

Sweden's agricultural revolution reassessed: A reconstruction of arable land and food production in 1810 and 1870*

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Abstract

This article presents the main results from the project Arable Land in Sweden. By examining some 9,400 cadastral maps, the acreages of arable land for the years 1810 and 1870 have been reconstructed. The calculations have thereafter been combined with other data in order to estimate agricultural production these years. As a result of the project, researchers have for the first time accurate data to quantify developments during the agricultural revolution. Surprisingly, Sweden had less arable land in the beginning of the nineteenth century than researchers have come to believe. Also, the acreage of arable land in 1870 must be adjusted downwards, but not as much. Land reclamation was thus faster than expected and firmly exceeded population growth. In addition, the data show that the expansion of the arable went hand-in-hand with increased productivity, surmounting the pitfalls of diminishing returns. In a concluding part, a partially new interpretation of Sweden's agricultural revolution is put forward.

Agriculture transformed nineteenth-century Sweden. After 1800, ecological, institutional and technological constraints of the old agrarian regime were overthrown. A new situation in which the increase in agricultural production permanently outpaced population growth can be discerned. These developments are commonly referred to as the agricultural revolution.¹ Various trends have been adduced to support such an interpretation:

* Earlier versions of the paper were presented at Rural History 2019, Paris; Swedish Economic History Meeting 2019, Uppsala; Dept of Economy and Society, Univ. of Gothenburg, 2021; Agricliometrics IV, Madrid 2021. We gratefully acknowledge all comments on these occasions. A special thanks to Thor Henrik Brodtkorb for helpful advice on statistics and for the bootstrapping and Per Larsson for discussions on grinding losses. We also thank two anonymous reviewers for extraordinarily ambitious comments on the manuscript. Author contributions: E. Hallberg project manager, designed research; E. Hallberg, L. Nyström, L. Leijonhufvud and L. Palm performed research and developed method; E. Hallberg and L. Nyström contributed analytic tools and analyzed data; L. Nyström compilation of database and GIS infrastructure; E. Hallberg and L. Nyström wrote the paper. The project was funded by Riksbankens jubileumsfond, IN16-0854:1

¹ For an overview, see Carl-Johan Gadd, *Svenska jordbrukets historia Bd 3. Den agrara revolutionen [History of Swedish agriculture, III, The agrarian revolution]* (Stockholm, 2000); Carl-Johan Gadd, *The agricultural revolution in Sweden: 1700–1870*, in Janken Myrdal and Mats Morell (eds), *The agrarian history of Sweden: from 4000 BC to AD 2000* (Lund, 2011), pp. 118–65. Overviews of other cases are, e.g.: Mark Overton, *Agricultural Revolution in England* (1996); Jan Luiten van Zanden, *The transformation of European agriculture in the nineteenth century: The case*

- Before the nineteenth century, severe mortality crises frequently hit Sweden, usually in connection to food shortage. In the nineteenth century, however, the crises became milder and less frequent, even as the population doubled. This new pattern suggests that there must have been enough food to keep starvation at the door. In short, Sweden had escaped the Malthusian trap.²
- Swedish imports of grain decreased from the late eighteenth century. In the 1830s Sweden became instead a net exporter of grain, mainly oats. At its peak in the 1870s, the value of exported oats surpassed the value of exported iron, traditionally Sweden's major export.³
- Price trends indicate that living standards improved. Grain prices fell while real wages rose. The combination of strong population growth, falling food prices, grain exports and rising real wages could only be achieved in a situation of improved agricultural productivity.⁴
- A continually enhanced prosperity was manifested in rural areas. Farmhouses became larger. The peasantry could afford novelties such as coffee, iron stoves and tableware. Overall, the peasantry's economic, political and cultural influence grew.⁵

Several technological and institutional changes that might explain these developments have been identified. Freeholders' property rights were strengthened. Taxes were fixed, incentivizing farmers to increase production without having to share the fruits of the investment with the Crown. Enclosure reforms did away with the commons and the open fields. Convertible husbandry and new fodder plants such as clover were introduced. Tools became heavier and more efficient.⁶

Researchers, however, have had difficulty giving a quantitative and substantive account of the development. Agricultural statistics were introduced early in Sweden, but are hampered by severe underestimations. Researchers have had therefore to reconstruct acreage and production from other sources. As within the international research community, this has been done in two ways.⁷

One path has been what Mark Overton labelled as 'top-down studies'. Within this tradition, macro-level production has been deduced from national series of wages, prices, population, per capita consumption, imports and exports. Following this approach in 1974, Bengt Holgersson

Note 1 continued

of the Netherlands (1993); Erik Thoen and Leen Van Molle (eds), *Rural history in the North Sea area. An overview of recent research (Middle Ages – beginning twentieth century)* (2006). For a discussion on the definition of the agricultural revolution, see p. 14.

² Erland Hofsten, *Svensk befolkningshistoria. Några grunddrag i utvecklingen från 1750* [Swedish population history. Some basic features of the development from 1750] (Stockholm, 1996), pp. 104–8, 163–71.

³ Gunnar Fridlitzius, *Swedish corn export in the free trade era* (Lund, 1957), p. 84.

⁴ Rodney Edvinsson and Johan Söderberg, 'Prices and the growth of the knowledge economy in Sweden and Western Europe before the industrial revolution',

Scandinavian Econ. Hist. Rev. 59 (2011), pp. 250–72; Rodney Edvinsson, 'Swedish GDP 1620–1800: stagnation or growth?', *Cliometrica* 7 (2013), pp. 37–60; Lennart Jörberg, *A history of prices in Sweden, 1732–1914* (Lund, 1972), esp. p. 337.

⁵ Christer Ahlberger & Johannes Daun (eds), *Bondeherrgårdar. Den nyrika bondeklassens gårdar 1750–1850* [Farmer's mansions. The farms of the nouveau riche peasantry 1750–1850] (Lund, 2018).

⁶ Gadd, *Svenska jordbrukets*, esp. pp. 195–7 (taxation), 198–205 (tenants and freeholders), 231–41 (land reclamation), 242–54 (new tools), 273–304 (land reforms), 305–14 (new cultivation systems).

⁷ Overton, *Agricultural revolution*, p. 74.

estimated Sweden's arable land and grain production in 1840–1939 on the basis of the population's need for subsistence. Holgersson's calculations were later used by Lennart Schön in his reconstruction of Sweden's nineteenth-century national accounts.⁸

The other path has been what Overton calls 'bottom-up' studies. Within this tradition micro-level data on, for example, acreage and production are used in order to reconstruct figures at the level of the region or national. In 1971, the geographer David Hannerberg estimated arable land and grain production in Sweden 1800–1900 by the use of area data from a sample of cadastral maps in Närke, one of Sweden's 25 counties. The figures were later used by, among others, Carl-Johan Gadd and Rodney Edvinsson.⁹

Both the top-down and the bottom-up approaches are characterized by rough estimates. One limitation with top-down studies such as Holgersson's is that agriculture is reduced to being a dependent factor. No deeper understanding of the causes and content of the agricultural development can be reached from such investigations. Hannerberg's bottom-up study, on the other hand, faces the problem of estimating aggregate numbers on the basis of a limited set of micro-level data. Furthermore, none of the mentioned studies can capture the regional mosaic of different paths of developments, so important in the study of agricultural history.

The project Arable Land in Sweden has reconstructed acreages of arable land and meadows in 1810 and 1870 following the bottom-up tradition and using microdata, but on a much larger scale than in previous studies. Close to ten thousand cadastral maps were examined in order to calculate the acreage of arable land on the *härads* (the local jurisdiction district) level for all of Sweden. The calculations have thereafter been combined with trustworthy data in order to reconstruct agricultural production and consumption for these benchmark years. This article presents the methodology and the main empirical results of the project.

I

Agricultural statistics were established early in Sweden. From the beginning of the nineteenth century comprehensive data for each of the 2,300 parishes in the kingdom was collected as a part of a larger demographic questionnaire by *Tabellverket*, the statistical bureau of the time. Every fifth year from 1805–20, the clergy estimated the size of arable land, how much of it was sown and also the number of livestock. Annually from 1802–20, they approximated the seeding rates and yields of the most important crops. The material is uniform, complete and well preserved.¹⁰

After 1820, the clergy were freed from this duty. A few years earlier bailiffs had been made responsible for the collection of a new series agricultural statistics, which was published in the

⁸ Bengt Holgersson, 'Cultivated land in Sweden and its growth 1840–1939', *Econ. and Hist.* 17 (1974), pp. 20–51. Lennart Schön, *Historiska nationalräkenskaper för Sverige*. 1. *Jordbruk med binärningar 1800–1980* [Historical national accounts for Sweden. 1. Agriculture with ancillary industries 1800–1980] (Lund, 1995).

⁹ David Hannerberg, *Svenskt agrarsamhälle under 1200 år. Gård och åker, skörd och boskap* [Swedish rural

society for 1200 years. Farm and field, harvest and livestock] (Stockholm, 1971). Gadd, *Svenska jordbrukets*, pp. 231–4, 379; Rodney Edvinsson, 'Harvests and grain prices in Sweden, 1665–1870', *AgHR* 60 (2012), p. 3.

¹⁰ The Swedish National Archives, *Tabellverket 1749–1859*, reference code SE/RA/420439, published online at <http://rystad.ddb.umu.se:8080/Tabellverket/Tabverk>.

County governor's reports to the government every fifth year. However, the original documentation is only sporadically preserved.¹¹

In 1858, a so-called Finance Committee was appointed to study the economic and financial development of the previous 25 years. As a basis for the investigation, the vestries of all parishes were asked to fill out a questionnaire, which was distributed by the regional Husbandry Societies (*Hushållningssällskap*), semi-official organizations for the promotion of agriculture. The material is extensive but has never been published on a micro level.¹² Furthermore, there are differences in form and content of the data between the provinces.

In 1865 the SCB (Statistiska centralbyrån), the Central Bureau of Statistics, initiated a more ambitious attempt to create a set of national agricultural statistics. Annual information on acreages of arable land, seeding rates, harvests, and the number of farm animals was published in annual volumes, *BiSOS, Bidrag till Sveriges officiella statistik* (Contributions to the Official Statistics of Sweden), including data at the national, county, district and in most cases also parish level. The Husbandry Societies were (again) responsible for the collection of the data. They did not however develop a uniform approach. In most counties, the parish councils or some other local committee submitted information. In other counties the Husbandry Societies organized local enquiries with varying degrees of ambition.

It was only in 1913 that the methodology for collecting information was made uniform, with detailed local surveys, organized by the SCB. In connection with the emergency measures taken during the First World War, the surveys included meticulous records of acreage and livestock inventories at the farm level.

II

Unfortunately, the nineteenth century agricultural statistics leave much to be desired. Microstudies strongly indicate that the actual amount of arable land was considerably higher than that recorded in the official figures. Contemporary officials were well aware of these problems. In 1809, Henric Nicander, head of *Tabellkommissionen*, the authority responsible for the statistics, assumed the published figures on acreages and harvests to be roughly one third too low.¹³

The problem of underestimation was to be an enduring cause of worry. The Finance Committee of 1858 considered the result of its local agricultural survey inadequate and refrained from publishing more than just a small part thereof. Some years later Fredrik Theodor Berg, head of SCB, estimated the official figures of grain production in 1865 to be about one fifth too

¹¹ Femårsberättelser [Five-year reports] (Stockholm, 1817–1855). Published online at <https://www.scb.se/hitta-statistik/aldre-statistik/innehall/officiell-statistik-1811-1860/femarsberattelser-18171855/>

¹² The Swedish National Archives, Finanskommitén 1858 [Committee of Finance], reference code SE/RA/310496.

¹³ Henric Nicander, 'Om Svenska Tabell-Werket, åren 1801–1805, Utsäde, Skörd, Öppen jord, Kreatur',

Kungl. Svenska vetenskapsakademiens handlingar, T. 30, *För år 1809* ['On the Swedish Tabellverket, the years 1801–1805, Seed, Harvest, Open land, Cattle', *Documents from the Royal Swedish Academy of Sciences*, T. 30, *För år 1809*] (Stockholm, 1809), pp. 116–21, esp. p. 119. See also Carl af Forsell, *Statistik öfver Sverige, grundad på offentliga handlingar* [Statistics of Sweden, based on public documents] (sec. edn, Stockholm, 1833), pp. 94–5.

low, given the nutritional need of the population, the use of grain as fodder, and imports and exports of grain.¹⁴

Why were the agricultural statistics not reliable? The main reason was that no closer examination of acreages and yields were carried out. Instead the persons in charge of the investigation were directly or indirectly dependent on information from the farmers. The farmers in turn were worried that the information submitted to the authorities would form the basis for future taxation. Consequently, they tended to submit understated production figures. In fact, the clergy seems to have disliked the task precisely because of its delicate social implications. The collection soured their relationship with the peasantry, who suspected public officials of having hidden motives behind their interest in local level production figures.¹⁵

During the BiSOS-period, 1865–1912, the level of underestimation in the statistics seems to have been gradually reduced. As shown by Jörn Svensson, the material however also became increasingly heterogeneous, as the Husbandry Societies developed different methods for the collection of data. Another problem was that figures collected at the local level were not updated annually. Once a parish or a district had been examined more closely, the data on acreages and seeding rates were often left unchanged until the next investigation, which could happen one or two decades later. Even if the quality of the local inquiries improved over time the aggregated level figures thus still tended to lag behind the actual development. Svensson believed BiSOS to be accurate only around 1900 at the earliest. Still in 1905 the SCB itself noted that the overall data in BiSOS appeared inaccurate.¹⁶

III

One way to try to recover the official statistics has been systematic upward adjustments. The fundamental idea for such attempts is that real production has been downgraded to a more or less consistent extent in the statistics. An increase by a certain percentage would therefore result in accurate figures.

In 1913 the distinguished statistician Gustaf Sundbärg raised the figures of the official statistics by 12 per cent for 1805, by 10 per cent for the period 1810–70, by 5 per cent for 1880 and, finally, by 0 per cent for 1900. At the turn of twentieth century, the official statistics were thus supposed to finally show accurate numbers.¹⁷

Subsequent research has determined Sundbärg's adjustments to be too small. On the basis of land survey acts, Hannerberg found acreage in the county of Närke in 1800 to be roughly

¹⁴ [Fredrik Theodor Berg], BiSOS N, *Jordbruk och boskapsskötsel* [Agriculture and stock raising] (1865), pp. 24–5.

¹⁵ Hannerberg, *Svenskt agrarsamhälle*, pp. 29–31; Gadd, C-J 1999. 'Präster och landshövdingar berättar', *Svensk jordbruksstatistik 200 år* ['Clergymen and governors recount', *Swedish agricultural statistics 200 years*] (SCB, 1999), p. 30. John Hellstenius, 'Skördarna i Sverige och dess verkningar' ['The harvests in Sweden and their effects'], *Statistisk tidskrift* 29 (1871), p. 104.

¹⁶ Jörn Svensson, *Jordbruk och depression 1870–1900*.

En kritik av statistikens utvecklingsbild [Agriculture and depression 1870–1900. A critique of the statistic's depiction of the development] (Lund, 1965). Karl Medin, 'Statistiska centralbyrån tar över' ['The national bureau of statistics takes over'], *Svensk jordbruksstatistik 200 år* (SCB, 1999), pp. 63, 78–9.

¹⁷ Gustaf Sundbärg, *Emigrationsutredningen, bilaga 22. Betänkande i utvandringsfrågan*. [The Emigration investigation, Suppl. 22. Report on the emigration issue] (Stockholm, 1913), p. 91.

100 per cent higher than according to the official statistics. He assumed that the national figures were underestimated to the same degree. For 1865, Hannerberg considered official acreages in his sample area to be trustworthy. Nevertheless, he assumed the national acreage to be underestimated by c.20 per cent. This was still a modest estimation compared to Holgersson, who raised the official acreage in 1870 by 30 per cent.¹⁸

Hannerberg's estimations from 1971 were never intended to be more than a preliminary sketch. Hannerberg himself stressed the importance of further studies, advocating a wider investigation on acreages on the basis of land survey material. Subsequent local studies have demonstrated a large variation in extent of deviations from the true situation in the statistics around 1800.¹⁹ Nevertheless the original assessment of Hannerberg has had an enduring normative effect on the state of research.²⁰

The growing interest in databases and the collection of 'big data' in the last decades has however given rise to new attempts to estimate Sweden's nineteenth-century agricultural production. At the regional level, Mats Olsson and Patrick Svensson have compiled the extremely rich source material that exists for the province Scania (and nowhere else) into a database, namely eighteenth- and nineteenth-century farm-level tithe records.²¹ In another project, led by Mats Morell, land survey acts are used to study and chart the development in the Mälardalen region.²² At the national level Lennart Palm and Rodney Edvinsson have presented new production estimates.

Lennart Palm's project Swedish Database of Agricultural History aimed at offering agricultural statistics at the parish level with 60-year intervals 1570–1810. For 1810 the main source was some 9,000 probate inventories from all over the country. The material proved to be highly useful in the reconstruction of animal husbandry. Regarding cereal production, the plan was to use farm level seed-data from the inventories, following a methodology developed by Lars Herlitz and Carl-Johan Gadd. However, information on seeds was only included in the inventories in a few counties in western Sweden. For the rest of the country other sources and methods had to be utilized: local reports, previous micro-level studies, the official statistics, guesstimates and analogies combining a wide range of different information. The material is thus very heterogeneous. Compared to Hannerberg, Palm's reconstruction

¹⁸ Hannerberg, *Svenskt agrarsamhälle*, pp. 69–71. Holgersson, 'Cultivated land', tab. 12, p. 47.

¹⁹ Calculated acreage of arable land in relation to the official statistics: +250%, Maths Isacson, *Ekonomisk tillväxt och social differentiering 1680–1860: bondeklassen i By socken, Kopparbergs län* [Economic growth and social differentiation 1680–1860. The peasant class in By parish, Dalarna County] (Uppsala, 1979), p. 83; table E in the Appx; +116% and +233%, resp. (two different areas), Folke Karlsson, *Mark och människor: befolkning och försörjningsresurser i västra Småland 1800–1850* [Land and people. Population and livelihood resources in western Småland 1800–1850] (Göteborg, 1976), p. 224; +105% (Herlitz, Urban, *Restadtegen i världsekonomin. Lokala studier av befolkningstillväxt,*

jordbruksproduktion och fördelning i Västsverige 1800–1860 [Restadtegen in the world economy. Local studies of population growth, agricultural production and distribution in Western Sweden 1800–1860] (Göteborg, 1988), p. 209.

²⁰ Gadd, *Svenska jordbrukets*, pp. 231–2, 379. See also Edvinsson, 'Harvests', p. 3

²¹ Mats Olsson and Patrick Svensson, *Historical Database of Scanian Agriculture, version 3.0* (Dept. of Economic Hist., Lund University, 2017).

²² Mats Morell and Marja Eriksson, *Institutionell förändring och agrar-ekonomisk tillväxt i Sverige 1810–1880* [Institutional change and agrarian-economic growth in Sweden 1810–1880], ongoing project.

TABLE 1. Different estimates of acreage in Sweden 1810, 1870 and 1920, hectares (thousands)

<i>Author</i>	<i>Method</i>	<i>Acreage c. 1810</i>	<i>Acreage c. 1870</i>	<i>Acreage 1920</i>	<i>Utilization within research</i>
A. Official statistics (<i>Tabellverket</i>)	Local estimations provided by the clergy as part of the <i>Tabellverket</i> -collection of data	827			Adjustments by Sundbärg, <i>Emigrationsutredningen</i> (D) and Hannerberg, <i>Svenskt agrarsamhälle</i> (E)
B. Official statistics (BiSOS)	Local estimations provided by the regional Husbandry Societies, based on heterogeneous methods of data collection.		2,546		Adjustments by Sundbärg, <i>Emigrationsutredningen</i> (D) and Hannerberg, <i>Svenskt agrarsamhälle</i> (E)
C. Official statistics (SCB)	Uniform and meticulous local enquiries.			3,795	Widely accepted
D. Sundbärg, <i>Emigrations- utredningen</i>	Adjustments of the official statistics based on guesstimates.	925	2,831		
E. Hannerberg, <i>Svenskt agrarsamhälle</i>	Adjustments of the official statistics based on acreages according to land survey acts in Närke historical province.	1,500 (year 1800)			Schön, <i>Historiska nationalräkenskaper</i> (H); Gadd, <i>Svenska jordbruket</i> (I), conference papers (J, K, L); Edvinsson, 'Annual estimates' (M) and 'Gross domestic product' (N), via Gadd conference papers (J, K)
E. Hannerberg, <i>Svenskt agrarsamhälle</i>	Guesstimate		3,000 (year 1865)		Gadd, <i>Svenska jordbruket</i> (I), conference papers (J, K, L); Edvinsson, 'Gross domestic product' (N), via Gadd conference papers (J, K)
F. Holgersson, 'Cultivated land'	Estimations based on nutritional needs of the population		3,300		Schön, <i>Historiska nationalräkenskaper</i> (H)
G. Linde & Palm, <i>Sverige 1810</i>	Heterogenous sources and methods	1,211			

Sources:

- A. As compiled in *Minnesskrift med anledning av den svenska befolkningsstatistikens 200-åriga bestånd* [Anniversary publication on the occasion of two hundred years of population statistics in Sweden] (Stockholm, 1949), p. 193, table 2.
- B. *Bidrag till Sveriges officiella statistik N Jordbruk och boskapsskötsel* [Contributions to the Official Statistics of Sweden N Agriculture and stock raising] (1870), pp. 22–3, table 1.
- C. *Jordbruk och boskapsskötsel / Statistiska centralbyrån* [Agriculture / Central Bureau of Statistics] (1920), p. 4.
- D. Gustav Sundbärg, *Emigrationsutredningen, bilaga 22. Betänkande i utvandringsfrågan* [The emigration investigation, Suppl. 22. Report on the emigration issue] (Stockholm, 1913), p. 91.
- E. David Hannerberg, *Svenskt agrarsamhälle under 1200 år. Gård och åker, skörd och boskap* [Swedish rural society for 1200 years. Farm and field, harvest and livestock] (Stockholm, 1971), p. 31.
- F. Bengt Holgersson, 'Cultivated land in Sweden and its growth 1840–1939', *Econ. and Hist.* 17 (1974), pp. 20–51.

TABLE 8. *continued*

- G. Martin Linde and Lennart Andersson Palm, *Sverige 1810. Befolkning, jordbruk, skog, jordägande* [Sweden 1810. Population, agriculture, forest, land ownership] (Göteborg, 2014), p. 1.
- H. Lennart Schön, *Historiska nationalräkenskaper för Sverige. 1. Jordbruk med binärningar 1800–1980* [Historical national accounts for Sweden. 1. Agriculture with ancillary industries 1800–1980] (Lund, 1995).
- I. Carl-Johan Gadd, *Svenska jordbrukets historia Bd 3. Den agrara revolutionen* [History of Swedish agriculture, III, The agrarian revolution] (Stockholm, 2000), pp. 331–3.
- J. Carl-Johan Gadd, 'Underskattningsproblemet i svensk jordbruksstatistik omkring år 1800' [The issue of underestimation in Swedish agricultural statistics c.1800], paper presented at Dept. of Human Geography, Stockholm University (2007)
- K. Carl-Johan Gadd, 'Swedish agricultural production: preliminary version', paper presented at Svenska ekonomisk-historiska mötet, Stockholm (2007).
- L. Carl-Johan Gadd, 'Swedish agricultural production, 1800–1910. A study of three periods', paper presented at Svenska ekonomisk-historiska mötet, Uppsala (2019).
- M. Rodney Edvinsson, 'New annual estimates of Swedish GDP, 1800–2010', *EcHR* 66 (2013).
- N. Rodney Edvinsson, 'The Gross Domestic Product of Sweden within present borders, 1620–2012', in Rodney Edvinsson, Tor Jacobson, Daniel Waldenström (eds), *House prices, stock returns, national accounts and the Riksbank balance sheet 1620–2012* (Stockholm, 2014).

suggests a lower acreage of arable land in 1810, roughly 50 per cent more than the official figures of *Tabellverket*.²³

Rodney Edvinsson's studies of agricultural production were part of his revisions of *The Historical National Accounts of Sweden*. His most important empirical contribution is his compilation of yield ratios from county level annual harvest reports. This series enabled Edvinsson to reconstruct inter-annual variations in agriculture's contribution to the GDP.²⁴ The volume of production cannot be deduced from the material, however. In order to estimate seeds, Edvinsson made use of conference papers by Carl-Johan Gadd. Gadd's calculations in turn were based on a revised version of Hannerberg's previous estimates.²⁵ Table 1 summarizes the different estimations on how much arable land there was in Sweden c. 1800–1915.

²³ Martin Linde and Lennart Andersson Palm, *Sverige 1810. Befolkning, jordbruk, skog, jordägande* [Sweden 1810. Population, agriculture, forest, land ownership] (Göteborg, 2014). Lars Herlitz, *Jordegendom och ränta. Omfördelningen av jordbrukets merprodukt i Skaraborgs län under frihetstiden* [Land ownership and rent. The redistribution of the surplus of agriculture in the county of Skaraborg during the age of liberty] (Göteborg, 1974). Carl-Johan Gadd, *Järn och potatis. Jordbruk, teknik och social omvandling i Skaraborgs län 1750–1860*. [Iron and potatoes. Agriculture, technique and social change in the county of Skaraborg 1750–1860] (Göteborg, 1983).

²⁴ Rodney Edvinsson, 'The Gross Domestic Product of Sweden within present borders, 1620–2012', in Rodney Edvinsson, Tor Jacobson, Daniel Waldenström (eds), *House prices, stock returns, national accounts*

and the Riksbank balance sheet 1620–2012 (Stockholm, 2014), p. 101–82; Rodney Edvinsson, 'New annual estimates of Swedish GDP, 1800–2010', *EcHR* 66 (2013), pp. 1101–26.

²⁵ Edvinsson, 'New annual estimates', p. 1105, quotes Carl-Johan Gadd, 'Underskattningsproblemet i svensk jordbruksstatistik omkring år 1800' [The issue of underestimation in Swedish agricultural statistics c.1800], paper presented at Dept. of Human Geography, Stockholm University, 2007, but Edvinsson must also have used another conference paper, Carl-Johan Gadd, 'Swedish agricultural production: preliminary version', presented at Svenska ekonomisk-historiska mötet, Stockholm 2007. Gadd's idea was that Hannerberg's acreages were correct, but included areas, etc. that were never sown, resulting in a lower 'effective acreage'.

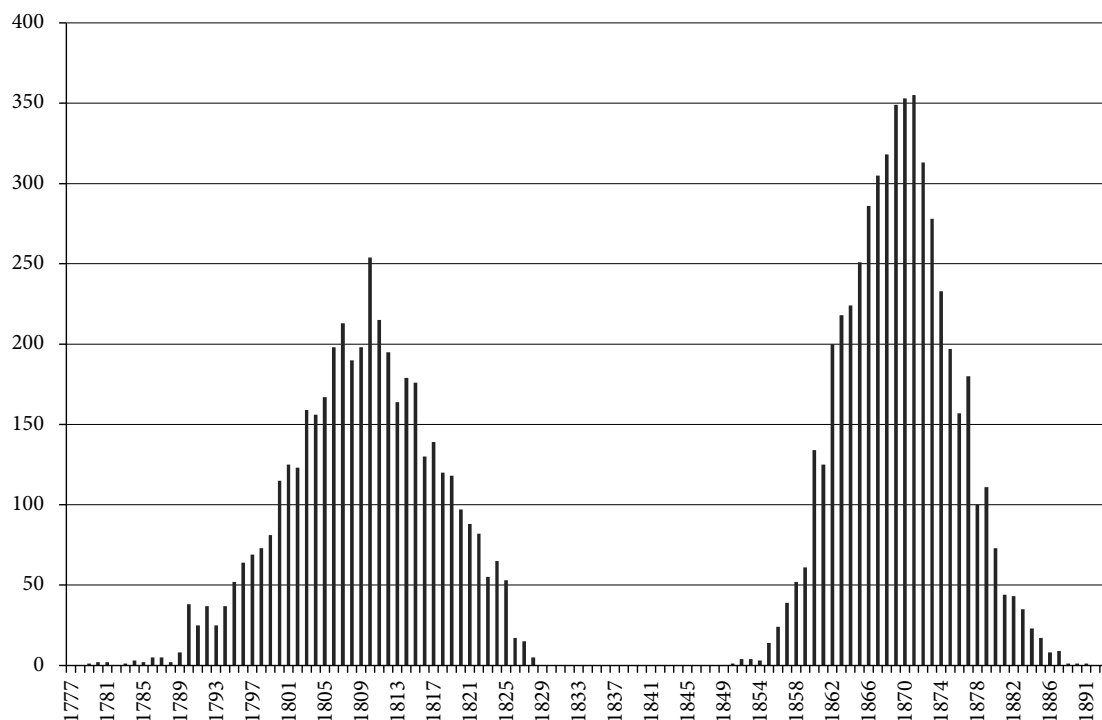


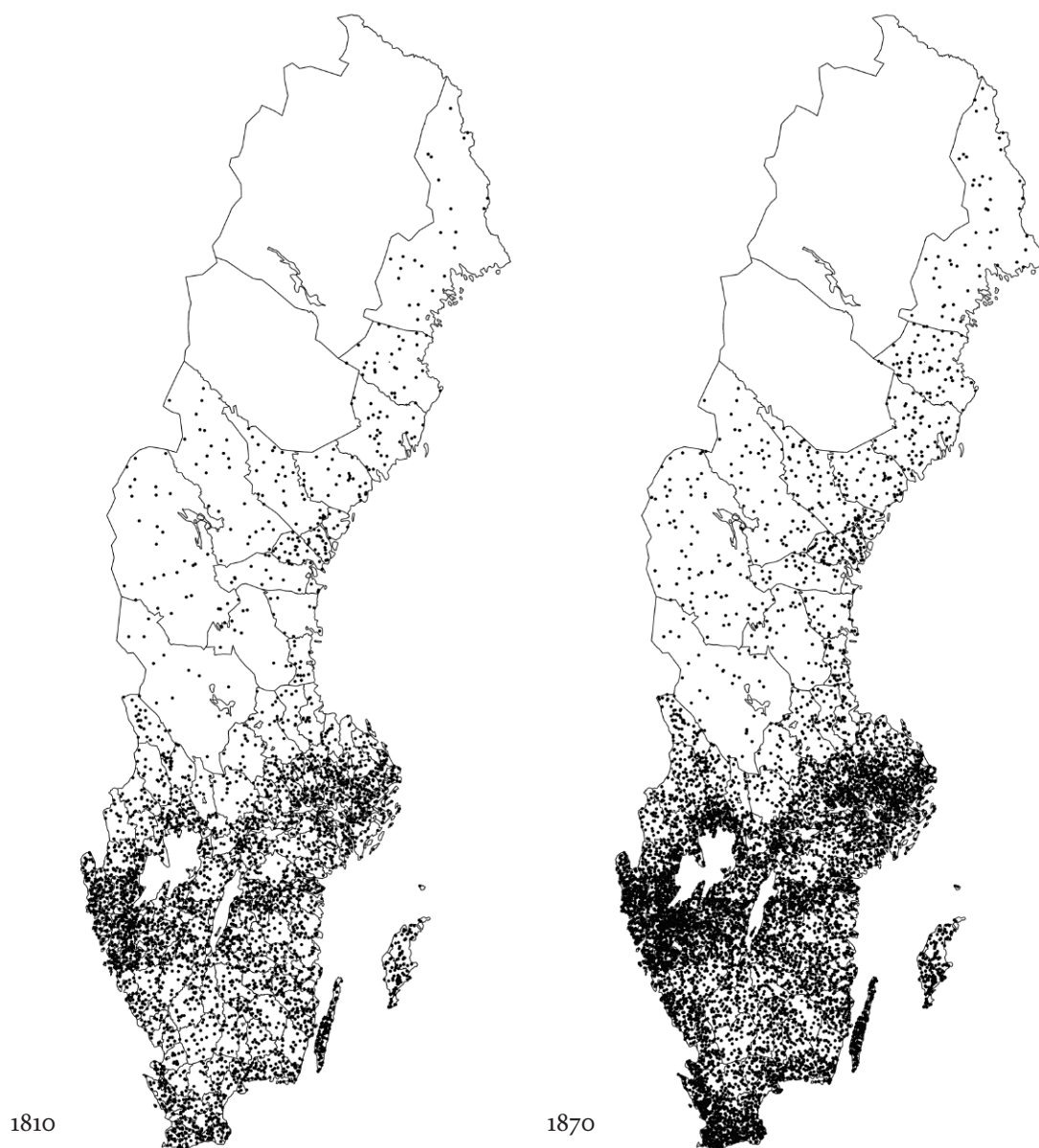
FIGURE 1. The chronological spread of observations (number of maps per year)

IV

While tithe records, probate inventories and yield reports have been drawn on in recent years, Sweden's treasury of nineteenth-century cadastral maps has not. Hannerberg insisted the map material would enable significantly safer estimations of acreage than any other source. Prior to digitalization, the compilation of the maps was rather time-consuming, which explains why it has only been employed in local-level studies. However, after the Land Survey scanned the maps and made the material available on the Internet, the task became significantly more straightforward and made large-scale nationwide studies possible.

The national land survey of Sweden dates back to 1628. During the following centuries tens of thousands of maps were produced covering almost every corner of the land. For the study period in question, the Land Survey archive contains maps from the three important Swedish land reforms: *Storskifte* (1747–1827), *enskifte* (1803–1827) and *laga skifte* (1827–1926). Numerous maps were also produced as a result of partitions of farmsteads, *hemmansklyvning*. In addition, both the Crown and private landowners used the land survey in order to assess their property.

This present study is based on 9,401 maps. The selected maps were mainly from within a decade before and after the two survey years, respectively (Figure 1). The collected material covers all parts of the country with the exception of the towns and the arctic Lappland region (Maps 1 and 2). The basic unit of investigation of the project was the *härads*, the local jurisdictional district. The ambition was to collect information from a minimum of 15 maps



MAP 1-2. The geographical spread of observations (one dot = one map)

covering at least 30 land register units (*hemman*) for each district. If possible, every parish should be represented in the sample. These requirements were not always met. For large parts of northern Sweden, jurisdictional districts were frequently merged into wider survey areas in order to get a sufficient number of observations. In total, 230 areas were investigated.

The land survey maps covered a village, a hamlet, or a just a farmstead. The methodological key that allowed data from a variety of maps to be combined into series for larger areas was the *mantal*, the official assessment unit of land. The *mantal* dates back to the earliest Swedish

land registers in the sixteenth century. It was primarily used in taxation but also, for example, as a basis for the new distribution of land in the enclosures of commons. During the eighteenth century the *mantal* of each farm register unit was fixed and remained in principle unchanged throughout the period studied.

Cadastral maps report the acreage of arable land as well as the *mantal* of the unit mapped. These data were compiled for all investigated maps. The sum of acreage of all observations in a district was then divided by the sum of *mantal* of the same observations. This specific ratio of acreage per *mantal* was thereafter multiplied by the total sum of *mantal* in that district. For instance, in Kind's district in Älvsborg County, 31 maps were studied for the year 1810. The sum of arable acreage from these maps was 199.7 hectares and the corresponding sum of *mantal* 28.0; the ratio arable per *mantal* was thus 7.2. The total sum *mantal* in Kind's district was 525.5, which, multiplied by the ratio, makes 3,758 hectares of arable land.

The investigation revealed a variety of problems that have to do with the fact that agriculture, terminology, assessment traditions, and enclosure processes differed at the regional level. One recurrent problem in, above all, southern Sweden was the reuse of older cadastral maps at the time of enclosures. Close attention thus had to be paid to when the survey was actually done. In Dalarna and Gävleborg Counties the investigation was aggravated by the fact that most maps lacked information on the *mantal*. Other source materials then had to be consulted, such as tax registers. The project's user manual contains county level information on sources and farming practices of importance for the study.

V

Table 2 presents an overview of the empirical base of the investigation and its main results. According to the official statistics, arable land in 1810 comprised 827,000 hectares. Our project finds arable land to be 61 per cent greater: 1,334,000 hectares.

Compared with Hannerberg's estimation, of about 100 per cent greater acreage, this is a low figure. Actually, we find the same high level of underestimation as Hannerberg in his own case study area, Örebro County. The level of underestimation is however lower in most other counties, which demonstrates the difficulty in using geographically limited micro-level investigations as the basis for macro-level estimates.²⁶

During the 60 years, 1810–70, much land reclamation was done. According to BiSOS, arable land measured 2,546,000 hectares in 1870. This figure is not far from the result of this project. We find acreage in general to have been a merely 14 per cent greater, 2,906,000 hectares. Arable land in Sweden thus more than doubled (+118 per cent) between 1810 and 1870.

Taken together, these results alter the established narrative of nineteenth-century agricultural development in Sweden. The pace of expansion was faster, and the scope was longer. Sweden had less arable land in the beginning of the nineteenth century than researchers have come

²⁶ Lars Nyström and Erik Hallberg, 'Att komma till "möjligaste sannolikhet; om icke alldeles träffa sanningen". Kring präststatistiken 1802–1820 – världens äldsta jordbruksstatistik' [To arrive at the "best probable probability; if not quite meet the truth". About the priest statistics 1802–1820 – the world's oldest agricultural statistics]. *Scandia* 89 (2023), forthcoming.

TABLE 2. Acreage of arable land in Sweden 1810 and 1870, present project

	1810	1870
N (maps used)	4,266	5,135
<i>Mantal</i> studied	6,208	4,186
National coverage	9.5%	6.2%
Estimated acreage, thousands of hectares	1,334	2,906

to believe. In 1870, arable land must also be adjusted downwards compared with both Hannerberg's and Holgersson's estimates, but not as much. Land reclamation was thus faster than expected and firmly exceeded population growth. Another consequence of these results is that land reclamation after 1870 was stronger than previously assumed.

The regional differences in the rate of cultivation were considerable. Compared with the national average, land reclamation was smaller in the major grain producing areas around the lake Mälaren and on the fertile plains of southern Scania. Regions of stronger cultivation were western and northern Sweden. These two latter regions were less cultivated around the turn of the nineteenth century and agriculture more oriented towards animal husbandry.

VI

Compared to previous studies this investigation makes use of massive amount of empirical evidence. The sample of maps at the district level however seldom cover more than a small part of the district's total *mantal*. The basic assumption is that acreage per *mantal* as estimated from the investigated maps is an unbiased average of the entire district. How confident can we be?

The *mantal* did not specifically correspond to a geometric area. Rather was it an assessment of the general capacity of a land register unit to pay taxes; to some extent even the result of a process of negotiations.²⁷

Agrarian Sweden was anything but uniform and, as the project demonstrates, the ratio of arable land per *mantal* varied greatly between districts: from 5 to 75 hectares per *mantal* in 1810; and from 15 to 150 hectares per *mantal* in 1870. Two main factors explain why *mantal* and nineteenth-century acreages were not more closely correlated nationwide. Firstly, the *mantal* was an assessment not only of arable land, but also of other resources such as meadows, pastures, forests and fisheries. Secondly, the *mantal* was set in the early eighteenth century. The

²⁷ Bruno Johnsson, *Åkerns omfattning vid 1600-talets mitt enligt de geometriska jordeböckerna: kulturgeografiska metodstudier tillämpade på Västmanlands län* [The extent of the field at the middle of the seventeenth century according to the geometric land registers. Cultural-geographical method studies applied to Västmanland County] (Stockholm, 1956) pp. 51–5; Gerhard Hafström, *Ledung och marklandsindelning. [Ledung (=medieval tax) and markland (=medieval assessment unit of land) division]* (Stockholm, 1949) pp. 196, 227; Folke Dovring, *Agrarhistorien. En översikt av dess uppgifter, forskningsmetoder och resultat* [Agricultural history. An overview of its tasks, research methods and results] (Stockholm, 1953) pp. 63, 66; Gadd, *Svenska jordbrukets*, pp. 42–3, 195–7.

TABLE 3. Bootstrap 95% confidence interval of the estimates of arable land, 1810 and 1870

	<i>Lower (%)</i>	<i>Upper (%)</i>	<i>Mean</i>	<i>Lower</i>	<i>Upper</i>
1810	-2.48	+2.46	1,334	1,301	1,367
1870	-1.98	+2.02	2,906	2,848	2,966

ensuing development did not subsequently reflect how farms and regions developed differently in terms of the reclamation of land.

As the acreage of each district is estimated separately in the project, the great variation in the ratio *between* districts is not a problem. More important is to explore to which extent variation *within* districts might influence the results.

A calculation of the statistical variation was made according to the bootstrap model. Bootstrap is based on the calculation of random samples and is used to explore the statistical uncertainty when the sample (in this case per district) is small and a normal distribution cannot be assumed. The method was used as follows: a macro program randomly retrieved a sample of maps from each of the 230 survey areas (districts), calculated the ratio (acreage per *mantal*) per district (based on the random sample), multiplied the ratio with the total sum of *mantal* of the district and finally summarized the different 230 acreage sums. This procedure was repeated 10,000 times. The 95 per cent confidence interval was then calculated for the 10,000 estimates. The result of the bootstrapping is reported in Table 3.

Three main factors are considered to contribute to the statistical variation: firstly, the variation in the ratio of acreage per *mantal* between land register units also *within* districts; secondly, the use of observations of different statistical weight, given their different size in *mantal*; and thirdly, the relatively small samples at the district level: on average 18 (1810) and 21 (1870) maps. Once district level data is aggregated into larger investigation areas, the statistical variation decreases. At the national level, figures show a very low degree of uncertainty.

Bootstrapping only explores the risks of random statistical variation within a sample. It cannot check for the risk of a *biased sample*, that is the representativeness of the sample. The samples used in this study were not random. Instead, we were dependent on the availability of suitable cadastral maps. There is a risk that farms that were objects of land surveys at average had more (or less) arable per *mantal* land than farms that were not, as these farms might have been forerunners (or laggards) in regards to land reclamation. Importantly, however, we don't rely on just one category of maps. For 1870 we use many maps from late *laga skifte* enclosures. Possibly land reclamation in these villages had been slower than in villages that were enclosed early. We also use many maps from the partitions of farmsteads, that is when a farm was spilt into two or more units. Here we might suspect the opposite tendency, that land reclamation had been faster than on farms that were not divided.

One way to check for the risks of a biased sample is to compare local level results with other reliable series which do not have the same selection problems. In 1860, the National Geographical Survey started mapping the country at the regional level in 1:20,000 scale. In the

TABLE 4. Acreages of arable per *mantal* according to the Geographical Survey mappings 1860–77 and according to the present study

Area	Mantal covered	Number of study areas compared	1. Geographical Survey		2. This present investigation		Acreage index 2/1
			Hectares/ mantal	Average year of survey	Hectares/ mantal	Average year of survey	
Uppsala County	3,560	13	30.21	33 (1861)	30.96	72 (1868)	102.5
Örebro County	2,878	12	42.74	25 (1866)	45.9	75 (1867)	107.4
Östergötland County	5,484	22	39.62	29 (1872)	37.21	83 (1867)	93.9
Norrbottnen Province	822	1	25.50	96 (1873)	25.30	18 (1870)	99.2
All areas	12,745	48	36.79	97 (1867)	36.66	21 (1868)	99.7

TABLE 5. Acreages of arable per *mantal* according to local surveys conducted by the Husbandry Societies 1869–1876 and according to the present study

Area	Mantal covered	Number of study areas compared	1. Geographical Survey		2. This present investigation		Acreage index 2/1
			Hectares/ mantal	Average year of survey	Hectares/ mantal	Average year of survey	
Blekinge County	1,076	4	46.68	95 (1871)	43.21	36 (1868)	92.6
Kalmar County	2,148	9	38.53	85 (1872)	46.07	94 (1869)	119.6
Jönköping County	3,860	9	22.23	76 (1873)	23.14	01 (1869)	104.1
Älvsborg County	2,269	12	38.89	04 (1873)	35.66	57 (1868)	91.7
Västmanland County	2,851	7	43.53	75 (1873)	42.14	27 (1868)	96.8
Värmland County	429	4	83.56	82 (1875)	86.91	48 (1868)	104.0
All areas	12,634	45	36.92	39 (1873)	37.45	85 (1868)	101.4

mid 1870s, most of Uppsala, Östergötland, Örebro and Norrbotten Counties had been charted. The published map protocols include information on acreage sums at the land register unit level as well as at the county level. These figures can be compared to ours.

Another series that enables cross-checks with the project's acreages are district level data of the official BiSOS statistics. As discussed previously this material suffers from a number of shortcomings, not least the vast heterogeneity regarding the methods of collection of data. In some districts, the regional Husbandry Societies however carried out detailed local inquiries of acreages and agricultural production. By the use of Svensson's thesis, 45 such districts (surveyed 1869–1876) can be identified, spread over six different counties.

Tables 4 and 5 show acreages at county and aggregated levels according to, on the one hand, the geographical survey and the regional Husbandry Societies' high-quality local enquiries, respectively, and, on the other hand, the present project. Taken together, the compared areas cover more than one third of the total *mantal* of the country. In Figure 2 the correlation between the sources at district level is displayed.

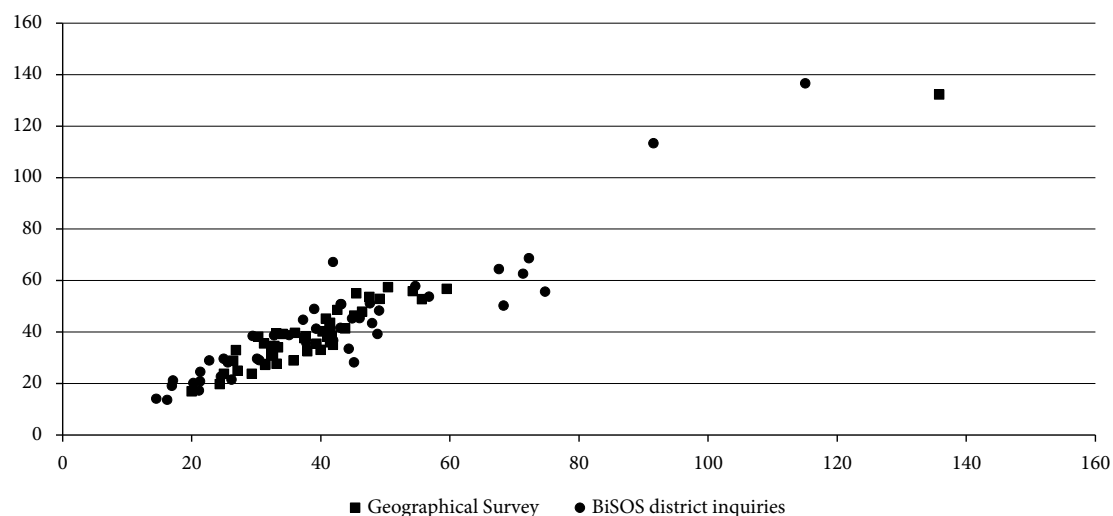


FIGURE 2. Acreages of arable per *mantal* at the district level according to the Geographical Survey and BiSOS district surveys (X-axis) and according to this present study (Y-axis)

The comparisons give no reason to suspect the samples of the study of being biased. District-level figures sometimes differ more than optimally, but deviations occur in both directions. At an aggregated level, deviations thus tend to neutralize one another. The differences in the ratio acreage per *mantal* between the project and the other two series are down to 1–2 per cent.

Which of the three series is the most accurate? The Land Survey maps are outstanding in quality and richness of details as they are large scale, but cover only part of a district. In contrast, the Geographical Survey is comprehensive but based on much more rudimentary field work. The BiSOS surveys are more difficult to evaluate since the methods employed by the different Husbandry Societies varied. Nevertheless, given the huge problems involved in the process of estimating acreages, the degree to which the three sources coincide is striking. The correlation in acreages of arable per *mantal* at the district level between our investigation and the Geographical survey is an impressive 0.97 and between ours and BiSOS a handsome 0.93. Unfortunately, there is no corresponding reference material for 1810.

These comparisons along with the bootstrapping sensitivity analysis result in the conclusion that although our figures are associated with a certain margin of error at the district level, at the aggregated level, numbers are solid and reliable.

VII

The next step is to use the revised series of acreages in a reconstruction of Swedish food production c.1810 and 1870. The main purpose of the reconstruction is to facilitate a deeper analysis of farming and nutrition in Sweden during the agricultural revolution; but it will also work as a third check of the project data, indicating to what degree our estimated acreages of arable land are plausible or not. In the following sections seeds, harvests and animal

husbandry will be estimated sequentially. Then the calorific content of the production will be assessed.

Let us start with the most important foodstuff, grain. The most straightforward method to calculate harvests from acreage would have been to adjust the grain production figures from the official statistics with the same magnitude as acreages differed from the official statistics: 25 per cent more arable land than according to the official statistics, would then, consequently, have resulted in the increase of seed sown and harvests by 25 per cent as well. Such a method would however only be reliable if the relative measures used in the statistics, such as sowing density and harvest ratios, were trustworthy. Unfortunately, they are not.

In several conference papers, Carl-Johan Gadd has analysed the inner coherence of the Swedish agricultural statistics. One observation is that the yield ratios reported by the bailiffs to the County governors (running from 1817) are 20–25 per cent higher than according to those that the clergy reported to the *Tabellverket* (running to 1820). Gadd's interpretation is that the clergy's yield ratios are too low.²⁸ We agree with this conclusion. If the official acreages were biased by the farmer's fear of increased taxes, why would yield ratios be any different?

Our investigation has furthermore cast doubt on the ratio of seed per acre in the early agricultural statistics. Tests that combine the information on acreages, the percentage of land lying fallow per annum and seeds of different crops show that the clergy frequently turned to very rough templates regarding the ratio of seed per acre. Most often, the clergy assumed that one barrel (*tunna*) of grain (regardless of the crop) sowed one *tunnland* (literally 'barrel land', equivalent to about half a hectare). Such rough-and-ready guestimates provide an uncertain basis for further calculations on agricultural production.

During the BiSOS period from 1865, the problems regarding sowing density had been sorted out. According to the persons in charge of the compilation of the material, there was however still a risk that yield ratios were slightly underestimated.²⁹ The problems have been addressed as follows:

- 1) The yield ratios of the official statistics have been replaced by what we, Carl-Johan Gadd, and Rodney Edvinsson think is a more trustworthy series, namely the yield ratios submitted by the bailiffs to the County governors in annual growth reports from 1818 and onwards. This material has been compiled by Edvinsson who generously made it available to us. We use figures for the period 1818–22 in order to assess the normal county level yield ratios around 1810. For 1870 figures for the period 1866–74 have been used.
- 2) Regarding sowing density, only scattered evidence exists prior to the establishing of BiSOS agricultural statistics in 1865. In this reconstruction we assume that the county level ratios seed per acreage were the same in 1810 as in 1870.³⁰

In the end, only two datasets from the official statistics of the early nineteenth century were used in the reconstruction of production in 1810: the proportion of land annually lying

²⁸ See Carl-Johan Gadd, 'Swedish agricultural production'.

²⁹ BiSOS N, *Jordbruk* (1870), pp. 13–18.

³⁰ BiSOS N, *Jordbruk* (1870), our compilation and

processing. By using constant data on seed density and grain weights, i.e. to use the 1870 figures also for the year 1810, we avoid the problematic question of the different sizes of barrels (*tunna*) in 1810.

TABLE 6. Estimated production of grain and potato in Sweden 1810 and 1870, hectares and tons (thousands)

<i>Indicator</i>	<i>1810</i>	<i>1870</i>	<i>Index 1810=100</i>
Hectares of arable land	1,334	2,906	218
Hectares sown with grain, peas or potatoes	866	1,418	164
Seeds of grain	172	283	165
Gross harvest of grain	909	1,880	207
Gross yield ratio grain	5.3	6.6	125
Seeds of potatoes	14	188	1360
Gross harvest of potatoes	103	1,361	1326
Gross yield ratio potatoes	7.4	7.2	98
Population, thousands	2,396	4,169	175

fallow and the relative distribution between the crops sown.³¹ These data were combined with acreages according to this present investigation, seeding ratios from BiSOS 1870 and yield ratios from the annual growth reports. For 1870 the official data on seeds was increased with the same magnitude as we had increased acreages. To calculate harvests, we multiplied the adjusted seed data with yield ratios according to the growth reports. For both 1810 and 1870, weights of crops have to be estimated according to the BiSOS 1866–70 averages: (in kilograms per hectolitre): wheat 75; rye 70; barley 58; dredge corn (a mixture of barley and oats) 51; oats 47; peas 79; potatoes 70.³² Table 6 provides an overview of the results at national level.

The overall result shows a strong increase in production, in absolute numbers as well as relative to population growth. The increase was driven both by the massive land reclamation and by rising yields. In addition, the cultivation of potatoes was greatly expanded.

VIII

A reconstruction of food production must also include animal husbandry. Land Survey acts have no such information. The best available source is the probate inventories. From the 1760s and onwards this material includes most deceased farmers in the country. As the livestock was among the most valuable assets, it was in general comprehensively listed. As previously mentioned, probate inventories were used to reconstruct the number of livestock at the local,

³¹ Retrieved from the official *Tabellverket* statistics of 1805 by Linde and Palm, *Sweden 1810*. We have assumed that peas and potatoes were sown on the fallow (except from in areas with continuous cropping). For 1870, we have compiled information from the official statistic, BiSOS N., *Jordbruk* (1870, or nearby year).

³² As compiled by Hannerberg, *Svenskt agrarsamhälle*. See also Gadd, 'Swedish agricultural production',

Table S3 ab; and Mats Morell, *Studier i den svenska livsmedelskonsumtionens historia: hospitalhjonens livsmedelskonsumtion 1621–1872* [Studies in the history of Swedish food consumption. Food consumption among institutionally supported paupers 1621–1872] (Uppsala, 1989), pp. 333–4. Morell's eighteenth-century estimates come close to the BiSOS weights, while Gadd advocates lower figures.

TABLE 7. Estimated number of farm animals in Sweden 1810 and 1870, thousands

	1810	1870	1810=100
Horses	521	477	92
Cows	1,132	1,379	122
Oxen	240	296	123
Bulls	52	54	104
Steers	147	161	109
Heifers	300	328	109
Hogs	373	400	107
Sheep	1,965	1,751	89
Goats	358	145	40
Livestock units	2,749	2,976	108

regional and national level in the compilation of the database *Sweden 1810*. Its data have also been used in this project.

A reconstruction of livestock based on probate inventories is however yet to be conducted for the year 1870. Consequently, it has been necessary to use the official figures (the BiSOS statistics). The varying and uncertain quality of this material has been discussed repeatedly throughout this paper. As demonstrated, acreage statistics were better than previously assumed, and there is no reason to believe livestock statistics were worse. It must have been easier for the various regional Husbandry Societies to count the numbers of livestock in the barns than to estimate the area of fields. In the early nineteenth-century statistics, we discovered data on animals to be more trustworthy than data on acreages.³³ Consequently, we have for 1870 increased the official figures on cattle by 10 per cent, slightly less than acreage. Table 7 presents estimated number of farm animals in Sweden 1810 and 1870.

The number of livestock units increased slightly between 1810 and 1870, but did not keep pace with population growth or land reclamation. Consequently, there were fewer cows per capita and fewer draft animals per hectare of arable land in 1870 than in 1810.

IX

So far acreages, seeds, harvests and livestock have been reconstructed. In order to find out how much food was actually produced and available for human consumption, some further steps are required. Each step raises a number of research questions. In general, our calculations follow mainstream interpretations. In a few cases it has been necessary to reach a reasonable guesstimate as sources and literature provide limited help.

Milk and meat yields must be estimated. In 1810, most estimates suggest an annual return of about 600 kilograms of milk per cow; and per sheep and goat 60 kg, respectively. In 1870,

³³ Nyström and Hallberg, 'Att komma till "möjligaste sannolikhet".'

most assessments put forward a milk yield of 1,000 kg per cow, and 90 kg per sheep and goat. For both years we estimate that 20 per cent of the milk-fed calves, lambs and kids.³⁴

To calculate early nineteenth-century meat yields, we use a template developed by Hannerberg and Gadd with some minor adjustments.³⁵ Annual livestock replacement rates, that is the share of the adult breed that was slaughtered and replaced by younger animals, are set at 0.14 for cows, oxen and bulls; 0.5 for pigs; and 0.3 for sheep and goats. We further assume that 0.67 calves per cow and 0.6 lambs/kids per sheep/goat were born annually, and that young animals not used for the replacement of old animals were slaughtered. Meat yields are estimated at 80 kg per cow; 100 kg per ox and bull; 30 kg per pig; 15 kg per sheep and goat; 20 kg per calf and 8 kg per lamb and kid. In addition, we assume a yield from piglets averaging at 4 kg meat per litter.

For 1870, we use the 1924 Customs Committee's estimations of animal production for the years 1871–75.³⁶ Annual livestock replacements rates are set at 0.12 for cows; 0.2 for oxen; 0.35 for bulls; 0.5 for sheep and goats and 1.0 for pigs. We further assume that 0.8 calves per cow were born annually and 0.9 lambs/kid per sheep/goat. Meat yields are estimated at 150 kg per cow; 200 kg per ox and bull; 80 kg per pig; 17 kg per sheep and goats; 50 kg per calf/heifer/steer and 10 kg per lamb and kid. We further assume a yield from piglets averaging at 6 kg meat per litter. We suppose that no horse meat was consumed in either 1810 or 1870.

Thereafter, the share of the grain used to feed animals must be assessed, as must imports and exports as well as the spill, that is the share of the foodstuff lost in transport, storing and processing.

For 1810, Henrik Nicander, claimed that 6.5 per cent of the gross harvest (by volume) was used as fodder.³⁷ We accept this figure and assume that all of it was oats. Regarding forage use in 1870, we agree with Gadd's processing of the Finance Committee 1858 material and assume that 20 per cent of the net harvest (by volume) was used as fodder, 68 per cent thereof oats; the rest mainly barley.³⁸ We suppose potatoes were used as fodder to the same degree as grain.

For imports and exports, we use previous compilations of official statistics.³⁹ Grain, flour and sugar are included in the reconstruction. In the case of animal products, imports and exports were so marginal that the level of consumption was hardly affected.

British consumption estimates generally include processing losses from grinding at 20 per cent or more.⁴⁰ These calculations are based on the underlying assumption that the flour

³⁴ 1810: Linde and Palm, *Sverige 1810*, p. 3; Gadd, *Järn*, pp. 135–6. 1870: Mats Morell, *Det svenska jordbrukets historia Bd 4 Jordbruket i industrisamhället, 1870–1945* [*The history of Swedish agriculture, IV, Agriculture in industrial society, 1870–1945*] (Stockholm, 2001) pp. 258–61; Gadd, *Svenska jordbrukets*, pp. 315–16.

³⁵ Hannerberg, *Svenskt agrarsamhälle*, pp. 107–8; Gadd, *Järn*, p. 136. We use Gadd's figures. Some estimations of animal weights have been slightly adjusted upwards. Meat from piglets has been added.

³⁶ Statens offentliga utredningar 1924:38. Betänkande angående tullsystemets verkningar i Sverige före världskriget. Del 2. [State Public Investigations 1924:

38. Report on the effects of the customs system in Sweden before the World War. Part 2] (Stockholm 1924), pp. 75–9. Some weights have been slightly adjusted (mostly downward). Meat from piglets has been added.

³⁷ Nicander, *Om svenska tabellverket*, p. 118 (adjusted for weights of different crops).

³⁸ Gadd, 'Swedish Agricultural Production', p. 21.

³⁹ Grain and flour 1810: Linde and Palm, *Sverige 1810*, p. 1 (1801–1820); grain and flour 1870 (1865–1874); sugar 1810 and 1870 (1815–1820, 1865–1874): *Historical statistics of Sweden. Part 3. Foreign trade 1730–1970* (Stockholm, 1972).

⁴⁰ For an overview, see Bernard Harris, Roderick

was sifted to ensure a product that contained only endosperm. In nineteenth-century Sweden, however, practically all flour consumed was wholegrain, which meant that the bran and the germ was also included. As a consequence, the milling losses were down to a maximum of 2 or 3 per cent.⁴¹ Distillation, brewing and cheese making likewise meant losses. In addition, there were losses from transport and storage (often estimated at c.10 per cent). Overall, we have assumed that processing, transport and storage losses amounted to 15 per cent of the gross production of all food in both 1810 and 1870.

After these steps, the quantity of different types of food consumed can be calculated. These figures must then be converted into nutritional content. Calories per kilogram of grain were set slightly under today's whole grain content: wheat and rye 3,200 kcal/kg; barley 3,300 kcal/kg. For oats and dredge corn, we assume that 30 per cent and 20 per cent of the cereal weight, respectively, was hull (which is not digestible), resulting in a calorie content of 2,520 kcal/kg for oats and 2,800 kcal/kg for dredge corn. In addition, we assume a calorie content in kcal/kg of 2,900 for peas, 800 for potatoes and 3,800 for sugar. For animal products we use the following figures: cow's milk 700; sheep's milk 1,000; goat's milk 650; beef 2,500, veal 1,700; pork 2,400; mutton 2,900; and goat meat 1,400 (kcal/kg).

X

So, how much food was consumed in Sweden in 1810 and 1870? In Tables 8 and 9 the estimations of crops and animal husbandry are presented. In Table 10 the calorie consumption of different foodstuffs per capita and per day is summarized.

The results indicate that the consumption of calories per capita per day was about 2,750 in 1810 and 2,900 in 1870. This is slightly higher than according to most estimates of calorific intake in nineteenth-century England, but this difference is mainly due to the latter assuming higher losses during the journey from the field to the table.⁴² In present-day Sweden, per capita consumption is 3,110 kcal a day according to official UN figures.⁴³ Unlike in the nineteenth century, Swedes now tend to consume more food than they need. At the same time, the need for food is smaller since most jobs require less physical activity than in the past.

Note 40 *continued*

Floud and Sok Chul Hong, 'How many calories? Food availability in England and Wales in the eighteenth and nineteenth centuries', in *Res. in Econ. Hist.* 3 (2015), pp. 133–7.

⁴¹ An official source from 1755 states a grinding loss in weight of less than 1% for rye: 1755-06-14 Kongl. majt:s: Beskrifning om det wid Kongl. Amiralitetet brukelige Bakningssättet ... hwaraf finnes hela Processen med Sädens utgifwande til malning, hwad afgång i wigten : wid Qwarnen : skier, och huru mycket mjukt eller torrt bröd hwar tunna säd med säkerhet gifwer., [1755-06-14 His Royal Majesty's Description of the Baking Method customary at the Royal Admiralty ...

which describes the whole process when the grain is ground, how much loss in weight at the mill, and how much soft or dry bread each thin grain will by certain yield.] (Stockholm, 1755). See also Craig Muldrew, *Food, energy and the creation of industriousness. Work and material culture in agrarian England, 1550–1780* (2011), pp. 146–7.

⁴² Harris *et al.*, 'How many calories', p. 140, appendix (graph).

⁴³ Food Consumption Nutrients. *Food and Agriculture Organization of the United Nations*, http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/FoodConsumptionNutrients_en.xls. Accessed 5 June 2021.

TABLE 8. Estimated production and consumption of grain and potatoes in 1810 and 1870, thousand tons

	<i>Grain</i>		<i>Potatoes</i>	
	<i>1810</i>	<i>1870</i>	<i>1810</i>	<i>1870</i>
Gross harvest	909	1,880	103	1,361
Seeds	-172	-283	-14	-188
Net harvest	737	1,597	89	1,173
Forage use	-37	-285	-6	-199
Net of import/exports	32	-134	-	-
Transportation, storage and processing losses	-141	-294	-15	-204
Net for human consumption	591	883	68	769
Consumption/capita/year (kg)	249	212	28	185
Consumption/capita/day calories (kcal)	2,116	1,792	62	404

TABLE 9. Estimated production and consumption of meat and milk in 1810 and 1870, thousand tons

	<i>Cows' milk</i>		<i>Sheep and goats' milk</i>		<i>Meat</i>	
	<i>1810</i>	<i>1870</i>	<i>1810</i>	<i>1870</i>	<i>1810</i>	<i>1870</i>
Total production	679	1,379	139	171	52	144
Used for calves	-136	-276	-28	-34	-	-
Transportation, storage and processing losses	-102	-207	-21	-26	-8	-22
Available for human consumption	441	896	91	111	44	122
Consumption/capita/year (kg)	184	215	38	27	22	29
Consumption/capita/day calories (kcal)	353	412	98	71	120	184

Our figures indicate a consumption of 3,450 kcal per unit of consumption (adult male equivalent) and day in 1810 and of 3,650 in 1870. Some calories from fish, egg, vegetables, fruit and game meat should be added, but probably not more than 100 per day and capita.⁴⁴ Given that a large share of the population did heavy physical work the estimated consumption figures are probable and at a level with nutritional needs. At the same time, it must be remembered that several factors in the calculation are rough estimates.

⁴⁴ English estimates range between 0 and 200 kcal/day, see Harris *et al.*, 'How many calories', appendix. Cf. Morell, *Studier*, pp. 194-5.

TABLE 10. Estimated per capita/day calorie consumption of different foodstuffs in 1810 and 1870

	<i>Kcal/capita/day</i>		<i>Percent of total consumption accounted for</i>	
	<i>1810</i>	<i>1870</i>	<i>1810</i>	<i>1870</i>
Grain	2,116	1,792	77	62
Potatoes	62	404	2	14
Imported sugar	10	45	0	2
Total vegetables	2,189	2,241	79	77
Cow milk	353	412	13	14
Sheep and goat milk	98	71	4	2
Meat	120	184	4	6
Total animal products	571	667	21	23
Total consumption accounted for	2,759	2,908		

XI

What do these new figures say about Sweden's agricultural revolution? From a nutritional point of view, it may seem the improvements were not that impressive. Swedes had access to slightly more food in 1870 than in 1810 and the share of calories from animal products had increased by two percentage points. The most important change in the food basket was that some of the grain had been substituted for potatoes – an even cheaper vegetable calorie source. More sugar did indeed add a bit of sweetness to people's everyday lives. However, this development was the result of trade and globalization – not of a domestic agricultural revolution.

Once we go beyond consumption, it becomes clear that the agricultural economy changed profoundly. In 1810, virtually all grain was needed to sustain the population. If the harvest failed, only imports could save the population from dearth and hunger. In 1870 the situation was different. A fifth of the net harvest was used to feed the animals. A further tenth was exported. Yet there was enough food to meet the needs of the people. Despite strong population growth, food security had improved drastically.

Within previous research, the agricultural revolution has been defined either from its content or its results. While *Encyclopaedia Britannica*, for example, describes it as the sum of a number of interrelated transformations (enclosures, new crop rotations and so on), a scholar like Robert Allen understands the agricultural revolution as an increase in both production and productivity.⁴⁵ Given the empirical content of this present study, we find Allen's approach most useful, but we believe his definition needs a delimitation against the era of industrial agriculture, in which progress was even more impressive. We define the agricultural revolution

⁴⁵ <https://www.britannica.com/topic/agricultural-revolution>. Accessed 5 Jan. 2022; Robert C. Allen, 'Tracking the agricultural revolution in England', *EcHR* 52 (1999), p. 217. Cf. Overton, *Agricultural Revolution*, p. 193; Gadd, *Svenska jordbrukets*, pp. 11–12.

as an increase in both production and productivity prior to the point in history when imported fertilizers and fossil fuels freed agriculture from its local ecological constraints.⁴⁶ So, what does the present study say in respect to this discussion?

The most striking feature of the agricultural development in Sweden in the nineteenth century is without doubt the strong quantitative expansion of arable land. In France and the Netherlands, the extent of arable land hardly increased at all after 1800.⁴⁷ In England 1800–70, it merely expanded by one-sixth. In Sweden, by contrast, arable land more than doubled in the same period. Compared to many other western European countries, an extraordinary potential for cultivation thus still existed in Sweden around 1800. More land under cultivation meant that much more food could be produced. However, this development did not in itself imply a situation where also productivity grew. The expansion of the acreage of arable land could just as well have led straight into the trap of diminishing returns.

Diminishing returns has been a common topic within the study of agricultural growth since the days of Ricardo. Ricardo's original example was how land reclamation led to falling yields, as more poor land was cultivated. In fact, land reclamation also worried early nineteenth-century Swedish agricultural expertise. Their fear was that the fragile balance between arable farming and animal husbandry would be disrupted.⁴⁸ If meadows and pastures were turned into arable, there would be less hay and grass to feed the animals. If the number of animals decreased accordingly, there would be less traction to work the land and less manure to maintain soil fertility. Consequently, yields would drop. Scholars have identified this 'food-feed dilemma' as one of the shackles of Early Modern agricultural growth.⁴⁹

The Swedish development of 1810–70, however, defies these risks. Here, fields and returns increased simultaneously: arable land more than doubled; yield ratios increased by a fifth. Similar tendencies can be discerned regarding animal husbandry. The number of cows increased during the period studied, albeit at a slower rate than land reclamation. Still, the increase in productivity per animal is striking. As referred to earlier, cows in 1810 produced on average about 600 kg of milk per year, but in 1870 about 1,000 kg.⁵⁰ The simultaneous

⁴⁶ Cf. F. M. L. Thompson, 'The second Agricultural Revolution, 1815–1880', *EcHR* 21 (1968), pp. 62–77.

⁴⁷ For a European overview, see Giovanni Federico, *Feeding the World. An economic history of agriculture, 1800–2000* (2005), pp. 33–5; for England, see Harris *et al.*, 'How many calories', p. 121.

⁴⁸ Gadd, *Svenska jordbrukets*, pp. 235–6. Eli F. Heckscher, *Sveriges Ekonomiska historia. Det moderna Sveriges grundläggning* [*The economic history of Sweden: The founding of modern Sweden*] (Stockholm, 1949), pp. 222–3.

⁴⁹ See for example, Mark Overton and Bruce M. S. Campbell, 'Productivity change in European agricultural development', in Bruce M. S. Campbell and Mark Overton (eds), *Land, labour and livestock: historical studies European agricultural productivity* (1991), p. 2; David Grigg, *Population growth and agrarian change. An historical perspective* (1980), p. 27; Jerome

Blum, *The end of the old order in rural Europe* (1978), p. 118; Gadd, *Svenska jordbrukets*, pp. 235–8.

⁵⁰ Admittedly, the reconstruction of animal husbandry is based on a less solid empirical basis than the grain production. However, the rapid increase in productivity per animal could hardly be questioned. A solid and complementary evidence is studies on animal prices, which show an even stronger increase c.1810–70. See Pablo Wiking-Faria, *Freden, friköpen och järnplogarna: Drivkrafter och förändringsprocesser under den agrara revolutionen i Halland 1700–1900* [*Peace, freeholding and iron ploughs: Motivating forces and processes of change during the agricultural revolution in Halland 1700–1900*] Göteborg (2009), pp. 286–9, 298–9; Lars Nyström and Erik Hallberg, 'Two parallel systems: The political economy of enclosures and open fields on the plains of Västergötland, Western Sweden, 1805–65', in *Historia agraria* 76 (2018), pp. 105–6.

increase in population, in agrarian production, in yield ratios, in milk and meat yields per animal, and in food consumption per capita clearly indicate that the agrarian economy had entered a phase in which both land, labour and total factor productivity grew. What had actually happened?

According to contemporary agronomic expertise and agricultural historians alike the two main ingredients in the breaking up of the old agricultural regime were enclosures and convertible husbandry.⁵¹ Through the introduction of new crop rotations that included fodder plants such as clover, farmers could leave the 'food-feed' dilemma behind and enter a positive loop where arable farming and animal husbandry could expand in parallel. Legumes grown on the fields meant more fodder, more fodder meant more animals, more animals meant more manure, more manure meant higher yields and so on. An important factor in the new ecological equation was the fact that legumes such as clover fixated nitrogen, enabling higher yields even as the proportion of land laying fallow was reduced. In order to implement the new crop-rotations, it has been argued that a breaking up of the old territorial organization of the open fields was necessary. In the textbook trajectory of the agricultural revolution, convertible husbandry and enclosures thus walked hand-in-hand.⁵²

A closer look at Sweden's agricultural revolution reveals that these developments were just part of the story, however. Both enclosures and convertible husbandry were indeed important; the crux is that the breakthrough of these two processes were rather late. With the notable exception of the fertile plains in the southernmost province of Scania, enclosures in most provinces did not gain momentum until the 1840s, 1850s or even the 1860s. The spread of convertible husbandry was even later. By 1870 many provinces were still in the process of adopting it.⁵³ Other and earlier developments must, as Carl-Johan Gadd has emphasized, have contributed to the momentum of agriculture.

Gadd highlights the importance of iron ploughs and potatoes.⁵⁴ With the iron plough, the number of draft animals needed to plough one hectare of land decreased by up to 50 per cent. Farmers could now double the size of the fields without having to increase the number of horses or oxen.⁵⁵ The main advantage of the potato was that it enabled a more productive use of the land: compared to grain, it provided about twice as many calories per acreage.⁵⁶

⁵¹ See for example Blum, *The end of the old order in rural Europe* (1978), pp. 257–62. Overton, *Agricultural Revolution*, pp. 109–11; Grigg, *Population growth*, pp. 175–6.

⁵² Gadd, *Svenska jordbrukets*, p. 285; Overton, *Agricultural Revolution*, pp. 164–7.

⁵³ On the chronology of enclosures: Staffan Helmfrid, 'The Storskifte, Enskifte and Laga Skifte in Sweden: General features', *Geografiska Annaler* 43 (1961), pp. 114–29; Gadd, *Svenska jordbrukets*, p. 300 (map); on convertible husbandry: Folke Lågnert, *Syd- och mellansvenska växtföljder. De äldre brukningssystemens upplösning under 1800-talet* [Southern and central Swedish crop rotation. Dissolution of the older cultivation systems during the nineteenth century] (Lund, 1955); Carl-Johan Gadd, 'Jordbruksteknisk förändring i Sverige under 1700- och 1800-talen. Regionala aspekter', in *Ett föränderligt agrarsamhälle* [Agricultural technical change in Sweden during the eighteenth and nineteenth centuries. Regional aspects', in *A changing rural society*] (Göteborg, 1998) pp. 198–200. See also Lars Nyström and Erik Hallberg, 'Two parallel systems: The political economy of enclosures and open fields on the plains of Västergötland, Western Sweden, 1805–65', in *Historia agraria* 76 (2018), pp. 85–122.

⁵⁴ Gadd, *Järn*.

⁵⁵ Ibid., pp. 234–7, 248, 335.

⁵⁶ Gadd, *Svenska jordbrukets*, pp. 256–7.

As a consequence of these developments, large amounts of grain previously needed for the population (or used within distilling) were released for other purposes. According to Gadd, the potato was a necessary condition behind Sweden's transition from a grain importing to a grain exporting country after c.1830. However, the domestic use of the emerging grain surplus seems to have been even more strategic. Cast in the shadow of the much-highlighted export of grain (mainly oats) to (above all) England, which around 1870 accounted for 134,000 net tons annually, is the estimated 285,000 tons of oats and barley used as feed, more than twice as much as net exports.

The increased use of oats as fodder, that has been largely neglected within research, could be identified as one of the key factors in Sweden's agricultural revolution. This practice opened up a way out of the old 'food-feed dilemma' even before the breakthrough of clover and convertible husbandry. Compared to clover, oats may seem to be the more expensive choice of fodder crop. It is also true that it lacked the capacity of the clover to fixate nitrogen from the air. Oats had however other benefits. In contrast to clover, oats could be cultivated in large quantities without the breaking up of the old cultivation systems on the open fields. In addition, oats could yield decent harvest even with little or no manure.⁵⁷

In animal husbandry, oats was feed of the highest quality. The fact that oats was increasingly used as feed is probably an important reason why the animals were bigger, more expansive and yielded more milk and meat in 1870 than in 1810. Better-fed animals also offered more muscle power. The increased energy output per draft animal was most likely an equally important factor as iron tools for the impressive increase in acreage per draft animal in 1810–70. In addition, bigger animals produced more manure. This should be kept in mind when discussing the increased yield ratios during the same time period.

Arable farming and animal husbandry were never separate entities in Western agriculture. In Sweden during the agricultural revolution, the productivity of livestock farming increased more than the productivity of arable farming. Milk yields increased by two thirds, while grain yields were raised by one fifth. The benefits of land reclamation were thus also taken advantage of within stock raising. While human calorie consumption only improved slightly, there was a massive increase in the feed budget for farm animals. In the end, the fear of the contemporary expertise – that land reclamation would result in shortage of feed and manure and disrupt the ecological equilibrium of agriculture – was turned upside down.

In summary, the massive land reclamation combined with the spread of potatoes and new uses of oats provided Swedish agriculture with sufficient calories in order to reach a new level. Importantly, much of this development took place within the traditional cultivation systems on the open fields. Only gradually, and at a different pace in different parts of the country, were enclosure and convertible husbandry finally adopted.

Then, shortly after 1870, Swedish agriculture entered a new phase, defined by a rapidly increasing imports of fertilizers.⁵⁸ This was the first step taken towards a new agricultural

⁵⁷ Richard J. Moore-Colyer, 'Oats and oat production in history and pre-history', in Robert Welch (ed.), *The oat crop* (1995), pp. 1–33. Herman Juhlin-Dannfelt and Abraham Sjöström, *Handbok i jordbruksekonomi* [*Handbook of agricultural economics*] (Stockholm,

1911), pp. 800–5.

⁵⁸ For imports of fertilizers, see *Historical statistics of Sweden ...*, p. 200. Also imports of oil cakes started to take off in the 1870s and 1880s (p. 199).

economy where food security was made dependent on a constant inflow of nutrients and traction power from outside of the local ecological system.

XII

By virtue of the project, Arable Land in Sweden, accurate calculations of acreages and food production can be carried out for the first time. While researchers previously had to make do with top-down estimates based on price trends, population development, etc., or bottom-up surveys of smaller areas assumed to represent the national level, the project offers a large-scale empirical approach to estimate agricultural production in nineteenth century Sweden.

The project has revised earlier suppositions. Sweden had significantly smaller fields in 1810 and slightly smaller fields in 1870 than expected. The agrarian revolution was thus a relatively faster process than previously thought. The project also shows that the expansion of the arable went hand in hand with an increased productivity – bigger and more productive animals in the barns and higher yields in the fields. In spite of the rapid population growth, the margins of the agrarian economy widened.

This article has highlighted national trends. The database, which is freely available on the Internet, makes it possible to study regional and district level trajectories as well. In this way, even closer studies of developments are made possible, allowing for an ever better assessment of Sweden's agricultural revolution.