Supplementary online material

Census techniques

The censuses were performed by teams of ornithologists, and a database was maintained at the *Dipartimento di Biologia Animale*, University of Pavia. Standardized instructions were provided to the collaborators, and training sessions in the fields were held each year, in order to homogenize the counts. The re-occupation of traditional heronry sites, and the repeated, independent discovery of the same heronries by different collaborators, assured that virtually all the heronries within the study area had been identified, even though a few isolated nests of grey or purple herons may have been occasionally overlooked. It was not possible to evaluate the inter-observer differences in nest counts, and we are aware that collaborators accuracy can be low (Graham et al. 1996). However, the censuses were performed by the same teams for several years, and for the whole study period in some cases. Therefore, though the accuracy of our population estimates cannot be determined, we are confident that the census data are reasonably accurate. Additionally, population trends estimates which are the specific aim of our work, should not be confounded by inter-observer variability, since many sites were visited by the same observers throughout the study period.

The collaborators were asked to visit each heronry at least 2 times during the breeding season, and to provide an estimate of the total number of nests at the peak of colony occupation, using one of the following four standardized techniques (Dodd and Murphy 1995), each suited to differing habitats, colony size, and heron species, in order of decreasing preference (summarized in Fig. S1): 1) ground count of all the nests, performed at the peak occupation of each heronry with one or several passes throughout it, and particularly suitable for easily accessible, small (< 100 nests), and monospecific heronries when birds were not severely disturbed by the observers; 2) post-nesting ground count, a technique tested and advocated by Gibbs et al. (1988) for great blue herons *Ardea herodias*. During breeding, the proportion of each species was estimated on a sample of nests observed during at least 2 visits. These proportions were then extrapolated to the total number of nests, counted during the next fall when the nests were clearly visible on leafless trees. Grey heron nests were distinguished during post-breeding counts thanks to their larger size. The number of nests counted during fall was then multiplied by a conversion factor that accounted for the average number of nests that disappear between breeding and fall count, 1.12 for the grey heron, and 1.06 for the other species. These conversion factors had been estimated as the average ratio between total counts performed twice, during breeding and during the subsequent fall, at 20 sample heronries (M. Fasola, unpublished data). Post-breeding nest counts were adopted particularly for large heronries with many little egrets and black-crowned night herons, and when the disturbance of a complete count during breeding was not advisable. Even in these heronries, however, the scarce species, purple and squacco herons, cattle and great egrets, were counted individually during breeding, because their estimated proportion could be less precise than for the abundant species; 3) aerial photographic count, i.e., count of nests on low-altitude photos, used particularly for the few cases of purple heron colonies in reed beds; 4) perimeter count, i.e., expert estimates based on the number of visible nests and of foraging flights, observed from the colony edge. This technique was adopted in a few cases of small (< 100 nests) and inaccessible heronries where other techniques were inapplicable.

A single census technique was usually adopted year after year for the same colony until its size and characteristics remained suitable. The unit of count was in any case the number of nests, counted in the portion of the colony that was active during the breeding season. The few nests that may have remained in abandoned portions of the heronry from previous years were identified during breeding season surveys, and were not included in the count. Within the active portion of the heronry, on the other hand, we deemed irrelevant to consider whether a nest had been used or not during the present breeding season, because observations of large samples of marked nests at several colonies, performed as count tests and for recording breeding success (Fasola 1998), showed that in active heronries unguarded nests disappear in a few days because neighbour breeders rapidly steal their twigs. The synchrony of breeding within and between heronries was usually high within each heronry, with some variation among them. Eggs development plus chick growth, lasting about 50 days in the small squacco heron, and 90 days in the large grey heron (Kushlan and Hancock 2005), occurred from April to July throughout our study area. The limited phenological variations were taken into account by performing the counts of each heronry and species at the peak of the breeding season.

The shortcomings of the census techniques currently used for colonial waterbirds are well known, and still insurmountable (Kushlan 1992). Different census techniques provide estimates which have large confidence intervals (> 20%, Dodd and Murphy 1995) and accuracy is weakened by incomplete synchrony of breeding (Frederick et al. 2006), and by short nest persistence (Piazza and Wright 2004), so that no practicable technique can count all the nests that existed throughout the breeding season. Therefore, neither the actual number of nests, nor of breeders, may be approximated using the current techniques. Despite all our efforts to standardize the techniques adopted for the censuses in our study area, the results we obtained can only be interpreted as indicators of nest numbers at peak breeding. Within these limits, however, we believe that the number of nest recorded during our standardized counts can be used for the aims of this paper, i.e., to estimate long-term temporal changes in breeding numbers.

References

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Figure S1. Proportion of heronries censused in each year using each of the four counting techniques. Proportions were calculated by considering each species present in a heronry in a given year as one separate case, because in some instance the different species in given heronry and year were counted by different techniques.

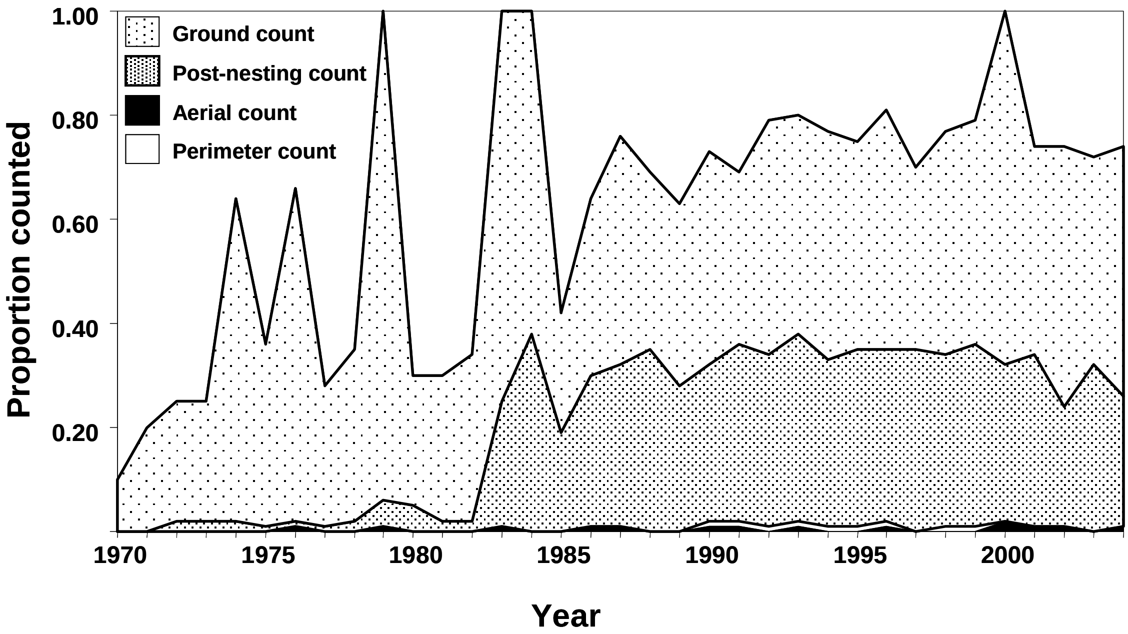

Figure S2. Trends in population size (estimated number of nests, derived by the TRIM Imputed index; see Methods) according to levels of the "habitat" covariate. Graphs are shown only if the effect of the covariate was statistically significant in the TRIM models (see Table S2).

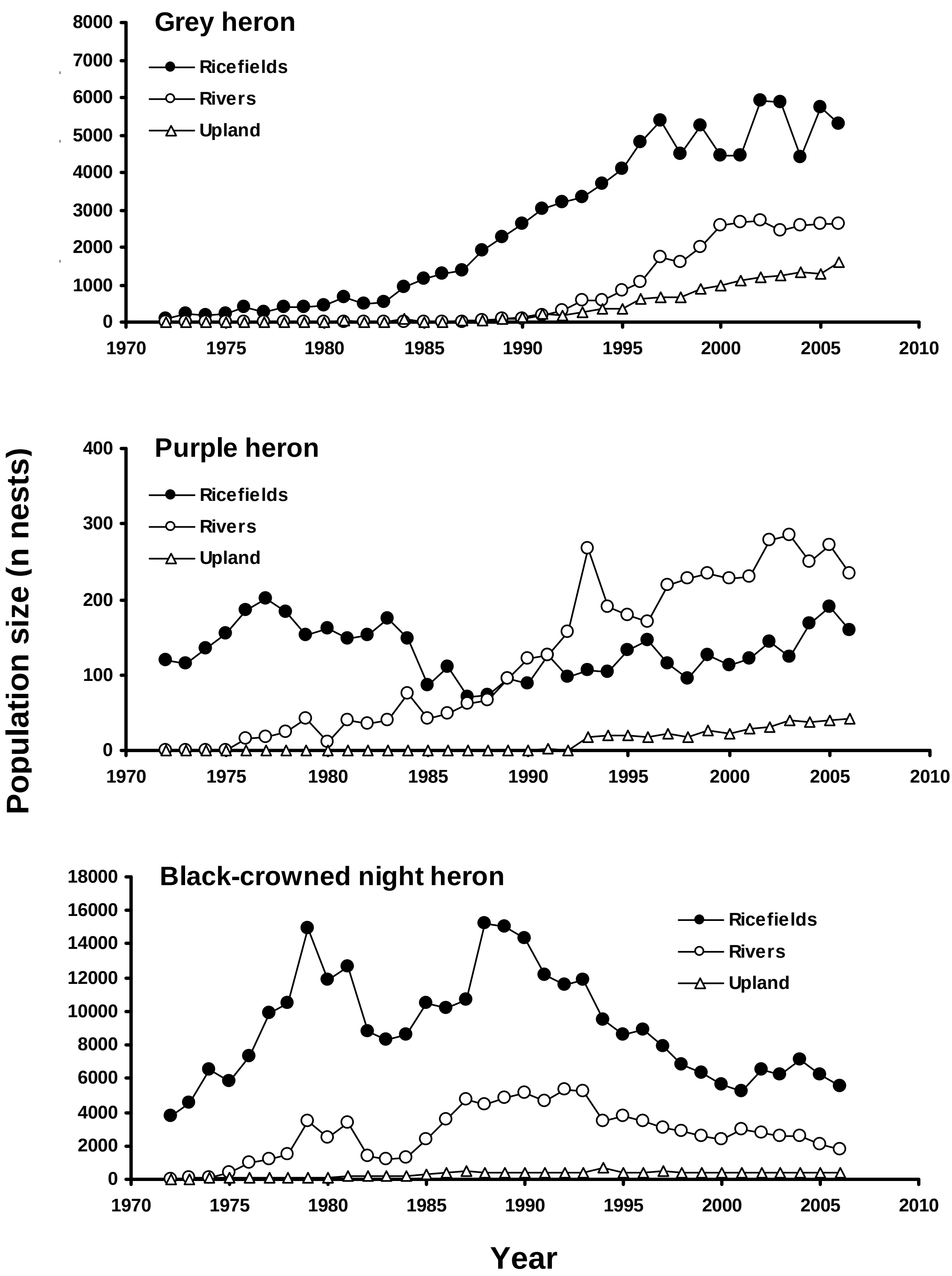

Figure S3. Trends in population size (estimated number of nests, derived by the TRIM Imputed index; see Methods) according to levels of the "protection" covariate. Graphs are shown only if the effect of the covariate was statistically significant in the TRIM models (see Table S2).

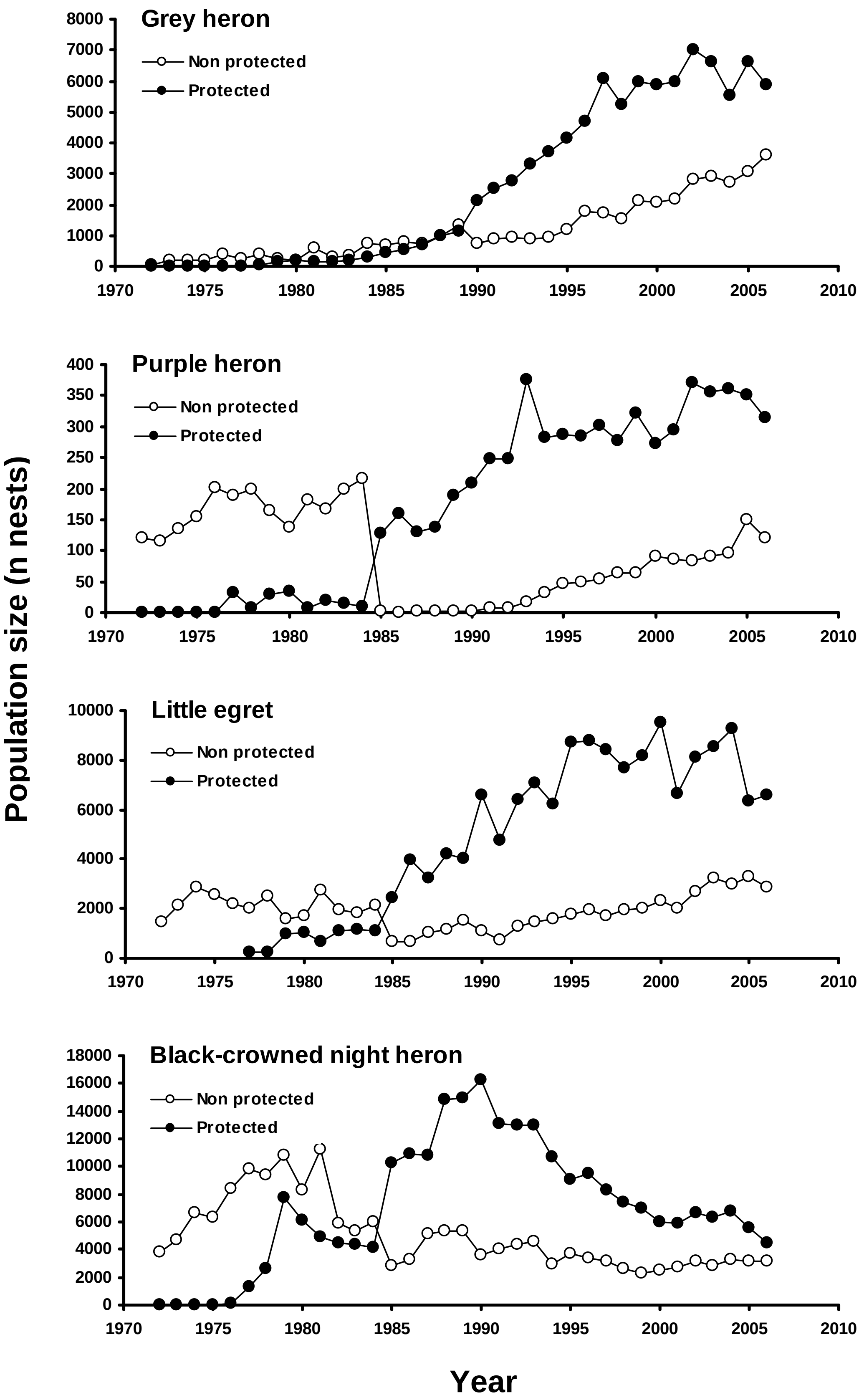

Table S1. Best-fitting regression models describing population trends of the five species that bred throughout the study period, 1972 to 2006. The following annotation was adopted for parameter values: B_0 refers to the constant, B_1 refers to the regression coefficient of the linear or unique term, B_2 refers to the regression coefficient of the quadratic term.

Species	Best function	Parameters (SE)	R^2	*F*	*df*	*P*	AICc	Second ranked function	ΔAICc
Grey heron	logistic	B_0 = 102.4 (13.47); B_1= 0.8 (0.01)	0.971	1108.90	1,33	< 0.001	-196.1	quadratic	36.8
Purple heron	quadratic	B_0 = 0.43 (0.06); B_1= -0.004 (0.008); B_2=0.001 (0.0002)	0.868	105.195	2,32	< 0.001	-139.9	quadratic	16.5
Little egret	logistic	B_0 = 7.6(0.79); B_1= 0.9 (0.004)	0.907	320.91	1,33	< 0.001	-149.9	linear	1.9
Squacco heron	linear	B_0 = 0.1 (0.07); B_1= 0.02 (0.003)	0.596	48.64	1,33	< 0.001	-145.3	logistic	41.1
B-c night heron	quadratic	B_0 = 0.4 (0.18); B_1= 0.2 (0.02); B_2=-0.004 (0.001)	0.623	26.49	2,32	< 0.001	-74.3	logistic	17.5

Table S2. Summary results of TRIM final models for each species: covariates retained in the models, change points and associated statistics.

	Model			Covariates				Change points			
Species	χ^2 Goodness of Fit	*df*	*P*	Variable	Wald-Test	*df*	*P*	Year	Wald-Test	*df*	*P*
Grey heron	58411	3590	< 0.001	Habitat	121.6	4	< 0.001	1997	253.0	4	< 0.001
				Protection status	22.0	2	< 0.001				
Purple heron	11591	1243	< 0.001	Habitat	53.1	6	< 0.001	1977	15.1	4	0.004
				Protection status	23.1	3	< 0.001	1988	2.7	4	0.61
								1993	9.3	4	0.06
Little egret	177662	1889	< 0.001	Protection status	16.9	3	0.001	1985	4.0	2	0.14
								1996	25.9	2	< 0.001
Squacco heron	6727	940	< 0.001	Habitat	7.3	6	0.29	1990	7.4	3	0.06
				Protection status	5.5	6	0.49	1994	10.6	3	0.014
								1995	15.9	3	0.001
								1997	16.4	3	0.001
								2002	19.1	3	< 0.001
B-c night heron	391082	2563	< 0.001	Habitat	19.1	10	0.039	1979	35.1	4	< 0.001
				Protection status	21.9	5	0.001	1983	22.7	4	< 0.001
								1988	34.3	4	< 0.001
								2000	4.5	4	0.34
Cattle egret	3693	709	< 0.001	-	-			1995	3.7	1	0.053
								2000	12.9	1	< 0.001
								2003	46.1	1	< 0.001
								2005	68.4	1	< 0.001
Great egret	597	171	< 0.001	-	-			2000	26.1	1	< 0.001
								2005	3.7	1	0.055