Birds as a tool in reserve planning

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I discuss the prospects of using birds as criteria in establishing nature reserves in two complementary contexts: (1) the protection of birds, and (2) the use of birds as indicators of valuable ecosystems. For bird protection, knowledge of the autecology of endangered species is indispensable. I suggest that groups of bird species with similar geographic distribution and habitat requirements can be used as indicators of habitats that are typical of particular biogeographic zones.

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Introduction

An element of frustration is often evident in discussions on the relationship between ecological research and nature conservation. Indeed, sometimes these two activities seem to be far removed from each other. Conservation comprises a diffuse cloud of practical challenges facing humanity, whereas ecological research often deals with problems only distantly related to any practical considerations and apparently driven by their internal dynamics. However, the relationship is a historical variable, and it can be changed. The frustration is a consequence of approaching the relationship in too general terms. Instead, specific questions need to be phrased by defining the conservation need and asking how it can be formulated as an ecological research problem; or, *vice versa*, by examining the practical implications of an ecological idea for humanity-nature interactions. In the development of science, including ecology, *problem* is an important integrating category.

In this paper I discuss relations between bird ecology and nature reserve planning. Ever since the establishment of nature reserves was adopted as a strategy for preserving the ecological diversity of the biosphere (as formulated by Unesco 1974, IUCN 1980), ecologists have been faced with the practical problem of evaluating the ecological worth of natural areas, and assessing their conservation value (Helliwell 1973, Smith 1976, Everett 1979, Usher 1979, Fuller 1980, Margules & Usher 1981, Margules 1984, Nilsson 1984). In the case of a particular taxon, such as birds, the task can be divided into two components: (1) definition of criteria for the reserves that will ensure that they protect the bird species; and (2) use of the bird fauna as an indicator of valuable natural ecosystems. These components are closely linked, as endangered species often have special environmental requirements and may, consequently, be dependent on the availability of certain natural habitats. The questions are not identical, however, for two reasons. First, protection of endangered populations may also require other measures, such as habitat and breeding site management, or even breeding in captivity (see, e.g., Halliday 1980). Second, reserves are subject to constant ecological change, partly due to human-induced alterations in the surrounding areas, and this may strongly affect the populations breeding there (Väisänen & Järvinen 1977, Kushlan 1979). Different measures may thus be necessary for protecting the area or the endangered populations.

Reserves as islands

The equilibrium approach. An approach to deriving criteria for nature reserve planning that has gained wide popularity since the 1970s is based on the equilibrium theory of island biogeography (MacArthur & Wilson 1967, see also Diamond 1975, Wilson & Willis 1975). The starting point in the theory is the empirical generalization that the species number and area of an island are positively correlated with each other. According to the equilibrium hypothesis, the species number on each island is determined as an equilibrium between immigration and extinction rates, which are functions of the area (and isolation) of the island. This would explain why the species number is generally higher on a large island close to the mainland than on a small, distant island.

Nature reserves can be regarded as islands surrounded by a "sea" of inhabitable human-modified environments. Various rules for the design of reserves have been derived from this approach, including the recommendation that a single large reserve should always be preferred to several small ones with the same total area (see Diamond 1975). The approach has met with increasing criticism, however (summarized, e.g., by Simberloff & Abele 1976, 1982, Helliwell 1976, Järvinen 1982a,b, Margules et al. 1982, Lahti 1984). An important objection is that the recommendations have not been tested, because adequate data are lacking. Theoretically, the recommendations can be questioned, because the equilibrium hypothesis is not the only possible explanation for the positive correlation between species number and island area. Other alternatives are: (1) the habitat diversity of islands usually increases with area as well, which would cause the inclusion of habitat specialists in the species list of the island; and (2) the number of pairs residing on a large island is greater than on a small one, and rare species are expected to be included in the community as a statistical consequence of increasing sample size (see Connor & McCoy 1979, Williamson 1981, Haila & Järvinen 1983).

The alternative explanations would lead to rules for planning reserves partly differing from those derived from the equilibrium hypothesis. If the habitat diversity hypothesis is correct, the species number in reserves can be maximized by selecting areas that represent many different habitat types. Different factors are probably important in different conditions, and the species-area relationship is best viewed as a general expression of how populations and communities vary in space (Williamson 1981, Haila 1983a). This implies that no recommendations about the design of reserves can be based on the species-area relationship alone. The equilibrium approach has also been applied for migratory birds in small non-isolated habitat fragments (for references, see Haila 1985), but a serious methodological problem is involved: the equilibrium theory is based on mere presence or absence of species, but in conditions where most of the bird species disperse efficiently (e.g., regular long-distance migrants), colonization ability is clearly a function of population numbers (see Haila & Järvinen 1983, Haila & Hanski 1984, Haila 1985).

Colonization of insular environments. The application of equilibrium island biogeography to conservation has had the merit of being one of the few cases in which the implications for conservation of a particular ecological idea have been elaborated in detail. As a strict explanatory model the approach is unrealistic, but it can be used as a research programme that suggests further investigations (see Haila & Järvinen 1982). An alternative way to approach the consequences of the insularity of reserves would be to formulate general models about how birds colonize an insular environment, and maintain populations there.

Data from bird communities on small islands in the Åland and Inari archipelagoes (southern and northern Finland, respectively) suggested a model for the colonization of non-isolated islands by northern land birds (see Haila 1983a,b, 1985, Haila et al. 1983). The model is based on the hypothesis that different species colonize an island (or a habitat fragment) independently of each other, and in numbers that depend on (1) their abundance in the surrounding area, and (2) the habitat composition of the fragment (relative to the requirements of individual bird species). A stochastic element is inherent in the actual colonization process, however. This is reflected in the site selection of individual pairs: on any single island the species list and population numbers of the breeding community vary from year to year, although population levels in the archipelago as a whole were approximately constant. The communities of small islands can thus be viewed as samples that are "drawn" by the islands from a surrounding species pool, and year-to-year changes in population numbers on any single island can be expected as a statistical consequence of random sampling. Comparable mainland data are scarce (but see Preston 1960). Recently Svensson et al. (1984) observed that the population fluctuations of most passerines in a study plot in northern Sweden in a 20-year period could be approximated by the Poisson series, i.e., the local populations in the plot behaved as if they were random samples from a stable avifaunal pool in the surrounding areas.

The sampling model implies that the insularity of reserves would not be a major issue. The probability that a species is found in a single reserve depends on its abundance in the surrounding areas, and the habitat composition of the reserve (relative to the requirements of the species). Due to the inherent stochasticity of colonization, the population numbers in any single reserve will vary from year to year, however, even though the regional population is stable.

Which species are sensitive to insularity? The conclusions derived from the sampling colonization model are tentative but suggest problems for further research. First, it is necessary to specify the biogeographic domain in which the sampling model is valid. The model is certainly unrealistic (1) where geographic isolation is important (distant oceanic islands), or (2) where the habitats of the islands are so different from those on the mainland that they lead to special ecological adaptation in the populations breeding there. The second conditions is true, e.g., in the archipelagoes north of Scotland (Lack 1942) and on the Faroe Islands (Bengtson & Bloch 1983). In the Åland and Inari archipelagoes neither of these factors is important: the isolation is insignificant for the great majority of the species, and the islands have vegetation similar to that on the mainland, although the spatial structure of their habitats is somewhat different.

Second, although the sampling model is adequate as a general model of colonization of small islands (or habitat fragments) by birds in northern conditions, it does not follow that it is valid for each individual species. The main characteristics that can be used for comparing different species in this respect are (1) dispersal ability, and (2) specificity of habitat requirements. On the basis of these criteria, four categories of species can be formed:

A. Habitat generalists with good dispersal ability.
B. Sedentary habitat generalists.
C. Habitat specialists with good dispersal ability.
D. Sedentary habitat specialists.

In the Finnish conditions, species belonging to categories A and B cannot give many cues for planning reserves: they include species that have only a small fraction of their total population breeding in reserves. This is obviously true of abundant species, but is presumably valid for scarce species as well. To demonstrate this point, I refer to the study by Tjernberg (1984) on the habitat selection of the Red-breasted Flycatcher *Ficedula parva* in Uppland, central Sweden, where the species is scarce. Tjernberg (1984) checked 50 breeding sites of the Red-breated Flycatcher and noticed that these forest stands were distributed among different age classes in the same proportions as forests in Uppland in general (stands less than 40 years old excluded). This indicates that the species is not restricted to old forests, which are protected in reserves (contrary to the prevailing view on its habitat selection, see, e.g., v. Haartman et al. 1963–72).

Characterization of species such as the Red-breasted Flycatcher along the generalist-specialist axis is not straightforward. The species is abundant and fairly generalized in its main distribution range in Siberia. It is often regarded as a habitat specialist in northwestern Europe; this is probably true on a local scale, but as the study of Tjernberg (1984) suggests, not necessarily true on a regional scale. The northwest European population of the Red-breasted Flycatcher has been increasing in the twentieth century, which has probably also broadened its habitat amplitude.

For the species with specialized habitat requirements, in categories C and D, reserves are more important. Category C includes migratory species breeding in habitats that are patchy also in natural conditions (such as wetlands and peatlands; e.g., peatland waders and *Acrocephalus* warblers). Colonization of habitat patches far from each other belongs to their natural dispersal pattern. The probability that any single suitable habitat island will be colonized is influenced by the regional population level, i.e., the total area of suitable habitats. Consequently, preservation of high-quality habitats everywhere, even in small patches, has a high priority for the protection of these species.

Birds of prey are a special group in this respect: they usually have specialized nest-site requirements, but combined with an ability to include various types of environment in their hunting territory (Newton 1979, Mikkola 1983). Lundberg (1980, 1981) observed that the Ural Owl *Strix uralensis* may profit by fragmentation of its breeding environments, provided that a suitable nesting locality is preserved. This implies that establishment of reserves would not be of primary importance for the protection of birds of prey in northwestern Europe; it is more important to protect nesting localities, construct artificial nests (Saurola 1978), and prevent persecution.

Sedentary habitat specialists are least tolerant of insularity of the breeding environment. A sad example is provided by the recent extinction of the Middle Spotted Woodpecker *Dendrocopos medius* in Sweden. According to Pettersson (1985) the foremost cause of the extinction was increasing isolation of the small Swedish population, which made it more vulnerable to various harmful factors such as inbreeding depression, variation in resource availability and cold winters. Another species belonging to this category in northwestern Europe is the White-backed Woodpecker *D. leucotos*, which requires light deciduous stands. Knowledge of the precise environmental requirements of a habitat specialist is necessary for a successful protection strategy. Pettersson (1985), for instance, emphasized that the specialized habitat selection of the Middle Spotted Woodpecker is due to its dependence on oak for foraging. The occurrence of oak in the environment is important, but the composition of the plant community can be variable.

There is no substitute for good knowledge of the autecology of endangered species: it can give guidelines for the design of reserves. The more urgently conservation is needed for a particular species, the better its specific requirements must be known, and the less reliable are general assessments of habitat quality. A general classification of sites that are potentially valuable for the protection of birds (such as was provided by Fuller (1980) for Britain) is certainly valuable for a general conservation strategy, but I want to emphasize two methodological points.

First, the analogy between reserves and islands should not confine consideration to reserves. For some types of species establishment of proper reserves is very important, but the future of all bird populations is decisively influenced by developments in human-modified environments. Indeed, for most species it is unrealistic to believe that they can be preserved exclusively in reserves; exceptions are strictly localized populations in the tropics or on oceanic islands.

Second, the presence of rare species is often regarded as an important criterion of areas that are important for bird protection (e.g., Graber & Graber 1976, Fuller 1980). Rarity is a problematic characteristic, however, because it can be a consequence of various ecological factors (Drury 1974, Harper 1981, Rabinowitz 1981). The White-backed Woodpecker and the Red-flanked Bluetail *Tarsiger cyanurus*, for instance, are both rare in Fennoscandia, though abundant in a vast area east of Finland. Their conservation status is completely different, however. The tiny Finnish population of the Red-flanked Bluetail is probably wholly dependent on population changes in its main breeding area, whereas the White-backed Woodpecker, as a sedentary species, would profit by good management even at the limits of its distribution.

Birds as indicators of valuable ecosystems

"Typicalness" and "representativeness" are attributes that are often used as criteria of valuable natural areas (see the review by Margules & Usher 1981). Such criteria are necessarily scale-dependent: what is representative of a local area may be exceptional in a larger region. Consequently, the definition of "representativeness" requires both data from a wide geographic region and thorough knowledge of the community types within the area considered (Margules & Usher 1981). Even then a subjective element remains in the assessment of the representativeness of a particular site (Margules 1984).

The use of any single taxon, such as birds, as a criterion in searching for representative ecosystems is problematic, for several reasons. Combined indices are suspect because they usually emphasize exceptional rather than ordinary habitat types (apart from the other problems inherent in the use of indices, see Järvinen 1985). Single species are not particulaly useful either: abundant species occur everywhere, and the stochasticity inherent in the site selection of scarce species makes their local occurrence vary from year to year.

As a possible procedure, I suggest formation of groups that contain species with similar habitat requirements and geographic distribution. A framework for such groups is given by the distributional types elaborated by Chernov (1975; see Haila 1983b). They are based on the assumption that general agreement can be found between the evolutionary history and environmental requirements of individual species and the biogeographic zonality of the environment.

The "zonal distribution" of Chernov (1975) is a distribution that is mainly restricted to habitats that are typical of a given biogeographic zone. The zonal species of the Palaearctic taiga would be species restricted to typical northern coniferous forests. Groups of zonal species might be used as indicators of the representative habitats of that zone. Such a group is formed, for instance, by the species of the northern taiga: in Finland it includes the Capercaillie *Tetrao urogallus*, Three-toed Woodpecker *Picoides tridactylus*, Siberian Tit *Parus cinctus*, Siberian Jay *Perisoreus infaustus*, Crossbill *Loxia curvirostra*, Pine Grosbeak *Pinicola enucleator* and Rustic Bunting *Emberiza rustica*. No single one of these species could be used to differentiate between different sites, but taken as a whole the group might indicate important areas of taiga habitats. The group can be supplemented with taiga species that are rare in Finland, such as the Red-flanked Bluetail, Arctic Warbler *Phylloscopus borealis*, Two-barred Crossbill *Loxia leucoptera* and Little Bunting *Emberiza pusilla*, but their year-to-year occurrence at the margin of their range is greatly influenced by chance.

Similar indicator groups can be compiled for other zonal habitats. The biogeographic framework of the approach makes it possible to combine local and regional (even continental) scales. It is also important that species belonging to other faunal types be left out of consideration; for instance, the populations of southern species in north Finnish forests seem to be influenced by population changes in more southern areas (Väisänen et al. 1986).

Birds in reserves: concluding remarks

I have emphasized the significance of ecological information on the species that need protection. Indeed, it seems improbable that any general recommendations on the design of reserves can be based on bird occurrence. The need of reserves for bird protection must be specified case by case, and the detailed design depends on the species that are protected. It is possible to name groups of bird species that are in need of reserves, particularly habitat specialists. However, the insularity of reserve systems is a much more serious risk for sedentary than for migratory habitat specialists. General ecological criteria could presumably be established for the reserves of these species groups separately.

It is also questionable whether birds can be used as broadly applicable criteria in assessing the conservation value of natural sites. Subjective decisions are involved in the definition of criteria, and in evaluating the agreement between criteria and observation data for any particular site. However, as Margules (1984) suggested, one way to a more objective evaluative procedure would be to inspect the relations between different communities and environmental types. As the relations between birds and their environment are well known compared with those of most other taxa, avian ecology certainly has potential in this respect.

My discussion in this paper is restricted to northern Europe, but biogeographic differences certainly exist. The insularity of reserves is a more pronounced problem in southern areas, where isolation is more important for breeding birds than in the north. Whatever the biogeographic region, however, general biogeographic ideas about the design of reserves should be substantiated with adequate ecological data.

Selostus: **Linnut suojelualueiden suunnittelussa**

Kirjoituksessa käsittelen lintujen käyttöä suojelualueiden suunnittelussa kahdessa, toisiaan täydentävässä mielessä: 1) lintujen suojelussa ja 2) arvokkaiden luonnonalueiden osoittamisessa. Lintujen suojelun kannalta on välttämätöntä tuntea uhanalaisten lajien ekologia. Levinneisyydeltään ja ympäristövaatimuksiltaan samankaltaisten lintulajien ryhmiä voidaan käyttää tietylle eliömaantieteelliselle vyöhykkeelle tyypillisten ympäristöjen ilmaisijoina.

References

Bengtson, S-A. & Bloch, D. 1983: Island land bird population densities in relation to island size and habitat quality on the Faroe islands. — Oikos 41:507—522.
Chernov, Yu. I. 1975: Prirodnaya zonal'nostj i zhivotnyj mir sushi. — Mysl', Moskva.
Connor, E. F. & Coy, E. D. 1979: The statistics and biology of the species-area relationship. — Amer. Nat. 113:791—833.
Diamond, J. M. 1975: The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. — Biol. Conserv. 7:129—146.
Drury, W. H. 1974: Rare species. — Biol. Conserv. 6:162—169.
Everett, R. D. 1979: The functions of wildlife and their possible use for deriving site selection components. — Biol. Conserv. 16:207—218.
Fuller, R. J. 1980: A method for assessing the ornithological interest of sites for conservation. — Biol. Conserv. 17:229—239.
Graber, J. W. & Graber, R. R. 1976: Environmental evaluations using birds and their habitats. — Illinois Nat. Hist. Survey, Biol. Notes 97:1—39.
v. Haartman, L., Hildén, O., Linkola, P., Suomalainen, P. & Tenovuo, R. 1963—72: Pohjolan linnut värikuvin (in Finnish). — Otava, Helsinki.
Haila, Y. 1983a: Land birds on northern islands: sampling metaphor for insular colonization. — Oikos 41:334—351.
Haila, Y. 1983b: Colonization of islands in a north-boreal Finnish lake by land birds. — Ann. Zool. Fennici 20:179—197.
Haila, Y. 1985: Northeuropean land birds in forest fragments: evidence for area effects? — *In* Verner, J. D., Morrison, M. L. & Ralph, C. J. (eds.): Modeling

habitat relationships of terrestrial vertebrates. Univ. Wisconsin Press, Madison (in press).
Haila, Y. & Hanski, I. K. 1984: Methodology for studying the effect of habitat fragmentation on land birds. — Ann. Zool. Fennici 21:393—397.
Haila, Y. & Järvinen, O. 1982: The role of theoretical concepts in understanding the ecological theatre: a case study on island biogeography. — *In* Saarinen, E. (ed.): Conceptual issues in ecology: 261—278. Reidel, Dordrecht.
Haila, Y. & Järvinen, O. 1983: Land bird communities on a Finnish island: species impoverishment and abundance patterns. — Oikos 41:255—273.
Haila, Y., Järvinen, O. & Kuusela, S. 1983: Colonization of islands by land birds: prevalence functions in a Finnish archipelago. — J. Biogeogr. 10:499—531.
Halliday, T. 1980: Vanishing birds. Their natural history and conservation. — Penguin, Harmondsworth.
Harper, J. L. 1981: The meanings of rarity. — *In* Synge, H. (ed.): The biological aspects of rare plant conservation: 189—203. Wiley & Sons, Chicester.
Helliwell, D. R. 1976: The effects of size and isolation on the conservation value of wooded sites in Britain. — J. Biogeogr. 3:407—416.
IUCN 1980: World conservation strategy. — IUCN - UNEP - WWF.
Järvinen, O. 1982a: Conservation of endangered plant populations: single large or several small reserves? — Oikos 38:301—307.
Järvinen, O. 1982b: Studies in island biogeography and their relevance for fauna conservation and management. — *In* Pettersson, B. (ed.): Current problems in fauna conservation: 36—39. Sveriges Lantbruksuniversitet, Inst. Wildl. Ecol., Uppsala.
Järvinen, O. 1985: Conservation indices in land use planning: dim prospects for a panacea. — Ornis Fennica 62:101—106.
Kushlan, J. A. 1979: Design and management of continental wildlife reserves: lessons from the everglades. — Biol. Conserv. 15:281—290.
Lack, D. 1942: Ecological features of bird faunas of small British islands. — J. Anim. Ecol. 11:9—36.
Lahti, T. 1984: Luonnonbiotooppien pirstoutuminen ja luonnonsuojeluekologia (in Finnish). — Ympäristön- ja luonnonsuojeluosaston julkaisu A:13. Ympäristöministeriö, Helsinki.
Lundberg, A. 1980: Why are the Ural Owl Strix uralensis and the Tawny Owl S. aluco parapatric in Scandinavia? — Ornis Scand. 11:116—120.
Lundberg, A. 1981: Population ecology of the Ural Owl Strix uralensis in Central Sweden. — Ornis Scand. 12:111—119.
MacArthur, R. H. & Wilson, E. O. 1967: The theory of island biogeography. — Princeton Univ. Press, Princeton.
Margules, C. R. 1984: Vegetation inventory and conservation evaluation: a case study from the North York Moors, England. — Appl. Geography 4:293—307.
Margules, C. & Usher, M. B. 1981: Criteria used in assessing wildlife conservation potential: a review. — Biol. Conserv. 21:79—109.
Margules, C., Higgs, A. J. & Rafe, R. W. 1982: Modern biogeographic theory: are there any lessons for nature reserve design? — Biol. Conserv. 24:115—128.
Mikkola, H. 1983: Owls of Europe. — Poyser, Calton.
Newton, I. 1979: Population ecology of raptors. — Poyser, Berkhamsted.
Nilsson, C. 1984: Kriterier för biologisk värdering av natur från skyddssynpunkt (in Swedish). — Statens naturvårdsverk PM 1881. Stockholm.
Pettersson, B. 1985: Extinction of an isolated population of the Middle Spotted Woodpecker Dendrocopos medius (L.), in Sweden: relations to general theories on extinction. — Biol. Conserv. (in press).
Preston, F. W. 1960: Time and space and the variation in species. — Ecology 41:611—627.
Rabinowitz, D. 1981: Seven forms of rarity. — *In* Synge, H. (ed.): The biological aspects of rare plant conservation: 205—217. Wiley & Sons, Chicester.
Saurola, P. 1978: Artificial nest construction in Europe. — *In* Greer, T. A. (ed.): Bird of prey management techniques: 72—80. British Falconer's Club, Oxford.
Simberloff, D. S. & Abele, L. G. 1976: Island biogeography theory and conservation practice. — Science 191:285—286.
Simberloff, D. S. & Abele, L. G. 1982: Refuge design and island biogeographic theory: effects of fragmentation. — Amer. Nat. 120:41—50.
Smith, R. L. 1976: Ecological genesis of endangered species: the philosophy of preservation. — Ann. Rev. Ecol. Syst. 7:33—55.
Svensson, S., Carlsson, U. T. & Liljedahl, G. 1984: Structure and dynamics of an alpine bird community, a 20-year study. — Ann. Zool. Fennici 21:339—350.
Tjernberg, M. 1984: Breeding habitat of Red-breasted Flycatcher Ficedula parva in Uppland, eastern Sweden (in Swedish with English summary). — Vår Fågelvärld 43:275—282.
Unesco 1974: Task force on criteria and guidelines for the choice and establishment of biosphere reserves. — Unesco and Unep, Paris.
Usher, M. B. 1979: An assessment of conservation values within a large site of special scientific interest in North Yorkshire. — Field Studies 5:323—348.
Väisänen, R. A. & Järvinen, O. 1977: Dynamics of protected bird communities in a Finnish archipelago. — J. Anim. Ecol. 46:891—908.
Väisänen, R. A., Järvinen, O. & Rauhala, P. 1986: How do large-scale, human-caused habitat alterations translate to the scale of local bird populations in boreal forests? — Ornis Scand. 17 (in press).
Williamson, M. 1981: Island populations. — Oxford Univ. Press, Oxford.
Wilson, E. O. & Willis, E. O. 1975: Applied biogeography. — *In* Cody, M. L. & Diamond, J. M. (eds.): Ecology and evolution of communities: 522—534. Harvard Univ. Press, Cambridge, Mass.

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