DOCUMENTARY EVIDENCE OF DROUGHTS IN SWEDEN BETWEEN THE MIDDLE AGES AND c1800

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Abstract

This article explores documentary evidence of droughts in Sweden in the pre-instrumental period (1400-1800). The database has been developed using contemporary sources such as private and official correspondence letters, diaries, almanac notes, manorial accounts, and weather data compilations. The primary purpose is to utilize hitherto unused documentary data as an input for an index that can be useful for comparisons on a larger European scale.

The survey shows that eight sub-periods can be considered as particularly struck by summer droughts with concomitant harvest failures and great social impacts in Sweden. That is the case with 1634-1641, 1652-1657, 1665-1670, 1677-1684, 1746-1750, 1757-1767, 1771-1776 and 1780-1783 and 1641-1646. Among these, 1652 and 1657 stand out as particularly troublesome. A number of data for dry summers are also found for the middle decades of the 15th century and the 1550s.

Introduction

Drought is not the most typical meteorological anomaly in a country like Sweden. Stretching from 69° N to 55° N it is characterized by arctic climate in the extreme north and temperate climate in the south. Located between the Baltic Sea and the Scandian mountain range it is normally affected by wet weather from the Atlantic. The length of the winter and the length of the growing period have the most distinct effect on agricultural production and society in general. Still, the early modern history of Sweden gives evidence of repeated periods of severe droughts.

In general, drought at the latitude of Sweden is caused by deficient precipitation and only occasionally by excessive temperature and evapotranspiration. But sometimes several meteorological and hydrological factors do combine to produce severe drought with serious socioeconomic consequences. For example, apart from deficiency in precipitation (meteorological drought) seasonal lack of streaming water can also be the result of late spring or low summer temperatures in the Scandian mountain range when snow fail to melt at a normal pace resulting in insufficient discharge into the rivers which produces streamflow (hydrological) droughts and/or low flows (Hisdal and Tallaksen, 2000). Insufficient spring floods also partly lies behind failed harvests of hay grown in wet meadows and in historical times concomitant raised cattle mortality. Conversely, low water levels in streams due to dry autumn/summer weather facilitates quick freezing in the early winter and implies further obstacles to running watermills. Therefore, in the long run droughts do affect agriculture but strike more directly at industrial activities depending on water power. Socioeconomically this has had serious consequences for Sweden, to a large degree dependent on mining and exports of iron and copper especially from the 17th century.

In this article, the annual indices from documentary data have been based on the stated intensity of the drought event and its spatial extension. It has only been possible to construct reliable indices for the 16th, 17th and 18th centuries since no continuous time series

can be reconstructed before that due to insufficient amounts of documentary records. Nevertheless, an overview of documentary data from the 15th century will be given.

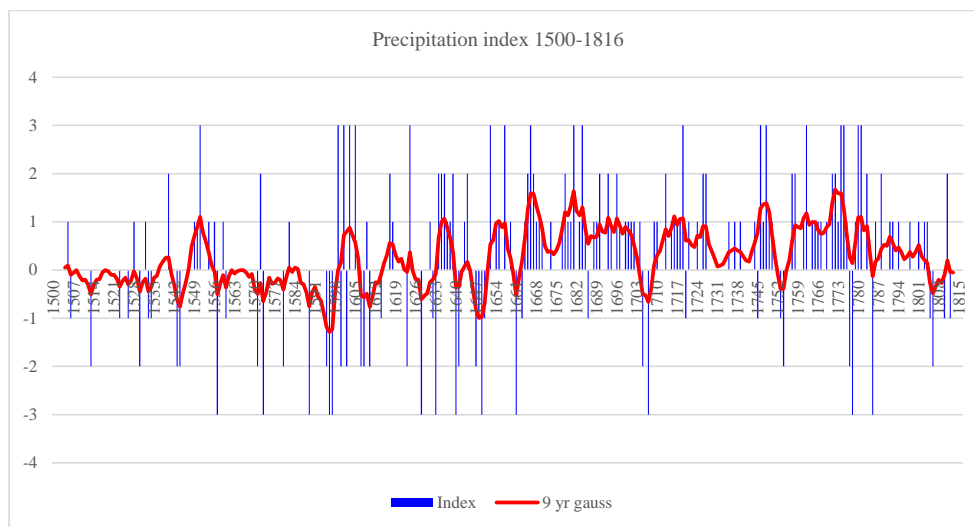
For some years, the documentary data are too contradictory to enable any definite conclusions. In some cases, it derives from regional variations. One example is from 1554, when there was "severe drought" in the province of Uppland and at the same time good harvest in the Kronoberg province further to the south (Forssell 1884, bil A p 161). But even when data are relatively plentiful they can be contradictory. One such example is the year 1733. Some data from that year speak of an "unusual" drought in the provinces of Västergötland in the west, and Hälsingland and Dalarna further to the north in May (Broman, 1911-1949; Olofsson and Liedgren, 1974: 261; Svanberg, 1987: 209f). In a period of 18 weeks between early March and the end of June only three short showers of rain is said to have fallen in Västergötland, a province with typical humid weather conditions, and the water level of Lake Vänern was quite low (Bergstrand, 1934: 196; Wallén, 1910: 13). At the same time the harvests were good in general in Sweden and there are no reports of harvest failures (Utterström, 1957, II: 429). In Västergötland itself the harvest was even said to have been plentiful (Olander, 1951: 119). The explanation for this discrepancy can be different timings of sowing of different crops, where e.g. early-maturing crops like barley and wheat (which was only cultivated in Sweden to a small degree before the 19th century) (Söderberg and Myrdal, 2002) suffered most and crops with a long growing season, like rye and buckwheat, could survive. In no case there are evidence of droughts covering the entire growing season, which means that no generalized nutritional catastrophe has been registered. A mitigating factor was that periodically local demand for foodstuffs was reduced through the absence abroad of a large part of the male population in the numerous wars Sweden fought in Europe between 1630 and 1718.

Method

The most important part of establishing climatic variations in the past is the construction of an index that represents notions of drought and wet periods along a 7-point scale ranging from -3 (extremely wet) to +3 (extremely dry). This has been done here for the period 1500-1816. This consists of reading notes from different sources and interpret how these notes may be transformed into the index. For this study, we already had index of wet years (Retsö 2015) and complimented it with indexed notices concerning droughts.

As can been seen in Fig 1, there are many more notices which we have labelled "dry", especially in the 18th century, than there are notices on "wet" conditions. The word "rain" occurs 3,361 times in the database (of a total of 20,896 entries), while the word "sun" only occurs 1,224 times. However, varieties of "heat", "dry", "warm" occur 1,726 times compared to the two words describing "wet" in Swedish, which only occur 292 times. Many notices regarding rain is of the kind "A beautiful rain fell". Generally, wet conditions are defining for agriculture in Scandinavia, but many fields are located such that they have a natural drainage (Leijonhufvud, 2001: 130). These findings suggest that although notices of rain are more frequent than notices describing fine weather, consequences of "fine" weather were more troublesome.

Figure 1 depicts the precipitation index that has been constructed. Positive signs indicate years that were dryer than normal, while negative values indicate years that were wetter than normal.

Fig. 1. Precipitation index for Sweden 1500–1816

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102 Instrumental measurements
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104 In this study we have used homogenized historical instrumental data from the observatory
105 (*Observatorielunden*) in Stockholm. The temperature record begins in 1756 and the
106 precipitation data in 1859. The datasets are freely available and were downloaded from Bolin
107 centre https://bolin.su.se/data/stockholm-historical-temps-monthly on 7th December 2019 and
108 from the Swedish Meteorological and Hydrological Institute (Sveriges meteorologiska och
109 hydrologiska institut, SMHI): https://www.smhi.se/data/meteorologi/ladda-ner-
110 meteorologiska-observationer/#param=precipitation24HourSum,stations=all,stationid=98210
111 on 22nd January 2020. E-mail contact with SMHI confirmed that precipitation data from 1863
112 are missing.
113   Correlation between proper instrumental data of temperature and precipitation,
114 from the same observational site of Observatorielunden in central Stockholm showed, rather
115 surprisingly, a slightly negative correlation between summer temperatures and precipitation of
116 -0.35 (Table 1). This result is also in accordance to personal experience: a rainy summer in
117 Stockholm is usually also a rather chilly one.
118
119 Table 1: Correlation between temperature (℃) and precipitation (mm) at Stockholm 1
120 (*Observatorielunden*) 1859-2011. Instrumental records

Precip\Temp	May	Jun	Jul	Aug	JJA	MJJ
Pmay	-0.238					
Pjun		-0,301				
Pjul		0,020	-0,385			
Paug		0,039	0,010	-0,334		
PJJA		-0,077	-0,320	-0,375	-0,349	
PMJJ	0.027	-0,187	-0.358			-0.246

121

122 Figure 2 depicts a scatter plot of June, July, August (JJA) precipitation over JJA temperatures.
123 The warmer the summer, the less it rains.
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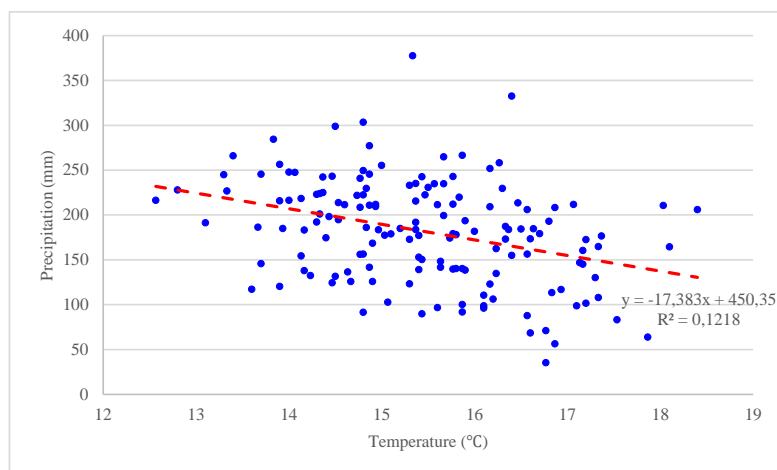
126

127   Fig. 2: Scatter plot of JJA precipitation and temperature JJA 1859-2011

128
129
130   Turning our attention to the index, we get a similar result, although the highest correlation is
131   received using MJJ-temperatures (hence the inclusion of this parameter in Tab. 1).
132   However, since correlation for instrumental data between precipitation and temperature in
133   May was very weak (non-existing), we argue that the standard season of summer months
134   (June, July, August) will be more adequate in our exploration of droughts.
135   Another difference is that the index hardly has any correlation with August
136   temperatures, while instrumental data renders a (slight) correlation between temperature and
137   precipitation in August. We believe the main reason for this might be that the database may be
138   more stringent when it comes to weather related events occurring during the first half of the
139   year. It is also possible that a cool May, may be experienced as "wet", and therefore described
140   as such in the sources forming the foundation of the index.
141   Since there are no precipitation data before 1860, we have tested the
142   precipitation index against Stockholm temperature series from 1756.
143   Correlation between the index and average monthly temperature for the period 1756-1816
144   turned out significantly for the months May, June and July (Table 2).
145
146   Table 2: Correlation between average monthly temperatures against the drought index 1756-
147   1816 and precipitation of Stockholm for the period 1859-2011

	April	May	June	July	Aug	MJJ	JJA	C-Scan
Index	0.2552	0.3048	0.5150	0.3853	0.1288	0.5060	0.4708	0.0842
Precip	-0.148	-0.238	-0.301	-0.385	-0.334	-0.246	-0.349	0.20 (Jan)

148   Precipitation data were downloaded from https://www.smhi.se/data/meteorologi/ladda-ner-meteorologiska-
149   observationer/#param=precipitation24HourSum,stations=all,stationid=98210 on 22nd January 2020
150
151
152
153   Documentary data on droughts for the 15th and 16th centuries

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155 For the 15th and 16th centuries documentary data are scarce, uneven and spread out in a
156 number of different source categories. Indeed, there is a number of evidences for harvest
157 failures, although the reasons are rarely stated. But in a region like Scandinavia it can be
158 assumed that most of them has to do with drought rather than hydrological extremes like
159 excessive rains, at least in the east. Furthermore, most data in accounts and letters tell about
160 the date for sowing and reaping. Although these activities can be assumed to have varied
161 within the framework of normal spring and autumn temperatures their variability should
162 depend on hydrological conditions.
163   Information on grain prices in medieval Sweden are found in several sources,
164 most often in municipal, Church, and other institutional accounts. Combined, they form a
165 fairly complete annual series from the early 15th century onwards (Figure 3) and can be used
166 as a proxy. Most of the price information stems from the province of Uppland, where
167 Stockholm is located (Söderberg, 2007).

168

169 Fig. 3: Grain price per hectolitre in Sweden, harvest years 1291-1500

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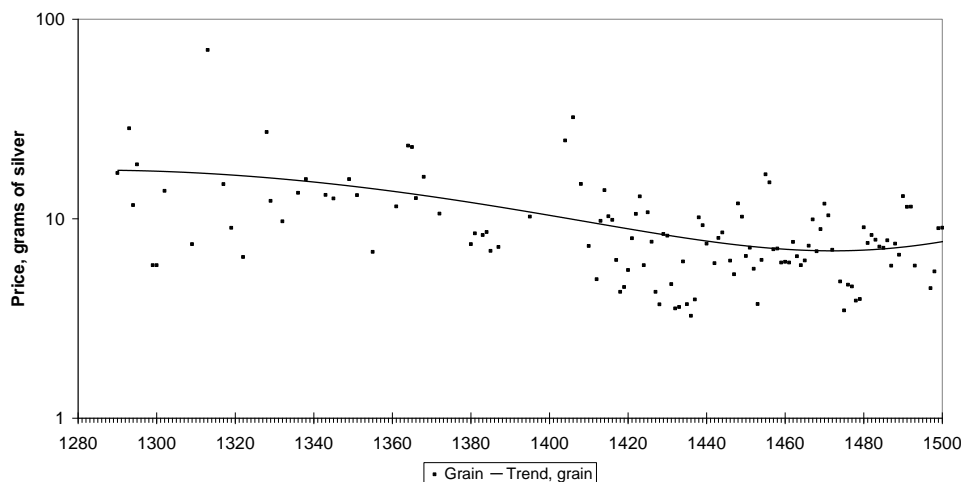
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175 Since demand for foodstuffs in medieval society can be assumed to have been very stable,
176 unusually high grain prices, as in the first decade of the 1400s and in the 1470s, can be
177 attributed to fluctuations on the supply side, i e weather impact on harvests. For example, in
178 1403 there was famine on the island of Gotland (Joachim, 1896: 295; Ziesemer, 1921: 539;
179 Eimer, 1966: 218) and in 1405 harvests were reported in nearly contemporary annals to have
180 failed in Denmark and Sweden. A mild winter this year was followed by a dry spring and
181 summer until the end of July, when a long rainy period began (Paulsson, 1974: 399. See also
182 Weikinn, 1958; 286-8; Ogilvie, 1992: 242).
183   Apart from grain prices, it is likely that prices of certain other goods contain
184 climatological information, in particular wax (in medieval society used primarily for the
185 making of candles for religious ceremonies) and honey, both highly dependent on weather
186 conditions in the summer. During the last three decades of the 16th century, production of bee
187 wax was much reduced in Sweden, probably due to the transition to a cooler and wetter
188 climate which was damaging to the bees (Husberg, 1994). Further research may be able to

189 clarify if short-run price changes in the price of wax during the medieval epoch could have a
190 similar explanation.
191   Data on agricultural activities in the province of Östergötland are found for a few years
192 in the first and last decades of the 15th century. Harvesting dates for 1402, 1407 and 1410
193 suggest close to normal summer temperature and precipitation (Lundén, 1958: 141, 161, 133;
194 Retsö, Normality and anomaly, in preparation) while available data on dates for sowing of
195 barley and other grains and fodder for the swine indicate somewhat late or cold spring in
196 1491, and early or warm spring in 1489, 1490 and 1492 (Alvered, 1999: 104, 145, 192, 245).
197   Food crises are frequently mentioned in the 15th century, in particular the four decades
198 between 1430 and 1460s. It is assumed here that the mentioning of a food crisis in a particular
199 year reflects a harvest failure the preceding year. As for the 1430s, we know that a period of
200 crisis years began in 1435 and although we have no Swedish evidence of dearth for the first
201 years of the decade, it can be noted that Danish and German sources mention hard times and
202 high corn prices in 1433 that could be connected to cold springs (compare Camenisch et al.,
203 2016: 2110). It is also conspicuous that a major peasant uprising occurred in Sweden in 1434
204 and it can be suspected that it had something to do with a food crisis in combination with
205 unusually high taxes. In the spring of 1437 there was a lack of food grains in Finland and
206 famine and dearth in Sweden are mentioned in early 1438 (Hausen, 1921 no. 2220; Tunberg,
207 1937: 214). The monetary valuations of the barley tithes in Funbo parish in Uppland in 1438
208 and 1439 more than doubled compared to the preceding years (Andræ, 1965). These years are
209 well-known in continental Europe as a time of food crises with concomitant social and
210 economic impacts. The harvests of 1437 and 1438 were the worst in England during the 15th
211 century, and the price of grain rose to an exceptionally high level in 1439. The famines of the
212 mid-1400s occurred in a context of repeated plague epidemics also hitting Sweden (Myrdal,
213 2003: 249). They also fall within a subperiod of colder summers related to a Spörer minimum
214 of solar activity within a longer period (1400-1550) of slightly warmer summers as compared
215 to the 20th century, at least in northern Fennoscandia, according to tree-ring data; the eruption
216 of Mount Fuji in Japan in 1435/1436 may have contributed to cold winters and late and cool
217 summers in north-western Europe during these years (Moberg et al., 2006: 24, 26ff;
218 Campbell, 2009: 30; Camenisch et al., 2016: 2110).
219   The 1440s were also troubled by harvest failures. In 1442 the rye and hops harvest
220 failed in Finland (Hausen, 1921 nos. 2512 and 2517; Bunge and Hildebrand, 1889 no. 955.
221 See also Hausen, 1921 nos. 2521, 2528, 2529, 2535) and just a few years later the Vadstena
222 abbey had been forced to sell some of its valuable chalices and shrines in order to buy food,
223 due to the harvest failures in 1445 and 1446 (RA Medieval codex A21 fol. 89r-v). From 1446
224 there is information on famine in Sweden (Hadorph, 1674: 370ff) and 1448 was described as
225 a year of dearth in Stockholm due to a dry spring and much rain from late May onwards
226 (Klemming, 1866: 255).
227   The Vadstena annals describe the years 1454-1457 as struck by famine, which in the
228 first of these years was combined with an outbreak of plague (Gejrot, 1996: 286f, 292f;
229 Styffe, 1870: 85. See also Christensen, 1895: 297 n. 2; Fant, 1818: 173, 175; Codex dipl. lub.
230 1:9, no. 328; Ropp, 1883 nos. 516, 520) and in 1470 there was famine in Finland (Hausen,
231 1924 no 3142). This, as well as the harvest failure of 1460, may have had something to do
232 with a volcanic eruption in the Pacific in 1453, marking the onset of a 15-year cool period
233 (Esper et al., 2017).
234   Also the early 1470s display evidence of a period of hot and dry weather, seemingly a
235 general European pattern (Camenisch et al., 2020). In August 1474 the council of the Swedish
236 realm issued a statute regulating the use of watermills due to repeated droughts, i e
237 presumably causing lack of water (Hadorph, 1676 no. 9). Furthermore, food crisis is indicated
238 in a letter from Åbo (Turku), Finland, from May 1471 (Hausen, 1890 no. 625), in Sweden

239   nominal grain prices display an unprecedented peak in the early 1470s, (Franzén and
240   Söderberg, 2006) and the Danish Roskilde annals speak of a "severely hot and burning
241   summer" in Denmark in 1473 (Rørdam, 1873).
242   Summarizing, the years in the 15th century with harvest failures and/or unusually early
243   onsets of the growing season are the following: 1402, 1405, 1436-1437, 1439, 1442, 1445-
244   1446, 1448, 1453-1456, 1460, 1469-1470, 1473-1474, 1489, 1490 and 1492.
245   From the first decade of the 16th century there are a number of reports of harvest failures
246   and famine. In Västergötland, Småland and the Stockholm area they speak of unsown fields,
247   starving peasantry forced to eat bark, and expensive corn that point to a harvest failure in 1503
248   (RA Sturearkivet nos. 255, 637; Styffe, 1875 no 232). Shortage and poverty among the peasants
249   are reported for the following year (Wegener, 1866-1870: 319-20). In southwestern Finland the
250   harvest of 1507 had been consumed already in June 1511 and the peasantry suffered famine
251   and ate "more bark than ever" (Hausen, 1930 nos. 5324, 5329). Similar reports are found for
252   the same year from mid-Sweden and the Stockholm area (RA Sturearkivet nos. 573, 597). 1508
253   seems to have been even worse. Again, prices on rye were high in March 1509, but already by
254   harvest time in 1508 prices were rising in Finland and the misery was said to be the worst in
255   ten years; by the end of the year the country was ravaged by both great poverty and plague,
256   unabling the peasantry to pay their taxes (Sjödin, 1937: 336; Hausen, 1930 nos. 5341, 5347,
257   5354, 5368). The same was reported from Sweden; in March 1509 the peasants northeast of
258   Stockholm starved and ate bark (Styffe, 1875 no. 229; Sjödin, 1937: 322, 344; RA Sturearkivet
259   no. 1053; Styffe 1875 no. 229). Widespread poverty was also reported as a result of a bad
260   harvest in 1509, already in December in central Sweden, and in the spring and summer of 1510
261   (Sjödin, 1937: 350; Styffe, 1875 nos. 302, 304; RA Sturearkivet no. 1467).
262   In both Finland and southeastern Sweden there was severe drought in late spring and
263   summer of 1551 (Almquist, 1905: 115ff, 123ff, 212f, 430ff). Also in the autumn there was a
264   severe drought in the Bergslagen mining area (Almquist, 1905: 430ff, Johansson, 1882: 159f).
265   In June 1559 the harvest of both rye and barley in Östergötland and southeastern Småland were
266   in danger already in its blooming time due to both night frost and drought (Almquist, 1916:
267   190, 202, 651). The same was reported from Finland in September (Almquist, 1916: 287). Apart
268   from 1551 and 1559 there are also reports from other years of the 16th century but they are
269   sporadic and it is uncertain as to how extensive the droughts were. In 1599, there are evidence
270   from southeastern Småland of severe heat and forest fires (Edman, 1985: 74; see also
271   Utterström, 1955: 29, Hallendorff, 1902: 79) and the production of honey was reduced
272   drastically (Husberg, 1994: 275). Other single years seem to have been dry on an all-European
273   scale, like 1540 (Wetter et al., 2014). Although some of the dry periods recorded in Sweden
274   coincide with similar drought episodes in other areas of Europe (see e. g. Brázdil et al., 2016),
275   negative spatial correlations are to be expected between northern and southern Europe.
276
277   Documentary data on droughts for the 17th and 18th centuries
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279   For the 17th and 18th centuries sources are far more abundant and continuous, among other
280   things thanks to a number of private diaries. Eight periods stand out as particularly critical in
281   terms of drought in the 17th and 18th centuries (for references for the particular years, see Table
282   4 below).
283   1) 1634-1641. There are reports of drought from the north as well as the south
284   every year in this period. Weather conditions are characterized in the relatively detailed sources
285   as generally dry with a typical pattern of dry and cold springs, hot and warm summers and
286   rather wet fall seasons. The result was disaster for the harvest of hay but rather good harvests
287   of rye. The hardships could even have begun earlier than 1634; in June 1635 Gabriel Gustafsson

288 Oxenstierna wrote to his brother that poverty was widespread in the whole country after the last
289 years (in plural) of dearth (Sondén, 1890: 363).
290   2) 1652-1657. 1652 was called the Great Drought Year already in contemporary
291 sources. Several reports from virtually all regions of the country tell about dry weather caused
292 by lack of rain and excessive heat. According to one source no rain fell between early May and
293 late September, except for some thunder rains in Karlstad and at Letstigen in the province of
294 Närke in June. Grain and hay harvests suffered severely except for rye and particularly in
295 Finland, which fared slightly better. Great bushfires were rampant, destroying forests and rye
296 in the fields. Watermills stood still due to dried out rivers. The heat caused epidemics killing
297 many people, including members of the Royal Council. Also from 1657 there are reports
298 covering all of Sweden about severe drought. Already in April the gardens were "longing for
299 rain". In Johan Rosenhane's diary from Östergötland every day is noted to have been hot or
300 very hot weather from early May to late August. Both the month of August and the entire year
301 is said to have been so dry and hot that wells and streams went dry in Småland and Östergötland
302 and that no one could remember such a drought. In the spring, eleven out of 65 iron mills in the
303 Bergslagen region were unable to operate due to lack of water, especially those located by
304 smaller rivers, and most of them had to limit their operations considerably during the whole
305 year. The lack of water in the rivers running into Lake Mälaren is also shown by the fact that
306 the water level of the lake was so low that sandbanks were visible. Even in the northern province
307 of Norrbotten the summer drought caused forest fires and much damage to the harvest.
308   3) 1665-1670. The last years of the 1660s was a new period of dry years. 1666
309 seems to have been the worst; already in July harvests were forecasted to fail and at least in the
310 west there was a lack of rain between late June and late September. But also in all of the
311 following four years harvest failures are reported and water levels in lakes and streams were
312 extremely low.
313   4) 1677-1684. The same pattern was repeated in the end of the 1670s and early
314 1680s. In particular, 1681 and 1684 stand out; in the former year Stockholm had no rain at all
315 in April and May and hay harvests were weak, and in 1684 there was a food crisis, the peasants
316 requiring to pay their church tithes in cash rather than in grains.
317   5) 1746-1750. A new prolonged drought period occurred in the mid-1700s.
318 Beginning in 1746, there are repeated reports on spring drought, and in the following years also
319 summer drought from Hälsingland in the north to Västergötland in the west. Streams dried up
320 and harvests failed and bark beetles, favoured by the hot weather, destroyed timber wood.
321   6) 1757-1767. Most of the growing seasons of this period were affected by dry
322 weather with harvest failures and dried up wells and marshes. Spring was particularly late in
323 1758; in the Stockholm harbor ice was said to be one meter thick in late April and there was
324 still ice in inlets and small lakes in early May. The following summer was hot and dry, as were
325 the summers of 1759, 1762 and 1764. According to one source, the dry period extended from
326 1749 to 1767 at least in the north and with annually varying degrees of intensity.
327   7) 1771-1776. According to sources covering most of the southern half of the
328 country these years were all characterized by cold springs and hot and dry summers. Hay
329 harvests failed due to dried up wet meadows and even rye failed to mature in due time. In
330 particular 1775 stand out as a critical year. Barley, peas and hay suffered severely and lake
331 water levels reached record lows. In the Stockholm region famine threatened in 1771.
332   8) 1780-1783. From Västerbotten in the north to Blekinge in the south there are
333 reports on cold springs and dry summers, dried-up wells and streams, bushfires, and in
334 Västergötland marshes were even so dry that they caught fire. In 1782, sowing was delayed
335 until the first week of May in the Stockholm region due to persisting ground frost. In
336 Västerbotten in the north it only rained twice from summer to October in 1780 and roots and
337 cabbage failed, while the rye harvests were quite good as was the hay harvest, probably due to

338 cultivation on wet meadows watered by meltwater from the mountains. On the other hand, in
339 all regions in the south the hay harvest seems to have failed and the price of rye rose with more
340 than a third over the year. The same pattern was repeated in 1781 and 1783.
341   Since we have temperature measurements for the latter half of the 18th century, it
342 is possible to quantify points 6, 7 and 8 above. In Table 3, average monthly temperature for
343 June, July and August, as well as the summer season JJA, are compared to average monthly
344 temperature for the entire period 1756-1816, i.e. until the year when the index ends. None of
345 the dry sub-periods differ significantly from average monthly temperature for any of the
346 summer months, or of the summer season. The period of 1771-1776 has the highest difference
347 compared to average monthly temperature for the whole period 1756-1816, being c. 1 degree
348 warmer.
349
350 Table 3 Dry periods in Sweden in the second half of the 18th century reflected in instrumental
351 measurements. Average monthly temperature for 3 sub-periods

Period	June	July	Aug	JJA
1756-1816	14.88	17.81	16.47	16.39
(Index period)	(1.62)	(1.61)	(1.51)	(1.17)
1757-1767	15.69	17.99	16.19	16.62
	(1.44)	(1.59)	(1.18)	(0.63)
1771-1776	16.50	18.95	17.13	17.53
	(1.44)	(1.16)	(1.68)	(1.13)
1780-1783	15.63	18.58	17.53	17.24
	(1.58)	(2.25)	(2.02)	(1.56)

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355 Discussion and conclusions
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357 The main problem with the precipitation index is that we have no precipitation data overlapping
358 the index. There is some correlation between the precipitation index and summer temperatures
359 in Stockholm, just like there is some correlation between precipitation and summer
360 temperatures. Correlation between the precipitation index and summer temperatures are higher
361 than between summer temperatures and precipitation, so it is possible that the precipitation
362 index is rather a "good-summer-weather-index". We think that the ideal would be to extend the
363 documentary database until – at least – early 20th century.
364   Despite the shortcomings of the index, we still think that some conclusions may
365 be drawn from it.
366   The height of the Little Ice Age, between c. 1570-1630, is, rather surprisingly,
367 characterized by very high variations with some years extremely wet, and some years extremely
368 warm. After c1660, wet years become increasingly uncommon, and most years are either dry
369 or very dry, especially from the mid-1700s onwards. Although previous estimates of Stockholm
370 summer temperatures after 1756 have been shown to be positively biased, this seems to
371 correspond to trends in tree-ring widths and density in at least northern Fennoscandia (Moberg
372 et al., 2003; Grudd, 2008).
373   Since the index is made of discrete variables, we thought it less meaningful to try
374 out a regression analysis and model (which would only render 7 different "temperatures"),
375 especially since we have been concentrating on precipitation and not temperature.
376   The drought chronology presented here is likely to be related to the climatic
377 variability in northern Europe caused by atmospheric circulation patterns over the North
378 Atlantic area (the North Atlantic Oscillation, NAO). Although there seems to be no determinant
379 influence by NAO on local summer conditions, especially in the inter-annually and seasonally
380 very variable Baltic Sea area, the evidence does suggest a connection between dry periods and

381 positive NAO values. Further research into documentary data from Sweden and the Baltic
382 region on wind conditions and storms, especially for the Middle Ages, may further illuminate
383 the issue.
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Table 4: Drought periods in Sweden 1600-1800

Period	Sources
1634-1641	Falkengren, 1781; Bergh, 1886: 194; Bergh, 1888: 155; Sondén, 1890: 363; Edén, 1905: 216; Norberg, 1956: 23; Löf, 1942: 151
1652-1657	Sjöberg, 1915: 21, 343; Hausen, 1880: 198-201, 272-3, 275, 293-6, 302, 319, 338, 340ff, 363; Fryxell, 1836: 137f; Thunaeus, 1968: 252; Petersson, 1942: 66; RA Landshövdingen öfver Skaraborgs län Tord Bonde Ulfssons berättelser 1850: 144; Osbeck, 1922: 18; Ahlqvist, 1825: 295; Rääf, 1856-1875: 349; Westerlund and Setterdahl, 1917: 6; Tilander, 1976: 186; Olofsson and Liedgren, 1974: 227; Lindroth, 1955: 157; Sillén, 1855: 103; Hannerberg, 1941: 206; Malmberg, 1917: 87; Ambrosiani, 1923: 255-6; RA Oxenstiernaregistret 3/8 1652; Isacson, 2004: 130; Jansson, 1995; Weinhagen, 1947: 68; Hülphers Abramsson, 1793: 318; Göthe, 1929: 119; Steckzén, 1981: 77
1665-1670	Nordlander, 1938: 115; Sjöberg, 1976: 35; Bergstrand, 1955: 36-7; Söderberg, 1999: 110; Jansson, 1947: 74f; Brunnström, 1913: 78f; Hegardt, 1975: 144; Fredriksson, 1979: 175; Wijkmark, 1995: 246, 254, 265; RA Brev från Catharina Wallenstedt 4/5 1681, 30/6 1681; Levander, 1934: 37; Norberg1958-1959: 376; RA Landshövdingars skrivelse t K M:t (Östergötlands län 20/6, 1684 9/7 1684; Södermanlands län 13/10 1684); Kollegiers m. fl. skrivelser t. K. M:t. Generalguvernörers skrivelser, generalguvernören över Skåne, Halland samt Göteborgs- och Bohus län, 21/7 1684, 28/7 1684, 8/8 1684 (with letter from peasantry in Luggude county 11/7 1684), 21/8 1684, 15/9 1684, 6/10 1684; Omberg, 1992: 46; Johanson, 1924: 67
1677-1684	Kellgren, 1931: 24f, 39; Weibull, 1923: 114; Hegardt, 1975: 108; Broman, 1911-1949: 340, 347ff, 352f, 355ff, 359, 362, 364, 366-7, 372, 374ff, 524, 530ff; Wallén, 1910: 13; Olander, 1946: 79f; Schartau, 1918: 282; Widegren, 1828: 613; Ekman, 1783: 165
1746-1750	Nordenström, 1894: 42ff; Utterström, 1957: 109, 430f; Olander, 1951: 119; Pehrsson, 1781; Lindgren, 1971: 127; Hiorter, 1747; Wallén, 1910: 13; Elvius, 1748: 39, 53f; Hiorter, 1752: 101-109; Hofrén, 1984: 296f; Palm, 1997: 134; Wallerius, 1779; Trolle-Bonde, 1894: 149; Ejdestam, 1969: 77ff; Fritz 2010: 68; Osvald, 1965: 68; Hannerberg, 1941: 215; Omberg, 1992: 50; Schissler, 1753: 52;
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