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Ecosystem services as a tool for conservation argument: Emphasis on pollination and seed dispersal

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ABSTRACT

Ecosystem Services (ESS) are the benefits of goods and services that humans enjoy from nature which are usually taken for granted. It has been used in this paper as a veritable tool for the conservation argument. Biodiversity and their critical services such as pollination, seed dispersal, climate regulation, drought mitigation and water purification as only some of these services are continually been threatened at an alarming rate. In order for these ecosystem services (ESS) to be better appreciated, their value needs to be emphasized. Ecosystem services (ESS) can be a powerful tool for conservation argument but placing a value on these services is difficult, this paper tries to put forward ecosystem services (ESS) by highlighting some of these important services and their values economically and otherwise as an approach that is working by influencing decision makers, the paper also gave evidence to support the relationship between biodiversity per species richness and ecosystem services to support the conservation movement.

Keywords: Biodiversity, conservation, ecosystem services, pollination, seed dispersal

1. INTRODUCTION

The dynamic complex of plants, animals and micro-organism communities and non-living components interacting as a functional unit is referred to as ecosystem [1-2]. Ecosystem ecology focuses on the interactions that occur between living organisms and their environment as an integrated system [1]. Biodiversity is being viewed more expansively, to include genes, species, populations, communities, ecosystems, and landscapes, with each level of biological organization exhibiting characteristic and complex composition, structure, and function [3-4]. As a result, current recommendations for biodiversity conservation focuses on the need to conserve dynamic, multi-scale ecological patterns and processes that sustain the full complement of biota and their supporting natural systems [5-6]. Humans derive a vast number of services from biological communities and these services emerge from the ecosystem functions provided by the species within the communities [7]. The biodiversity argument has two phases which are the anthropocentric (conserving for human benefit) and intrinsic (conserving for its own inherent value) [2].

Ecosystem services are the components of nature, directly or indirectly enjoyed, consumed or used to yield human wellbeing. The processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants are all ecosystem services [8]. The ecosystem services (ES) concept places emphasis on the multiple benefits of ecosystems to humans [9], and its use can facilitate collaboration between scientists, professionals, decision-makers, and other stakeholders. Although the concept has gained considerable interest inside and outside of science, it is increasingly contested and encounters multidimensional objections [10].

The science of conservation biology has evolved from a crisis-oriented discipline focused on rare or endangered vertebrates to a more proactive experimental discipline focused on patterns and processes at multiple scales [11]. Recently, ecosystem service is been included in measuring biodiversity [12]. Ecosystem function and services can be grouped as regulation function, habitat function, production function and information function [13].

2. GENERATION AND MAINTENANCE OF BIODIVERSITY AND HABITAT FUNCTION

This contributes to the in situ conservation of biological and genetic diversity and evolutionary control processes. Natural ecosystems serve the purpose of providing refuge and also habitat for reproduction to biodiversity. Biodiversity is generated and maintained in the natural and semi-natural ecosystems where organisms encounter a wide variety of living conditions and chance events that shape the evolutionary trends that affect them in special ways. For instance, our ability to increase crop production in the face of new pests and diseases has depended heavily on the transfer of genes to our crops from their wild relatives that confer some resistance this has increased food production by about 1 percent [14].

3. REGULATORY FUNCTION (CLIMATE AND LIFE)

This category include those services enjoyed by humans such as clean water and soil, and other biological control services and includes the capacity of natural and semi natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biosphere processes. The earth's climate has fluctuated tremendously ever since the human race inhabited it. For instance about 20,000 years ago (peak of the last ice age), much of Europe was covered by mile-thick ice sheets. While the global climate has been relatively stable since the invention of agriculture around 10,000 years ago, periodic shifts in climate have affected human activities and settlement patterns. Fluctuations that have occurred and is still occurring, thought to be caused by alterations in the earth's orbital rotation or energy output of the sun and/ or events on earth itself, climate has been remarkably buffered by some events throughout the change occurrence to have enable it sustain life for over 3.5 billion years [15].

Climate plays a major role in the evolution and distribution of life over the planet. Life itself plays important role in the buffering and regulation of the earth's climate by helping to offset the effect of episodic climate oscillations by responding in ways that alter the greenhouse gas concentrations in the atmosphere. For instance, natural ecosystems have played important role in stabilizing climate and preventing overheating of the earth by removing more of the greenhouse gas carbon dioxide from the atmosphere as the sun becomes brighter and brighter over millions of years [16]. "Climate and natural ecosystems are tightly coupled and the stability of that coupled system is an important ecosystem service"[17].

Ecosystems exert direct physical influence that helps to moderate regional and local weather. Transpiration for instance, which is the giving off of water by plants in form of vapor, in the morning causes thunderstorms in the afternoon, thereby, limiting both moisture loss from the region and rise in surface temperature.

3.1. Mitigation of Floods and Droughts

The ecosystem serves a vital role in erosion control in many ways and helps conserve the soil. Plant and plant litters help shield the soil from the full, destructive force of raindrops and hold it in place [18]. Plants roots absorb much of the water from the surface of the earth while remaining is gradually drained into aquifers and surface streams this saves the earth from being over flooded by water coming from the amount of rain received annually on the earth which is said to be about 119,000 cubic kilometers and enough to cover land to an average depth of 1 meter [19].

Living vegetation with its deep roots and above ground evaporating surface also serves as a giant pump that returns water from the ground into the atmosphere. Clear-cutting plant cover disrupts this link in the water cycle and leads to potentially large increases in surface runoff along with nutrient and soil loss. A classic example can be seen in [20] whereby, New Hampshire forest was cleared and applied herbicide to prevent regrowth, and this resulted to significantly higher average stream flow. The wetlands also play a vital role in flood control and can reduce the need for constructing flood control structures. Floodplains and saltmarshes help in slow the flow of floodwaters and allow sediments to be deposited within the floodplain rather than washed into downstream bays and oceans [13].

3.2. Soil Ecosystem Services

The role of soil organisms, particularly mycorrhizas in regulating the diversity of plant species or guilds is essential in the ecosystem due to the fact that most noteworthy ecosystem services such as primary productivity, nutrient cycling (as in the symbiotic relationship of root nodules of legumes and mycorrhizal fungi) and trophic patterns are based on response mechanisms between below ground and above ground organisms. Mycorrhizal fungi are the critical mediators in these processes [21-22]. Soils moderate the water cycle, shelter seeds and provide root anchorage to plants, provide nutrients, decompose and degrade about 130 billion metric tons of organic waste each year and serve as key factor in regulating the earth's major element cycles of carbon, nitrogen and Sulphur and they render these services free of charge [13].

3.3. Information Function/Aesthetic, Intellectual and spiritual Stimulation

This contributes to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience. Ecosystems provide an essential reference function. Many people have deep appreciation of natural ecosystems this can be seen manifest in the art, religion and traditions of many cultures. Activities such as garden and pet-keeping, Film making, bird-watching and feeding, ecotourism and mountaineering, fishing and hunting are all important benefits derived from the ecosystem.

3.4. Production Function of the ecosystem

This is used by secondary producers to create even larger variety of biomass goods for human consumption, ranging from food and raw materials to energy resources and genetic materials. Processes such as photosynthesis and nutrient uptake by autotrophs and conversion of energy, carbon dioxide, water and nutrients into variety of carbohydrate structures, pollination services all fall in this category. Materials are continually been obtained from organisms and their parts directly for human benefit. For instance, fish, honey and other animal products are commonly sold in economic markets. UNFAO, 1993, reported that annual world fish catch amounted to about 100 million metric tons and valued between $ 50 billion and $ 100 billion and is the leading source of animal protein. The variety of vegetation serve as food to man also timber, wood, fuel wood, fibre, fruits, nuts, mushrooms, thatching, spices and pharmaceutical and industrial products and so on [23].

Grasslands are important sources of usable human goods and services including animals used as important labor force such as camels, mules, bullocks among others and those whose parts and products are consumed such as milk, meat, wool and leather. The grasslands are also useful for animal grazing especially in the tropics [24].

From the above classification and examples, it is clear that some of the ecosystem services can be regarded as direct benefits (example; meat, fuel wood, timber and the likes) while others indirect. The indirect benefits are as important as the direct benefits, for example, pollination and seed dispersal which will be discussed further.

3.5. Seed Dispersal

A fully grown plant remains rooted in one place as long as it lives. For plants to move to new sites beyond the parental shadow, seeds need to be dispersed. The seeds of some plants such as the dandelion are modified for wind dispersal some others by water such as the seafaring coconut seeds. Many other seeds yet are dispersed by animals as many in this category have co-evolved with animals for their seed dispersal. Mutualistic congruency between plants and vertebrate frugivores dispersing their seeds initially suggested plants-disperser coevolution and prompted some co-evolutionary models [25].

Seed dispersal is an important ecological process that provides a number of ecosystem services and economic benefits such as removal of seeds from parent plant, where seed and seedling mortality is high, escape from seed predators, enhanced germination, increased gene flow and regeneration in and restoration of natural and disturbed habitats [26]. It is a key process for the spatial and genetic structure of plant populations [27] for the regeneration of disturbed habitats and for vegetation dynamics in general [28].

An understanding of dispersal is needed to assess recruitment limitation in plant communities and to predict population responses to global change [29]. Dispersal can be summarized by a "seed shadow," describing the density of juveniles with distance from the parent, movement at several spatial scales. At fine scales, the fraction of seed that remains near the parent vs. that dispersed broadly affects aggregation and, thus, competition [30-31].

3.6. Dispersal as co-evolution

Plants have co-evolved with some animals for the dispersal of their seeds to suitable environments and conditions. Interactions between fruiting plants and their seed dispersers are now largely recognized as diffuse mutualisms with seeds dispersed by an array of fruit consumers, whose behavior and composition may vary both geographically and temporally [32-33], the tight co-evolutionary relationships between plants and seed dispersers are considered rare and limited to cases where seed size constrains a potential disperser assemblage, or to areas where the disperser community is impoverished [33-34]. Vertebrate dispersers deliver ingested seeds to different microhabitats, this act of dispersal from the maternal environment is important in the diversification of germination timing [35], Plants dispersed by vertebrates have evolved seed appendages or coverings that are ingested and digested by animals that later eject the seeds in conditions suitable for germination. Dispersal can be carried out on the exterior of the animal or can be carried out after seeds have passed through the digestive system of the animals.

3.7. *Endozoochory vs Exozoochory*

Endozoochory: Seeds enter digestive system of animals, generally when they ingest plant structures closely associated with seeds, these are subsequently spat out, regurgitated or defecated in conditions suitable for germination [27], as seeds pass through vertebrate guts, they experience a variable scarification which serves as seed treatment. This process might diversify their timing of germination that is, asynchrony which may be advantageous in unpredictable environments [36-38]. Passage of seeds through mammal guts changes the timing of germination, generally accelerating it and increasing its diversification that is, asynchrony. Prompt germination often enriches plant fitness [39-40] by allowing early seedlings to outcompete later seedlings. The Elephants for example ingest and subsequently disperse seed of many plants such as Parinari excelsa.

B. Exozoochory: This explains how animals carry seeds on their exterior and further disperse them to areas they may find suitable to germinate. This can be seen in the dandelion and other plants that have burs and / or spicules that stick to animal bodies and are further dispersed.

3.8. Pollination

Pollination occurs when pollens are transferred from one flower to another resulting in fertilization and seed production [41]. It is an essential ecosystem service that contributes to both the maintenance of biodiversity and food production [42]. Pollinators are vital components of both wilderness and farmland ecosystems [14], they are therefore regarded as keystone species due to the disproportionately large role they play in the community structure [2].

It is estimated that 75% of crop species identified as globally significant, require a degree of animal pollination [43]. Fruits and vegetables, which add variety to the human nourishment and provide essential nutrients, tend to depend greatly on pollinators [44-45].

Wild pollinators are important for agricultural production [46-47] and it has been shown that diverse pollinator assemblages increase pollination services as a result of complementary resource use arising from variations in morphology and behavior among pollinator taxa [6, 48]. In many developing regions, wild pollinators are the sole provider of pollination services available, particularly for small-scale farmers, because of the high costs associated with maintaining managed colonies [49] and perhaps limitations in technology to maintain a managed colony.

4. PLACING VALUE ON THE ECOSYSTEM ?

The issue of conferring value on the ecosystem and its services has been undergoing a lot of arguments. Some argue that it is impossible or unwise, that we cannot place a value on intangible resources as human life or other aesthetics. Meffe and Carrol, (1994) argue that when construction standards are set for roads, bridges and others [2]. We are automatically valuing human life because spending more on the project will eventually save lives. The world today is in an economic age. Financial language is one that we understand in our discourse. It is an age of financial literacy and nations measure how well they are faring by measures such as GDP, profits and income. Books that nowadays emerge as best sellers are those on financial literacy. Little wonder there are headlines from the environmental protection such as, "global ecosystems are worth $33 trillion", "Bats' estimated monetary value is placed at $3 billion annually" and so forth [50].

Opinions can be contrasting on whether or not nature and biodiversity should be conferred economic valuations but as it is established throughout this write-up, nature provides us with direct goods and services which are valuable economically and affect our economy directly, nothing seems wrong in discussing and measuring or analyzing those values to gain them better appreciation [50].

The services enjoyed from the natural ecosystems are very difficult or impossible to replicate. While it is also difficult to place direct monetary value on these services, what is possible is calculating some of the financial values. For instance, 80 percent of world's population depends on natural medicinal products, the value of pollination services rendered by animals such as bees, bats and birds for free can worth trillions of dollars, for example, in U.S only, it is estimated at 6 billion dollars annually [2].

The Financial based ecosystem valuation is partially a communication strategy since the monetary language is a much simpler and interesting one to the people of this age and for the fact that the economic value of ecosystem services is a reality, it is huge and noteworthy to a wide range of policy and decision makers [50]. For instance, globally, about 75% of the crops depend to some extend on pollinators in order to produce food enjoyed by man [43] this service of crop pollination has been estimated at about 200 billion dollars [51]. In the US, a recent study estimated the value of pollination by managed honey bees alone at 14.6 billion dollars and this is aside the services provided by feral pollinators which would have further raised this value [52].

Demand and supply determine price, as seen in the water and diamond paradox. It is only obvious that diamond is scarce as compared to water and therefore the reason for its higher price but unlike diamond, if there is no water at all in this world, life and its many processes may stop. The world would pay all it has to avoid losing its life support system [50, 53]. Another technique that can be used in the valuation of ecosystem services or nature in general, is to examine the costs avoided by the presence of an ecological feature or ecosystem service. For example, consider the amount we will have to invest in water treatment plants if we lose the wetlands and their service of water purification [54].

Ecosystem benefit indicator is an alternative to economic valuation and is a quantifiable feature of physical and social landscapes that relates to and defines the value of ecosystem goods and services [55-56]. Both the monetary valuation and the Ecosystem benefit indicator can complement each other. Though the monetary approach tends to gain much attention and weight [50]

If well-articulated, ecosystem valuation could serve both interest of conservation and society [50]. Economic arguments are already winning by way of influencing decision makers and takers and thereby helping the conservation movement and gaining collaborations within and outside of science [50, 57].

4. SPECIES RICHNESS AND ECOSYSTEM SERVICES

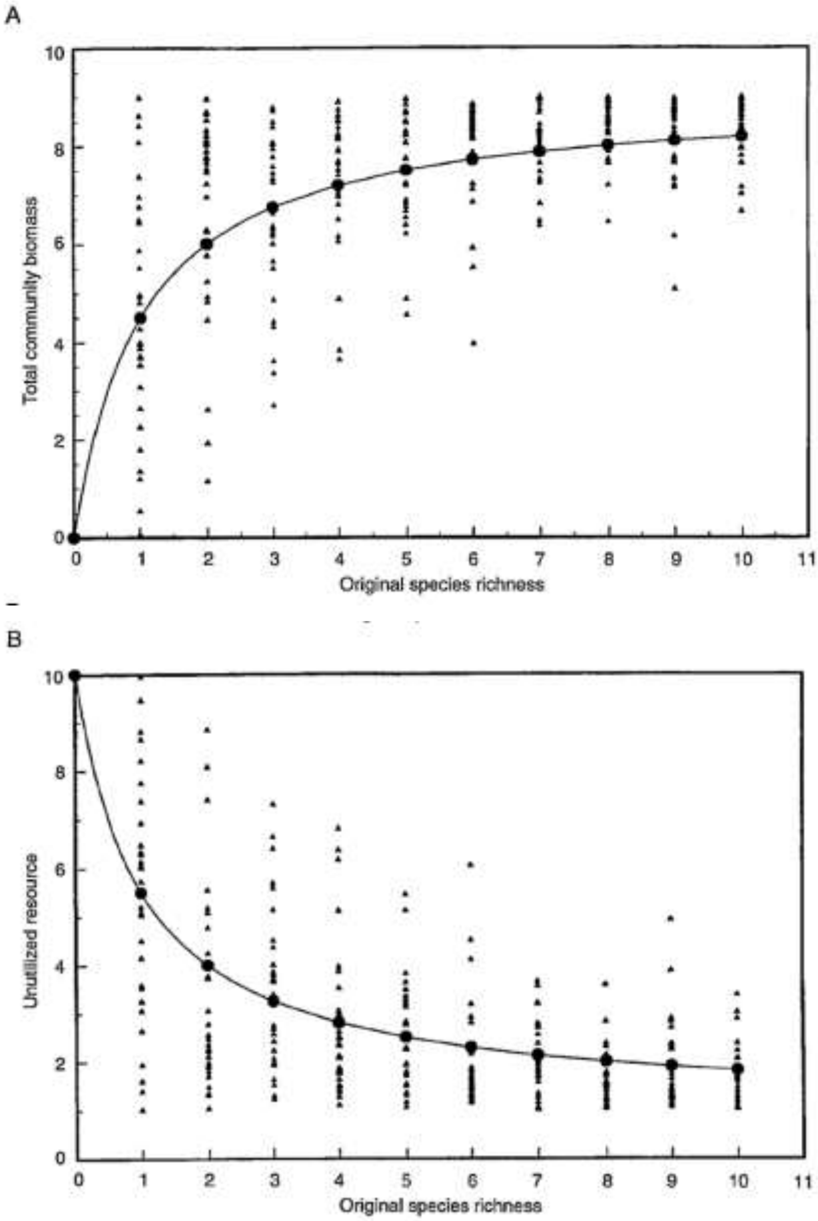

Fig 1. (A) The sampling effect model predicts that productivity should be greater at greater functional diversity, here measures by the number of species present. The variation within a given level of species richness is caused by different species compositions. (B) Productivity is higher in plots with greater functional diversity because of greater capture of the limiting resource. The concentration of unutilized resource is predicted to decline as diversity increases. (SOURCE: Tilman et al., 1997 [62])

Links between plant diversity and ecosystem functioning has been a controversial issue [58]. Recent consensus is on that biodiversity influences ecosystem services [59] and the role of biodiversity in ecosystem functioning has been the focus of high profile debates in the literature [58]. Recent reviews of experimental findings indicate a positive relationship between plant species richness and ecosystem processes as seen in Schwartz et al., (2000) and Schlafter & Schmid, (1999) [60-61]. It is worthy of note that it is the assemblage of species in the ecosystem that delivers the ecosystem service [13]. For example, higher pollinator diversity may result in higher pollination services [6, 48].

Higher ecological overlap of species and the presence of more species performing similar or same ecological function confer greater resistance in the face of disturbance and stochasticity, as ecologically equal or similar species can recompense for the loss of one or more other species within the same functional group. This fact can be buttressed clearly using figures adopted from Tilman et al., 1997 (figure 1)[62].

5. THE PROBLEMS AND THREATS TO ECOSYSTEM SERVICES

Despite the enormous benefits gained by humans from the ecosystem, biodiversity is still been lost at alarming rates courtesy human activities. The major problem coming from habitat's degradation and fragmentation creating unfavorable matrix. The loss of habitat of these biodiversity and the introduction of non- native species which become invasive [2, 13]. It has been estimated that about one species is lost per hour which is more than the time it takes for the evolution of a species [63-64]. Studies show a decline in pollinators and pollination services and this has been shown to have immense economic impact [65].

Major challenge in the area of land management and biodiversity conservation in the tropics is to meet the ever-growing demand for agricultural products while conserving biodiversity, providing critical ecosystem services and maintaining rural livelihoods. The industrialization of farming through mechanization and high use of farming inputs specifically agrochemicals in forms of pesticides are the compounding issues on habitat fragmentation and degradation and even loss [66].

Increase in human population and rate of consumption are likely to lead to greatly increased agricultural demand over at least the next 40 years [67] which could lead to further habitat destruction, loss of ecosystem services, ecosystem simplification and species loss [62] This requires serious attention on how food production and biodiversity conservation can best be reconciled [68-70].

6. CONCLUSION

The world is dependent on the ecosystem services that are usually taken for granted even though they are worth trillions of dollars. As for some of these goods and services evaluating them financially may not be feasible though they are actually human life support systems. We established that some of the nature's services save our lives and if for anything, "a good turn deserves another" and the least we can do is to save the ecosystem's life by whatever noble way possible.

Conferring economic values on ecosystem services which has raised a lot of debate is an important way of putting forth our conservation argument if the ecosystem approach is anything to go by, going with the fact that this generation understands the value of any goods or services when a price tag is placed on it. As a matter of fact, the financial valuation of ecosystem services is already winning arguments as it influences decision makers and gains conservation collaborations.

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8. CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

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