 1:4000, but maps at scales of 1:2000 and 1:8000 were also produced and generally show the new division of holdings in both arable land and meadows. In some cases, the outlying land (utmark) held in common was also surveyed and divided into private parcels. Sometimes, the 'older' division was mapped and visible 'behind' the new proposed division (see Figure 9). The reduction in the number of new plots was based on the quality of the soils, specifically, the quality of the old plots expressed in *korntal* (crop yield). Crop yield numbers are discussed in the methodology section. Other surveyors, generally of maps from a later date, delineated the varying soil conditions/quality in greater detail without specifying the older division. This was obviously of importance because land exchanges were necessary and land quality was compensated with acreage, and a plot of a certain size with high crop yields was exchanged with a larger piece of land of lower quality.

The surveying technique developed in the storskifte surveys and measurements of arable land and meadows were detailed spatially and registered in the text documents, which are rich in information. There are regional variations in the manner in which they are done depending on the surveyor and when the survey was conducted. Sporrong (2007 p. 75) raised the issue that maps sometimes can give 'idealised accounts of the physical conditions' and that the regulated tofts of the medieval organisation in some cases were registered as more systematic than they actually were. However, this does not affect the measurements of arable land and the assessment of soil quality.

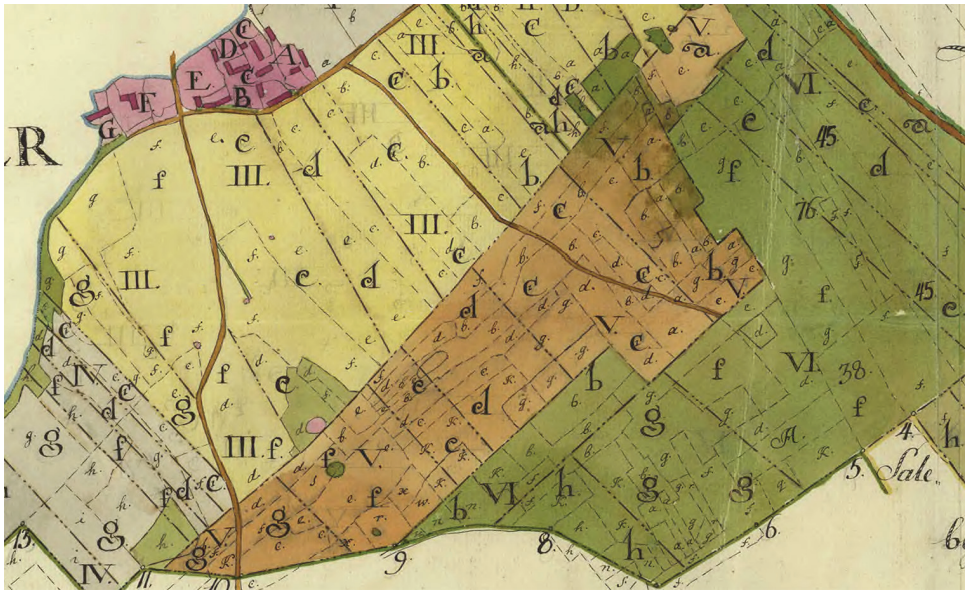

Figure 9. Reorganisation of the open field and the old division according to the Storskifte. The surveyor includes both the new (proposed) division and the old. The map reveals the division in the meadows that were divided in a similar fashion as the arable. Soil quality is specified in the text and with different colours and Roman numerals on the map. Storskifte map of Gunnestorp village (1778), Falköpings parish, Skaraborg County. (Source: LSA P43-3:1)

Crop yields in storskifte maps

In this section, the storskifte maps are assessed as a source for spatial and statistical data on crop yields. Uncertainties and unknowns always exist when working with historical sources, and there is a risk for 'over-interpretations' and assumptions about the continuity and representability of sources at an earlier point in time – prior to the source. Crop yield information is retracted from the storskifte maps and has been used to compare holdings based on soil quality and spatial configurations in open fields. The manner in which surveyors registered the crop yields varies, and some were meticulous in spatially defining the quality of various areas on the map assigned with a number that in the text description specifies the crop yield for the specific number and area (Figure 10–11). Other surveyors only wrote numbers on the map that referred to a crop yield number in the text but without any spatial reference to its distribution. Another method used by surveyors was that old land division was delineated and its quality was assessed and registered to the farm to which it belonged (see Figure 9). The varying manner in which crop yields are registered calls for different

methods to extract and digitally manage them, which is presented in the method section.

Figure 10 & 11. Above: Detail of the storskifte map of Friggeråker (1800). Below: Segerstad storskifte (1822). In the two surveys the new division and borders between holdings are marked with straight lines with letters referring to which farm it belongs (A, B, C and so on). In Segerstad (below) the number within each new parcel refers to the text section were the soil quality is specified for each number. 'Underneath' the new division, the dotted lines delimits differences in quality. In Friggeråker (above) the procedure is the same, in addition, the surveyor has written the korntal *(crop yields) on the map as well. (Source: Friggeråker LSA P54-5:4; Segerstad LSA P175-9:6)*

In the storskifte survey, the assessment of soil quality was essential because land exchanges were necessary to reorganise holdings equal to the division in the open field. This was the main reason farmers refused storskifte; in those cases in which it was carried through, plots were slightly reduced (Helmfrid 1961 p. 117). To assess the infields, both arable land and meadows were assessed, and surveyors relied on the participation of farmers, and farms had their say in the matter.

The storskifte regulation of 1757 states that the rating (*gradering*) of soils was the responsibility of the village members and that reorganisation was not to be carried out until all neighbours were in agreement. The storskifte regulation of 1783 (*storskiftesförordningen*) stipulated that if the best soils produce a crop yield of 6 (*6:e kornet*), then soils of less quality should be rated proportionally (5, 4, 3). The soil rating was directly related to crop yields (Ollner 1961 p. 13). In storskifte maps before approximately 1780, surveyors used the term *korntal*. After 1780, the term *gradering* was more common, but there was no strict use of these terms, and both occurred before and after 1780 and often on the same map. In the *laga skifte* regulation of 1827, the rating based on crop yield numbers was replaced with the *abstrakta graderingsmetoden*¸ an abstract rating based on soil quality but not based on a concrete estimation of yields. Thereby, what was considered best soil was relevant within the village but not comparable with other villages. (Ollner 1961 p. 12)

In the map of Brunnhem 1810 (LMS P25-2:4), the term *gradering* is used, and the highest rating is 4.5, which supports the correlation between rating and crop yields. In the map text, the surveyor commented that the soil rating in a specific area in which the villagers had participated in the estimation:

> […] in the northern field based on the villagers' information that the best and thereby of the highest grade agreed would not exceed a crop yield of 4 and in proportion to the poorer.
>
> […] uti norrgjärdet efter Delägarnas egen uppgift som de bästa och således uti högsta graden som efter öfverenskommelse ej fick öfverskrida 4de kornet och proportionaliteter för de sämre. (LMS P25-2:4)

The soil ratings in the storskifte maps have been used to compare holdings in the open fields of geometrical maps from the 1640s. The information in the younger maps have been 'transferred' to the digitised copy of the geometrical map.

There are 130 to 180 years between the storskifte survey and the older, large-scale maps. Moreover, the crop yield numbers in younger maps cannot be assumed to be the same in 1640. However, it is unlikely that the crop yield numbers were higher in 1640, but they may have been lower. This is unlikely, especially in the three-field system because the crop yield numbers are quite low, and crop yields under 2−3 are not probable.

Crop yields (*korntal*) are a measurement of agricultural productivity, the number of seeds in return from one sown seed. Crop yield estimates are known from 13th-century France and England at an average of 3−4. In Sweden, sources of crop yields are scarce, and some of the earliest records

are from the second half of the 15th and first half of the 16th centuries. One of the most comprehensive sources indicates an average of 2.7–2.8 (Myrdal 1985 pp. 148–9).

McCloskey's records are from large demesnes based on studies of tithe records by Ballard (1908) in the years 1243–1249. In one demesne (Blandon), the gross yield of wheat was 2.6 ('2.6 bushels of output per bushel of seed'). In another demesne, an even lower gross yield of wheat was found, 1.69 bushels per bushel seed (McCloskey 1976 p. 133), which likely indicated crop failure. This figure is comparable with the average crop yields from Uppland in 1481–1529 of 2.7–2.8 (Myrdal 1985 p. 149). Myrdal (1985) concludes that crop yields in Sweden were slightly lower than those in France and England, and the average crop yields of approximately 3 in late medieval Sweden and Myrdal argue that the most important cause was insufficient preparation and clearing of weeds on the fallow and insufficient fertilisation. In the 16th century, more records are available, productivity increased, and the average crop yields in southeast Sweden in the 1540s were 4–5. Records from the crown's demesnes (Kungsgårdar/avelsgårdar) was higher, on average, 7 (Uppland). They were lower in Västergötland, at approximately 4 (Myrdal 1985 pp. 149–50).

The lower crop yields on the crown's demesnes in Västergötland are relevant in the estimates of the studied villages to assess the recorded crop yields in the storskifte surveys. Myrdal (1985 p. 150) argues that the crop yield numbers may have been exaggerated to some degree by Reeve/Bailiff (*Fogde*) if the stipulated goal of a certain crop yield number was not achieved or because of stealing. However, this would probably have a marginal effect on the overall estimation.

6.1.3 Parish descriptions

Parish descriptions was a result from the growing interest in economics and the ambition to collect knowledge and statistics as initiated by central authorities from the middle of the 18th century to the first half of the 19th century (Gadd 2000, pp. 329–330). In 1741, Jacob Faggot published a questionnaire, *Tankar om fäderneslandets känning och beskrifwande* (Faggot SBL), consisting of a list of 165 questions in 12 paragraphs mostly on the economy, trade, industry and agriculture, which was published at the Swedish Academy of Sciences in 1741 (Gadd 1983, pp. 47–8). Parish's descriptions were produced in various parts of Sweden. In this thesis (primarily in Paper 1), a description from Västergörland is used. Approximately 80 parish descriptions were preserved from the diocese of Skara produced in 1755–1814

– 106 total descriptions were produced. The Parish descriptions are actually descriptions of pastorships that consisted of 2–5 parishes. In general, they were written by the vicars in these congregations.

These descriptions are a valuable source that provides detailed information on farming practices, field system descriptions, technology and tools, number of draught animals, types of crops, amount of different crops per farm, preparation and sowing times, different chores associated with cropping, available resources and quality of pastures and woodlands.

The parish descriptions have been used to obtain information on the chores involved in working arable land, the crops that were used, the number of different crops and the temporal aspects of farming practice and the use of space. Generally, the information has been considered reliable in research (Gadd 1983; Hallgren 2016); however, there are some uncertainties and unknowns. The writers had a local connection and were, in most cases, living in the village and parish being described. However, the information is aggregated, and specific information applies to all farmers in the parish, or the average-sized farm sowed a certain amount of each crop. Whether this situation also applies to smaller farms is difficult to say. Every farmer did not necessarily do all of the chores specified – something that Carlmark in the case of Kleva notes – and the lazy farmer settled with ploughing arable land one time instead of two. These variations are difficult to compensate for.

In article 1, the description of the village of Kleva is used. The Kleva description is one of the most detailed descriptions and was transcribed and published by Sallander (1978). The Kleva description was written by the vicar Magnus Carlmark in the 1780s, who was living in the village and who participated in the open field, meaning that he had first-hand knowledge about farming practices in this specific village. In addition to the parish description of Kleva, this study is based on 35 parish descriptions covering 102 parishes/congregations (SuSaml).

6.2 Methodology

In this section, the different methodological approaches and tools utilised in this thesis are presented. The studies that form the empirical basis of this thesis have different aims and, to some extent, require different methodological approaches. Fundamental in all studies is the processing of historical maps and making map overlays by digitalising and georeferencing maps to rectify them to the modern map and coordinate system to make accurate measurements and perform spatial and statistical analyses. The process of digitising and drawing (re-drawing) also serves another purpose and is an important step in analysing

the information on a map. Maps hold a large amount of information, mistakes and inconsistencies that are not obvious at first glance. The process of redrawing them and scrutinising every line made by the surveyor is a methodological step in reading and analysing the map(s). In addition to being a valuable source of land division and land use, maps also have the potential for extended analysis for which other historical records can complement and add information to the spatial analysis.

The geographer Torsten Hägerstrand argues that maps provide us with the possibility of making interpretations that are not intentionally inscribed in the maps initially (Hägerstrand 2009 p 99). The time-geographical aspects of agriculture are important in estimating and understanding the practical implications and possibilities involved. A retrogressive method and analysis is another approach to making use of the polychrone (multi-layered) characteristics of historical maps (and landscapes) as a source for the analysis of earlier conditions – before the map, which was not the purpose of the survey in the first place (Karsvall 2013 p. 412).

In the empirical studies presented in the papers, the sources are analysed at different levels of detail, and how the maps have been methodologically approached influences the level of detail required regarding how they have been processed. The strength of the analysis depends on methodology, how the empirical evidence is interpreted and the reliability of the actual sources. The analysis is based on combining different sources, written records and different generations of maps to add information to historical maps. This process serves the purpose of analysing the situation at the time of the maps and the spatial and cadastral context that is relevant for an analysis of open fields at an earlier stage. How the sources have been managed and the different methodologies in georeferencing and spatial analysis and estimations are subsequently presented.

6.2.1 Map overlays and georeferencing

To generate spatial statistical data to estimate transportation/distances, the historical maps need to be georeferenced to a modern coordinate system and the modern map. However, adjusting and transforming an inaccurate geodesy in a historical map never produces one hundred per cent accurate rectification. All of the maps in the three studies were rectified to the modern map; however, to do this, different methods and computer software have been used, including *ESRI ArcMap* (GIS), *Adobe Photoshop* (Ps), and

Illustrator (Ai)[15]. Spatial analysis of historical maps is the fundamental method used in all three papers for overlays, and a GIS is used to generate statistical information to quantify and compare the spatial configuration of individual holdings, villages and field systems.

Making map overlays is about ensuring accurate quantitative measurements and understanding what is actually measured, that is, the plots that belong to which farm and the distribution of physical boundaries. The methodology to quantitatively and qualitatively process the maps in a GIS and to interpret the historical map and land use in relation to the physical 'modern' landscape is essential for the type of analysis performed in this thesis. Using the GIS to georeference historical maps is the customary analytical method in various historical landscape studies and to generate spatial statistical data for analysis. However, despite the mathematical capabilities of the GIS, the reliability of the generated data depends on the quality of rectification and adjustment of the historical maps. There are inherent distortions and deviations in geometrical maps that are caused by surveying methods that an automated rectification cannot compensate for and that require different methodological approaches to manage.

Georeferencing using a GIS

A raster image – the digital image of a historical map – does not contain spatial references. To measure acreage and distances, the map's image has to be georeferenced. The process of georeferencing historical maps is to assign known coordinates on the modern map by identifying a number of coordinates in the historical map that correspond to the same coordinates in the modern map. Property borders between settlements are quite stable over time and are, in many cases, reliable and identifiable, whereas road intersections can be useful, at least in younger maps.

To georeference the historical map, control points are registered and link the coordinates in the two map layers. The software is then able to automatically rectify the historical map to the modern map by aligning the registered control points. The quality of the identified and registered links affects the degree of transformation. The number of control points required depends on the geodesic accuracy of the historical map (Wästfelt 2020 pp. 6–10). At least three control points are required for a transformation as the historical map contains systematic deviations and errors.

[15] Esri ArcMap version 10.6. Adobe Photoshop and Illustrator CC 2017 and 2020.

The GIS software returns a measurement of errors, and the residual error is expressed as the RMS, which is the mean square root of the residual of each control point. The residual of each control point is the difference between where the point in the historical map ended up after the transformation in relation to the point on the modern map. A low RMS value indicates transformation accuracy but is only as good as the quality of the registered control points (ESRI 2020)[16]. In Paper 1, the historical map of the village of Kleva (1749) was georeferenced in GIS. Four control points were registered, and the RMS value of 1.6 indicates good accuracy and transformation. In this case, the map was initially adjusted to younger maps – the economic maps (1877–1882 and 1960) – to obtain a preliminary evaluation of the accuracy of the map and to identify potential control points. However, a low RMS value is not a guarantee for fully accurate georeferencing, similar to a high RMS value not meaning that the rectification is inaccurate (ESRI 2020).

There are difficulties and uncertainties associated with making an automated rectification based on identified control points that have to do with systematic, angular deviations and differences in scale and unsystematic distortions that are inherent in geometrical maps. These types of errors are related to the methodology used by the surveyors (Wästfelt 2020 pp. 1, 5–6). When there are errors in the original map, transformations are necessary (Affek 2013 p. 377). This is certainly the case when working with geometrical maps from the first half of the 17th century. The double intersection surveying technique used by surveyors in the 17th century meant that each station location was measured from two different positions. An area/polygon on the map was the result of a number of station points.

Unlike in modern surveying, 17th-century surveyors did not measure the distance between the station points and the measured object. The individual objects (polygons, lines) could be accurately measured, and the distance between different objects was inaccurate (Wästfelt 2020 pp. 5–6). These measuring errors require independent adjustments to achieve the best possible alignment on the modern map. Georeferencing in GIS is insufficient for managing these unsystematic distortions and results in erroneous alignments.

The georeferencing process is the balance between, on the one hand, the mathematical power of the GIS software in calculating and compensating for systematic errors in the original source and assigning coordinates to the

[16] The procedures for the georeferencing and mathematics performed in the ArcGIS Pro software are available via the ESRI ArcGIS Pro Desktop help: https://pro.arcgis.com/en/pro-app/help/data/imagery/overview-of-georeferencing.htm

historical map. On the other hand, making the best possible rectification of older maps requires a researcher's trained eye to make manual rectification(s). Managing unsystematic errors requires a combination of manual and automatic georeferencing methods.

Manual rectification

In manual rectification, different generations of maps from the 17th, 18th and 19th centuries have been used to ensure the most reliable georeferencing of the modern map. Manual rectification is a way to qualitatively compensate for unsystematic geometric distortions, and younger reference maps are used to identify and use points to match each map to the next chronological one, starting with the youngest. In Paper 3, different generations of maps are also used to reconstruct fence-organisations in which younger maps are used to complement and fill gaps made by older, missing large-scale maps. In Paper 2, storskifte maps are used to retrieve spatial information on soil quality. In addition, maps from the first half of the 18th century with an equal level of detail enable comparisons over time, continuity and changes.

In Papers 2 and 3, large-scale maps from the first half of the 17th century are primary source materials and are used for a spatial analysis of villages/hamlets and individual farms and plots. In the studies, all maps are georeferenced to the modern map, with varying levels of detail because the analysis is performed at different scales and requires different levels of detail. In Paper 3, the distribution of the fences and the spatial interlinking of villages and hamlets are in focus and do not require the exact rectification of arable land. However, the fundamental methodology using Photoshop and Illustrator to manually rectify the maps is used in both papers. In Photoshop, different raster images of maps are aligned in individual layers to the modern topographical or historical economic map, whose coordinate system and scale are known. The last step is to manually rectify the oldest map using the reference maps to properly align the modern map. The map layers are imported to Illustrator, which digitally redraws the oldest map using vectors to make a digital copy to trace borders, fences and individual plots. The rectified historical maps are then imported into GIS for georeferencing.

The process of rectifying maps manually involves different generations of maps – the modern topographical map and different generations of historical maps, both geographical and geometrical. As a reference map to

which the historical map(s) are rectified, the *Ekonomiska kartan* (EK) 1960[17] has been used. The EK is a historical map and was made based on aerial photographs specifics, such as property boundaries, farmland, buildings, roads and railroads. The EK was made on 5x5 km sheets, the same grid and scale used for the modern property map (1:10 000). The grid (vector file) is used to rectify the economic map to the modern map to achieve proper alignment and georeferenced in the GIS.

The method is to utilise a series of historical maps by working backwards from the youngest (the economic map) to the oldest geometrical map because rectifying two maps with fewer years between them is easier than trying to fit the oldest map to the modern/youngest. Rectifying a geometric map on an economic map is possible without additional historical reference maps, but the method is more thorough and reliable, in addition to being more time consuming. The method obviously requires the existence of several maps for the same village, which is the case in the study area. In the village of Segerstad (Paper 2), the *Häradsekonomiska kartan* (HK) (1877–1882), the storskifte map (1822) and the geometrical survey (1702) were used. In addition to the economic map, two or three historical reference maps were used.

The first step in Photoshop is to adjust all maps to a similar scale (1:10 000) to make proper alignments. This scale adjustment is approximate for the older maps, and fine adjustments are necessary because of the scale deviations from the measurement techniques by the surveyors and/or paper shrinkage (Wästfelt 2020 p. 3). Unsystematic errors become evident when trying to manually adjust the orientation and scale of the oldest map and to properly align the different arable areas in the image that was cut up into sections. Each section was then individually rectified to the modern map using additional historical maps to identify the actual location of arable land and its distribution. The different historical maps combined show the changes over time that provide the possibility to compensate for the measurement errors in the first survey. The manner in which the geometrical map was cut into sections is based on identifying these unsystematic errors when compared with the reference maps and the areas that require adjustments. After rectification, the map still needs to be georeferenced and set with modern coordinates. The image with the historical map rectified onto the economic map (1960) is imported into the GIS and, instead of georeferencing the oldest map to the modern map, the economic map is set

[17] Ekonomiska kartan was produced in 1935–1978 by a Swedish land survey at a scale of 1:10 000 (1:20 000 in the northern hinterland), and replaced the *Häradsekonomiska kartan* (1859–1934) 1:20 000.

with control points that are defined by the grid of the modern property map. Once the village is georeferenced in the GIS, the historical map is digitised in a separate shape file for statistical analysis. For a detailed analysis of holdings and individual plots, accurate georeferencing is needed.

Reconstruction of fence-organisations

Paper 3 analyses how villages and hamlets cooperated spatially, and the study involves both the identification and reconstruction of *fence-organisations* and georeferencing. In the geometrical maps, the surveyors were meticulous in marking out fences and borders. Fences are depicted to look like the actual wooden fences (*hankgärdesgård*) that represent the typical and dominating type and technique in Scandinavia. The land surveyors illustrated them in a pictorial and stylised manner, with transverse planks and straight poles in pairs (see Figure 12).

Figure 12. The surveyor marked borders between villages with a red dotted line. The borders in the two maps is not a perfect match but it is obvious that it was the surveyor intention. Note that the outer fence on the left hand side in the both maps, protecting the infield from animals getting in and out.
Details of the large-scale maps of Gunnestorp and Luttra (1645).
(Source: P3:176; P3:180a. Riksarkivet)

If there are no fences along a village boundary, it was marked with a red dotted line. If there is only a red dotted line, we know that there was no fence along that border. It is thus clear where the fences started and ended, enabling the reconstruction of complete fence-organisations. Figure 13 is a schematic reconstruction the result of the initial identification in the maps.

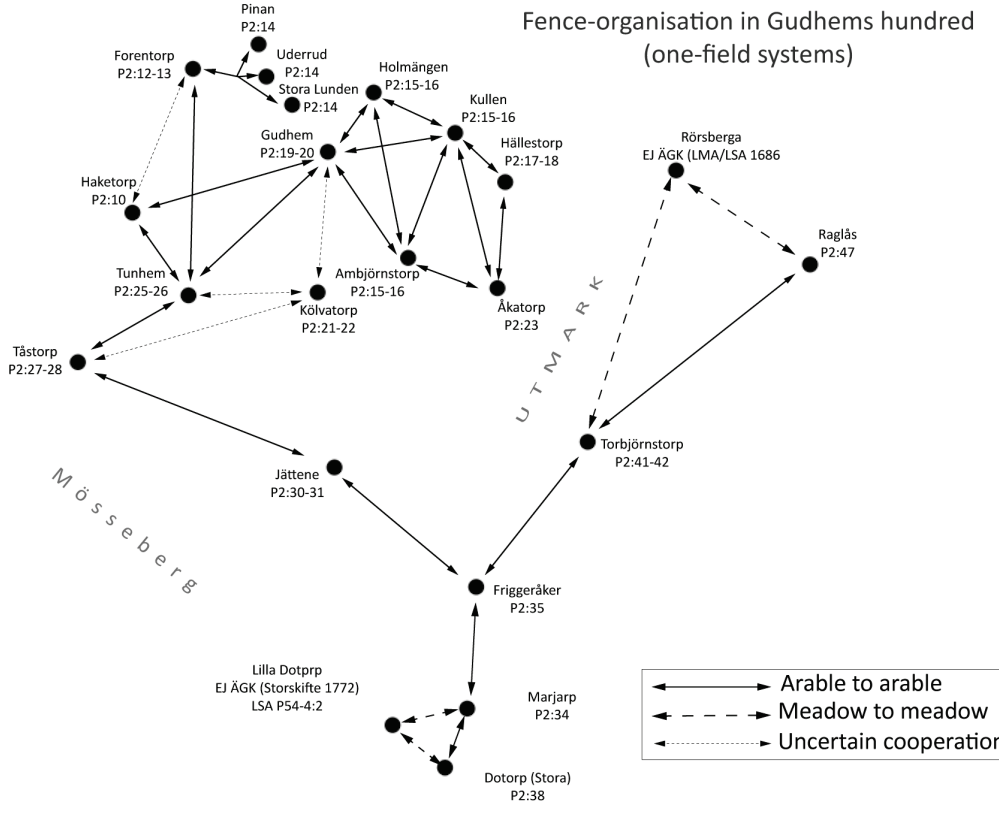

*Figure 13, Schematic reconstruction of a fence-organisation (*hägnadslag*) involving 22 settlements in Gudhems hundred, Skaraborgs County. The reconstruction is based on the large-scale maps from the 1640s. Not all settlements involved was surveyed, and the participation of* Lilla Dotorp *and* Rörsberga *that were surveyed in 1772 and 1686 is uncertain. However, the younger maps indicates that they were part of the fence-organisation and most likely in the 1640s as well.*

Digitisation and reconstruction of fence-organisations are performed in both Photoshop and Illustrator. As previously described, all geometric maps have been rectified in Photoshop using younger reference maps to adjust the scale

and orientation, to fit the oldest map to the economic map and to reconstruct how villages were connected to each other. The dataset with the reconstructed fence-organisations with rectified geometrical maps on the economic map, with each map in its own layer, is then imported into Illustrator to digitise the entire system. Illustrator is a powerful tool for drawing and digitising maps, is compatible with ArcMap (GIS) and supports the shape files used in the last step to georeference the systems in the GIS to measure the lengths of fences and borders. In this study, statistics on the acreage of arable land and meadow yields were taken from the maps and surveyors records in the text description.

6.2.2 Methods for analysis

Different methods for analysis have been undertaken in the empirical studies. In this section different methodological and technical aspects of combining information from different sources is discussed.

Crop yield numbers in storskifte maps

The implementation of the storskifte required surveys and maps that delineated the new division of the holdings. This proposed division was based on a detailed evaluation of the quality of the soils to make exchanges between neighbours and to consolidate holdings into fewer plots of land. The way this division was done and registered in the maps varies by surveyor, but all the specified and graded different areas were based on their capacity and crop yields. The method calls for digitising the surveyor's classification of soil quality in the GIS, creating a layer of the soil conditions at the time of the storskifte. To do this, the storskifte maps were thoroughly examined and interpreted.

In the studied villages, the storskifte was introduced at different times by different surveyors who recorded the soil quality in a slightly different manner in the studied villages. In two villages, the storskifte maps were made in 1774 (*Luttra* village) and 1775 (*Saleby* and *Slöta* villages), and the surveyors delineated the 'old' division in open fields. Each plot was assigned a number that was registered in the text description under the holding/farm to which it belonged, along with the quality and crop yield number for the specific plots(s). The proposed new division was also delineated in the map. In *Segerstad* village, the storskifte map was made relatively late, in 1822. The basic principle was the same; however, the old division was not specified, and instead, larger areas with different crop yields were delineated in the map. In the old division, a holding consisted

of 27 plots on average, whereas in the new division, farms held 6 large plots (arable and meadow). Within each farm's new holdings, different soil conditions were specified with different numbers representing different crop yields specified in the text. In the case of the village of *Brunnhem*, the surveyor specified the soil quality in the same manner, with the exception of specifying the boundary between different crop yields, which used only numbers throughout the map that corresponded to the soil quality. These different ways of registering the crop yield number have implications for digitising the information in the GIS.

The aim of digitising is to assign the plots in open fields with the crop yield value taken from the younger sources. In the first step, the areas specified with different crop yields in the georeferenced map are digitised in different layers (shape files). In the case of *Brunnhem* village, the different numbers were registered in the GIS with a point (with an assigned crop yield value). The GIS analysis tool *create Thiessen polygons* was used to create a polygon of this point layer. The tool creates proximal zones (polygons), which are areas based on the location of the neighbouring points, creating a statistical polygon layer. The second step involves merging the crop yield information with the open field layer, and the digitised geometrical maps (1640s) use the analysis tool *overlay > identity* in the GIS. This procedure cuts away the areas in the crop yield layer that do not coincide within any plots in the 1640 layer. Because of the way crop yields were registered in the 19th-century maps, the old plots (1640), to various degrees, have different crop yield values. The third step is to calculate a weighted mean value based on the area of the different crop yields within a plot.

For the villages mapped in the late 18th century, the process is different because the surveyors mapped the plots that were in use at the time of the survey. In addition to some expansion of arable land in the meadows, the division is, to a high degree, the same as that we find in the 1640 maps. Furthermore, in these three villages organised in a one-field system, the soil quality was homogenous, and the crop yields specified in the storskifte maps were registered when the older map was digitised. The data produced enable a cross-tabulation analysis and the calculation of a linear regression between pairs of variables, such as plot size, number of plots (farm, village), area and perimeter per plot, distance from settlement to each plot, distribution of crop yields and crop yield per plot.

Estimating transportation costs

In Paper 1, the time spent on transportation for each farm when preparing arable plots in a three-field system was estimated in three steps. The first step was to calculate the actual *Euclidian* distance between each farm and all of its plots. This distance was generated from the georeferenced map by joining layer attributes with the settlement location and arable polygons, based on location. The distance was automatically generated by the software and measured from the coordinates for the location of the farmsteads and the nearest point within each polygon (plot). The Euclidian distance is the shortest distance between the different points/coordinates; however, farmers most likely did not walk across other plots being prepared. Sources did not indicate whether farmers walked across unprepared plots, but it may have occurred. The soils in the studied village were for the most part light and sandy, and little evidence exists of ditches in arable land to hinder transport. The second step was to calculate the *Manhattan distance* to compensate for avoiding crossing over neighbours' plots. The actual distance between point A and B was increased by a factor of 1.3. This factor is consistent with studies on transportation in agriculture by Gonçalves et al. (2014) in which the Manhattan distance increased by a factor of between 1.2 and 1.4 (Ibid. p. 880). The third step was based on the farming practice specified in the parish description on the diversification of crops and the temporal sequence of preparing and sowing. Because many plots were designated for a specific crop, the number of plots depends on the amount sown of the different crops, and the plots were cultivated in clusters. All chores were carried out in each plot within the cluster, and transportation occurred between plots and not back and forth from the farm to each plot. The reduction in distance from working a number of plots at a time was estimated for one farm. The plots used for certain plots are hypothetical and based on the proportionate acreage of the individual farms and the acreage per crop required.

In total, in Field A, the distance travelled was reduced by 54 per cent, in Field B by 31 per cent and in Field C by 40 per cent. The reduction in transportation for the two fields was used to calculate the time spent on transportation for all of the farms. Finally, the time spent on transportation was estimated by multiplying the Euclidian distance by 2 (the total distance from the farm and back). This amount was then multiplied by 1.3 to generate a weighted distance (Manhattan distance) and to compensate for not crossing any arable plots. The weighted travelled distance was then multiplied by the reduction when working the plots in clusters in different fields. The final calculation was to multiply the estimated number of trips required from the settlement (4 times) because all chores were not carried out at once.

Estimating time consumption of arable work

The aim is to generate a crude but plausible estimate of time consumption for arable farming to compare arable work and transportation costs to conduct a time-geographical analysis of how the fragmented holdings in open fields were integrated into farming practices. Time consumption is estimated for the chores performed on arable land (ploughing, harrowing, sowing, compressing and transporting) for individual farms. The estimates are based on a practical experiment on ploughing by Karlsson (2015) and an agricultural reference book, *Lexikon för landthushållare* (1845).

The agricultural reference book provides information on numerous aspects involved in farming; however, the information is not very detailed, specifically regarding work on arable land. Under the heading plöjning (in English 'ploughing'), horses were estimated to be able to plough 0.5 ha in one day in moderately hard soils, whereas oxen could plough 0.375 ha. In heavier clay soils, horses could plough 0.375 ha in one day, and oxen could plough 0.25 ha. Thus, oxen required 25 per cent more time to plough the same area than horses. A key issue is that the length of a workday is not specified. Under the heading höbergning (in English 'haymaking'), it is stated that work from 9 or 10 a.m. until the evening makes a 0.75 workday.

Regarding arable work, the endurance of animals compared with that of farmers is the deciding factor. Myrdal (1981) makes estimations based on nine different reference books from 1690, 1780, 1801, 1850, 1866, 1886, 1921, 1926 and 1932 and estimates the average workday to have been 10 hours, even though the information in the sources varies significantly. Myrdal specifies that according to books from 1690–1850 and 1926–1932, the average number of workdays needed to plough 0.5 ha was one day. According to the book from 1866, two days were needed, and the books from 1886 and 1921 stated that 1.5 days were required (Myrdal 1981 pp. 151–2). According to Myrdal, the ploughing speed did not increase between the 17th and 19th centuries; in contrast, it decreased in the 19th century because leys and heavier soils were ploughed, and the ploughing depth was increased from approximately 10 cm in the 18th century to 18–20 cm in the 19th century (Myrdal 1981 pp. 153–4).

An estimate of one day to plough 0.5 ha is quite consistent with international research, which found that a medieval farmer could plough an acre a day (Dahlman 1980 p. 27; Langdon 1982 p. 38). A furlong was the length that a plough team could pull until it needed to rest, and in a day, a plough team could plough 22 yards, which equalled an acre (Bridbury 2008 p. 33).

Statistical analysis of GIS generated data

The analyses performed in Papers 1 and 2 are based on statistical data generated in GIS. Paper 1 mainly concerns distance and acreage in estimating time consumption for transportation and working the arable land. In Paper 2, the open fields in five different villages, two practising a three-field system and three practising a one-field system (continuous cropping), are compared based on the detailed statistics generated in the GIS. The primary source is two generations of maps for each village: a large-scale geometrical map depicting in detail the division of holdings and a younger map produced in the storskifte that provided spatial data on crop yield. The method combines information on the spatial organisation of open fields in geometrical maps from the 1640s and grading soils (crop yields) in maps produced during the land reform of storskifte (1774–1821).

The main method was to separately digitise each holding's plots and transfer the large-scale map into the GIS to calculate a number of variables of interest on three levels: the plot, farm and village levels. The data were organised in a database on these three scale levels, making it possible to analyse them. The data produced were analysed by cross-tabulation and a linear regression between pairs of variables, such as plot size, number of plots (farm, village), annual and total acreage and perimeter per plot, distance from settlement to each plot, distribution of crop yields and crop yield per plot. In addition, information from the original map on hay loads per farm, farm size and access and quality of outlying pastures and woodlands was included and compared with the data generated in GIS.

Retrogressive method and interpretations

The process of georeferencing historical maps relies on the continuity of various landscape features relating to settlements and (historic) land use. As previously stated, landscapes are polychrone and consist of multiple layers/elements from different historical periods that are visible in the physical landscape and evident when georeferencing a series of historical maps over the same village or hamlet. Georeferencing relies on the 'retrogressive quality' of maps and the continuity of physical elements, such as borders, roads and settlements, to achieve high quality in the alignment. The retrogressive approach is not at the centre of the analysis in this thesis, and the primary aim is not to trace the open fields visible in the historical maps back to their original state and origin. However, the possibility of using younger sources, such as maps, to analyse medieval conditions has been proven in several studies (Helmfrid 1962; Sporrong 1985; Tollin 1999).

In Paper 1, both the stability and changes in holdings and the spatial configuration of farms are analysed by combining historical maps with additional sources, cadastral registers (*Jordeböcker*) and tax registers (*Mantalslängder*). These sources provided a more complete picture of the conditions in the mid-18th century, on the one hand, the functional level and the actual number of farms that historical map do not provide. On the other hand, the map provides spatial information on how holdings were subdivided at an earlier point in time. The retrogressive approach provides insight into the development and changes in the physical layout of holdings and simultaneously offers a way to understand.

The retrogressive method has been proven useful but is also associated with the risk of misleading interpretations. Karsvall (2013) highlights three potential problems, the first being an exaggerated emphasis on continuity and stability in the agrarian landscape when swift changes are overlooked. The second is associated with the tendency to observe systematic elements in the landscape – a planned landscape. The third is the lack of contemporaneity of different sources and what is examined (Karsvall 2013 p. 432). In contrast, this is not a built-in problem of the method itself. The retrogressive approach is useful for identifying changes and comparing the older situation with the younger.

7 Summary of papers

7.1 Paper 1: The Function of Open Field Farming – Managing Time, Work and Space

The first study shows that farming practices are spatially and temporally linked to fragmentation as a way to manage time, space and work.

Open fields were the dominant agricultural feature in central, western and northern Europe for nearly a millennium. The spatial organisation of villages and the degree of communal management of common resources varied, but the basic characteristics of open fields were individual holdings fragmented into several small unfenced plots and intermingled into one or more fields, which were common features. Research on this subject is extensive, and several explanations for its cause(s) have been presented; however, the answer to its rationale and persistence over time is still up for debate.

The overarching aim of this paper is to present new findings concerning open field farming from a functional and practical perspective. The following three questions are raised. 1. How was the spatial organisation in open fields integrated into that practice? 2. What chores were involved in farming and how much tide did they require? 3. What were the transportation costs in open fields?

The empirical foundation of this study is primarily two large-scale geometrical maps, one from 1688 and the other from 1749 (Figure 14), and a Parish description of the village of Kleva in southwest Sweden that was written by the vicar in a Kleva village in the 1770s–1780s. The maps provide spatial information on the layout of the open field, the spatial configuration of individual holdings and the extent of the arable land. The parish description offers a detailed account of farming practices, including which ones and the amount of crops used, different chores, procedures for working the fallow and others. In addition, cadastres and tax registers have been used

to assess the actual number of farms at different times by tracing the subdivisions of cadastral farms.

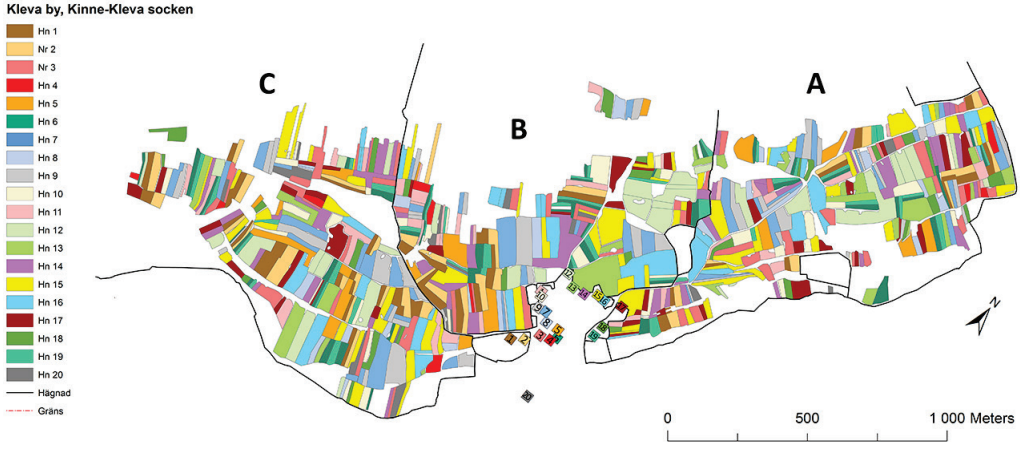

Figure 14. Digitalisation of the geometrical map of Kleva (1749).

Farming in the village of Kleva was organised in a three-field system in which farms held a number of plots in each field, allowing for the temporal and spatial allocation of arable work in spring and autumn. Plots are distributed in an unsystematic manner throughout the three fields and farm size, number of plots and plot size vary between farms. However, between 1560 and 1764, the number of holdings increased from 20 to 39. The cadastre of 1560 indicated that two cadastral farms were subjected to subdivision. In 1764, another nine cadastral farms were subdivided, which means that of the 39 individual holdings in 1764, 9 were never subjected to subdivision and, except for a probable increase in acreage, they remained unchanged (Figure 15). The subdivisions varied, and some cadastral farms were subdivided into two farms, whereas others were divided into up to 5 farms. By combining the information from the cadastre of 1560 and the map of 1749, the two early subdivisions were created by dividing each plot into two parts. The spatial configuration was maintained, and the size of the 'new' subdivided farms was reduced.

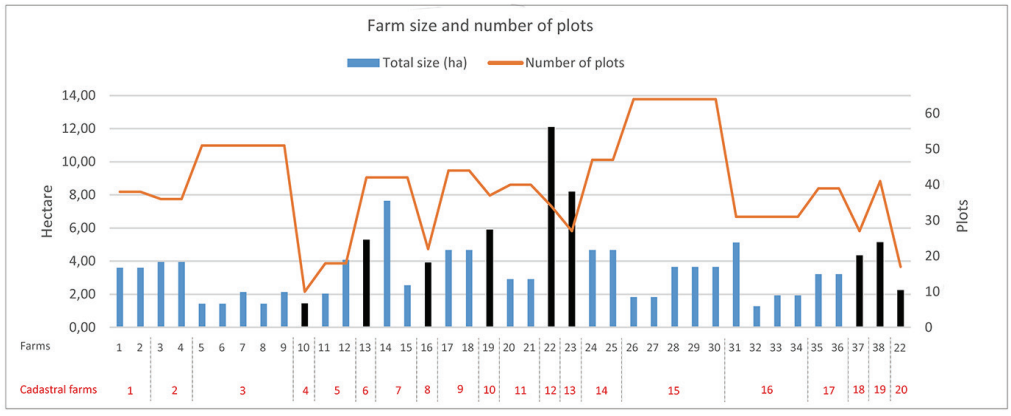

Figure 15. The diagram show acreage and number of plots per farm and which of the cadastral farms subjected to subdivision. Subdivisions are based on the tax register of 1764, and the acreage is taken from the survey of 1749. A total of 9 of the village farms were not subdivided, and these are marked with black bars (numbers 10, 13, 16, 19, 22, 23, 37, 38 and 39). The right axis and the orange line show the number of plots per farm.

The empirical evidence shows that work in the arable and the sowing of different crops were carried out in a sequence – one crop at a time. Furthermore, the sources indicate that the scattered plots in the open fields were integrated into this sequence and certain plots were designated for certain crops to be sown at a certain moment in time. Preparation of arable plots involved 4 chores, and each plot was worked for a total of 5–6 times by ploughing twice, harrowing twice and sowing (broadcasting) crops. For some of the crops, the soils were compressed (barley, mixed barley and oats). The estimated time required to complete all chores involved – to completely prepare and sow 0,5 ha – was 21 hours using horses or 25 hours using oxen as draught animals (transport excluded).

The method of combining two sources to provide a spatial context to written accounts on farming practices in the village provided for a detailed analysis of how farming was carried out and how diversification of crops was part of the temporal sequence in preparing and sowing arable land. Soil quality throughout the arable could not be determined, but different types of soils were most likely designated for certain crops as a way to optimise practice and outputs. The sequence is important to understand how work was spatially and temporally allocated and, by doing so, one (larger) or a number of smaller plots were cultivated for a certain crop to reduce transportation costs.

In addition to estimations of different chores, transportation was estimated based on the use of oxen as the draught animal of a wagon and on the

practice of sowing crops in a sequence and working plots in clusters, which reduces the amount of transportation because a farmer does not go back and forth to each individual plot. The results of the study in Paper 1 show that transportation was relatively low in relation to the total workload. The share or transportation of the total workload for the undivided farms (over 2 ha) was estimated at 14 per cent and was estimated at 22 per cent for the subdivided farms (over 2 ha). Transportation costs were low relative to the time spent working the arable land. For these farms, the transportation costs are not likely to be the deciding factor for open field efficiency or inefficiency. For the smaller farms (two undivided and twelve subdivided), the transportation cost was high and, in some cases, very high and actually required more time spent on transportation than cultivation. The cause was the reduction in farms' total size and, more importantly, the reduction of plot size when the spatial configuration and degree of fragmentation were maintained.

In addition to the importance of the number of plots and their distribution, the location and spatial characteristics of the fields affected transportation. In two of the fields, transport varied for different farms between approximately 5 and 45 work hours. In the third field, which was less elongated and had a larger portion in contact with the settlement, transportation was less prominent and was between 5 and 21 work hours. On average, 26% of the total workload was spent on transportation for the entire village.

The result from this study shows that fragmented holdings in open fields were closely integrated with farming practices, and scattered holdings allowed for precision in arable production and the temporal allocation of work in a sequence at different locations. This study presents empirical evidence for Stefano Fenoaltea's theory on spatial diversification in open fields. In the village of Kleva, the open fields enabled a precision in cultivation and a way to manage time, work and space.

The practice in the village of Kleva is not an exception but is common in the 80 parishes throughout the county of Skaraborg. Diversification of crops is present regardless of field systems, even though both the number and type of crops vary.

7.2 Paper 2: Function and spatiality – adaptation in open field farming

The overarching aim of this paper is to analyse the potential benefits and disadvantages of scattering by examining the inner diversification of unsystematic open fields in the first half of the 17th century. The analysis focuses on comparisons of the spatial configuration of arable plots (sizes, shape and localisation) and crop yields in individual plots. These variables are aggregated at the farm level, and comparisons are made among farms within each village and among farms in one- and three-field systems. By investigating differences in yields, scale and distribution of holdings in five open field villages and between these villages, a deeper assessment of the variations is used for analyses of possible adaptations, flexibilities and rationalities behind the differences and similarities. These detailed studies are used to discuss possible interpretations of the function of scattered holdings in different spatial settings.

This paper analyses differences in efficiencies and pros and cons with different spatiality's in two different field systems. Was the transition from a one-field to a three-field system a development to amend for an intensification and to increase arable production? The question of efficiency is in focus, but efficiency in a broader sense not only refers to productivity and labour inputs. In a context in which surplus production is not pursued, efficiency in production involves other parameters. Instead, it is the outcome and the possible pros and cons of production in different spatial arrangements/settings (field systems) with scattered holdings that are emphasised.

Empirically, this paper relies on the large-scale, geometrical maps surveyed during 1644–1647. The five villages studied were surveyed in the first large nationwide survey in Sweden during 1633–1655, when approximately half of Sweden's villages were mapped. The second source is maps of the same villages made between 1774 and 1821 – during the storskifte reform that sought to reduce scattering and reorganisation of the open fields. The maps produced in the first surveys of Sweden provide detailed information on the layout of the open fields and the spatial distribution of each individual holding. The storskifte maps offer detailed information on crop yields – the output potential of different parts of arable land. Scattered holdings were reorganised by exchanges between neighbours, and these exchanges were based on soil quality for each farm to receive the equivalent of the sum of the old plots in fewer plots in new, reorganised open field(s).

The studied villages are characterised by a mixed farming system in two different spatial infield(s) arrangements. The one-field system practices

continuous cropping with one large piece of arable land and a meadow field with scattered and intermingled holdings. However, an irregular fallow is practised in which individual plots are left to fallow over a number of years (4–6). The three-field system requires three open fields (a fourth meadow field is common) with scattered holdings and regular fallow.

The method used in this paper combines information in two map generations by transferring spatial information on crop yields in the younger storskifte maps and applying it to the spatial division of holdings in older, geometrical maps. All maps have been digitised and georeferenced in GIS to achieve proper alignment between the two generations of maps. Each holding (arable plots) in the older maps has been digitised individually to enable comparisons between farms. The areas of various crop yield numbers in the storskifte maps have been digitised. The spatial information in the two map generations was then merged, and the crop yield information is spatially assigned to the plots in the open field, (Figure 16).

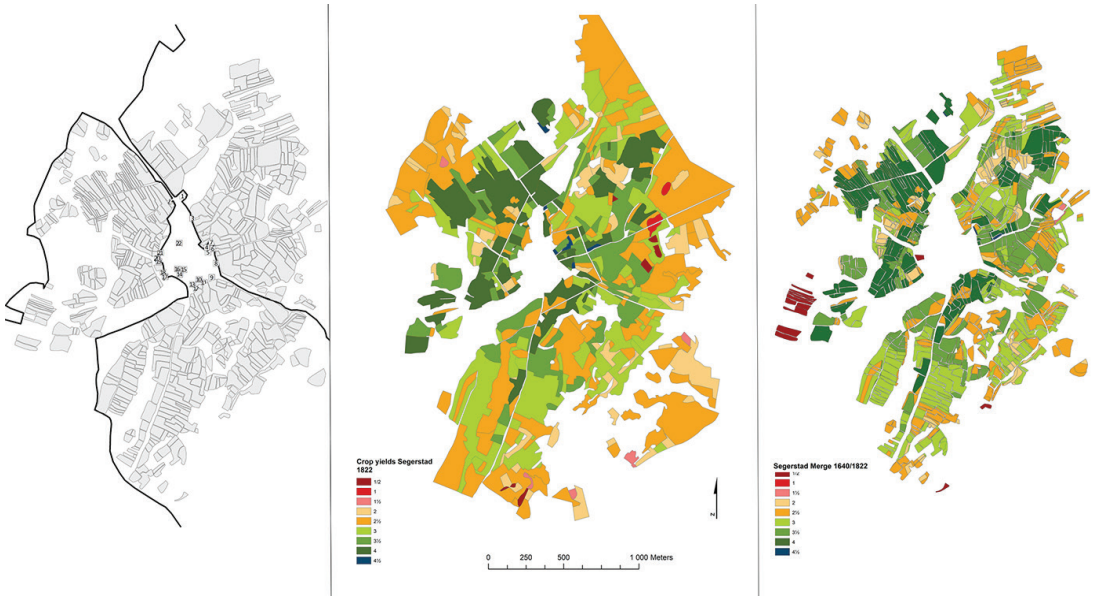

Figure 16. Merging of crop yield numbers generated from the storskifte map (1822) in to the scattered holdings in the large-scale map of Segerstad village 1644. The process involves several steps. The division of arable land in the older map (to the left) and the crop yield 'areas' in the storskifte map (in the center) is digitised. The map to the right is the result of merging the crop yields information in the storskifte and the scattered holdings in the old division.

By quantifying the inner diversification of holdings, the spatial configuration and characteristics of farms in the two systems with different variables are produced. The data produced are analysed using cross-tabulation and linear regression between pairs of variables, such as plot size, number of plots (farm, village), area and perimeter per plot, distance from settlement to each plot, distribution of crop yields and crop yield per plot. In addition, information is included from the original map regarding hay loads per farm, farm size and access and quality of outlying pastures and woodlands.

This study shows that there are fundamental differences between the two systems. The soil conditions in the two systems differ. The soils in the three-field system are fragmented and generally of poorer quality than those in the one-field system, which has soil of relatively high and homogenous quality. Soil quality is not sufficient to explain the degree of fragmentation in both systems, but it is more pronounced in the three-field system. Each farm held land in each of the three fields, and holdings in the three-field system were significantly more dispersed. The one-field system is characterised by large areas with homogenous quality and plots that are still intermingled but generally oriented in proximity to the farms. Soil quality cannot explain scattering in these systems – something else is behind the scattering. If good and poor soil arguments for scattering are not sufficient, then functional aspects might reveal answers as to why holdings are fragmented, including relatively insufficient access to pastures.

In contrast to the argument in Lindgren (1939), this paper implies that the logic of three-field systems cannot be understood as an evolutionary development to increase arable production but as a transition out of necessity to secure additional pastures. Villages in the three-field system reach higher labour productivity through grazing on the infields in sequence with the harvesting meadow and preparing fallow, harvest and autumn seeding. This praxis also gives rise to more diversified seeding and the time-spatial management of tasks.

7.3 Paper 3: Fenced open fields in mixed-farming systems – Spatial organisation and cooperation in southern Sweden during the seventeenth century

This paper analyses how villages cooperated spatially and functionally through fence-organisations (*hägnadslag*) in open fields in parts of early modern western Sweden. A fence-organisations is characterised by physical interconnections, through a reduction of fences, between villages that required synchronisation and cooperation in agricultural activities and organisation.

The organisation of fields and fences in agriculture that emerged during the Middle Ages and the early modern period was a complex system that combined individual ownership and the communal practise of arable land, meadows and pastures. This system was adapted for small and mid-size family-based farming and was another way to organise agriculture than medieval estates (demesnes) and larger coherent fields of the 18th century and onwards.

The last decade of research on historical geography and economic history has highlighted the origin of this system, often referred to as the open field – open in the sense that it promoted communal farming of primarily arable land. However, this pre-modern farming system was, in fact, a physically closed landscape in many areas – a landscape in which fences stood out as significant elements.

The empirical base is a reconstruction of fields and fences (fence-organisations) drawn from detailed large-scale maps dating from the mid-17th century. In Sweden, the use of wooden fences (Sw. hankgärdesgård) was common, but dry-stone walls and earthworks were also used in some regions, and a field in the Swedish context includes, by definition, a physical barrier. Fences and village borders are meticulously mapped out on the maps, which allows for the reconstruction of how villages were interlinked with each other. Historical maps focus on the collaboration and interaction between farms and settlements. We argue that the open field system cannot be fully understood without regard to an in-depth analysis of the fences and institutions holding the complex collaboration together. The occurrence or absence of fences in relation to open fields involves several questions: What are the characteristics of fences in the pre-modern farming system known as open fields? What can be said about the spatial distribution and interconnections between settlements sharing the same open fields? Could an agrarian landscape in which fences were prominent elements be considered open fields?

The results show that fences appear to be a key factor in understanding settlement patterns and open fields in Scandinavian regions. A large number of fences created small, fenced open fields. Moreover, the divisions of arable plots had less importance in the creation of open fields that appear as collaborations between settlements that included arable land, meadows and pastures. Hence, as a central part of open fields, farmers collaborated outside the village organisation. The regional differences within the system of open fields provide an understanding of the precondition and organisation of mixed-farming, combining small-scale arable cultivation and large-scale pastures.

Figure 17. Reconstruction of two fence-organisations on Falbygden. 14 settlements in a one-field system with 14 settlements, 115 holdings to the left and 14 settlements, 102 holdings in three-field systems in the fence-organisation to the right. These fence-organisations have been reconstructed based on large-scale maps from the 1640s.

Different open fields are delimited by fences regarding the cooperation between farms and settlements. To its core, these smaller fenced open fields could be understood as simultaneous collaborations among farmers on a different scale. The analysis shows two types of fenced open fields within the mixed-farming system: 1/ single, continuous open fields with many participants (the one-field system), and 2/ smaller open fields with fewer

participants who also participate in other, smaller open fields (three-field system and other regular fallow systems), see Figure 17.

This paper argues that the common denominator for open fields is cooperation among participants of a defined area – an open field. The existence or not of fragmented holdings is not the deciding factor, and the spatial division of arable land within a village is that village's concern. Furthermore, in a fence-organisation the degree of intermixture or the complete lack of scattering in a defined space do not affect the need for regulation and cooperation regarding the utilisation of that space.

The scattering of arable plots within settlements does not explain these collaborations. For instance, farms with no arable divisions could share meadows, pastures and fences with others in an open field farming system. Fragmentation of arable land is less important for the definition of smaller, fenced open fields in a mixed farming system.

The term 'open field' thus could refer to a single shared field and fence-organisations and to the regulations and institution of effective mixed-farming combining arable land, meadows and pastures.

The lack of grazing land (outlying pasture) in the three-field system appears as a possible explanation for the different forms of cooperation. The effort was to minimise the number of fences needed, but the cost (length) of the fences was double in a three-field system than in a one-field system. The fallow system offered solutions to overcome the lack of pastures by enabling grazing in different fields at different times.

A final conclusion is that open field cooperation, institutional rules and fence systems promoted efficiency, sustainability and utility in early modern rural society. The key to the function of the practice of open field farming was spatial and temporal cooperation and regulation.

8 Results and conclusions

As the title of this thesis suggests, its aim is to study the practical aspects and the function of scattered holdings in arable land and to understand the logic of open fields. What does this dissertation bring to the table that previous researchers on the subject over the last century have not already considered? The initial ambition was not to debunk all of the previous work and theories and to present a 'final explanation' but, instead, to analyse the sources and scattering in open fields in Västergötland in Sweden and to discuss the outcome of these studies in the broader international context of theories and explanations on the cause(s) and function of scattered holdings in open fields. Empirical studies are important, and theoretical models and explanations of open fields should be compared and tested based on empirical evidence. In this final chapter, I discuss the results and conclusions from the papers in relation to previous research on the subject and theories on the logic of self-sufficient family farms and time-geography to answer the general aim and research questions of this thesis.

In the first section in this chapter, the research questions are answered using the findings from the empirical studies and are discussed in relation to how they have been viewed and explained by other scholars. In the second section, a synthesis of and concluding remarks on the function of scattered holdings are presented.

8.1 Questions and discussion

The overarching aim and central question of this thesis are two-fold and relate to the basic function of scattered holdings and village organisations.

Question 1:
What was the purpose of fragmented holdings in open fields, and how was the spatial organisation integrated in farming practices?

In Paper 1, the practical and time-geographical aspects of open field farming, with a focus on arable land, was studied. The analysis of the village of Kleva combines spatial information in the survey map from 1749 and detailed information on farming practices in the same village in a parish description contemporary with the map. Furthermore, subdivisions of holdings are traced back to the mid-16th century, and the consequences of the spatial configuration of individual farms are discussed in comparison to farms that were never subjected to any subdivision.

This paper shows that farming is characterised by diversification of crops and that scattering catered to the diversification of time, space and work. Time is the most limiting factor in farming and can be saved and allocated towards different tasks but cannot be expanded (Myrdal 1981 p. 147). Scattered holdings enable a spatial and temporal sequence and crop diversification. Farming chores and the location of the work were integrated into the sequenced cultivation, and chores were not carried out one chore at a time but for a number of plots and for one crop at a time. The preparation and sowing of each crop were completed before the next crop was sown. This practice also reduced the required transportation costs because plots were worked in clusters.

An important variable of the required time spent on transportation is the spatial layout and proximity to the settlement. The overall layout of (open) fields influences transport efficiency, and an elongated field requires more transportation than a spatially compact field. Furthermore, the degree of subdivision has a negative effect on transportation because the spatial configuration of the 'original' holding was intact as the size of the new, subdivided farms decreased through the practice of subdividing each plot. Undivided farms (larger than 2 ha) spent on average 14% of the total workload on transportation, whereas subdivided farms spent 22%. Subdivided farms smaller than 2 ha spent approximately 50% of the total workload on transportation.

The manner in which scattered holdings were integrated into farming suggests that the division of arable land into several small plots offered precision when adapting practices to the phenology of crops (growth period) and the physiological conditions of the land. Furthermore, the division of arable land into several small plots offered an intensification of cultivation. In contrast to the assumption of the burdensome and time-consuming practice in open fields, this study indicates that scattering offered an efficient way to manage time, space and work. Farming is restricted by climate and seasonal changes, the length of the day and the labour capacity of those

involved. There are time-space constraints to what is possible to achieve in a day's work and if more hands are not available, then more hours or intensification is the only way to ramp up production. These constraints and restrictions were managed by scattered holdings by allocating work in the most suitable place for the most suitable crop.

The results presented in Paper 1 provide empirical evidence that supports Stefano Fenoaltea's hypothesis (1976, 1988) of spatial diversification and the allocation work in different areas at the most appropriate time. Fenoaltea's studies lack empirical evidence, and the analysis concerns regular common fields and systematic open fields – at least that is my interpretation. However, not specified but suggested is that '[t]he clearly superior solution … is a division into systematically diversified peasant farms; for if each peasant landholding, large or small, is a microcosm of the entire arable, then the optimal allocation of the village labor to the village land characteristic of the village-wide farm is exactly reproduced' (Fenoaltea 1988 p. 191). Papers 1 and 2 show that a 'microcosm' of the entire arable land is not reproduced, that scattering in villages in southwest Sweden was highly unsystematic and that the spatial configuration varied between farms. However, the solution presented by Fenoaltea can be applied regardless of whether the diversification was systematic or unsystematic.

Fenoaltea argues that one of the keys to understanding scattering in open fields is the spatial diversification that actually increased productivity and did not decrease it, which is suggested by others, such as McCloskey (1972). In Paper 1, no estimations of productivity were possible; however, maximisation does not necessarily mean higher outputs. Chayanov's theory on consumer work balance suggests that non-capitalistic family farms were more concerned with balancing the ratio between work and consumption and that surplus production was not wanted if the annual product was adequate for its needs. Any increase in production required an increase in labour and, according to the operational logic of the family farm, lacked the incentives to seek profits. The increase in labour costs was unwanted and, in that sense, unproductive. However, a tolerance level exists in changes in this balance and the degree to which a family farm could handle an increase in the drudgery that is related to demographic factors of family size and number of and age of the children.

The key to an increase in productivity is intensification, that is, the number of times a certain area is worked/prepared before sowing (Myrdal 1985 p. 92). A block or strip of land that is ploughed one time and then sowed yields less than if the same area is ploughed two or three times, run over with a harrow two times and then possibly compressed. Working the fallow also

increases the output, and the same principle is relevant here: the number of times the fallow is worked, the better the outcome. Myrdal technological complexes exist in which one or more technological innovations enable or lead to new practices. The development of tools influences farming practices and, subsequently, has spatial consequences. In the same way, open fields can be incorporated into a technological complex as a spatial consequence of intensified arable farming in which the increased number of times that arable land is worked is balanced by a more or less appropriate plot size. Paper 1 shows that small plots (less than a day's work) were worked in clusters that reduced transportation, and the spatial distribution of holdings was in this way implemented in the overall sequence of time and work.

Much of the research has been performed on open fields in contrast to enclosures. McCloskey argues that the persistence of open fields 'after all, must be related logically to the reasons for its eventual dissolution' (McCloskey 1975 pp. 73–4).

However, this thesis refutes the notion that the driving forces and reason for villagers to choose to enclose were to achieve what was not possible within the open field system – an increase in productivity. In England, most villagers were actually opposed to enclosing (Clark 1998 pp. 74–5), and a reluctance towards reorganisation was also common in the Swedish storskifte (Helmfrid 1961). The number of villages that actually reorganised was in the minority at first. Not until the legislation changed was it stipulated that if one farmer wanted to enclose, then that was enough to carry it through. This is obviously not evidence for the efficiency of open fields, but rather the weight of tradition; yet, it is an indication of who would profit from it? The interest from farmers was at least, initially, cold.

Various hypotheses on the cause of this development have been suggested for institutional explanations, and property rights were strengthened, imposed by landlords and large non-peasant farms (Brenner 2001 pp. 297–8). Others stress that it was a bottom-up development by farmers (Allen 1992; Svensson 2006). Allen argues that these changes and the following increase in agricultural output occurred within the open fields and was what Allen calls the 'landlords revolution' that imposed enclosures – farm consolidations – but had little effect on growth (Allen 1992 p. 310). Surely, behind institutional change lays inventions – implementations of new ideas and technology that spur productivity. Francesca Bray (1985) discusses the development of new ideas and innovations in agriculture (comparing China and Europe) and argues that, before the 18th century, innovations were not achieved by experiments by educated scholars but almost exclusively by peasants, and agricultural works were based on the efforts made by

husbandmen (p. 90). Developments after the 18th century were the opposite, and a 'quantum leap occurred: agriculture was transformed from a traditional skill to an experimental science', and new ideas and innovations were spread in various agricultural publications, pamphlets and books, among others (Bray 1985 pp. 90–2). Other explanations suggest external factors affecting agricultural production: urban markets and increased demand for agricultural products induced productivity. McCloskey (1975) argues that open field villages in (relative) proximity to markets enclose earlier than those further away. Furthermore, stable prices, increased trade facilitated by deregulation were incentives for increased productivity and economic growth.

Most studies on growth in the agricultural revolution have been estimated at the macro level. Olsson and Svensson (2010) use micro-level data in their study of institutional change and agricultural outputs. Their study shows that production more than quadrupled and that secure property rights were an important factor, together with fixated taxes and rising prices. Freeholders produced more than other tenants under the crown or nobility (pp. 296–8). The debate on the effects of enclosures on productivity concerns increased rents on enclosed land opposed to communal land.

Using Arthur Young's data from 1799 that show that rents doubled on enclosures, which was also interpreted as an increase in productivity, McCloskey estimates an increase of 13% (McCloskey 1975 p. 87)[18]. However, Allen (1982 p. 949) argues the opposite – that yields of common fields were higher than of land held in private, which was also based on Young (1770). How open fields have been viewed is closely linked to enclosures and the development of agricultural practice up to the modern era, and the comparison between farming in consolidated holdings and those held in common is inevitable. However, the risk exists of using the wrong variables when evaluating past practices and ways to spatially organise farming.

According to Clark, the privatisation of land through enclosures increased productivity and 'even the least successful of these enclosures were enormously profitable. Here was profit without risk' (Clark 1998 p. 74). The data indicate that between 1600 and 1839, there was a doubling of returns on enclosures. The question is why open fields were not enclosed earlier and in a more widespread manner (in England) when the returns for the landlords were high, and different explanations have been suggested. According to

[18] There is no reference in McCloskey (1975) regarding the basis for the 13% reduction of outputs. In McCloskey (1972 p. 35, note 15), the calculations of rents are based on, among others, Arthur Young's *Agricultural Survey of Lincolnshire* 1799, pp. 77–83.

McCloskey, open fields were efficient in providing insurance through risk aversion and scattered holdings in the absence of markets, whereas other explanations are that enclosures favour larger landholders and small holders, and therefore, the landless lose. In an English context, the landlord was strong enough to impose enclosures, whereas the smallholders and peasantry in other parts of Europe were generally stronger and, even though enclosures were advocated by experts, there was a reluctance among open field farmers (Clark 1998 pp. 74–5).

Allen (1992) supports Fenoaltea's hypothesis and argues that open fields were indeed efficient – even more efficient than land held in severalty – and shows that open fields produced higher yields than private farms (Allen 1992 pp. 130–149). According to Allen, enclosures were a redistribution of the 'existing agricultural output' and did not increase efficiency but raised landlords' incomes through rents that were increased to market value (Allen 1992 p. 181). However, Clark argues that Allen raises new problems instead of resolving the one under examination. That the difference in rents on open land as opposed to enclosed land were double has been identified as early as the mid-15th century, and the explanation for why rents were lower than market value is that there was a common belief that private land was worth double the value of open fields (Clark 1998 p. 76). Clark argues that the costs of enclosing were high, the actual gains were small, and the enclosure was the 'result of changes in the costs and benefits of enclosure, not institutional innovation or a new profit-centered ethos in the countryside' (1998 p. 77).

The discussion of rents and the productivity, efficiency and inefficiency of open fields can lead to misguided conclusions. As Paper 1 shows, the development of holdings in the village of Kleva eventually led to a situation in which the benefits of scattered holdings of the open field in its 'prime' became unsustainable through population increases and continuous subdivisions of holdings into smaller and smaller farms. The reasons for the dissolution of open fields do not necessarily have that much to do with their function. In this sense, viewing open fields through the glasses of modernity might blur rather than sharpen the analysis.

McCloskey's economic perspective is contradicted by the Chayanov perspective that the economic behaviour of peasants was not driven by profits. Chayanov's family farm persisted despite conditions that required more work, lower prices and no net surplus when a capitalist farm would have gone bankrupt (Thorner 1986 p. xviii). This thesis argues that Chayanov's theory brings an important perspective to understanding the purpose of the open field farmer. However, Chayanov's analysis is in a sense clinical and strictly focused on the economics of the family farm and not the

broader communal context of the village or the spatial arrangements and preconditions.

The first research question might be rhetorical, and farming practice extends beyond arable land to include other aspects in the mixed farming system, meadows, managing grazing on the fallow and stubble, access to outlying pastures and other resources and fence-organisation. All of these required timing even though the labour input was less than that for arable land. A delicate balance exists in the mixed farming system when managing these various activities regarding work input and temporal restrictions. Thus, the institutional organisation of these different activities and of the open field village is important to our understanding of its logic. Because the scattered holdings on arable land are intermingled, other activities are also, in a sense, 'intermingled'. Meadow plots are distributed in the same manner as arable land, and the utilisation of fallow pastures and outlying pastures are communal. The responsibility of maintaining fences was individual, and the fences were divided into sections in which each farm/individual was responsible for a number of sections that related to their share of the arable land (Paper 3). The share principle is fundamental, and the individual's responsibilities and rights are related to their respective shares of the village. Undoubtedly, an egalitarian aspect exists to scattering in open fields in the sense that each farm held plots in each field, in close proximity and in peripheral areas of the arable land, as well as in between. The evidence of any equitability distribution and the theory of risk aversion are further discussed in the second question.

Scattered and intermingled holdings facilitated the efficient management of time, work and space. The temporal aspects of farming are essential regarding both allocating work and the time required to execute different chores in cultivation and the timing of these activities – the 'right time' to act to ensure the best conditions for the right crop in the right place for a good harvest. Spatial organisation was integrated into farming practice and allowed for a spatial and temporal sequence and the diversification of work and crops.

Question 2:
Was the spatial division of holdings equitable and does the empirical evidence support that scattering in unsystematic systems reduced risks?

In the Swedish context, the unsystematic scattering patterns outside the region of the systematic solskifte system were considered somewhat of an enigma – an unsolved puzzle. The solskifte is associated with a defined land

assessment unit related to farm size and the apparent systematic distribution of holdings in proportion to their shares in each field and furlong. The open fields in the county of Skaraborg lack any land assessment and equitable and proportionate division of holdings. The principle of egalitarianism – of each farm participating in good and poor soils – has been difficult to apply.

In Paper 2, the spatial layout of villages and holdings in unsystematic open fields is analysed and farms in one- and three-field villages are compared. The evidence of 'spatial equity' in the layout of open fields is inconclusive, and farms in both field systems show a variety in size of plots, spatial distribution (distance from settlement), in the number of plots and their shapes and output potential (crop yields). A strong correlation exists between low crop yields and distance from settlements in one-field villages, suggesting the conversion of meadows to arable land at a later date. In three-field villages, the spatial distribution of crop yields is, to a higher degree, variable. However, the tendency is that crop yields decrease with distance but not as pronounced as in the one-field system.

No clearly defined furlongs exist in either field system, and the statistical and spatial data do not support division based on egalitarianism. Distinct differences exist between the one- and three-field systems, and the plot size and number of plots are greater and the distance per hectare (per farm) is more than double that of the one-field system. Furthermore, access to outlying pastures (*utmark*) in the one-field system is generally good and, in the three-field villages, access to pastures and woodlands is either sufficient or lacking. The correlation between field systems and access to extensive pastures has been concluded to be an important factor in the transition to the three-field system (Paper 3).

The geographer Gunnar Lindgren (1939) hypothesised that the three-field system was the result of a transition from the one-field system and that the redistribution of holdings was carried out by exchanges. Each farm in the former one-field system split its larger, block-shaped plots into three smaller sections. Certainly there are many three-field villages with what is generally referred to as strip-fields, however, his is not consistent in all villages, and large block-shaped plots does not characterising of all one-field villages (see Figure 18–19). Each farm then swapped two of the three new smaller plots with its neighbour(s) to get land in the other two fields. The assumption that Lindgren makes is plausible to some degree by observing that some of the one-field villages did not change to the three-field system, but these characteristics are not consistent. Furthermore, the correlation between the dispersed settlement in one-field villages and nucleated settlements in three-field villages, as suggested by Lindgren and Gadd (2018) is inconsistent. The

exchange hypothesis indicates that the dispersion and degree of scattering were the effect of the redistribution of properties to ensure that each farm participated in all three fields but does not suggest equal distribution.

Figure 18 & 19. To the left the three-field system in Ranstad village (1644–47) Stenstorp parish, with predominance of block-shape plots. To the right Lovene village (1645), Karleby parish, with continuous cropping in one field with long narrow stips in the arable. Narrow strips are not necessarily a key feature in the three-field system and neither is block-shaped plots in the one-fields. This does not contradicts Lindgren´s (1939) hypothesis of exchanges in the transition from one- to three-fields but it was not necessarily thru splitting. In the case of Lovene it is plausible that the strip-shaped plots relate to function rather that reorganisation. (Sources: Ranstad P2:55-56; Lovene P3:171 Riksarkivet).

In addition to Maitland's (1997) and Vinogradoff's (1892) egalitarian explanation, McCloskey's (1972) concept of scattering to reduce risk gained broad support. McCloskey's hypothesis on scattering as a way to reduce risk does not suggest that risk aversion was the initial cause of scattering but that risk aversion could be the effect or function that can explain the long

persistence of the open field system (McCloskey 1991). Without existing markets for providing insurance or the possibility of insurance through storage spatial diversification by scattered holdings, land was held in areas sensitive to droughts or floods to ensure at least some harvest, even if disaster struck. The argument is that the system is upheld as long as it is economically rational and the system is abandoned when economic conditions change.

A criticism is that McCloskey restricted the discussion to the common fields of the English Midlands and that the theory is not applicable to other regions in Europe with different types of open fields and other geological conditions –not solely the heavy clays that characterise some but not all common fields. This criticism has apparent implications on the validity of risk aversion in systems with scattering but that are situated in completely different spatial contexts. Another issue is that risk aversion only protects the individual farm against crop failure, not the village as a whole, and in a manorial system the land owner loses. The problem with this argument is that it is difficult to prove and assumes that the open field farmer is aware of the risk-reducing effect, and farmers and land owners acted to reduce risk by scattering (Dodgshon 1980 p. 23).

The risk theory is problematic because it is difficult to prove. McCloskey suggests that her calculations on aggregated data on annual yields for a number of years from enclosed farms and scattered holdings on demesnes within the same region show the risk aversion effect. However, these data have been criticised as biased and exaggerated (Bekar & Reed 2003 pp. 315–6). McCloskey's logic is that risk aversion is the only explanation sufficient for why the open field farmer accepts the inefficiencies of scattered holdings and lower productivity relative to consolidated holdings. This argument has some backward logic to it. It is difficult, if not impossible, to know what the open field farmer thought, and it is unlikely that they were aware of what they were missing in productivity. The argument is based on the economic rationality of humans, and peasants adjusted their manner of production and the spatial organisation of open fields, and enclosed when it is more economically efficient.

In a recent study, Nyström (2019) argues that McCloskey's risk theory is valid in both open fields and on enclosed farms. According to Nyström, scattered holdings provided risk aversion in non-catastrophic years but that the reversed pattern – that enclosed farms performed better – is evident in years with severe crop failure. The explanation presented is settlements in close proximity to the arable would thereby be more carefully managed than in scattered holdings. Improvements in farming technology with better ditching and more thorough preparations protect crops during lengthy

periods of rain, which on the other hand, are not favourable during droughts (pp. 187–9). As for the criticism of McCloskey's data, a bias exists when a long series of aggregated data does not include the size of the arable land, changes over time and the use of fallow. Changes in practice and the amount of land put under the plough can potentially affect the interpretation of performance and the correlation with risk aversion.

The example of the one-field system (Paper 2) shows that soil conditions and output potential are stable and evenly distributed throughout arable land and a transition to a three-field system never occurred. Still, holdings were scattered – not to the same degree – and clustered instead of dispersed but divided into several small plots. If risk aversion under such conditions was unnecessary, then why were holdings scattered? According to McCloskey, a higher degree of scattering is unnecessary if the natural conditions did not require it. An interpretation is that the cause of scattered holdings points towards functional and practical reasons. Transportation costs were negligible, even more so than in the three-field system (Paper 1), given the possibility of convertible husbandry and precision in fallow with easier access to distributed manure and good access to pastures. The time-geographical constraints are similar to those of a consolidated holding with the exception that the communal arrangement of open fields did not require fencing costs.

Finally, the concept of scattering as insurance against risk and crop failure corresponds to the notion that scattering compensates for wet and dry areas and good and poor soils. Risk aversion could thereby be linked to the shareholding principle and the egalitarian explanation. The shareholding principle is evident, and the correlation between shares of arable land and, thereby, the corresponding responsibility of a number of sections of the fences (Paper 3) suggests a proportionality and communal system based on shares. To what extent shares correspond to other aspects, rights to pastures, fallow grazing and others has not been studied. The communal organisation of villages and the individual's rights and responsibilities towards the collective indicate egalitarianism even though this is not reproduced in the spatial distribution of holdings in arable land (Paper 2). Nevertheless, avoiding risks or, rather, ensuring the best possible output is fundamental in agriculture.

The studied open field villages are characterised by a strong communal organisation, and the rights and responsibilities of each farm were based on egalitarianism. However, no empirical evidence exists that supports scattering and the spatial configuration of holdings based on equity. With varying spatial

distributions of holdings, the degree of risk aversion at the farm level has been highly variable and have been provided for some but not all.

Question 3:
What role did fences play in the open-fields and what constitutes the common denominator of open-fields?

Agriculture in Europe before enclosures and reorganisations in the 18th and 19th centuries is characterised by both consistency and variation. On a local, regional and even national scale, there are variations in the spatial and organisational characteristics of open fields. Various patterns of distributions, shapes and sizes of plots, field systems and degree of communal regulation form different *types* of open and common field systems. In contrast, elements of consistency exist in all of these different types of systems characterised by small-scale arable farming in a mixed farming system. On a broad scale, we can talk about a common practice rather than a system. The scattered plots correspond not only to intensive farming but also to the institutional arrangement of villages, individual ownership and communal regulations and property, the temporal alternation of private/individual holdings and communal rights in the same field.

In the Swedish context, fences were a key component of the open fields. In Paper 3, the communal organisation of farms beyond the confinement of the village or hamlet in larger fence-organisations is studied. This study examines two fence systems and reconstructs how villages were spatially and organisationally interlinked, thus forming greater cooperation: *fenced open fields*. These fields could be understood to be a simultaneous collaboration among farmers on different scales. They shared arable land, meadows and pastures and synchronised their work with other settlements. They also shared the responsibility of keeping fences. The collaboration occurred both within and between settlements and, together with others, formed a group of functionally coordinated settlements. Hence, the term 'open field' referred to a single shared field and fence system but also the regulations and institution of effective mixed-farming combining arable land, meadows and pastures.

These systems have different spatial expressions in which in the one-field system, one large area with a common outer fence forms a continuous open field with many participants. In the three-field system, the fence organisation is characterised by several smaller open fields with fewer participants. In both types, open field organisations were based on agreements between settlements. The scattering of arable plots within the settlements does not

explain these collaborations. For instance, farms with no arable divisions shared meadows, pastures and fences with others in an open field farming system. The conclusion is that the scattering of holdings in arable land is less important for the definition of open fields in a mixed farming system.

The analysis of maps in the three papers has challenged the basic definition of open fields or, at least, put forward some empirically founded evidence that the feature of small-scale and fragmented plots is not exclusive for villages and hamlets. Put another way, the 'feature' or practice of cultivation in several small plots is present in single farms and dispersed hamlets with consolidated holdings without physical boundaries separating them. In single farms or dispersed hamlets in which each farm had a defined area, there was no need or incentive for a division based on shares or piecemeal colonisation of the village (hamlet) domain. Still, these farms cooperate or could cooperate (it is not always the case) in fence organisations with common pastures on the infields after harvest. The existence of several plots in privately consolidated farms indicates that the functional and practical reason is to be found in intensive, small-scale cultivation.

The institutional arrangement within fence systems functioned at different scales and relied on the individual ownership of and responsibility towards the collective. The practice of tethering is a good example of this. Tethering occurred to some extent in Swedish open fields. However, tethering had 'communal' implications. An example was a court case in Falbygden in which a farmer had let his meadow plot(s) be grazed (tethered) but was accused of 'withholding' pastures from his neighbours (Lindgren 1939 p. 155–7). A farmer allowed tethering on his land, but when all of the animals were let out onto the field for communal grazing, including onto farmers' plots that had already been grazed, he benefitted from other farmers' plots, but they could not benefit from his. The problem is obvious – individual freedom and rights had implications for the communal responsibility and rights that accompanying private rights in open fields.

The basic characteristics of Swedish open fields are consistent with other parts of Europe and represent an agricultural system based on mixed farming in an institutional arrangement of individual rights and communal responsibilities. This thesis argues that although scattering is present in most open fields, it does not define them all. In fence-organisations (fenced open fields) in which two or more settlements (villages and/or single farms) are spatially and functionally interlinked, cooperation among their participants is the common denominator of all open fields.

8.2 Synthesis

In this thesis, open fields have been examined at different scales, from a detailed analysis of individual plots and holdings to larger systems and fence organisations that involved several villages. To answer the question of why peasants scattered their holdings, this thesis has shown that we have to understand how holdings were utilised in practice. Open fields are spatial arrangements in a communal context with private ownership and individual responsibility and rights with varying degrees of communal regulation. A detailed spatial analysis of the configuration of individual farms is required to understand their existence. It is a strictly practical undertaking that relies on the knowledge of the individual farmer within a collective body or space of a communal organisation. Thus, the practical undertaking of farmers within a village that involves both constraints and provide security, is to minimises the division of labour. As humans, we tend to live in groups and communities, and open fields always exist within a community. To understand scattering, we have to understand the cooperation among the participants, the time-geographical prerequisites surrounding agriculture and the purpose of farming for the individual family farm.

The spatial arrangement in open fields allowed for a sequence to allocate work and crops to specific areas at a particular time. Time, work and space are fundamental variables that, in some sense, work against each other. Increased acreage allows for higher outputs and requires more work and time. Although time cannot be expanded, intensification is possible if additional labour is available. The conclusion in this thesis is that, in addition to the disadvantages and drudgery of manually driven agriculture in general, scattered holdings should also be interpreted as a solution that allowed for spatial and temporal precision in farming.

Turner (1986) argues that a key to understanding the higher yields in enclosed farms is the reduction of fallow. It is not the yields per area unit (plots) that increased, which were the same as in open field plots, but the efficient and precise use of fallow led to an increase in the annual acreage. This can obviously not explain the increase in agricultural output in the late 19th and early 20th centuries, but it points to farming techniques and changes in production rather than the costs of scattering. The results in Paper 3 support both Turner and the argument that the precise use of fallow supports higher yields. In the one-field system, crop yields are higher than those of the three-field system. The one-field system practised an irregular, long fallow of individual plots in which one plot could lay fallow over 4–6 years until it was used again as arable land. Holdings were fragmented, but plots were in closer proximity to the farm, and several plots could be allocated

side-by-side within a certain area. However, it is not an enclosed system – it was a communal field with scattering. The higher yields are likely the result of easier access for manure with less transport and somewhat smaller acreage. In contrast, the one-field system was open field farming, production was communally regulated (work was individual) and the spatial distribution of plots does not support a spatial organisation to minimise risks.

Different field or fallow systems had implications on the degree of scattering. The three-field system resulted in an increase in labour input in transportation but simultaneously offered spatial diversification and, to some degree, flexibility, even though it is likely that it was introduced out of necessity because of insufficient access to outlying grazing land. Three arable fields with an additional fourth field (common in the study area) were different fields that could be utilised for different purposes at the same time. It is plausible that the three-field villages have higher labour productivity because they do not need to look after animals that, instead, are grazing in the fallow, meadows and/or fenced open fields in sequence from spring, summer and autumn. In this way, they could reach higher labour productivity by grazing on the infields in sequence with harvesting meadow, preparation of fallow, harvest and autumn seeding.

Unsystematic open fields were based on shares, and the regulation of responsibilities and rights is based on equity among the participants. However, this is not 'repeated' in the spatial division of holdings. Scattering is individual and seemingly random in its distribution. Whether such a random distribution actually corresponded to equity, but an uneven 'equity', is uncertain. Even in the one-field system, with relative homogenous soil conditions throughout the arable land, holdings are still scattered, which shows that the division into smaller plots is related to practice rather than necessity. The increase or higher degree of scattering in the three-field system has a negative effect on the work-transport ratio, which in a sense is a trade-off for additional pastures and the diversification of work and space. Although there is an increase in acreage in a transition from the one-field to the three-field system, the annual acreage per farm is more or less the same (Papers 2 and 3), whereas the required transportation increases. This negative effect is more pronounced in a subdivision (Paper 1) in which each plot is split by the proportion of transports in relation to acreage and workload increases.

The main conclusion that this thesis promotes is that there is a fundamental component in open field farming, besides scattering itself, and the division of holdings in several small plots has to do with scale and functionality. Efficiency is correlated with scale – the physical scale of a plot,

and a small plot can produce a higher area-productivity than a large plot. Various field patterns, such as the size and shape of plots and the size of arable land, depend on geographical context and preconditions. The correlation between size, productivity and manual labour is arguably the foundation in an open field system. Still, small-scale, intensive cultivation can be achieved in consolidation though several small plots. This does not refute the arguments of this thesis or Fenoaltea, but the efficiency, in the sense that it produced the necessary output to satisfy needs without labour costs becoming too large, does not solely derive from spatial and temporal diversification.

Large open fields – fence-organisations (*hägnadslag*) – composed of interconnected villages an arrangement that reduced the length of fences along the village borders required cooperation. However, there is no economic or work-related reason for not cooperating. In contrast, the arrangement saved material and labour costs. Synchronisation in practice was already required within villages, and extending cooperation with neighbouring villages is an extension of an institutional arrangement that communal practice already established. Whether holdings were scattering in both arable land and meadows is argued as not being the denominating factor of whether such an area should be defined as an open field. The existence of loosely connected villages with dispersed single farmsteads (with a common place name) without intermixed holdings – but with arable land divided into a number of small plots – further strengthens this argument. These villages can have a common outer fence; however, no inner fences separating the infields and, thus, forming an open field without intermingled holdings is still – or is in this thesis – considered an open field. What ultimately defines examples such as these as open fields is both the open physical landscape and, more so, the requirement of the cooperation and synchronisation of key activities of farming that are similar to that of scattered holdings.

In addition to the spatial, temporal and functional aspects of open field farming, this thesis argues that the efficiency of scattered holdings also correlates with the scale of the operations and the intensive cultivation that small plots offer. Area productivity and the inverse relationship that describes that productivity decrease with an increase in scale, and a small(er) plot has yields higher than large(r) plot (Barret & Bevis 2019; Altieri et al. 2012; Carter 1984). The inverse relationship is also associated with edge effects, which is the perimeter-area ratio of which the productivity of a plot is higher in the peripheral areas than in the central areas (Barchia & Cooper 1996). Regarding plot shape, the perimeter-area ratio is important. Consequently, a long, narrow plot gives more ‘edges’, a higher percentage

of peripheral areas and less internal areas, whereas a square or triangular plot generates the opposite. There is a strong correlation between edge effects and the inverse relationship, and the biophysical causes – sunlight, drainage and soil nutrients – that are more plentiful at the edges explain the higher yields of crops at these edges (Barret & Bevis 2019 pp. 12–13, 56).

The inverse relationship or any potential edge effect is not suggested as causing scattering and that the open field farmer was aware of it. However, this suggests that any inefficiency in scattered holdings is not necessarily correlated with the plot scale. In contrast, it promotes higher outputs.

This thesis has brought another piece to the puzzle of open fields. Still, further research needs to be done on this subject. The aim here was to analyse the spatiality of scattering in historical maps and to incorporate the empirical findings in a broader European context in an attempt to broaden the discussion and analysis of national and regional studies. New questions and ideas for future studies have been raised along the way. Additional detailed studies on spatiality and the practice in open field villages are needed, as are comparative studies that engage in a detailed spatial analysis that compares open fields in different European contexts. Furthermore, combining economic studies on productivity over longer periods using aggregated data at regional and national levels with detailed studies at the village and farm levels can bring insights into spatial and practical changes, not the least in the transition from open fields to enclosures.

On the one hand, this study on open fields is historically specific and focuses on an arrangement of production since long gone in most parts of Europe, even though it is still in use in some parts (Renes 2010). On the other hand, from a global perspective, agriculture faces future challenges. In present-day farming, small farms of 2 hectares or smaller account for 84% of the total number of farms globally but operate only 12% of all agricultural land (Lowder et al. 2019 p. 6). Small-scale farming, which characterises open field farming, is thus far from only being a historical fact. Does historical knowledge of open fields have any relevance for implementation to meet future challenges in modern agriculture? What insights can the manually driven, small-scale production that characterises open fields bring to today's discussion on sustainability, biodiversity and climate? The FAO changed its policy to meet the challenges in agriculture expressed in the 2009 report, 'How to feed the world in 2050', which suggested that an increase in food production by 70% was needed to meet future demand. In short, this was suggested as being achieved through the intensification and mechanisation of production, primarily in the developing world (low- and middle-income countries). However, in the reports (FAO 2017; 2018), this strategy of

‘business as usual’ is dismissed, and guidelines for a new policy were expressed. Previous policies promoting high-input and resource-intensive farming are not sustainable and have caused negative effects, such as massive deforestation, loss of biodiversity, greenhouse gas emissions, water scarcity and soil depletion. Instead, innovative systems secure and enhance natural resources and simultaneously increase productivity. A holistic approach is needed based on agroecology, agro-forestry and climate-smart and conservation agriculture. Furthermore, the approach should also build on indigenous and traditional knowledge and technological improvements to address climate change. Research on open fields, with their ‘peculiar’ spatial organisation that has persisted for nearly a millennia, have interested historians, geographers and economists ever since their dissolution and can potentially bring valuable insights into the biodiversity and sustainability of small-scale, intensive farming of today and tomorrow.

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GEORG/ KARL (www.riksarkivet.se/geometriska)
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Kammararkivet

Skara stifts- och landsbiblioteks arkiv (SSLB)

Sundholmska samlingen (SuSaml)

Lantmäteriet/Swedish Land Survey

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Popular science summary

This thesis studies the spatial organisation of farms in what is called *open fields*. Open fields refers to the way farms was divided in several small(er) plots. A farms plots was scattered and intermingled with its neighbour's plots. Open field characterized agriculture in Europe north of the Alps for the last millennium and is still present in some parts. Arable production stands at the heart of open fields and generally also includes animal husbandry in mixed farming systems. There are local variations and differences in field-systems, with varying spatial patterns of how farms holdings were scattered. There is a common theme of manually driven farming and it is generally carried out in small units, in small arable plots. Time, scale and labour are important variables for understanding open field farming and, thereby, its practical aspects. Farming practice and how scattered holdings are integrated in farming practice are essential to understand the logic and/or the rationale behind open fields. The conundrum of the open fields is; why small-scale farming necessarily had to be organised with intermingled holdings? The papers in this thesis mainly focuses on open field systems on Falbygden and Kinnekulle in Skaragborgs County. The overarching aim is to study the practical aspects and the function of scattered holdings in the arable land and how this contributes to understanding the logic of the open fields. Furthermore the aim is to analyse how the practice and spatiality of open fields were closely integrated in the larger institutional and communal arrangement that characterises open fields in the mixed farming system.

These aims is examined in three papers and the introductory chapters. The papers analyse open fields on different scales; farms, villages and between villages. Paper 1 combines historical maps and contemporary written sources on farming practice for analysis of how scattered holdings in a three-field system was integrated in farming practice, and the expenditure of time on

cultivation and transportation is estimated. Paper 2 compares scattering in two different field systems, and compares how different farms was scattered in the two different field systems and analyses the potential benefits and disadvantages of scattering by examine the number, size and shape of plots, their spatial localisation in the fields and their quality. Paper 3 focuses on how villages were interconnected and cooperated in what is called fence-organisations (sw. *hägnadslag*). In fence-organisations there are no fences between neighbouring villages. Two large fence-systems is reconstructed and analysed using large scale maps. The main source material is the large scale historical maps produced in the first half of the 17th century.

Theoretically this thesis uses time-geography Hägerstrand (1985; 1990) as the underlying approach in analysis how open fields functioned. A time geographical perspective is applied in all studies to understand the spatial configuration of open fields in relation to agricultural practice in general. In addition theoretical work by the Russian economist Alexander Chayanov, the *labour – consumer balance* is used. His theory argues that the logic and rationale of the family farm is to balance the drudgery of labour and to satisfying the family needs to ensure self-sufficiency. The family farm would not produce more than it needed since the cost of labour got too high.

The thesis concludes that the spatial organisation in open fields facilitated for an efficient management of time, work and space. The temporal aspects of farming is essential, both regarding allocating work and the time required to execute different chores in cultivation and the timing of these activities to ensure the best conditions for the right crop in the right place for a good harvest. Spatial organisation was integrated in farming practice and allowed for spatial and temporal sequence and diversification of work and crops. The thesis argue that the communal arrangement of individual farms responsibilities towards the community and each individuals rights is based on egalitarianism however, there is no empirical evidence that supports that the spatial distribution of holdings was based on equity. Finally, scattering in the arable is characteristic of most open fields but not all. A field that is to some extent utilised in common, between neighbours is to be considered an open field even without scattering and the common denominator among all open fields is cooperation among its participants.

Populärvetenskaplig sammanfattning

Avhandling undersöker den rumsliga organisationen av gårdar i vad som kallas *open fields*. Med open fields avses hur gårdarnas ägor i en by var uppdelade i flera mindre åker- och ängstegar och som var utspridda och sammanblandade med varandra i vad som i en svensk kontext kallas för *tegskifte*. Open fields är kännetecknade för byar i stora delar av Europa, norr om alperna, under det senaste milleniet och förkommer i viss utsträckning än idag. Det är ett system som bygger på ett individuellt ägande men som samtidigt förutsatte en kollektiv organisation. Åkerproduktion är central men generellt så kombinerades åkerbruket med djurhållning. Hur byar var rumsligt organiserade och på vilket sätt enskilda ägor var fördelade varierar men den gemensamma nämnaren för manuellt drivet jordbruk i open fields är att det var småskaligt. Tid, skala och arbete är grundläggande variabler i jordbruket och för att förstå varför jorden tegskiftades är det nödvändigt att förstå hur det var integrerat i jordbrukets praktik. Open fields jordbruket var småskaligt och den grundläggande frågan är; varför tegskiftades jorden? Artiklarna i avhandlingen studerar tegskiftade byar på Falbygden och Kinnekulle i Skaragborgs län. Det övergripande syftet är att studera funktionella och praktiska aspekterna av tegskiftet för att förstå dess logik. Vidare är syftet är att analysera hur jordbrukets praktik och rumslighet var integrerad i de övergripande institutionella och gemensamma arrangemangen som kännetecknar open fields.

Dessa syften undersöks i tre artiklar och i den sammanfattande kappan. Artiklarna analyserar open fields på olika skalnivåer från den enskilda gården, byn och slutligen samverkan mellan byar. Artikel 1 kombinerar historiska kartor över Kleva by med samtida skriftliga källor om redogör för den tillämpade praktiken i samma by. Studien analyserar hur tegskiftet i ett tresädessystem var integrerat praktiken och estimeringar av tidsåtgång i åkerbruket samt för transport. Artikel 2 jämför tegskiftet i två trädessystem

på Falbygden och jämför hur gårdarna var tegskiftade, och analyserar de potentiella för- och nackdelar genom att undersöka antal tegar per gård, dess storlek, form, avstånd från bebyggelsen och deras kvalitet (korntal). Artikel 3 fokuseras hur byar var sammankopplade och samarbetade i vad som kallas *hägnadslag*. I hägnadslag samverkar byar genom att inte hägna mellan åker- och ängsgärden. Artikeln undersöker hur dessa tar olika rumsliga uttryck beroende på trädessystem genom rekonstruktion och analys av två hägnadslag på Falbygden. Det huvudsakliga källmaterialet i samtliga artiklar är de äldre geometriska kartorna från första hälften av 1600-talet.

Teoretiskt tillämpar avhandlingen Torsten Hägerstrands (1985; 1990) tidsgeografi som människan och naturens grundläggande tidsrumliga förutsättningar. Ett tidsgeografiskt perspektiv tillämpas i alla studier för analys av tegskiftets tidsrumsliga förutsättningar i förhållande till tegskiftes-jordbrukets funktion och praktik. Därutöver har den ryska ekonomen Alexander Chayanov teoretiska arbete kring balansen mellan arbete och konsumtion (*Labour – Consumption balance*). Teorin förklarar familje-jordbrukets logik och rationell i grunden handlar om att balansera arbetets slit och familjens behov för att säkerställa självförsörjning. Familje-jordbruket måste förstås utifrån självförsörjning och inte som kapitalistiska företag med strävan mot maximerad vinst. Familjejordbrukets logik ligger snarare i att incitament för att producera mer än vad som behövdes saknades då arbetskostnaderna blev allt för höga.

Avhandlingen argumenterar för att den rumsliga organisationen i open fields underlättade för en effektiv hantering av tid, rum och arbete. De tidsmässiga aspekterna i jordbruket är grundläggande och reglerar vad var möjligt. Tegskiftets rumsliga organisation var integrerad i praktiken genom en diversifiering av grödor och genom att arbetet utfördes i en tidsrumslig sekvens, teg för teg, gröda för gröda. Genom att dela upp arbetet kunde rätt plats vid rätt tid och för rätt gröda bearbetas för att skapa de bästa förut-sättningarna för en god skörd. En annan slutsats är att det gemensamma/ kollektiva arrangemanget som betecknar open fields där individens skyldigheter gentemot bysamfälligheten och individens rättigheter var i grunden baserat på jämlikhet. Det finns emellertid inga empiriska bevis som stödjer att den rumsliga fördelningen baserades på en rättvis fördelning. Slutligen, tegskiftad jord är karakteristisk för de flesta open fields men inte alla. Ett gärde som nyttjas gemensamt, bör betraktas som ett open field och den gemensamma nämnaren för alla open fields är snarare samverkan mellan dess deltagare oavsett huruvida jorden tegskiftad eller inte.

Papers

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Doctoral Thesis No. 2020:45

This thesis examines open fields, which was the dominating system in large part of Europe for nearly a millennium. Why peasants scattered their holdings in open fields have been the subject of numerous studies. This thesis studies open fields from a functional perspective and examine the spatiality and temporality of open field farming in early modern agriculture in Sweden, using large-scale maps from 17th and 18th century for detailed spatial and statistical analysis of farms and villages.

Kristofer Jupiter holds a Degree of Master of Social Science with a major in Human Geography at the Department of Human Geography, SU. He received his graduate education at the Department of Urban and Rural Development, Division of Agrarian History, SLU.

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