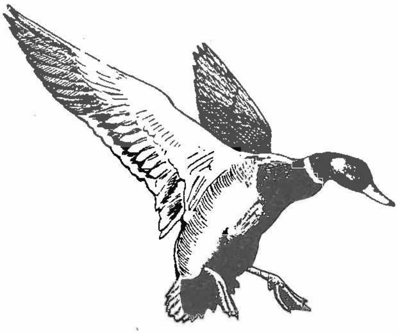
The influence of weather on catches of ducks in Steeple Decoy, Essex, in 1714-1726.



HUGH BOYD

Over 50,000 immigrant Wigeon, Mallard and Teal were caught at a decoy in Essex built in 1714 and apparently abandoned after 13 seasons. Though there were measurements of temperature and rainfall in England at that time, there were no instrumental weather records from Scandinavia and northwest Russia, the most likely principal source of the Teal and Wigeon. Variations in English summer weather had no detectable effects on the numbers of ducks caught in autumn and early winter. Wigeon and Teal arrived earlier than they do now, yet more were taken in seasons when the winter months were cold. More ducks, especially Mallard, were caught in seasons when rainfall from September to February was below average. An increase in the sale price of ducks after the catches had declined suggests that a regional scarcity of ducks, rather than poor use of the decoy, may have brought about the decline. Using annual tree-ring widths from Finland and the Polar Urals as proxies for summer weather in their breeding ranges, 49% of the variation in the catches of Teal and 27-32% in those of Wigeon seem attributable to differences in summer conditions, with larger catches of Teal and Wigeon in years of strong tree growth in Fennoscandia. In the context of climatic change, there is a need for studies of long-term changes in wildfowl populations and their sensitivity to climatic variations.

Keywords: Duck Decoy Catches, Historical Change, Seasonal Climates.

A great deal of numerical information on the status of wildfowl populations has been collected since about 1950, in many parts of the world, so that much is known about the scale of their recent variability. Long-term variations, perhaps driven by different environmental forces, have received little attention. That may be largely because there is little earlier quantitative information on wildfowl populations. In the British Isles, records of shooting bags and of catches in duck decoys provide most of the information recorded before systematic wildfowl counting began in 1948 (Atkinson-Willes 1963). Both present problems, if they are to be used as proxy measures of changes in duck numbers.

This note uses one of the earliest known records of decoy catches to look for effects of weather on the relative abundance of surface-feeding ducks wintering in southeast England early in the 18th century, when the countryside looked very different from that of today, and when decoys, taking ducks for the market, not recreational shooting, were the chief man-made cause of duck deaths. Though the run of years is short, and many of the original data have been lost, what remains is sufficient to allow some of the possibilities and limitations of relating decoy catches to variations in local and distant weather to be explored.

In an account of duck decoys in Essex, Christy (1890) included long extracts from an article by J.E. Harting that had appeared in *The Field* of 5 July, 1879, about a decoy that was once "situated in Canney Marsh, just behind Steeple Church, and rather more than half-way between Maldon and Tillingham". The decoy was completed and ready for use by September 1714. Detailed records of the catches until 1726-27 were kept "in a small folio volume, bound in vellum", which disappeared soon after Harting had studied it. That is the more regrettable because it must have contained much more information than could be used in an article in *The Field*. The catch at Steeple was unusual in that 44,677 (88%) of the 50,787 ducks caught in the 13 seasons of operation were Wigeon *Anas penelope*. The annual revenue from the sale of ducks was also recorded. The records refer to seasons, not calendar years, although remarkably few ducks seem to have been taken after December.

The English temperature records used here are taken from Lamb's (1977) seasonal regrouping of monthly temperatures for the years from 1659 to 1973 in 'Central England', originally assembled by Manley (1974). Lamb converted these into seasonal means [Spring=MAM, Summer=JJA, Autumn=SON, Winter=DJF]. He listed 'Winter' as the first season in the year. For the present purpose it is better to let 'Winter 1714' follow 'Autumn 1714', and be the mean of (Dec.1714 + Jan.+ Feb.1715). Most of the catching seasons at the Steeple Decoy fall in the period 1707-1722, for which there is a gap in the English observations, which Manley filled by adjusting records made at Delft in Holland, assembled by Labrijn (1945), who qualified them as not very reliable. However, Van den Dool, Krijnen & Schuurmans (1978) have shown that the observed winter temperatures at Delft compare reasonably well with a set for The Netherlands as a whole, calculated by de Vries (1977) from administrative records of transport on the Dutch canal system. From those two sets, Van den Dool *et al.* compiled a third series of winter temperatures for De Bilt, the station which later became the standard for the Netherlands. Both Manley's 'hybrid' series and that for De Bilt have been used here. For the other seasons, only Manley's estimates are available. The weather on the Essex coast may well have been better represented by Delft than by the estimates for 'Central England', based on pooled data from stations near Oxford.

The best available measure of rainfall in southeast England early in the 18th century is the revised monthly series for 1697-1976 compiled by Wales-Smith (1980) for 'Kew, Surrey'. Recording at Kew Observatory itself did not begin until 1774, so that the estimates for the early 18th century are derived from readings at Upminster (42 km WSW of Steeple) in 1697-1716 and in central London (64 km W by S) in 1725-1735. As there are no known measurements of rainfall in London in the years 1717-1724, Wales-Smith used the Upminster and central London data to adjust upwards records for that period from Richmond, Surrey, (80 km WSW of Steeple). Despite the complexity of the computations, the resulting estimates should be adequate to establish both the general levels of seasonal precipitation in southeast England and any substantial departures from the seasonal means.

Instrumental weather recording was in its infancy at the start of the 18th century and no records have been found from stations in Scandinavia, the Baltic countries or northwest Russia, the most likely breeding places of these English immigrant ducks. The only proxy data yet found that have proved useful are several series of annual index values for variation in tree-ring widths in northern Fennoscandia (Lamb 1977, Briffa & Schweingruber 1995) and in the Polar Urals (Graybill & Shiyatov 1995). Tree growth in Lapland should reflect conditions affecting many of the Teal *Anas crecca* and some of the Wigeon reaching southeast England. Most English-wintering Wigeon now breed in northwest Russia, to at least 90°E (Boyd 1970); although a map of recoveries in Owen, Atkinson-Willes & Salmon (1986) does not include any east of 60°E. Thus they might be influenced by conditions in the foothills of the Urals.

The Lapland tree-ring index published by Lamb, due to G. Siren, was not converted into estimates of summer temperature. Siren measured total seasonal growth. Briffa & Schweingruber concentrated on measuring latewood densities, which enabled them to reconstruct mean temperatures for July-August in northern Fennoscandia, but is less informative about conditions in May and June, of greater importance to the breeding success of ducks. Their reconstructions are expressed as anomalies (departures from the mean for the base period 1951-1970). Because the level of summer temperature may be

Table 1. Seasonal catches of Mallard, Teal and Wigeon at Steeple Decoy, 1714-15 to 1726-27.

Season	Mallard	Teal	Wigeon	Total catch
1714-15	675	347	6296	7634
1715-16	449	518	6088	7097
1716-17	392	154	5817	6378
1717-18	329	30	5207	5567
1718-19	193	40	3138	3377
1719-20	207	14	825	1048
1720-21	81	7	2789	2877
1721-22	267	24	3317	3611
1722-23	568	17	4514	5107
1723-24	449	70	3260	3786
1724-25	498	145	1306	1953
1725-26	202	19	1671	1896
1726-27	266	11	449	726
Total	4576	1396	44677	50787
Mean	352	107	3437	3907
St.dev.	171	156	2023	2237

more important to ducks than its variability, I have used the mean of the 1951-1970 normals at Arkhangelsk and St. Petersburg to represent northwest Russia, and of Stockholm and Trondheim to yield base levels for northern Fennoscandia, for the months May-August, pairing them when appropriate to correspond to the June-July and July-August means derived from the tree-ring studies.

No suitable data from the probable breeding range of immigrant Mallard *A.platyrhynchos*, around the Baltic Sea and in north Germany and the Low Countries, have yet been found. Lamb (1977) reproduced two tree-ring series from southern Germany, in areas unlikely to produce many Mallard. For the period 1714-1726 these series are poorly correlated with each other, and they show no significant correlations with any of the catch or weather data used here.

Results

Catches and prices

Table 1 shows the numbers of Mallard, Teal and Wigeon caught each season. A few Pintail were also taken, the most 46 in 1714, fewer than ten in any season after 1716-17. The largest catches were made in the first season (7.364) and in the following three, with a rapid reduction to only 1,048 in 1719-20, a recovery to 5,107 in 1722-23, then another decline, to no more than 726 in the final season. The catches of all three species followed the same pattern.

Table 2 shows the seasonal revenues from the sale of ducks, and the prices per dozen in most seasons. Teal and Wigeon counted as 'half birds', while Mallard and Pintail were 'whole birds' (i.e. one Mallard sold for as much as two Teal or Wigeon). The original prices were in pounds, shillings and pence. Here they are given as 'shillings per dozen' and in pounds, to 0.1. Though the receipts from sales fell off as the catches decreased, the price per dozen increased from 9.5 shillings in the first year to 16 in the last four. In 1722-23, ducks sold for 12 shillings a dozen early in the season and 14 shillings later, when fewer ducks were presumably being caught (though there are no monthly records of catches in that season).

Table 2. Seasonal revenue from sale of ducks (pounds, to 0.1) and price per dozen (shillings)

Season	Revenue from sales	Price per dozen
1714-15	150	9.5
1715-16	143.2	
1716-17	147.2	10
1717-18	130.4	10.5
1718-19	78.7	
1719-20	27.8	
1720-21	62	
1721-22	94.8	12
1722-23	164.8	12 early, 14 late
1723-24	142.4	16
1724-25	81.8	
1725-26	69.9	16
1726-27	33	16
Total	1326	–
Mean	102	12.9

Table 3. Numbers of ducks caught each month in Steeple Decoy in 1714-1715; and of Wigeon over the entire period of operation. Totals include Pintail. (% of column total in parentheses.)

Month	1714-1715 Mallard	Teal	Wigeon	Total	Wigeon 1714-1726
Aug.		not operating			1085 (2.4)
Sep.	39 (5.8)	81 (23.3)	3907 (62.1)	4036 (54.8)	15897 (35.6)
Oct.	26 (3.9)	19 (5.5)	1899 (30.2)	1945 (26.4)	18671 (41.8)
Nov.	185 (27.4)	92 (26.5)	244 (3.9)	524 (7.1)	7655 (17.1)
Dec.	219 (32.4)	103 (29.7)	153 (2.4)	488 (6.6)	1085 (2.4)
Jan.	206 (30.5)	52 (15.0)	93 (1.5)	371 (5.0)	275 (0.6)
Feb.		no catches		0	9 (0.02)
Total	675	347	6296	7364	44677

The increase of 68% in price over the 13-year period may be evidence of a general decline in the numbers of ducks visiting southeast England. Grigg (1980) summarized the period between 1700 and 1750 as "an era of prosperity both for farmer and labourer", because, while the population was stagnant, there was a substantial increase in cereal output and exports, despite rising wages and falling prices. One index of the cost of living, the amount of wheat that could be bought with a carpenter's daily wage, fell from about 13kg in 1700 to 12.3kg in 1710, then rose, to 12.7kg in 1720 and 14kg in 1730 (Martell 1976). Thus, at the time when the price of ducks rose most sharply, the cost of living was decreasing, more rapidly than in the previous decade. The combination of rising prices and falling catches suggests that ducks were becoming scarcer.

Many of the changes in catches in any decoy are due to local happenings, which constitute 'noise' in the detection of larger-scale changes, should they exist. Accounts of the working of duck decoys (e.g. Cook & Pilcher (1982)) identify many immediate influences. The price obtainable for ducks was often, if not always, important. So were (in no particular order) damage to the 'pipes' by accumulated frost or snow, draining or flooding of the decoy (by accident or by design), the death of a decoy dog, the illness or replacement of a decoyman, the sale of an estate, and so on. Though records of some of these events exist, many do not. At Steeple, Mr Woodward, the decoyman in the first four, highly successful, seasons, was replaced by Mr Carter, who caught fewer ducks. Catching ducks involves skill, so that part of the decline may be attributable to this change.

Catching for the market is a form of 'sampling without replacement'. It seems likely that, for some species in some decoys, the ducks removed were numerous enough to have reduced the 'lead'[the birds coming into the decoy]. If that were so, a decline in the size of catches through the season would be expected, though probably not to the extent indicated by the records for 1714-15, the only season for which month-by-month catches were published (**Table 3**). The times of capture of the three main species that season were very different from what would be expected today: the Mallard relatively scarce and late, Wigeon dominating and mostly taken in September and October, very few ducks taken after December. The only other set of monthly totals given by Harting refers to the entire catch of Wigeon over 13 seasons (last column of **Table 3**). Though this confirms that most Wigeon continued to be taken early in the season, there are significant differences between the monthly distribution in 1714-15 and in the sum of the other years, suggesting that there may have been substantial seasonal variations in times of capture.

In the 18th century, more Teal probably bred in England than have done so since, but they were not plentiful in the south (Montagu 1802). Breeding Mallard may have been less common than the semi-wild ones of today; they had been seriously depleted by the practice of netting moulting birds in midsummer, even after it had been declared illegal (Cook & Pilcher 1982). Wigeon did not breed. So most of the ducks caught must have been immigrants.

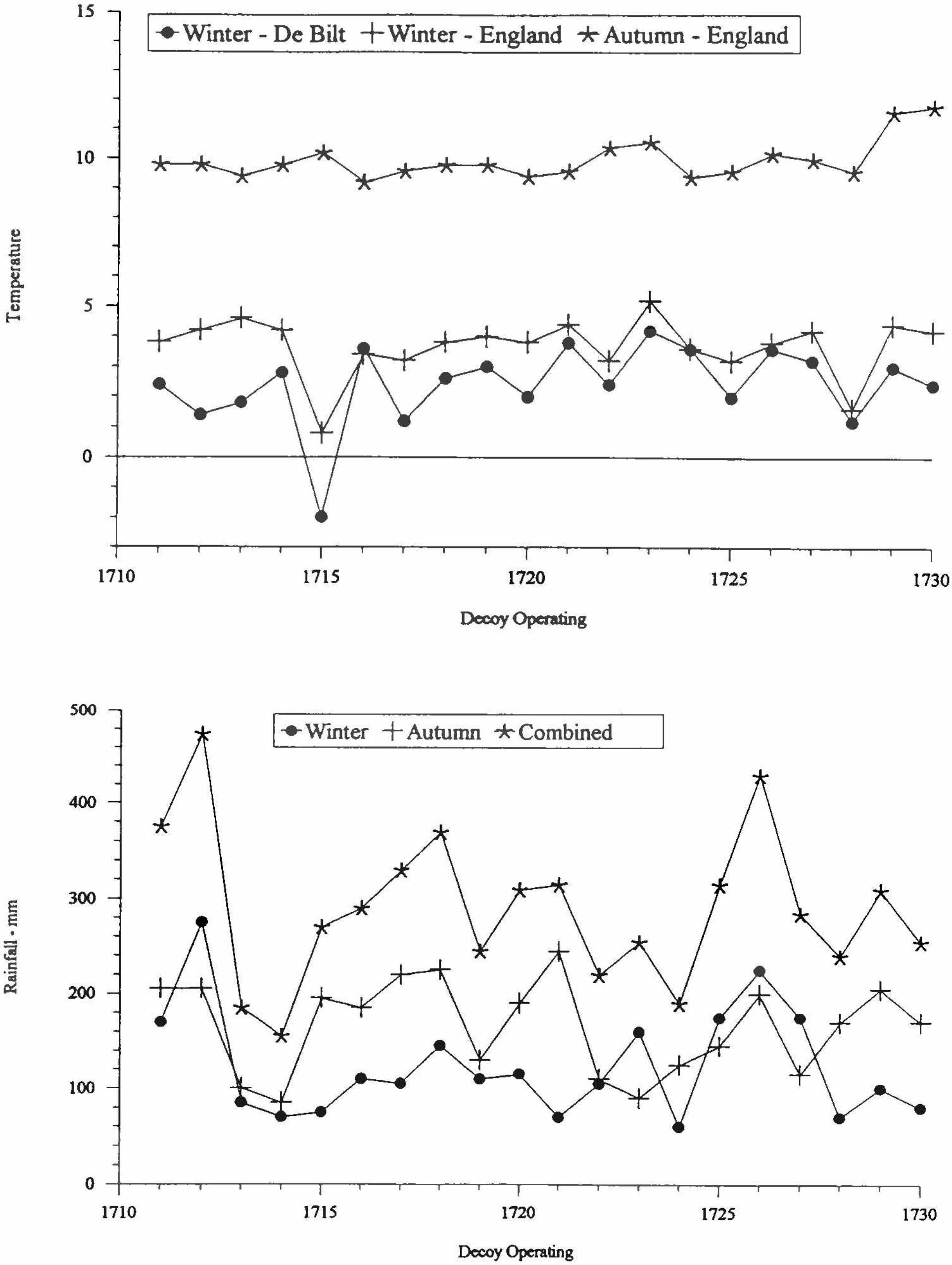


Figure 1. Central England temperatures (deg. C) and rainfall at Kew (mm.) in autumn and winter, 1711-1730; with winter temperatures at De Bilt, The Netherlands.

English weather

The annual variations between 1710 and 1730 in temperature and precipitation in central and southeast England in autumn and winter are shown in **Figure 1**. The records for spring and summer are omitted because, as is reported below, they did not seem to influence the catches.

In western Europe this was a time of climatic transition, between the very cold decade of the 1690s and the unusually warm 1730s, which were to be

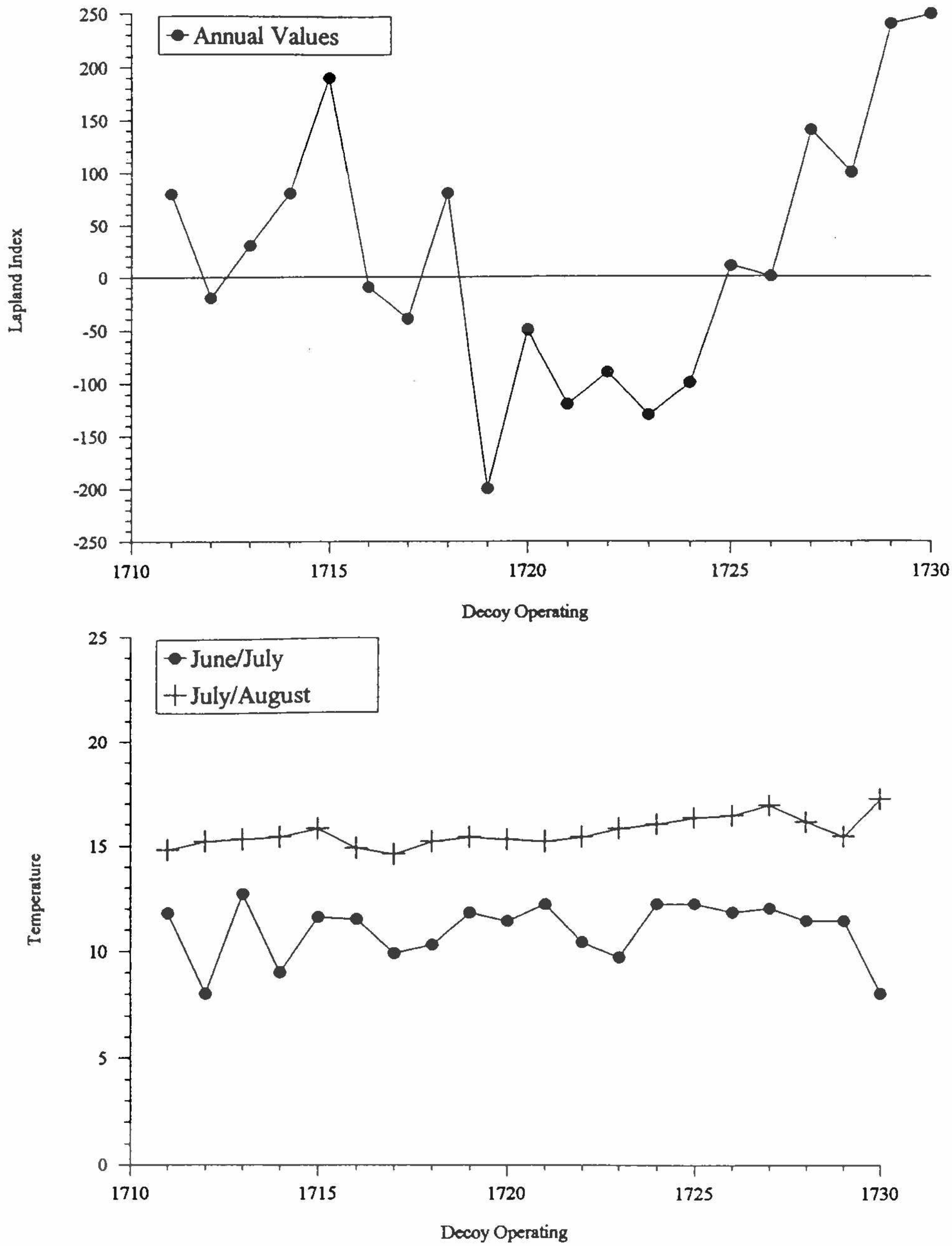


Figure 2. Measures of summer temperatures in breeding ranges of Teal and Wigeon: (a) annual values of Siren's Lapland tree-ring index; (b) summer temperatures reconstructed from latewood densities in series of Pinus sylvestris: (i) mean temperatures in July-August in northern Fennoscandia and (ii) June-July means in the Polar Urals.

followed by a long cold spell. The variability of the annual temperature and rainfall was unusually great during this transitional period (Lamb 1982). Very little is known about how wildfowl numbers respond to long-period environmental changes, which certainly affect both natural vegetation and agricultural crops, with lags of varying length. Wheat yields in England seem to have been unusually stable during the time when the decoy was being operated (Grigg 1980), although Lamb (1977, 1982) reports that the summers of 1718 and 1719 were exceptionally hot in England and over much of Europe, while the summer of 1725 was the coldest recorded in England since measurements began in 1659. Despite those extreme events, there were no statistically significant correlations between the numbers of ducks caught and the local weather in spring and summer.

For western Europe as a whole, the winter of 1715-16 was unusually cold, and those of 1716-17 and 1724-25 unusually mild (Lamb 1977), raising the expectation that immigration to southeast England might have been increased in 1715-16, and reduced in the two mild winters. The Steeple catches do not reflect such responses. **Table 4** shows that, for the Teal, the only element of weather in southern England showing a significant linear correlation with catch size is the winter temperature (r= -0.564, P<0.05; the correlation with winter temperature at De Bilt was slightly larger: -0.592), i.e. catches were larger in colder seasons. The correlation with autumn and winter precipitation was also negative, with larger catches in drier seasons. The Wigeon shows the same negative relationships, but with P>0.1. The catches of Mallard showed no relationships to temperature, but a strong negative correlation with autumn/winter precipitation (r=-0.714, P<0.01).

Steeple duck catches and tree growth in Lapland

Figure 2a illustrates the annual variations in growth increments of *Pinus sylvestris* in Siren's Lapland series, which extended from AD 1181 to 1960, with extreme values of +590 and -697. Thus the fluctuations within the period 1714-1726 were not as great as might appear. Growth seems to have been greater in 1714-1718 and in 1725-1726 than in the intervening years: Briffa *et al.* (1988), using the latewood density technique on different samples, identified 1716-1724 as a cool period in northern Fennoscandia.

Given the general resemblance of the trend in catches (**Table 1**) to the changes in this tree-ring index, it is not surprising to find that the correlation between annual catches and ring-width indices is 0.697 for Teal (P<0.01) and 0.518 for Wigeon (P=0.05), though only 0.184 (NS) for Mallard. Partialling out the negative time trends in both the catch and the tree-ring values reduces the correlations to 0.592 for Teal and to 0.281 for Wigeon.

Thus, for the winter visitors to southeast England that today come chiefly from Scandinavia (especially Finland) and northwest Russia (Owen *et al.* 1986), it appears that, early in the 18th century, years favourable for tree growth in Lapland tended to be accompanied by larger catches in Steeple Decoy. The variations in the Lapland tree-ring index account for 49% of the variation in catches of Teal and 27% of those of Wigeon.

Today, Mallard visiting southeast England in winter come mainly from the North Sea and Baltic countries, with relatively few from Finland and northwest Russia (Owen *et al.* 1986). If that were also the case around 1720, the lack of correlation between Mallard catches and Lapland tree growth is not surprising.

Table 4. Correlation coefficients (r) of seasonal catches of Mallard, Teal and Wigeon with temperature and rainfall in southern England in autumn and winter, and with the Lapland tree-ring index. Entries only where P<0.1; *P<0.05, ** P<0.01.

	Mallard	Teal	Wigeon
Years		–0.612*	–0.802**
Winter Temperature		–0.564*	
Autumn/ Winter Precip.	–0.714**		
Lapland Index		0.697**	0.518

Catches and summer temperatures in Fennoscandia and northwest Russia

Figure 2b shows the mean temperatures in northern Fennoscandia in July and August and near Salekhard in June and July, as reconstructed from tree-ring increments and converted into 'actuals'. Although Siren's Lapland annual tree growth index is significantly correlated with the numbers of Teal and

Wigeon taken at Steeple in the following season, the July and August temperature in Fennoscandia (estimated from latewood density) is not, presumably because late summer conditions are less important to ducks than those in May and June.

The June-July temperatures in the Polar Urals are not correlated with the numbers of Teal caught at Steeple, perhaps reflecting a situation like that at present, when few of the Teal breeding as far east as the Urals winter in England. More puzzlingly, the correlation between this June-July temperature series and the catch of Wigeon at Steeple is -0.570 ($P<0.05$), implying that eastern-nesting Wigeon may have bred better in cool summers than in warm ones, unlike those further west. In 1951-1970, the mean June-July temperature was 15.5° ± 1.4°C in northern Fennoscandia and 14.6° ± 1.5°C in the Russian breeding range of English-wintering Wigeon, a difference that seems unlikely to be of decisive importance. Graybill and Shiyatov (1995) note that their historical reconstructions for this area are not in close correspondence with those for Fennoscandia; and in recent years the temperatures in the two regions often seem to vary independently (unpublished analyses of data in Jones *et al.* (1993). In such a situation, ignorance of the relative abundance of Teal and Wigeon across their Russian breeding ranges is a handicap in trying to understand their responses to summer weather.

One possibility is that this seemingly contrary result was due to low rainfall. There are no precipitation records from the early 18th century for either part of the range; but Borisenkov (1995) summarizes the summer weather in Mid-Russia during the thirty-year period 1711-1740 as cooler than the mean for 1500-1980 and notes: "At the start of the third decade of the 18th century, Russia suffered several severe famines due to droughts and recurring summer cold spells". Briff *et al* (in press) have shown that several summers in the northern Urals were notably cool in the 1720s. There is no indication of whether at that period droughts were associated with cool or with warm summers. [In the 20th century, cold seasons occurred most frequently in the dry period from 1917-1936: (Borisenkov 1995).]

Given the different character of the summer and winter indices, it would be inappropriate to make a quantitative estimate of their relative importance. However, though the correlations of the tree-ring index with winter temperature and with catching season rainfall are not significant, it is worth noting that partialling out the effect of winter temperature lowers the correlations between catches of Teal and Wigeon and the tree-ring index much less than partialling out the effect of the tree-ring index reduces the correlations of catches with winter temperature.

The tree-ring correlations suggest linkages between summer weather and the breeding success of Teal and Wigeon. The correlations with winter temperatures and catching season precipitation might reflect 'catchability', rather than abundance. This is why the sharp increase in the price of ducks in the middle of the period assumes importance as evidence of their scarcity.

Discussion

This very limited inquiry was made as a pilot for a more intensive search for relationships between variations in weather and in catches of ducks in decoys and baited traps in the second half of the 20th century. Both are related to a perceived need to learn more about the importance of climatic change in determining where ducks will live, in what numbers and with what success, if practical steps to maintain and improve wetland and wildfowl conservation are to be successful. Although the future will not be like the past, it should be possible to learn from historical studies how sensitive wildfowl may be to changes in climate greater in magnitude than those they have experienced in the recent past. Although the climate in western Europe when the Steeple Decoy was in use proves not to have differed greatly from that at present, the apparent sensitivity then of Teal and Wigeon to variations in summer weather in their presumed breeding range encourages two lines of enquiry: (1) did the large climatic changes in Scandinavia and northwest Russia later in the 18th century and through the 19th century have different effects on the breeding of ducks than the conditions in 1714-1726, or those in the late 20th century? (2) if so, were their effects on ducks limited to breeding, or might they have also been responsible for the changed timing of immigration to southeast England? From comments in Christy (1890) the present pattern seems to have developed by the mid-19th century. Is it possible to find out when, and why, immigrant Mallards became out-numbered by British-reared ones; and when Russian Wigeon ceased to arrive in England in large numbers in early autumn? That kind of natural history is not simple antiquarianism. It may hold valuable lessons for dealing with the effects on wildfowl of future climatic changes.

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References

Atkinson-Willes, G.L. (Ed.) 1963. *Wildfowl in Great Britain.* H.M. Stationery Office. London.

Borisenkov, E.P. 1995. Documentary evidence from the U.S.S.R. In: Bradley, R.S. & Jones, P.D. (Eds.). *Climate Since A.D.1500.* Rev.ed. Routledge. London. Pp. 171-183

Boyd, H. 1970. The migrations of British geese and ducks. In: Sedgwick,N.M., Whitaker, P. & Harrison, J. (Eds.). *The New Wildfowler in the 1970s.* Barrie & Jenkins. London. Pp.76-85

Bradley, R.S. & Jones, P.D. (Eds.). 1995. *Climate Since A.D.1500.* Rev.ed. Routledge. London.

Briffa, K.R., Jones, P.D., Pilcher, J.R. & Hughes, M.K. 1988. Reconstructing summer temperatures in northern Fennoscandinavia back to A.D.1700 using tree-ring data from Scots Pine. *Arctic and Alpine Research* 20:385-394.

Briffa, K.R. & Schweingruber, F.H. 1995. Recent dendroclimatic evidence of northern and central European summer temperatures. In: Bradley, R.S. & Jones, P.D. (Eds.). *Climate Since A.D.1500.* Rev.ed. Routledge.London. Pp.366-392

Christy, M. 1890. *The Birds of Essex.* Edmund Durrant. Chelmsford.

Cook, T. & Pilcher, R.E.M. 1982. *The history of Borough Fen Decoy.* Providence Press. Ely, Cambridge.

De Vries, J. 1977. Histoire du climat et economie: des faits nouveaux, une interpretation differante. *Annales Economies Societes Civilisations* 32:198-227. [In: Van den Dool et al. 1978; not seen]

Graybill, D.A. & Shiyatov, S.G. 1995. Dendroclimatic evidence from the northern Soviet Union. In: Bradley, R.S. & Jones,P.D. (Eds.). *Climate Since A.D.1500.* Rev.ed. Routledge. London. Pp.393-414

Grigg, D.B. 1980. *Population growth and agrarian change.* C.U.P. Cambridge.

Jones, P.D., Raper, S.C.B., Cherry, B.S.G., Goodess, C.M., Wigley, T.M.L., Santer, B., Kelly, P.M., Bradley, R.S. & Diaz, H.F. 1993. An updated global grid point surface air temperature anomaly data set: 1851-1990. ORNL/CDIAC-37. *Environmental Sciences Division Publication No.3520.* Oak Ridge National Laboratory, Tennessee.

Labrijn, A. 1945. The climate of The Netherlands during the last two and a half centuries. *KNMI Mededelingen en Verhandelingen 49.* [In: Van den Dool et al. 1978: not seen]

Lamb, H.H. 1977. Climate: present, past and future. Vol.2 *Climatic history and the future.* Methuen. London.

Lamb, H.H. 1982. *Climate, history and the modern world.* Methuen. London.

Manley, G. 1974. Central England temperatures: monthly means from 1659 to 1973. *Quart.J.Roy.Met.Soc.*:389-405. [In: Lamb 1977; not seen]

Martell, G. 1976. *A climatic analysis of English wheat prices 1200 to the present.* Unpublished research paper. Pp.43. Department of Meteorology, University of Wisconsin-Madison.

Montagu, G. 1802. *Ornithological dictionary; or, alphabetical synopsis of British birds.* J.White. London.

Owen, M, Atkinson-Willes, G.L. & Salmon, D.G. 1986. *Wildfowl in Great Britain.* Second Edition. C.U.P. Cambridge.

Van den Dool, H.M., Krijnen, H.J. & Schuurmans, C.J.E. 1978. Average winter temperatures at De Bilt (The Netherlands): 1634–1977. *Climatic Change* 1:319-330.

Wales-Smith, B.G. 1980. Revised monthly and annual totals of rainfall representative of Kew, Surry for 1697-1870 and an updated analysis for 1697–1976. *Hydrological Memorandum No.43.* Meteorological Office. Bracknell, Berks. Pp.34

H. Boyd, National Wildlife Research Centre, Canadian Wildlife Service, Ottawa, Ontario, Canada K1A OH3