Acta Universitatis Latviensis, 2005, Vol. 691, Biology, pp. 93–109

Impact of changes in agricultural land use on the Corncrake *Crex crex* population in Latvia

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Abstract

Data on Corncrake numbers and agricultural land use were collected in 68 freely chosen sample plots (0.67 - 44.38 km2; mean = 8.42; SD = 7.458) in Latvia 1984 - 2004. The annual TRIM index of Corncrake numbers in Latvia increased significantly during the study period ($p < 0.003$). The total area of all abandoned agricultural lands have increased significantly ($p < 0.0006$) at the expense of cultivated pastures ($p < 0.015$) in the survey plots. The area of intertilled crops also decreased ($p < 0.07$). The area of both cultivated and uncultivated meadows increased significantly during the period of 1989 - 1998 ($p < 0.005$), and decreased in 1999 - 2004 ($p < 0.025$). The habitat-specific annual TRIM index of Corncrake numbers was positively correlated with the TRIM index of area of uncultivated meadows ($p < 0.001$), all meadows combined ($p < 0.001$), uncultivated pastures ($p < 0.05$) and abandoned agricultural lands ($p < 0.0025$), but negatively with the TRIM index of area of intertilled crops ($p < 0.05$). The total Corncrake TRIM index was positively correlated ($p < 0.002$) with the total amount of precipitation during the Corncrake breeding season (May - July). The highest breeding density (on average – 3.05 males km^2) was observed in abandoned grasslands, followed by uncultivated meadows > abandoned arable lands > cultivated meadows > other (miscellaneous) habitats > uncultivated pastures > shrubland > winter crops > cultivated pastures > spring crops > intertilled crops. More Corncrakes than expected were observed in abandoned grasslands, uncultivated meadows and abandoned arable lands ($p < 0.001$), but Corncrake numbers were smaller in winter crops, cultivated pastures, spring crops and intertilled crops ($p < 0.001$). Despite the recent increase of the Corncrake numbers in Latvia, the projected long-term dynamics since 1940 show a significant decrease in numbers ($p < 0.0001$) due to decrease of area of suitable habitats (e.g. meadows) in Latvia.

Key words: agricultural land use, Corncrake, *Crex crex*, habitat preference, population trends.

Introduction

Agriculture has shaped various ecosystems worldwide. It has been recently recognized that production of food for the still growing human population in environmentally and ecologically sustainable way might be the greatest challenge for agriculture (Robertson, Swinton 2005). Agricultural habitats are used by many organisms, even rare and endangered species, and thus it is very important to achieve better integration of agriculture and conservation biology (Banks 2004). In Europe, semi-natural grasslands i.e. hay meadows and pastures, especially those managed using traditional method, are the main breeding habitat for Corncrake *Crex crex*, a bird species recognized as *near-threatened* globally by the IUCN (Hilton-Taylor 2000). In Western Europe, Corncrakes have been declining in numbers and their distribution range has been shrinking since the 19th century, when mechanical grass mowing was introduced and earlier mowing became possible due to accelerated grass growth stimulated by intensive fertilization of fields (Glutz von Blotzheim et al. 1973). Although the species has declined also in Latvia since the First World War (von Transehe 1965), today the Baltic States support a considerable part of the European Corncrake population (Green et al. 1997). The recent increase of the Corncrake population in Europe (Schäffer, Koffijberg 2004) is predicted to be short term since both intensive agriculture and cession of agriculture is detrimental for the species (Keišs 2003) and its conservation status in European Union therefore has been evaluated as *unfavourable* (Papazoglou et al. 2004).

Despite the fact that historic declines of Corncrake numbers are often associated with changes in agricultural practices, reliable data are rarely available (Glutz von Blotzheim et al. 1973). Green and Stowe (1993) analyzed Corncrake declines in Britain and Ireland associated with changes in vegetation of the Corncrake habitats and changes in land use (Stowe et al. 1993). Vegetation impact on habitat selection in Corncrakes has been described also by Schäffer and Münch (1993) in Murnauer Moss, Germany and by Schäffer (1999) in valleys of the rivers Biebrza and Narew in Poland. Despite these indepth studies on vegetation, long-term data connecting agricultural land use (e.g. availability of various Corncrake habitats in a scale of a country) and respective Corncrake numbers are still lacking [but see "snapshots" provided by Elts (1997) for Estonia and Keišs (1997) for Latvia].

In the present study, the dynamics of Corncrake population numbers is related to changes in agricultural land observed in sample plots. Historical dynamics of Corncrake population in Latvia is projected by past land-use data for the territory of Latvia.

Materials and methods

Data were collected in 68 freely chosen sample plots in 1989 - 2004, the Snēpele sample plot has been surveyed since 1984 (Fig. 1, Table 1). On average, 19 sample plots were surveyed each year, but only four plots were surveyed for more than ten years. The area of the sample plots were determined by using 1:50 000 and 1:10 000 topographic maps. Total area of open landscape (excluding forests, open waters and towns) in sample plots varied between 0.67 and 44.38 km^2 (mean = 8.42; SD = 7.458). Habitats were mapped and the area of each habitat was calculated according to following categories: (i) cultivated meadows and perennial grasslands – sown or fertilized and managed grasslands, used for mowing; (ii) uncultivated meadows – semi-natural grasslands which are not fertilized and are mowed once per year; (iii) cultivated pastures – see (i), but used for grazing; (iv) uncultivated pastures – see (2), but used for grazing; (v) winter crops – fields of winter rye, winter wheat, winter barley and triticale; (vi) spring crops – fields of spring barley, oats, spring wheat, spring rye, buckwheat and mixed cereals; (vii) intertilled crops – fields of various kinds of intertilled crops (potatoes, beets etc.), this category was called "other arable land" in Keišs (1997); (viii) abandoned grasslands; (ix) abandoned arable lands; (x) abandoned lands with unknown last usage; (xi) shrubland; (xii) other (miscellaneous) habitats.

Preferably, habitat mapping were repeated every year before the Corncrake surveys. At least once, the habitats were mapped in 63 sample plots. Corncrakes were surveyed at night by counting all calling males. Each calling male was attributed to one of the given habitat categories. In 205 (67.7 %) cases of all 303 cases Corncrakes were surveyed twice per season, in 129 (62.9 %) of all these cases (n = 205) calling males were recorded on the map and if males were observed >250 m in first and second count, they were considered as two different individuals (Peake, McGregor 2001; Schäffer, Mammen 2003). For the rest of repeated surveys, survey with greatest observed number was used for analyses.

The *TRends and Indices for Monitoring data* (TRIM) version 3 software (Pannekoek, van Strien 2001) was used for analyses of Corncrake count and habitat data. To meet the requirements of the mathematical model, data used for calculation of the annual TRIM index for Corncrakes were taken only from those sample plots (n = 61) where surveys were conducted two or more years (Fig. 1). Similarly, the annual TRIM index for the area of each habitat category could only be calculated for those plots where habitat data were available for two or more years and only for the given habitat was present at least in one year (i.e. value is not 0). Therefore, the number of sample plots used for calculating annual TRIM index of each habitat category differed. For analytical purposes, habitat- specific annual TRIM indices for Corncrake numbers were calculated using the same subset of sample plots as for respective habitat category index (Table 2). The Spearman's rank correlation coefficient (ZAR 1996) was calculated for the obtained habitat-specific Corncrake indices. The φ-test (Plohinski 1972) was used to determine if Corncrakes prefer a specific habitat category.

Latvian State Meteorological Agency data on precipitation in six observational stations in Latvia (Ainaži, Daugavpils, Rūjiena, Stende, Zīlāni and Zosēni) during the Corncrake breeding season (May - July) were obtained and the relationship with the annual Corncrake

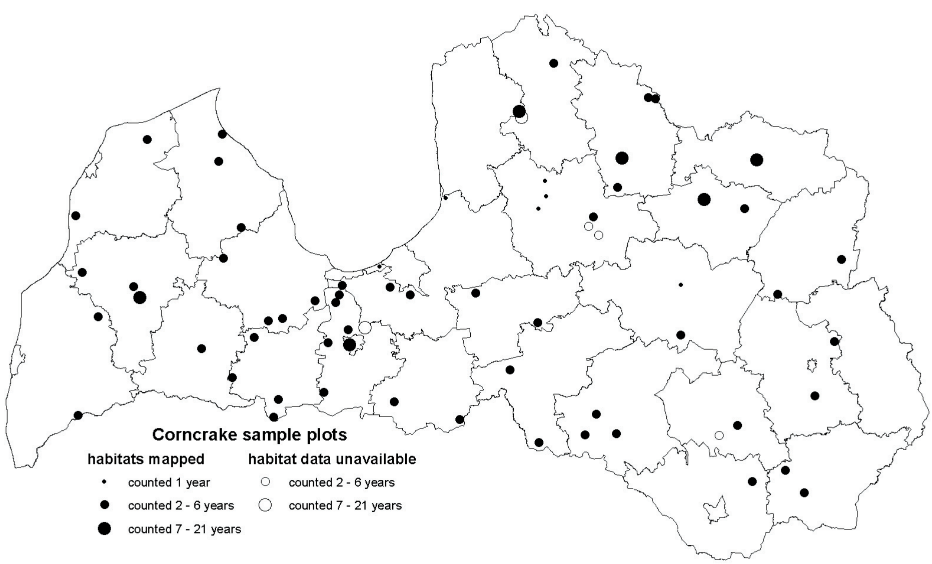

Fig. 1. Locations of Corncrake survey sample plots in Latvia 1984 - 2004.

Table 1. Corncrake survey plots and annual breeding density in Latvia (1984 - 2004)

Year	Surveyed plots with habitat data	All surveyed plots (plots, started in the given year)	Annual density (males km^{-2})
1984	1	1 (1)	0.65
1985	1	1 (0)	0.48
1986	1	1 (0)	1.31
1987	1	1 (0)	0.54
1988	1	1 (0)	0.48
1989	4	5 (4)	1.02
1990	7	10 (7)	1.38
1991	7	12 (4)	1.10
1992	4	7 (2)	0.78
1993	2	8 (0)	0.86
1994	8	14 (6)	0.73
1995	11	18 (1)	1.92
1996	22	25 (17)	1.76
1997	7	10 (4)	1.55
1998	3	11 (3)	1.99
1999	6	14 (8)	2.26
2000	6	12 (1)	1.38
2001	10	19 (1)	2.10
2002	35	44 (5)	2.14
2003	42	50 (4)	1.73
2004	42	45 (0)	1.97

TRIM index was determined.

The historical population dynamics of Corncrakes were projected by using statistical information on land use in Latvia in the past (Appendix 1; Anonymous 1959; 1967; 1976; 1986; 1991; 1993; 1994; 1996; 1997a; 1997b; 1999a; 1999b; 2000a; 2000b; 2000c; 2001; 2002; 2003a; 2003b; 2004a; 2004b). Habitat categories used in this study are consistent with statistical data collected on agricultural land use in Latvia and therefore allow to project the total number of calling Corncrakes in Latvia. Since the categories of statistical data collected in various decades since 1940 has slightly changed, for projection of Corncrake numbers in the past, it was necessary to combine some categories (e.g. cultivated and uncultivated meadows into "meadows"; cultivated and uncultivated pastures into "pastures"; meadows and pastures together and all types of abandoned lands together, Appendix 1).

Results

The annual TRIM index of Corncrake numbers in Latvia increased significantly during the period of observation (1989 - 2004: $r = 0.79$; $p < 0.0003$; adding the data of the single

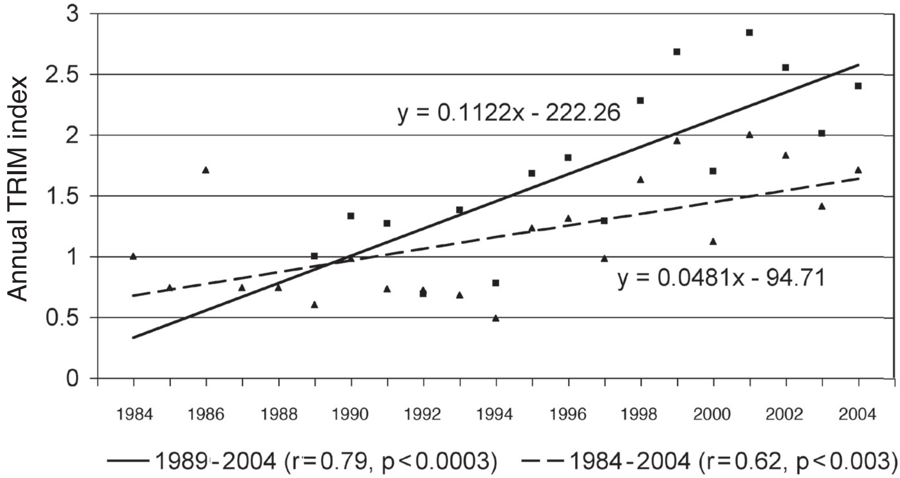

Fig. 2. Changes in the annual TRIM index of Corncrakes in Latvia (in the period 1984 – 1988 only one sample plot was surveyed).

plot available for period 1984–1988, $r = 0.62$; $p < 0.003$; Fig. 2).

The area TRIM indices of agricultural land use in Corncrake survey sample plots during the period of 1989 - 2004 changed as follows: area of abandoned agricultural lands increased very significantly ($r = 0.76$; $p < 0.0006$), while the area of cultivated pastures decreased ($r = -0.60$; $p < 0.015$), along with the area of intertilled crops ($r = -0.47$; $p < 0.07$). The area of both cultivated and uncultivated meadows increased significantly

Table 2. Number of sample plots surveyed at least two years and used to calculate TRIM indices for area of specific habitat categories (habitat present at least one year) and indices of total Corncrake number

Habitat category	Survey plots used in analyses (number)
Cultivated meadows	43
Uncultivated meadows	44
All meadows	47
Cultivated pastures	33
Uncultivated pastures	35
All pastures	41
Winter crops	41
Spring crops	43
All crops	45
Other arable land	42
Abandoned neadows	40
Abandoned arable land	35
All abandoned agricultural land	45

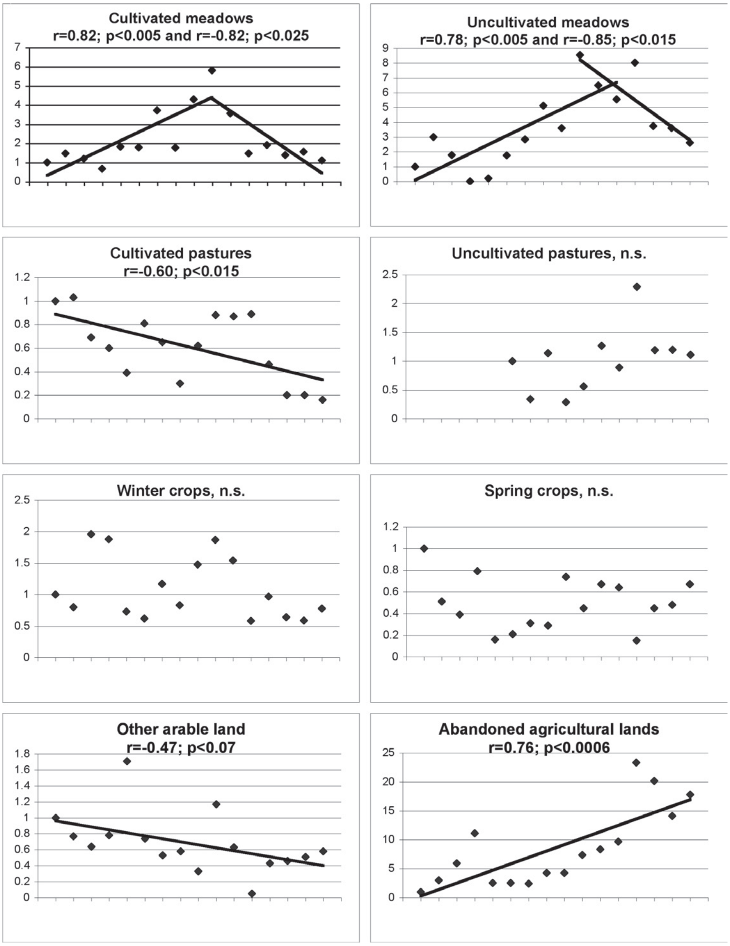

Fig. 3. Changes in the annual TRIM indices of various agricultural habitat categories in Corncrake sample plots in Latvia 1989 - 2004.

until 1998 ($r = 0.82$ for cultivated and $r = 0.78$ for uncultivated meadows; $p < 0.005$), but decreased in 1999 - 2004 ($r = -0.82$; $p < 0.025$ for cultivated and $r = -0.85$; $p < 0.015$ for uncultivated meadows). The area indices of uncultivated pastures, winter crops and spring crops did not change significantly in sample plots during the study period (Fig. 3).

The Corncrake index calculated for habitat-specific subsets of sample plots (see *Materials and Methods*, and Table 2) was positively correlated (Fig. 4) with the area index of uncultivated meadows in respective subset of sample plots (Spearman's rank test, $p < 0.001$), all meadows combined ($p < 0.001$), uncultivated pastures ($p < 0.05$) and abandoned agricultural lands combined ($p < 0.0025$). The area index of intertilled crops and index of Corncrake number were negatively correlated ($p < 0.05$), but the correlation coefficients for area indices of cultivated pastures, spring crops and winter crops related to the respective indices of Corncrake numbers were close to zero (Fig. 4).

The total Corncrake TRIM index and the total amount of precipitation during the

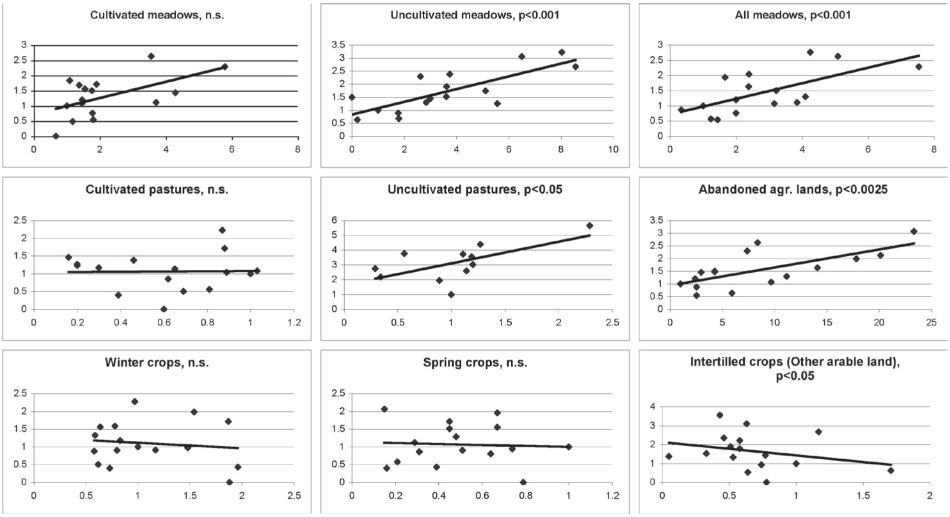

Fig. 4. Annual TRIM index of Corncrake numbers (Y-axis) explained by the annual TRIM index of the respective habitat (X-axis), p values for Spearman's rank correlation coefficient are given (see also Table 2).

Corncrake breeding season (May - July) was positively correlated (Fig. 5; $r = 0.86$; $p < 0.002$).

The habitat area data were available for 3300 Corncrake registrations during the period of 1989 - 2004. Calling male density was calculated and observed vs. expected Corncrake proportion in each habitat type was compared (Table 3). The highest breeding density (3.05 calling males per km^2) was observed in abandoned grasslands, followed by uncultivated meadows and abandoned arable lands. More Corncrakes than expected by area covered of the respective habitat category were observed in all of these three habitat categories (φ-test, $p < 0.001$). Cultivated meadows, other habitats, uncultivated pastures

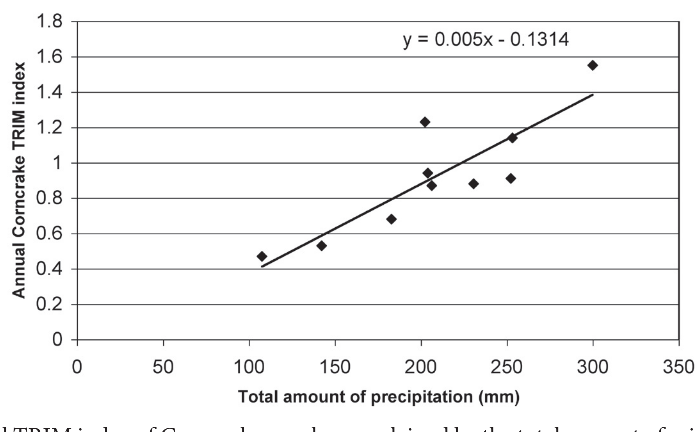

Fig. 5. Annual TRIM index of Corncrake numbers explained by the total amount of rainfall in May-July in six meteorological stations in Latvia in the respective year..

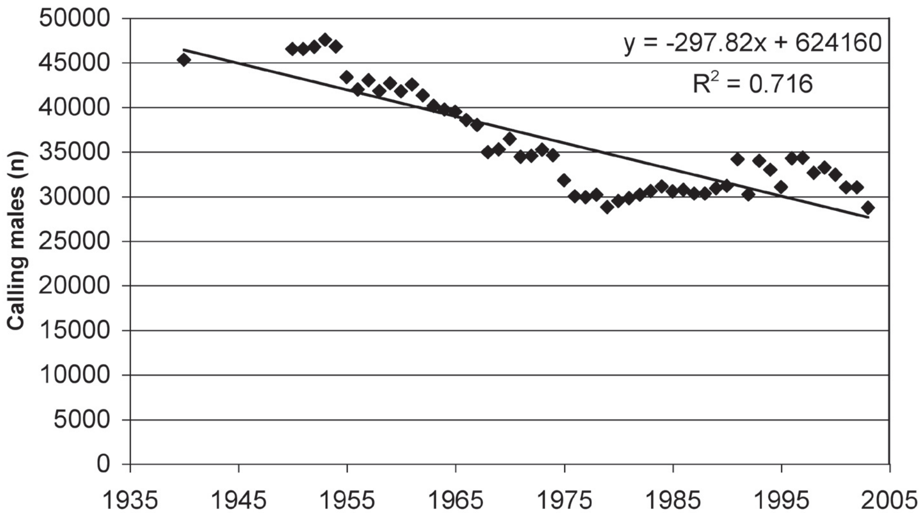

Fig. 6. Expected population of Corncrake in Latvia according to land-use data (for sources see *Materials and methods* and Appendix 1).

and shrubland had insignificantly less Corncrakes than expected, but in some years there were more Corncrakes than expected in a respective habitat (Table 3). Observed Corncrake numbers were smaller than expected in winter crops, cultivated pastures, spring crops, and intertilled crops (φ-test, $p < 0.001$ for all respective habitats).

The dynamics of Corncrake population numbers since 1940 (Fig. 6), obtained by habitat specific breeding densities (Table 3) and respective agricultural statistics (see *Materials and methods*), show a significant decrease in numbers ($r = 0.80$; $p < 0.0001$).

Discussion

Precision of the survey

This study used registrations of calling males as a basis for all calculations and conclusions on Corncrake population dynamics. This method has been used in many other Corncrake studies across Europe (Schäffer, Koffijberg 2004). However, a calling Corncrake male does not always mean that breeding on the site occurs (Schäffer 1994). Further, even if breeding occurs, the population density alone might not always show the quality of the site adequately (van Horne 1983), because breeding success is not known (e.g. Schäffer 1994) and might be lower in high density sites due to so called "ecological traps" caused by anthropological impact, predators etc. (Bock, Jones 2004). Despite all of the given uncertainties, no better method for surveying Corncrakes is available.

Two counts per season is a widely recognized method for surveying Corncrakes (Schäffer, Mammen 2003) as well as "the 250 m rule" for combining of the results of both counts (Peake, McGregor 2001). If Corncrakes are moving more than 250 m, this method might lead to an overestimation of the number of Corncrakes present. Nevertheless, Peake and McGregor (2001) showed that only 66 % of resident males in a given territory

Table 3. Number of sample plots surveyed at least two years used to calculate TRIM indices for area of specific habitat categories (habitat present at least one year) and indices of total Corncrake number

Habitat category	Density (males km^{-2})	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	All years together
Abandoned neadows	3.05	n.a.	+	+*	+**	+	+	+*	+*	+*	+	+	+	+*	+*	+*	+***	+***
Uncultivated meadows	2.85	+	+	+	+	0	+*	+*	+***	+**	+*	+*	–	–	+***	+***	+***	+***
Abandoned arable land	2.70	+	+	0	n.a.	0	–	+	+	+	n.a.	+	+	–	+	–	+**	+***
Cultivated meadows	1.68	+	+	0	–*	+	+	–*	+	–*	–	–*	0	+	–*	+	+	–
Other habitats	1.60	+	n.a.	n.a.	n.a.	n.a.	0	+	n.a.	n.a.	+	n.a.	n.a.	–	–	–	–	–
Uncultivated pastures	1.56	n.a.	n.a.	n.a.	n.a.	n.a.	0	+	–	0	0	+	+	–*	–	–	–*	–
Bushes	1.27	n.a.	n.a.	n.a.	n.a.	n.a.	+	0	n.a.	n.a.	n.a.	n.a.	n.a.	–*	–	–***	–	–
Winter crops	1.25	–	–	–	–***	+	–**	–	–	0	–	+	+	+	+	–***	–***	–***
Cultivated pastures	0.81	–*	–*	–*	–**	–	–***	–	–	–**	–*	–	–	–	–*	–	–	–***
Spring crops	0.69	–	–	+	–***	–	–**	–	–***	–	–**	–*	–	–	–***	–***	–***	–***
Other arable land	0.12	–*	–**	–	–	–*	–***	–	–***	–*	–*	–**	n.a.	–	–***	–***	–***	–***
Corncrakes registered		47	65	34	29	10	57	113	305	83	64	164	48	223	646	643	769	3300

are detected in two counts when "the 250 m rule" is applied. Reduced calling activity of males during pairing (Schäffer 1995; Tyler, Green 1996) was mostly responsible for the undetected 34 %. Therefore, the results obtained by this method are underestimates rather than overestimates of population size and calling male density.

Volunteers were allowed to choose sample plots freely, which might lead to overestimates, because observers will always tend to count birds where they are, but not in places, where birds are absent. In the last three years (2002 - 2004) the number of surveyed plots increased substantially (Table 1), which might be another source of error. However, the majority of these plots were been initialy surveyed already in previous years. Most of the sample plots were established in 1996, when plots were chosen randomly (Keišs 1997) and survey in 17 of them was repeated in following years. Corncrake is still evenly distributed in the whole territory of Latvia (Repeated Latvian Breeding Bird Atlas 2000 - 2004, Ornithological Society of Latvia unpublished data) and observers were specially asked to include all available potential Corncrake habitats (all open agricultural lands) at the site in the survey plot. Therefore, it is doubtful that the choice of the study plots had a major bias on the obtained results.

Impact of agricultural land use on Corncrakes

Differences in the intensity of agriculture and recent changes in the political systems in Eastern Europe are having an effect on bird populations (Green, Rayment 1996; Donald et al. 2001; Auniņš et al. 2001). The rapid increase of agriculturally abandoned lands in Latvia in the 1990s seems to be the main reason for the increase of Corncrake numbers (Fig. 2; Fig. 3; Fig. 4). Pesticide use in Latvian farmlands has dropped considerably after 1990 (Anonymous 1999c) suggesting that generally the management of those agricultural lands still in use (meadows, pastures and even winter crops) has been under low management intensity during the 1990s, which allowed Corncrake numbers to increase. Müller and Illner (2001) showed that in Germany, Corncrakes can successfully reproduce in managed arable lands such as crop fields,which is probasbly true also in Latvia.

Auniņš and Priednieks (2005) observed that Corncrake has shown a tendency to decline in Latvia since 2000, but the methods (morning 5 min counts) applied by Auniņš and Priednieks (2005) were not designed to survey Corncrakes and their results might well be only artifacts. Although a decline of Corncrake population is expected in the future (Keišs 2003), the annual TRIM index (Fig. 2) shows that Corncrake numbers fluctuate, but have not decreased since 2000.

The observed increase of meadows until the end of the 1990s in the sample plots (Fig. 3) are in conflict with the decline tendency observed in Latvia in general (Appendix 1). This might be explained by a methodological error, caused by additional arable lands with grass vegetation and abandoned grasslands without any shrubs to the category "meadows". When shrubs become clearly visible, these habitats become "abandoned agricultural lands". Unfortunately, observers were not given specific instruction on when "abandoned agricultural land" should be counted as "shrubland". Therefore observers might have interpreted this category differently. It was not possible to find also any published definition on the term "shrubland" used in official land-use statistics. However, the total area of shrublands in the sample plots was small. Since Latvia's accession to European Union, many abandoned areas have been moved or even ploughed again in 2005, since EU funds became available for farmers. Consequently, the land use in

Latvia is again experiencing changes. It is most likely that these changes will not favour Corncrakes, since intensive farming methods are been introduced.

Due to many uncertainties associated with the calculation of Corncrake numbers in the past, the results shown (Fig. 6; Appendix 1) can be classified as a crude estimation. Although the calculations are very simple and speculative, since Corncrake surveys in the past in Latvia were not performed, the obtained results indicate that the recent population increase in Latvia has not compensated the losses experienced earlier (Fig. 6). The estimation illustrates only losses due to land-use changes, mainly due to decrease of the area of meadows (Appendix 1). Quality of habitats (e.g. meadows) might have also decreased since 1940 due to changes in mowing methods from hand-scythe and horse-drawn mower, which ensured slow and prolonged mowing late in the season. Therefore, the decline of the Corncrake population in Latvia in the past century might well have been larger than shown in Fig. 6.

This study showed a close positive correlation between amount of precipitation during the Corncrake breeding season (May - July) and the annual Corncrake index. The tendency to have higher Corncrake numbers in years with more rainfall has been observed also by Kiss (2004) in southern Hungary. Better food availability in wet years might be one of possible explanation for the observed tendency. Koffijberg and van Dijk (2001) hypothesized that the influx of Corncrakes in The Netherlands in 1998 was due to immigration from populations in Belarus and Russia, where large amounts of rainfall in 1998 resulted in high water tables, which prevented breeding in floodplain meadows. Such as immigration cannot be excluded also in Latvia, further investigation in Corncrake habitats during the breeding season is needed to confirm this.

International and standardized Corncrake monitoring has been started only recently (Schäffer, Mammen 2003), and therefore precise information on the population dynamics even in the past decade is scarce in most European countries. This case study provides useful insights into Corncrake population dynamics on the East-European scale.

Acknowledgements

The study was supported by the Royal Society for the Protection of Birds (United Kingdom) and Science Council of Latvia (doctoral grant Nr. 678). The European Social fund provided support during the preparation of the manuscript. Numerous volunteers are acknowledged for collecting Corncrake and habitat data. I am grateful to Skaidrīte Keiša and Anete Keiša for assistance on the analysis of field maps. I thank Aivars Mednis, Jānis Priednieks and Jānis Vīksne for advice and many helpful comments on earlier drafts of the manuscript. Baiba Strazdiņa technically prepared the map of Fig. 1.

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Lauksaimniecības zemes lietošanas izmaiņu ietekme uz griezes *Crex crex* populāciju Latvijā

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Kopsavilkums
Griežu un lauksaimniecības zemes izmantošanas monitoringu veica 68 brīvi izvēlētos parauglaukumos (0,67 - 44,38 km^2; vid. = 8,42; SD = 7,458) Latvijā no 1984. līdz 2004. gadam. Griežu kopskaita indekss novērojumu periodā būtiski pieauga ($p < 0,003$). Parauglaukumos novērojumu laikā pieauga atmatu platības indekss ($p < 0,0006$), bet kultivētu ganību ($p < 0,015$) un rušināmkultūru indekss samazinājās ($p < 0,07$). Gan kultivētu, gan nekultivētu pļavu platības indekss parauglaukumos pieauga līdz 1998. gadam ($p < 0,005$), bet pēc tam krasi samazinājās ($p < 0,025$). Griežu skaita indekss pozitīvi korelēja ar nekultivētu pļavu platības indeksu ($p < 0,001$), visu pļavu indeksu ($p < 0,001$), atmatu platības indeksu ($p < 0,0025$) un nekultivētu ganību platības indeksu ($p < 0,05$). Negatīvi griežu indeksu ietekmēja rušināmkultūru indekss ($p < 0,05$). Griežu indekss korelēja ar kopējo nokrišņu daudzumu griežu ligzdošanas sezonā: maijā, jūnijā un jūlijā ($p < 0,002$), kas norāda uz citu populāciju īpatņu iespējamu ieceļošanu Latvijā slapjās vasarās. Vislielākais griežu ligzdošanas blīvums (3,05 tēviņi uz km^2) bija neapsaimniekotās pļavās, tām dilstošā secībā seko nekultivētas pļavas (2,85) > aramzeme atmatā (2,70) > kultivētas pļavas (1,68) > citi biotopi (1,60) > nekultivētas ganības (1,56) > krūmāji (1,27) > ziemāji (1,25) > kultivētas ganības (0,81) > vasarāji (0,69) > rušināmkultūras (0,12). Analizējot 3300 griežu reģistrācijas dažādos biotopos, neapsaimniekotās pļavās, nekultivētās pļavās un atmatā atstātās aramzemēs tika novērots ievērojami vairāk griežu, nekā sagaidāms ($p < 0,001$), bet griežu bija ievērojami mazāk ziemājos, kultivētās pļavās, vasarājos un rušināmkultūrās ($p < 0,001$). Neskatoties uz pašreizējo griežu skaita pieaugumu Latvijā, ilgtermņa populācijas dinamika kopš 1940. gada parāda būtisku skaita samazināšanos ($p < 0,0001$) piemēroto biotopu (pļavu) platības samazināšanās dēļ.

Appendix 1. Corncrake population density and statistical data on agricultural land use (thousands of hectares) used for calculations of Corncrake numbers 1940–2004 (statistical data compiled from Anonymous 1959; 1967; 1976; 1986; 1991; 1993; 1994; 1996; 1997a; 1997b; 1999a; 1999b; 2000a; 2000b; 2000c; 2001; 2002; 2003a; 2003b; 2004a; 2004b); n.a. – data were not available; * – the value is most likely 0; values in bold are used for calculations; values in parentheses are calculated assuming gradual change between two closest available values.

Appendix 1. *Continued*

Land use		Years														
		CD	1940	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
1	Sown perennial grasslands	1.68	520.2	282.2	318.5	333.1	410.8	380.8	376.6	364.1	479.9	491.3	521.5	504.7	532.4	494.4
2	Meadows	1.88	915.8	905.9	904.2	897.8	884.9	865.5	694.8	684.6	691.1	691.1	697.6	706.5	723.4	742.8
3	Pastures	0.89	600.5	423.8	419.8	419.8	394.0	394.0	437.1	394.0	387.5	381.1	374.6	362.4	342.3	297.1
4	Meadows and pastures	1.38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
5	Winter crops in total	1.25	362.2	257.0	235.0	269.3	234.7	264.0	221.4	281.8	265.7	213.6	270.7	249.0	276.0	280.0
5.1	*Winter rye*	n.a.	291.9	227.8	202.0	221.0	189.0	203.3	176.8	216.8	212.1	178.1	220.1	220.0	240.0	227.0
5.2	*Winter wheat*	n.a.	70.3	29.2	33.0	48.3	45.7	60.7	44.6	65.0	53.6	35.3	50.6	29.0	36.0	53.0
5.3	*Winter barley*	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n.a.	n.a.	n.a.	n.a.
5.4	*Triticale*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
6	Spring crops in total	0.69	730.2	518.9	525.0	556.2	588.2	570.0	370.6	322.6	284.3	295.6	275.8	301.0	329.0	265.0
6.1	*Spring wheat*	n.a.	87.6	105.1	127.4	131.7	179.0	145.0	99.2	98.3	54.8	56.2	38.2	34.0	34.0	28.0
6.2	*Spring rye*	n.a.	3.0	1.0	0.8	0.9	1.2	1.0	0.4	0.2	0.2	0.1	n.a.*	n.a.*	n.a.*	n.a.*
6.3	*Spring barley*	n.a.	169.9	110.8	121.1	138.8	199.0	164.5	93.0	62.8	63.4	78.5	72.7	84.0	102.0	114.0
6.4	*Oats*	n.a.	387.1	213.5	203.0	212.6	156.8	207.2	129.6	111.0	114.6	102.3	103.9	102.0	54.0	31.0
6.5	*Mixed crops*	n.a.	n.a.	42.3	35.7	40.0	38.4	39.0	37.1	40.4	39.7	45.3	47.0	59.0	96.0	71.0
6.6	*Mixed crops and legumes*	n.a.	82.6	46.2	37.0	32.2	13.8	13.3	11.3	9.9	11.6	13.2	14.0	22.0	43.0	21.0
6.7	*Buckwheat*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7	Intertilled crops (other arable land) in total	0.12	303.9	277.6	295.5	316.3	279.2	297.8	380.9	363.4	332.9	327.0	329.7	372.9	372.0	425.2
7.1	*Legumes*	n.a.	35.5	24.4	20.1	20.2	8.5	16.4	15.9	15.0	10.1	8.8	9.0	14.0	28.0	14.0
7.2	*Oil flax*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.3	*Long-fibred flax*	n.a.	58.6	42.6	50.3	55.0	31.6	35.3	45.6	49.9	42.7	32.8	28.9	30.2	29.5	29.1
7.4	*Sugar beets*	n.a.	14.9	17.2	17.5	18.3	20.2	20.9	18.9	18.0	17.5	18.9	19.2	19.8	20.5	19.0
7.5	*Potatoes*	n.a.	138.7	149.1	150.6	155.4	149.8	149.0	142.2	142.6	151.7	152.6	159.8	159.8	154.2	142.8
7.6	*Vegetables*	n.a.	9.1	15.8	20.9	21.4	20.9	21.9	20.5	22.7	23.5	20.1	18.8	16.1	14.8	15.3
7.7	*Fodder roots*	n.a.	47.1	21.4	24.0	25.3	25.5	25.5	21.6	24.7	19.2	24.3	24.0	22.0	24.0	44.0
7.8	*Fodder sugar beets*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.9	*Fodder cabbage*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.10	*Green crops and ensilage excl. maize*	n.a.	n.a.	7.1	12.1	20.7	22.7	28.8	6.7	24.5	39.4	49.7	43.0	50.0	12.0	50.0
7.11	*Maize*	n.a.	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	48.5	35.8	18.8	13.9	27.0	62.0	89.0	111.0
7.12	*Green manure cultures*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	61.0	30.2	10.0	5.9	n.a.	n.a.	n.a.	n.a.
7.13	*Nectar cultures*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8	All abandoned agriculture lands	2.87	n.a.*	251.2	239.0	213.1	219.6	213.1	315.4	290.6	284.2	258.4	251.9	230.8	219.6	226.1
9	Shrubland	1.27	n.a.*	294.3	297.1	297.1	290.7	297.1	248.1	235.6	229.2	229.2	222.7	212.7	196.9	190.4

Appendix 1. *Continued*

Land use	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	475.0	435.3	511.2	469.7	467.0	482.0	502.9	597.4	602.8	633.9	662.6	657.2	664.1	524.0	525.0	531.0	527.0	523.5	555.3	569.7	582.5
2	788.0	794.4	745.2	737.3	704.0	484.4	484.4	469.9	258.4	258.4	264.8	258.4	229.8	229.4	228.0	228.2	214.3	231.8	235.4	238.1	238.9
3	322.9	316.5	278.3	428.0	490.9	755.7	762.2	752.8	943.0	943.0	936.5	955.9	628.0	610.2	599.2	596.8	614.3	599.6	598.5	595.6	596.2
4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
5	199.0	346.0	360.0	231.0	256.0	257.0	216.0	183.6	193.0	196.0	208.0	186.0	189.2	229.0	174.0	213.0	77.0	193.9	158.0	181.0	240.0
5.1	161.0	278.0	277.3	183.0	196.0	189.0	141.0	108.8	111.0	120.0	129.0	99.0	105.2	123.0	80.0	111.0	53.0	111.1	90.0	n.a.	n.a.
5.2	38.0	68.0	80.6	48.0	60.0	68.0	75.0	74.8	82.0	76.0	79.0	87.0	84.0	106.0	94.0	102.0	24.0	82.8	68.0	n.a.	n.a.
5.3	n.a.	n.a.	2.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
5.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
6	409.0	294.0	244.1	301.0	309.0	296.0	357.0	383.0	411.0	375.0	399.0	434.0	449.8	467.0	542.0	522.0	580.0	493.9	523.0	531.0	480.0
6.1	48.0	33.0	25.8	23.0	21.0	13.0	5.0	2.2	1.0	1.0	0.0	0.0	0.3	0.0	0.0	n.a.	n.a.	0.2	n.a.	n.a.	n.a.
6.2	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*
6.3	179.0	128.0	119.6	156.0	166.0	179.0	245.0	278.3	294.0	269.0	291.0	313.0	322.8	356.0	415.0	404.0	490.0	396.7	396.0	n.a.	n.a.
6.4	45.0	48.0	50.7	68.0	84.0	104.0	91.0	88.9	104.0	93.0	95.0	107.0	113.5	97.0	111.0	104.0	78.0	81.7	90.0	n.a.	n.a.
6.5	109.0	66.0	47.5	54.0	38.0	n.a.	16.0	13.6	12.0	12.0	13.0	14.0	13.2	14.0	16.0	14.0	12.0	15.3	28.0	n.a.	n.a.
6.6	28.0	19.0	0.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
6.7	n.a.	n.a.	0.2	n.a.	n.a.	n.a.	n.a.	0.0	n.a.	n.a.	n.a.	n.a.	0.0	n.a.	n.a.	n.a.	n.a.	0.0	n.a.	n.a.	n.a.
7	381.3	362.9	393.2	372.4	351.6	350.9	304.3	329.7	304.3	340.3	317.0	328.9	302.5	292.0	292.0	286.0	334.0	318.1	289.6	144.9	144.8
7.1	19.0	11.0	19.7	17.0	12.0	9.0	6.0	6.2	6.0	8.0	8.0	6.0	6.1	7.0	9.0	5.0	4.0	4.1	9.0	n.a.	n.a.
7.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.3	27.0	26.6	24.7	23.3	23.0	22.9	21.9	18.9	18.9	18.9	18.9	18.9	18.9	19.0	18.0	18.0	18.0	17.8	15.0	14.6	14.4
7.4	26.1	22.5	22.4	22.0	22.3	17.2	9.8	9.8	9.6	9.4	9.5	9.6	9.6	11.0	12.0	11.0	13.0	13.0	12.7	13.1	13.5
7.5	135.6	131.1	140.6	137.6	135.9	135.4	132.0	130.7	119.4	119.4	119.8	120.6	120.2	107.0	108.0	107.0	107.0	105.9	103.7	102.6	102.2
7.6	15.6	14.7	14.5	14.5	14.4	14.4	14.6	15.0	12.4	12.6	12.8	12.8	12.8	11.0	11.0	14.0	15.0	15.3	15.2	14.6	14.7
7.7	34.0	34.0	26.1	34.0	33.0	35.0	32.0	27.9	34.0	36.0	39.0	39.0	39.1	41.0	40.0	38.0	39.0	38.6	36.0	n.a.	n.a.
7.8	n.a.	n.a.	10.9	n.a.	n.a.	n.a.	n.a.	3.9	n.a.	n.a.	n.a.	n.a.	0.1	n.a.	n.a.	n.a.	n.a.	0.6	n.a.	n.a.	n.a.
7.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.10	22.0	46.0	73.2	79.0	65.0	75.0	54.0	74.7	54.0	85.0	52.0	59.0	35.0	31.0	38.0	44.0	96.0	77.5	47.0	n.a.	n.a.
7.11	102.0	77.0	61.1	45.0	46.0	42.0	34.0	42.6	50.0	51.0	57.0	63.0	60.7	65.0	56.0	49.0	42.0	45.3	51.0	n.a.	n.a.
7.12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8	148.6	135.6	129.3	119.7	90.4	45.2	38.8	41.2	25.8	25.8	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	171.1	164.6	187.5	185.5	184.0	177.5	177.5	176.4	190.4	184.0	177.5	164.6	190.8	189.9	180.2	173.7	167.4	164.7	157.2	148.8	144.6

Appendix 1. *Continued*

Land use	Years																			
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1	591.3	595.1	604.1	608.3	624.5	634.7	655.9	861.6	598.6	536.0	540.6	374.7	398.4	389.7	392.7	383.1	347.2	344.3	335.1	282.9
2	241.0	240.0	238.3	239.0	246.3	248.6	245.8	246.3	n.a.	n.a.	n.a.	n.a.	246.0	n.a.	238.6	211.8	n.a.	217.2	n.a.	n.a.
3	597.6	598.6	599.3	596.6	599.7	599.1	598.0	597.0	n.a.	n.a.	n.a.	n.a.	479.1	n.a.	379.1	346.6	n.a.	246.4	n.a.	n.a.
4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1423.7	1339.4	1341.1	1172.8	n.a.	1067.6	n.a.	n.a.	958.5	n.a.	948.2	811.5
5	238.0	195.0	204.4	184.8	206.1	246.6	272.8	142.7	261.2	352.4	141.1	136.0	177.5	180.8	179.7	152.8	182.4	206.4	178.5	194.6
5.1	n.a.	100.7	107.3	82.1	101.2	128.7	130.7	69.2	131.4	187.6	62.7	40.4	56.4	62.5	57.7	47.2	54.8	55.8	42.3	44.2
5.2	n.a.	94.3	97.0	102.4	104.7	117.8	140.7	69.8	123.1	153.0	72.9	85.5	117.4	109.7	109.2	95.2	117.4	131.3	115.9	127.9
5.3	n.a.	n.a.	0.1	0.3	0.2	0.1	1.4	1.1	3.4	5.0	2.4	7.4	2.0	5.8	7.5	4.6	4.3	6.3	4.8	3.4
5.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.6	3.3	6.8	3.1	2.7	1.7	2.8	5.3	5.8	5.9	13.0	15.5	19.1
6	515.0	495.8	495.2	484.6	429.2	419.3	402.6	505.6	435.5	341.2	345.2	272.4	268.7	302.0	282.6	263.0	237.6	237.3	236.5	233.9
6.1	n.a.	0.6	0.5	0.7	0.2	0.2	0.8	1.7	5.5	16.1	21.7	24.1	31.8	42.6	41.7	51.0	40.7	35.5	37.6	39.9
6.2	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*
6.3	n.a.	396.9	408.1	402.0	352.5	331.6	306.6	397.4	347.0	270.3	264.1	195.9	176.4	188.7	165.9	142.7	130.6	124.0	132.1	129.2
6.4	n.a.	91.6	77.1	67.3	65.5	75.6	82.4	92.7	69.4	48.5	54.0	45.6	53.6	59.1	59.7	47.2	45.5	55.2	47.1	49.4
6.5	n.a.	6.7	9.5	14.6	11.0	11.9	12.7	13.7	13.5	6.2	5.3	6.8	6.8	11.0	13.6	7.9	5.3	4.1	3.4	2.9
6.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	11.9	9.3	7.9	5.8	6.0
6.7	n.a.	0.0	0.0	n.a.	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.6	1.7	2.3	6.2	10.6	10.5	6.5
7	144.6	279.3	269.4	270.6	270.0	237.5	221.5	291.1	274.5	192.7	164.5	145.2	139.7	129.1	122.4	106.3	105.3	112.4	107.7	113.4
7.1	n.a.	36.6	36.6	27.2	20.4	14.6	10.5	9.0	6.7	2.8	2.8	3.0	3.6	4.7	6.8	2.5	2.1	3.2	2.5	2.9
7.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.3	0.4	0.1	0.1
7.3	14.5	14.3	13.7	13.2	12.9	12.7	11.9	8.8	7.6	0.6	1.5	1.4	1.3	1.6	2.2	2.0	1.6	1.4	2.1	2.1
7.4	13.7	13.5	13.5	13.6	13.6	13.5	14.7	14.6	24.8	12.1	12.0	9.5	10.0	10.9	16.3	15.5	12.7	14.1	15.9	14.4
7.5	101.6	94.3	91.9	90.3	87.6	84.7	80.3	82.2	96.9	87.7	80.4	75.3	78.7	69.6	58.8	50.1	51.3	55.1	53.6	54.6
7.6	14.8	12.1	12.1	12.2	12.2	11.0	10.8	12.7	19.1	18.6	17.5	17.5	15.7	13.5	11.6	9.8	9.7	13.3	12.5	14.3
7.7	n.a.	33.4	34.1	35.3	35.1	35.6	36.2	39.1	36.5	29.6	26.2	19.8	17.3	14.9	13.1	9.1	9.0	9.6	7.5	7.1
7.8	n.a.	0.5	0.4	0.6	0.6	0.5	0.8	0.3	0.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.4	0.7	0.5	0.3	0.3	0.2	0.3	0.1	n.a.	n.a.	0.0	0.1
7.10	n.a.	26.4	19.3	29.3	40.8	18.7	11.5	84.9	56.7	31.4	20.9	17.8	11.6	13.2	12.8	12.0	11.4	8.4	7.2	9.9
7.11	n.a.	48.2	47.8	48.9	46.8	46.2	44.8	39.5	24.8	9.2	2.7	0.6	1.2	0.5	0.5	0.7	1.2	1.0	1.2	1.7
7.12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4.5	6.0	4.7	4.1	4.8
7.13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.2	1.0	1.4
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	(169.2)	(233.8)	279.0	390.0	402.0	361.8	434.0	(410.6)	(387.2)	(363.8)	340.4
9	140.6	143.7	(137.7)	(131.8)	125.8	124.5	112.1	111.7	(114.9)	(118.0)	(121.2)	124.3	131.9	144.3	144.2	149.2	(154.2)	(159.2)	(164.2)	(169.2)