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Birds as Biodiversity and Environmental Indicator

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Abstract
Ecosystem monitoring can be carried out by ecological indicators to preserve and manage the natural environment. Since it is impractical to monitor all ecosystem components, a few individual species or groups of species can be used as indicators of wider conditions. Biological components chosen with this aim are called bioindicators. Bioindicators are organisms that are used to monitor the health of the environment, the presence of pollution and its effect on the ecosystem, the progress of environmental cleanup and test substances, and to detect changes in the natural environment,. Bioindicators are also the best tools to measure the progress made on biodiversity conservation, to assess the impacts and threats on biodiversity, to evaluate sustainability use of biodiversity. Birds are excellent bioindicators for the health of the environment and ecological/ environmental change. Generally, birds have been used as indicator species for a range of environmental parameters. They act as biodiversity indicators with a number of reasons. The cause-and-effect link between an environmental change and birds are direct and simple one.
Keywords: Biodiversity, Bioindicators, Birds, Environmental change, Environmental health

Introduction

Ecosystem monitoring is necessary to preserve and manage the natural environment. It can be carried out by an ecological indicator (Nguyen, 2007). Conservation agencies would like to monitor all properties of interest within a natural ecosystem. In the absence of comprehensive data on whole ecosystems, conservation agencies may choose to monitor a set of indicators: physical, chemical or biological properties that indicate the status of un-sample parameters of the environment. The organisms and organism associations are monitored for changes that may indicate a problem within their ecosystem. Often, individual species or groups of species are selected to function as biological indicators. One of the aims of monitoring is to provide information for ecological assessment, which can provide early warning of changes that could negatively affect species or ecosystems (Burger 2006). Since it is impractical to monitor all biological and physical components, a few of them can be used as indicators of wider conditions. Biological components chosen with this aim are called bioindicators (Matsinos and Wolf, 2003).

Bioindicators are organisms that are used to monitor the health of the environment. They are also relevant for ecological health whereby structural and functional ecosystem characteristics are maintained. Bioindicators are used to: detect changes in the natural environment, monitor for the presence of pollution and its effect on the ecosystem in which the organism lives, monitor the progress of environmental cleanup and test substances (Saulović *et al*., 2016). Bioindicators are also the best tools to measure the progress made on biodiversity conservation. Some of them are used to assess the impacts and threats on biodiversity, others to evaluate sustainability of the use of biodiversity (EEA, 2007).

In order to understand the health of the environment it is necessary to use indicators because ecological systems are too complex to measure fully (KBO, 2013). Birds are excellent barometer for the health of the environment (Carignan and Villard, 2002). They occur in many habitats, reflect changes in other animals and plants, are sensitive to environmental change and have great resonance with the public (IUCN, 2010). Birds are also more sensitive to environmental contaminants than other vertebrates, therefore can act as bioindicators (Vashishat and Kler, 2014). Besides, often birds are the focus of volunteer efforts and there is possibility to involve communities in monitoring schemes and action (IUCN, 2010). Birds are bellwethers of our natural and cultural health as a nation—they are indicators of the integrity of the environments that provide us with clean air and water, fertile soils, abundant wildlife, and the natural resources on which our economic development depends (The State of the Birds, 2009).

Birds are popular subjects for research and monitoring, and long-term datasets of bird counts often provide a useful resource as indicators of ecological change (Amat and Green, 2012). Never previously has been pointing to opportunity for us to inform and advices environmental indicator decision makers. Ornithologists have special contribution to make the extent quality of information available to us regarding properties of effective environmental indicators. Attention is given to globally threatened species, common bird monitoring schemes, summarizing trend data from many species and to spatial question about distribution of biodiversity (Bibby, 1994). This seminar paper has two aims: To review the ability of birds to function as indicator species in light of the published scientific literature and to recommend for establishing a reliable monitoring program.

Indicator concepts

Definition of indicator

An indicator is a surrogate measure for a parameter that is too ephemeral or difficult technically or practically to measure and capture directly (Lindenmayer *et al*., 2000; Gregory and Strien, 2010). For examples lichens indicating air quality, plant species indicating soil moisture or soil fertility, or bird of prey populations reflecting pesticide contamination (Gregory and Strien, 2010). Indicator defined as ”an organism or ecological community so strictly associated with particular environmental condition that pressure is indicative of the existence of these condition. Detailed root of indicators concepts as applied to the plant and animals communities including birds are to be assign symptom or index of” change in bird population tends to integrate asset of ecological factors. Given adequate ecological knowledge they can provide the use full indicator environmental change (Bennun and Fanshawe, 1997).

Indicators are often used in research and environmental management as diagnostic tools. The term indicator is routinely applied in the scientific literature to both a species to be monitored (i.e. the indicator species) and the specific characteristic of the indicator species that informs the status of the ecological property of interest (e.g. presence or absence, density, mortality rate, reproductive success). Species that are used as ecological indicators are done so under the assumption that the response of that individual species characterizes current habitat conditions and/or is representative of the responses of other species within that same habitat or community (Canterbury *et al*., 2000). In other words, indicator species are assumed to signify the status of the environment and/or serve as proxies for a larger number of species which can then provide information on measurements of biodiversity condition and transformation (Nguyen, 2007).

Indicator Species (IS) are living organisms that are easily monitored and whose status reflects or predicts the condition(s) of the environment where they are found (Burger, 2006; Siddig *et al*., 2016). They are one or more taxa selected based on its sensitivity to a particular environmental attribute, and then assessed to make inferences about that attribute. Commonly used in the context of wildlife conservation, habitat management and ecosystem restoration. The strategy of using IS is derived from the hypothesis that cumulative effects of environmental changes are integrated over, or reflected by, the current status or trends (short- or long-term patterns of change) in the diversity, abundance, reproductive success, or growth rate of one or more species living in that environment (Burger, 2006; Siddig *et al*., 2016). One or more living organisms used as an indicator of the quality of the environment it is living in and the biological component associated with it. Bioindicators or biomonitors are used most commonly to monitor chemical changes in the environment in fields (Burger, 2006; Siddig *et al*., 2016).

Characteristics of Indicator Species

To be considered for use in an environmental monitoring program, an indicator species must possess essential qualities. For indicators to be effective, they need to meet a range of sometimes competing practical and scientific criteria (Table 1). Note that indicators should not be seen as a short cut, or substitute for the detailed knowledge needed to explore and understand the causes of change in individual species or ecosystems, and then to formulate adaptive actions to remedy perceived problems. Indicators might, to a certain degree, inform each step in this process, but they cannot replace sound autecological research and experimental and other research (Gregory and Strien, 2010). No single indicator species will possess all of the desired attributes identified (Noss, 1990). Indeed, some desired attributes conflict with one another, for example, cosmopolitan distribution versus habitat specialism (Hilty & Merenlender 2000). Issues that may be encountered when assessing candidate indicator species is that many of the desirable attributes listed below assume a sound and detailed knowledge of the biology and ecology of the species in question.

Table 1. Key attributes of an effective bioindicator

Attribute	Details
Representative	Includes all species in a taxon or a representative group
Immediate	Capable of regular update, ideally on an annual basis
Simplifying	Reduces complex information into an accessible form
Easily understood	Simple and transparent to a range of audiences
Quantitative	Accurate measurement with assessment of precision
Responsive to change	Sensitive to environmental change over short time scales
Timeliness	Allows rapid identification of patterns and early warning of issues
Susceptible to analysis	Data can be disaggregated to understand the underlying patterns
Realistic to collect	Quantitative data can be collected within the resources of manpower and finance over medium to long term
Indicative	Representing more general components of biodiversity than the constituent species trends, ideally reflecting ecosystem health
User driven	Developed in response to the need of policy and decision makers
Policy relevant	Allow policy makers to develop and adapt policy instruments
Stability	Relatively buffered from highly irregular natural fluctuations
Tractable	Susceptible to human influence and change

Source: Gregory and Strien, 2010

Types of Indicator Species

According to their function, indicator species can be classified into three ways (Lindenmayer and Burgman 2005)

1. Environmental indicators**:** indicate the presence and/or intensity of stressors. In this class five types of pollution indicator species identified:
    1. Sentinels**:** are sensitive species that are introduced into a target environment, for example, to provide early-warning of the presence of pollutants or to determine the effects of pollutants on biota.
    2. Detectors**:** are species that are endemic to a target area and may exhibit a measurable response to change in their environment, *e.g*. changes in behaviour, mortality or age-class structure.
    3. Exploiters**:** are species whose presence indicates probable disturbance or pollution. Exploiter species often thrive in disturbed or polluted areas because competitors are unable to persist in the altered environment and/or because they can utilize polluted ecosystems or the pollutants themselves.
    4. Accumulators**:** are species that accumulate pollutants in measurable quantities in their body tissue.
    5. Bioassay organisms: are used in laboratory studies to detect the presence and/or concentration of pollutants or to determine pollutant toxicity.
2. Ecological indicators: indicate the impacts of stressors on other taxa.
3. Biodiversity indicators**:** indicate the diversity of other taxa within a habitat or set of habitats.

Use of Birds as Indicator Species

Indicator species have been used in practical management of biodiversity at the local, regional, national and international levels (Nguyen, 2007). Birds have been utilized as indicator species by government agencies elsewhere. Several studies show that birds may be used as bioindicators of conditions encounter in ecosystem, at both local and regional spatial scales. In the UK, composite bird indices are one of 20 'framework' indicators (and one of 68 indicators in total) used to measure progress towards a government goal of achieving sustainable development by 2020. Composite indices for farmland birds, woodland birds, coastal/estuarine birds and wintering waterbirds are produced in a collaborative effort by the British Trust for Ornithology (BTO), (H. M. Government, 2005). The Pan-European Common Bird Monitoring Scheme (PECBMS) uses composite indices for common birds to track the state of biodiversity across Europe (PECBMS, 2007). In North America, the United States Department of Agriculture Forest Service are required by internal policy to identify and monitor 'management indicator species' within each national forest. The management indicator species are monitored to determine the impacts of management regimes on forest communities (U.S. Congress Office of Technology Assessment, 1992).

Generally, birds have been proposed, assessed or used as indicator species for a range of environmental parameters, including the following:

1. Biodiversity and species richness (Mattsson and Cooper 2006), including patterns of occurrence of rare and threatened species (Thomson *et al*. 2007). In some instances, birds have been used as surrogate taxa for biodiversity to priorities areas for conservation (Jiguet and Julliard 2006; Loyola *et al*. 2007).
2. Environmental contamination by pollutants such as pesticides, heavy metals and polychlorinated biphenyls (Matz and Parsons 2004; DeWitt *et al*. 2006; Papp *et al*. 2007).

3. The condition of ecosystems including forests, rainforests, grasslands, rangelands, riparian ecosystems, terrestrial wetlands, marine ecosystems, and urban areas or mosaics (Chambers, 2008).
4. Ecosystem responses to disturbances and processes including urban expansion, logging regimes, hydrological regimes, eutrophication, replacement of endemic ecosystems with plantations, grazing, hunting and habitat restoration programs (Chambers, 2008).

Birds as Good Biodiversity Indicators

Birds are likely to be a very useful and appropriate component of biodiversity monitoring elsewhere (Mac Nally *et al*., 2002). Birds are very useful indicators of species richness and endemism patterns (Bibby *et al*., 1992; Burges *et al*., 2002). They are often considered to be good indicators of the general condition of the environment, although doubt exists over their ability to directly and rapidly indicate changes in ecosystem properties and the impacts of such changes on other taxa (Mac Nally *et al.* 2004; Gregory *et al.* 2005). There are a number of reasons to think that birds as a group might act as reasonable biodiversity indicators.

1. The taxonomy of birds is well-resolved, species are generally easy to identify in the field (Gregory *et al.* 2005) and relatively stable: e.g., the number of recognized bird species has grown by just 5–8% per decade in recent years compared to 15–24% for mammals and amphibians (Gregory and Strien, 2010; Bird Life International, 2013).
2. Birds are easy to detect and observe (*e.g*. birds are often the most conspicuous faunal taxon in an ecosystem; many species are diurnal and/or brightly-coloured and/ornadvertise their presence by call) (Mac Nally *et al.* 2004). They are generally easy to identify, survey and monitor, and there are valuable historical data sets for a wide range of species: e.g., birds comprise over 50% of the populations included in global wildlife trend indicators (Gregory and Strien, 2010).
3. Birds are diverse, found in nearly all habitats and occur across the world: e.g., there are over 10,000 bird species globally with, on average, over 400 species occurring per country (Gregory and Strien, 2010).
4. The distribution, biology, ecology and life history of birds are well known compared with other taxa (Gregory *et al.* 2005). e.g., over 16,000 scientific papers on bird biology are published per year (Gregory and Strien, 2010).
5. Bird distribution generally reflects that of many other wildlife groups: e.g., the network of key sites for bird conservation (IBAs) covers 80% of the area of those identified for other wildlife groups (Gregory and Strien, 2010).
6. Their habitat requirements are typically fairly specialized: e.g., more than half of all bird species predominantly occur in one or two habitat types (Bird Life International, 2013),.
7. Birds are typically positioned at or near the top of the food chain or high trophic levels in food webs. This makes birds sensitive to changes at lower levels of the food chain and to environmental contaminants (*e.g*. persistent organochlorines) that accumulate at each level of the food chain (Mac Nally *et al.* 2004; Gregory *et al.* 2005; Gregory and Strien, 2010).
8. Their population trends often mirror those of other species: e.g., mammals, reptiles, amphibians, plants and invertebrates have shown trends similar to farmland birds in the UK since the 1940s (Chambers, 2008; Gregory and Strien, 2010).
9. Birds are economically important: e.g., pest control and pollinate or disperse the seeds of plants. These species may be directly or indirectly linked to the fitness of many other species and play a critical role in the maintenance of natural ecosystems (Gregory *et al.* 2005; Gregory and Strien, 2010).
10. Birds are flagships for nature—they are of interest and concern to both the public and decision-makers (Mac Nally *et al.* 2004; Gregory *et al.* 2005): e.g., 20% of people in the USA and 30% in the UK watch or feed birds regularly (Gregory and Strien, 2010). This interest generates strong support for conservation programs that involve birds and provides an opportunity for skilled volunteers to be recruited from a large number of amateur birdwatchers. The inclusion of volunteer personnel in a monitoring program may reduce costs or facilitate an increase in the scope of the monitoring program (Gregory *et al.* 2005).

Bird as environmental change indicator

An old age pursuit of biologist has been to relate the distribution and abundance of organisms to some aspects of their natural environmental factors influencing their evaluation, and reproductive success. Dispersal and migration plus other aspects of their ecology have been investigated. However, the use of animals as indicators of environmental change have been critically evaluated (Michael, 1986).

Birds are useful resource as indicators of ecological change. They can be reliable indicators of nutrient status and the abundance of other organism (Amat and Green, 2012). Birds live in an environment that is subject to both regular and irregular fluctuations, and bird populations respond to these changes in predictable ways. The cause-and-effect link between an environmental change and birds are direct and simple one. The effects of environmental changes on bird populations are more often influenced by one or more intermediate factors or by

many interacting effects. The most immediate and direct responses of birds to environmental changes are behavioral and physiological involving changes in the characteristics of individual. These changes in turn, affect several basic population rates: birth rate, death rate, and rate of dispersal. Changes in these three primary population parameters can then generate changes in several secondary population parameters, such as density, population size, geographic range, habitat occupancy, age structure, sex ratios, or the proportion of birds that breed (Temple and Wiens, 1989).

Birds are recognizing as a good indicators of environmental changes and as useful proxies of wider change in nature. The willed bird index (WBI) measures average population trends of suit of representative wild bird as indicators of general environmental health (BLI, 2001). WBI deliver scientifically robust representative indicators for bird to support formal measurement and interpretation of regional, national and global target to reduce the rate of bio diversity loss. WBI measures extinction and colonization process at a local scale among wide spread and familiar bird in environment. In doing so, they shed light on the sustainability of human use of that environmental and hoe human impact is changing. By grouping species tied to particular habitats. It is possible to create habitat based indices. Hence, providing a sight in to the health of those habitats and indicators of sustainability of human use (Lawler *et al*., 2003).

Bird community is also viewed as possessing a dynamic stability that tends toward an equilibrium composition of environments. This composition may be repeatable or constant under similar environmental conditions allowing recognition of community type. Shortly, this implies the environmental natural balance was conserved and sustained by the existence of several groups of bird species. Last not but the list, community of bird species possess emergent properties in structure and functioning of environmental balance. This definition does not make any taxonomic restriction indicating that co-occurring species that are interacting compitators. For one or more limiting resource form communities with predictable and structural functional attribute (Holmes *et al*., 2004).

A classical example is the response of some waterbirds to eutrophication of wetlands. In the Mar Menor lagoon of south-eastern Spain the great crested grebe, *Podiceps crista- tus*, increased in abundance as eutrophication increased as a result of nutrient inputs into the wetland, resulting from intensification of agricultural practices in the basin of the lagoon. A parallel change in the number of grebes was not recorded in other sites of Spain, indicating that the increase in the Mar Menor lagoon did not result from external factors affecting the population at other spatial scales (Martínez Fernández *et al*., 2005).

Birds also have been widely studied for their responses to changes in agricultural landscapes, particularly in terms of habitat fragmentation, with an increasing focus on habitat quality (Major *et al*., 2001). The effects of agricultural changes in wetlands are provided by wetland birds. There decline of wetland bird largely attributed to changes in the agricultural practices in the basins of wetlands, which accelerated siltation rates, and therefore shortened hydroperiods, affecting the quality of food plants of bird. Indeed, the assimilation efficiency of birds was negatively affected when the quality of their food plants was low, which usually occurs in early summer when water levels start to decline (Varo and Amat, 2008). Therefore, the population dynamics of birds over long periods (e.g. decades) could be used as indicative of changes occurring in wetlands at slow rates (e.g. siltation processes).

Agricultural changes may also have effects on bird habitats at large spatial scales. As a result of feeding on agricultural crops in winter and on migration, some populations have increased and these increasing numbers have had a strong negative long-term effect on intertidal salt-marsh vegetation at breeding site. Here, loss of vegetation and salinity of bare ground precluded re-establishment of vegetation (Abraham *et al.* 2005). The monitoring of breeding colonies of birds may provide information on the conditions of habitat used for feeding. Here, colony size affected by water levels in the foraging site.

Conclusions and Forward Recommendations

Birds are diverse and they represent a large number of specific ecological conditions. Importantly, birds are well-studied so their habitat associations are generally well-known. They are also cost-effective to survey; a simple standardized methodology providing information about associated ecological conditions. Additionally, birds tend to be high on the food chain so their persistence on the landscape depends on the presence of multiple other species. Finally, birds are effective indicators because they respond to habitat changes at various scales, due to their links to taxa that respond to small- and large-scale disturbance. It is apparent that bird monitoring programs provide useful information about the integrity and functioning of the environment as a whole and used as environmental and biological indicator. Birds are excellent bio indicators of health of biodiversity as well as particular habitat and its productivity. They are also important in monitoring environmental changes because of their ecological diversity.

Overall, this review and analysis of papers published in birds as indicators suggest several lessons for ecologists and environmental professionals. The number of publications of birds as indicator implies widespread and continued growth in the use of birds in environmental monitoring and management. My analysis suggests

that birds are effective in applications such as environmental quality and ecosystem integrity and restoration, and they are used as early warnings of environmental change and assessment of environmental and climate change. Therefore, it is essential to carry out maximum effort in the identification of biodiversity of the country conservation sites and preservation of the endangered species which includes conservation of birds and other wild animals. For instance, protecting important bird area (IBA) identified to date would make an enormous contribution towards maintaining not jest birds but other biodiversity as well maximizing involvement of local community, stake holders and environmental sustainability without biodiversity lose.

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