Conservation indices in land use planning: dim prospects for a panacea

Olli Järvinen

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This paper discusses the technical properties and ecological interpretation of various synthetic conservation indices that have been presented in the literature. Both technical and ecological arguments lead to the conclusion that conservation indices attempting a generally valid assessment of the conservation value of different ornithological sites are and probably always will be inadequate. Such indices may, however, be useful in more limited contexts, e.g., in comparisons between two alternatives for a powerline or other construction. It is also possible to design consistent indices for a limited purpose by using ornithological expertise and common sense as an aid. Instead of encompassing all information in synthetic conservation indices, one should try to identify areas supporting an unusually high number of endangered species or of individuals of an endangered species, or to examine bird population trends and their causes in monitoring programmes. Even though the attempts at devising adequate conservation indices have not led to a panacea, they have nevertheless made it necessary to define conservation goals more accurately than before, and these attempts have also shown the importance of a precise distinction between different geographical scales in conservation: international, national, regional, and local.

Olli Järvinen, Department of Zoology, University of Helsinki, P. Rautatiekatu 13, SF-00100 Helsinki, Finland

Introduction

A few years ago the so-called Bermuda triangle excited many minds. It was believed that the Bermuda triangle, a triangular area defined by Bermuda, Puerto Rico and South Florida, mysteriously attracts ships and other vessels that then disappear within the abominable triangle. Another mystery triangle is defined by birds, the human population, and the environment. The purpose of this paper is to indicate that this triangle similarly tends to acquire mystery features.

Different studies emphasize different aspects of our ornithological triangle (cf. also Järvinen & Väisänen 1979). One possibility is to look intensely at bird populations and their changes and then try to associate these changes with changes that are known to have taken place in the environment. For example, this has been done in ornithological studies in the Finnish archipelago and forests (e.g., Kilpi, this issue, Järvinen & Väisänen 1979). In many cases reasonable grounds exist for connecting a particular change in the environment with certain changes in bird populations, even though one often has to resort to *ad hoc* hypotheses. This approach could perhaps be called *conservationist*, for one wants to monitor potentially harmful changes in the environment before they exert an effect on the human population. Or if one stresses scientific aspects, then studies of this kind usually belong to the domain of *descriptive ecology*.

Another approach could be called *hypothetico-deductivist*. The starting point is a survey of environmental changes that are supposed to be particularly relevant to bird life. One may then construct qualitative or quantitative predictions about the trends expected in different bird populations in different areas. The result is a verbal or mathematical *model*, and if the predictions are satisfactorily confirmed, some understanding of the system has been gained.

Examples of this approach include a paper by Haila et al. (1980) on the changes of the land bird populations of the Åland Islands in southern Finland over the last 50 years. Haila et al. (1980) showed that predictable changes in bird populations followed certain major changes in land use, for example the abandoning of forest grazing, which resulted in an increased dominance of spruce and in an increased coverage and density of the bush layer. Another more quantitative approach is that by Helle & Järvinen (1985), who found that the edge preferences and successional preferences by forest birds can be used to predict not only the direction but also the magnitude of long-term changes in the abundant forest bird populations in Northern Finland. The conclusions drawn from hypothetico-deductivist studies tend to stress problems of general ecology, rather than applied problems that are important in land use planning.

A third approach to the ornithological Bermuda triangle is that of a land use planner, and it looks similar to the first: there is an emphasis on birds, but birds are now used as *indicators* of environmental quality. The whole approach can be rationalized on the basis of a very practical problem: too many needs, too few funds. Therefore objective criteria are needed that can be used in allocating the limited funds in the most rational manner (e.g., Ulfstrand 1977). Such criteria are necessary for various purposes in land use planning, and we should be aware of the fact that in addition to ornithological, or more broadly ecological, criteria, other criteria are also used such as tourism, land ownership, or education.

In this paper I will critically discuss one particular aspect of using birds as a tool in land use planning, namely the attempts that have been made for an "objective" assessment of conservation value on the basis of *conservation indices*. My sceptical conclusions (see also Järvinen & Ranta 1982) should not be extended beyond the exact scope of the paper, which is the index approach to ranking ornithological sites according to their conservation importance. I will not dwell on the problems of environmental monitoring in general (but see Vickholm et al. 1984), though I believe that most of the arguments presented below not only apply to birds but also to many other taxa.

Quantitative indices of conservation value: different alternatives

For the purposes of land use planning, quantitative criteria are evidently more attractive than qualitative classifications, for numbers are easy to use in allocating the economic resources rationally. Qualitative classes such as "important", "fairly important", "average", etc. are obscure. Should one, for example, protect ten "fairly important" areas instead of one "important" area? I here make the unwarranted assumption that bureaucracy is rational. I also make an assumption that perhaps not all conservationists accept, namely that ecologists and conservationists should be able to indicate a realistically limited number of natural areas that are in need of urgent protection, instead of merely pointing out that *Homo sapiens* has now become so abundant and widespread that all natural habitats need special protection against humankind. This argument is perhaps valid, but certainly not accepted in society at large, especially at the global level, and therefore such a position gives free rein to non-ecologists and anticonservationists.

There are infinitely many possible indices for assessing the conservation value of a certain area. Probably the simplest index is *species number*; insofar as nature conservation is defined as an attempt to preserve natural diversity, this index is also easily justified. Another related index is *species diversity*, measured, for example, by the Shannon index, which was used in Bavaria by Bezzel & Reichholf (1974) in order to assess the conservation value of waterfowl habitats. The *number of pairs of birds* can also be used to identify valuable areas. The Finnish programme for wetland conservation (Anon. 1982) defined conservation value largely in terms of pair numbers, although different species were weighted differently according to their "wetland character".

A somewhat more complicated trend was started by Nilsson & Nilsson (1976) who defined the conservation value of a species in an area as a function of its pair numbers in the area and the population size of the species in West Europe. An area that supported a substantial proportion of the West European populations of one or more *rare* species received a higher conservation value than an area that had the same number of pairs and species but did not support European rarities. Population sizes, diversity, and rarity were also the criteria chosen by Fuller (1980) in his quantitative attempt at developing an assessment method of ornithological sites.

Järvinen & Väisänen (1978) modified the Nilssonian approach to encompass greater complexity. Our index (cf. also the index by Nord 1978 based on related ideas) was defined on the habitat level. Different habitats are so weighted that a good habitat for a species is considered especially valuable. We also pointed out that selecting the reference area is arbitrary, i.e. depends on the conservation goals set. An area may be important to conserve in Kuusamo (a province in northern Finland), even though the same area may not be important from the North European or Eurasian perspective. In other words, the index compels us to make an explicit decision on the criteria used in setting conservation goals. Fuller (1980) also emphasizes the distinction between different levels of conservation importance: he distinguishes between the international, national, regional, county and local levels (see also Klopatek et al. 1981).

When we applied our index to North Norwegian data, oceanic heaths received the highest priority. The species that contributed most to the index value of oceanic heaths were the Snowy Owl *Nyctea scandiaca*, several shorebirds, including the Purple Sandpiper *Calidris maritima*, and a few exotic passerines, such as the Shore Lark *Eremophila alpestris*, the Snow Bunting *Plectrophenax nivalis* and the Red-throated Pipit *Anthus cervinus*. Wet peatlands were another priority habitat because of some northern shorebirds and passerines. Generally these results were reasonable in the North European perspective, although the index is very sensitive to occasional sightings of European rarities.

An approach entirely different from those reviewed above was presented by Nagasawa & Nuorteva (1974). They argued that if the species-abundance distribution of a bird community cannot be fitted by either the logseries distribution or by the truncated lognormal distribution, the failure can be interpreted as an indicator of environmental disturbance. They wrote, "...two different kinds of mathematical population models were inapplicable to the data of the bird survey performed in the centre of a city. This implies that man has created environmental conditions which upset the normal ecological balance." As many factors besides human disturbance contribute to the species-abundance distributions in bird communities, the suggestion by Nagasawa & Nuorteva (1974) should be examined further before practical applications. One would especially like to know whether "unnaturalness" must be as excessive as in a centre of a modern city (Helsinki) before the technique detects the difference. It is also important to find out how often the technique would identify undisturbed communities as out of "balance".

Instead of reviewing other indices that have been used (they seem to be variations on the above themes) I wish rather to express some doubts about the utility of these or other similar indices. These doubts are partly technical, partly ecological.

Technical problems with conservation indices

Some technical problems with conservation indices are evident. For example, species number and species diversity do not take into account the identity of the species, but conservation attempts cannot ignore species names. Endangered species should always receive the highest priority. (For the same reason, the island biogeographical rules for reserve design miss a major point, as they are also based on considering species numbers only; see Järvinen 1982a, 1982b.)

Another problem is that some of the indices tend to be *dependent on total area*, and this is related to the total price of the area. Species number obviously increases with pair numbers, that is, with area, even if the area is completely homogeneous. The comparisons between large and small areas should therefore be made by considering a set of small areas whose total area equals the area of the large reserve examined (e.g. Järvinen 1982a). Or if one wishes to think in terms of money, one should compare areas of the same total worth in money. Pair numbers, and related indices, such as the Finnish waterfowl habitat index (Anon. 1982), are also dependent on area. The potential danger is that large areas may be overly preferred to combinations of very good, but smaller areas. Techniques such as rarefaction and prevalence functions (Haila et al. 1983) derived in studies of insular communities could be a useful aid here.

Area-dependence of indices would not be a serious handicap if index values could nevertheless be compared meaningfully. However, this is not the case. Comparing areas on the basis of different conservation indices is practically impossible except for a simple ordering of the sites, for arithmetic operations based on non-additive and non-multiplicative numbers will lead to nonsense. Let us assume that the areas A and B have conservation values of 50 and 80 units, respectively. B is in this case a clearly better alternative than A, but if A costs half the price of B, should we buy A or B? The answer is that we have no idea. Conservation indices can be used to order different areas according to conservation value, but the numerical differences or ratios of the index values are meaningless. Also, if one has to choose between one area that has a conservation value of 80 units, or two areas with a conservation value of 50 units each, the choice is difficult. It is by no means clear that all units of different conservation indices have the same value from the conservation standpoint (perhaps most sites in the region reach 50 units, but only the high-quality ones reach 80?). If the total prices are the same, probably all conservationists would prefer one excellent area to two mediocre reserves.

Because conservation indices have no meaningful ratios or differences, interpreting changes in index values will be difficult. This is all the more important because rarities tend to influence many indices. A relatively minor change in the numbers of a rare species may mask important fluctuations in the more common species, as all conservation indices are *amalgamations of information* where the constituents are drowned in the depths of the ornithological Bermuda triangle. Therefore, one is usually forced to dispense with numerical exactness in favour of ornithological experience and common sense. Fuller (1980) defined the conservation value of different sites on the basis of the breeding, migrating, and wintering birds, and was able to identify sites that were of international (national, regional, etc.) importance for one or several taxa during one or several seasons. However, he (correctly, in my opinion) did not attempt to pool the results into a single index measuring the overall importance of the site. Moreover, how the critical values were set was not based on theoretical argumets but on practical ornithological experience and personal judgement (cf. also Bezzel & Ranftl 1974).

I doubt whether any of the present indices of conservation value are technically adequate. Can we realistically expect to find useful indices in future? In other words, is it probable that new indices will have a sufficient number of the desirable properties, once the present technical problems have been overcome?

Ecological problems with conservation indices

The history of the North European bird fauna shows that species numbers in the breeding bird fauna have increased during the past century (e.g., Järvinen & Ulfstrand 1980). The number of extinctions has been negligible compared with the number of new arrivals. This does not mean that the present situation is satisfactory; to the contrary, many species are now more threatened than before, and therefore species number may be a misleading index for conservation value. Bezzel (1974) also pointed out that increasing species richness "can be as critical as a rapid decrease (e.g. eutrophication of inland waters)".

A similar remark applies to species diversity. A good counterexample to using diversity as a criterion of conservation value comes from the Krunnit Islands in Finland. A series of censuses made from 1939–1972 (Väisänen & Järvinen 1977) indicate that the bird communities of the islands recovered from persecution after the establishment of the sanctuary in 1936, and thus the conservation value of the island group definitely increased during the study period. However, species diversity decreased as a result of protection, for some colonial gulls and terns profited more from the protection against intruders than many solitary breeders did.

The index by Järvinen & Väisänen (1978) has been so little used that I am not aware of counterexamples showing that it is inadequate in some situations, but I would guess that oddities could be found (e.g., the second power in the formula may not be a good solution; T. Fagerström and F. Götmark, personal communications). The logarithmic version of the Nilssonian index has been shown to give an inordinate conservation value to the most abundant species and is therefore of no use in conservation practice (Järvinen & Väisänen 1978).

At a more general level, we have good reasons for being conservative about conservation indices. First, natural communities are *dynamic systems* but index values are based on a snapshot view of reality. Populations increase and decrease, and even the social preferences and the economic worth of natural resources change. Even populations within natural reserves are affected by changes outside the reserves ("no park is an island"; Janzen 1983). Evidently (e.g., Haila et al. 1979, Svensson, this issue) many bird populations are affected by changes in the wintering grounds rather than by changes in their breeding habitats. Using conservation indices in such situations may be entirely misleading. This argues that conservation indices may not have a particularly good predictive value for the future conservation value of an area.

Second, what really matters in conservation is the threat to which different areas are exposed (e.g., Bezzel & Ranftl 1974). Practical conservation efforts are therefore usually directed at finding habitats that are threatened and valuable. It is a fair guess and good practice that the urgency of threat (instead of the rank order of an area in a list based on conservation value) is particularly important in the allocation of resources.

Third, some attempts have been made by Graber & Graber (1976) to incorporate *recovery times* to conservation indices, but generally this is difficult. Moreover, it is not clear how one should judge different time scales. A slow recovery time makes a habitat more in need of protection, but the assessment of conservation value should also take into account the availability of different habitats. A peatland area takes thousands of years to recover completely, but if peatlands are common a rare habitat may well be more valuable from the conservation standpoint, even if the recovery time would be only one hundred years.

Fourth, bird compose much less than 1 % of the animal taxa (but often a substantial proportion of terrestrial vertebrates). If larger taxa are used for conservation purposes, the results may be more representative. However, as very few taxa are autecologically as well known as the birds, greater representativeness may lead to increasingly superficial ecological interpretations. — After this paper was submitted, a thoughtful review by Nilsson (1984) was published. His discussion is different from but complementary to mine.

Conclusions

I see little hope in creating generally valid, synthetic conservation indices on the basis of bird data. The reasons are partly technical, but mainly ecological. One must be especially aware that indices tend to be numbers and numbers tend to possess an aura of objectivity, irrespective of their scientific validity. Therefore, conservation indices may be used to create a disguise of scientific objectivity which may be tactically advantageous when bureaucrats and engineers are ignorant about bird ecology and are persuaded only by numbers. Although this is probably true in most cases the reasoning is not ecological but psychological and political.

The arguments I have given apply for generally valid conservation indices. My arguments do not exclude the possibility that some indices may be useful in a restricted comparison (see also Nord 1978). For example, which of two lakes is conservationally more valuable? Or which of two alternatives for a powerline is preferable? Or is this threatened but only recently found area equally or more valuable as areas recognized as conservationally important before? Even in these cases, though, one should naturally bear in mind the technical problems and limitations.

It may be argued, and I agree, that *indicator species* (e.g., Utschick 1976) can be a useful guide in identifying valuable conservation areas, at least if the comparisons are restricted to relatively small regions where the habitat requirements of the indicator species are consistent. This is the approach of Bezzel & Ranftl (1974) who obtained useful results by identifying areas that support an unusually high number of endangered or indicator species, and by also identifying the (autecological) factors threatening these species. The index adopted in the Finnish wetland programme (Anon. 1982) also gives considerable weight to indicators of eutrophic wetlands and the final index is decisively affected by the pair numbers of the most characteristic indicators. I believe that most of the interesting attempts at quantifying the conservation value of different localities are in fact based on a similar procedure. The crucial point is that ornithological expertise is used to rank different areas, and the indexes are based on a more or less *ad hoc* method that yields "reasonable" results for the problem at hand but not necessarily in other contexts.

Certainly the pains taken in creating poor conservation indices have not been wasted, but have compelled us to think more precisely and more explicitly about conservation and about preferences in conservation. If one of the conclusions from this exercise in constructing indices is that one should instead focus on monitoring alarming population trends and identifying key areas for endangered species (see also Järvinen 1982a), then one has at least gained some insight into the complexity of the conceptual problems involved in rational conservation.

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Selostus: **Voidaanko suojeluindeksejä käyttää hyödyksi maankäytön suunnittelussa?**

Kirjallisuudessa on esitetty lukuisia vaihtoehtoja eri alueiden luonnonsuojeluarvon mittaamiseksi. Mahdollisuuksia ovat mm. parimäärään perustuvat laskelmat, lajimäärä sekä linnuston diversiteetti. Lukuja voidaan myös painottaa ottamalla huomioon lajien harvalukuisuus esimerkiksi Suomessa tai Länsi-Euroopassa. Kirjoituksessa käsitellään kriittisesti erilaisten luonnonsuojeluarvon mittaustapojen sekä teknisiä että ekologisia ongelmia.

Teknisistä epäkohdista merkittävimpiä on, että indekseihin usein vaikuttaa ratkaisevasti tutkittavan alueen laajuus — alue arvioidaan sitä arvokkaammaksi, mitä suurempi se on. Tällainen mittaustapa saattaa syrjäyttää huomion arvokkaista pienalueista. Toinen vakava tekninen epäkohta on, että indeksien numeroarvoja ei yleensä voi millään tavalla kvantitatiivisesti vertailla; esimerkiksi erotukset tai osamäärät aiheuttavat lähinnä sekaannusta. Lisäksi indeksit yhdistävät itseensä hyvin suuren määrän erityyppistä informaatiota, vaikka luonnonsuojelussa ensi sijassa olisi keskityttävä turvaamaan uhatuimpien lajien asema (pesimäalueet, muuttokautiset levähdyspaikat jne.).

Ekologisesti suojeluindeksien haittoihin kuuluu, että esimerkiksi lajimäärän tai diversiteetin muutoksia ei ole helppo yksiselitteisesti tulkita. Esim. vesien rehevöityminen lisää vesilinnuston lajimäärää, mutta ao. ympäristön muutos ei sinänsä ole erityisen ilahduttava. Toisaalta suojelun ansiosta esim. Iin Krunnien merilinnuston diversiteetti on viime vuosikymmeninä laskenut, vaikka Krunnien linnuston suojeluarvon kasvusta samana ajanjaksona ei ole vähäisintäkään epäilystä. Diversiteetin lasku johtuu vain siitä, että muutamat yhdyskuntalajit ovat runsastuneet Krunneilla muita lajeja nopeammin. Ekologisesti harhauttavaa on myös, että luonnonsuojeluindeksit kuvaavat pysähtynyttä ajanhetkeä, vaikka suojelualueetkin ovat jatkuvasti muuttuvia ja vaikka ympäristössä tapahtuvat muutokset heijastuvat suojelualueiden lajistoon. Periaatteessa vieläkin tärkeämpi epäkohta on, että luonnonsuojelullisesti erityistä huomiota tulisi kiinnittää lajistoon ja elinympäristöön kohdistuvaan uhkaan ja siihen mitä tulevaisuudessa todennäköisesti tapahtuu; samoin tulisi kiinnittää huomiota siihen, kuinka nopeasti jokin luonnonalue ihmistoiminnan kohteeksi jouduttuaan palautuu edes siedettävään tilaan. Näiden seikkojen kuvaaminen indeksein on hankalaa.

Esitetyt tekniset ja ekologiset näkökohdat viittaavat siihen, ettei yleispäteviä, informaation yhteen tai pariin lukuun tiivistäviä suojeluarvoindeksejä ole mahdollista luoda. Tämä ei luonnollisestikaan merkitse, etteikö linnustotietoja muuten olisi mahdollista käyttää hyväksi maankäytön suunnittelussa. Päinvastoin: esimerkiksi populaatioiden muutosten seuranta ja muutosten kytkentä ympäristönmuutoksiin tarjoaa erinomaista ja käyttökelpoista tietoa myös maankäytön suunnitteluun. Samoin voidaan pyrkiä löytämään alueita, joilla poikkeuksellisen moni uhattu laji elää.

Vaikka luonnonsuojeluindeksit eivät näytä tarjoavan Viisasten Kiveä, on niiden kehittämiseen uhrattu vaiva silti tuonut esiin joitakin arvokkaita näkökohtia. Indeksejä kehitettäessä on jouduttu täsmällisesti määrittelemään suojelun tavoitteita, ja eri indeksejä tutkittaessa on voitu havaita, kuinka tärkeää luonnonsuojelutyössä on määritellä selkeästi suojelutavoitteiden maantieteellinen ulottuvuus — alue, joka kuusamolaisittain saattaa olla poikkeuksellisen arvokas, ansaitsee kyllä suojelua, vaikka koko pohjoisen pallonpuoliskon perspektiivissä alue ei kovin merkittävä suojelukohde olisikaan. Myös mm. poliittisten rajojen olemassaolosta johtuu, että esim. uhanalaisten lajien suojelu joudutaan yleensä määrittelemään valtiokohtaisesti. Syytä onkin erottaa toisistaan luonnonsuojelun kansainvälinen, kansallinen ja maakunnallinen, miksei paikallinenkin taso.

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