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DAIVA VAITKUVIENE

MINDAUGAS DAGYS

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Two-fold increase in White Stork (*Ciconia ciconia*) population in Lithuania: a consequence of changing agriculture?

Daiva VAITKUVIENĖ*, Mindaugas DAGYS
Nature Research Centre, Vilnius, Lithuania

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Abstract: A countrywide White Stork (*Ciconia ciconia*) nest census was carried out in Lithuania in 2009 and 2010 by over 20 observers using standardised equipment and methods. The census revealed that the White Stork population has doubled since the previous census in 1994, possibly due to favourable changes in farming practices, with birds increasingly settling on the overhead electricity line poles and gradually abandoning nests in trees. In total, 21,192 White Stork nests were recorded, of which 18,782 (81.4%) were occupied by breeding birds, compared to 9400 occupied nests recorded in 1994. The mean density of occupied nests in the country was 29 nests/100 km^2. Electricity line poles were the most common nest sites (49% of all nests), followed by trees (21%) and specially erected poles with nesting platforms (11%). Mean breeding success of White Storks was rather high, with 2.7 young raised per successful pair, suggesting a favourable conservation status for this species in Lithuania.

Key words: White Stork, nest census, nest site, nest density, breeding success

1. Introduction

White Stork (*Ciconia ciconia*) is a typical species of agricultural landscapes and is often considered a good indicator of sustainable and ecofriendly agriculture (Tryjanowski et al., 2005; Chernetsov et al., 2006; Sæther et al., 2006; Kosicki and Indykiewicz, 2011; Kosicki, 2012).

In the early 2000s, the European White Stork breeding population was estimated at 180,000–220,000 breeding pairs, of which Lithuania held 6%–7% (BirdLife International, 2004). Lithuania is located in the north-western part of the species' breeding range. This species is widespread across the entire territory of Lithuania. Systematic information on White Stork population size in Lithuania has been available since 1958, when the first White Stork census was carried out in the country. Almost 9000 breeding pairs were registered during the first census (Kisielius, 1974), followed by a gradual decline until a dramatic decrease down to just over 4000 pairs was registered in 1984 (Kazlauskas and Paltanavičius, 1985; but also see Ivanauskas et al., 1997). This decrease coincided with a Europe-wide decrease in the White Stork population in the 1980s (Schulz, 1999; Daniluk et al., 2006; Ots, 2009; Denac, 2010). A number of factors have been found to affect the population size of White Storks both on their breeding grounds and during migration and wintering: wetland drainage, intensification of agriculture, hunting, weather conditions, and increased feeding by White Storks in rubbish dumps (Kanyamibwa et al., 1993; Blanco, 1996; Barbraud et al., 1999; Tortosa et al., 2002; van den Bossche et al., 2002; Berthold et al., 2006; Higuchi et al., 2006; Kruszyk and Ciach, 2010). Electrocution on power lines is another factor affecting White Storks, particularly immature birds, both on breeding grounds and during migration (Bevanger, 1998; Janss, 2000; Garrido and Fernandez-Cruz, 2003; Schaub et al., 2004; Martin and Shaw, 2010; Kaluga et al., 2011). In Lithuania, large-scale monoculture practices in agriculture, coupled with intensive drainage of wetlands, may have contributed to the decline of the White Stork population before 1990 (Aleknavičius, 2007; Poviliūnas, 2007; Ribokas and Milius, 2008). Subsequently, the White Stork population in Lithuania rapidly recovered, reaching 9400 occupied nests in 1994 (Malinauskas and Vaitkus, 1995). Again, changes in agricultural practices after 1990 (Poviliūnas, 2007; Ribokas and Milius, 2008) were the likely driving forces behind these changes, since land-use regime is known to influence the demographics of White Stork populations (Tryjanowski and Kuźniak, 2002; Tryjanowski et al., 2005; Radović and Tepić, 2009). Furthermore, different changes in agriculture may have different and even opposing consequences for farmland birds (Tryjanowski et al., 2011).

* Correspondence: daiva@ekoi.lt

The aim of the present paper is to present the results of a countrywide White Stork nest survey, which was carried out in Lithuania during the EU LIFE+ project "White Stork (*Ciconia ciconia*) conservation in Lithuania" in 2009 and 2010, and to assess changes that have taken place since the last countrywide nest survey in 1994.

2. Materials and methods

The White Stork census in Lithuania was carried out in 2009 and 2010. It covered the entire terrestrial part of the country (65,281 km^2). The terrain of the country is rather even, with hilly uplands not exceeding 300 m above sea level, in the eastern–south-eastern and western parts of the country. Agricultural areas predominate in the country; 61% of the land surface is classified as such under the CORINE Land Cover (CLC) classification (Heymann et al., 1994). Forests and other natural areas cover another 32.3%, artificial surfaces (mostly built-up areas, roads, etc.) make up 3.3%, water covers 2.5%, and marshes account for 0.9%.

White Storks usually nest in proximity to human settlements; their nests are large conspicuous structures visible from a distance (Ptaszyk et al., 2003; Daniluk et al., 2006; Kosicki and Kuźniak, 2006; Gordo et al., 2007; Onmuş et al., 2012). The census was carried out by over 20 observers, who were specifically trained in the survey methodology and outfitted with identical equipment and other material (survey maps, nest registration cards). Nests were searched for while driving in all potential White Stork nesting habitats: various agricultural areas, homesteads, villages, settlements, and even suburbs of larger towns or abandoned and active farms. Single trees and tree groups, power lines, and water towers in agricultural landscapes were examined in detail as common White Stork nest sites. Areas to be surveyed were preliminarily identified using the 2006 CLC database for Lithuania (Heymann et al., 1994). Detailed topographic maps (scale 1:50,000) were used during the survey. Survey tracks were constantly recorded using GPS receivers (Magellan Triton 400) and were used for the assessment of area coverage and for planning further survey routes. Binoculars (8× and 10× magnification) were used during the survey.

Locations of White Stork nests were recorded with GPS receivers (GPS accuracy: 3–5 m). If it was not possible to approach a nest within 10 m, the distance (m) and direction (°) to the nest from the recorded location were also noted. All recorded nests were photographed both close-up and with their surroundings. These photographs, along with the aforementioned information on distance and direction to the nest from a GPS fixed position, were later used to improve the accuracy of White Stork nest locations on a detailed orthophoto background (Digital Raster Orthophoto Map M 1:10,000 of the Republic of Lithuania, 2009–2010, © National Land Service under the Ministry of Agriculture of the Republic of Lithuania) in a GIS environment.

Detailed information was collected about each recorded White Stork nest. Nest sites were classified as follows: tree (including tree species), building (including location on the building), pole (electricity, communication, special, etc.), water tower, other. In the case of nests located on power poles, information on whether or not these poles were in use was also recorded. It was also recorded whether a nest was built on a special manmade platform or not.

Distribution of White Stork nests in different land-cover types was assessed according to the CLC level 3 classification (Heymann et al., 1994). White Stork nest density was calculated for each of the 31 CLC classes present in Lithuania (Heymann et al., 1994; Vaitkus and Vaitkuvienė, 2005). Furthermore, CLC classes where White Stork nest density exceeded 5 nests/100 km^2 were classified as potentially suitable nesting habitats for the White Stork. Thus, all agricultural areas, sparsely built-up areas, and open natural areas were classified as such.

Breeding success of White Storks reported in this paper represents the average number of young fledged per successful nest (Tryjanowski et al., 2005; Vergara et al., 2007) and is based on a sample of successful nests recorded during the period of 1–20 July 2010, when the number of young was reliably recorded. During this period, young were at least approximately 6 weeks of age and were likely to fledge successfully (Onmuş et al., 2012). The number of young was recorded from the ground, preferably from a more elevated vantage point, with the help of binoculars or a spotting scope (20–60× magnification). Standard notation was used for the description of the reproductive parameters of White Storks (e.g., see Nowakowski, 2003): HPm – successful nests, i.e. nests with 1 or more grown-up young; JZG – number of nestlings in all nests; JZm – average number of grown-up young in HPm-type nests.

Spatial data handling and analysis was carried out in ArcGIS 10.0 (ESRI, 2011) while Statistica 6.0 was used for basic statistics (StatSoft, 2001).

3. Results

3.1. Abundance and distribution

A total of 21,192 White Stork nests were recorded during the survey, of which 18,782 (88.6%) were occupied by birds. Furthermore, 1531 nests (7.2% of all recorded nests or 8.2% of all occupied nests) were occupied by birds that did not attempt to breed. Thus, breeding birds occupied 81.4% of all recorded nests. The overall White Stork nest density was 32 nests/100 km^2 of the total area of the country, while the density of occupied nests was 29 nests/100 km^2.

Almost half of the recorded nests (44%) were located in areas with complex cultivation patterns (CLC class

242, representing small-scale agricultural areas with small villages and homesteads), while half (49%) were in only 3 other land-cover classes: discontinuous urban fabric (17%, CLC class 112, representing larger villages, settlements, and sparsely built-up suburbs), nonirrigated arable land (16%, CLC class 211, representing areas with more intensive agriculture), and land principally occupied by agriculture, with significant areas of natural vegetation (16%, CLC class 243, which is similar to CLC class 242 but intermixed with areas of natural vegetation).

Overall, 64.4% of the country's territory was classified as potentially suitable habitat for White Storks, with 98% of all registered nests located within it. The highest nest density was recorded in CLC class 112, with 249 nests/100 km^2, followed by CLC classes 242 (115 nests/100 km^2), 121 (91 nests/100 km^2), and 243 (67 nests/100 km^2). The average density of occupied White Stork nests in the potentially suitable habitat in Lithuania was 45 nests/100 km^2.

The highest densities of occupied nests were recorded in western and south-western Lithuania, where they exceeded 80 nests/100 km^2, with up to 160 nests/100 km^2 in some areas (Figure 1). High densities of nests (60–80 nests/100 km^2) were also recorded in north-eastern Lithuania. The lowest densities of occupied White Stork nests were recorded in central and northern Lithuania, characterised by more intensive agriculture, where nest density did not exceed 40 nests/100 km^2, as well as in forested eastern and south-eastern Lithuania (Figure 1).

Eight White Stork colonies, each comprising 10–22 breeding pairs, were recorded during this study. Most of the colonies were located in western Lithuania, with 4 of them within a distance of 25 km from each other (Figure 1).

The mean distance (mean ± SE) of White Stork nests from the nearest building was 35.6 ± 0.45 m, with median distance of 18.4 m and interquartile range of 30.1 m. Almost 95% of all registered nests were located less than 100 m away from a building (Figure 2). Only 78 nests, i.e. less than 0.5%, were located more than 500 m from the nearest building. The greatest distance recorded was 1700 m.

The mean distance (mean ± SE) between each nest and the nearest White Stork nest was 650.2 ± 3.72 m, median distance = 524.9 m, interquartile range = 674.0 m. Overall, the neighbouring White Stork nest was located more than 1000 m away in only 20% of cases (Figure 3). The greatest distance recorded between neighbouring White Stork nests was 7600 m. Particularly great distances between neighbouring nests were characteristic of nests located in villages surrounded by large forest expanses.

3.2. Nest placement

The majority (61%) of all recorded White Stork nests were located on various poles. Nests on overhead electricity line poles accounted for 49% of the total; 11% were on specially erected poles with nesting platforms, whereas only 1% of nests were on communication line poles, which were not in use any longer. Nests in trees accounted for 21% of all

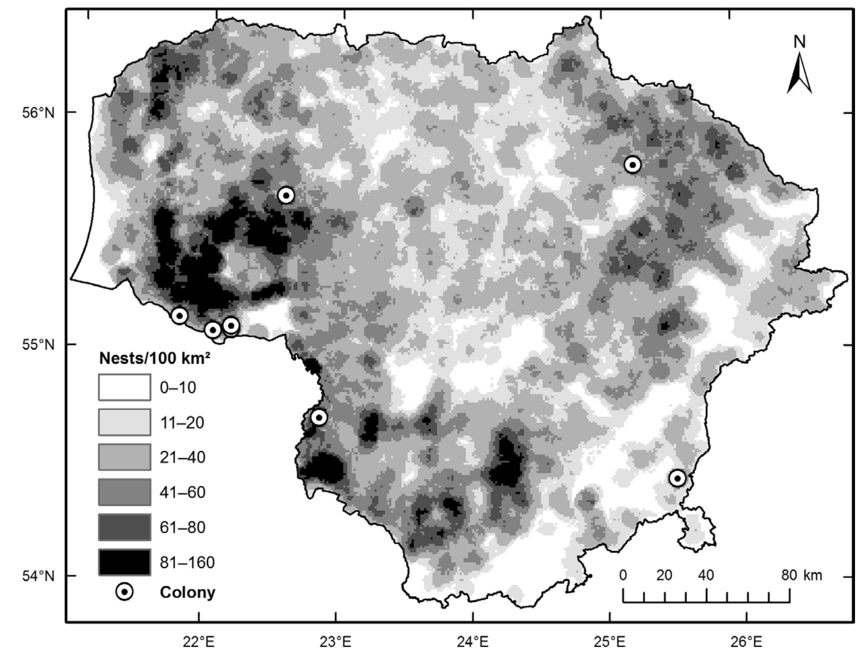

Figure 1. Distribution of densities of occupied White Stork nests and colonies in Lithuania.

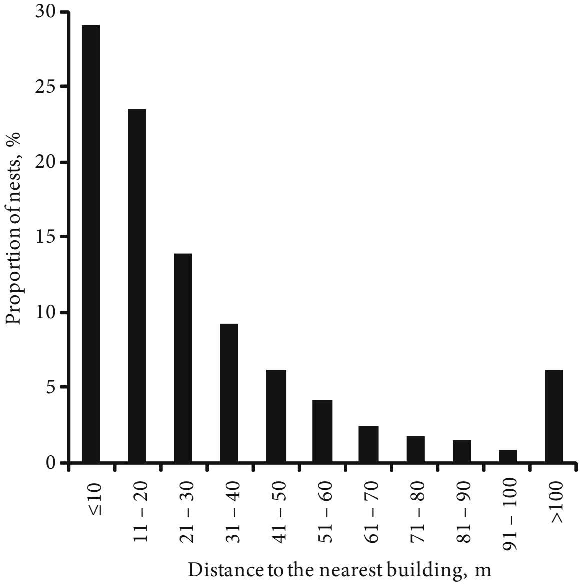

Figure 2. Distance from recorded White Stork nests to the nearest building.

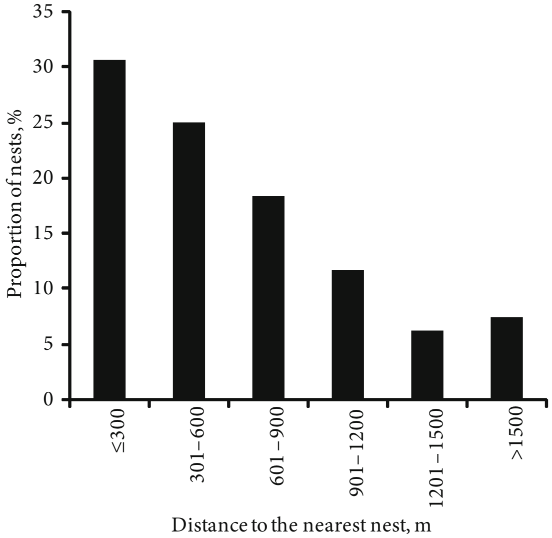

Figure 3. Distance from recorded White Stork nests to the nearest neighbouring nest.

nests, 9% of nests were on water towers, 9% were on various buildings, and only 1% were in various other locations.

White Stork nests were found in 22 different tree species, with oak (*Quercus*), lime (*Tilia*), and ash (*Fraxinus*) being the most common ones (18.5%, 18.5%, and 13.2% of all nests in trees, respectively; Figure 4). Overall, 90% of nests in trees were located in deciduous trees, while only 10% were in coniferous trees, in pine (*Pinus*) and spruce (*Picea*) equally. Interestingly, all 8 White Stork colonies recorded during the study were established in trees. Furthermore, 4 closely spaced colonies in western Lithuania were established in coniferous trees, namely pine, while in all other colonies the nests were located in deciduous trees: poplar (*Populus*), oak, and lime.

White Storks often breed on artificial nesting platforms that are installed specifically for this species. Overall, just over half (51.7%) of all registered nests were built on artificial nesting platforms. The proportion of nests on artificial nesting platforms differed among nest sites. The majority of nests on specially installed poles, in trees, and on buildings were built on nesting platforms: 89.3%, 71.9%, and 62.4%, respectively (Figure 5). On the contrary, nests on water towers and in various unusual locations were almost exclusively not built on nesting platforms: 99.5% and 92.1%, respectively (Figure 5).

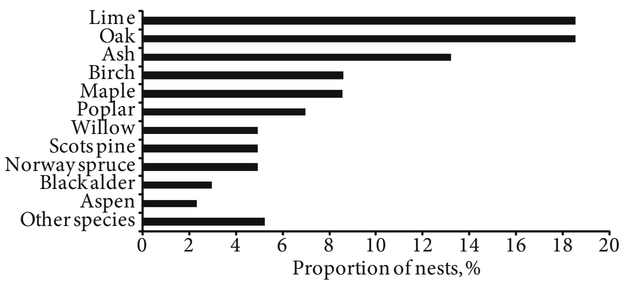

Figure 4. Proportion of White Stork nests built in different tree species (% of all nests in trees).

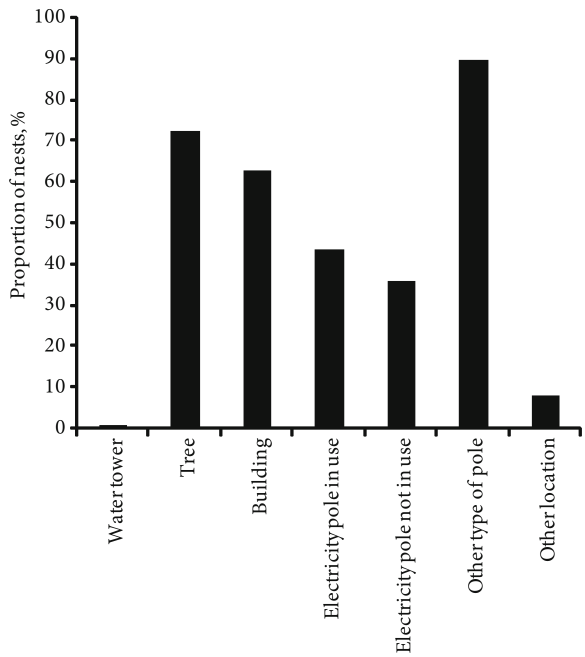

Figure 5. Proportion of White Stork nests built on artificial nesting platforms in different nest sites.

3.3. Breeding parameters

Breeding success was recorded in 3603 successful nests (HPm), which were visited during the period of 1–20 July 2010. In total, 9674 young (JZG) were raised in these nests, with average breeding success of 2.68 ± 0.89 young per successful pair (JZm ± SD). The number of young per successful pair ranged between 1 and 5, with 3 and 2 being the most common, accounting for 73% of all successful nests, while 5 young were registered in 44 nests only (Figure 6).

3.4. Changes between 1994 and 2010

In 1994, 11,204 White Stork nests were registered, of which 9400 (82%) were occupied (1994 data from Malinauskas and Vaitkus, 1995). Thus, compared to the 18,782 occupied nests recorded during the present study, the population of White Storks in Lithuania has approximately doubled during the last 16 years. Breeding nest density has also increased accordingly, from 17 to 29 occupied nests/100 km^2.

Distances between the neighbouring nests had decreased: in 2010, 79% of nests were located less than 1 km from the nearest nest, compared to 59% in 1994. Furthermore, this change was primarily due to the increase in nests located less than 0.5 km from the neighbouring nest (47% and 28% of all nests in 2010 and 1994, respectively), whereas the proportion of nests located 0.5–1 km from the nearest nest remained unchanged at 32% (1994 data from Malinauskas and Vaitkus, 1995).

Particularly prominent and significant changes over the 16-year period took place in the location of White Stork nests. There was a steep increase in the proportion of nests built on overhead electricity line poles, from 13% in 1994 to 49% in 2010. The opposite was true for nests built in trees; their share decreased from 52% in 1994 to 21% in 2010 (chi-square test, $\chi^2 = 5211.6$, df = 5, $P < 0.0001$; 1994 data from Malinauskas and Vaitkus, 1995).

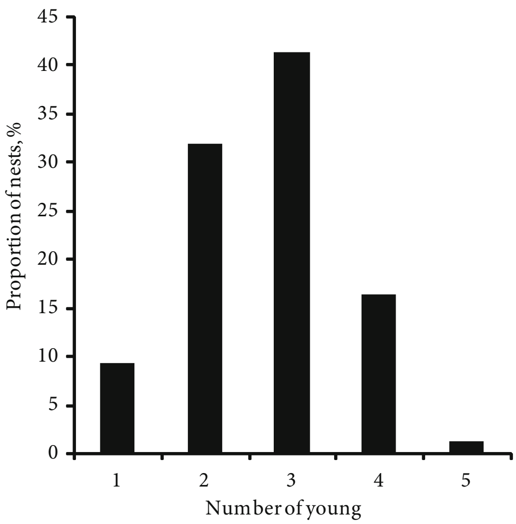

Figure 6. Number of young in successful White Stork nests.

The mean breeding success of White Storks in Lithuania in 2010 was 2.7 young per successful pair (JZm). This was very similar to the value recorded in 1994: 2.6 young per successful White Stork pair (Malinauskas and Vaitkus, 1995).

4. Discussion

Between 1994 and 2010, the population of White Storks in Lithuania doubled in size from 9400 registered occupied nests (Malinauskas and Vaitkus, 1995) to 18,800 registered occupied nests.

Such a prominent increase in the White Stork population size may be related to radical changes in farming practices that have taken place in Lithuania since the early 1990s. The breakup of large, intensively managed collective farms and subsequent land privatisation has resulted in a dramatic decrease in farming intensity, fragmentation of large monoculture fields, and complete land abandonment. Abandoned agricultural land constituted 26% of all the land used for agriculture until 1990. In some regions of the country, up to 60% of agricultural land was abandoned, while areas covered by meadows have almost doubled (Ribokas and Milius, 2008; Aleknavičius and Aleknavičius, 2010). Similar processes have occurred in some other post-Soviet countries, where collective agriculture was practiced under the socialist economic system (Tryjanowski et al., 2011). As a result of natural succession, permanent grasslands have gradually developed in such abandoned areas, which are only occasionally used for extensive grazing and small-scale farming (Ribokas and Milius, 2008). This has resulted in the formation of favourable breeding and feeding conditions for the White Stork in previously less suitable areas. The average size of farms has also decreased considerably since 1990 in Lithuania, for example from 17.9 ha in 1991 to 5.8 ha in 2001 (Poviliūnas, 2007), a change that has been beneficial to farmland birds including the White Stork (Nagy et al., 2009). Furthermore, less intensive farming has also been associated with the decrease in the use of fertilisers and other farming chemicals (e.g., insecticides), deterioration of land-drainage installations, and subsequent recovery of small wetlands, which are of particular importance for White Storks (Higuchi et al., 2006; Lourenço and Piersma, 2009; Janiszewski et al., 2013).

Other factors, such as species range shift (possibly facilitated by global climate change), or environmental conditions on wintering grounds, may have also contributed to the changes in the White Stork population size (Berthold et al., 2002; Tryjanowski et al., 2004; Schaub et al., 2005). Eastward range expansion, accompanied by an increase in breeding numbers, has been recorded in some countries on the north-eastern and eastern periphery of the White Stork distribution range, i.e., Estonia, Russia, and Ukraine (Ots, 2009; Galchyonkov, 2013; Grishchenko, 2013), which is in line with the climate change effects on this species stipulated by Žalakevičius (2007). However, the species' range shift alone is very unlikely to be responsible for the observed major increase in the Lithuanian White Stork population, since the country is located in the core area of the species' distribution range with some of the highest breeding densities across the entire range (BirdLife International, 2004). Furthermore, an increase in the White Stork population in the 1990s and the early 2000s was recorded in all parts of its range, with a particularly pronounced increase in the western and southern parts (Thomsen, 2013).

Particularly significant changes have taken place in the location of White Stork nests during the last 16 years. Although the proportion of nests on overhead electricity line poles has increased more than 3-fold while that in trees has more than halved during this period, changes in proportions of nests alone do not reveal the real situation. Comparison of the actual numbers of nests built in different locations reveals that there was a more than 7-fold increase in the number of nests on electricity poles during the 16-year period (from 1436 to 10,654 in 1994 and 2010, respectively), while the number of nests in trees has decreased by less than 25% (from 5928 to 4531) (Malinauskas and Vaitkus, 1995). This suggests that the increasing population of White Storks to a great extent settled in new nest sites: on overhead electricity line poles. The absolute majority of White Stork nests on power lines are located on poles of low-voltage (0.4 kV) overhead electrical lines that have horizontal placement of the wires, which is particularly suitable for supporting nests. Development of the low-voltage overhead electricity distribution network in Lithuania was completed by the mid-1970s, when it reached just under 70,000 km of lines or ca. 1.86 million poles (K Misikonis, unpublished data). Since the mid-1980s, the network has been gradually decreasing, to a great extent due to the replacement of overhead electricity lines with underground cables. During the study period, the length of 0.4 kV overhead electricity lines decreased by 12 %, from 65,000 to 57,000 km (K Misikonis, unpublished data), slightly reducing the availability of nest sites on electricity poles. Considering that overhead electricity line poles have been available in excess across the countryside for the last 40 years, it is reasonable to suggest that the recent increase in nesting on electricity poles is most likely a consequence of a gradual change in White Stork nesting behaviour in an increasing population, facilitated by the lack of traditional nest sites (in trees, on roofs of buildings), which are either already occupied by birds or no longer suitable for breeding due to the lack of appropriate maintenance.

A similar tendency of White Storks increasingly nesting on overhead electricity line poles and gradually abandoning their former traditional nest sites on roofs of buildings and in trees has been observed over the last decades in several other countries in Europe (Janaus and Stipniece, 2004; Tryjanowski et al., 2009; Denac, 2010; Onmuş et al., 2012). In Latvia, the proportion of nests in trees decreased from 86% to 40% during the period of 1974–1994, while the proportion of nests on electricity line poles increased from 1% to 38% (Janaus and Stipniece, 2004). Similarly, in Estonia, the proportion of nests in trees decreased from 68% in 1984 to less than 10% in 2008, while the proportion of nests on electricity line poles increased from 12% to 72% (Ots, 2009). In Slovenia, the last White Stork nest in a tree was recorded in 2008 (Denac, 2010). This same tendency has also been observed in Poland, both in the entire country, where the proportion of nests on electricity line poles increased from 4% in 1974 to 37% in 1995 (Jakubiec and Guziak, 1998), and in different regions of the country (e.g., Daniluk et al., 2006; Kuźniak, 2006; Tryjanowski et al., 2009).

Nesting on overhead electricity line poles may have both positive and negative consequences for White Storks. The inaccessibility of such nests to mammalian predators has been found to increase the breeding success of White Storks (Tryjanowski et al., 2009), while the instability of nests and their proximity to live wires poses serious threats to breeding birds and their young (Jakubiec, 1991; Garrido and Fernandez-Cruz, 2003; Schaub et al., 2004; Tryjanowski et al., 2009; Kaługa et al., 2011). Furthermore, the electromagnetic field generated by the electric current has been found to negatively affect various aspects of bird reproduction (Balmori, 2005, 2009, 2010).

Installation of artificial nesting platforms on overhead electricity line poles, in place of White Stork nests built in direct contact with electricity wires, has been widely used as a White Stork conservation measure, which both increases the stability of such nests and reduces the risk of electrocution to breeding birds by increasing the distance between the nest and the wires (Muzinic, 1999; Muzinic and Cvitan, 2001; Dolata, 2006; Tryjanowski et al., 2009; Onmuş et al., 2012). For example, 3260 such platforms were installed in Lithuania during the period of 2009–2012 (Dagys and Vaitkuviene, 2013).

Despite the steep increase in the White Stork population size during the last 16 years, their breeding success has remained almost unchanged, with 2.7 and 2.6 young per successful nest (JZm) in 2010 and 1994, respectively (1994 data from Malinauskas and Vaitkus, 1995). This suggests that breeding conditions have remained favourable to this species in Lithuania. Rather similar breeding success of White Storks has been observed in other countries. In Slovenia, the mean breeding success over the period 1999–

2010 was 2.6 young per successful pair (Denac, 2010). In Poland, which holds the largest population of White Storks (BirdLife International, 2004), breeding success in various regions varied between 2.5 and 3.0 young per successful pair in the 1990s and early 2000s (Nowakowski, 2003; Daniluk et al., 2006; Kuźniak, 2006). In France, the mean breeding success was 2.5 young per successful pair in 2003 and 2004 (Massemin-Challet et al., 2006). In Slovakia, the mean breeding success during the period of 1978–2002 was 3.05 young per successful pair (Fulin et al., 2009). Considerably higher breeding success was recorded in Turkey, which holds one of the highest populations of White Stork (BirdLife International, 2004), with 4.2 young per successful pair in central Turkey in 2004 (Göcek, 2006) and 3.8 young per successful pair in northern Turkey in 2010 (Yavuz et al., 2012).

The observed 2-fold increase in the White Stork population along with radical changes in agricultural practices once again supports the notion of this species being a good indicator of agrarian environment (Tryjanowski et al., 2005; Chernetsov et al., 2006; Sæther et al., 2006; Kosicki and Indykiewicz, 2011; Kosicki, 2012). High breeding success both now and 16 years ago further indicates that conditions for this species continue to be favourable. However, increase in farming intensity, signs of which are already becoming evident in Lithuania, as well as further natural succession of long-abandoned agricultural land towards scrub and eventually forest land, may both have significant negative consequences for the status of this species in the near future. Since different changes in agriculture may have contrastingly different consequences for agrarian bird species, as exemplified by Tryjanowski et al. (2011) in the case of West and Central-East Europe, effective conservation of White Storks will depend on the availability of region-specific knowledge and tailored conservation measures.

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