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White Storks (*Ciconia ciconia* L.) in Armenia: research for conservation

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Abstract. The entire population of White Storks (*Ciconia ciconia* L.) in Armenia was monitored annually during 2005–2016 and the data were compared with the previous study conducted in 1984. The population increased from 548 to 654 breeding pairs between 2005 and 2016, and there was an increase in average breeding success (number of fledglings per occupied nest). The storks have shifted their preferred nest locations since 1984, from roofs and trees to pylons. Nest sites on pylons are vulnerable to short circuits or wind, thus during 2005–2016 we recorded 450 cases of nest damage.

Introduction

In Armenia the White Storks (*Ciconia ciconia* L., hereafter storks) occupy Ararat Plane, Arpa River Valley, Shirak and Lori Plateau (Adamian 1990, Adamian & Klem 1999), and nest in villages located in close proximity to wetlands. Throughout Europe storks are used as a flagship species, which can encourage citizen scientists to be involved in their census and serve as an indicator of wetland ecosystems (Hötker & Thomsen 2013). Taking that into consideration, in 2005 we started a study of the storks in Armenia, which was dedicated to: (1) the identification of the stork population size and dynamics, (2) the measurement of trends in stork breeding success in Armenia, (3) justification of the conservation status of the species in Armenia and development of conservation measures, if necessary. The species was selected, being a top-level predator, charismatic enough to attract rural people into monitoring, and being an easy-to-survey bird, which can encourage the collection of a large amount of data, thus enabling a cost effective study. Identification of such an easy indicator of the wetlands' health is of particular importance, as the wetlands have been consistently pressured since the Soviet Period; in the Ararat Plain they have declined from 31,000 ha down to about 20,000 ha (Aghababyan 2011). Meanwhile, these wetlands host numbers of breeding waterbirds including some globally and nationally endangered bird species, such as White-headed Duck (*Oxyura leucocephala*), Ferruginous Pochard (*Aythya nyroca*), Common Pochard (*Aythya ferina*), Northern Lapwing (*Vanellus vanellus*), and others.

Methods

During 2005 the nests of storks were inventoried and then monitored annually, from March till September, between 2006 and 2016. The study area covered the Armenian regions of Ararat, Armavir, Aragatsotn, Yerevan, Lori, Shirak and Vayots Dzor provinces (see Figure 1). Data collection involved 284 expeditions lasting a total of 536 days. In total, we visited 245 locations, and detected nests in 116 of them.

In total, data on breeding pairs and nest outputs were collected from 1,026 stork nests, as in many areas the storks often change their nesting sites, build new nests, and abandon some others. In addition during the study period some nests were lost due to fire and wind, which also caused pairs to relocate. The data were collected via direct observations by our team and with the assistance of village inhabitants, which serve as citizen scientists (people who live closest to the storks' nests; hereinafter they are called "nest neighbours"). The nests were labeled with individual numbers and the nest neighbours were encouraged to provide quick feedback on every unusual occasion — e.g. construction of new nests in the village, storks' injury cases and so on.

Such a system of data collection enabled all the known nest sites to be under observation every

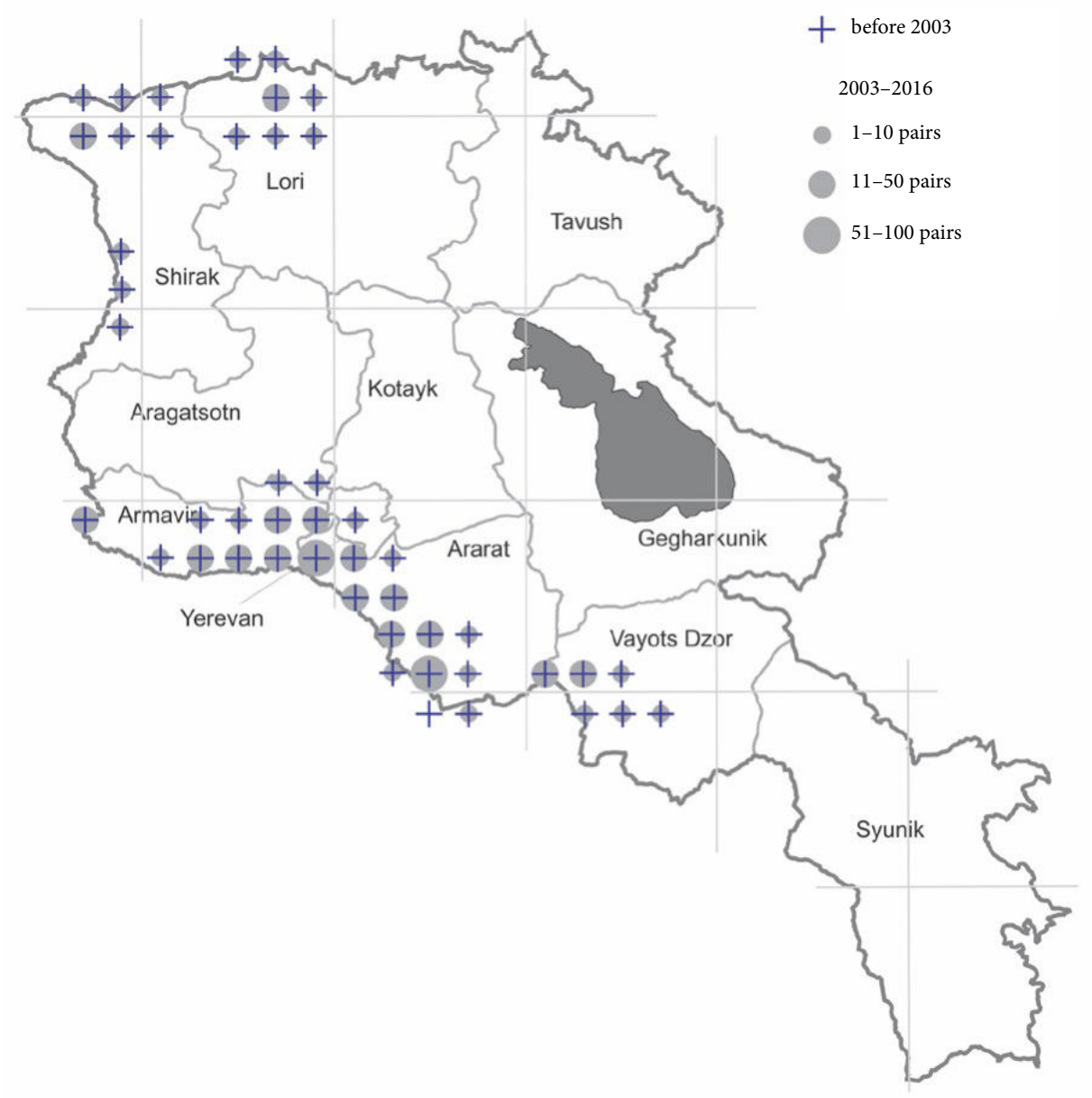

Figure 1. Distribution of the White Stork in Armenia

year; in addition our team travelled the same routes to secure the recording of newly constructed nests. Thus annual censuses of the number of storks in Armenia were based on absolute counts of occupied nests.

For every nest we recorded the following data:

- Geographical coordinates using GPS units.
- Location of the nest, e.g. located on ordinary pylons or high-tension electricity pylons, building roofs, trees, waterworks, statues, and cranes (done once during mapping the nests between 2005 and 2009).
- Data about the nest neighbours, i.e. names, surnames, and phone numbers (done once when the nest was found).
- Number of adult storks occupying the nest, number of nestlings and number of fledglings (recorded annually).
- Accidents that happened to nests were specified with the help of nest neighbours, who also recorded the causes of nest destruction (wind, nest burning by electricity wires, etc.), falling of nestlings and eggs from their nests, deaths of adult storks, etc. (implemented yearly).
- Records of the cases of conflicts between storks and people in the village (implemented yearly).

The data collected by researchers and students were recorded on special forms, while the ob-

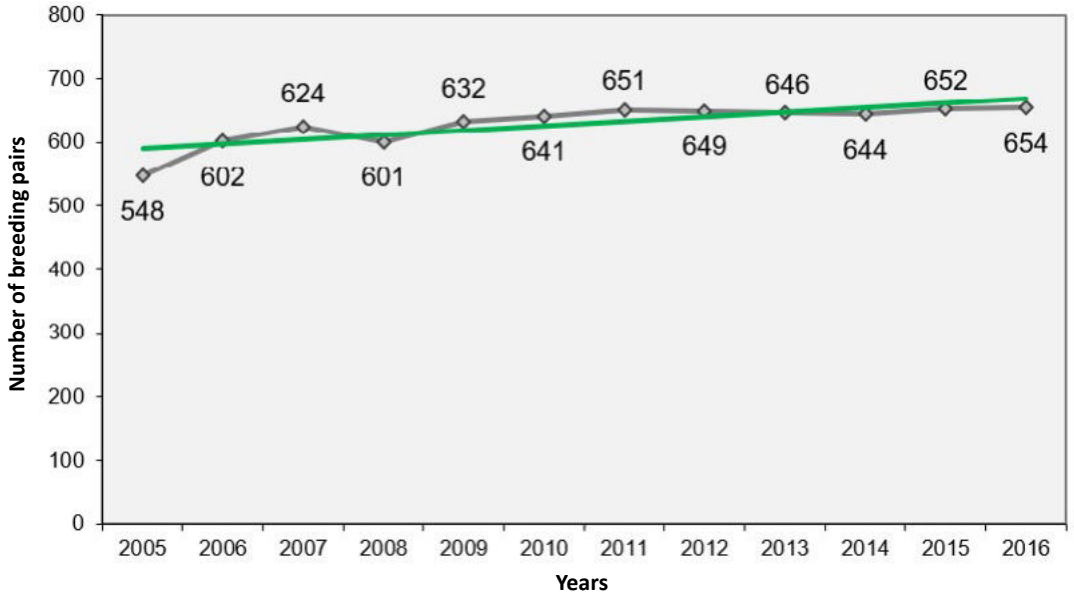

Figure 2. Population trend of the White Stork in Armenia during 2005–2016 (breeding pairs)

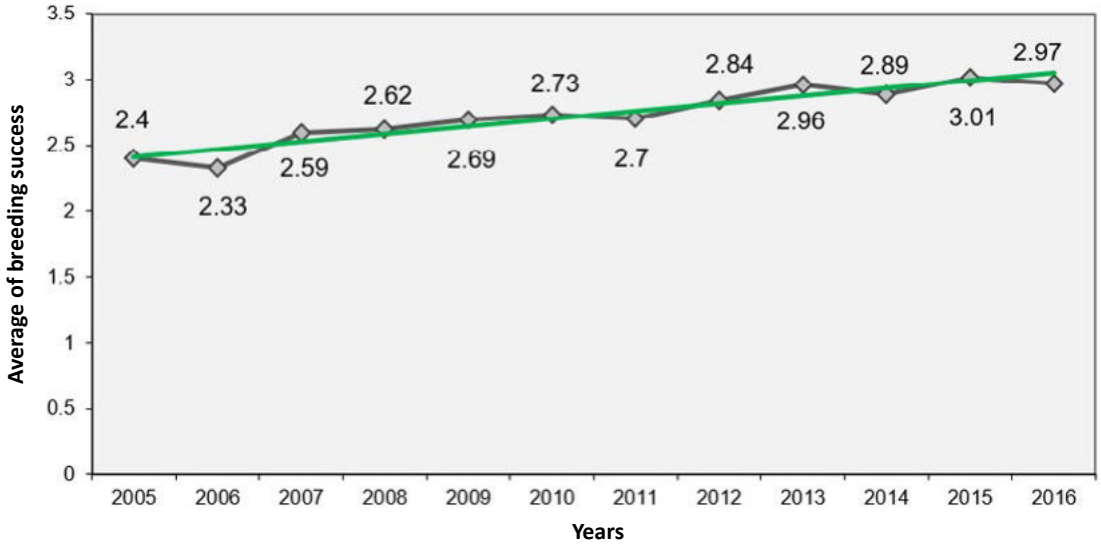

Figure 3. Mean breeding success of the White Stork in Armenia during 2005–2016

servations of nest neighbours were recorded on wall-calendars designed for the storks' nest monitoring.

The collected data were stored in a Microsoft Access 2003 database (later transferred into Microsoft Office 2010) for further data analysis. Statistical analyses were carried out with Excel 2010 (MS Office 2010) program package. The analyses include measurement of central tendencies and calculation and visualization of the trends. We calculated log-linear population growth rate during the period based on population surveys in 2005 and 2016. Mapping was conducted with ArcMap GIS 10.1 (ESRI, Redlands, CA).

Results

Distribution and abundance

During 2005–2016 the cumulative total of the storks' nests detected in Armenia was 1,026; located in Ararat, Armavir, Vayoc Dzor, Shirak, Lori, Aragatsotn and Yerevan provinces of Republic of Armenia (see the Figure 1). However, not all these nests were occupied every year. The population increased from 548 pairs in 2005 to 654 in 2016; the annual growth in breeding numbers is shown in Figure 2. The population growth from 2005 to 2016 was 19% and thus, on average, 1.6% per annum.

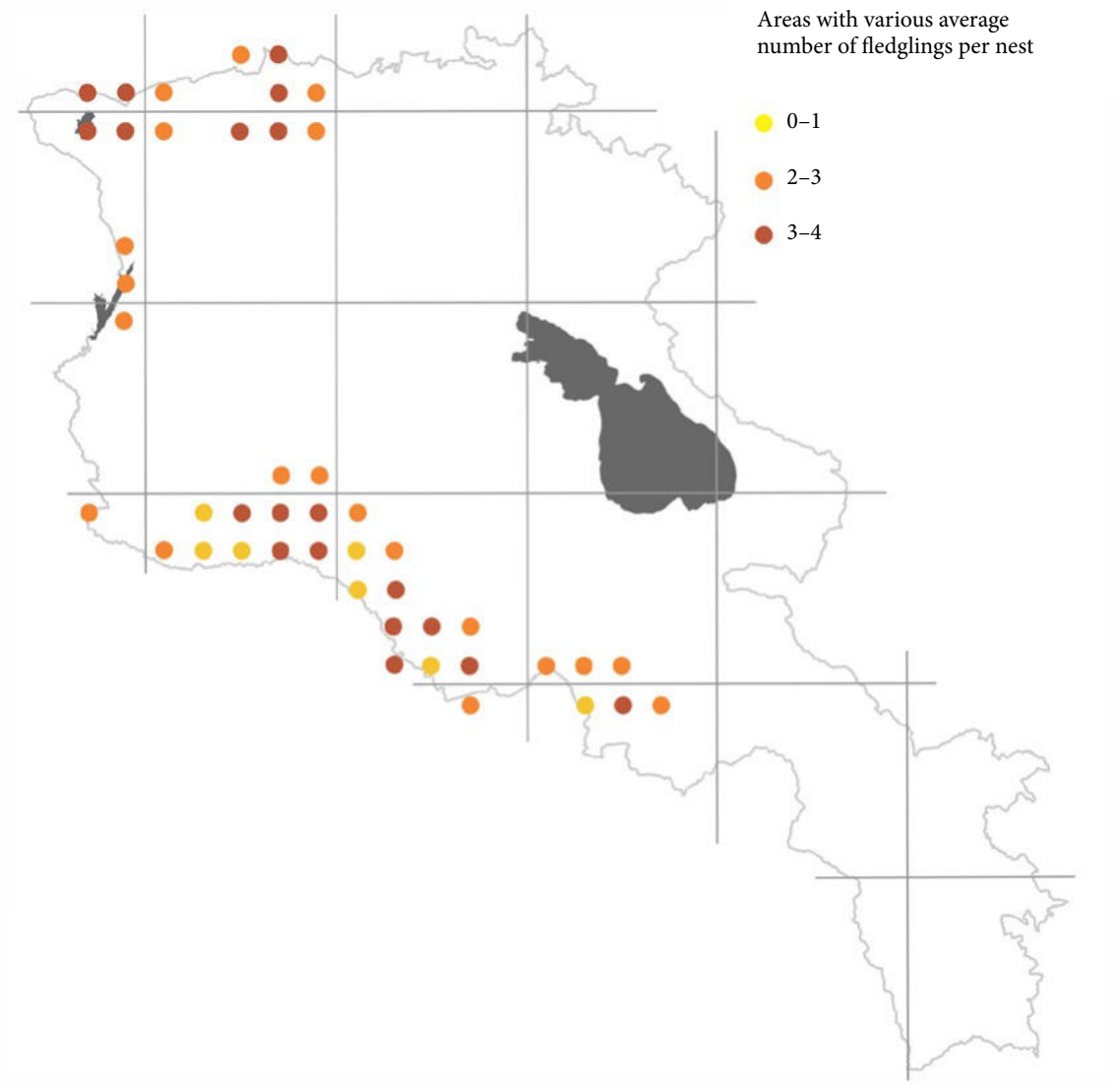

Figure 4. Areas with low White Stork productivity in Armenia during 2005–2016.

Prior to our investigations, storks were surveyed in Armenia in 1984 (Adamian 1990). Figure 2 demonstrates a moderate increase of the population during 2005–2016, but the data from 1984 suggests there had been a decline between 1984 and 2005. However, the methods used in 1984 were different than in our study and thus the apparent decline may be an artefact of this change (see Discussion section for details).

The storks are not uniformly distributed through the republic. Most of the nests are situated in the Ararat valley (562 pairs in 2016, 86%), while small subpopulations are found in the Shirak (32 pairs, 5%) and Lori (44 pairs, 7%) plateaus and Arpa river valley (16 pairs, 2%).

The average breeding success (number of fledglings per occupied nest) has also increased through our study period (see Figure 3). Unfortunately, the historical data on the number of storks' nestlings (Adamian 1990) is more descriptive rather than quantitative, and cannot be used for comparison with our study.

The breeding success has increased due to a rise in the proportion of nests with 4 fledglings, and a decrease in the proportion with 2 fledglings. Breeding success varied spatially, with the areas of lowest productivity being in the south (Figure 4).

Nest locations

In Armenia storks place their nests on electric pylons, roofs, trees, and sometimes even on monuments and on non-working tower cranes. Data for 993 nests available by the end of 2009 (see Table 1) shows that storks mostly bred on various types of electric pylons (82.4%): these included regular wood and concrete pylons, pylons of railway stations and high voltage iron pylons.

Table 1. Nest locations of the White Storks in Armenia in 1984 and in 2005–2009 (from Aghababyan 2011)

Nest location	1984 (Adamian 1990)		2005–2009 (Aghababyan 2011)	
	Number	Percent	Number	Percent
Water cisterns			8	0.8
Building tower cranes			5	0.5
Roofs of newer buildings	142	21.3	113	11.4
Pylons	335	50.1	818	82.4
Monuments			5	0.5
Trees and abandoned buildings	191	28.6	44	4.4
Total	668	100	993	100

Table 2. Number of damaged nests per year

Year	Total number of damaged nests	Number of nests destroyed by wind	Number of nests destroyed by fire
2005	25	20	5
2006	37	29	8
2007	35	27	8
2008	39	30	9
2009	42	33	9
2010	37	29	8
2011	40	30	10
2012	44	35	9
2013	39	31	8
2014	35	24	11
2015	41	32	9
2016	36	26	10
Total	450	346	104

The second most frequently used nest locations are roofs: storks place nests on roofs of schools and local administration buildings (usually the tallest buildings in a village), as well as on roofs of private houses.

Comparison of our data with data collected in 1984 (Adamian 1990) suggests that over the years storks have shifted their preferred nest locations from roofs and trees to pylons (Chi-square statistic $\chi^2 = 66.115$, $p < 0.00001$, $n = 668$ in 1984, $n = 975$ in 2005–2009). Nest sites on pylons are vulnerable to fire (due to short circuits) or wind. During 2005–2016 we recorded 450 cases of nest damage (see the Table 2) caused by wind and fire due to short circuits.

Discussion

Tendencies and their explanation

A comparison of data from 1984 and the 2005–2016 period may suggest that there was a decrease in the breeding population of storks in Armenia after 1984, and an increase from 2005 to 2016. However, this decrease may be not genuine, but due to differences in the methods used for data collection. The 1984 study (Adamian 1990) it was conducted by questioning via post: the author sent a simple questionnaire by post with a request to fill them out and send back. Using this method, it is hard to avoid duplication of the data: the 1984 population may have been overestimated. The study of 2005–2016 was done by mapping and providing individual numbers for the nests, which meant that there was no duplication and very low possibility of missing a nest.

The breeding success of storks increased in parallel with the moderately increasing population trend over our 2005–2016 study period. These patterns are probably related to the following factors:

1. From late 1990s – early 2000s there was a continuous increase in the number of fish and poultry farms on the Ararat Plain (e.g. the

largest poultry farm "Araks" was launched in 1997). These farms have poor waste management, and the waste from slaughtered and gutted fish and poultry provides a significant food supply for storks.
2. The increased number of fish-farms has been enabled by pumping deep artesian water from underground; the subsequent release of this water into natural ecosystems has created additional canals, streams, and wetlands and thus created foraging habitat for the storks. The number of fish-farms in Armenia increased from 35 in 2000 to 250 in 2014 (Aghababyan & Khanamirian 2014).
3. There is no limitation in nesting places, since Ararat Plain has high density of settlements, with appropriate infrastructure: pylons, buildings, and so on.
4. The new food supply options at the fish and poultry farms are available throughout the winter, which has supported an increased number of wintering storks of up to approximately 250 individuals per winter (Aghababyan *et al*. 2013), and therefore reduced incidence of mortality on migration.

Conservation Measures

The IUCN Global Red List status of White Stork is Least Concern (BirdLife International 2016), and the last assessment of its National conservation status also qualified it as Least Concern (Aghasyan & Kalashyan 2010). Nevertheless, the species is included in Appendix II of Bern Convention (ETS No.104). At present the breeding populations of the species are protected in Lake Arpi National Park and Gnishik Community-managed Protected Landscape. In addition, a number of the wetland areas in Ararat Plain and lakes in Lori Province have been proposed to be included in the Emerald Sites protected under Bern Convention (Fayvush *et al*. 2016). Even taking the recent increase of population into consideration, there are two threats that the local groups of storks face: first is related to human-wildlife conflicts, and second to the uncontrolled use of pesticides.

Human — Stork conflicts

By building nests on roofs storks can cause serious damage to houses, since they generally place nests on drainage system pipes which then become blocked. As a result, moisture accumulates in the walls, causing damage to homes; eventually this results in conflict between human and the storks. It should be mentioned that although local villagers are displeased by such harm, they avoid destroying nests, being under idea of "damnation for the nest-destroyers". Thus, in this case people suffer damage but cannot take measures to eliminate its source. To solve this dilemma we have suggested use of special constructions to house nests, which will help to preserve the nests, located on the roofs of buildings and at the same time preventing damage to buildings. The nest platform programme is an essential step to improve relationships between humans and storks (Ilichev 1990). These positive steps will lead to the restoration of storks to their status as a cultural symbol and to create a conservation model based on an ethical and respectful attitude of humans toward nature (Borejko & Grishenko 2004).

Nest damage also happens to nests located on pylons, due to fires caused by short circuits. Such cases destroy nests (often with nestlings) and cause problems for the Electricity Company. The solution is in building another type of platform on pylons, which can help to isolate nests from the wires and eliminate the risks. The relocation of the nests on such pylons is profitable for the company in a long-term perspective and beneficial for storks.

Pollution

During this study some areas with low breeding success were recorded (see the Figure 4). Sampling of the soil in those areas showed relatively high concentrations of DDT, DDD, DDE, Dieldrin, and Hexachlorobenzene in the soil; the low breeding success of storks may be related to the high concentration of these persistent organic pesticides, which are well known in this regard (Peakall 1970). Although DDT is officially banned in Armenia, its remains can stay in the soil up to 30 years (World Health Organization 1989). Flooding can stimulate the inclusion of DDTs derivatives into a new cycle of the trophic chain. Our survey showed that in areas with low reproductive success farmers have been irrigating land using flooding.

As it was mentioned above, storks can suffer from Persistent Organic Pesticides. It is also possible that they suffer from the other pesticides, e.g. pyrethroids. Thus, the monitoring of the storks can help in revealing the possible effect of use of the pesticides on the species and therefore

on the ecosystems (Cox 1991). Another potential pollutant which can significantly impact storks is lead pollution (Haig *et* al. 2014). Hunting may introduce lead into wetland ecosystems, since in Armenia shooting with lead ammunition is allowed. Over 47,000 ha of official hunting lands are located in Ararat Plain and are visited by at least 10,000 hunters per year (Sevak Baloyan, Bioresources Management Agency, personal communication), so lead pollution could become another significant threat for the local wildlife; however, this issue requires further investigation. Taking the current population increase into consideration, the White Storks can still be considered as Least Concern, and doesn't require any specific conservation measures. However, since the species is a good indicator of wetland ecosystems it is necessary to continue the monitoring of storks in Armenia, especially with regards to the potential impact of various pollutants. Such monitoring, which continues thanks to the network of nest-neighbours, can be an integral component of the management plan of Emerald Sites, like Lake Arpi, Armash, Metsamor, Gnishik, and others. Needless to say that monitoring of the storks across a extensive network of rural communities has a significant educational value. Thus, the stork serves as a flagship species which supports protection of wetland habitats and their endangered biodiversity.

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