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Links Between Biodiversity, Ecosystems Functions and Services: Systematic Review

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Abstract: The benefits that individuals receive from ecosystems are referred to as ecosystem services (ES). Biodiversity is important in this context since it supports the majority of ecological functions. This review aims to include in the body of knowledge about ecosystem function and services, as well as their relationship to biodiversity. Natural resource stocks and natural ecosystems are essential to the earth's life-support system's operation, and they are priceless to humanity since they contribute to human well-being and welfare. However, because to deforestation and forest degradation, humans has been decreasing these services over the last few decades. The value of ecosystem services is reduced by the loss of species caused by deforestation and forest degradation and lowers our quality of life. Ecosystem processes and services can benefit from biodiversity in a variety of ways. Biodiversity can function as a regulator of important ecological processes, a final ecosystem service, or a good in and of itself. Ecosystems' control, habitat, production, and information functions are all supported by these responsibilities. These functions, in turn, are essential for ecosystems to function properly and deliver services to humans. Biodiversity is woven into ecosystems in a variety of ways. Functional diversity, on the other hand, appears to be the most important component in sustaining ecological integrity and, as a result, providing ecosystem services.

Keywords: Ecosystem, Biodiversity, Ecosystem Function, Services

1. Introduction

Ecosystems, in general, contribute a lot more to a lot more individuals than just pristine intrinsic values. They supply us with natural products, food, water, pest and disease control, and soil conservation, among other things [45]. On a regional or a global level, they have the potential to have significant impacts on climate and hydrology, as well as serve as important carbon sinks (The REDD desk, 2015). Ecosystems, on the other hand, are under great stress; tropical deforestation, for example, is occurring at an unprecedented rate in history, as a result, both biodiversity and ecosystem services are reduced., with serious ramifications for civilization [47, 54]. The majority of global governments acknowledged at the inaugural Earth Summit in 1992 that human behavior was degrading ecosystems on the planet, eradicating biological, species features, and DNA at an shocking rate [13]. Species extinction is not rare in Earth's history; species appear and go at a regular rate (Center for Biological Diversity, 2015). However, complete habitat turnover for the benefit of one species (i.e., humans) is unusual and is currently occurring at worrying rates (Walker & Salt, 2006).

Biodiversity loss and declining ecological services contribute to worsened health, increased food insecurity, increased vulnerability, reduced material wealth, deteriorating social interactions, and less freedom of choice and action, either directly or indirectly [45]. Their result is unequivocal: biodiversity loss has a negative impact on human well-being. Despite the fact that ecosystem functioning, species richness, species composition, functional group richness, and genetic variety appear to have an impact on humanity's well-being, species extinction has increased rates by 1,000 to 10,000 times the normal rates that occurred during Earth's history over the past centuries [17, 40]. For birds, mammals, amphibians, and reptiles, current extinction rates are larger than or equal to those that would have occurred during any of the five previous big extinction events

[37, 9]. Because the drivers of biodiversity damage are either constant, show no signs of reducing in the future, or are even growing in intensity, 30 to 50 percent of all species may be on the verge of extinction by mid--century [18]. People have understood that ecosystem services, biodiversity, and our well-being are all intertwined, hence the recent and past loss of biodiversity is causing concern. This link exists because threat of biodiversity can lead to a reduction or loss of ecosystem services, which can lead to a fall in our well-being [45]. Scientists have improved their understanding of the link between biodiversity and ecosystem services over the last few decades, and people are increasingly comprehending the relevance and value of this link [67]. "With rising losses of unique species, humanity, far from hedging its risks, is getting progressively closer to the day when we will run out of options on a more unstable planet [62]. As a result, if humanity is to continue surviving and increasing on a planet that essentially provides for all of our basic needs, we must be able to conserve our ecosystems while also learning more about the relationship between ecosystem services and biodiversity.

Biodiversity is essential for the generation of ecosystem services; biodiversity can serve as an ecosystem service in and of itself, as a regulator of fundamental ecosystem processes, or as a good. For example, wild crop relatives' genetic diversity can be important for crop strain improvement (biodiversity as a service), diverse biological communities have increased pest resistance (biodiversity as a regulator), and biodiversity has recreational, religious, and educational value (biodiversity as a good) [48]. Ecosystem services can be influenced by biodiversity in both direct and indirect ways. The majority of humanity's food and fibers come directly from plants and animals, but biodiversity has an indirect impact on regulating services (such as seed spreading and pollination) because of the way energy and materials are exchanged in ecosystems. Hence, changes in biodiversity loss can have a direct impact on an ecosystem's ability to generate and supply important services, and thus on economic, ecological, and social systems' long-term ability to adapt and respond to global influences.

To explain this relationship, the terms ecosystem services and biodiversity will be discussed first, followed by the link between the two. Nutrient cycling, oxygen production, carbon sequestration, water and air purification, and the creation of food, materials, and energy are just a few of these ecosystem services [45]. Finally, the main aim of this review was compiling the link between ecosystem function and services and biodiversity.

1.1. Defining Biodiversity

The CBD (2015) describes biological diversity as "the variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and among ecosystems; this includes diversity within species, between species, and among ecosystems." Biodiversity, is "the diversity of life in all its numerous expressions, a wide unifying notion covering natural diversity in all forms, degrees, and combinations, at all levels of biological organization [47, 25]. From E. coli bacteria under your shoes to eyeless shrimps dwelling near hydrothermal vents (>400°C) at 5000 meters depth in the Caribbean Sea, biodiversity is fundamentally cosmopolitan [74, 8]. Some habitats, on the other hand, have more species (i.e. are more species rich). Coral reefs, tropical rainforests, deciduous woods, vast tropical lakes, and the deep oceans are among the most species-rich ecosystems [19].

Tropical rain forests and coral reefs are among the planet's most ecologically diverse ecosystems [45], while little is known about a number of ecosystems, such as deep marine habitats. The world's tropical rainforests, for example, cover only 7% of the planet's geographical area yet are homebased to more than partial of the world's species [19]. These statistics, however, are based on the present number of described species, which is over 1.5 million, with insects being one of the most characterized taxonomic groupings. However, it is believed that 3 to 5 million species remain undescribed (figure 1), and roughly every year, 20,000 new species are discovered with the majority of these still being insects or other arthropods [47]. Today's biodiversity is made up of currently identified taxa, yet biodiversity evolves over time, and the biological diversity we see today is neither what it was previously nor what it will be in the future. Since the estimated birth of sustained, self--producing life on Earth 3.5 billion years ago, around four billion species have evolved on the planet [60]. Over 99 percent of these four billion species are now extinct [57]. Although these figures appear large, according to IUCN standards, between 10% and 50% of the world's species are currently endangered with extinction [45].

Furthermore, because the majority of species on the planet have yet to be properly described, documented numbers are likely to be grossly underestimated [27]. Species extinction rates have surged 1,000 to 10,000 times faster in the last few decades than they were in the past [17]. This shows that we are on the verge of a sixth mass extinction event, which might be triggered by human actions such as global climate change, habitat fragmentation, the introduction of non-native species, and pathogen expansion [37]. Due to the fact that the evolution of new species can take hundreds of thousands of years and the recovery from major extinction events can take millions of years, this poses a serious danger to ecosystem functioning [78, 4]. Nonetheless, the drivers of biodiversity loss and changes in ecosystem services are either constant, show no signs of diminishing in the future, or are intensifying [45]. If existing dangers to many species are not mitigated, the globe could achieve dramatic diversity loss that marked the five major extinctions within just a few centuries [47]. The loss of species diversity should be cause for concern, not only because of the loss itself, but also because of the impact on ecosystem services and ecosystem functioning, which will be examined further in the next chapters.

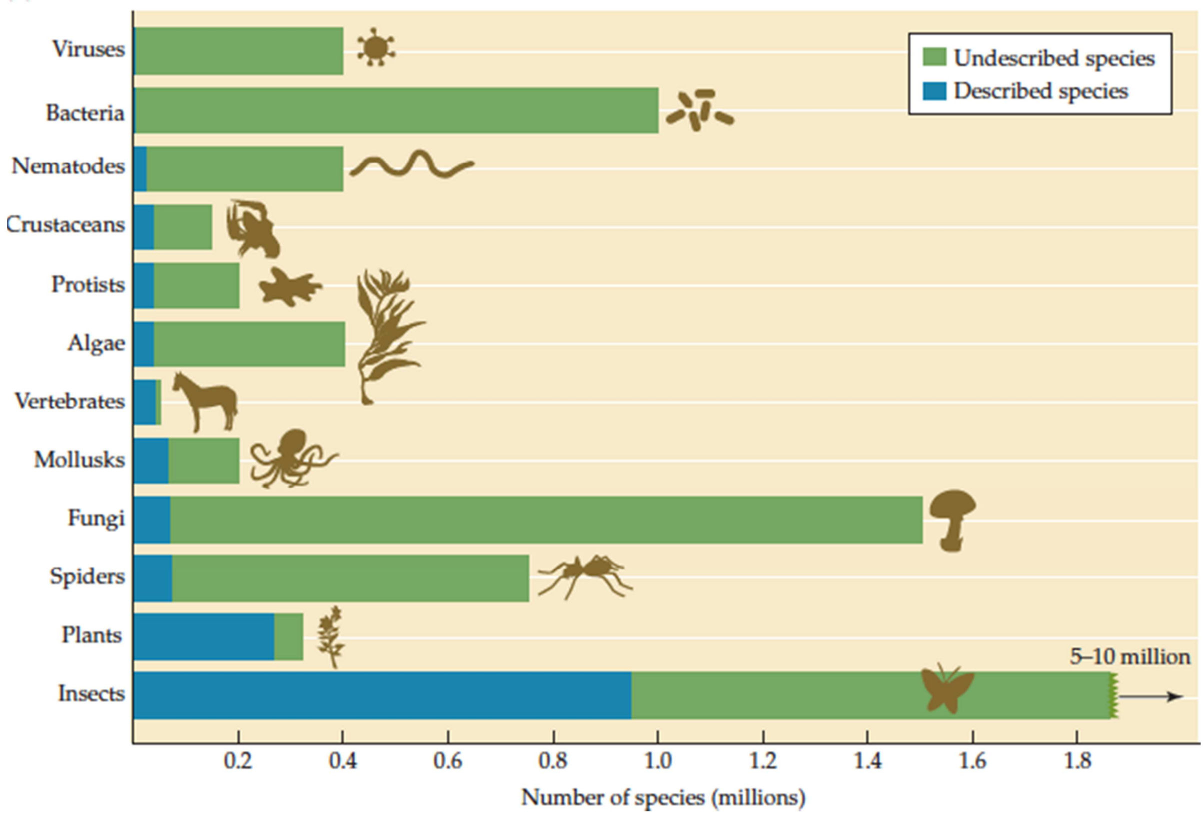

Figure 1. *The number of identified species and an estimate of the number of undescribed species for each category [19].*

1.2. Components of Biodiversity

Several studies have shown that ecosystems are highly dependent on a variety of biodiversity components, which will be discussed in further depth in the following chapters. Species richness, species composition, and functional group richness are some of these components, and ecosystems can also be influenced by genetic diversity and species evenness [40]. Species composition refers to the relative abundance of each species in an ecological community, whereas species richness refers to the total number of species present. The number of groups of species with similar functional trait qualities is called functional group richness, genetic diversity is called diversity within species, and relative abundance of the different species that make up the richness is measured by species evenness. Functional diversity, defined as the kind, relative abundance, and range of functional features present in a community, appears to be a key component in preserving ecological integrity and, as a result, providing ecosystem services [16, 38, 23]. Functional diversity affects and is affected by major drivers of global change, such as changes in land use, atmospheric composition, climate, and biotic interactions [47]. Numerous recent studies have demonstrated the relevance of functional diversity as the primary supplier of ecosystem services [47]. (Luck et al., 2003; Andersson et al., 2007; Vandewalle et al., 2008). The ecosystem becomes increasingly vulnerable as functional diversity declines, and little external events are more likely to cause changes. This could lead to simpler ecosystems that are more vulnerable to perturbations in their ability to develop service--providing functions" [23, 72].

In addition to the link between biodiversity and ecosystem services, ecological stability (a natural system's ability to return to a steady state after a disturbance) is also highly connected. For example, the effects of biodiversity loss on ecological processes could be as significant as the effects of many other global sources of environmental change. The effects of species loss on primary productivity are similar to those of ozone, UV radiation, fire, global warming, drought, herbivory, acidification, high CO2, and nutrient pollution [13, 38]. As a result, a decline in biodiversity and ecosystem functioning will almost certainly result in a reduction in ecological service provision. Ecosystems maintain a natural, steady state of functioning, and they have the ability to recover when they are disturbed or perturbed. However, an unbalanced ecosystem that is unable to operate correctly, for example owing to a loss of diversity, will not be able to recover, let alone provide any services useful to humans [20].

To summarize, biodiversity has altered over time and will continue to change in the future; nevertheless, the rate at which it is changing currently is unparalleled in Earth's history and is a result of human activity. Our health, monetary prosperity, food security, vulnerability, social interactions, and freedom of choice and action all suffer as a result of the loss of biodiversity, ecosystem functions, and services [45]. The value of biodiversity, as well as the accompanying ecosystem functions and services, is critical to humanity's survival and should be our primary conservation goal. The term biodiversity will be used throughout this review to refer to all types of life on Earth.

1.3. Ecosystem Functions and Services

Over one billion people living in extreme poverty rely on ecosystem services [6]. Furthermore, 80% of the world's population is reliant on natural-source medicines [60], and crop pollination by bees is responsible for 15--30 percent of the United States' food output [43]. Ecosystem functions supply us with valuable services and goods, and these services and goods are necessary for our survival [24]. According to Daily, ecosystem functions are "the capacity of natural processes and components to provide goods and services that directly or indirectly satisfy human needs," and ecosystem services are "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life". Many of these functions and services are not just useful but also necessary for our survival (air purification, temperature regulation, crop pollination), while others may only serve to improve it (aesthetics). Ecosystem are the set of ecosystem functions that are helpful to humans [43]. As a result of this definition, it is evident that if ecosystems do not function properly, we will have fewer, if not no, ecosystem services. The dominance of humans over the biosphere has resulted in major changes in ecosystem structure, composition, and function [76]. These alterations may have such a significant impact on ecosystem function that their ability to function correctly and offer services has already been harmed [51]. Over 60% of ecosystem services are deteriorating or already overused [45]. Despite the fact that natural ecosystems have long been recognized as supporting human cultures, ecosystem services have only recently been recognized officially [51].

Ecosystem functions are divided into four categories: regulation, habitat, production, and information [24], which will be discussed more below. Regulation functions refer to ecosystems' ability to control life support systems and ecological processes via biogeochemical cycles and other biospheric processes including nutrient cycling and climate regulation [77]. These functions support various services that benefit humans, including as clean water, soil, and air, and biological control services, in addition to preserving ecosystem health. Through the provision of reproduction habitat and refuge for flora and wildlife, habitat functions contribute to evolutionary processes and the maintenance of genetic and biological variety. Autotrophs convert water, energy, nutrients, and carbon dioxide into a variety of carbohydrate structures, which are then utilised by secondary producers to form a wider range of living biomass [25]. Food, energy resources, raw materials, and genetic materials are among the numerous goods that this variety provides for humanity. The information functions that contribute to human health by giving possibilities for spiritual enrichment, reflection, recreation, aesthetic experience, and cognitive development are known as information functions [24, 42].

These ecosystem functions are essential for ecosystems to function properly and deliver services to humans. Provisioning, regulatory, cultural, and supporting services are the four categories of ecosystem services that are delivered to humankind. Provisioning services supply us with actual ecosystem items like fuel, food, fibers, and fresh water. The benefits from the regulation of ecological processes that have a more indirect impact, such as climate regulation, water regulation, erosion control, and air quality maintenance, are known as regulating services. The non--material advantages acquired from ecosystems through recreation, spiritual enrichment, and aesthetic experiences are known as cultural services. Supporting services help mankind indirectly or over time, and are part of the complex structures and processes that provide other benefits. Nutrient cycling and soil formation are examples of supporting services [35, 69].

2. Ecosystem Functions and Services Classification

2.1. Regulation Functions

Natural ecosystems are essential for the proper functioning of life support systems and ecological processes. “The survival of the earth's biosphere as humanity's only life support system in an otherwise hostile cosmic environment is contingent on a careful balance between various ecological processes” [20]. The storage and transfer of energy and minerals in food chains, the mineralization of organic matter in sediments and soils, the translation of energy into biomass, biogeochemical cycles, and the regulation of the physical climate system are just a few examples of these processes. Regulation functions are critical to human survival on Earth, but they're generally only discovered after they've been badly disrupted or gone. We must protect the integrity and existence of natural ecosystems and processes in order for humanity to continue to benefit from these functions [35, 22].

2.2. Habitat Functions

All plants and fauna have a place to live in the earth's ecosystems. Because most of the world's ecosystem functions are provided by the diversity of species and their roles in ecosystems, maintaining healthy habitats is essential for the provision of all ecosystem services and products. Nursery and refugium functions are the two sub--functions of habitat functions [9, 11]. Many ecosystems across the world provide nursery and breeding habitats for species that are both crucial for humanity's survival and profitable. Natural ecosystems are also necessary for the preservation of genetic and biological variety on the planet since they provide living space. These ecosystems can be thought of as a genetic library, and maintaining their viability necessitates the preservation of natural ecosystems [20, 9].

2.3. Production Functions

Water, food, oxygen, medical and genetic resources, energy, and raw materials are just a few of the resources that the Earth supplies. Humans have discovered how to alter ecosystem productivity to give greater than natural quantities of resources [20, 9]. These production functions can be further subdivided into the following categories:

Food and raw materials: Although most foods are now sourced from crops and animals, natural flora and fauna still provide a significant portion of the diet. Natural ecosystems provide an almost limitless supply of edible plants and animals, including fruits, vegetables, fungus, game, fish, and fowl. Wood, biochemicals, fibers, and organic matter are among the renewable resources they supply use these resources for construction, fuel, handicrafts, and apparel [3, 75, 35].

Genetic resources: Without the genetic diversity of their wild relatives, humans would be unable to sustain many commercial crops. Regular inputs of genetic material from wild relatives are required to improve a crop's quality (e.g., size, taste, and disease resistance) or sustain its productivity [24, 68].

Medicinal resources: Chemicals found in nature can be employed as medications and therapies. Epibatidine, a chemical derived from the skin of the Phantasmal poison frog, is one example (Epipedobates tricolor). This chemical's derivative has the power to kill pain 200 times more effectively than morphine while avoiding the undesirable side effects (Johnson, 1998). Animals are also employed as medical equipment, student specimens, or to test novel medications [24, 31].

2.4. Information Functions

Natural ecosystems offer a wide range of recreational, educational, spiritual, and mental growth opportunities. Nature is a crucial source of inspiration for art, science, and culture, as well as a wealth of research and educational opportunities [2]. Environmental environments provide a highly inspirational and instructional kind of recreative experience, with potential for spiritual enrichment, cognitive development, and contemplation through exposure to living processes and natural systems [15].

2.5. Valuing Ecosystem Functions and Services

Ecosystem valuation is a notion that can help us comprehend and quantify the value of the functions and services offered by nature. These roles and services must be valued in order to guide future human actions in a sustainable manner. The economic, ecological, and socio-cultural values of an ecosystem's functioning and services can be classified into three categories, as stated below.

2.5.1. Economic Value

Direct market value, indirect market value, group value, and contingent value are all methods for determining the economic value of an ecosystem. The exchange value of an ecosystem service in commerce, namely production (e.g. food), regulation (e.g. water filtration), and information functions, is known as direct market value (e.g. recreation). When an ecosystem lacks explicit market values, indirect market values are used. Indirect valuation strategies include people's willingness to accept compensation and pay for the availability or loss of ecosystem services. Contingent valuation entails polling people to determine how much they are prepared to pay for specific ecosystem services, as well as how much compensation they are willing to take in exchange for those services. Social justice, fairness, and non-human values are among the value kinds captured by group valuation, which are not included in contingent valuation approaches [24, 64, 59]. Unfortunately, the value of ecosystem services is not completely reflected in commercial markets, and expressing their worth in monetary terms is challenging, thus they are frequently overlooked in key policy choices. There are calculated the value of 17 ecosystem services on a global scale [20]. The computation only took into account renewable ecosystem services; non--renewable minerals and fuels, as well as the atmosphere, were left out. Ecosystems are expected to produce at least $33 trillion in annual services, and possibly as much as $54 trillion. In 1997, its annual value was about 1.8 times the worldwide Gross National Product. The value of ecosystem services is only likely to rise as these services become more stressed and s carcer [29, 5, 16].

2.5.2. Ecological Value

The ecological value of an ecosystem's services and functions can be described as the capacity of an ecosystem to deliver these services and commodities based on the ecosystem processes and components that provide them. To ensure the continuous availability of ecosystem functions, the use of these services and goods should be limited to sustainable levels. If we continue to use services and things in an unsustainable way, the pressure on ecosystems will grow until they collapse. An ecosystem will be unable to fulfill its potential services at this time. Ecological guidelines establish the limits of sustainable use (e.g., resistance, resilience, and integrity). Ecosystem metrics such as diversity, rarity, and complexity, as well as the integrity of the regulation and habitat functions, are ecological measurements of ecosystem worth [7, 4].

2.5.3. Socio---Cultural Value

Many people consider biodiversity and natural ecosystems to be important sources of non-material well-being because of their impact on people's national, historical, religious, ethical, and spiritual values. Environmental functions, education, physical and mental health, independence, and cultural diversity and identity are all influenced by social factors [55, 21]. As a result, natural systems are critical for a sustainable civilization and a source of non--material wellbeing [56, 11, 67].

2.6. Biodiversity, Ecosystem Functions, and Services

The role of biodiversity in ecosystem delivery has been a hot topic in recent years, and one of the most essential approaches to bolster the case for biodiversity protection is to promote and execute the ecosystem services framework [14, 23, 1]. The framework acts as a foundation for defining, tracking, and valuing environmental services. It also helps to raise awareness about the necessity of conserving biodiversity, natural habitats, and ecosystems. Although some studies considered biodiversity to be an ecosystem service in and of itself, the basic assumption that biodiversity in a given ecosystem sustains the majority of the ecosystem's functions is widely recognized [28, 7, 3, 40]. Although some research considered biodiversity to be an ecosystem service in and of itself, the overall assumption that biodiversity in a given ecosystem sustains the majority of the services is still valid [28, 40, 34].

Ecosystem functioning, as well as the extent to which species contribute to it, are essential for ecosystem services to be delivered [34]. As a result, grasping the concept of ecosystem function is particularly challenging. To explain the significance of biodiversity in ecosystem functioning, two hotly contested processes have been proposed: selection effects or sampling effects and niche complementarity/facilitation effects [39, 2]. The selection effect hypothesis states that dominant species or features are more likely to occur in ecosystems with greater diversity. Highly diverse ecosystems, according to the niche complementarity hypothesis, allow for a greater range of functional features and more efficient resource usage, resulting in higher ecosystem functions. Because it's difficult to tell the difference between niche complementarity and facilitation in practice, the "complementarity effect" is used to refer to both [46]. Forest biomass and productivity can increase as a result of a few highly productive and dominating species, or as a result of improved performance of all species present through facilitation and increased resource use efficiency [30, 32].

Ecosystem service delivery is continuing to deteriorate [12, 49, 80]. The worrisome rate of ecosystem deterioration has brought the problem of biodiversity and ecosystem function and services to the forefront of research priorities [1, 31, 70]. Understanding these connections is important not only for confirming theoretical predictions (niche complementarity and selection implications), but also for creating conservation strategies for biodiversity and ecological services [6, 13].

Over the last two decades, the relevance of biodiversity in ecosystem functioning and service delivery has been extensively researched [13, 53]. In a meta-analysis, [11] discovered that plant litter diversity increased component breakdown and recycling following organism death. Another example is stand productivity and/or biomass, which is by far the most common of ecosystem functions in plant communities. Previously, stand biomass was used as a significant productivity indicator [36, 40]; however, increment of biomass, basal area, or carbon could be more relevant metrics for aboveground biomass production [30, 32]. An analysis of the relationship between mean biomass and gross primary production based on data from a positive correlation across varied forest ecosystems (Figure 2), showing that biomass can be used as a proxy for productivity [66]. Only 14 percent of the biodiversity-productivity links looked at productivity directly, while 34.4 percent used biomass as a proxy [50, 41]. Log-log productivity-biomass data revealed models, showing a strong link between productivity and biomass, and cautioned against using biomass to forecast productivity recklessly. The majority of productivity or biomass-based biodiversity and ecosystem function studies have focused on natural and experimental grasslands systems [14]. Mixed temperate forest stands, and less diverse forest ecosystems [58, 59, 71, 63]. Those who have studied the relationship between biodiversity and production in natural forests, on the other hand, have found little agreement [61].

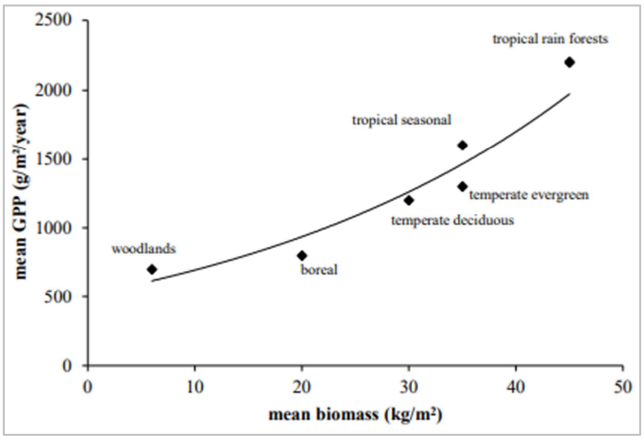

Figure 2. *Across different forest ecosystems, the relationship between mean biomass and gross primary output is examined [66].*

If it is assumed that increasing plant diversity in forest ecosystems improves ecosystem functions and that loss of biodiversity has a negative impact on ecosystem functioning and services provided [6, 34], it must be noted that current knowledge of the mechanisms 7is limited [58, 6, 44]. A negative relationship between species diversity and biomass production, as did [59, 67]. Such links have been demonstrated to be inconsequential in other studies [33, 10]. While the inconsistent results, particularly in forest ecosystems, may show that the mechanisms that drive the biodiversity-ecosystem function relationship are environment-dependent, a key conclusion coming from the literature is that natural tropical forests are largely under-represented. This is true despite the fact that these forests can contain hundreds of species with a wide range of functional characteristics, and studies from temperate mixed species or less diversified forest ecosystems may not be applicable.

It's also worth mentioning that, as a basic indicator of biodiversity, richness (species richness) has been used to describe the relationship between biodiversity and ecological services for years. The current research trend is to look into how functional diversity, phylogenetic diversity, and functional dominance play a role in ecosystem function [15, 19, 73]. Functional diversity refers to the value and variety of functional qualities of the organisms present in a given ecosystem [26, 3], therefore it may be more important to predict the functional contribution of individual species in ecosystem level processes. Functional diversity can be used as a proxy to measure niche space and niche differentiation among species, and hence can be used to test the niche complementarity hypothesis [52]. Dominance in terms of functionality (Figure 3) is a metric for how important a functional feature is in comparison to other attributes. It's commonly utilized to investigate dominance patterns and assumptions about selection influence [14, 30]. Phylogenetic diversity, or the evolutionary history of a community, has also been proposed as a strategy for forecasting ecological roles [11, 65, 1]. Understanding whether and how functional diversity, functional dominance, and/or phylogenetic diversity convey the full effects of diversity on ecosystem function will help researchers figure out which mechanism is the most relevant.

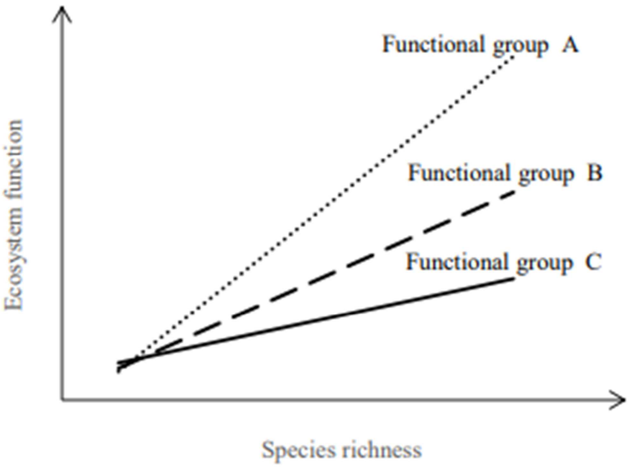

Figure 3. *For each functional group of species, the relationship between ecosystem function and species richness [79].*

3. Conclusion

Most ecological services are directly linked to biodiversity, but not always in a straightforward way. For most ecosystem services, the nature of the link between biodiversity and ecosystem service delivery is largely unknown. Relationships are highly variable and can be positive, negative, or non-linear for those that are known. The number, identity, functional qualities, and evenness of species all have a role in ecosystem functioning and, as a result, the supply of various services. We now have a better knowledge of these interconnections because to concepts and methodologies like ecosystem service providers and trait-based approaches, as well as a better understanding of the mechanisms by which variety affects ecosystem function. At numerous spatial scales, biodiversity is likely to influence the long-term sustainability of functional social-ecological systems and the flow of benefits from nature to societies. Multi-scale, multidisciplinary research in partnership with stakeholders is required to comprehend these longer and larger-scale dynamics. Long-term studies and assessments of numerous ecosystem services show that the extinction of a few species can have a negative impact on service availability and, as a result, human well-being.

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