



Ecosystem Roles of Birds: A Review on Birds' Conservation Insight

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Abstract

Ecosystem service refers to any service which is provided by the ecosystem to sustain the livelihood of mankind. These services may be offered directly or indirect through several complex ways. The utilization of these services implies dependency of humans on ecological resources. The MEA identified four broad categories of ecosystem services, namely; provisioning, regulation, supporting and cultural services. Among several services in the ecosystem, birds provide an interesting wide range of ecosystem services that sustain human life. For instance they have incredible value in pest control, seed dispersal, pollination, nutrient cycling, soil formation, ecotourism and many other services. These services provided by birds are further categorized as marketable and nonmarketable values depending on their monetization process. However, the decline of birds' population worldwide means these birds' ecosystem services are also declining. The services birds' provide are of great significant ecologically and economically, but remain unaccounted because of insufficient information. Therefore, this review article is aimed to clearly affirm the ecosystem roles of birds and their benefits to human to foster their conservation. Research driven policies fostering lasting conservation of avifauna; conservation, restoration and management of their habitats and control of illegal birds' trade are highly needed. The attempts of conserving and maintaining healthy birds population and their habitats would preserve diverse ecosystem services by benefiting many different living species and finally human well-being.

Keywords: Birds; Birds' Conservation; Ecosystem Roles; Ecosystem Services; Pest Control

Introduction

Ecosystem services are those features of the earth which provide direct or indirect benefits to humans through various ways of resources and processes [1]. The term "ecosystem services" was initially coined by Ehrlich and Mooney [2] and later became common throughout scientific literatures. Valuing these services by humanity dated back to Plato when he realized deforestation could lead to soil erosion and desertification [3]. The utilization of these services reflects the communal reliance on the natural life supporting system supplied by the biosphere [4]. These services are often varies and comprise the operational aspects of the ecosystem functions provided by both the biotic and abiotic components

of the ecosystem through immediate and lasting factors [5]. The Millennium Ecosystem Assessment (MEA) [6], a study initiated by the United Nations identified four broad categories of ecosystem services, namely: (i) provisioning services, (ii) regulation services, (iii) supporting services and (iv) cultural services. Though many scientists and ecologists use different terms, their original intent is meaning the same thing (that is "services provided by the ecosystem for the benefit of mankind). Even though wide varieties of ecological entities may take role in contributing to the provision of these valuable services, MEA recognized that birds contribute the four types of ecosystem services mentioned above. However, the decline of bird populations worldwide, especially those of more specialized species, means these birds' ecosystem

services are also declining. Therefore, this review article is aimed to clearly affirm the ecosystem roles of birds and their benefits to human to foster their conservation.

Ecological Services of Birds

Birds have a wide range of attributes making them more efficient in providing many valuable ecosystem services. They are found almost in every habitat across the globe from tropics to Polar Regions. Their ability to flight allows them to respond to immediate and urgent environmental condition in ways normally impossible for other classes of the phylum chordate. Their success in providing wide ranges of ecosystem services is highly associated with their flight capability. Their mobile nature allows them to locate resources abundance, leave areas with scarce resources and move to areas where resources are sufficient. Because of the migratory behavior of many species, birds link different geographical regions and habitats separated by great distances in space and time. The activities of birds can have large consequences for the ecosystems they inhabit, making them incredibly important in the overall functioning of various ecosystems.

In contrast to the Millennium Ecosystem Assessment's categories of ecosystem services where birds' role may be included, Mahendiran, et al. [7] stated a new category where the value of services provided by birds and their products are categorized as marketable and non-marketable. In considering the concept of monetization, the four categories of ecosystem services are further classified as marketable and non-marketable services as follow.

Marketable Services

Provisioning services: Meat, Feathers, Integument, Skin (Medicinal values), Blood (Medicinal values), Nests (food), Nutrient /fertilizers (Guano) [7].

Cultural services: Customs/Religious/cultural/ Ethnic value, Entertainment, Photography, Aesthetics /Recreation, Bird Watching [7].

Regulating services: Scavenging, Insect pest control, Nutrient transfer [7].

Non-Marketable Services

Supporting Services: Seed dispersal, Pollination, Disease control, Energy Transfer, Nutrient Transfer, Bioturbation, Reforestations, Maintenance of vegetation profile in water bodies, Animal dispersal (endozoochory, epizoochory), Cavity Excavators and Drillers (for microhabitats), Soil regeneration and enrichment, Leaf litter gleaners, Mixed flock foragers, Feeding opportunities, Ship following birds, Tractor following bird in Agricultural field, Knowledge value (Ecological, taxonomic and genetic diversity) [7].

Role of Birds in Nutrient Cycling and Soil Formation

Nutrients transfer and soil formation are an important birds' services in an ecosystem allowing the primary producers to initiate and flourish resulting in the emergency of primary consumers and led the area to be colonized by the top predators and maintaining biodiversity. They are an ecosystem services where events found in these grouping are requisite for all other services to be initiated making them the basis of process without which other ecosystem services could not be produced [6].

Birds' role in nutrient cycling has been documented in many habitats so far. Because of their ability to flight and move through different habitats, birds can carry nutrients from one place to another, which is mainly important in areas where plants growth is limited by nutrient availability. Birds contribute to nutrient cycling in all habitats, but most impressively where aquatic birds nest colonially on islands [8]. Seabirds often nest in dense colonies both in coastal areas and on islands where they process large amounts of food in small areas. In this manner, seabirds transport nutrients from the aquatic zone to the terrestrial zone. Such large inputs of phosphate-rich guano, birds' excreta, can influence the structure and composition of plant communities [9]. On the contrary, removal of nesting birds after introduction of a predator fundamentally alters the plant community [10,11].

This ecosystem service is mostly delivered by aquatic birds where they transferred nutrients between aquatic and terrestrial ecosystems. A study on the islands in the Gulf of California indicated that when birds rested on them, the guano deposits they left behind provided nutrients to plants on the island [8]. Thus, islands with roosting seabirds tend to have tall and fast growing vegetations and become more productive when compared to those without birds. Since the quality and quantity of these vegetations determine the number of consumers and the structure of the food web, the present of these seabirds applied a bottom-up effect on the food web by regulating primary productivity. The above explained services of birds are also important from an ecological perspective because it demonstrate the complex ways where different habitats are connected and can impact one another.

The presence of primary producers in the seas and oceans control the amount of fish they can support, which then determine the number of birds that can feed on these fish, which then influence the number of birds will roost on the island and leave guano deposits, eventually determining the primary productivity and food web structure on the island. Moreover, Barry Commoner, stated that "Everything is connected to everything else," a premise implying that birds

serve as a vector for nutrients between aquatic and terrestrial habitats [12]. By stimulating primary productivity, birds are also able to support the ecosystems' functioning in other ways. This is exemplified by birds in salt marshes of Alaska, where lesser snow geese and Canada snow geese stop-over in salt marshes during spring migrations. While foraging in these marshes, they trample the ground, which tears up leaf litter and incorporates it into the soil. The smaller particle size and increased contact with the soil promotes greater decomposition, freeing nitrogen from the leaf litter and allowing it to cycle through the ecosystem [13].

Birds as Pest Controller

Biological pest control is a major farmer concern and an important ecosystem service delivered by a wide range of organisms, expected to offer a sustainable solution to pest management in agro-ecological settings [14-16]. Avian control of insects and other pests that do damage to valuable plants can have a large economic value. Recent studies have highlighted the important role of insectivorous birds feeding on pest populations in different agro-ecology [17-19]. Insectivorous birds have been observed to reduce insect pest damage in various agricultural systems, such as apples, broccoli, cacao, coffee, corn, kale, grapes, and oil palm. For example, in Dutch apple plantations, Mols, et al. [20] found that birds' reduction of insect pest damage translated to a 66 percent increase in the yield of domestic apples. Similarly, researchers in Borneo estimated that bird pest control prevented 9 to 26 percent of the fruit loss in oil palm plantations [21].

Birds are efficient arthropod predators in farmland, where 50% are predominantly feeding on insects, and 75% consume invertebrates at least occasionally [18,22]. Avian predation on insects' pests has been studied in various natural and agricultural systems where most studies report a marked reduction in invertebrates' biomass by birds, usually ranging from 20% to 70% [17,23,24]. This predation not only lowers herbivorous abundance but also significantly reduces leaf damage and plant mortality, potentially leading to up to 60% increase in crop yield or fruit production [25,22].

The study conducted in Guatemalan coffee plantations reported that the presence of higher abundances of insectivorous birds lower the number of insect pests which resulted in less herbivorous damage to the leaves of crops [26]. Matt Johnson and colleagues discovered that by reducing the damage caused by coffee berry borer beetles, birds in Jamaican coffee plantations increased coffee yield and farmers' income by \$310 per hectare [27]. In addition, nest boxes construction for great tits in apple orchards has been shown to lead to greater numbers of birds in the area, which feed on caterpillars which can cause damage to

crops, resulting in significantly higher crop yields [25,26]. The construction of bird nest boxes can eliminate the need for pesticides, reducing farmers' expenses by avoiding purchasing harmful pesticides and limiting the usage of potentially dangerous chemicals.

The contribution of birds in pests control is not only restricted to invertebrate pests, but also extended to vertebrate such as rodent pests. It was revealed by the field experiments in Israel with a trained Barn Owl that the presence of an avian predator creates a "landscape of fear" that can significantly decrease seed consumption by small rodents [28]. Owls have also been shown to control rat populations in various field crops, such as wheat, rice, and corn. In Malaysia, oil palm farmers put up Barn Owl nest boxes when local rodents developed resistance to the rodenticide warfarin [29]. The switch to owls had the added benefit of population increases of other species that were being poisoned by warfarin, including mammalian predators, such as common palm civets and leopard cats.

A mutual relationship between birds and livestock has been documented so far and is also believed to be beneficial to humans. Many birds land on livestock like cattle and forage on arthropod pests that may live on them. This relationship could be exemplified by cattle egrets which are particularly well known for surviving this way [30]. While the birds benefit from a readily available food source, on the other hands, the animals on which the birds forage on benefit from the removal of harmful parasites. People keep and depend on cows for meat (food) and milk in many parts of the world. When cows are infested with ticks or other parasites, they become weak and milk production drops. This is confirmed by study in Pakistan where birds are proficient of effectively preying on these parasites, leading to healthier and more productive cows [31]. The predation of parasites on livestock by birds is even more effective than pesticides in many ways. Through these birds-livestock interactions, humans gain a benefit by not spending money for purchasing expensive pesticides and by having more productive and healthier livestock.

Birds in Seed Dispersal and Pollination

Birds as Seed Dispersers

Because of their mobile nature, birds connect habitats in a landscape, and contribute to ecosystem functions and resilience through their foraging and seed dispersal behavior. Seed dispersal is crucial for biodiversity, species distributions, population dynamics and gene flow. Birds disperse seeds of many woody plant species with direct value to humans for timbers, medicine, food and other uses [32]. This services is mostly observed in frugivorous birds

species comprising nearly 48 families, (1/3 of the total living birds' species), which exclusively use fruits as their food [7].

Birds take the seeds to much longer distance than wind or other means of dispersal [33]. Being an important dispersers of plants (vascular, terrestrial, aquatic or otherwise), birds become an integral part of complex mutualistic network among the carriers and the carried; enhance and maintain the biodiversity and community structure in several natural ecosystem [34]. Birds are one of the primary drivers of plant succession and recruitment in natural biomes, a service very valuable, but never given due attention. It is notable that birds alone disperse as many as 80,000 species of angiosperms, of which about 25,000 are trees, woody shrubs, lianas, vines, and herbaceous plants [35,36]. Furthermore, birds contribute in reforestation by germinating the dispersed seeds, reducing the costs of restoring the deforested areas [37]. In oak forests in Sweden, the cost of replacing the seed dispersal services of Eurasian jays in oak regeneration is estimated to be \$9,400 per hectare [38]. Birds provide an important service in promoting forests' growth, which sequester carbon there by aiding climate change mitigation and perform a number of other services that stand to benefit humans.

Birds as Pollinators

Bird-plant interaction of pollination and seed dispersal has large impacts on ecosystems [39]. The role of wild birds' pollinators in food production is reported by many literatures to be very crucial for food production [40,41]. Pollination process of some trees species is assisted by birds mainly nectarivorous (family: Nectariniidae) which only consume nectar. It has been found that preclusion of pollinators such as bees, birds and bats have differential role in fruit setting in several plants, both domesticated and wild [42]. Among birds, over 920 species are known to involve in pollination: E.g. hummingbirds (Americas), sunbirds (Africa and Asia), false-sunbirds (Madagascar), flower peckers and white-eyes (Southern Asia), honeyeaters and Lories (Australasia), and Hawaiian honeycreepers (Hawaii) [7].

Although studies on bird-pollination are relatively uncommon, in India studies show that birds such as Black Drongo, mynas, crows, babblers, Rose ringed Parakeet, Golden backed Woodpecker, bulbuls, flower peckers, tits and lorikeets visiting the flowers, most of which carrying out pollination [43,44]. More than 290 bird species are said to be serving in pollination and seed dispersals, of which sunbirds, mynas, starlings, and Oriental White-eye are the frequent flower visitors and probably the prime avian pollinators [36,45,46]. Although there were a few attempts to value the service in economic terms, especially focusing crops and insect pollinators, not much attempt is known to have made focusing on birds [47]. The role of birds as pollinators

positively impact ecosystem by sustaining plants species with direct or indirect benefits to human and maintain floral diversity.

Birds as Scavengers and Sanitary Agents

Birds are believed to be essential scavengers in many ecosystems, removing the carcasses of dead animals. Many birds' species opportunistically depend on animal carcasses when it is available, whereas vultures are doubtlessly well known and obligate feeder of this food type. Vultures provide one of the most important, yet underappreciated and less studied ecosystem services of any avian group. These scavengers are particularly important in developing countries where sanitary waste programs may be limited or nonexistent. By scavenging, vultures and other carnivorous vertebrates contribute to waste removal, disease regulation, and nutrient cycling [48]. In removing carcasses rapidly and efficiently, vultures cleanse the environment and protect humans, livestock and wildlife from infections and other disease. Vultures possess the ability to resist and possibly detoxify bacterial toxins in rotting flesh. Extremely acidic secretions of the vulture stomach kill all but the most resistant spores, reducing the pathogenic bacteria by consuming carcasses and thereby reducing disease. In Serengeti, vultures have an outstanding capability of consuming hundreds of pounds of carrion per kilometer annually and in Yemen, vultures can remove up to 25% of the organic waste produced in towns by humans [49,50].

Scavenging ability of birds is an important means of waste removal in many places helping in preventing the diseases outbreak than can occur when these animal carcasses had accumulated. In India, the declines in vultures as a result of poisoned carcasses led to an increase in number of feral dogs and rats as there was less competition for carrions as a food sources. The increase in these potential disease vectors (the feral dogs) led to an increase in rabies outbreak and human injuries from dog attacks, and possibly caused the 1994 bubonic plague outbreak in western India that killed 54 people and health cost of over \$2 billion [51]. This vulture declines led to approximately 48,000 additional human rabies deaths with the total health cost of \$34 billion [51]. It is obvious in this case that the value of birds to humans is significantly high and highlights the direct importance of healthy birds' populations to humans.

Birds in Ecotourism and Sacrament

Birds in Ecotourism

Recreational value is an important service provided by birds and it is documented in many scientific literatures. Well-known and mostly practiced among them is bird-watching or birding. Bird watching is an activity enjoyed by most

people as source of refreshment after a long strenuous work hours. It can also be used to advance ecotourism as a means of making money. Many conservation agencies and other similar organizations generate income by taking tourists on bird watching expeditions. In 2008, 81 million people in the United States enjoy bird watching, and it is estimated to rise to 108 million people by 2030 [52]. While engaging in birding activities, bird-watchers spend a lot of money in order to use this precious service. In 2001, the US bird-watchers spent \$32 million for refreshment on bird watching, indirectly boosting the economy by \$85 million and creating nearly one million job opportunities [53]. Therefore, the demand for bird-watching trips for recreations and bird hunting contributes to the current boom in ecotourism industry as well as economy in general.

Sacred Value of Birds

Birds often represent symbolic values and significant roles in tradition and religion in many cultures across the globe, from ancient times to today [54]. Particular bird species, due to their magnificent appearance, power of flight or absolute beauty pertaining to both visual and vocal, were considered symbols of deities. For example, in many Native American religions, eagles are considered sacred messengers that carry prayers to the spiritual world. Eagle feathers are believed to have holy powers and capturing eagles to remove the feathers is part of a sacred ritual [55]. In many religions, vultures are considered deities that play a large part in their mythology and traditions [56]. The spiritual enrichment and appreciation of nature that birds provide is an essential part of the human experience.

Conclusions

Birds provide a numerous key roles in the ecological balance of resources in each habitat in the biosphere. Birds' seed dispersal mechanism help to facilitates wider distribution of numerous plants species to remote parts of the earth building up the biodiversity and richness of the receiving ecosystems, movement of the offspring away from the parent, thus helping to reduce competition. In addition, their scavenging nature prevents various infectious diseases by cleaning local habitat's carcass which may harbor pathogenic microorganisms. Moreover, their role in nutrient cycling promotes growth of primary producers which in turn attract top predators exerting bottom-up effect on food web. Other services like recreational, pest control, pollination and sacrament also have significant importance in sustaining ecosystem and human welfare.

Most of the services provided by birds are in one way or other have economic and ecological value but few of them are not classified. Acknowledging these important ecosystem

services birds offer still uneasy and unaccredited because of insufficient information. Moreover, these services remain out of the market, perhaps, because they are generally obscure and hard to evaluate. Research driven policies fostering lasting conservation of avifauna; conservation, restoration and management of their habitats and control of illegal birds' trade are highly needed. The attempts of conserving and maintaining healthy birds population and their habitats would preserve diverse ecosystem services by benefiting many different living species and finally human well-being.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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