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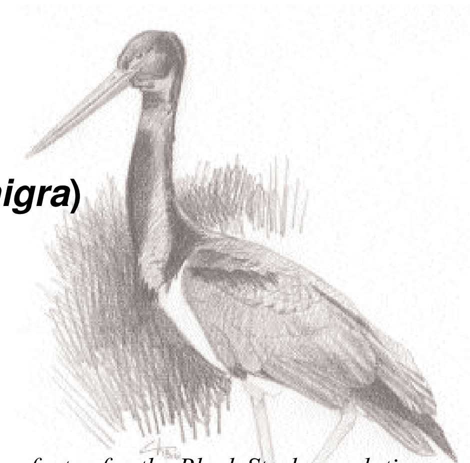

Nest trees - a limiting factor for the Black Stork (*Ciconia nigra*) population in Estonia

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ABSTRACT - *To assess the role of nest trees as a limiting factor for the Black Stork population in Estonia, we have described 49 nest sites and have explored the availability of potential nest trees in randomly selected plots. Compared with the composition of neighbouring nest stands, the storks strongly preferred to nest on oaks and aspens, followed by pine, and avoided spruce. Our analysis shows that the disproportional use of tree species could be explained by their canopy structure, notably the opportunity to hold a large nest away from the main trunk. On average, the nest trees were 25.6 m high, 120 years old and had a 66-cm diameter at breast height. Different tree species became suitable at different ages. Similarly to the other Baltic countries, nest trees were older than nest stands, showing that older tree retention during forest management practices is important for the species. In a random landscape, 3.5% of forest land contained at least one tree suitable for nest building, but after considering also stand structure and location, only 0.3% of forest land could be listed as suitable. We conclude that the shortage of potential nest trees is severe enough to limit the Estonian Black Stork population, and that sylvicultural management for retaining or creating such trees in forested areas are by far under-used.*

Introduction

The Estonian population of the Black Stork (*Ciconia nigra*) is the northernmost one in Europe. Here the storks are exclusively tree-nesting and forage mostly at waterbodies. The population totals 100-120 nesting territories (pairs and single adults that hold nest sites), which is at least twice less than in the late 1970s (SELLIS, 2000). To improve this unfavourable status, determination of the causes of the decline is of utmost importance. The very low productivity of the population suggests that the reasons may be related to negative habitat changes in breeding grounds (SELLIS, 2000).

Previously, we have rejected the hypotheses that the decline of the Estonian Black Stork population is due to increased disturbance by forest management (ROSENVALD & LÕHMUS, 2003) or changes in forest structure (LÕHMUS *et al.*, in prep.) At the moment, the most plausible explanation seems to be the gradual degradation of foraging habitat (permanent water courses in forests) as a long-term impact of forest drainage (LÕHMUS & SELLIS, 2001). However, this hypothesis has yet to be tested, and - even if it appears to be true - some other factors are probably contributing as well.

Here, we concentrate on some specific features of the Black Stork's nest trees in Estonia. The lack of suitable trees can pose a problem for the species since its nests are very large, often on a branch away from the main trunk, and therefore prone to falling down (in 2001, 20% of all nests were classified as being in immediate danger in Estonia). While many studies have described the nest trees of the Black Stork (e.g., CIESLAK, 1988; IVANOVSKY, 1990; DROBELIS, 1993; SKUJA & BUDRYS, 1999), we do not know any analyses of the availability of such trees in forested landscapes, and hence their possible role in population limitation. Yet the lack of suitable trees near high-quality foraging areas may force the birds to forage at unfavourably long distances, and given that the conservation aim in Estonia is not simply the survival of the current population but also its recovery (LÕHMUS, 2001), retention or creation of suitable trees may be a successful restoration technique. In this paper, we describe the nest trees of the Black Stork in Estonia and their differences from other trees in nest stand, and then explore the availability of such trees in a large reference area.

Material and method

As a part of a larger study, we sampled 49 breeding territories of the Black Stork (ca 50% of the current population) all over Estonia. For most analyses, only the most recently occupied nest was studied from each territory. If the storks had both an artificial and natural nest on a territory, the latter was chosen for analyses. Only the frequency distribution of nest tree species (Table 1) is shown for previous descriptions of natural nests taken from the literature, since the separation of nesting territories was not possible for those older data.

The nest sites were described in 1998 and 2001. For nest trees (in random plots: the most suitable trees, see below), height, diameter at breast height and age were measured. Trees were aged by taking increment cores; in some partly decayed nest trees (aspens), we took the cores from other trees of the same generation nearby. To compare nest trees with those generally available in the stands, we measured the mean age of overstorey trees and assessed their species composition at 5% accuracy within 30 m.

The availability of suitable nest trees was assessed in random forest plots. First, from each described nest, three plots were described at different distances (200, 500 and 700 m) in random directions. Secondly, 733 random plots were described on forest land of a 900-km² area with random borders in east-central Estonia (58°25'N, 26°20'E). The area includes nature reserves as well as different production forests, reflecting the management regimes typical to Estonia (see LÕHMUS, 2002; for details of the area and its forests). The estimation was carried out in two steps. In the field, experienced workers explored canopy structure and size of the largest (best) tree within 30 m from the plot centre and assessed whether it could support a stork nest (*impossible* - no nest can be built; *poor* - a one-year nest can be built; *good* - a nest lasting at least two years can be built). Then the plots having good nest-building possibilities were explored for other key factors (using minima or lower quartiles of nest sites as thresholds) and were classified as otherwise unsuitable due to disturbed location (forest edge closer than 90 m, arable land closer than 200 m or large road up to 100 m) or unsuitable stand structure (share of spruce less than 20% or the maximum crown coverage near the "nest tree" less than 50%).

Results and discussion

Tree species

In the last fifty years, the Estonian Black Storks have most often nested on Scots pine, aspen, birch, and - recently - on oak (Table 1). The appearance of oak as an important nest tree may be related to changes in the stork distribution, which nowadays includes Saaremaa Island and some West-Estonian „oak areas" where the storks were absent during most of the 20th century (SITS, 1936; MANK, 1967).

Compared with the composition of occupied nest stands, the storks avoided to nest on spruce, while they strongly preferred oak and aspen, followed by pine (Table 1). The preferences are even more pronounced when nest tree use is compared with the composition of forest land: oak stands make up less than 1 % and aspen stands only 5 % in Estonia (VIILUP, 2000). At the same time, pine stands make up 34 % and spruce stands 18 %, which suggests that pines are, in fact, used opportunistically (but pine stands are avoided), while spruce is avoided only as nest tree and it is strongly preferred in the surroundings of the nest. The latter has been noticed also by PETRINŠ (1986) in Latvia.

Regarding the causes of the preferences, we assumed that if the storks require only a support for a large nest, the actual nest trees and those distinguished by the observers as potential nest trees (according to canopy structure and size) should have similar species distributions. Indeed, the share of oaks and aspens among potential nest trees in the 46 random plots (200-700 m away from nests; at least "poor" nesting conditions) was close (57 %) to that of real nests (52 %). However, there tended to be more spruces among potential trees (9 %) than nest trees (3 %). This suggested that although a strong platform seems to be a major criterion of nest tree selection by the storks, other factors might be involved too. We found that most nests on preferred tree species (oaks and aspens) were placed on side branches away from the main

Table 1 - *Nest tree species used by Black Storks in Estonia during three study periods. For nest stands, the average ± 95% confidence intervals have been shown. Sources: [1] MANK 1967; [2] the archives of Anti Õun; [3] this study. - Fréquence des différentes espèces d'arbres utilisées par les Cigognes noires pour l'installation de ses nids en Estonie au cours de trois périodes d'étude. Les fréquences de ces espèces dans les peuplements forestiers des mêmes sites sont exprimées par les moyennes accompagnées des intervalles de confiance de 95%.*

Species	Frequency (%)			
	Black Stork nests			Nest stands
years:	1962-64 [1]	1976-84 [2]	1994-2002 [3]	[3]
Scots pine *Pinus sylvestris*	40.3	40.7	32.8	19 ± 7
Norway spruce *Picea abies*	4.5	7.4	3.0	42 ± 8
Birch *Betula sp.*	16.5	19.8	10.4	17 ± 6
Aspen *Populus tremula*	31.3	22.2	37.3	16 ± 6
Black alder *Alnus glutinosa*	7.4	3.7	-	2 ± 2
Oak *Quercus robur*	-	4.9	14.9	2 ± 4
Ash *Fraxinus excelsior*	-	1.2	1.5	2 ± 5
Sample size	67	81	67	49

trunk (11 of 15), while this was very rare on other tree species (1 of 16) - a highly significant difference (χ^2_{adj} = 12.7, df = 1, P < 0.001). Similarly, the birds strongly preferred oak and tended to nest on side branches of this, but not other, tree species in Poland (CIESLAK, 1988). Therefore, a preference to build its nest away from the main trunk may further explain the tree species use by the Black Stork. Notably, the under-use of spruce may be related to the fact that even very large spruces never provide such a possibility.

Tree age and size

On average, the trees carrying natural nests were 25.6 ± 5.2 (S.D.) m high (n = 35), 120 ± 38 years old (n = 33) and had a diameter of 66 ± 20 cm at breast height (n = 35). The real mean age is probably higher because the largest oak and pine of the sample were not measurable because of technical reasons. Of the measured nest trees, 90 % were at least 80 years old. However, there is no general suitability limit, since different tree species become suitable for nesting at different ages (ANOVA for the four most common species : $F_{3, 27}$ = 6.7, P = 0.002). The average age was 161 ± 29 years for oak (range 120-200, n = 6), 134 ± 46 years for pine (range 68-213, n = 8), 101 ± 24 for aspen (range 55-135, n = 12) and 97 ± 10 years for birch nest-trees (range 80-105, n = 5). The only measured ash was 120 and a spruce 107 years old. The relevant data from Lithuania (mean age 132 and 106 years for oak and pine nest-trees, respectively; DROBELIS, 1993) indicate that the "maturation" of trees takes decades more in Estonia, obviously due to the harsher situation for vegetation development.

In the whole Baltic region, Black Storks nest on trees older than the nest stands. In Estonia, the nest trees were of similar age than those in

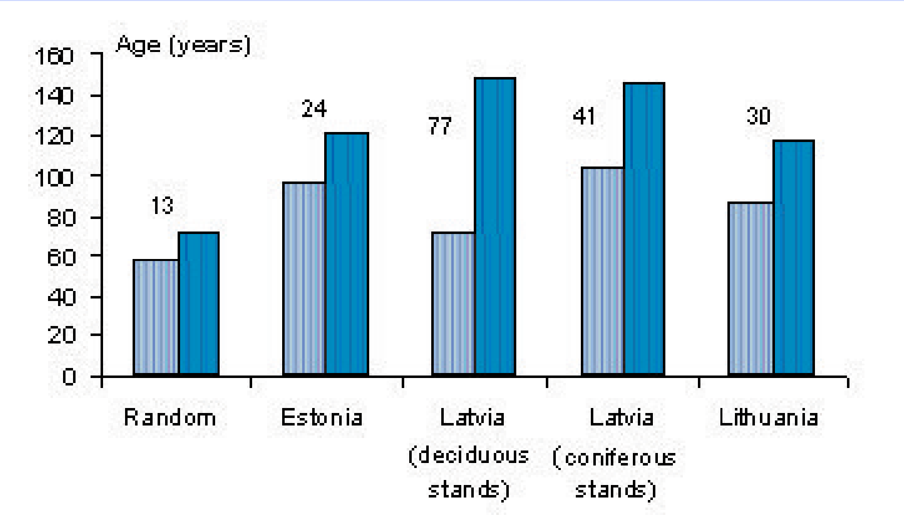

Fig 1 - *Mean age of nest stands (white bars) and nest trees (black bars) of the Black Stork in the Baltic states (according to this study, Strazds et al. 1996 and Skuja & Budrys 1999). "Random" indicates the random stands 200-700 m away from the stork nests in Estonia; the numbers above bars show differences (years) between stand and nest-tree age. - Age moyen des peuplements forestiers comprenant des nids (en blanc) et des arbres porteurs de nids (en noir) de la Cigogne noire dans les Etats Baltes. L'échantillon de référence ('Random') est constitué par des peuplements forestiers distants de 200 à 700 m des nids de cigogne en Estonie; le nombre au-dessus des barres donne la différence entre l'âge moyen du peuplement et celui des arbres porteurs de nids.*

Lithuania and slightly younger than in Latvia (Fig. 1). The differences between nest tree and stand ages were, however, smallest in Estonia (24 years), particularly when compared with the deciduous stands in Latvia (77 years; STRADS *et al.* 1996). Hence (1) the storks could greatly benefit from green tree retention during forestry practices, allowing them to nest in younger forests than nowadays; (2) the tree retention has yet to be put into practice, since the present stands are nearly even-aged in Estonia (only 13-year difference between potential nest trees and the stands; Fig. 1).

Nest tree availability

In the random forest landscape in east-central Estonia, only 26 plots (3.5% of forest land, 4.1% of stands) contained at least one tree with "good" nesting opportunities for the Black Stork. This was considerably less than in the random stands near the stork nests (19-25% of forest land), which indicates the aggregated pattern of potential nest trees in forest landscapes. Moreover, starting from a distance of 500 m from nests, most plots with suitable trees were unsuitable for other reasons (Fig. 2). Most drastically, in the random landscape, only two of the 26 plots could be finally accepted as suitable for the stork, i.e. only 0.3% of forest land. Of the 24 "lost" plots, eight were unsuitable because of stand structure, four due to stand location, and twelve because of both stand structure and location.

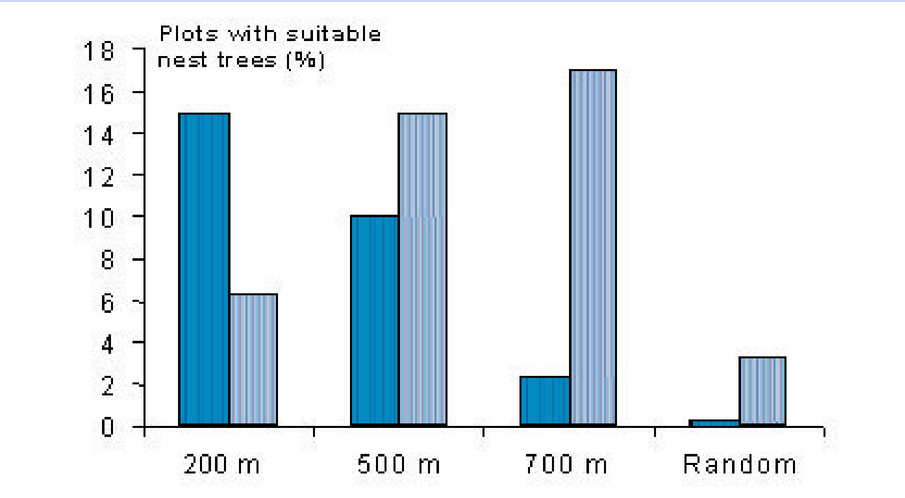

Fig 2 - *The share of forest land containing at least one tree with "good" nesting opportunities for the Black Stork in random plots with 30-m radii (200-700 m from nests as well as a random landscape in east-central Estonia). According to stand location and structure, otherwise suitable (black bars) and unsuitable sites (white bars) have been distinguished. - Proportions de zones forestières contenant au moins un arbre présentant de "bonnes" opportunités pour les nids de Cigogne noire dans des placettes aléatoires de 30 m de rayon (situées soit à 200-700 m des nid soit au hasard dans le centre-est de l'Estonie - 'Random'). Selon la localisation et la structure des peuplements forestiers, les sites par ailleurs favorables (en noir) et défavorables (en blanc) ont été distingués.*

Conclusions

1. Given the specific features (species, size and age) of nest trees and the scarcity of such trees in forests, nest tree availability probably limits the current Black Stork population in Estonia: (a) the historical clear-cutting systems have produced highly even-aged stands, which means that the storks can breed mostly in old forests; (b) old forests are scarce and disappearing in Estonia (LÕHMUS, 2002), and even those existing are usually unsuitable for the stork because of their structure or location; (c) the sites containing suitable trees are aggregated, so that after one is being used by a stork, further areas may become unavailable for new settlers due to territoriality. The impact to the stork population may be both direct (otherwise suitable landscapes are not occupied) and/or indirect (via reduced productivity due high energetic costs of foraging flights, or additional mortality of nestlings due to less time the adults can spend on attending nests).

2. The sylvicultural tools for retaining or creating nest sites for the Black Stork have been by far under-used in Estonia as indicated by (a) the small age-differences between trees in stands, compared with the large differences recorded in the nest sites in other countries, and (b) a lower proportion (39%) of nests in the preferred location on side branches away from the main trunk, compared with some other countries with strong populations of the species (50% in Latvia and Byelorussia - PETRINŠ, 1986; IVANOVSKY, 1990). Building of artificial nests may be a successful short-term strategy for improving the local nest site supply (e.g. DROBELIS, 1993), but in the long term, the retention of large trees - particularly oaks, aspens and pines - in remote forest areas during forestry operations should be preferred as a more natural and also cheaper tool (CARLÉN *et al.* 1999).

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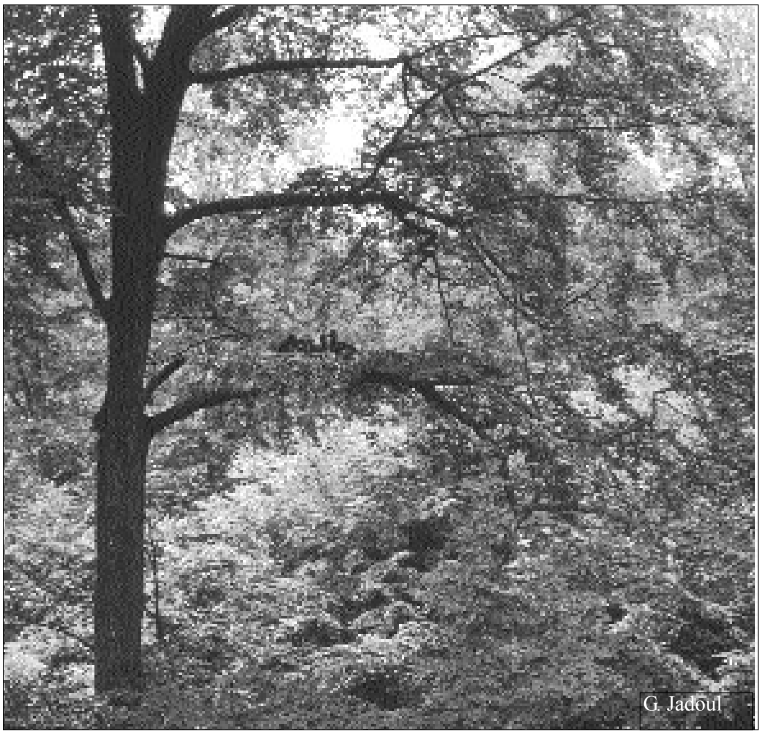

Résumé

L'insuffisance d'arbres adéquats pour les nids, un facteur limitant pour la Cigogne noire (*Ciconia nigra*) en Estonie

Avec 100 à 120 couples nicheurs, la population estonienne de Cigognes noires (*Ciconia nigra*) est la plus septentrionale d'Europe. Une diminution des effectifs dépassant les 50 % depuis 1970, ainsi qu'une très faible productivité, posent la question sur les causes d'un tel déclin. Une d'entre elles paraît être une dégradation progressive des sites de nourrissage, résultant d'une politique de drainage forestier. Le présent article indique qu'une autre cause est apparemment le manque d'arbres convenables pour supporter le nid.

49 sites de nidification ont été décrits entre 1998 et 2001. Pour chaque nid, trois sites-échantillons à différentes distances (200, 500 et 700 m) et dans des directions aléatoires ont été également analysés. Enfin, 733 échantillons aléatoires situés dans un massif forestier de 900 km^2 au centre du pays (58°25'N, 26°20'E) ont fait l'objet de la même enquête. Cette dernière région comprend aussi bien des réserves naturelles que des forêts de production. A l'intérieur de chaque échantillon, différents paramètres ont été notés : hauteur, diamètre et âge des arbres, taille du plus gros arbre, structure de la canopée. Ensuite, les échantillons disposant d'au moins un arbre apte à supporter un nid de cigogne ont été inspectés sur la base d'autres facteurs importants pour une éventuelle nidification : distance par rapport à une lisière, une zone cultivée, une route importante, composition et structure forestière...

Il résulte de ces analyses que la Cigogne noire niche majoritairement sur quatre essences, par ordre de préférence décroissante : chêne (*Quercus sp.*), Peuplier tremble (*Populus tremulus*), Pin sylvestre (*Pinus sylvestris*) et Bouleau (*Betula sp.*) (Tableau 1). Par contre, l'Epicéa commun (*Picea abies*) est évité pour l'installation du nid, alors que sa présence semble nettement recherchée dans les environs de celui-ci. La grande majorité des nids sur des chênes et peupliers sont placés sur des branches latérales, ce qui est très rarement le cas pour les autres essences.

La hauteur moyenne des arbres porteurs de nid est de 25,6m. pour un âge moyen de 161 ans (Chêne), 134 ans (Pin sylvestre), 101 ans (Peuplier tremble) et 97 ans (Bouleau). Dans les Pays Baltes, la Cigogne noire niche sur des arbres nettement plus âgés que le peuplement de la station environnante. Cette différence est toutefois relativement faible en Estonie : 24 ans en moyenne (30 à 77 en Lettonie et Lituanie) (Fig. 1). Le manque d'arbres aptes à supporter un nid de cigogne peut s'expliquer par une gestion sylvicole pratiquant les coupes à blanc et produisant par conséquent des peuplements équiens. Seules les parcelles les plus âgées pourraient convenir, mais elles sont souvent défavorables à cause de leur structure ou de leur localisation. Les rares sites propices à l'espèce sont agrégés, de sorte que la territorialité d'un couple empêche l'installation d'autres individus sur des sites à proximité. Ainsi, sur les 733 échantillons aléatoires dans la forêt au centre du pays, seuls 26 abritaient au moins un arbre convenant pour l'installation d'un nid, mais 24 de ces derniers présentaient une localisation ou une structure de peuplement alentour défavorable à l'installation d'un couple (Fig. 2).

En conclusion, si la construction de nids artificiels peut être une solution provisoire pour enrayer le déclin de la Cigogne noire en Estonie, une solution à long terme implique un changement dans les pratiques sylvicoles, notamment le maintien d'arbres âgés au sein des différentes zones forestières.