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Fenced open-fields in mixed-farming systems: spatial organisation and cooperation in southern Sweden during the seventeenth century

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ABSTRACT

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 of and communal practices in arable land, meadows and pastures. It was adapted for small and mid-size family-based farming and was a different way to organise agriculture than the medieval estates (demesnes) and the larger coherent fields of the eighteenth century and onwards. The past decade of research in historical geography and economic history has highlighted the origin of this system, which is often referred to as the open-field system; it was open in the sense that it promoted communal farming of primarily arable land. This pre-modern farming system was, however, in many areas a physically closed landscape – a landscape where fences stood out as significant elements. This article investigates the use of fences in a part of early modern western Sweden. The empirical base is a reconstruction of fence-organisations from detailed large-scale maps dating from the mid-seventeenth century. Using historical maps, this study focuses on the collaboration and interaction among 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 the 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 the fences in the farming systems known as open-field? What can be said about the spatial distributions and connections between the settlements sharing the same open-field? Can agrarian landscapes where fences were prominent elements be considered open-field? 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 the arable plots had less importance in the creation of open-fields, which included arable land, meadows and pastures. Instead, cross-settlement collaborations and arrangements are central for the open-fields in the study region. The regional differences within the open-field system provide an understanding of the preconditions and organisation of mixed farming, which combined small-scale arable land cultivation and large-scale pastures.

In historical, geographical and economic research, a specific term – open-field – is used to name agriculture and farming in Europe during the Middle Ages and the early modern period. The open-field has been related to the expansion of grain production and the population growth during the High Middle Ages, prior to land reforms and enclosures mainly in the eighteenth and nineteenth centuries, which resulted in a more individually-divided rural landscape. Since the open-field is believed to have existed for centuries, it appears to be a key concept for understanding the basic conditions for agrarian life during the last millennium.

Current research views open-fields as a functional and rational way of organising agriculture during the times when work largely was non-mechanised. It withstood the late medieval crisis and was the preferred way to organise farming during the recovery of cultivation and in later periods. However, it is not very clear in the literature how open-field should be defined. In research, there are

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at least three general discussions about open-fields. One discussion is about the combination of individual and common cultivation in open-field farming, especially the principle of allowing arable land, which was individually owned, be used for common pastures after the harvest.[1] A second discussion focuses on the fragmentation of arable land into small plots and the scattering of the plots. The meaning of the physical layout of the arable land, which could take irregular or regular forms, has been debated for a long time with little progress. A third discussion captures open-fields as a visual open landscape, targeting the arable fields, which may have hedges or fences but in most cases lack physical boundaries.[2]

The plain arable landscapes in Central Europe are often emphasised, but the land of smaller farms in the Scandinavian countries has also been described as open-fields.[3] Furthermore, different arable field patterns in Sweden have been regarded as different types of open-fields.[4] In other words, the functional and visual aspects of the open-field – the lack of fences and the usage of small plots as the basic unit for cultivation – are believed to have characterised a large part of the European agricultural landscape. The conversion of the arable land into grazing land each season and the collaboration between farmers who share fields are also emphasised as different from the opposite system, an enclosed field.

However, in Northern Europe, where grain cultivation was often mixed with animal husbandry and where the availability of forest and timber were good, the open-fields were not as visually open as those in other parts of Europe. 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). Such arrangements were investigated by the geographer Gunnar Lindgren in the 1930s.[5] By examining historical large-scale maps, Lindgren could show that the farmers had coordinated their fences in a way that promoted cooperation and 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. Despite this, the existence and usage of fences is less of a concern in the classical work on open-fields by Carl Johan Dahlman and is also absent in recent research.[6] The reports of open-fields as collaborations without fences seem, at least in Scandinavian regions, to be misleading. Instead, 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 paper the term *fence-organisation* is used for these spatial arrangements.[7] By reducing all or some of the inner fences farming activities, within the larger interconnected field, required synchronisation from its participants (see Fig. 1). The question in this article is as follows: To what extent are fence-organisations related to open-fields? By raising this question, we challenge the idea of an open-field as a visually open landscape and a system primarily based on arable land sub-division in hamlets and villages and stress the importance of cooperation and institutional arrangements in the Scandinavian mixed-farming systems, which combined arable land, meadows and pastures.[8]

The empirical base of this study is an examination of large-scale maps from the seventeenth century and spatial analysis of the fences, fields and settlement structures. The study area is located close to the town of Falköping in a region of southwestern Sweden called *Falbygden*. This region was studied by Gunnar Lindgren, but this study has a new approach. Within the chosen area, two types of fence-organisations have been analysed in detail and compared; one relates to the one-field system and another relates to the three-field system (which is described later). The primary target is not to analyse the origin behind the different field-systems, as Lindgren did, but rather to examine whether there is a relationship between the fence and field patterns and the degree of cooperation between farms (holdings). The focus will be on the interconnections (or lack thereof) between the settlements/farms sharing the same fields and fences. The fence-organisations that are described will then be related to questions about collaborations, farming institutions and open-fields.

The spatial organisation of grazing

Settlements in Sweden in the seventeenth century were typically small hamlets consisting of two or three holdings within an *infield system* with cultivated arable land and meadows, which were fenced and kept separated from the outlying land (pastures, forests and fishing grounds). The outlying land where common land (known as *allmänning* in Swedish) belonging to the hamlet, the parish or the hundred (district). In addition, many settlements had smaller permanent paddocks that were owned individually and used for calves and other animals. As in many parts of Europe, the infield systems in Sweden combined grain production and livestock farming. What distinguished these systems were the rather small hamlets, the sparse population, the access to outlying land and the frequent use of fences.

The fences were used to separate cultivated land from outlying common land and for spatial division of arable and meadow within the infield. Settlements thus had both *inner* and *outer* fences (see Fig. 1). This was evident from the historical large-scale maps (to be analysed later), which reveal a field system consisting of several fenced fields (within the infield) and an outer fence to keep wild and grazing animals on the common land. Not every field had its own fence. Several fields of arable and meadow could lie within the same fence, and settlements could be connected by sharing inner and outer fences (see Fig. 1). There were regional differences. In densely populated areas on the plains of southern Sweden, where access to outlying land was limited or non-existent, not every

[1] H. Renes. Grainlands. The landscape of open fields in a European perspective, *Landscape History*, volume 31 (2010) 40, 65. As emphasised by Hans Renes, the functional aspect is also known as common fields. Open and common fields could therefore be understood as overlapping concepts, even if open-fields, according to Renes, is a broader term, which also includes the visual aspect of open arable landscapes.

[2] C. Dyer, E. Thoen and T. Williamson (Eds). *Peasants and their Fields. The rationale of Open-Field agriculture, c. 700–1800*, Turnhout, 2018; Renes, Grainlands, 37–41.

[3] U. Sporrong, *Mälarbygd: Agrar bebyggelse och odling ur ett historisk-geografiskt perspektiv*, Stockholm, 1985, 50–58.

[4] See articles by C-J. Gadd and H. Antonsson in Dyer, Thoen and Williamson, *Peasants and their Fields*.

[5] G. Lindgren, *Falbygden och dess närmaste omgivning vid 1600-talets mitt: En kulturgeografisk studie*, Uppsala, 1939.

[6] C. J. Dahlman. *The Open Field System and Beyond: A Property Rights Analysis of an Economic Institution*, Cambridge, 1980.

[7] *Magnus Erikssons landslag* (The Country law of Sweden), Stockholm, 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.

[8] Regarding institutional arrangements, see E. Ostrom, Beyond Markets and States: Polycentric Governance of Complex Economic Systems, *The American Economic Review*, Vol. 100 (2010) 641–672.

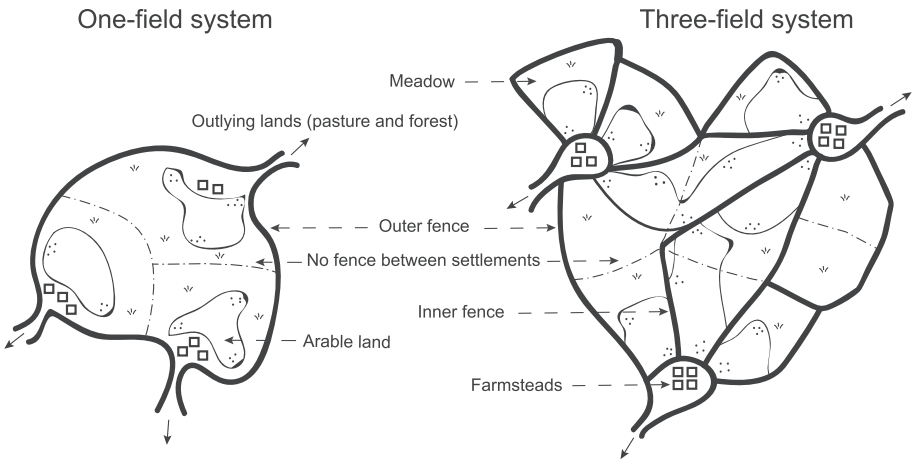

Fig. 1. Models of the two different fence organisations in the early modern Swedish infield-system.

settlement had an outer fence. In these cases, the pastures were located on the infields, the parts of the arable land and the meadows that lay in fallow at the time of grazing. An aspect of this is regular fallow, as a way of systematically adding manure to the fields, but which also has been linked to the need for grazing.[9]

In other words, the fences were not used to separate one's property from the other's, as was the case from the latter half of the eighteenth century. Although the fences coincided with property borders, they were not primarily boundary markers. The rules for marking where the border began and ended, using mainly stones on the ground, were described in the medieval laws.[10] There was thus a proven system for marking properties without the need for physical boundaries such as fences. Rather, the fences were used to create functional areas for cultivation. As long as the grain grew, they protected the hay and the growing crops from the animals. After the harvest, they became paddocks for grazing on the fallow. In this way, it was possible to increase the size of the arable land while maintaining and ensuring access to pastureland.

The widespread use of fences in Sweden, as in other parts of Scandinavia, did not necessarily mean that the need for shepherds or herdsmen was lower than in other countries. Shepherds are depicted and described in medieval sources, and from the middle of the 1400s, the country law stated that villagers should cooperate on bringing livestock to grazing land.[11] One interpretation is that the development after the Black Death, when the population was greatly reduced, went towards animal husbandry.[12] It is generally known that abandoned farms were converted into meadow and pasture, and it is likely that more cooperation was needed to manage pasture operations. Consequently, more fencing and collaborations were needed to keep grazing animals away from the fields.

The commonly used fence in Sweden, Norway, Finland, parts of the Baltic and Russia was made of wood using a round fence pole that could be easily erected (called *hankgärdesgård* in Swedish). The great access to coniferous forests has been raised as a factor in why an organisation around fences predominated in this region, ahead of the practise of herding with shepherds that was generally more common in Europe.[13] Fence-organisations could also be seen in areas with no or sparse access to forest. In the southernmost parts of Sweden and Denmark, fences were usually made of stone, which was comparatively more demanding to build. The way of organising fences should also be seen in the light of reducing costs, as not all fields were fenced individually.[14] Another factor to consider is the limited size of the settlements. Although larger hamlets/villages (ten holdings or more) also existed, there were few villagers per settlement in late medieval and early modern Sweden. Therefore, in addition to minimising cost for shepherds, the use of fences was likely driven by limited labour supply and a need for pasture and meadows for extensive land use (to be further discussed in the analysis below). As mentioned, the protection of crops and meadows from wild and grazing animals was also important.

Early legal evidence of fence-organisations

The historical large-scaled maps are undoubtedly the most important source for understanding early modern use of fences. In Sweden, there is a large collection of such maps from the seventeenth century; maps that in detail depict the spatial distribution of fences (see map details in Fig. 2 below). However, there are also earlier written evidences for an organisation around fences in the Middle Ages.

There is reason to believe that the regulations of fences in Sweden developed with the expansion of settlements during the twelfth and thirteenth centuries, with a further expansion after the late medieval crisis. Archaeological evidence is certainly lacking, but rules concerning fencing in the Middle Ages is manifested in the provincial law books in Scandinavia and the first country law of Sweden, that was adopted in the middle of the fourteenth century and, with few revisions, was in use until 1734. Also the older laws contain several, though rather brief, descriptions on fencing. For example, *Äldre Västgötalagen* from the 1220s states that farmers should divide the work of making and maintaining fences according to the share principle that was used for dividing arable plots. This law also states that those who wanted to lay arable in fallow

[9] Dahlman, *The Open Field System and Beyond*, 142.

[10] The Country law of Sweden, from the mid-fourteenth century, mentions stones, fences and streams as possible border markers, see MEL, BB XXI, 111. The same principle was used to distinguish different individual plots in arable land and meadows.

[11] *Magnus Erikssons landslag,* BB XXXV, 124.

[12] J. Myrdal. *Boskapsskötseln under medeltiden: En källpluralistisk studie*. Stockholm, 2012, 62–72.

[13] J. Myrdal. *Landbon, ladan och lagen och hägnaderna, arbetstiden och bygdelaget samt ytterligare 20 agrarhistoriska artiklar*, 1996, Stockholm, 137.

[14] See e.g. the article by C-J. Gadd in Dyer, Thoen and Williamson, *Peasants and their fields*, 50.

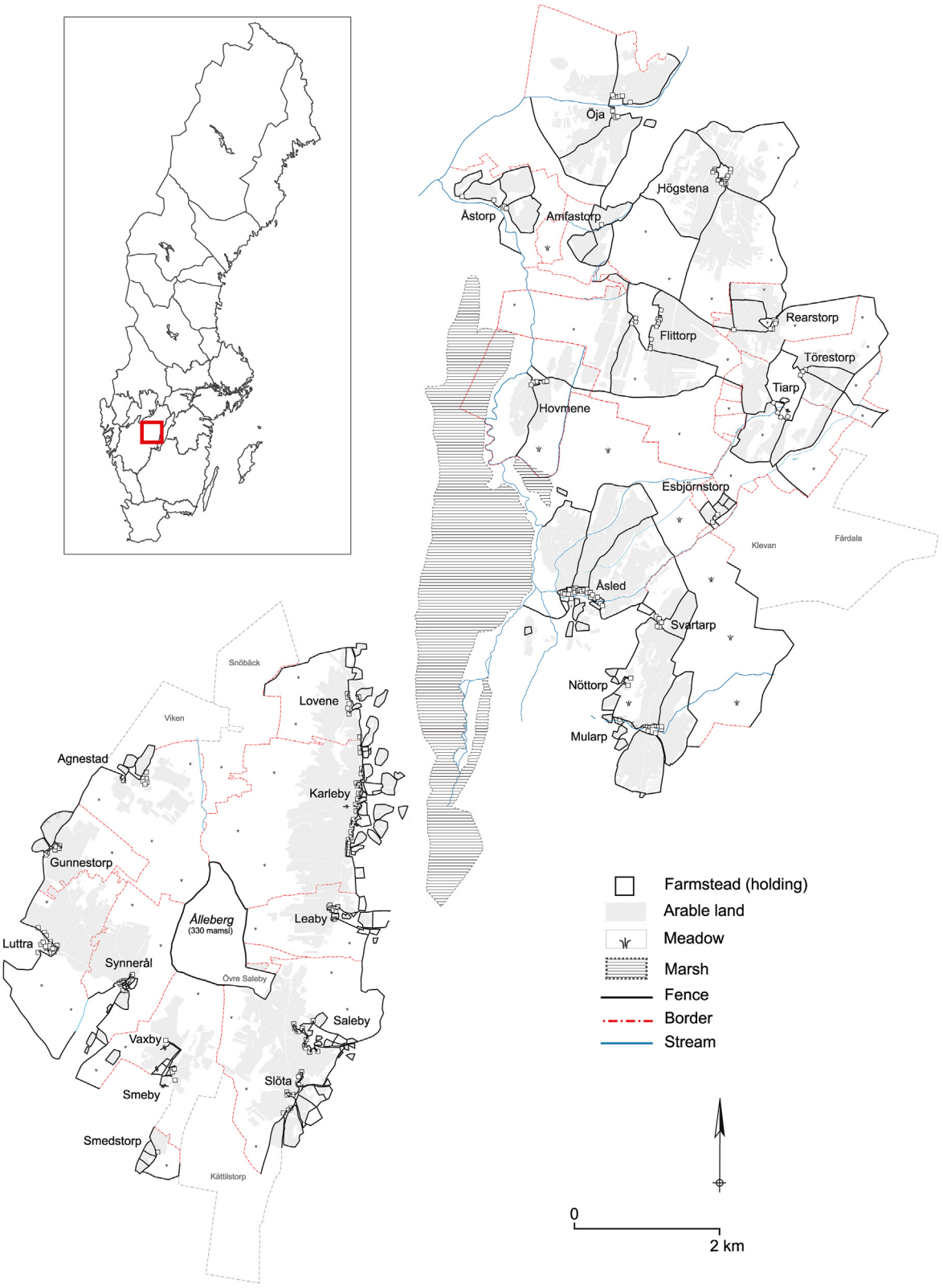

Fig. 2. The two study areas in southwestern Sweden, province of Västergötland, which are adjacent to each other but differ in that area A (to the left) is a one-field system and area B (top right) is a three-field system.

should use fences around it.[15] Hence, the farmers who owned arable land were responsible for fencing their land. Similar rules existed for roads, bridges and ditches. The responsibility was obviously individual, but the work could not be done without cooperation between the neighbours.

From the latter part of the thirteenth century, in the country law, the rules on fencing are more comprehensive. Among other things, it states that the fences should be in good condition before seeding the fields and that the grazing animals would go out to graze the fields as soon as possible after harvesting. Efficient land use obviously required synchronisation and collaboration between farmers. When farmers shared fields, they needed to agree on the timing of the harvest and when the animals could be released into the fields for grazing after the harvest. Hence, one could ignore the cultivation of arable land but not stay outside of the fence-organisation, which was a communal concern.

It was of common interest to ensure that all the fences were in good condition. If grazing animals were to get past a fence and trample the arable land, then all other farmers sharing the same field would be affected. The law is extensive regarding disputes with fines as sanction.[16] The shepherds could, on the other hand, be chastened by the landowners without sanction.[17] As emphasised by Janken Myrdal, the number of references in the laws to fencing – often related to conflicts and fines for violating the rules – is considerably higher than the references to, for example, ploughing.[18] This attention by the laws shows the importance and the difficulties of organising fences. The essence of these conflicts was the relationship between grain and livestock production, which were regulated by the fences. The maintenance of the fences was, likely, not a major common concern. It was not as labour intensive as harvest and haymaking, and it could be handled individually.[19]

These fence-organisations in Sweden, which arose from the fourteenth century at the latest as a result of the common interest and need for grazing, were important in the village community and a factor in the collaborations *between* settlements.[20] As stated in the country law, disputes on fencing could be handled within the hamlet but could also be subject to the court in the parish and in the hundred.[21] Bylaws and court records from the seventeenth century and later provide insight into such cases.[22] In a court case, referred to by Gunnar Lindgren, a farmer that held a single plot of arable land in another hamlet had responsibility for a section of the fence surrounding the field that was connected to that plot of land.[23] Since every farmer was accountable for his part of the fence, the village council had to know which farmer was responsible for which sections. In a three-field system, a farmer would be responsible for at least three sections. In this way, the organisation of fences showed similarities with the distribution of the arable plots.

To conclude, these early written sources indicate institutional arrangement regarding the management of the fences within and between settlements. A further question in relation to open-fields is: What did the fence-organisations looked like, regarding for example spatial extent and the number of settlements and farms in collaborations?

Fence-organisations in historical large-scale maps

The ability to deepen our knowledge about the spatial organisation of the open-field depends on the availability of source material. Primarily, the large-scale maps that were made prior to the land reforms in the nineteenth century are important source materials, providing details on the farming organisation that no written source other than maps can elucidate.[24] Obviously, such available maps should be studied closely and compared. The most important aspect in this context is the extent of the fence-organisations, in other words, how the farms were connected spatially or the way that farmers from different settlements cooperated, which are spatial patterns that can be reconstructed using large-scale maps.

In Sweden, there are over 12,000 large-scale maps from 1633 to 1655. These cover almost one-third of the agrarian settlements in seventeenth century Sweden. The maps were made by surveyors using the plain table and instruments that enabled precise geometrical mapping of the landscape and its fields. The scale of the maps was usually 1:5000, although the maps in this study area have a scale of 1:3333, and show in detail the fences and the division of holdings in scattered and intermingled plots throughout the arable fields. Since the surveyors used the same instructions and methods and conducted the survey for a limited time (a 25-year period), the maps are suitable for the comparisons and analysis of different settlements, farms and fields.

The fact that the fences were carefully marked by the surveyors shows that they were important in the open-field system. The fences were drawn to look similar to the actual wooden permanent fences, which was the typical and dominant 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 Fig. 5). Even the fence gates were marked out. If there are no fences along a village boundary, it was marked with a red dotted line. It is thus clear where the fences started and ended, which enables reconstructions of the complete fence-systems. It should be noted that the surveyors did not map the outlying land, the common lands, that were used for grazing without the use of fences. Therefore, virtually all fences that were in use are on the maps.

The study area in southwestern Sweden

To answer the research question – about the significance of the fences in open-fields – the remaining part of this paper will describe different fence-organisations in a part of southwestern Sweden. The aim is to compare the differences and similarities between them to identify the generic elements in the organisation of open-field farming in the study area. The focus will be on the spatial organisation of the fences, but the use of arable land, meadows and pastures will also be discussed. First, some prerequisites about the study area and the chosen method should be discussed.

[15] P-A. Wiktorsson (Ed.) *Äldre Västgötalagen och dess bilagor I-II*, Skara, 2011, 115–117, 28v–29(r) = [r]. Fences are briefly mentioned in the Scanian law from the same time period, see Å. Holmbäck and E. Wessén (Eds), *Skånelagen och Gutalagen*, 1979, 110 and 185–186. See also MEL, BB XXI, 112.

[16] *Magnus Erikssons landslag,* BB VII, VIII, 101–102.

[17] *Magnus Erikssons landslag,* BB XXXV, 124.

[18] As suggested by Myrdal. *Boskapsskötseln under medeltiden*, 135.

[19] Myrdal. *Boskapsskötseln under medeltiden*, 140. Janken Myrdal calculates that on average it required five to nine days, depending on the density of the poles, to establish 100 m of wooden fences in the 1700s and 1800s.

[20] Long chains of settlements connected by sharing fields and fences have been discussed by Staffan Helmfrid regarding the province of Östergötland, Gunnar Lindgren for Västergötland and Sölve Göransson for Öland, see e.g. S. Helmfrid. *Östergötland "Västanstång": Studien über die ältere Agrarlandschaft und ihre Genese*, 1962, Stockholm, 128–132.

[21] *Magnus Erikssons landslag,* BB VII, XXI, 101–112.

[22] W. Ehn (Ed). *Byordningar från mälarlänen: Stockholms, Södermanlands, Uppsala och Västmanlands län*, 1982, Uppsala. Wolter Ehn references bylaws that mention fences, most dating from the eighteenth and nineteenthcenturies.

[23] Lindgren, *Falbygden och dess närmaste omgivning vid 1600-talets mitt*, 83–84. A section of a fence is called *gärdesländ* by Gunnar Lindgren.

[24] As discussed in Dyer, Thoen and Williamson, *Peasants and their fields*, 257.

The study area is located in one of the central agricultural regions in Sweden called *Falbygden*. The prefix *fal*-points to the landscape type called *falan*, a hilly, open terrain characterised as a forestless high plain.[25] The agrarian landscape in the study area is characterised by a one-field system in the west and a three-field system in the east (area A and B on Fig. 2). For those two areas, different fence-organisations have been identified on the basis of a spatial reconstruction of the fences that connect groups of settlements. While area A, the one-field system, is uniform and rather isolated, area B, three-field system, is more difficult to spatially define. For a comparison of the two areas, we have chosen to delimit area B with an equal number of settlements as exist in area A.

Map data on the fences, as well as other geographical data on land use, have been excerpted from twenty-two large-scale maps from the 1640s. First, all lines on the maps (fences, fields, borders, etc.) have been digitalised and transformed into a modern coordinate system using geographic information system (GIS) software. Then, all data have been merged into a single digital comprehensive landscape image that shows all fences and other landscape line elements. The result, which is shown as an overview in Fig. 2 and in greater detail in Figs. 3 and 4, is thus based on careful processing, rectification and interpretation of the fences depicted on historical maps.[26]

We can initially conclude from Fig. 2 that there is a connection between fence-organisation and field system. Area A – the one-field system – forms a larger continuous field of arable land and meadows that is shared by nearly all farmers in this area. It is delimited by a common outer fence structure that surrounds most of the area. The one-field system is further characterised by continuous cropping of the arable and no fallow, however, irregular fallow of individual plots of land occur. Inner fences separating the different fields are absent, except from some smaller enclosed fields located next to the farmsteads (as seen in Fig. 3).[27] Hence, most of the area is cultivated as one open large field, which is functionally divided into plots of land belonging to different owners.

Area B – located adjacent to area A – has a three-field rotation and consist of three arable fields and one meadow field separated by fences. Two of the fenced arable fields were cultivated annually, while the third lay fallow to be used as a paddock. Hence, the inner fences related to fallow as a way to improve soil quality and increase access to the pastures. Does area B comprise one or several open-fields? There is no clear outer fence in area B. Instead, the inner fences form various smaller cooperative and open subareas. Unlike in enclosure systems, where fences separate individually owned fields, the fences here are used to create different smaller open-field areas. This will be analysed in greater detail below.

In other words, areas A and B are two separate spatial systems that do not connect or interact. The farming practices and cooperation took place within each area. In the next section, the two survey areas will be described and compared in more detail using quantitative and spatial data that have been extracted from the historical maps. This applies to the number of fences and to the size of settlements and farms. The purpose is to see if there are any variables that can explain spatial similarities and differences in fence-organisations. For instance, is area A – a large cohesive field with no inner fences – more an open-field system, as an institutional cooperative organisation, than the smaller fenced fields that exist in area B? Our hypothesis is that the definition of open-field, which is discussed at the beginning of this paper, needs to be seen on the basis of another criterion: collaborations within delimited areas.

Analysis of the differences between area A and B

Area A was characterised by a large plateau mountain called *Ålleberg*, located 330 m above sea level, in the middle of the area, with settlements surrounding the plateau. In the provincial laws, Ålleberg was listed as common land (*allmänning*) in the province of Västergötland.[28] Cultivated lands, such as arable lands and meadows, surround the mountain. The steep cliffs form a natural fence/wall that makes it inaccessible; towards the south, the slope is closed with a fence. The land closest to the farmsteads was used as arable land, while the land nearer the plateau mountain was used as meadows.

In a one-field system such as this, the infields of all settlements lay open. Everybody was dependent on synchronisation, e.g., no animals were allowed to graze on the arable land and meadows between spring preparation and the harvest in the autumn. The timing of these fundamental activities was essential, especially during the temporary transition from private to common usage after the harvest when this entire field functioned as a single large paddock for pasture, which was available for the villagers that had a share in the field.

Fourteen settlements (hamlets/villages) and a total of 115 holdings (cadastral farms) were involved and synchronised in area A and its fence-organisation, which covered approximately 3000 ha.[29] This gives a measure of how many farms collaborated when managing the arable land, meadows and pastures. It should be added that they do not follow any parish boundaries. The parishes in western Sweden, in the province of Västergötland, were significantly smaller than those in many other provinces. Area A includes settlements from four different parishes, with no obvious relation to the open-field and fence-organisation. In addition to parishes, there was another administrative local district in this region of Sweden, called *åttingar* and *fjärdingar*, used for collecting taxes. As seen on a comment on the map, the whole area A constituted one such district called *Ållebergs fjärding*. The smaller fence-organisations in area B show no relation to administrative boundaries.

The settlements in area A are relatively large units with up to 24 holdings, with an average of eight holdings. In comparison, an average settlement unit in Sweden in the middle of the 1600s was no greater than two or three holdings, i.e., smaller hamlets dominated. In this area, we therefore find some of the largest settlements in the country at the time, e.g., Karleby, Luttra and Slöta, which reasonably had an impact on agriculture in this area. A manor farm in Saleby (called Övre Saleby) has its core land enclosed and kept outside the open-field and fence-organisation. It is located remotely next to the plateau mountain Ålleberg. However, it also shares arable plots and meadows with the other farms in Saleby, as commented on the map.[30] This is the only farm that is distinguished from the open-field pattern in area A. However, it is only

[25] I. Lundahl. *Ortnamnen i Skaraborgs län D. 17 Naturnamn*. Uppsala, 1970, 139.

[26] How historical large-scale maps can be rectified is described in A. Wästfelt, Ambiguous Use of Geographical Information Systems for the Rectification of Large-scale Geometric Maps, *The Cartographic Journal*, 2020, https://doi.org/10.1080/00087041.2019.1660511.

[27] It was not uncommon in seventeenth century Sweden that farmers had smaller enclosed fields, known as *vretar*, which were exempted from the communal organisation.

[28] *Äldre Västgötalagen och dess bilagor*, 181, 45[r].

[29] Three settlements were not mapped in the 1640s but more recent maps show they took part in the fence-organisation.

[30] Large-scale map collection P3, 1645, by Johan Botvidsson, Lantmäteristyrelsens arkiv (LSA), Riksarkivet, 279–280. Available at http://riksarkivet.se/visa-kartsamlingar, accessed 21 October 2019.

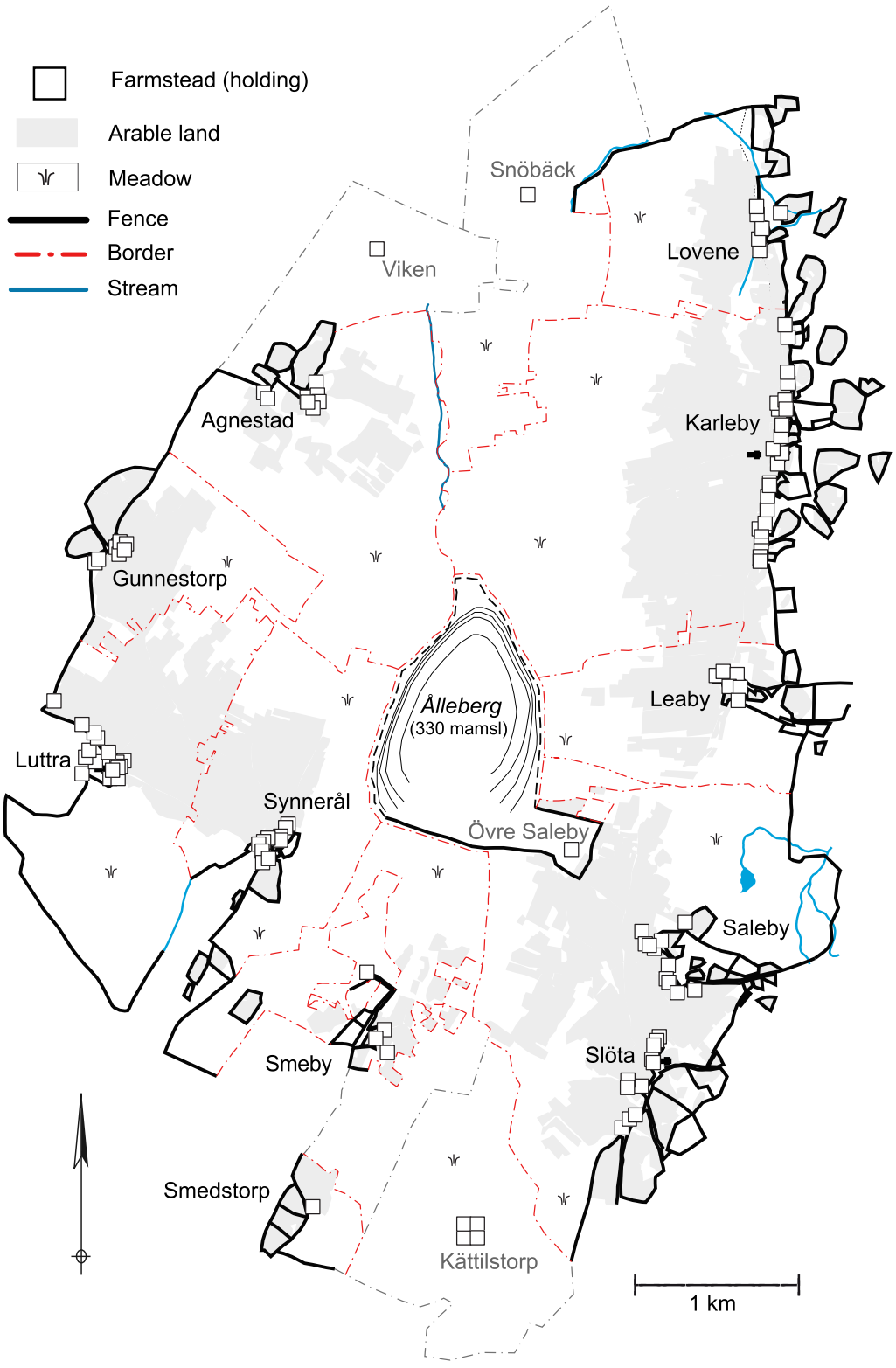

Fig. 3. Study area A consists of one larger field that is spatially delimited and enclosed by a common outer fence that connects all settlements and farms in the area.

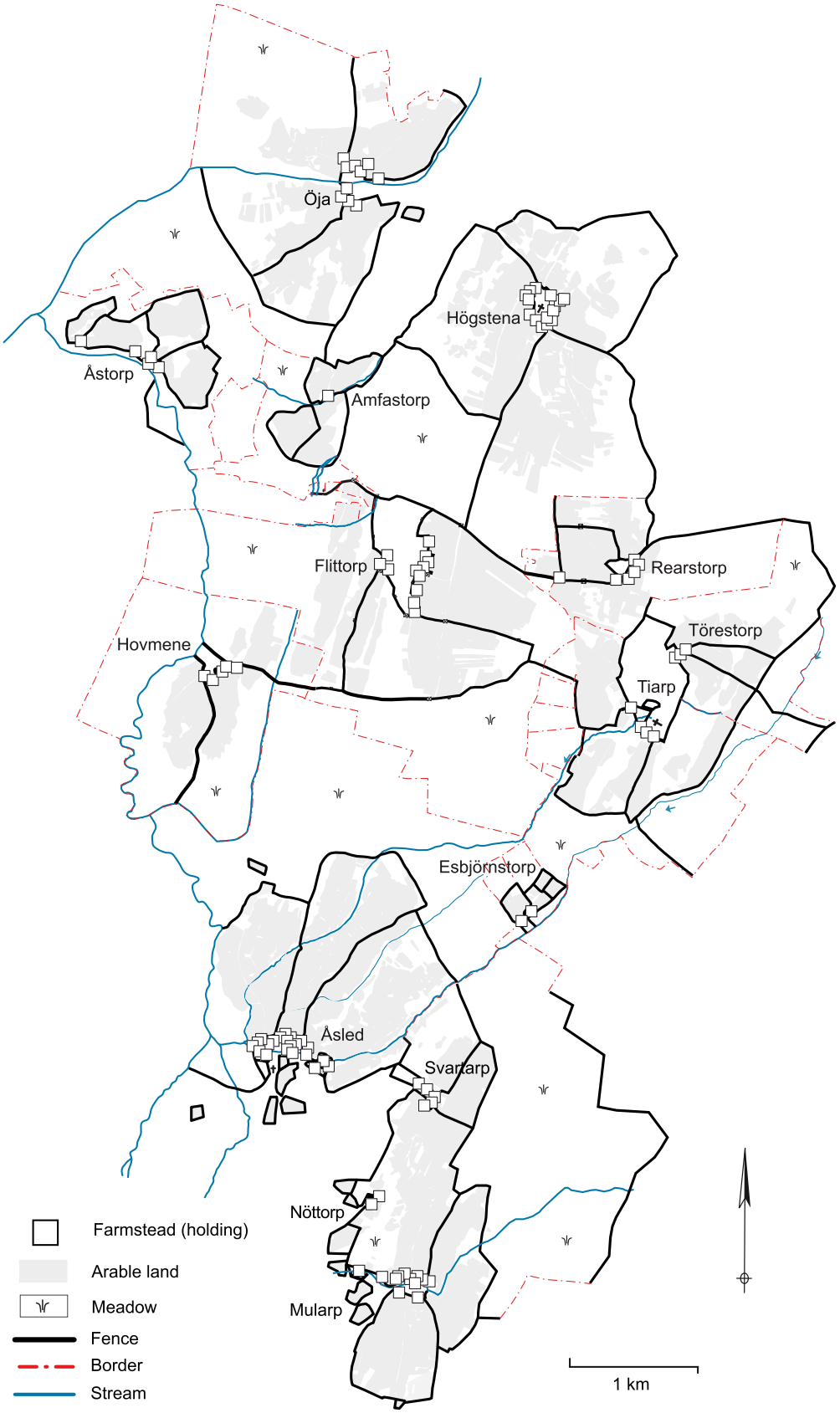

Fig. 4. Study area B with its arable land, meadows, fences and settlement boundaries.

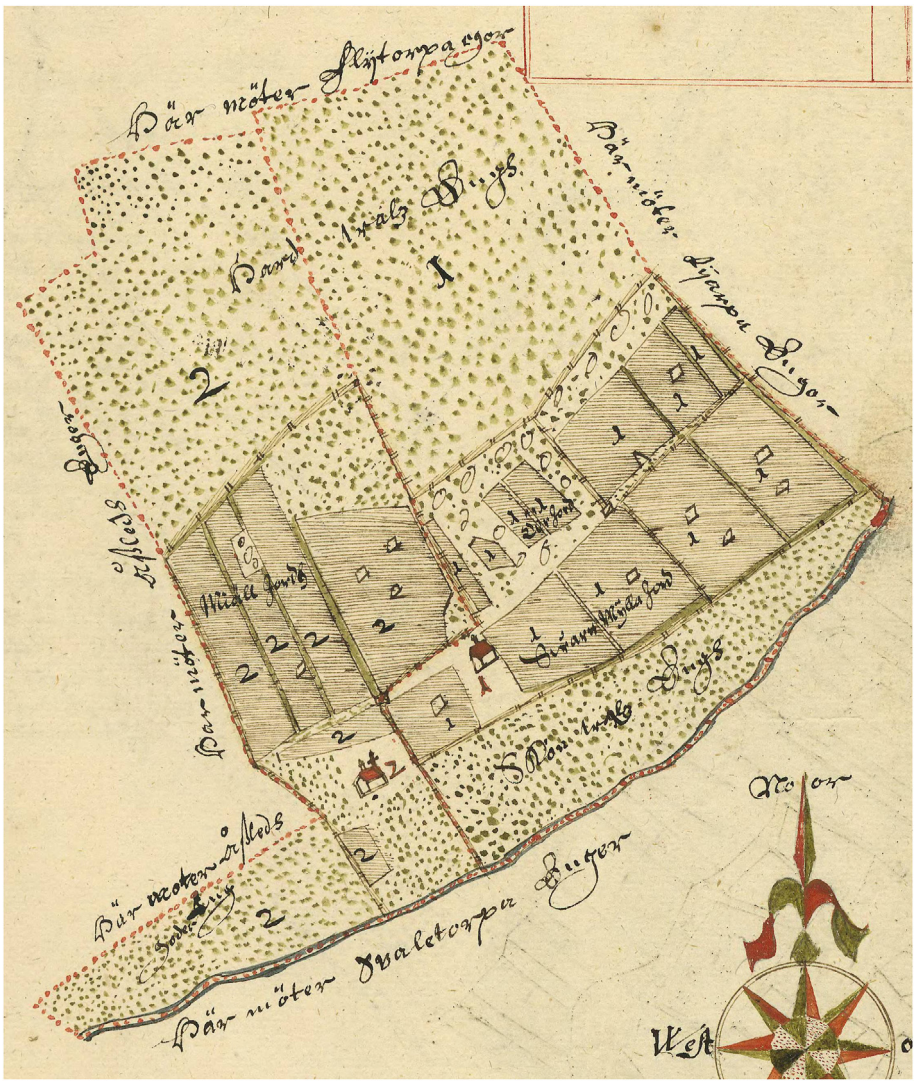

Fig. 5. Large-scale map of the hamlet Esbjörnstorp in 1645, in which the arable land is enclosed and the meadow and pasture is part of an open-field. Source: P3:213, available at https://sok.riksarkivet.se/bildvisning/R0000181_00123, accessed October 21, 2019.

partially enclosed and can still be regarded as a participant in the open-field system.[31]

Area B is located in the three-field region next to area A. The arable fields, which followed a three-year rotation, also contain meadows of various extents. Most settlements also have a fourth field used for meadows. With three arable fields and an extra meadow field, the way neighbouring settlements could cooperate was less straight forward compared to the one-field system. The inner fences created constellations with fewer participants involved. These smaller subareas might be viewed as more easy to manage, but in practice the different group of settlements were interdependent, as crop rotations and other farming practises had to be synchronised at a larger scale. The timing also differs from the one-field system, as a three-field system allows grazing at an earlier stage, both on the fallow field and on the meadow field after haymaking.

In the three-field region, fourteen settlements have been selected for comparisons with area A. There are four large settlements in area B: Åsled with 21 holdings, Högstena 15 holdings, Flittorp 11 holdings and Öja 10 holdings. In addition, there are ten smaller hamlets of one to six holdings; altogether 102 holdings. Hence, the number of farms per settlement is almost equal between the two areas. A few smaller farms in area A (in Esbjörnstorp and Amfastorp) differ from the others by not sharing arable land with other settlements.[32] However, they still take part and cooperate in the open-fields in the meadow. Only one larger settlement, Ålsed, did also not share any arable land with its neighbours.

However, the majority of the settlements in area B did share fields and were connected through the fences. The basic layout was three arable fields, of which at least one was shared with other settlements and a meadow field that was shared by several settlements. In addition, most settlements had small enclosed fields (referred to as *vretar*), which appear close to the farmsteads or on the outlying land.

[31] Manors with separated enclosed land occur in several regions in Sweden and are in several cases interpreted as medieval demesne farms, see O. Karsvall and K. Jupiter (Eds). *Medeltida storgårdar: 15 uppsatser om ett tvärvetenskapligt forskningsproblem*, Uppsala, 2014.

[32] Such a small farm with separated land was probably a late medieval or later established settlement.

As shown, the one- and three-field systems influenced farming visually and functionally. While the one-field system created a large fenced (enclosed) open-field, the three-field system formed and several fenced open-fields of different smaller sizes. It should be investigated how the two areas compared on a farm level. More precisely, did the size of the settlements and farms have any bearing on how the fields and the fences were organised?

Many of the farms (holdings) in the two areas cultivated between ten and twenty acres of arable land yearly. Some had less arable land, giving an average of twelve acres in area A and sixteen acres in area B – rather common sizes for farms during this period in Sweden as a whole.[33] Individual farm size is therefore not a factor that distinguished various fence-organisations. The arable land per farm was admittedly higher in area B, but the proportion of arable that lay in fallow was slightly higher because only two out of three fields were cultivated every year. This means that out of sixteen acres, approximately eleven acres were cultivated annually. Hence, both areas used approximately the same amount of arable land. Additionally, the amount of hay harvested from the meadows was similar in the two areas: approximately eighteen hay loads annually per farm in area A and approximately twenty hay loads per farm in area B. The one-field system is, in research, to a higher degree associated with animal husbandry than the three-field system. But in this case, there is no such correlation regarding hay production. Nor does land ownership have any significance for the fence-organisations. Settlements in both areas consist of holdings with a mix of different ownerships; some were free holders, and others were tenant farms belonging to the nobility or the crown (often former church or monastery land).

Moreover, the geology and the soil conditions of these two regions is homogenous; the soils were rich in lime and slate that created good conditions for cultivation.[34] However, preliminary results in another study indicate that the crop yield capacity in this three-field region was quite low, averaging two and a half seeds returned from each seed sowed. The arable land is also spatially incoherent or fragmented in the fields. The crop yields were much higher in the one-field region, with five seeds returned from each seed on average.[35] Here the maps show that the core arable land is more cohesive. The higher yield in the one-field system could possibly be explained by more frequent fertilisation.[36]

To summarise, as shown in Table 1, the number and size of the settlements, as well as the access to arable lands and meadows, are equivalent between areas A and B. Most of the farms in this region appeared to be self-sufficient in cereals and livestock products. The geological conditions are, as stated, largely similar. Furthermore, in both areas, the arable land is divided into intermingled plots. The obvious difference between the two areas is the number and the spatial extent of open-fields and fence-organisations.

The number of fences and, indirectly, the time and material needed to build them, is another factor to consider. It proves to be the case that the farmers in the three-field system used more fences compared to those on the farms with the one-field system. The total amount of fences in area A amount to 48.2 km. Area B has almost double that area, with 86.5 km total. Additionally, the number of fences around individual smaller enclosed fields is higher in area B. The same applies to the number of fences per farm. In area A, farms have approximately 434 m of fences on average, to compare with approximately 848 m in area B. The total length of property boundaries between settlements that were not fenced, that were marked on the ground with stones or other markers, is equivalent; 39.3 km in area A and 43.8 km in area B. In other words, the amount of fences reduced (as a way of saving effort and material) is equal in both areas – but area B, the three-field system, required twice as much fencing (see Tables 2 and 3).

Another difference is that the settlements in the one-field system have good access to grazing in the outlying lands, while the settlements in the three-field system often lacked grazing access. For each settlement, the land surveyors assessed the availability of pasture, as either good, moderate or missing.[37] In area A, the surveyor provides information on good grazing access for ten hamlets. In four cases, no information was provided, but these probably also had access to grazing. This means that the villagers in area A could bring their grazing animals to outlying fields and let them graze there from spring until autumn. After the harvest, the entire one-

Table 1
Summary of quantitative data provided by the surveyor on the large-scale maps from the 1640s (1 *tunnland* equals approximately 1.2 acres). Source: National Edition of the Oldest Geometrical Maps, database available at https://riksarkivet.se/geometriska, accessed October 21, 2019.

	Area A	Area B
field system (fallow rotation)	one-field	three-field
number of settlement units	14	14
number of holdings (farms)	115	102
number of farms per settlement unit	8.2	7.3
total size of arable land (*tunnland*)	1371	1630
size of arable per settlement unit (*tunnland*)	98	116
size of arable per holding (*tunnland*)	12	16
total yearly hay yield (loads of hay)	2030	2082
hay yield per settlement unit (loads of hay)	145	149
hay yield per holding (loads of hay)	17.7	20.4

Table 2
Total lengths of the fences on the large-scale maps from the 1640s. Source: National Edition of the Oldest Geometrical Maps, database available at https://riksarkivet.se/geometriska, accessed October 21, 2019.

	Area A	Area B
total length of fences (metres)	48,210	86,506
total length of unfenced borders (m)	39,341	43,817
length of fences for smaller enclosed fields (m)	6671	17,061
fence per farm/holding (m)	434	848
unfenced border per farm (m)	354	430
smaller enclosed fields per farm (m)	281	783

Table 3
The surveyors' comments on access to pasture on the outlying land. Source: National Edition of the Oldest Geometrical Maps, database available at https://riksarkivet.se/geometriska, accessed October 21, 2019.

	Area A	Area B
settlements with specified good access to pasture	10	5
settlements with sufficient access to pasture	0	5
settlements with no/very little access to pasture	0	4
settlements with no comment on pasture access	4	0

[33] O. Karsvall, Åkerstorlek 1640 som indikator på stora medeltida bebyggelser, in: O. Karsvall and K. Jupiter (Eds), *Medeltida storgårdar: 15 uppsatser om ett tvärvetenskapligt forskningsproblem*, Uppsala, 2014, 193.

[34] It should be added that parts of the arable in area A (in Karleby, Lovene, Luttra och Synneråll), according to the land surveyor, contained so-called wild oats or *Avena fatua* (referred to as *vildhavre*, see e.g. P3:286–287), a weed that could suffocate the grains. The soil quality was otherwise good in this area and was described as black soil and clay soil.

[35] K. Jupiter and A. Wästfelt, Different spatialities, Different Rationalities? – Field systems in 17th century Open Fields, forthcoming.

[36] It should be added that some pieces of land were also left unused in the one-field system, as mentioned by the land surveyors (see e.g. P3:293–294). Gunnar Lindgren (1939) estimated that 25% of the arable land in the one-field system could lie in fallow.

[37] The surveyor's comments on grazing were in conjunction with other comments about forests, which suggest that these comments refer to the outlying pastures and not the pastures on the infields.

field system could serve as a large paddock. The conditions were different in area B. Five settlements are described as having good access, while the rest were assessed to have inadequate or no access to pastures.[38] Additionally, the access and availability of the forests was a necessary resource for building materials and fuel. With no forest the timber had to be bought elsewhere as commented by the surveyors.[39]

Thus, in area B, approximately half of the settlements had to keep their animals on the infields the whole year, which meant that they needed to be on one of the three fields that lay in fallow each year. Consequently, grazing after haymaking and harvesting was of central importance. Because of the fallow rotation, grazing occurred in different fields at different times. These different activities would have to be spatially and temporally synchronised within the fence-organisation. To improve the availability of grazing, two settlements, Tiarp and Flittorp, which both lacked outlying land, had supplemental grazing around the farmsteads (see Figs. 3 and 4).

The lack of grazing land (outlying pasture) in area B was likely related to the need for grazing on the infield and thus the greater use of fences. Hence, the higher cost (length) of the fences in the three-field system is motivated by the need for grazing on the infields. The lack of grazing areas in area B could also be related to fewer grazing animals. This is not supported by the fact that the output from meadows was roughly the same between the two areas, although Gunnar Lindgren has shown that the prevalence of cattle was higher in area A and in the one-field region (approximately 30%) compared with the three-field region. A further analysis of the number of animals in relation to the one- and three-field systems could potentially provide more clues on this question, but this could not be covered in this study. It can be concluded here that both areas practiced mixed-farming, but as shown by the analysis herein, the way in which this practise was spatially solved and organised differed, and these disparities likely relates to the basic needs for pasture.[40]

Smaller open-fields and collaboration between settlements

Open-fields are usually discussed in relation to arable land, and we will continue to analyse this topic on the basis of the historical maps. The arable plots were irregularly distributed in this western part of Sweden, and the shape and size of the plots varied. The size and allocation of the arable plots and the distance between plots and farmsteads differ between areas A and B. In area A, the arable plots were situated closer to the farmsteads, and the plots were generally larger and less scattered than those in area B, characterised by a high degree of scattering. In Area B, for example, in Högstena and Tiarp, farms are located around a village green, and each farm has equal distance to the arable fields. However, with a high degree of scattering and more and smaller plots, the annual distance (total transport to each plot in two fields) is on average three times longer than Area A. This because the plots are generally clustered close to each farmstead and not dispersed throughout the whole arable fields.[41]

Another difference between the two areas was that the settlements in area A more often had some of their plots of arable land and meadows within the boundaries of a neighbouring settlement. The villages of Saleby and Slöta are examples of this. The surveyor had, in this case, not marked any boundary between them because the farms in both villages had their plots partly within the other's core area. Moreover, the surveyor noted that Saleby and Slöta shared meadow land with Leaby, Karleby and Smedby, which were the settlements bordering in the north and west.[42] There are more indications of this in area A, e.g., between Luttra, Gunnerstorp and Agnestad. One explanation could be that the absence of inner fences in area A led to a greater exchange due to sales and trading of plots between neighbours. This shows that neighbouring settlements in the one-field system were closely connected. This was probably a consequence of the lack of inner fences, between hamlets and farms.

In area B, the degree of collaboration was less significant in the sense that the settlements had at least one arable field separated from those of their neighbours. In some cases, there was no collaboration in the arable fields. For example, Åsled, Åstorp and Amfastorp all had individual arable fields, but did share the meadow field with their neighbours. One point here is that a settlement could have been part of a fence-organisation and does not necessarily involve arable land. It was sufficient that the collaborations only include the meadow land.

Furthermore, the strategy for the division of the arable fields into plots is not the factor that explained the open-field cooperation. An example of this is Esbjörnstorp in area B (for location see Fig. 4), which consisted of two farms, each with separated and fenced arable fields. One farm had one field, and the other had three fields. The division between the two holdings was marked by a red dotted property boundary that cuts through the infield. Since there was no cooperation in arable land, this could not be considered an open-field but rather an enclosed arable field. Despite this, the arable land was divided into plots that were numbered by the surveyor (the same number as the farmstead, see Fig. 5). This indicates that the division of plots was related to farming practises rather than collaboration among farmers, or ownership of land.[43] However, the two farms in Esbjörnstorp were in sync with the neighbours in the meadow that formed a joint open-field, belonging to the farms in Esbjörnstorp, Flittorp, Åsled and Tiarp. The surveyor states that there was no access to outlying land in Esbjörnstorp. The absence of grazing was compensated by the fact that the meadow field is used as a paddock after haymaking. Consequently, the timing of when the grazing animals were released on the meadow field must have been synchronised among all neighbours sharing the same field. To summarise, in Esbjörntorp, the arable land was individually enclosed, but the meadow field was shared by several neighbouring farms, which was a collaboration that could be considered an open-field.[44]

This type of smaller open-fields, which are spatially delimited by the fences, occurs in several locations in areas B. A full reconstruction of the settlements in area B that collaborated in some

[38] In Swedish stated as “inget vidare utrymme”, “mulbete trångt”, or “nödtorftigt mulbete”.

[39] See for instance Karleby, “ingen skog utan för penningar” (P3:293–294). See also Ö. Kardell. *Hägnadernas roll för jordbruket och byalaget 1640–1900*, Uppsala, 2004, 192–193.

[40] Lindgren, *Falbygden och dess närmaste omgivning vid 1600-talets mitt*, 51–59.

[41] Jupiter and Wästfelt, Different spatialities, Different Rationalities?. The manuscript compares scattering in one- and three-field hamlets in the study area using spatial and temporal analysis in GIS based on the same sources.

[42] On the map, it says “These villages [Saleby and Slöta] have their meadows intermixed with the meadows belonging to Leaby, Karleby and Smedby” (P3: 279–280).

[43] This question is examined in more detail in K. Jupiter, The function of open-field farming – managing time, work and space, *Landscape History*, 41:1 (2020), 69–98.

[44] Another village that combined individual arable land with open-field for meadow and pasture was Hedared, which was located in the parish of Sandhult in the province of Västergötland (04:102–104). The six farms in this hamlet were scattered. Their arable field was divided into pieces but not intermixed. Several farms still share the field and fences that create open-fields, primarily for haymaking and pasture.

parts of their land is shown in Fig. 6. The open-fields between the settlements are specified with brown colour for arable land and green colour for meadow land. In total, there are eight such open-fields in area B. The spatial boundaries for these open-fields are determined by the extent of the fences, but natural barriers such as streams also delimit some open-fields.

Most arable fields in area B adjoin several settlements without fencing. The only exceptions – fields that could have been connected without using fences as a boundary – are found in Åsled and Svartarp. All other fields were laid out in a way that minimised the need for fences. As shown in Fig. 6, the open-fields in the arable and the fenced areas numbered 2, 3, 5, 7, and 8 involved two, three or

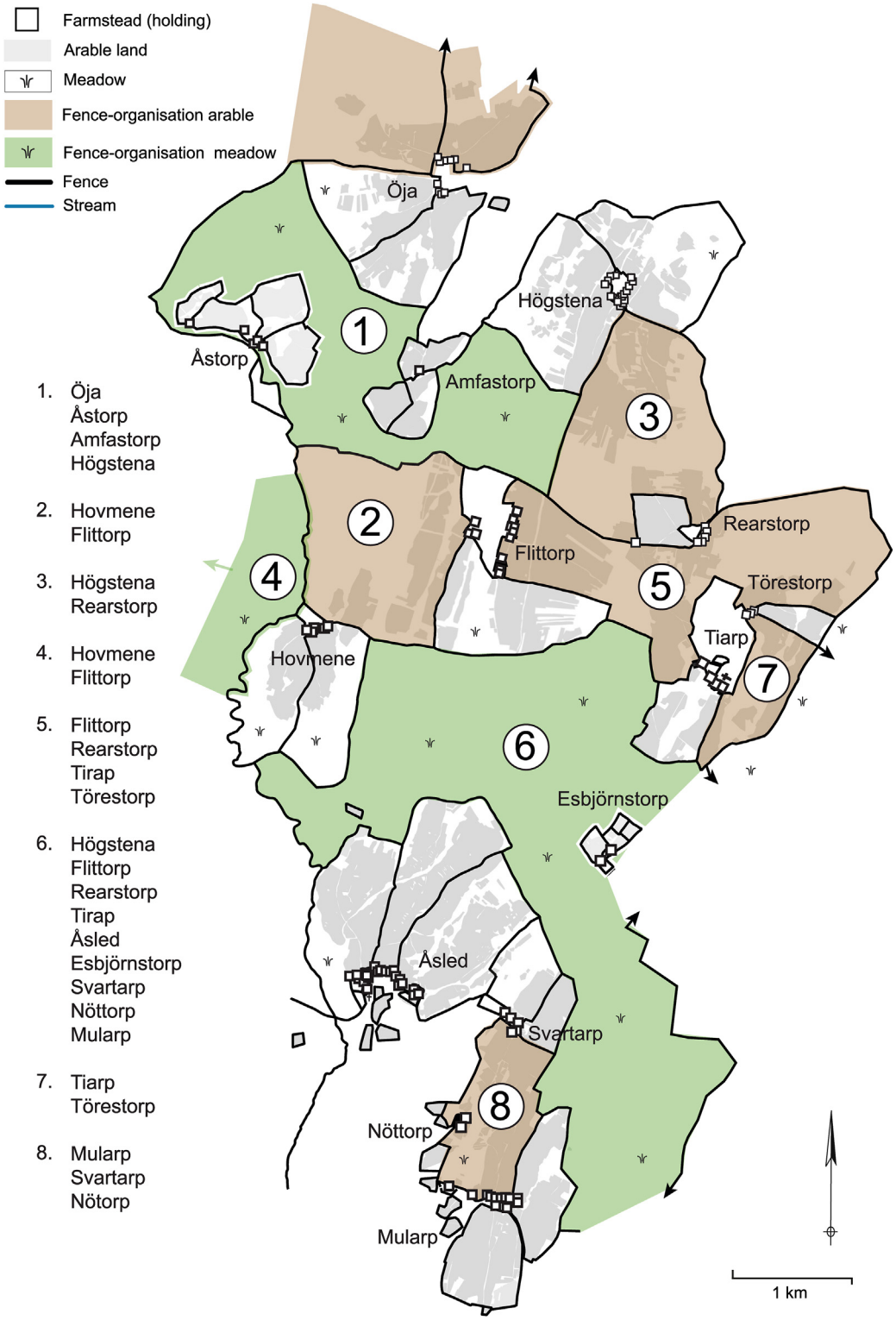

Fig. 6. Small open-fields in arable and meadow lands in study area B.

four settlements each. Based on the need to keep the fields fenced, the spatial integration had reached its maximum in all these cases. The same applies to the meadow fields numbered 1, 4 and 6 in the figure. Number 6 involves nine settlements, while number 1 consists of four cooperating settlements. Number 4 had two settlements in the study area but extended further to the west.[45] The meadows thus formed larger open-fields than the arable land, but all these open-field were smaller than the single open-field found in area A. Decision-making was therefore divided between several institutions in area B. Another observation is that the smaller settlements in area B (Esbjörnstorp, Amfastorp and Åstorp) appeared as enclaves on the meadow fields, and they were thereby restricted from cooperating in the arable land.

To conclude, in both areas A and B, several settlements had to reach consensus on an organisation scheme, although the degrees and scale of the cooperation varied. The one-field system in area A was one large open-field and was a cooperation among many settlements that required synchronisation among all participants. In the three-field system in area B, the cooperation was delimited to several smaller open-fields that could be used at different times for different purposes. This optimisation was a result of the fields being spatially delimited by fences. Synchronisation was required in both areas but was less demanding in the three-field system where the different smaller open-fields of arable land and meadows were kept separate and fenced separately. Participants in an open-field of meadow land required cooperation for haymaking and grazing, while the open-fields of arable land also required synchronisation regarding cropping arrangements and fallow rotation.

Discussion

Initially we pointed to that this study is not about the historical change processes. One of the main reasons for this is that the old research in Sweden on the topic of open-field systems regarded the transition from a one-field to a three-field system as an evolutionary step, going from an old, primitive mode of production to a modern and more efficient system. By avoiding this perspective our focus has instead been to understand the possible advantage and disadvantages with the two different field-systems. However, the central role of fences in early medieval laws indicates that these types of arrangements have a history that dates back to at least the latter half of the thirteenth century. The historical maps show that these organisations were in use until the enclosure reform, known as *Laga skifte,* in the second half of the nineteenth century.

Based on this study, it is possible to interpret that groups of settlements collaborated and formed different open-fields. Adjustment and adaptation to needs and circumstances, as well as benefits from cross-farm and village collaboration, has driven these systems. When looking back to past times and forward to recent times, an important aspect emerges, and it is the balance between land and labour efficiency and the overall outcome of farming. Even if arable farming in the three-field region in this study (area B) produced less cereals than the one-field region (area A), the higher flexibility and the possibility to hold animals on the infield had advantages, which was partly a result of the fallowing. On the other hand, in area A, the land productivity was higher but the necessity to synchronise work and activities with a larger group of neighbours, as well as more extensive protecting of animals on the outlying commons, costs a lot of labour and led to loss of efficiency. The farmers in the seventeenth century was aware of the different way of organising small-scale farming within open fields. The one-field and three-filed system may have existed in parallel for a long time, and developed simultaneously, which makes the question of their origin less relevant.

Conclusions

In this study, two fence-organisations in a part of southwestern Sweden (Falbygden, Västergötland) have been reconstructed. The aim has been to identify and analyse how different open-fields were delimited by fences in regard to cooperation between farms and settlements.

The cooperation in fence-organisations has different spatial consequences depending on field-system. At their core, fenced open-fields can be understood as multiple simultaneous collaborations among farmers on different scales. Villagers from different hamlets shared arable land, meadows and pastures. They also synchronised the agricultural work, for instance the responsibility of maintaining the fences. The collaboration occurred both within and between settlements, and together with others, they formed groups of functionally coordinated settlements. The term “open-field” or “open-field system” could in this context refer to either a single shared field of a hamlet or a fence-organisation comprised of several hamlets with interconnected fields. The reconstruction of these fence-organisations in this study show the spatial consequence they have on the physical landscapes. The institutional and organisational arrangements of these systems has not been examined but given the communal “nature” of intermingled holdings in the open-field system, these fence-organisations would require functional synchronisation and regulations to maintain institutions of effective mixed-farming.

The analysis shows that fence-organisation in different field-systems result in two different types of fenced open-fields within the mixed-farming system: 1) a single continuous open-field with many participants (the one-field system) and 2) smaller open-fields with fewer participants, who also took part in other smaller open-fields (three-field system and other regular fallow systems). Despite few variations in the natural conditions for agriculture or any difference in the size of settlements or farms, for instance, in the size of arable land and meadow land, the two compared areas demonstrated diverse spatial patterns. In both types, the open-field organisations were based on agreements between settlements. The one-field system required synchronisation among many participants, while the requirements in the three-field system were less demanding and spatially delimited to several smaller areas. The scattering of arable plots, which occurred within the settlements, do not relate to these collaborations. One could keep the arable land individually but still share meadows, pastures and fences with others in an open-field. This leads us to the conclusion that the fragmentation of the arable land is less important for the definition of open-field, at least within the mixed farming system in Scandinavia.

The fences in the seventeenth century Scandinavia were built to be permanent. They were used to keep the grazing animals away before harvest and to ensure pasture after harvest. This study also shows that they delimited the different open-fields by setting the spatial boundaries of the farming collaborations. The lack of grazing land (outlying pasture) – which characterizes the three-field region in this study – is a possible explanation for the different forms of

[45] The study area B was limited to fourteen settlements, but cooperation was not restricted to this area but rather was continuous and involved neighbouring villages/hamlets outside of area B. In the northern part, the settlement of Öja was connected via two arable fields with two other settlements, and in the eastern parts, the meadow field number 6 continued east and involved additional settlements.

cooperation. The seventeenth century farmers made efforts to minimise the number of fences needed, but the cost (length) of the fences was doubled in the three-field system compared to the one-field system. By enabled grazing in different fields at different times, the fenced open fields in the three-field regions offered solutions to overcome the lack of pastures. The one-field system included more participants and had better access to outlying pasture less fences to maintain and, consequently, less conflicts concerning fences.

The final conclusion of this work is that the open-fields of Scandinavia were physically delimited by fences, which gave rise to various forms of collaborations, and these small-scale mix farming systems promoted efficiency, sustainability and utility in the early modern rural society.

Announcement

This study originated from a collaboration between two research projects, “An efficient farming system – Open-field systems in the 17th century”, funded by Jan Wallanders och Tom Hedelius stiftelse (P2014-0247:1), on which Kristofer Jupiter is a doctoral student, and the TORA project at the Swedish National Archives, which is led by Olof Karsvall and funded by Riksbankens Jubileumsfond and The Royal Swedish Academy of Letters, History and Antiquities (1506P131).

Declaration of competing interest

None.