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Are Indices Reliable for Assessing Conservation Value of Natural Areas? An Avian Case Study

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ABSTRACT

Bird censuses in two wetland habitats (bogs and wet meadows) in SW Sweden were used to test the applicability of five conservation indices suggested for birds. The censused sites were first evaluated and ranked by the authors, then ranked according to each of the indices. Two indices based on species diversity (H' or λ) showed a poor agreement with our evaluation; we suggest that they should not be used for ranking of sites of ornithological interest. Three indices based on rarity showed a better agreement with our evaluation, but were influenced by the size of the geographical area for which rarity was assessed. None of the five indices takes into account all of the relevant aspects for an evaluation of the bird fauna at the different sites. Before constructing further indices, conservationists must reach agreement on which evaluation criteria to use, and how to use them. It may, however, not be feasible to construct a single index; a better strategy might be to construct indices only for single evaluation criteria.

INTRODUCTION

The problem of how to evaluate and rank natural areas considered for protection has received increasing attention in recent years (e.g. Margules & Usher, 1981; Spellerberg, 1981). Until recently, few ecological criteria have been considered in the evaluation of natural areas, and even fewer have been quantified. Mainly as a reaction against earlier practice, ecologists began constructing quantitative conservation indices (e.g.,

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Goldsmith, 1975; van der Ploeg & Vlijm, 1978; Klopatek *et al.*, 1981; see also below). Many indices are now available, and there is a need to test if they are appropriate in practical conservation work.

Criteria used for evaluation of natural areas may be principally 'scientific' or 'political' (see Margules & Usher, 1981); here we will only test indices which are solely based on scientific criteria. Our major concern is to assess the ornithological conservation values of a number of sites with a similar habitat type. Such comparisons of sites within a habitat are often made in practical conservation work. Quantitative census data for the breeding bird fauna are available for our sites, and these data were applied to five conservation indices suggested for birds (since we have census data, we did not test semi-quantitative indices which only rank and sum different factors, e.g., Wright, 1977; Rodebrand, 1979). The five indices are compared and related to an evaluation of the sites performed by ourselves.

MATERIAL AND METHODS

We used data from two censuses of birds, carried out by ourselves in two provinces in south-west Sweden. One census was of grazed wet meadows in 'Södra Älvsborgs län' (Eriksson, 1981*a*; Eriksson & Larsson, 1981), and the other was of bogs in 'Bohuslän' (Götmark *et al.*, 1983). Fifteen wet meadows (mean size 10 ha, range 2–22 ha) were censused five times between April and June 1979, and 47 bogs (mean size 27 ha, range 8–69 ha) were censused twice in May and June 1980. The number of breeding pairs was estimated from field maps. A few species, which are common also in other habitats, were not censused (e.g. *Anthus trivialis* on bogs, *Alauda arvensis* on wet meadows) since they would contribute very little to the conservation value of each site. Nesting species, number of pairs, and censused area at each site are given in the Appendix. Further details about sites and census methods are given in Eriksson & Larsson (1981) and Götmark *et al.* (1983).

In our original reports, we grouped the sites in three or four classes according to their ornithological value. For the purpose of this study, the ten sites regarded as the most valuable ones in each of the two habitats were chosen and ranked by ourselves. The remaining sites were of lower and more equal quality (see Appendix), and we found it difficult to separate them. The criteria used in our evaluation were degree of

rarity of the species (population size in a larger area, e.g., a region of a country), species richness, and density and number of pairs of different species at the site. Some other important factors taken into account are presented below. Because subjectivity cannot be avoided in evaluation of natural areas, our own ranking of the sites cannot be regarded as the 'true' ranking. The relevance of our ranking is discussed below.

We used the following five indices;

(1) Shannon's index of species diversity:

$$H' = -\sum_i p_i \ln p_i$$

where p_i = relative frequency of the ith species. This index was suggested as a useful indicator of the conservation value of waterfowl habitats (Bezzel & Reichholf, 1974) and of the ecological quality of freshwater marshes (Harris *et al.*, 1983).

(2) The θ index, which may be used 'when assessing areas that are candidates for conservation schemes' (Chanter & Owen, 1976):

$$\theta = \log(\beta N),$$

where N = total number of animals, and $\beta = 1 - \lambda$; λ is Simpson's index of diversity

$$\lambda = \frac{\sum_i n_i(n_i - 1)}{N(N-1)},$$

where n_i = number of individuals of the ith species and N = total numbers.

(3) CV, or 'Conservation value index', suggested by Nilsson & Nilsson (1976) as useful for the evaluation of wetlands as breeding habitats for birds:

$$CV = \sum_i \frac{n_i}{N_i},$$

where n_i = number of pairs of the ith species at a site, and N_i = population size (pairs) of the ith species in W. Europe [Nilsson & Nilsson (1976) used 'log N_i' in the denominator, but this should be avoided (S. G. Nilsson, pers. comm.; Järvinen & Väisänen, 1978; Andersson & Staav, 1980)]. Unfortunately, few accurate population estimates for 'W Europe' are available for the observed species. Instead, we used three different 'reference areas' in which we could more accurately

estimate N_i: Sweden (410 000 km^2 land area), South Sweden (166 000 km^2 south of the river Dalälven), and the provinces Bohuslän (for bogs; 5110 km^2) and Södra Älvsborgs län (for wet meadows; 7690 km^2).

(4) The V_k index, or 'the conservation value of the kth habitat' (Järvinen & Väisänen, 1978):

$$V_k = \sum_i V_{ik},$$

where V_{ik} is the conservation value of the ith species in habitat k,

$$V_{ik} = \frac{n_i A}{N_i^2} \delta_{ik}.$$

Here, n_i = population size of the ith species in a smaller region, such as a country or part of a country, A = area of this region, N_i = population size of the ith species in a larger region, such as several countries, and δ_{ik} = density of the ith species in habitat k. Järvinen & Väisänen (1978) used this index to compare the conservation value of single populations (V_{ik}) or different habitat types (V_k); we will use it to compare different sites within a single habitat type. In our calculations the parameters were defined as follows: n_i = population size of the ith species in the province (Bohuslän or South Älvsborgs län), A = area of the province, N_i = population size of the ith species in South Sweden or Sweden, and δ_{ik} = density of the ith species at site k.

(5) The B index (the avian component in an 'overall ecological index'; Klopatek *et al.*, 1981), for which the index value of the ith site is:

$$B_i = \sum_j F_{nj} F_{rj} F_{bj} F_{tj},$$

where the F's are defined for the jth species as follow:

$$F_{nj} = 1{\cdot}0 - \frac{\text{no. of individuals of the } j\text{th species in the country}}{\text{total no. of individuals of all species in the country}},$$

$$F_{rj} = 1{\cdot}0 - \frac{\text{no. of individuals of the } j\text{th species in the region}}{\text{total no. of all species in the region}},$$

$$F_{bj} = \frac{\text{no. of the } j\text{th species in stratum N}}{\text{no. of the } j\text{th species in Bailey Ecosection N}},$$

$$F_{tj} = F_{nj} + F_{rj} + F_{bj}.$$

Our 'country' is Sweden and our 'region' is South Sweden. For the 'ecoregional' or local level, instead of 'stratum' and 'Bailey Ecosection' (for definitions, see Klopatek *et al.*, 1981) we used site and province, respectively. Although the provinces are more heterogeneous than an ecosection, they were the only units which we could use (our sites occur as small isolated habitat islands in the provinces).

There are other conservation indices or schemes for ornithological sites (Kikkawa, 1976; Nord, 1978; Rodebrand, 1979; Fuller, 1980; Williams, 1980; Lloyd, 1984), but they were not applicable for this study. The 'GRIM' index presented in van der Ploeg & Vlijm (1978) is very similar to the CV index, and we have therefore not used it.

In all calculations, we use 'pair' (not individual) as the unit for n and N. Estimates of population sizes for birds in Sweden are from Ulfstrand & Högstedt (1976) and Andersson & Staav (1980). For South Sweden and the provinces, we estimated population sizes from the areal extension of different habitats and breeding bird densities in these habitats (various sources, most of them summarised by Ulfstrand & Högstedt, 1976). For the provinces we also used censuses published in local ornithological publications.

RESULTS AND DISCUSSION

Use of different reference areas

The selection of reference area (Sweden, South Sweden, or province in our case) relates to the 'problem of scale' (Margules & Usher, 1981), i.e., should rarity be assessed on a local, regional, national, or zoogeographical level? Among the indices, CV and V_k may be affected by which area is chosen to represent N_i (population size). If the CV index is used to calculate a conservation value for a single pair of the species concerned (Table 1), the value depends strongly on the choice of reference area. To what extent does choice of reference area affect the final ranking of sites by the CV index? To examine this, we produced three rankings of all 47 bogs, each based on a particular reference area. This was repeated for all 15 wet meadows. For each habitat type, we then selected the ten sites which we regarded as the most valuable (see above) and calculated correlation coefficients between the ranks in pairwise comparisons of reference areas. The ranks were fairly well correlated for the ten bogs

TABLE 1

Conservation Value (CV Index) for a Single Pair of Species Nesting in Wet Meadows and Bogs in SW Sweden: Effects of Using Different-Sized Reference Areas.[a]
(In parentheses, population size (pairs))

Species	*Province*				*Region*		*Nation*	
	Älvsborgs län[b]		*Bohuslän*[c]		*S Sweden*		*Sweden*	
Anas platyrhynchos	—		0·6	(2 000)	3	(60 000)	17	(90 000)
A. crecca	—		4	(300)	22	(9 000)	33	(45 000)
Bucephala clangula	—		2	(600)	40	(5 000)	29	(52 000)
Haematopus ostralegus	44	(75)	—		27	(7 500)	188	(8 000)
Charadrius dubius	44	(75)	—		222	(900)	1 500	(1 000)
Pluvialis apricaria	—		22	(50)	89	(2 250)	30	(50 000)
Vanellus vanellus	2	(1 550)	0·4	(3 000)	2	(100 000)	12	(120 000)
Philomachus pugnax	330	(10)	—		200	(1 000)	19	(80 000)
Gallinago gallinago	2	(1 700)	0·6	(2 000)	3	(75 000)	10	(150 000)
Numenius arquata	13	(250)	73	(15)	13	(15 000)	75	(20 000)
Tringa totanus	110	(30)	—		25	(8 000)	94	(16 000)
T. ochropus	3	(1 000)	3	(350)	6	(35 000)	25	(60 000)
T. glareola	22	(150)	—		100	(2 000)	9	(160 000)
Alauda arvensis	—		0·1	(10 000)	0·3	(600 000)	2	(800 000)
Anthus pratensis	1	(3 300)	1	(1 100)	1	(200 000)	1	(1 500 000)
Motacilla flava	5	(700)	7	(150)	4	(50 000)	4	(400 000)
Saxicola rubetra	—		0·2	(5 000)	1	(175 000)	4	(350 000)
Emberiza schoeniclus	—		0·1	(8 000)	0·7	(300 000)	2	(700 000)

[a] The value of each pair is inversely proportional to the population size in a given reference area. To obtain a manageable index value, we used the population size of *Anthus pratensis* (instead of 1) in the nominator.
[b] Wet meadows.
[c] Bogs.

TABLE 2
Correlation Coefficients, *r*, Between Ranks (CV Index) Based on Different Reference Areas: Province (*P*), South Sweden (*SS*) and Sweden (*S*).
(Ten sites were used in each habitat type (see text))

	Habitat type					
	Bogs			*Wet meadows*		
	P	*SS*	*S*	*P*	*SS*	*S*
P	—	0·83	0·88	—	0·82	0·79
SS	—	—	0·90	—	—	0·80

as well as for the ten wet meadows (Table 2). The three most valuable bogs were ranked in the same way irrespective of reference area, whereas only the most valuable wet meadow was recognised consistently. The results thus indicate a fairly good (but far from perfect) agreement between ranks based on different reference areas.

In the V_k index, only 'Sweden' or 'South Sweden' could be used as reference areas. For the same ten sites as above, the correlations between the ranks obtained using the two reference areas were 0·13 (bogs) and 0·73 (wet meadows). The V_k index thus seemed to be more sensitive for the use of different reference areas, presumably because it contains N_i^2 instead of N_i.

For indices such as CV and V_k, there is no simple solution to the problem of scale. One could argue that a particular reference area is the most appropriate one from a zoogeographical viewpoint; the composition of the fauna is rather homogeneous in that area. For example, we found it better to use 'South Sweden' as the reference area, because 'Sweden' includes the huge mountain heaths and bogs in the north, where, for example, several species of waders are more abundant than in the south (cf. Table 1). Klopatek *et al.* (1981) attempted to solve the problem of scale by incorporating rarity on three different levels (see above). However, for our sites the B values were almost completely determined by rarity on the local level (F_{bj}, range of values: 0·0001–0·3), which is undesirable if the aim is to give equal weight to different levels. For all our species, the values for the national (F_{nj}) and the regional (F_{rj}) level were close to 1 (mean: 0·9974, range: 0·9841–0·9999). If we use our highest value (0·9999) for both F_{nj} and F_{rj}, comparing it

with use of the lowest value (0·9841) for both terms, the value for any of the species at a site (that is, $F_{nj} \times F_{rj} \times F_{bj} \times F_{tj}$) do not differ by more than 4%. Only very abundant species will lower the terms F_{nj} and F_{rj} appreciably: among Swedish birds, the most common species (*Phylloscopus trochilus*, 15 million pairs) will still achieve values as high as 0·84 (F_{nj}) and 0·88 (F_{rj}).

For the indices CV and V_k, one possible way of incorporating rarity on different levels is to sum, for each site, the ranks achieved for two or more reference areas, and then attempt a final ranking. However, this new rank order may include both appropriate and less appropriate reference areas (see below).

Evaluation of the sites

Tables 3 and 4 compare the five indices and their ranking of the ten bogs and wet meadows which we judged to be the most valuable. Although the absolute index values might be useful for identification of particularly valuable sites, or for grouping of the sites, we only used

TABLE 3

Ranking of the Ten Most Valuable Bogs (chosen by the authors) according to the Authors and Five Indices
(Index values are given in parentheses)[a]

Site	*Authors' rank*	*Indices' rank*				
		H'	*θ*	*CV*	V_k^b	B^b
A	1	8 (1·32)	1 (1·75)	1 (1429)	1 (1·51)	1 (7·98)
B	2	22 (0·98)	3 (1·29)	2 (668)	5 (0·59)	2 (3·83)
C	3	14·5 (1·12)	2 (1·48)	3 (425)	8 (0·44)	3 (2·80)
D	4	19·5 (1·01)	5 (1·18)	4 (381)	7 (0·47)	5 (1·94)
E	5	1 (1·70)	4 (1·28)	5 (303)	14 (0·24)	7 (1·54)
F	6	16 (1·06)	6 (1·07)	6 (197)	9 (0·33)	8 (1·03)
G	7	12·5 (1·18)	12·5 (0·91)	9 (117)	17 (0·22)	4 (2·06)
H	8	21 (0·99)	16 (0·85)	8 (130)	12 (0·26)	10 (0·71)
I	9	12·5 (1·18)	11 (0·92)	11·5 (106)	10 (0·30)	14 (0·59)
J	10	4 (1·47)	12·5 (0·91)	10 (107)	15 (0·23)	18 (0·53)

[a] All 47 bogs were ranked according to their index value and therefore single sites could achieve a rank higher than 10. In the CV and V_k indices, we used 'South Sweden' to estimate N_i (for details about censuses and indices, see text).
[b] Index value multiplied by 10.

TABLE 4
Ranking of the Ten Most Valuable Wet Meadows (chosen by the authors) according to the Authors and Five Indices
(Index values are given in parentheses)[a]

Site	*Authors' rank*	*Indices' rank*				
		H'	*θ*	*CV*	V_k^b	B^b
A	1	1 (1·80)	2 (1·31)	1 (541)	1 (4·97)	1 (4·66)
B	2	2 (1·75)	4 (1·21)	7 (83)	7 (0·43)	4 (1·02)
C	3	3 (1·68)	8 (0·90)	3 (246)	5 (1·06)	2 (2·88)
D	4	7·5 (1·29)	1 (1·44)	2 (263)	3 (2·20)	3 (1·15)
E	5	9 (1·15)	3 (1·23)	4 (194)	4 (2·05)	6 (0·72)
F	6	6 (1·30)	5 (1·16)	5 (160)	2 (3·69)	8 (0·47)
G	7	5 (1·33)	9 (0·72)	9 (38)	12 (0·14)	5 (0·76)
H	8	12 (0·92)	6·5 (1·00)	8 (55)	10 (0·29)	9 (0·36)
I	9	9 (1·39)	10 (0·60)	13 (14)	13 (0·12)	11 (0·24)
J	10	7·5 (1·29)	6·5 (1·00)	6 (86)	11 (0·26)	7 (0·50)

[a] All 15 wet meadows were ranked according to their index value and therefore single sites could achieve a rank higher than 10. In the CV and V_k indices, we used 'South Sweden' to estimate N_i (for details about censuses and indices, see text).
[b] Index value multiplied by 10.

them to establish the order of conservation importance (all analyses are restricted to ranks).

For the five and ten most valuable sites (chosen by us), we calculated correlation coefficients between our ranking and that of each of the indices (Table 5). Five sites were used as it should be important to look at trends for the 'best' sites. Generally, a high correlation would indicate agreement between our evaluation and that of an index, but this could be obscured in some cases where many sites are ranked higher than ten by the indices: the ranks 1, 2, 3, 4, 5 and 12, 13, 14, 15, 16 would yield a perfect correlation, yet indicate little agreement. We therefore also checked how many of the five and ten sites, respectively, were missed by the indices, i.e., given a rank higher than five or ten.

There was much variation in the size of the correlation coefficients, both within and between indices and habitats (Table 5). For the same index and habitat type, the correlation or the number of missed sites in some cases differed substantially for the five and ten most valuable sites. The correlations obtained for the CV and V_k indices were to some extent influenced by the choice of reference area (summation of the areas

TABLE 5

Ranking of the Ten and Five Most Valuable Sites (chosen by the authors) in the Two Habitats: Correlation Coefficients between the Authors' Ranking and that of Each of the Indices.

(In parentheses, number of the chosen sites which were missed by the index, i.e. ranked lower than 10 or 5.)

Index	*Reference area*[a]	*No. of sites*			
		10		5	
		Wet meadows	*Bogs*	*Wet meadows*	*Bogs*
H′	—	0·58 (1)	−0·20 (7)	0·96 (2)	−0·30 (3)
θ	—	0·61 (0)	0·88 (4)	−0·06 (1)	0·80 (0)
CV	province (1)[b]	0·81 (1)	0·90 (2)	0·74 (1)	0·98 (1)
	S Sweden (2)	0·68 (1)	0·97 (1)	0·07 (1)	1·00 (0)
	Sweden (3)	0·58 (1)	0·88 (3)	0·62 (2)	0·80 (0)
	1 + 2 + 3[c]	0·75 (1)	0·95 (2)	0·66 (1)	1·00 (0)
V_k	S Sweden (1)	0·76 (3)	0·78 (4)	0·14 (1)	0·93 (3)
	Sweden (2)	0·71 (2)	−0·02 (7)	0·74 (2)	0·26 (4)
	1 + 2	0·73 (3)	0·20 (5)	0·46 (3)	0·31 (4)
B	—	0·84 (1)	0·91 (2)	0·74 (1)	0·98 (1)
Botanic[d] index	—	—	0·44 (4)[e]	—	0·15 (3)

[a] This is the area for which we estimated N_i in the indices CV and V_k.

[b] South Älvsborgs län (wet meadows) and Bohuslän (bogs).

[c] The ranks for single sites using reference areas 1, 2 and 3 were summed and a new ranking of sites was based on these sums (in the V_k index only reference areas 1 and 2 could be used).

[d] A semiquantitative botanical index based on seven evaluation criteria (Hallingbäck 1983).

[e] Includes only nine sites; one of the ten sites was not censused by the botanist.

yielded an 'average' correlation). The CV index showed the best agreement with our evaluation; it produced the highest correlations and missed few sites, and also seemed to be the most consistent of the indices (least variation in the *r* values). The B index is, at least in our case, very similar to the CV index. As noted above, the B index was determined almost exclusively by rarity and abundance of species in the province (the factor F_{bj}), and it yielded almost exactly the same values (both with regard to correlations and missed sites) as did the CV index for the province level (Table 5). H′ showed little agreement with our ranking;

the index produced negative correlations in two of four cases. Judging from correlations and number of missed sites, the indices θ and V_k seemed to be intermediate between CV and H′. H′ (Table 3) and θ (Table 4) once failed to recognise the site we ranked as 1, in both habitats a site of outstanding importance (see Appendix).

Assessment of the indices

Any correspondence between our ranking and an index ranking of the sites is likely to be due to similar evaluation criteria. Rarity was an important criterion in our evaluation and in the CV, B and V_k indices; this probably partly explains the correspondence between our and these indices' ranking. Rarity also was an important or major criterion in six other indices or schemes suggested for birds (Kikkawa, 1976; Nord, 1978; Rodebrand, 1979; Fuller, 1980; Williams, 1980; Lloyd, 1984), and in nine schemes examined by Margules & Usher (1981). The rationale for using this criterion is that rare species are more susceptible to human persecution and environmental changes induced by man.

Diversity (habitat diversity or species richness) is also a frequently used evaluation criterion (Margules & Usher, 1981). Species richness is not an essential criterion in the CV, B or V_k indices, or in Nord's index. In five other indices or schemes (Kikkawa, Rodebrand, Williams, Fuller, Lloyd), species richness is an important criterion. Bezzel & Reichholf (1974), Chanter & Owen (1976) and Harris *et al.* (1983) assumed that species diversity (H′ or λ) measures the conservation or ecological value of natural areas. However, a ranking of areas based on H′ often seems to give misleading results (Järvinen & Väisänen, 1978; Andersson & Staav, 1980; Haga, 1981). In the present study, there was only a weak correspondence between our ranking and those based on species diversity (indices H′ and θ). We therefore suggest conservationists should avoid using H′, λ or any similar index as an evaluation criterion (cf. Margules & Usher, 1981).

As applied in this study, the V_k index showed a fairly weak correspondence to our evaluation. A complicating factor in this index is that the distribution of a species in the reference area affects the conservation value. The larger the fraction of the N_i population in the smaller region (n_i), the larger the conservation value of the species (cf. Järvinen & Väisänen, 1978). This means that edge populations and populations that are evenly distributed may receive a small value, which may not

always be appropriate. Among the rare species on the bogs, *Bucephala clangula* received a large n_iA/N_i^2 value (0·12) since 12% of the regional population (N_i) breed in the province (n_i; cf. Table 1). A rarer species, *Pluvialis apricaria*, received a lower value (0·05) because only 2% of the regional population nest in the province. One pair of *B. clangula* nested on each of four bogs, ranked as 2, 3, 4 and 6 by the V_k index but far below 10 by us. For several reasons, *B. clangula* should be evaluated lower than, for example, *P. apricaria* (see next section). On the wet meadows, *Tringa glareola* received a high n_iA/N_i^2 value (0·29; cf. Table 1), and three sites, each with one pair of this species, were ranked as 2, 3 and 4 by the index, but lower by us (Table 4).

The disagreement between our ranking and that of the V_k index was also due to the density factor (δ_{ik}), which disfavoured some large sites and favoured some small sites (cf. Haga, 1981). For example, the 69 ha bog ranked as 14 by the V_k index (Table 3) would have been ranked as 6 if it had been of average size (30 ha). Density of different species was considered in our evaluation, but since the sites did not differ appreciably in area (see the Appendix), we attached little weight to density. If great weight were given to density in an index, it would be important to consider also total area or total number of birds at each site. Similarly, if density is not incorporated in an index, total area has also to be considered.

The B index was useful for assessing the bird fauna of wilderness tracts in the USA (Klopatek *et al.*, 1981), but it may sometimes be difficult to find appropriate reference areas to this index. As used by us, the B index evaluated rarity at the province level too highly (see above).

The final ranking of the bogs by the conservation authorities also included assessment of the flora. Our ranking of the ten bogs was weakly correlated with a ranking based on botanical value (Table 5). Thus, for a given bog, a high ornithological value does not necessarily imply a high botanical value.

Other considerations in the evaluation of the sites

Besides the evaluation criteria discussed above, some other criteria or considerations contributed to the disagreement between our ranking and that of the indices. Three important points are discussed below.

(1) We included small lakes at the margin of some bogs, together with a few pairs of some duck species (*Anas platyrhynchos*, *A. crecca*,

and *Bucephala clangula*). These species (especially *B. clangula*, see above) increased the index value of the bogs, but since they are not 'typical' for bogs (they are more common in lakes and other wetland habitats) they should be given little weight. Species which are rare and restricted to one habitat (for example, *Pluvialis apricaria* on bogs in South Sweden) should be given higher weight, because they are likely to be threatened if man starts to exploit this specific habitat (this is the case for bogs; Sjörs, 1980).

(2) One of the duck species, *B. clangula*, has increased in numbers during the 1960s and 1970s (e.g. Eriksson, 1981*b*), which should lower its present conservation value. On the other hand, a decreasing species should be given a higher value, particularly if it is rare and the population changes can be attributed to man (e.g. Adamus & Clough, 1978; Järvinen & Väisänen, 1978; Klopatek *et al.*, 1981).

(3) Our sites were only censused in one year and thus the long-term quality of a site may not be indicated: a rare species might have been absent during the census, but not in many other years. For the bogs we corrected for this by gathering older observations of *Pluvialis apricaria* and including them in the data.

GENERAL DISCUSSION AND CONCLUSIONS

When compared with our evaluation of the bird fauna on the investigated sites, none of the five indices could be considered as sufficient for a complete evaluation; additional criteria or factors need to be taken into account. Therefore, the indices cannot be used by laymen but only by ornithologists with the relevant knowledge. But, as the biologist must 'correct' index values and rankings, one may question if indices have any use at all in conservation work.

Different conservation indices emphasise different evaluation criteria and reflect the opinion of the index designer. In this situation, the most appropriate strategy would be a thorough and critical examination of the evaluation criteria, a process which has just started (e.g., Margules & Usher, 1981, 1984; Margules, 1984; Nilsson, 1984). Before agreement is reached about which criteria to use and how to use them, there is little point in constructing more 'overall' conservation indices.

Possibly, we will never be able to compare the conservation value of different areas by a simple index (cf. Järvinen, 1985). It may not be

feasible to solve all problems related to the construction of an overall index. First, some 'scientific' criteria such as naturalness and typicalness (Margules & Usher, 1981) are hard or impossible to quantify. Secondly, evaluation criteria are often correlated (e.g., the larger the area, the more species; the more species, the more rarities). Therefore, if several criteria are included in an index, scores given to different criteria cannot simply be summed, as this may overestimate the value of the 'best' sites. Thirdly, indices incorporating several criteria and several groups of organisms yield 'average' conservation values for different areas, and then may hide sites with outstanding qualities with respect to one criterion or organism group. Different criteria and organisms should therefore be considered both separately and together (e.g., Klopatek *et al.*, 1981). A final difficult problem is the weighting of different criteria and groups of organisms (for example, should insects be 'valued' less than birds?)

A better strategy might be to construct indices only for single evaluation criteria. Such indices will be easier to construct and perhaps more suitable for practical conservation work. For example, the CV, B or some similar index may be used as a rarity index, at least for birds. This approach requires further discussion and research on both the importance and the measurement of different evaluation criteria.

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APPENDIX

Nesting Bird Species, Numbers of Pairs, Rank Given by Authors and Censused Area for Each Investigated Site.
(Species: Ap = *Anas platyrhynchos*, Ac = *Anas crecca*, Bc = *Bucephala clangula*, Ho = *Haematopus ostralegus*, Cd = *Charadrius dubius*, Pa = *Pluvialis apricaria*, Vv = *Vanellus vanellus*, Pp = *Philomachus pugnax*, Gg = *Gallinago gallinago*, Na = *Numenius arquata*, Tt = *Tringa totanus*, To = *Tringa ochropus*, Tg = *Tringa glareola*, Aa = *Alauda arvensis*, Ap = *Anthus pratensis*, Mf = *Motacilla flava*, Sr = *Saxicola rubetra*, Es = *Emberiza schoeniclus*.)

No.	*Area (ha)*	*Rank*	*Ap*	*Ac*	*Bc*	*Ho*	*Cd*	*Pa*	*Vv*	*Pp*	*Gg*	*Na*	*Tt*	*To*	*Tg*	*Aa*	*Ap*	*Mf*	*Sr*	*Es*
Bogs																				
1	53	1	—	—	—			15	7		5	—		—		—	50	—	9	1
2	61	2	—	—	—			7	—		1	—		1		—	28	2	1	—
3	51	3	—	1	—			4	—		2	—		3		—	43	1	6	1
4	45	4	—	—	—			4	1		—	—		—		—	17	—	5	—
5	69	5	—	—	—			3	2		—	—		3		—	5	—	7	3
6	33	6	—	—	—			2	—		1	—		—		—	11	—	5	—
7	25	7	—	—	—			1	—		—	1		—		—	8	1	2	—
8	29	8	1	—	—			1	—		1	—		1		—	10	—	—	—
9	19	9	—	—	—			1	1		2	—		—		—	9	—	1	—
10	26	10	—	—	—			1	—		2	—		1		—	2	—	4	—
11	19		1	—	1			1	—		—	—		—		1	6	—	1	—
12	22		—	—	—			1	—		—	—		2		—	6	—	—	—
13	31		—	—	—			1	—		—	—		1		—	11	—	—	—
14	21		—	—	—			1	—		3	—		1		—	3	—	—	—
15	29		—	—	—			1	—		—	—		1		—	6	—	3	—
16	25		—	—	—			1	—		2	—		—		1	7	—	—	—
17	19		1	1	1			—	—		1	—		—		—	7	1	3	—
18	17		1	—	1			—	—		—	—		2		—	1	—	—	—
19	25		—	4	1			—	—		—	—		1		—	7	—	—	1
20	29		—	—	—			—	—		1	—		1		—	7	2	3	—

(*continued*)

APPENDIX—*contd.*

No.	*Area (ha)*	*Rank*	*Ap*	*Ac*	*Bc*	*Ho*	*Cd*	*Pa*	*Vv*	*Pp*	*Gg*	*Na*	*Tt*	*To*	*Tg*	*Aa*	*Ap*	*Mf*	*Sr*	*Es*
21	19		—	—	—			—	—		1	1		—		—	10	—	—	—
22	27		—	—	—			—	—		4	—		1		—	3	—	3	2
23	15		—	—	—			—	—		—	1		—		—	6	—	1	—
24	38		—	1	—			—	2		—	—		2		—	9	—	—	—
25	27		—	—	—			—	—		—	—		—		—	16	—	2	—
26	66		—	1	—			—	—		—	—		—		—	14	—	3	—
27	18		—	—	—			—	—		—	—		2		—	4	—	—	—
28	24		—	—	—			—	—		1	—		1		—	3	—	3	—
29	27		—	—	—			—	—		—	—		1		—	5	—	3	—
30	33		—	1	—			—	—		—	—		—		—	7	—	3	—
31	16		—	—	—			—	—		—	—		—		—	9	—	3	—
32	18		—	—	—			—	—		—	—		1		—	4	—	—	—
33	8		—	—	—			—	—		—	—		1		—	1	—	2	—
34	24		—	—	—			—	—		1	—		—		—	5	—	1	—
35	27		1	—	—			—	—		—	—		—		—	4	—	—	1
36	21		—	—	—			—	—		—	—		—		—	7	—	1	—
37	16		—	—	—			—	2		—	—		—		—	3	—	1	—
38	16		—	—	—			—	—		—	—		—		—	5	—	—	—
39	26		—	—	—			—	—		—	—		—		—	1	—	4	—
40	27		—	—	—			—	—		—	—		—		—	4	—	—	—
41	17		—	—	—			—	—		—	—		—		—	3	—	1	—
42	23		—	—	—			—	—		—	—		—		—	4	—	—	—
43	27		—	—	—			—	—		—	—		—		—	1	—	3	—
44	19		—	—	—			—	—		—	—		—		—	3	—	—	—
45	11		—	—	—			—	—		—	—		—		—	1	—	—	—
46	17		—	—	—			—	—		—	—		—		—	1	—	—	—
47	12		—	—	—			—	—		—	—		—		—	—	—	—	1

Wet meadows														
1	17	1		—	1		6	1	4	—	3	—	—	5	4
2	10	2		—	—		3	—	3	1	1	1	—	5	5
3	9	3		—	—		3	1	2	—	1	1	—	—	1
4	18	4		—	—		4	—	11	2	—	2	2	1	22
5	17	5		—	—		1	—	8	—	—	1	1	1	16
6	9	6		—	—		3	—	9	—	—	1	1	—	6
7	9	7		—	—		2	—	2	—	1	—	—	—	1
8	12	8		—	—		—	—	5	—	—	—	—	2	10
9	10	9		—	—		1	—	1	—	—	1	—	—	1
10	22	10		—	—		—	—	4	4	—	1	—	—	4
11	5			—	—		—	—	2	—	—	—	—	—	5
12	5			1	—		—	—	1	—	—	—	—	—	2
13	4			—	—		—	—	1	—	—	—	—	—	—
14	3			—	—		—	—	—	—	—	—	—	—	1
15	2			—	—		—	—	1	1	—	—	—	—	1