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Review

A Review of Forest Ecosystem Services and Their Spatial Value Characteristics

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Abstract: Forests provide a variety of resources and benefits, but only a few, such as timber, are traded on the markets. Ecosystem service valuation is a method for quantifying the non-market benefits of forests to understand the full costs of forest management. This review examines the forest ecosystem service valuations over the past 20 years, with a particular focus on their spatial modeling. The literature review method is designed to provide a systematic, explicit, and reproducible outcome concerning the valuations of forest ecosystem services and the contextual setting of these valuations. The findings suggest that there is a huge variation in the values reported for similar ecosystem services but that carbon sequestration, recreation in forests, and hydrological services, such as watershed protection and flood prevention, are the ecosystem services that are consistently valued highly in the reviewed studies. In the last ten years, studies have more frequently modeled ecosystem services in spatial terms.

Keywords: ecosystem services; review; spatial modeling; forest; valuation methods

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1. Introduction

Forests have long provided services for a variety of purposes. They provide building materials, paper, energy, and food, as well as several more intangible services, such as recreation, carbon sequestration, nutrient cycling, and water regulation. All these services can be classified as forest ecosystem services [1–3]. They explain the beneficial functions for society, some of which have market prices (e.g., roundwood), whilst others do not (e.g., water regulation). As such, many forest ecosystem services can be viewed as positive externalities that need to be valuated and included in policy and forest management decisions [4]. For example, forest management decisions might indirectly and unintentionally result in reduced levels of important unpriced ecosystem services, such as carbon sequestration or protection from landslides. By estimating a monetary value for the services a forest provides, a more effective and efficient forest management and policy design can be achieved.

Valuations of forest ecosystem services are normally site-specific, which also makes the monetary valuations specific to the context of the project. This research discusses estimates of the economic values of a wide range of forest ecosystem services using different methods and data applied to different geographical areas. By systematically reviewing the spatial characteristics of forest ecosystem service valuations, it is possible to identify and synthesize more general insights into the underlying characteristics influencing the values of ecosystem services. Previous review articles have attempted this approach on forest ecosystem services. For instance, Ninan and Inoue [5] compile valuations on different forest ecosystem services that summarize them across forest sites and countries (regions). They conclude that the valuations are sensitive to the number of forest ecosystem services valuated, the prices and method used, and the local contexts. The Ecosystem Service Valuation Database, which is described by de Groot et al. [6], is a database of ecosystem service valuations with 4000 value records, both from peer-reviewed articles and other sources, covering a wide range of different ecosystems. Englund et al. [7] review ecosystem services from a wider perspective than merely forest ecosystem services. Their review focuses on spatial mapping, i.e., spatial quantitative information and mapping techniques. However, most studies included in the review do not include economic valuations of ecosystem services. There are also meta-analysis assessing the impact of various determinants on the valuations, e.g., [8]. It has been suggested that spatial characteristics have an impact on the valuation of forest ecosystem services [9], but no attempts have been made to synthesize and analyze these effects in a systematic way.

This review expands these perspectives by identifying and synthesizing the spatial and contextual settings of the economic valuations of forest ecosystem services. For instance, forests closer to urban areas may have a higher recreational valuation than a forest further away, i.e., proximity and population density might affect the valuation. Similarly, an old forest may have a lower carbon sequestration valuation than younger forests, while an old forest may have a higher carbon stock, i.e., the age distribution of the forest affects its valuation. Thus, the extent of the forest ecosystem services, and their relative valuation, depends on their location and on their site-specific contexts, e.g., demographic, geographical, and topographical characteristics. In this respect, certain characteristics that are similar across the valuations might affect the valuations in similar ways. This is useful to know, given the ever-increasing need for future forest ecosystem service valuations, since it provides better estimates and use of the benefit transfer method..

The purpose of this review is to identify and qualitatively analyze valuations of forest ecosystem services based on the methodological approach and on their spatial and contextual settings. Specifically, the valuations are analyzed in terms of four main dimensions: type of forest ecosystem service, valuation method, size of the estimated valuation and the spatial and contextual characteristics. This review therefore addresses the following questions. (1) What forest ecosystem services are valuated, what is their valuation and which valuation method is used? (2) To what degree do identifiable spatial and contextual site characteristics affect the valuation? (3) How can the reporting of spatial characteristics in forest ecosystem services valuation articles be improved?

The rest of this review defines the basic concepts and definitions of forest ecosystem services, followed by an outline of the review methodology. A descriptive analysis of the main features of the valuations, methodological issues and spatial characteristics is then provided. Lastly, the findings are discussed in the context of benefit transfer, along with the shortcomings identified and possible future research endeavors.

2. Materials and Methods

2.1. Forest Ecosystem Service Classification

In general, the concept of a forest ecosystem services (FES) is defined as a function in a forest that directly or indirectly offers a benefit to society. It is therefore an anthropocentric term, unlike the more general ecosystem function [10]. The idea behind the concept is to concretize the environmental functions that are important but not traditionally considered in decision-making. A more detailed definition and classification of an FES is harder to pinpoint. A few different classifications have been proposed (see [7] for a discussion). In this review, we follow the classification outlined in the Millennium Ecosystem Assessment report [10] for ecosystem services in general, and in this context applied to FESs in particular. According to this report, FESs are defined in four categories:

- Provisioning—Products and materials acquired from ecosystems. This includes the production of timber, food, feed, and bioenergy.
- Regulating—Benefits and functions derived from the regulation of ecosystem processes with positive effects for society. This includes carbon sequestration, water regulation and protection against natural hazards.
- Cultural—Non-material benefits acquired from ecosystems that directly or indirectly enhance human welfare. This includes recreation, cultural heritage, and aesthetics.

- Supporting—Underpinning ecosystem services necessary for other ecosystem services to function. This includes soil formation and primary production (i.e., the production of organic matter).

The economic valuation of forest ecosystem services is among the more critical and complex issues in environmental economics. It is a critical issue because environmental accounting, assessment of natural resource damage and accurate pricing are necessary for the sustainable use of forest resources. It is a complex issue because of the intrinsic and delicate relationships between different ecosystem services and between ecosystem services and human welfare. By valuing forest ecosystem services (i.e., placing an economic price on them), their presence and influence on human welfare is acknowledged. The primary aim of the valuation is to explicitly show the implicit value of ecosystems and the services they provide to societies and economies. As illustrated in Figure 1, the total economic value includes both use and non-use values. Use values are derived from the direct or indirect use of forest ecosystem services; for instance, forest resources with commercial value have a direct use value, whilst carbon sequestration has an indirect use value. In this respect, direct use values are derived from the actual use of a forest resource. Indirect use values refer to non-removable (e.g., no extraction of forest products), off-site services or other processes that are impacted by the resource (e.g., flood protection or climate regulation). Non-use values are based on the benefits derived simply from the knowledge that a forest ecosystem service is being maintained (e.g., preservation of habitats for endangered species). Non-use values are not per se associated with the actual use of forest ecosystem services. They can be divided into existence values, which reflect values inherent to the continuous existence of forest ecosystem service; bequest values, which reflect values connected to future generations' access to the forest ecosystem service; and option values, which represent potential values in the future.

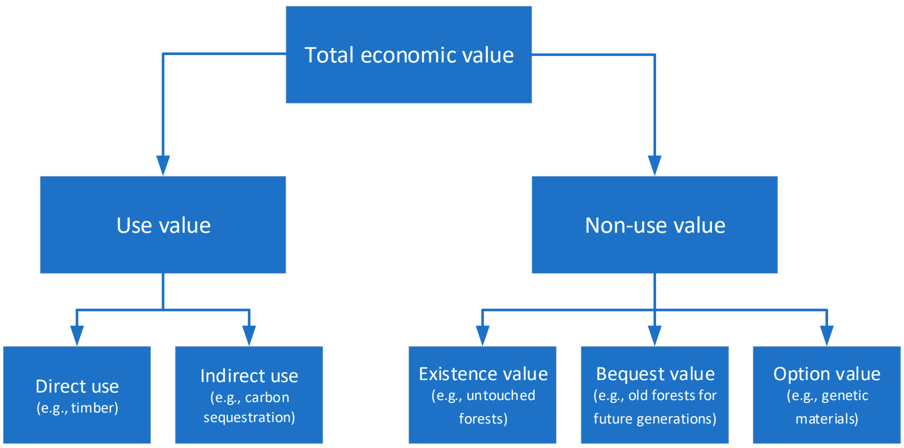

Figure 1. Total economic value and its subcategories.

2.2. Valuation Methods Used in Assessing Forest Ecosystem Services

Various methods for estimating the economic value of forest ecosystem services have been used in the literature (for both use and non-use values). Figure 2 illustrates different methods that have been developed, including the following. (1) The travel cost method, which uses the travel expenditures incurred to visit a specific site [11]. (2) The hedonic-pricing method, which can be applied when the differences in the prices of market goods (commonly, house prices) are assumed to capture the value of the FES [12]. Both the travel cost and hedonic-pricing methods are based on observed behaviors by linking priced market goods to unpriced non-market FESs. As such, they cannot capture non-use values. (3) Contingent valuation is a method whereby people are asked what they are willing to pay for a change in an FES [13]. A variant of this is choice experiments, whereby people are asked to choose between different scenarios [14]. Contingent valuation and choice experiment are the only methods that can capture non-use values. The travel cost, hedonic-pricing and contingent valuation methods estimate the consumer surplus, which is a theoretical measurement of a consumer's utility for an FES. However, other methods have been developed that use different proxies for consumer surplus. These methods include the following. (4) The replacement cost method, which valuates FESs based on the actual expenditures rather than the consumer surplus [15]. This suggests that a valuation can only be made if expenditure has been incurred. (5) The commercial value method, which uses market prices to valuate FESs [16]. However, this method only provides partial valuations because it only includes the parts of an FES that have market prices, ignoring other values. (6) The economic value of changes in an FES can be proxied by measuring the economic impact that the changes have on the regional economy [17]. The measurements of the economic impact can include changes in income, profits, employment, and tax revenues when using the FES. However, economic impact measurements are not economic values as defined by the consumer surplus. Lastly, (7) there is the benefit transfer method, which implies that under certain conditions, a valuation of a specific FES in a specific location and setting can be used to estimate the valuation of similar FESs in similar locations and settings [18]. The accuracy of this method depends on the quality of the original estimate and on the level of similarity between the original and transferred areas.

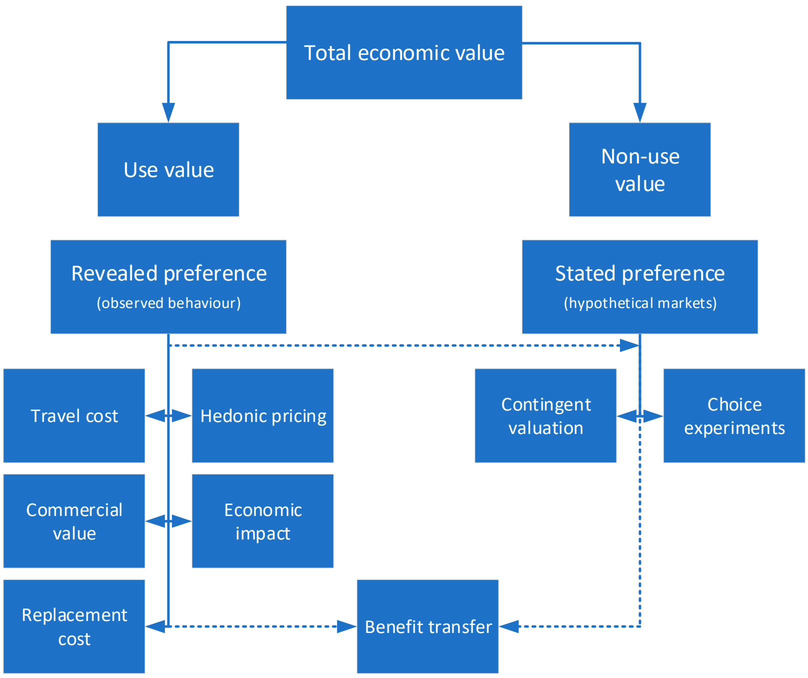

Figure 2. Economic valuation techniques for use and non-use values. The solid arrows indicate the most common method, while the dotted arrows indicate alternative methodological choices.

2.3. Literature Review Methodology

The literature review method is designed to provide a systematic, explicit, and reproducible outcome concerning the valuation of forest ecosystem services and the contextual settings of these valuations. The method is structured into two stages: first, an article selection stage, and then, an evaluation stage.

2.3.1. Article Selection

This review is limited to peer-reviewed journal articles published in English over the last 20 years. The comprehensive literature search was performed using the Web of Science and Scopus databases. For the initial screening of ecosystem valuation articles, the search terms "ecosystem services" or "environmental benefits" combined with "forests" and "valuation" or "payment" or "economic" are used. To include spatial aspects in the article selection procedure, the search terms are extended with "spatial", "GIS" and "mapping".

Additional articles are identified by checking their citations. This review does not consider articles that include valuations of timber provisioning, because pricing data from timber markets are widely available. A total of 239 articles are identified in the first screening.

In the second screening, we check that the titles and abstracts of the identified articles explicitly address forest ecosystem services and estimate their economic values. Moreover, articles that exclusively consider provisional ecosystem services with clearly defined market prices are excluded from the selection (mainly timber, but also some non-timber forest products). Based on the second screening, 46 articles are discarded due to not specifically addressing FESs. A further 86 articles are discarded for not including valuation estimates. The remaining articles form the set of articles included in the review. In total, 107 articles are included in the review, covering the valuation of 327 forest ecosystem services. Valuations that differentiate an ecosystem service based on vegetation cover or other factors are only counted once. A summary of the included articles, with their main characteristics, is available upon request.

2.3.2. Evaluation Approach

The articles and valuations identified are evaluated from two perspectives. Firstly, the main characteristics of the articles are evaluated, which describe and categorize the articles identified according to the journal type and area, year of publication, region analyzed and research designs. Secondly, the main characteristics of the valuations are evaluated according to the type and valuation of the forest ecosystem service as well as their contextual settings. The characteristics of the valuations (and their subcategories) are deductively derived from the overall research questions and inductively derived from the articles identified by an iterative process. Table 1 describes the main characteristics of the valuation of forest ecosystem services.

Table 1. Main characteristics of the valuation of forest ecosystem services.

	Description
Forest ecosystem service	The type and subdivision of forest ecosystem services analyzed in the articles.
Contextual setting	The demographic and geographical characteristics and properties of the forest ecosystem services valuated, including their spatial scale and application.

2.4. Main Characteristics of the Articles

The 107 articles identified cover multiple forest ecosystem services, with numerous different forest types in different countries and regions and with different contextual settings. They differ in the number of forest ecosystem services valuated and the valuation method applied. The research objectives of the articles are generalized into four categories. There are overlaps between the categories in many articles, but they are defined by the primary or most distinct research objective outlined in the article. First, the development of a valuation methodology relevant for FESs. Thirty-five articles have this as their primary research objective, e.g., [19]. Among these, 13 articles focus specifically on method development for spatial ecosystem service valuation, e.g., [20], while 4 articles focus on the integration of economic and ecological methods, e.g., [21]. Second, identifying and quantifying determinants of the valuation of FESs. There are 16 articles in this category, e.g., [22]. Several of them focus on recreation and on the factors that affect the demand for recreation, e.g., [23]. Another common focus in this category is the tradeoffs and synergies between different types of FESs, e.g., [24]. Third, the design of payment schemes and compensation systems offered to landowners for FESs. There are 20 articles in this category, e.g., [25]. Lastly, nearly half of the identified articles (58 articles) can be categorized as policy implications of FES valuations, e.g., [26]. Some articles in this category attempt to measure the total economic value of forests, e.g., [27], while others focus on the benefits to local stakeholders, e.g., [28].

The most frequent journal of publication is *Ecological Economics* with 19 articles published, followed by *Ecosystem Services* with 13 articles, *Forest Policy & Economics* with 6 articles, *Journal of Forest Economics* and *Sustainability* with 5 articles each, and *Journal of Environmental Management* with 3 articles. Several journals have no more than two articles published (*Environment & Development Economics*, *Environmental & Resource Economics*, *Ecology & Society*, *Ecological Indicators*, *Baltic Forestry* and *American Journal of Agricultural Economics*). None of the other journals has more than a single study in the sample. More than one-third (42 articles) are published in journals with a focus on economics, while 31 articles are published in journals primarily focusing on environmental sciences or sustainability. The remaining articles are published in journals covering areas such as forestry, geography, and ecology/biology. A majority (85%) of the articles were published over the last ten years and slightly over half (55%) over the last five years. Numerous articles with spatial mapping of FESs are identified, but many of them did not include an economic valuation, e.g., [29]. In total, 40 articles are identified that include both spatial mapping and economic valuation, e.g., [30].

Figure 3 illustrates the applied method and forest ecosystems service valuated by the reviewed studies. The replacement cost method is used in 86 valuations and is the most used method, e.g., [31]. Among these, 16 use the afforestation cost method developed in China, e.g., [32]. The second most common method is the avoided cost method, which is used in 77 valuations, e.g., [33]. The commercial value method is used in 53 valuations, e.g., [34]. This makes it a commonly used method, even after directly traded FESs have been excluded in the article selection process. Stated preference methods are used in 30 valuations, e.g., [35], evenly distributed between contingent valuations, e.g., [36] and choice experiments, e.g., [37]. Eleven valuations apply travel cost methods for recreation, e.g., [38] and tourism, e.g., [39]. The hedonic-pricing method is used in seven valuations based on changes in property prices, e.g., [40]. Lastly, the benefit transfer method is used in 51 valuations, e.g., [41]. In addition, 11 valuations use other methods, like expert panels [42].

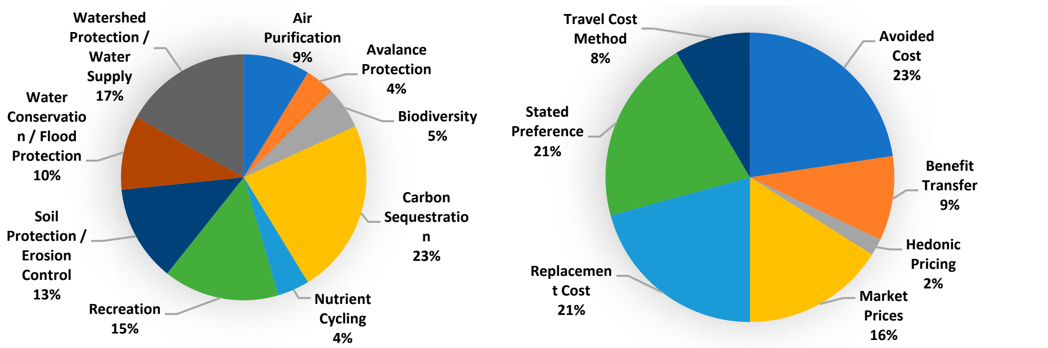

Figure 3. Share of ecosystem service valued and method applied in the selected articles.

The geographical distribution of the FESs analyzed, as presented in Figure 4, suggests that Europe is the region most commonly studied, with 40 articles, e.g., [43]. The second most common region is Asia with 25 articles, e.g., [44], followed by 18 articles for North America, e.g., [45], 13 articles for South America, e.g., [46], 9 articles for Africa, e.g., [47] and 1 article for Australia and Oceania [42]. In terms of individual countries, the three most common are the USA with fifteen articles, e.g., [48], China with nine, [49], and Italy with seven, e.g., [50]. In total, 47 different countries are represented in the articles.

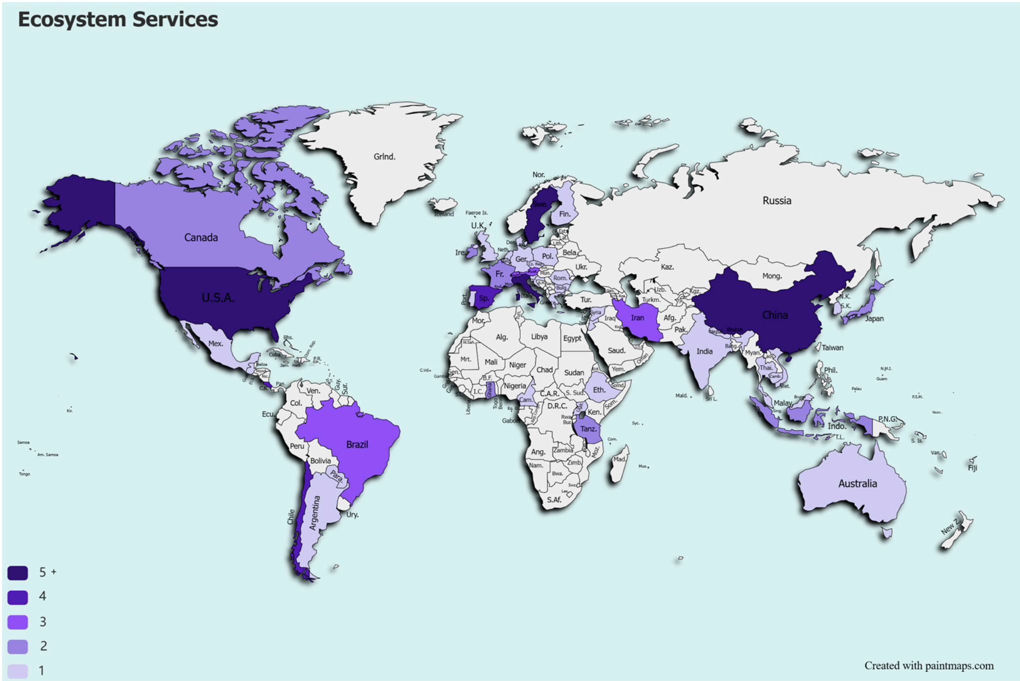

Figure 4. Spatial distribution of ecosystem service valuations.

3. Results

The evaluation is structured based on specific forest ecosystem services, with information compiled exclusively from the reviewed articles. A fundamental problem with the valuation of forest ecosystem services is that some of them are difficult to define and delineate from a practical perspective. Consequently, these forest ecosystem services have received less attention in the literature on economic valuation. The scarcity of valuations could be interpreted as suggesting that these forest ecosystem services are unimportant, but ecological assessments usually reject this notion. A particular example is forest biodiversity valuation, i.e., providing habitats for plants and animals. While the willingness to protect species from extinction is widespread, biodiversity valuations have been included in only a few articles [51,52]. For this reason, biodiversity valuations are not included. Moreover, this review focuses on the valuation of non-provisioning forest ecosystem services, since provisioning services have market-based valuations.

To the greatest extent possible, the evaluation of each forest ecosystem service includes aggregate statistical information on the valuations, methodological choices and their impact on the valuations and the specific contextual settings of the valuations (i.e., countries/regions, population proximity and density, income level, climate zones, forest types, topography, area size of the valuations). For ease of comparison, the valuations are expressed as the annual monetary value per hectare of forest, converted to USD, PPP-adjusted for 2018. Table 2 presents overall statistics on the valuations, with the mean and median values and standard deviation (SD). This table is for illustrative purposes only, as the services are aggregated across all the different forest types and valuation methods. Based on the FES types, the table illustrates that regulating ecosystem services have received the most attention. Table 3 presents summarized statistics on the specific forest ecosystem services evaluated.

Table 2. Overall statistics on the valuations of forest ecosystem services (USD ha^{-1} y^{-1} 2018 PPP).

Forest Ecosystem Service	No. of Valuations	Mean Valuation	Median Valuation	SD
Nutrient cycling	13	104	33	118
Prevention of soil erosion	38 [3]	223	104	392
Air quality improvements	27	467	58	1136
Recreation	45 [1]	595	87	1084
Carbon sequestration	71 [2]	595	133	781
Freshwater supply	53	834	100	2458
Flood protection	29	1790	197	3731
Avalanche prevention	12	9198	771	23,260

[1] Two valuations were excluded for recreation because of outlier values. [2] Two valuations were excluded for carbon sequestration because they estimated neither the carbon flow nor carbon the NPV, and two were excluded because they did not explain the carbon price used in the valuation. [3] One valuation was excluded for soil erosion because of outlier values.

Table 3. Valuations of forest ecosystem services (USD ha^{-1} y^{-1} 2018 PPP).

	# Valuations	Mean	Min	Max	SE
Recreation, of which:	45	595	0.3	3931	1084
Travel costs methods	11	985	6.7	3931	1332
Benefit transfer methods	15	782	2.6	3684	1246
Stated preference methods	8	448	1.7	2506	1008
Commercial value methods	10	72	0.3	411	131
Expert evaluation methods	1	6	--	--	--
Freshwater supply, of which:	53	823	0.4	16,752	2435
Stated preference methods	6	2887	2.1	16,752	6795
Replacement cost methods	16	1129	10	3824	1384
Benefit transfer methods	9	349	37	1746	555
Commercial value methods	14	335	5.8	3208	842
Avoided cost methods	7	57	0.4	149	56
Expert evaluation methods	1	13	--	--	--
Flood protection, of which:	29	1790	0.01	17,830	3731
Benefit transfer methods	4	2509	555	5082	1891
Avoided cost methods	7	1716	3.3	5803	2711
Replacement cost methods	16	1739	0.01	17,830	4547
Choice experiment methods	1	314	--	--	--
Avalanche protection, of which:	12	9198	70	81,631	23,260
Avoided cost methods	2	48,898	16,164	81,631	46,292
Choice experiment methods	1	3179	--	--	--
Replacement cost methods	8	1167	148	5357	1723
Hedonic-pricing methods	1	70	--	--	--
Soil erosion, of which:	38	223	0.03	2154	392
Benefit transfer methods	4	178	0.3	524	299
Avoided cost methods	7	387	0.03	2154	792
Hedonic-pricing methods	5	356	111	1027	380
Replacement cost methods	18	188	24	808	191
Stated preference methods	1	14.3	--	--	--
Commercial value methods	1	6.8	--	--	--
Expert evaluation methods	3	10.3	2.3	16.8	7.4
Nutrient cycling, of which:	13	104	6.5	366	118
Benefit transfer methods	5	160	24	366	158
Avoided cost methods	2	101	29	174	102
Replacement cost methods	3	94	6.5	208	103
Hedonic-pricing methods	2	28	24	33	6.5
Expert evaluation methods	1	9.0	--	--	--

Table 3. *Cont.*

	# Valuations	Mean	Min	Max	SE
Standardized annual flow (USD 25 $tCO_2{}^{-1}$), of which:	52	184	0.3	655	196
Replacement cost methods	16	379	36	656	188
Commercial value methods	13	115	16	474	131
Avoided cost methods	18	83	0.3	440	113
Benefit transfer methods	5	32	10	41	15
Standardized NPV (USD 25 $tCO_2{}^{-1}$), of which:	19	879	1.1	5210	1321
Commercial value methods	9	924	1.1	5210	1714
Avoided cost methods	10	839	101	2650	935
Air quality, of which:	27	468	0.1	5839	1136
Benefit transfer methods	3	2193	357	5839	3158
Avoided cost methods	17	279	1.7	1313	409
Replacement cost methods	6	214	0.1	1015	401
Expert valuation methods	1	16	--	--	--

3.1. Nutrient Cycling

Nutrient cycling is a supporting forest ecosystem service. Foster and Bhatti [53] argue that nutrient cycling in forest ecosystems is primarily controlled by abiotic and biotic properties, in addition to climate and site attributes. The contribution of forests to nutrient cycling has 13 valuations, e.g., [47,54]. These valuations are typically based on fertilizer prices or on replacement costs [32,55]. The annual average (median) valuation of nutrient cycling is USD 104 ha^{-1} (USD 33 ha^{-1}). This is relatively low compared to the valuation of other FESs. The highest valuation is for broadleaf forests in Maryland, USA, with a reported annual valuation of USD 366 ha^{-1} [56]. The lowest annual valuation is USD 6.5 ha^{-1} for a tropical forest in a biodiversity hotspot in India [51].

The method most commonly applied for valuating nutrient cycling is benefit transfer, as applied in five valuations, e.g., [18,47]. The annual average valuation applying the benefit transfer method is USD 160 ha^{-1}. The highest annual valuation of USD 366 ha^{-1} is for broadleaf forests in Maryland, USA [56], and the lowest of USD 24 ha^{-1} is for coniferous forests near an urban area in Sweden [54]. Replacement cost methods are applied in three valuations in two studies [32,51], with an average annual valuation of USD 94 ha^{-1}. The highest annual valuation of USD 208 ha^{-1} is for a mountain forest in a nature reserve in northern China [32] and the lowest of USD 6.5 ha^{-1} is for a tropical forest in a biodiversity hotspot in India [51]. Avoided cost methods are applied in two valuations. The Veun Sai-Siem Pang National Park in Cambodia has a reported annual valuation of USD 174 ha^{-1} [26] and forests in Maryland, USA, have a reported annual valuation of USD 29 ha^{-1} [21]. Similarly, commercial value methods are also applied in two valuations in one study. Broadleaf forests in Japan have a reported annual valuation of USD 33 ha^{-1} and coniferous forests in the same country have a reported annual valuation of USD 24 ha^{-1} [55]. Lastly, an expert valuation method is applied in one valuation for the Wet Tropics of the Queensland World Heritage area, with a reported annual valuation of USD 9 ha^{-1} [42].

The contextual settings for the valuation of nutrient cycling are harder to identify, given the small number of valuations for the FES, but the available valuations suggest that the average annual valuation of soil erosion prevention is highest in upper middle-income countries. For this group of countries, the average annual valuation is USD 138 ha^{-1}, e.g., [32]. This is followed by high-income countries, with an annual average valuation of USD 100 ha^{-1}, e.g., [54], and low-income countries, with an annual average valuation of USD 92 ha^{-1}, e.g., [47]. The lowest valuations are found for lower middle-income countries, with an annual average valuation of USD 90 ha^{-1}, e.g., [26]. Comparing the valuations by region, the highest valuations are in North America (USD 198 ha^{-1}), followed by Europe (USD 113 ha^{-1}), Africa (USD 92 ha^{-1}), Asia (USD 85 ha^{-1}), and Australia and Oceania (USD 9 ha^{-1}). No valuations are found for South America. Nutrient cycling is assigned a higher valuation in mountainous areas (USD 133 ha^{-1}) than in non-mountainous (USD 98 ha^{-1}) areas, while there are no nutrient cycling valuations for urban areas. Valuations are only found for temperate and tropical climates, with the former having a higher average valuation at USD 119 ha^{-1} than the latter at USD 70 ha^{-1}. Broadleaf (USD 138 ha^{-1}) and mixed forests (USD 102 ha^{-1}) are valuated higher for nutrient cycling than coniferous forests (USD 25 ha^{-1}). Study areas between 10,000 and 100,000 ha have the highest valuations at USD 98 ha^{-1}, followed by areas larger than 100,000 ha at USD 91 ha^{-1}. Areas between 1000 and 10,000 ha are valuated at USD 24 ha^{-1}, while no valuations exist for areas smaller than 1000 ha. Unlike most other ecosystem services, nutrient cycling is positively correlated with the area size (0.29) but negatively correlated with the population density (−0.28) and has almost no correlation with the size of the economy (−0.01).

3.2. Prevention of Soil Erosion

The prevention of soil erosion is commonly measured as the estimated soil loss, or the reduction in soil quality, multiplied by the cost of sediment removal [50,57], or by the opportunity cost of land [32,51]. It is classified as a regulating forest ecosystem service. In total, 38 valuations of forests' capability for soil erosion prevention are identified, e.g., [12,42]. The annual average (median) valuation is USD 430 ha^{-1} (USD 105 ha^{-1}). The highest valuation of USD 8316 ha^{-1} is an estimated average for all the forests in the Czech Republic [18]. The lowest annual valuation, for mountain forests in Romania, is almost negligible (USD 0.03 ha^{-1}) [16].

Replacement cost methods are applied in 18 valuations, e.g., [25,50]. They report an annual average valuation of USD 188 ha^{-1}. The highest valuation identified applying a replacement cost method is for Alpine forests in Italy [58]. They report an annual valuation of USD 808 ha^{-1}. The lowest valuation is for rainforest near agricultural areas in Indonesia, with a reported annual valuation of USD 27 ha^{-1} [59]. Avoided cost methods are applied in seven valuations, e.g., [21,26]. They report an annual average valuation of USD 387 ha^{-1}. The highest valuation identified when applying an avoided cost method is for a tropical forest in a biodiversity hotspot in India [51]. It reports an annual valuation of USD 2154 ha^{-1}. The lowest valuation is for mountain forests in Romania, with a reported annual valuation of USD 0.03 ha^{-1} [16]. Hedonic-pricing methods and benefit transfer methods are applied in five, e.g., [12], and four valuations, e.g., [24,47], respectively. The annual average valuation for the prevention of soil erosion when applying hedonic-pricing methods is USD 356 ha^{-1}. The highest annual valuation of USD 1027 ha^{-1} and lowest valuation of USD 111 ha^{-1} are both from Yoo et al. [12], and the different valuations are for different kinds of lakeside forests. The valuations when applying benefit transfer methods have a wider magnitude distribution as well as the highest annual average valuation of USD 2213 ha^{-1} among the different methods. The highest valuation applying benefit transfer methods is reported for forests in the Czech Republic, with an average valuation of USD 8316 ha^{-1} [18]. The lowest valuation is for mountain forests in Portugal, with an annual valuation of USD 0.3 ha^{-1} [24]. Expert evaluation methods are applied in three valuations in one study [42]. They have an annual average valuation of USD 10.3 ha^{-1}. Lastly, a stated preference method is applied in one valuation for an ecologically fragile mountain forest in Nepal, with an annual valuation of USD 14.3 ha^{-1} [36].

The contextual settings of the valuations of forests' capability to prevent soil erosion suggest that the average annual valuation of soil erosion prevention is highest in lower middle-income countries. For this group of countries, the average annual valuation is USD 448 ha^{-1}, e.g., [51]. This is followed by low-income countries, with an annual average valuation of USD 260 ha^{-1}, e.g., [47], and high-income countries, with an annual average valuation of USD 203 ha^{-1}, e.g., [58]. The lowest valuations are found for upper middle-income countries, with an annual average valuation of USD 148 ha^{-1}, e.g., [44]. Prevention of soil erosion receives the highest valuation in tropical climates, with an annual average valuation of USD 324 ha^{-1} [26,47,51]. Temperate climates have an annual average valuation of USD 201 ha^{-1}, e.g., [21,50]. Only one valuation has been performed for subtropical climates, with an annual valuation of USD 24 ha^{-1} [44]. No valuations for boreal climates have been identified. Soil protection is most highly valued in Africa, with a mean of USD 524 ha^{-1}, followed by Asia (USD 241 ha^{-1}), Europe (USD 237 ha^{-1}) and North America (USD 234 ha^{-1}), while South America and Australia and Oceania had the lowest valuations at USD 32 ha^{-1} and USD 10 ha^{-1}, respectively. The valuations are similar for mountainous (250 USD ha^{-1}) and non-mountainous (215 USD ha^{-1}) areas. Only one valuation is performed in proximity to urban areas, for an ecologically fragile mountain forest near urban areas in Nepal, with a valuation of USD 14 ha^{-1} [36], while non-urban areas have a mean of USD 228 ha^{-1}. Broadleaf (USD 242 ha^{-1}) and mixed forests (USD 211 ha^{-1}) are on average valuated higher for soil protection than coniferous forests (USD 137 ha^{-1}). The valuations do not follow the expected pattern in terms of the area size, with large (10,000–100,000 ha) study areas having the highest valuations at USD 479 ha^{-1}, followed by medium (1000–10,000 ha) areas at USD 307 ha^{-1} and small areas (<1000 ha) at USD 259 ha^{-1}, and very large (>100,000 ha) at USD 109 ha^{-1}. The correlation between the valuation of soil erosion prevention (per hectare) and the population density is 0.58. Like other FESs, the valuations of soil erosion prevention correlate negatively with the size of the area evaluated (−0.18). Similarly, the correlation between soil erosion prevention and the size of the economy is also negative (−0.13). However, the negative correlation between the valuations and the size of the economy runs contrary to other FESs.

3.3. Air Quality Improvement

Air quality improvements refer to a forest's ability to regulate ozone (O_3), sulfur dioxide (SO_2), nitrogen oxides (NOX), fine particles (PM10) or hydrogen fluoride (HF) in the atmosphere (no other air emissions are valuated in the identified articles). They are therefore classified as a regulating forest ecosystem service. The valuations for air quality improvements are based on either the costs of emission reductions through industrial means (replacement cost) or the estimated social costs of the emissions (avoided cost), often based on shadow prices [55,60,61]. The annual average (median) valuation for air quality improvements is USD 468 ha^{-1} (USD 58 ha^{-1}). However, the valuations vary depending on the valuation method applied and on the specific compound valuated. A total of 27 valuations are identified for air quality improvements, e.g., [61,62]. The highest valuation is for the removal of unspecified pollutants in an urban forest in Montreal, Canada, with an annual valuation of USD 5839 ha^{-1} [63]. The lowest annual valuation of USD 0.1 ha^{-1} is for removal of HF by urban forests in Beijing, China, and is almost negligible [60].

Four different valuation methods are applied, of which avoided cost methods are used in 17 valuations, e.g., [21,64]. The annual average valuation applying avoided cost methods is USD 279 ha^{-1}. The highest valuation identified is for PM10 removal by managed stands of Scots pine forest in Belgium [17]. They report an annual valuation of USD 1313 ha^{-1}. The lowest valuation is an average for all the forests in Finland, with a reported annual valuation of USD 1.7 ha^{-1} [65]. Replacement cost methods are applied in six valuations in two studies [55,60], which report an annual average valuation of USD 214 ha^{-1}. The highest and lowest valuations identified when applying a replacement cost method are both from Xie et al. [60] for the removal of different pollutants by urban forests in Beijing, China. The highest valuation of USD 1015 ha^{-1} is for PM10, and the lowest valuation is for HF, with a reported annual valuation of USD 0.1 ha^{-1}. Benefit transfer methods are applied in three valuations in two studies [18,66], with an annual average valuation of USD 2193 ha^{-1}. The highest valuation when applying this method is for urban forests in Montreal, Canada [63], with an annual valuation of USD 5839 ha^{-1}. The lowest valuation is for rural forests near Montreal, Canada, with a reported annual valuation of USD 357 ha^{-1} [63]. Lastly, expert valuation methods are applied in one valuation for the Wet Tropics of Queensland World Heritage area, with an annual valuation of USD 16 ha^{-1} [42].

The contextual settings for the valuation of air quality improvements suggest that urban forest areas have a higher annual average valuation than non-urban forest areas. The annual average valuation of urban forest areas is USD 813 ha^{-1}, e.g., [61], while non-urban forest areas have a valuation of USD 295 ha^{-1}, e.g., [65]. Comparing by country income levels, high-income countries have the highest valuations (USD 687 ha^{-1}) for air quality improvement, followed by lower middle-income (USD 354 ha^{-1}) and upper middle-income (USD 140 ha^{-1}) countries, with no valuations found for low-income countries. The valuation of air quality improvements is highest in North America, with an annual average valuation of USD 1408 ha^{-1} [21,64,66]. Europe has an annual average valuation of USD 429 ha^{-1} [17,61,64,67], followed by Asia, with an annual average valuation of USD 183 ha^{-1} [51,60,62]. Forests in temperate climates have the highest valuations (USD 640 ha^{-1}), followed by tropical (USD 269 ha^{-1}), subtropical (USD 6.4 ha^{-1}) and boreal climates (USD 5.7 ha^{-1}). Broadleaf forests have higher valuations (USD 584 ha^{-1}) than coniferous (USD 343 ha^{-1}) or mixed forests (USD 312 ha^{-1}). Valuations are higher for mountain (USD 539 ha^{-1}) than for non-mountain forests (USD 462 ha^{-1}), and forest sizes between 10,000 and 100,000 ha are found to have the highest valuations (USD 1192 ha^{-1}) compared to forests larger than 100,000 ha (171 USD ha^{-1}) or smaller than 10,000 ha (USD 220 ha^{-1}). The correlation between the valuation of air quality and the size of the forest area is negative (−0.13), whilst the correlation with the size of the economy is positive (0.21); these are expected outcomes. Somewhat surprisingly, the correlation between the population density and valuation is negative (−0.21).

3.4. Recreation

Recreation is classified as a cultural forest ecosystem service. Recreation is defined as local recreational visits to nearby forest areas. Unfortunately, the terms recreation and tourism are used interchangeably in the reviewed articles, which makes it difficult to separate them. Recreation has an annual average (median) valuation of USD 595 ha^{-1} (USD 146 ha^{-1}) based on 45 valuations, e.g., [63,68]. The highest valuation is for a state-owned forest near a major metropolitan area in Germany (Munich), with a reported annual valuation of USD 3931 ha^{-1} [69]. The lowest annual valuation of USD 0.3 ha^{-1} is for the recreational potential of dryland forest restoration in Mexico [70].

In terms of the methodological choice, eleven of the valuations apply travel cost methods, of which nine apply an individual travel cost method, e.g., [39,71], and two a zonal travel cost method [23,67]. The annual average valuation for recreation when applying travel cost methods is USD 985 ha^{-1}. The highest valuation of USD 3931 ha^{-1} is for an urban park in Germany [69]. Other articles applying travel cost methods report similar valuations. For instance, Zandi et al. [68] estimate the annual recreational value of forest reserves outside urban areas in Iran to be USD 2610 ha^{-1}. Similarly, Hein [67] estimates the annual recreational value of forest reserves outside urban areas in the Netherlands to be USD 1375 ha^{-1}. In Sweden, the reported annual recreational valuation of all the forests is USD 1117 ha^{-1} [11]. The lowest valuation is for a natural reserve in a tropical forest in India, with an annual valuation of USD 6.7 ha^{-1} [51]. Benefit transfer methods are applied in 15 valuations, e.g., [18,72,73]. The annual average valuation for benefit transfer methods is USD 782 ha^{-1}. However, the valuations vary significantly. The highest annual valuation for national parks in Europe is USD 3684 ha^{-1} [74]. The lowest annual valuation is USD 2.6 ha^{-1} for a small forest in Ireland [73]. Commercial value methods are applied in 10 valuations, e.g., [26,28]. The annual average valuation for commercial value methods is USD 72 ha^{-1}. The highest annual valuation is USD 411 ha^{-1}, which is reported by Hájek and Lípa [75] for recreational forests in the city of Prague. The lowest annual valuation is USD 0.3 ha^{-1} for the recreational potential of dryland forest restoration in Mexico [70]. Valuations applying these methods base the valuation of recreation on the average expenditure by tourists in the visited area. Normally, the lower range of valuations is based on actual expenditures. For instance, Bernard et al. [76] report an annual recreation valuation of USD 12.5 ha^{-1}. Using a similar approach, Birch et al. [70] report an annual valuation of USD 0.3 ha^{-1}. Other valuations using commercial value methods assume that the recreation valuation is a multiple of the actual expenditures. For example, Chen et al. [77] assume a recreation valuation that is twice the actual expenditures, estimating the annual average valuation to be USD 113 ha^{-1}. In addition, eight articles apply stated preference methods, divided equally between contingent valuation, e.g., [78,79], and choice experiment methods, e.g., [80,81]. The annual average valuation for the stated preference methods is USD 448 ha^{-1}. The highest annual valuation is USD 2506 ha^{-1} for two national parks in Costa Rica [79]. The lowest annual valuation is USD 1.7 ha^{-1} for protected forests in Uganda [81]. In general, studies applying contingent valuation methods are less concerned with the spatial contexts of the valuation because they only illustrate the willingness to pay for a specific recreational forest area [33,79]. However, valuations based on choice experiment methods have been designed to illustrate the heterogeneity of forest recreation areas by comparing different forest types [14,37].

The contextual setting of recreational valuations can also be observed. The average valuations exhibit a considerable variation, with noticeable differences across climate zones. For instance, the average annual valuation is highest in temperate climates (USD 1086 ha^{-1}), followed by boreal climates (USD 580 ha^{-1}), tropical climates (USD 188 ha^{-1}) and subtropical climates (USD 48 ha^{-1}). The valuations also vary across regions, with the highest average annual valuation found in Europe (USD 767 ha^{-1}), followed by South America (USD 631 ha^{-1}) and North America (USD 449 ha^{-1}), Asia (USD 421 ha^{-1}), and Africa (USD 27 ha^{-1}). When comparing the recreational value by country income levels, the results follow the expected pattern, with high-income countries (USD 701 ha^{-1}) having the highest recreational value, followed by upper middle-income countries (USD 589 ha^{-1}), and lower middle (USD 12 ha^{-1}) and low-income countries (USD 2 ha^{-1}) having considerably lower recreational values. The average annual valuations also vary depending on the proximity of urban areas to the forest recreation areas. For instance, recreation in urban and peri-urban forests is valuated higher (on average USD 1640 ha^{-1} y^{-1}) than recreation in other types of forests (on average USD 453 ha^{-1} y^{-1}). Interestingly, the valuations are not affected by whether the forest is in a national park or not. Another insight is that the forest types affect the variation of the recreational valuation. Broadleaf forests (USD 581 ha^{-1}) are on average valuated more highly than coniferous ones (USD 407 ha^{-1}), while forests with a mix of coniferous and broadleaf trees are more highly valuated (USD 773 ha^{-1}) than purely coniferous or broadleaf forests. Broadleaf and mixed forests are also valuated consistently higher than coniferous ones in valuations where all three types are included [14,38]. The topography, i.e., the recreational forest being in a mountainous area, has a negative effect on the valuation. The average annual valuation for recreation in mountainous areas is USD 44 ha^{-1}, compared to the average annual valuation of USD 595 ha^{-1} for all forests. Recreational values are also higher in small (<1000 ha) and medium (1000–10,000 ha) study areas, USD 3931 ha^{-1} and USD 1072 ha^{-1}, respectively, compared to USD 124 ha^{-1} for large (10,000–100,000 ha) study areas and USD 193 ha^{-1} for very large (>100,000 ha) study areas. For 10 of the valuations, the size of the study areas was not stated, e.g., [82]. The correlation between the recreational valuations and the population density, size of the economy (measured by GDP) and size of the valuated forest area (measured in hectares) provides interesting insights. The correlation between the recreational valuation and the population density is 0.05, suggesting that the population density has a low statistical relationship with the reported recreational valuations. The recreational valuation and GDP have a somewhat higher statistical relationship, with a correlation of 0.12. It was expected that the recreational valuations would be higher in areas with higher income. The correlation between the recreational valuation and the size of the valuated areas is 0.22, whereas a negative correlation was expected. This unexpected positive correlation might be explained by the fact that few of the valuations conduct an average-per-hectare valuation. Instead, valuations derived by the travel cost or benefit transfer methods are aggregated over large areas [18,83].

3.5. Carbon Sequestration

Carbon sequestration is a regulating forest ecosystem service. There are 71 valuations of forests' ability to sequestrate carbon, e.g., [84,85]. In general, the valuations of carbon sequestration in forests are reached by multiplying the expected level of carbon sequestered by the social cost of carbon (or by a proxy, i.e., the carbon price). Two distinct approaches (separate from the valuation method) can be distinguished. Firstly, the valuation of carbon sequestration is measured as the annual flow (or uptake) of carbon. In total, 52 valuations apply this approach, e.g., [17,65]. Secondly, the valuation of carbon sequestration is measured as the net present value (NPV) of current and future carbon stocks. This approach is applied in 19 valuations, e.g., [45,86]. The choice of the discount rate is an important feature of these valuations and has significant implications for the result. The used discount rates range between 3% [84] and 10% [87], with an average of 4.73%.

Since the valuations of carbon sequestration are determined by the social cost of carbon, or its proxies, the assumed cost levels are important. To compare the different valuation on equal premises, the valuations are standardized and adjusted to a carbon price of USD 25 tCO_2^{-1}. However, even when the carbon price is standardized, the valuations vary considerably. For the valuations applying the annual flows of carbon, the annual average valuation is USD 184 ha^{-1}. The highest reported valuation is for subtropical coniferous forest in China, with an annual average valuation of USD 656 ha^{-1} [44]. The lowest annual valuation of USD 0.3 ha^{-1} is for Sakhalin fir forests in Japan [55]. For the valuations applying the NPV of future flows of carbon, the annual average valuation is USD 879 ha^{-1}. The highest reported valuation is for the Atlantic Forest in Brazil, with an annual average valuation of USD 5210 ha^{-1} [46]. The lowest annual valuation of USD 1.1 ha^{-1} is for temperate dryland forest in Argentina [70]. In terms of the applied valuation methods, the two approaches have significant similarities. Valuations of both the annual flow of carbon (31 valuations), e.g., [88], and the NPV of future flows of carbon (19 valuations), e.g., [89], apply commercial value methods for the most part. In addition, valuations of the annual flow of carbon also apply avoided cost methods (16 valuations), e.g., [67], and, to a lesser extent, benefit transfer methods (five valuations), e.g., [63]. Several valuations are unclear regarding how they are performed; for instance, some valuations of carbon sequestration do not specify whether the annual carbon flow or carbon stocks are being evaluated [18].

For valuations of the annual flow of carbon sequestration, the highest valuations are found using the replacement cost method, which is applied in 16 valuations in 3 studies. These valuations have an annual average of USD 379 ha^{-1}, with the lowest valuation being USD 36 ha^{-1} for sparse mountain forest in northern China [32] and the highest valuation being USD 656 ha^{-1} for subtropical coniferous forest in China [44]. All the replacement cost valuations are from China for different forest types and use a method known as the afforestation cost method, which is not explained in detail in any of the studies providing the valuations. The second highest valuation applies commercial value methods and provides an annual average valuation of USD 115 ha^{-1}. The highest valuation is for forests in river basins and upstream mountains in Italy, with an annual valuation of USD 474 ha^{-1} [50]. The lowest valuation is for a tropical forest in a biodiversity hotspot in India, with an annual valuation of USD 16 ha^{-1} [51]. For valuations applying avoided cost methods, the annual average valuation is USD 83 ha^{-1}. The highest valuation is for managed stands of Scots pine forest in Belgium, with an annual valuation of USD 440 ha^{-1} [17]. The lowest valuation is for Sakhalin fir forests in Japan, with an annual valuation of USD 0.3 ha^{-1} [55]. Lastly, for valuations applying benefit transfer methods, the annual average valuation is USD 32 ha^{-1}. The highest valuation is for broadleaf forests in Maryland, USA, with an annual valuation of USD 41 ha^{-1} [56]. The lowest valuation is for forests in the northern and eastern Mediterranean region, with an annual valuation of USD 10 ha^{-1} [41]. For valuations of the NPV of future flows of carbon sequestration, when applying commercial value methods, the annual average valuation is USD 924 ha^{-1}. The highest valuation is for the Atlantic Forest in Brazil, with an annual valuation of USD 5210 ha^{-1} [46]. The lowest valuation is for dryland mixed forest in Argentina, with an annual valuation of USD 1.1 ha^{-1} [70]. For the NPV of future flows of carbon sequestration where the avoided cost method is used, the average is USD 839 ha^{-1}, while the highest average value is USD 2650 ha^{-1} for forests in central Europe [84] and the lowest average value is USD 101 ha^{-1} for temperate spruce forests in the United Kingdom [90].

The contextual settings for the valuation of carbon sequestration (combining the two approaches) indicate higher average valuations in upper middle-income countries (USD 1182 ha^{-1}), e.g., [60], compared to high-income countries (USD 105 ha^{-1}), e.g., [64]. For lower middle-income and low-income countries, the average valuations are USD 105 ha^{-1}, e.g., [33], and USD 133 ha^{-1}, e.g., [47], respectively. Comparing the valuations between regions, the highest mean valuation is in Asia (USD 821 ha^{-1}), followed by South America (USD 743 ha^{-1}), North America (USD 536 ha^{-1}), Europe (USD 378 ha^{-1}), and Africa (USD 133 ha^{-1}). Different climate zones affect the carbon uptake and thus the valuation of carbon sequestration as expected, i.e., the valuations follow a pattern with higher carbon uptake in warmer climates due to higher primary production. The annual average valuation in tropical climates is USD 716 ha^{-1}, e.g., [91], followed by subtropical climates, which have an annual average valuation of USD 498 ha^{-1}, e.g., [44]. Temperate and boreal climates have an annual average carbon sequestration valuation of USD 319 ha^{-1}, e.g., [57], and USD 149 ha^{-}, e.g., [65], respectively. In addition, the annual average valuation of carbon sequestration is higher for broadleaf forests (USD 589 ha^{-1}), e.g., [88], than for coniferous (USD 120 ha^{-1}), e.g., [30], and mixed forests (USD 101 ha^{-1}), e.g., [60]. Valuations are higher in non-mountain forests, USD 668 ha^{-1}, than in mountain ones, USD 269 ha^{-1}, and the valuations in non-urban areas (USD 625 ha^{-1}) are also higher than in urban areas (USD 202 ha^{-1}). Carbon sequestration is found to have higher valuations in large (USD 698 ha^{-1}) or very large (USD 709 ha^{-1}) areas, and lower valuations in medium (USD 178 ha^{-1}) or small (USD 112 ha^{-1}) areas. The correlations between the valuation of carbon sequestration and the area size (-0.11), population density (-0.14), and size of the economy (-0.34) are all negative. These characteristics are not surprising, given that carbon sequestration has global benefits and that many of the high-producing tropical forests are in low-income countries.

3.6. Freshwater Supply

The freshwater supply encompasses rivers, lakes, wetlands, and other freshwater environments. It is for the most part valuated as a regulating forest ecosystem service and includes areas such as waste assimilation [92], pathogen control [93], and regulation of climate [33]. In total, 53 valuations of the freshwater supply are identified, e.g., [94,95]. The annual average (median) valuation of the freshwater supply is USD 834 ha^{-1} (USD 100 ha^{-1}). The highest valuation of the freshwater supply is for forests adjacent to rivers [35]. An annual valuation of USD 16,752 ha^{-1} is estimated by applying a stated preference method based on 137 ha of forest. Similar valuations reporting relatively high valuations are offered by Honey-Roses et al. [96], who report an annual valuation of USD 3824 ha^{-1}, and Ko et al. [93], who report USD 3619 ha^{-1}. However, their valuations are also based on relatively small forest areas of 115 and 1475 ha, respectively, while the average size of the forest area valuated for the freshwater supply is 320,000 ha. The lowest valuation is for restoration of the Atlantic Forest in Brazil, with an annual valuation of USD 0.4 ha^{-1} [46]. Most valuations for the freshwater supply concentrate on drinking water, with an annual average valuation of USD 977 ha^{-1}, e.g., [16]. Six valuations in four studies are for water flows used to regulate hydropower plants [33,76,97,98]. These valuations are normally lower compared to drinking water, with an annual average valuation of USD 67 ha^{-1}.

Based on the method applied, the average size of the freshwater supply valuations can be divided into three groups. Replacement cost and stated preference methods report the highest annual average valuations (USD 1129–2887 ha^{-1}), benefit transfer and hedonic-pricing methods report mid-range valuations (USD 340–349 ha^{-1}) and avoided cost and expert evaluation methods report the lowest valuations (USD 13–57 ha^{-1}). The most frequently applied valuation method is replacement cost (16 valuations), e.g., [48,88]. The average annual valuation for the freshwater supply using the replacement cost method is USD 1129 ha^{-1}. The highest valuation is for the restoration of forests in Spain located adjacent to rivers, with an annual valuation of USD 3824 ha^{-1} [96]. Conversely, the lowest valuation is found for tropical mountain forests near watersheds in Tanzania, with a reported annual valuation of USD 10 ha^{-1} [92]. The studies vary regarding the type of projects that the replacement costs are derived from, and the valuations derived from desalination [48] or mechanical treatment costs [93] are generally higher than the valuations derived from the cost of alternative water sources, e.g., [99]. The commercial price method is the second most frequently applied method for the freshwater supply (13 valuations), e.g., [50,57]. The annual average valuation using commercial pricing is USD 340 ha^{-1}, which is approximately three times lower than valuations using replacement cost methods. The valuations are based on the market prices of water for drinking, hydropower, or irrigation. The highest valuation is for mountain forests in northern Portugal, which reports an annual valuation of USD 3208 ha^{-1} [24]. The lowest valuation is found for mountain forests in Bulgaria, with a reported annual valuation of USD 5.8 ha^{-1} [34]. Both the highest and the lowest valuations are based on the domestic prices of drinking water. A total of nine valuations apply benefit transfer methods, e.g., [41,56]. They report an annual average valuation of USD 349 ha^{-1}, which is similar to the valuations using commercial pricing methods. However, the highest annual valuation reported, an estimation for all the forests in the Czech Republic, is lower for the benefit transfer method (USD 1746 ha^{-1}) [18]. The lowest valuation using benefit transfer methods is for forests in the alpine region of Italy, with an annual valuation of USD 37 ha^{-1} [58]. Valuations applying avoided cost methods for the freshwater supply (seven valuations) report an annual average valuation of USD 57 ha^{-1}, e.g., [33,76]. The valuations have a relatively low variation. The highest annual valuation of USD 149 ha^{-1} is reported for forests in Maryland, USA [21]. The lowest valuation is for the Atlantic Forest in Brazil, with an annual valuation of USD 0.4 ha^{-1} [46]. Lastly, valuations applying stated preference methods (six valuations) report the highest annual valuation for the freshwater supply, with a mean of USD 2887 ha^{-1}. The highest valuation is USD 16,752 ha^{-1} for the afforestation of riparian zones in the USA [35]. Stated preference is also the method that produces the largest variation in the valuations. The lowest annual valuation of USD 2.1 ha^{-1} is for subtropical watersheds in southern USA [95].

The contextual settings for the valuation of the freshwater supply affect the valuations. The average annual valuation of the freshwater supply in high-income countries is USD 1351 ha^{-1}, e.g., [75]. This is almost three times higher than the average annual valuation in upper middle-income countries (USD 300 ha^{-1}), e.g., [46], and more than thirty times higher than in low-income countries (USD 43 ha^{-1}), e.g., [47]. Lower middle-income countries have slightly higher valuations than low-income countries, i.e., USD 69 ha^{-1}. When the valuations are compared across regions, the highest are found for North America (USD 2351 ha^{-1}), followed by South America (USD 767 ha^{-1}), Europe (USD 713 ha^{-1}), Asia (USD 137 ha^{-1}) and Africa (USD 71 ha^{-1}). The annual average valuations of the freshwater supply are highest in temperate climates (USD 1043 ha^{-1}) [24,35], followed by tropical climates (USD 433 ha^{-1}) [48,100] and subtropical climates (USD 421 ha^{-1}) [41,88]. No valuations for boreal climates have been identified. Moreover, forests providing freshwater supply in mountainous areas have a lower valuation compared to in non-mountainous areas. The average annual valuation in mountainous areas is USD 406 ha^{-1}, e.g., [92], while non-mountainous areas are valuated at USD 959 ha^{-1}, e.g., [35]. Lastly, the freshwater supply from urban and non-urban forests has received similar valuations. The annual average valuation for the freshwater supply from urban forests is USD 884 ha^{-1}, e.g., [96], and from non-urban forests, it is USD 817 ha^{-1}, e.g., [27]. Mixed forests have the highest valuations of the three forest types, with an average valuation of USD 1829 ha^{-1}, almost four times higher than broadleaf forests (USD 568 ha^{-1}) and more than twenty times higher than coniferous forests (USD 90 ha^{-1}). The valuations differ greatly between different study area sizes, with small areas having a mean valuation of USD 8100 ha^{-1}, medium study areas having a mean valuation of USD 647 ha^{-1}, and large and very large areas having mean valuations of USD 452 ha^{-1} and USD 172 ha^{-1}, respectively. For 17 valuations, the study area size is unstated, e.g., [99]. The correlation between the per hectare freshwater supply valuations and population density is negative (−0.12), suggesting that a higher concentration of people reduces the valuation of the freshwater supply. The statistical relationship between the per hectare valuation of freshwater supply and the size of the economy in the valuated areas indicates a correlation of 0.26.

3.7. Flood Protection

Flood protection is a regulating forest ecosystem service, including rainfall interception and infiltration by riparian forests. In total, 29 valuations of flood protection by forests are identified. Flood protection is commonly valuated by estimating the capacity of rainfall interception by forest vegetation and soil [101]. This is then compared to the costs of flood prevention measures or the potential damages from flooding. For example, as a flood prevention measure, the cost of constructing a water-regulating dam can be used [15,49,55,60]. The annual average (median) valuation for flood protection is USD 1790 ha^{-1} (USD 170 ha^{-1}). The highest valuation for flood protection benefits is based on the construction of a dam in Japan [55]. They report an annual valuation of USD 17,830 ha^{-1} and, unlike many other studies, also include the indirect costs related to the construction of the dam. In addition, flood protection of riparian forests in Germany [102], the USA [45], and Italy [50] also has relatively high valuations, ranging from USD 4794 to 5556 ha^{-1} y^{-1}. Similarly to the freshwater supply valuations, the high valuations for flood protection are based on relatively small forest areas, except for Ninan and Inoue [55], which encompasses an area of 83,890 ha. The lowest valuations are found for the Veun Sai-Siem Pang National Park in Cambodia, with an average annual valuation of USD 0.01 ha^{-1} [26].

The highest average annual valuations (USD 2508 ha^{-1}) are reported for benefit transfer methods, which are applied in four valuations in three studies [18,45,56]. The highest reported valuation is for coastal forests in the USA adjacent to rivers, and the lowest is for the same but without rivers [45]. The most frequently used valuation approach is the replacement cost method, with 17 valuations, e.g., [15,49], and it is also the approach with the highest variance in the estimations. The highest annual valuation of USD 17,830 ha^{-1} is for the construction of a regulating dam [55]. Conversely, the lowest annual valuation using replacement cost methods is negligible. Kibria et al. [26] report a valuation of USD 0.01 ha^{-1} for the construction of a reservoir in the Veun Sai-Siem Pang National Park in Cambodia. Most of the valuations applying the replacement cost method use the cost of constructing a dam or other type of reservoir. The avoided costs approach has similar average annual valuations to the replacement cost approach (USD 1716 ha^{-1}), e.g., [103], and it is applied for a total of seven valuations. The highest valuation applying an avoided cost method is for a broadleaf riparian forest near an urban area in Germany, which reports an annual valuation of USD 5803 ha^{-1} [102]. The lowest valuation is reported for a tropical forest in a biodiversity hotspot in India, with an annual valuation of USD 3.3 ha^{-1} [51]. Lastly, the stated preference method has been applied in a single valuation of USD 314 ha^{-1} [104].

The contextual settings for the valuation of flood protection suggest a higher annual average valuation in high-income countries (USD 3994 ha^{-1}) [102]. The annual average valuation in upper middle-income countries is USD 782 ha^{-}, e.g., [60], and in lower-middle income countries, it is USD 63 ha^{-1}, e.g., [101]. No valuations were found for low-income countries. The highest average Campbell annual valuations are reported for Europe (USD 5437 ha^{-1}), e.g., [50,102], followed by North America (USD 1993 ha^{-1}), e.g., [21,45], and Asia (USD 1094 ha^{-1}), e.g., [15,60]. The average valuations of flood protection in temperate climates are higher than the valuations in subtropical and tropical climates. For instance, the annual average valuation in temperate climates is USD 2546 ha^{-1}, while the valuations in subtropical and tropical climates are USD 149 and 80 ha^{-1}, respectively. In mountainous areas, the valuations of flood protection are lower compared to in non-mountainous areas. The average annual valuation in mountainous areas is USD 809 ha^{-1}, e.g., [15], while non-mountainous areas are valuated at USD 2164 ha^{-1}, e.g., [102]. Somewhat differently from watershed protection, broadleaf forests are found to have the highest valuations for flood protection at USD 2412 ha^{-1}, compared to USD 547 ha^{-1} for mixed forests, but coniferous forests have the lowest valuations for this FES at USD 235 ha^{-1}. All the valuations are from non-urban forests, so no comparison with urban forests could be performed. It should, however, be noted that forests not in proximity to urban areas can still prevent flooding downstream in urban areas [49]. Flood protection shows consistently high valuations across different area sizes but is higher for small (USD 5803 ha^{-1}) and medium (USD 2616 ha^{-1}) study areas than for large (USD 2333 ha^{-1}) and very large (USD 1014 ha^{-1}) areas. The correlation between the valuation of flood protection (per hectare) and the population density is 0.39, suggesting that flood protection is valuated higher in areas with a higher concentration of people. Similarly, the relationship between the valuation of flood protection and the size of the economy is 0.42. However, the valuation of flood protection decreases with the area size and has a negative correlation of −0.17.

3.8. Avalanche Prevention

Avalanche prevention is a regulating forest ecosystem service. A total of 12 valuations for avalanche prevention are identified, with an average (median) annual valuation of USD 9198 ha^{-1} (USD 735 ha^{-1}), e.g., [30,31]. Avalanche prevention has the highest annual valuation of all the services assessed in this paper. Teich and Bebi [105] report an annual valuation of USD 81,631 ha^{-1} for the forests surrounding a town in the Swiss Alps. This can be compared to the lowest valuation for avalanche prevention, USD 70 ha^{-1}, for the effect of avalanche risk on property prices in the Austrian Alps [40].

Replacement cost methods are for the most part applied in the valuation of avalanche prevention, e.g., [19,82]. For the eight valuations applying replacement cost methods, the average annual valuation is USD 1167 ha^{-1}. The highest annual valuation applying replacement cost methods is USD 5357 ha^{-1} [58], while the lowest annual valuation is USD 148 ha^{-1} [106]. Both the highest and lowest valuations are for Alpine forests in northern Italy. Avoided cost methods are applied in two valuations [30,105]. The annual average valuation for these valuations is USD 48,898 ha^{-1}. The highest annual valuation is USD 81,631 ha^{-1} [105] and the lowest is USD 16,164 ha^{-1} [30], both for urban forests in the Swiss Alps. Hedonic-pricing and choice experiment methods are applied in one valuation each. The valuation applying the hedonic-pricing method reports the lowest valuation for avalanche prevention of USD 70 ha^{-1} for the effect of avalanche risk on property prices in the Austrian Alps [40]. The valuation applying the choice experiment method reports an annual valuation of USD 3179 ha^{-1} for the willingness to pay for forests that prevent avalanches in the Swiss Alps [107].

The contextual settings for the valuation of avalanche prevention are harder to identify than for other ecosystem services. By default, only mountainous areas are included in the valuations. In addition, all the valuations are for the Alpine region, with the same climate and forest types, so a comparison between these contextual settings cannot be performed. Between countries, the annual valuation is USD 33,658 ha^{-1} in Switzerland [105], USD 454 ha^{-1} in Austria [40], USD 1384 ha^{-1} in Italy [31], and USD 1123 ha^{-1} in Slovenia [19]. Not surprisingly, the benefit of avalanche prevention is limited to small areas. However, the valuations are sensitive to the size of the included forest area. For instance, for areas between 24 and 4499 ha, the average annual valuation is USD 20,384 ha^{-1} [30,105,107]. For larger areas of between 38,500 and 55,000 ha, the average annual valuation is USD 432 ha^{-1} [19,43,106]. Avalanche protection is valued 38 times higher for urban areas (USD 48,898 ha^{-1}) than for non-urban areas (USD 1251 ha^{-1}). As expected, the correlation between avalanche prevention and the area size is negative, with a value of −0.41, a stronger negative correlation than for any other ecosystem service. The correlation between the valuation of avalanche prevention (per hectare) and the population density is 0.27, and the correlation between the valuation of avalanche prevention and the size of the economy is 0.56.

4. Discussion

Not surprisingly, the valuations vary considerably between forest ecosystem services. FESs provide different benefits and are not easily comparable with each other. However, even within specific forest ecosystem services, the variation is significant. For example, the annual valuation of flood protection ranges from USD 0.01 to 17,830 ha^{-1}, while the annual valuation of recreation ranges from USD 0.3 to 3931 ha^{-1}. Even if the valuations are disaggregated further, large variations can still be found within specific forest ecosystem services and within the same applied valuation method. For instance, the annual valuations for the freshwater supply applying replacement cost methods range from USD 10 to 3824 ha^{-1}, and for the prevention of soil erosion applying benefit transfer methods, the annual valuations range from USD 0.3 to 8316 ha^{-1}. Because the valuations vary depending on the forest ecosystem service evaluated and the method applied, direct comparisons of the valuations are difficult and perhaps not even appropriate. However, certain characteristics that are similar across the valuations, i.e., their contextual settings, might affect the valuations in similar ways. This knowledge is useful in relation to valuations applying benefit transfer methods. A discussion focusing on these topics will be conducted below.

4.1. Forest Ecosystem Service and Valuation Method

While a range of different ecosystem services are found in the studies reviewed, most of the highly represented ones are regulatory ecosystem services, judging by the MEA classification. Carbon sequestration and diverse hydrological services are found in many studies. Regarding cultural ecosystem services, only services with significant use values are found. Nor are supporting ecosystem services well represented, with the exception of nutrient cycling (even though this service is less represented than the others found in the review) and this is probably because of the difficulty in valuating supporting services or any services where non-use values are dominant. Biodiversity and habitat protection are only found in a few studies and are evaluated with stated preference or benefit transfer methods.

Even if direct comparisons of the valuation methods are difficult, a few general observations on methodological issues can be offered. Firstly, for an accurate valuation to be performed, the method must be appropriate for the forest ecosystem service evaluated. This is reflected in the differences in the main valuation methods for the different forest ecosystem services. For instance, flood protection valuations are predominantly performed by applying replacement cost methods. For replacement cost methods, the valuations must be for the cost-efficient substitute of the replaced forest functions. Thus, if valuations using replacement cost methods are not preceded by a cost-efficient assessment of the available replacement options, the valuations will be overestimated (unless the most cost-efficient replacement option is chosen by chance). Secondly, stated preference methods can be problematic since they do not necessarily provide a distinct valuation of the specific forest ecosystem service under assessment, especially contingent valuations. For example, if a contingent valuation approach is used in the valuation of the freshwater supply, it is reasonable to expect that the respondents' attitude toward recreation or the preservation of biodiversity, for example, will also influence their valuation. In this context, applying a choice experiment approach might be a more appropriate option since well-constructed choice experiments can separate the effects of different ecosystem services.

4.2. Contextual Settings

In general, valuations applying travel cost and choice experiment methods are more explicit in their contextual setting. For instance, travel cost methods normally compare different sites based on their characteristics to assess the heterogeneity of the recreational demand [23,30,38]. Moreover, valuations of the freshwater supply often include vegetation type and cover [49], soil type [21], land slope [96], and average rainfall [76]. A comparison of the valuations that take these contextual settings into account and those that do not indicates that the former (USD 479 ha^{-1}) have a lower annual average valuation than the latter (USD 1038 ha^{-1}). This strongly indicates that the contextual settings of valuations are important.

The valuations of carbon sequestration primarily relate to the annual uptake of carbon dioxide by trees, which depends on their biological growth function and soil properties [90]. In this respect, the growth rates and carbon uptake vary between different tree types and tend to be higher in warmer climates. In addition, biological growth functions are non-linear over time, i.e., growth is usually more vigorous during the early stages of the growth cycle. This suggests that the age and non-linear biological growth functions are important in the valuation of carbon sequestration. Generally, valuations that include the non-linear biomass growth function and age report lower valuations for carbon sequestration [90]. However, the large variance in the reported valuations of carbon sequestration cannot be explained by this alone; it is more likely that valuation methods are affecting the valuations.

Along with carbon sequestration, valuations of soil erosion prevention are the only ecosystem services that are more highly valued in tropical than in temperate climates. Erosion prevention receives a high valuation in tropical climates due to the increased vulnerability to erosion resulting from warmer climate [26,47,51]. All the other ecosystem services are found to have a higher valuation in temperate climates, but this is probably explained by the fact that most high-income countries have temperate climates and specific high-valuation ecosystem services (such as flood protection of forests adjacent to rivers and avalanche protection of Alpine forests), which are not found in tropical countries. Most valuations are from areas with a temperate climate; around 67% (218 valuations) of the total valuations are from temperate forests, and 20% (64 valuations) are from tropical forests, whilst 10% are from subtropical forests and 3% from boreal forests.

The valuations of forest ecosystem services are affected by demographic factors such as the proximity to urban areas and population density. Particularly, valuations of flood and avalanche prevention are strongly affected by the population density, whilst the proximity to urban areas affects the valuation of forest recreation. On the other hand, the proximity to urban areas and population density are less important to the valuation of carbon sequestration. Avalanche prevention shows the most striking difference between urban and non-urban areas, with urban areas being evaluated almost 20 times higher due to the magnitude of the destruction of life and property that severe avalanches could have in highly populated areas. While flood protection is not valuated for any urban areas, the fact that it shows high correlation with the population density also depends on the greater consequences of natural disasters in highly populated areas. The valuations of soil erosion prevention are relatively higher in areas where land is scarce, or where the risk or consequences of erosion are higher. The valuations of air quality improvement are relatively higher for forests inside or adjacent to urban areas but are less relevant to forests not in proximity to population centers. This could be an argument for preserving forests near urban areas and highlights the need for long-term forest management schemes, especially for densely populated countries. The recreational value that individuals place on forests depends on the proximity to the forest and its accessibility [14,71]. In this respect, forests in urban areas have particularly high recreational value due to the number of people living nearby, whilst forests that are remote or inaccessible provide low or zero recreational values. The valuations of forest recreation are higher in developed countries but are also lower in countries with large intact forest endowments, e.g., Finland and Sweden [65,72]. This suggests that the size of forest areas is important for recreational valuations but also that the valuation is more likely to increase if forests become scarcer.

Riparian forests and forest wetlands have high valuations (ha^{-1}) for the freshwater supply and flood protection [96,102]. However, most of these valuations are for relatively small areas (1000–1500 ha) compared to the median area of 84,000 ha for all the valuations. The recreational valuations for broadleaf forests are generally higher compared to those for coniferous forests. In addition, natural and constructed features such as enhanced accessibility, hiking trails and picnic areas also affect the recreational valuations. For instance, access to hiking trails and the presence of lakes have a positive impact on the recreational valuation of a forest [14], but other features, such as parking lots or picnic areas, can have an ambiguous, positive or negative effect on the recreational valuation [38]. Some of the variations in recreational valuations can be explained by these features [23,71].

The wide range of valuations found in this review has been surprising. Geographical and demographic differences are unlikely to explain the full magnitude of these differences. Carbon sequestration in temperate mixed forests near the city of Beijing in China has an annual valuation of USD 354 ha^{-1} [60]. This can be compared to an annual valuation of USD 33 ha^{-1} for temperate forests near the city of Uppsala, Sweden [54]. The climates of these cities are roughly similar and both valuations are based on the same standardized carbon price, suggesting that an urban forest in China can sequester 10 times as much carbon as a forest in Sweden with similar characteristics. This is probably not accurate. Similar problems with ecological principles can be observed in the estimates for carbon uptake. The annual uptake of carbon has been estimated at 59 tCO_2 ha^{-1} for coniferous forests in cold climate regions of China [44], whilst the annual uptake for coniferous forests in the United Kingdom [90] has been estimated at 3.48 tCO_2 ha^{-1}. This is a 20-fold difference that is left unexplained.

4.3. Challenges for the Future

This review found a wide range of methods and valuations for ecosystem services, and the lack of a consistent methodology is problematic for FES studies because the results are often difficult to compare or reproduce. This is a particular problem for the use of benefit transfer, as this method is frequently applied without explicitly defining the studies used as sources or whether the transfer is a direct value transfer or a benefit function transfer. The methodology for benefit transfer needs to be developed and consistently applied.

Research in recent years has seen an increasing focus on spatial details, which is a positive development and necessary for valuations of FESs to be accurate and useful in policy analysis. Future research must continue in this direction and future valuation studies should include detailed accounting of the terrain type as well as a better integration of ecological and economic factors when modeling ecosystem services. At the same time, most spatially explicit studies are performed on a very small scale, which limits their policy applications. For this reason, new geographical modeling methods are needed to valuate FESs over large areas without incurring unreasonably high time and money costs to map the services.

Another problem relating to the comparability and reproducibility of FES valuations is that many studies do not thoroughly explain the assumptions underlying the valuations. Some of the outlier valuations found in this review are far higher than in comparable ecosystems and do not present plausible explanations as to why the valuations are so high. The information presented in connection with the valuations needs to be expanded. Not only are the valuations per se important, so too are their contextual settings. Future valuations of forest ecosystem services also need to better integrate ecological and economic processes to avoid unrealistic assumptions in the valuation. In many policy analysis situations, the marginal valuation of FESs would be more useful than the total valuation, which most studies focus on. Future research would do well to focus on the marginal valuations of FESs as land use changes or other events alter the supply of ecosystem services.

5. Conclusions

The purpose of this review is to identify and qualitatively analyze valuations of forest ecosystem services based on the methodological approach and on their spatial and contextual settings. Valuations of forest ecosystem services differ in the results and method applied, but they represent the significant benefits that people derive from forests. They should therefore be taken into consideration by stakeholders utilizing forests. However, given the large variations in the valuations, this is not necessarily an easy task, and researchers should help by stating their assumptions and results more clearly.

FESs that prevent natural disasters are some of the highest-valuated FESs and are naturally more highly valuated when in proximity to urban areas. The same holds true for recreation, as forests adjacent to cities have very high recreational values. Forests far from centers of population have lower values for many FESs but are nevertheless important for carbon sequestration and as habitats for plants and animals. There are a range of geographical factors that affect the value of FESs and some of the more important ones are the degree of vegetation cover, biological growth and the slope of the terrain affecting the valuation of forest ecosystem services. Climate and average rainfall are also relevant factors.

It is important to remember that whilst the economic valuation of forest ecosystem services can be a useful policy tool, it is not the only aspect that needs to be considered. This is particularly true given that the current methodology largely fails to take biodiversity into account; it would be a mistake to assume that biodiversity is not important simply because it is difficult to quantify in monetary terms. FES valuations are still in their early stages and it is likely to be a concept that will be relevant and better developed in the future.

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References

1. Ehrlich, P.R.; Ehrlich, A.H. *Extinction: The Causes and Consequences of the Disappearance of Species*; Random House: New York, NY, USA, 1981.
2. Daily, G.; Postel, S.; Bawa, K.; Kaufman, L. *Nature's Services: Societal Dependence on Natural Ecosystems*; University of Chicago Press: Bibliovault OAI Repository: Chicago, IL, USA, 1997.
3. Costanza, R.; d'Arge, R.; O'Neill, R.V.; Paruelo, J.; Raskin, R.G.; Sutton, P.; van den Belt, M.; de Groot, R.; Farber, S.; Grasso, M.; et al. The Value of the World's Ecosystem Services and Natural Capital. *Nature* **1997**, *387*, 253–260. [CrossRef]
4. Müller, A.; Knoke, T.; Olschewski, R. Can Existing Estimates for Ecosystem Service Values Inform Forest Management? *Forests* **2019**, *10*, 132. [CrossRef]
5. Ninan, K.N.; Inoue, M. Valuing Forest Ecosystem Services: What we Know and what we Don'T. *Ecol. Econ.* **2013**, *93*, 137–149. [CrossRef]
6. de Groot, R.; Brander, L.; van der Ploeg, S.; Costanza, R.; Bernard, F.; Braat, L.; Christie, M.; Crossman, N.; Ghermandi, A.; Hein, L.; et al. Global Estimates of the Value of Ecosystems and their Services in Monetary Units. *Ecosyst. Serv.* **2012**, *1*, 50–61. [CrossRef]
7. Englund, O.; Berndes, G.; Cederberg, C. How to Analyse Ecosystem Services in landscapes—A Systematic Review. *Ecol. Indic.* **2017**, *73*, 492–504. [CrossRef]
8. Taye, F.A.; Folkersen, M.V.; Fleming, C.M.; Buckwell, A.; Mackey, B.; Diwakar, K.C.; Le, D.; Hasan, S.; Saint Ange, C. The Economic Values of Global Forest Ecosystem Services: A Meta-Analysis. *Ecol. Econ.* **2021**, *189*, 107145. [CrossRef]
9. Zandersen, M.; Termansen, M.; Sondergaard Jensen, F. Testing Benefits Transfer of Forest Recreation Values Over a Twenty-Year Time Horizon. *Land Econ.* **2007**, *83*, 412–440. [CrossRef]
10. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being: Synthesis*; Island Press: Washington, DC, USA, 2005.
11. Ezebilo, E.E. Economic Value of a Non-Market Ecosystem Service: An Application of the Travel Cost Method to Nature Recreation in Sweden. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* **2016**, *12*, 314–327. [CrossRef]
12. Yoo, J.; Simonit, S.; Connors, J.P.; Kinzig, A.P.; Perrings, C. The Valuation of Off-Site Ecosystem Service Flows: Deforestation, Erosion and the Amenity Value of Lakes in Prescott, Arizona. *Ecol. Econ.* **2014**, *97*, 74–83. [CrossRef]
13. Iranah, P.; Lal, P.; Wolde, B.T.; Burli, P. Valuing Visitor Access to Forested Areas and Exploring Willingness to Pay for Forest Conservation and Restoration Finance: The Case of Small Island Developing State of Mauritius. *J. Environ. Manag.* **2018**, *223*, 868–877. [CrossRef]
14. Abildtrup, J.; Garcia, S.; Olsen, S.B.; Stenger, A. Spatial Preference Heterogeneity in Forest Recreation. *Ecol. Econ.* **2013**, *92*, 67–77. [CrossRef]

15. Mashayekhi, Z.; Panahi, M.; Karami, M.; Khalighi, S.; Malekian, A. Economic Valuation of Water Storage Function of Forest Ecosystems (Case Study: Zagros Forests, Iran). *J. For. Res.* **2010**, *21*, 293–300. [CrossRef]
16. Popa, B.; Borz, S.A.; Nita, M.D.; Ioras, F.; Iordache, E.; Borlea, F.; Pache, R.; Abrudan, I.V. Forest Ecosystem Services Valuation in Different Management Scenarios: A Case Study of the Maramures Mountains. *Balt. For.* **2016**, *22*, 327–340.
17. Schaubroeck, T.; Deckmyn, G.; Giot, O.; Campioli, M.; Vanpoucke, C.; Verheyen, K.; Rugani, B.; Achten, W.; Verbeeck, H.; Dewulf, J.; et al. Environmental Impact Assessment and Monetary Ecosystem Service Valuation of an Ecosystem Under Different Future Environmental Change and Management Scenarios; a Case Study of a Scots Pine Forest. *J. Environ. Manag.* **2016**, *173*, 79–94. [CrossRef] [PubMed]
18. Frélichová, J.; Vačkář, D.; Pártl, A.; Loučková, B.; Harmáčková, Z.V.; Lorencová, E. Integrated Assessment of Ecosystem Services in the Czech Republic. *Ecosyst. Serv.* **2014**, *8*, 110–117. [CrossRef]
19. Grilli, G.; Ciolli, M.; Garegnani, G.; Geri, F.; Sacchelli, S.; Poljanec, A.; Vettorato, D.; Paletto, A. A Method to Assess the Economic Impacts of Forest Biomass use on Ecosystem Services in a National Park. *Biomass Bioenergy* **2017**, *98*, 252–263. [CrossRef]
20. Troy, A.; Wilson, M.A. Mapping Ecosystem Services: Practical Challenges and Opportunities in Linking GIS and Value Transfer. *Ecol. Econ.* **2006**, *60*, 435–449. [CrossRef]
21. Campbell, E.T.; Tilley, D.R. Valuing Ecosystem Services from Maryland Forests using Environmental Accounting. *Ecosyst. Serv.* **2014**, *7*, 141–151. [CrossRef]
22. Gołos, P. The Value of the Water-Protecting Function of Forests. *J. Water Land Dev.* **2009**, *13*, 187–204. [CrossRef]
23. Baerenklau, K.A.; Gonzalez-Caban, A.; Paez, C.; Chavez, E. Spatial Allocation of Forest Recreation Value. *J. For. Econ.* **2010**, *16*, 113–126. [CrossRef]
24. Sil, A.; Rodrigues, A.P.; Carvalho-Santos, C.; Nunes, J.P.; Honrado, J.; Alonso, J.; Marta-Pedroso, C.; Azevedo, J.C. Trade-Offs and Synergies between Provisioning and Regulating Ecosystem Services in a Mountain Area in Portugal Affected by Landscape Change. *Mt. Res. Dev.* **2016**, *36*, 452–464. [CrossRef]
25. Corbera, E.; Kosoy, N.; Martínez Tuna, M. Equity Implications of Marketing Ecosystem Services in Protected Areas and Rural Communities: Case Studies from Meso-America. *Glob. Environ. Chang.* **2007**, *17*, 365–380. [CrossRef]
26. Kibria, A.S.M.G.; Behie, A.; Costanza, R.; Groves, C.; Farrell, T. The Value of Ecosystem Services obtained from the Protected Forest of Cambodia: The Case of Veun Sai-Siem Pang National Park. *Ecosyst. Serv.* **2017**, *26*, 27–36. [CrossRef]
27. Corona, P.; Quatrini, V.; Schirru, M.; Dettori, S.; Puletti, N. Towards the Economic Valuation of Ecosystem Production from Cork Oak Forests in Sardinia (Italy). *iForest-Biogeosci. For.* **2018**, *11*, 660–667. [CrossRef]
28. Carvalho Ribeiro, S.M.; Soares Filho, B.; Costa, W.L.; Bachi, L.; de Oliveira, A.R.; Bilotta, P.; Saadi, A.; Lopes, E.; O'Riordan, T.; Pennacchio, H.L.; et al. Can Multifunctional Livelihoods Including Recreational Ecosystem Services (RES) and Non Timber Forest Products (NTFP) Maintain Biodiverse Forests in the Brazilian Amazon? *Ecosyst. Serv.* **2018**, *31*, 517–526. [CrossRef]
29. Asadolahi, Z.; Salmanmahiny, A.; Sakieh, Y. Hyrcanian Forests Conservation Based on Ecosystem Services Approach. *Environ. Earth Sci.* **2017**, *76*, 365. [CrossRef]
30. Gret-Regamey, A.; Brunner, S.H.; Altwegg, J.; Christen, M.; Bebi, P. Integrating Expert Knowledge into Mapping Ecosystem Services Trade-Offs for Sustainable Forest Management. *Ecol. Soc.* **2013**, *18*, 34. [CrossRef]
31. Notaro, S.; Paletto, A. The Economic Valuation of Natural Hazards in Mountain Forests: An Approach Based on the Replacement Cost Method. *J. For. Econ.* **2012**, *18*, 318–328. [CrossRef]
32. Xue, D.; Tisdell, C.Y. Valuing Ecological Functions of Biodiversity in Changbaishan Mountain Biosphere Reserve in Northeast China. *Biodivers. Conserv.* **2001**, *10*, 467–481. [CrossRef]
33. van Beukering, P.J.H.; Cesar, H.S.J.; Janssen, M.A. Economic Valuation of the Leuser National Park on Sumatra, Indonesia. *Ecol. Econ.* **2003**, *44*, 43–62. [CrossRef]
34. Ivanova, E.; Koulov, B.; Borisova, B.; Assenov, A.; Vassilev, K. GIS-Based Valuation of Ecosystem Services in Mountain Regions: A Case Study of the Chepelare Municipality in Bulgaria. *Eur. J. Sustain. Dev.* **2016**, *5*, 335–346. [CrossRef]
35. Lewis, S.E.; Popp, J.S.; English, L.A.; Odetola, T.O. Willingness to Pay for Riparian Zones in an Ozark Watershed. *J. Water Resour. Plan. Manag.* **2017**, *143*, 4017006. [CrossRef]
36. Bhandari, P.; Mohan, K.C.; Shrestha, S.; Aryal, A.; Shrestha, U.B. Assessments of Ecosystem Service Indicators and Stakeholder's Willingness to Pay for Selected Ecosystem Services in the Chure Region of Nepal. *Appl. Geogr.* **2016**, *69*, 25–34. [CrossRef]
37. Juutinen, A.; Kosenius, A.K.; Ovaskainen, V. Estimating the Benefits of Recreation-Oriented Management in State-Owned Commercial Forests in Finland: A Choice Experiment. *J. For. Econ.* **2014**, *20*, 396–412. [CrossRef]
38. Bestard, A.B.; Font, A.R. Estimating the Aggregate Value of Forest Recreation in a Regional Context. *J. For. Econ.* **2010**, *16*, 205–216. [CrossRef]
39. Ankomah, E.; Osei Adu, K. Recreational Value of National Parks in Ghana: A Case of Kakum National Park. *Int. J. Ecol. Econ. Stat.* **2015**, *36*, 125–133.
40. Getzner, M.; Gutheil-Knopp-Kirchwald, G.; Kreimer, E.; Kirchmeir, H.; Huber, M. Gravitational Natural Hazards: Valuing the Protective Function of Alpine Forests. *For. Policy Econ.* **2017**, *80*, 150–159. [CrossRef]
41. Croitoru, L. How Much are Mediterranean Forests Worth? *For. Policy Econ.* **2007**, *9*, 536–545. [CrossRef]
42. Curtis, I.A. Valuing Ecosystem Goods and Services: A New Approach using a Surrogate Market and the Combination of a Multiple Criteria Analysis and a Delphi Panel to Assign Weights to the Attributes. *Ecol. Econ.* **2004**, *50*, 163–194. [CrossRef]

43. Häyhä, T.; Franzese, P.P.; Paletto, A.; Fath, B.D. Assessing, Valuing, and Mapping Ecosystem Services in Alpine Forests. *Ecosyst. Serv.* **2015**, *14*, 12–23. [CrossRef]
44. Li, J.; Ren, Z.Y.; Zhou, Z.X. Ecosystem Services and their Values: A Case Study in the Qinba Mountains of China. *Ecol. Res.* **2006**, *21*, 597–604. [CrossRef]
45. Schmidt, J.P.; Moore, R.; Alber, M. Integrating Ecosystem Services and Local Government Finances into Land use Planning: A Case Study from Coastal Georgia. *Landsc. Urban Plan.* **2014**, *122*, 56–67. [CrossRef]
46. Strassburg, B.B.N.; Barros, F.S.M.; Crouzeilles, R.; Iribarrem, A.; dos Santos, J.S.; Silva, D.; Sansevero, J.B.B.; Alves-Pinto, H.N.; Feltran-Barbieri, R.; Latawiec, A.E. The Role of Natural Regeneration to Ecosystem Services Provision and Habitat Availability: A Case Study in the Brazilian Atlantic Forest. *Biotropica* **2016**, *48*, 890–899. [CrossRef]
47. Temesgen, H.; Wu, W.; Shi, X.; Yirsaw, E.; Bekele, B.; Kindu, M. Variation in Ecosystem Service Values in an Agroforestry Dominated Landscape in Ethiopia: Implications for Land use and Conservation Policy. *Sustainability* **2018**, *1*, 1126. [CrossRef]
48. Kaiser, B.; Roumasset, J. Valuing Indirect Ecosystem Services: The Case of Tropical Watersheds. *Environ. Dev. Econ.* **2002**, *7*, 701–714. [CrossRef]
49. Zhang, B.A.; Li, W.H.; Xie, G.D.; Xiao, Y. Water Conservation of Forest Ecosystem in Beijing and its Value. *Ecol. Econ.* **2010**, *69*, 1416–1426.
50. Morri, E.; Pruscini, F.; Scolozzi, R.; Santolini, R. A Forest Ecosystem Services Evaluation at the River Basin Scale: Supply and Demand between Coastal Areas and Upstream Lands (Italy). *Ecol. Indic.* **2014**, *37*, 210–219. [CrossRef]
51. Ninan, K.N.; Kontoleon, A. Valuing Forest Ecosystem Services and Disservices—Case Study of a Protected Area in India. *Ecosyst. Serv.* **2016**, *20*, 1–14. [CrossRef]
52. Pechanec, V.; Machar, I.; Sterbova, L.; Prokopova, M.; Kilianova, H.; Chobot, K.; Cudlin, P. Monetary Valuation of Natural Forest Habitats in Protected Areas. *Forests* **2017**, *8*, 427. [CrossRef]
53. Foster, N.; Bhatti, J. Forest Ecosystems: Nutrient Cycling. In *Encyclopedia of Soil Science*; Springer Science & Business Media: New York, NY, USA, 2006; pp. 718–721.
54. Nikodinoska, N.; Paletto, A.; Pastorella, F.; Granvik, M.; Franzese, P.P. Assessing, Valuing and Mapping Ecosystem Services at City Level: The Case of Uppsala (Sweden). *Ecol. Model.* **2018**, *368*, 411–424. [CrossRef]
55. Ninan, K.N.; Inoue, M. Valuing Forest Ecosystem Services: Case Study of a Forest Reserve in Japan. *Ecosyst. Serv.* **2013**, *5*, e78–e87. [CrossRef]
56. Campbell, E.T. Revealed Social Preference for Ecosystem Services using the Eco-Price. *Ecosyst. Serv.* **2018**, *30*, 267–275. [CrossRef]
57. Guo, Z.W.; Xiao, X.M.; Gan, Y.L.; Zheng, Y.J. Ecosystem Functions, Services and their Values—A Case Study in Xingshan County of China. *Ecol. Econ.* **2001**, *38*, 141–154. [CrossRef]
58. Rodriguez Garcia, L.; Curetti, G.; Garegnani, G.; Grilli, G.; Pastorella, F.; Paletto, A. Enhancement of Forest Ecosystem Services: A Case Study in the Italian Alps. *Bosque* **2016**, *37*, 41–52.
59. Pattanayak, S.K.; Butry, D.T. Spatial Complementarity of Forests and Farms: Accounting for Ecosystem Services. *Am. J. Agric. Econ.* **2005**, *87*, 995–1008. [CrossRef]
60. Xie, G.D.; Li, W.H.; Xiao, Y.; Zhang, B.A.; Lu, C.X.; An, K.; Wang, J.X.; Xu, K.; Wang, J.Z. Forest Ecosystem Services and their Values in Beijing. *Chin. Geogr. Sci.* **2010**, *20*, 51–58. [CrossRef]
61. Manes, F.; Marando, F.; Capotorti, G.; Blasi, C.; Salvatori, E.; Fusaro, L.; Ciancarella, L.; Mircea, M.; Marchetti, M.; Chirici, G.; et al. Regulating Ecosystem Services of Forests in Ten Italian Metropolitan Cities: Air Quality Improvement by PM_{10} and O_3 Removal. *Ecol. Indic.* **2016**, *67*, 425–440. [CrossRef]
62. Jim, C.Y.; Chen, W.Y. Assessing the Ecosystem Service of Air Pollutant Removal by Urban Trees in Guangzhou (China). *J. Environ. Manag.* **2008**, *88*, 665–676. [CrossRef]
63. Dupras, J.; Alam, M. Urban Sprawl and Ecosystem Services: A Half Century Perspective in the Montreal Area (Quebec, Canada). *J. Environ. Policy Plan.* **2015**, *17*, 180–200. [CrossRef]
64. Klimas, C.; Williams, A.; Hoff, M.; Lawrence, B.; Thompson, J.; Montgomery, J. Valuing Ecosystem Services and Disservices Across Heterogeneous Green Spaces. *Sustainability* **2016**, *8*, 853. [CrossRef]
65. Matero, J.; Saastamoinen, O. In Search of Marginal Environmental Valuations—Ecosystem Services in Finnish Forest Accounting. *Ecol. Econ.* **2007**, *61*, 101–114. [CrossRef]
66. Dupras, J.; Alam, M.; Reveret, J.P. Economic Value of Greater Montreal's Non-Market Ecosystem Services in a Land use Management and Planning Perspective. *Can. Geogr.* **2015**, *59*, 93–106. [CrossRef]
67. Hein, L. Economic Benefits Generated by Protected Areas: The Case of the Hoge Veluwe Forest, the Netherlands. *Ecol. Soc.* **2011**, *16*, 13. [CrossRef]
68. Zandi, S.; Limaei, S.M.; Amiri, N. An Economic Evaluation of a Forest Park using the Individual Travel Cost Method (a Case Study of Ghaleh Rudkhan Forest Park in Northern Iran). *Environ. Socio-Econ. Stud.* **2018**, *6*, 48–55. [CrossRef]
69. Lupp, G.; Foerster, B.; Kantelberg, V.; Markmann, T.; Naumann, J.; Honert, C.; Koch, M.; Pauleit, S. Assessing the Recreation Value of Urban Woodland using the Ecosystem Service Approach in Two Forests in the Munich Metropolitan Region. *Sustainability* **2016**, *8*, 1156. [CrossRef]
70. Birch, J.C.; Newton, A.C.; Alvarez Aquino, C.; Cantarello, E.; Echeverria, C.; Kitzberger, T.; Schiappacasse, I.; Garavito, N.T. Cost-Effectiveness of Dryland Forest Restoration Evaluated by Spatial Analysis of Ecosystem Services. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 21925–21930. [CrossRef]

71. Termansen, M.; McClean, C.J.; Jensen, F.S. Modelling and Mapping Spatial Heterogeneity in Forest Recreation Services. *Ecol. Econ.* **2013**, *92*, 48–57. [CrossRef]
72. Bostedt, G.; Mattson, L. A Note on Benefits and Costs of Adjusting Forestry to Meet Recreational Demands. *J. For. Econ.* **2006**, *12*, 75–81. [CrossRef]
73. Cullinan, J.; Hynes, S.; O'Donoghue, C. Using Spatial Microsimulation to Account for Demographic and Spatial Factors in Environmental Benefit Transfer. *Ecol. Econ.* **2011**, *70*, 813–824. [CrossRef]
74. Schagner, J.P.; Brander, L.; Maes, J.; Paracchini, M.L.; Hartje, V. Mapping Recreational Visits and Values of European National Parks by Combining Statistical Modelling and Unit Value Transfer. *J. Nat. Conserv.* **2016**, *31*, 71–84. [CrossRef]
75. Hájek, M.; Lípa, J. Evaluation of Ecosystem Services from Urban Forests in the City of Prague. *For. J.* **2015**, *61*, 52–57.
76. Bernard, F.; de Groot, R.S.; Campos, J.J. Valuation of Tropical Forest Services and Mechanisms to Finance their Conservation and Sustainable use: A Case Study of Tapanti National Park, Costa Rica. *For. Policy Econ.* **2009**, *11*, 174–183. [CrossRef]
77. Chen, N.; Li, H.; Wang, L. A GIS-Based Approach for Mapping Direct use Value of Ecosystem Services at a County Scale: Management Implications. *Ecol. Econ.* **2009**, *68*, 2768–2776. [CrossRef]
78. Scarpa, R.; Chilton, S.M.; Hutchinson, W.G.; Buongiorno, J. Valuing the Recreational Benefits from the Creation of Nature Reserves in Irish Forests. *Ecol. Econ.* **2000**, *33*, 237–250. [CrossRef]
79. Shultz, S.; Pinazzo, J.; Cifuentes, M. Opportunities and Limitations of Contingent Valuation Surveys to Determine National Park Entrance Fees: Evidence from Costa Rica. *Environ. Dev. Econ.* **1998**, *3*, 131–149. [CrossRef]
80. Hong, S.K.; Kim, J.M.; Jo, H.K.; Lee, S.W. Monetary Valuation of Urban Forest Attributes in Highly Developed Urban Environments: An Experimental Study using a Conjoint Choice Model. *Sustainability* **2018**, *10*, 2461. [CrossRef]
81. Naidoo, R.; Adamowicz, W.L. Biodiversity and Nature-Based Tourism at Forest Reserves in Uganda. *Environ. Dev. Econ.* **2005**, *10*, 159–178. [CrossRef]
82. Paletto, A.; Geitner, C.; Grilli, G.; Hastik, R.; Pastorella, F.; Garcia, L.R. Mapping the Value of Ecosystem Services: A Case Study from the Austrian Alps. *Ann. For. Res.* **2015**, *58*, 157–175. [CrossRef]
83. Ezebilo, E.E.; Boman, M.; Mattsson, L.; Lindhagen, A.; Mbongo, W. Preferences and Willingness to Pay for Close to Home Nature for Outdoor Recreation in Sweden. *J. Environ. Plan. Manag.* **2015**, *58*, 283–296. [CrossRef]
84. Ding, H.; Chiabai, A.; Silvestri, S.; Nunes, P.A.L.D. Valuing Climate Change Impacts on European Forest Ecosystems. *Ecosyst. Serv.* **2016**, *18*, 141–153. [CrossRef]
85. Ramirez, O.A.; Carpio, C.E.; Ortiz, R.; Finnegan, B. Economic Value of the Carbon Sink Services of Tropical Secondary Forests and its Management Implications. *Environ. Resour. Econ.* **2002**, *21*, 23–46. [CrossRef]
86. Bulte, E.; van Soest, D.P.; van Kooten, G.C.; Schipper, R.A. Forest Conservation in Costa Rica when Nonuse Benefits are Uncertain but Rising. *Am. J. Agric. Econ.* **2002**, *84*, 150–160. [CrossRef]
87. Li, T.; Cui, Y.; Liu, A. Spatiotemporal Dynamic Analysis of Forest Ecosystem Services using "Big Data": A Case Study of Anhui Province, Central-Eastern China. *J. Clean. Prod.* **2017**, *142*, 589–599. [CrossRef]
88. Ovando, P.; Caparros, A.; Diaz-Balteiro, L.; Pasalodos, M.; Begueria, S.; Oviedo, J.L.; Montero, G.; Campos, P. Spatial Valuation of Forests' Environmental Assets: An Application to Andalusian Silvopastoral Farms. *Land Econ.* **2017**, *93*, 87–108. [CrossRef]
89. Nielsen, A.S.E.; Plantinga, A.J.; Alig, R.J. Mitigating Climate Change through Afforestation: New Cost Estimates for the United States. *Resour. Energy Econ.* **2014**, *36*, 83–98. [CrossRef]
90. Brainard, J.; Bateman, I.J.; Lovett, A.A. The Social Value of Carbon Sequestered in Great Britain's Woodlands. *Ecol. Econ.* **2009**, *68*, 1257–1267. [CrossRef]
91. Felardo, J.; Lippitt, C.D. Spatial Forest Valuation: The Role of Location in Determining Attitudes Toward Payment for Ecosystem Services Policies. *For. Policy Econ.* **2016**, *62*, 158–167. [CrossRef]
92. Ashagre, B.B.; Platts, P.J.; Njana, M.; Burgess, N.D.; Balmford, A.; Turner, R.K.; Schaafsma, M. Integrated Modelling for Economic Valuation of the Role of Forests and Woodlands in Drinking Water Provision to Two African Cities. *Ecosyst. Serv.* **2018**, *32*, 50–61. [CrossRef]
93. Ko, J.Y.; Day, J.W.; Lane, R.R.; Day, J.N. A Comparative Evaluation of Money-Based and Energy-Based Cost-Benefit Analyses of Tertiary Municipal Wastewater Treatment using Forested Wetlands Vs. Sand Filtration in Louisiana. *Ecol. Econ.* **2004**, *49*, 331–347. [CrossRef]
94. Vincent, J.R.; Ahmad, I.; Adnan, N.; Burwell III, W.B.; Pattanayak, S.K.; Tan-Soo, J.S.; Thomas, K. Valuing Water Purification by Forests: An Analysis of Malaysian Panel Data. *Environ. Resour. Econ.* **2016**, *64*, 59–80. [CrossRef]
95. Chaikaew, P.; Hodges, A.W.; Grunwald, S. Estimating the Value of Ecosystem Services in a Mixed-use Watershed: A Choice Experiment Approach. *Ecosyst. Serv.* **2017**, *23*, 228–237. [CrossRef]
96. Honey-Roses, J.; Acuna, V.; Bardina, M.; Brozovic, N.; Marce, R.; Munne, A.; Sabater, S.; Termes, M.; Valero, F.; Vega, A.; et al. Examining the Demand for Ecosystem Services: The Value of Stream Restoration for Drinking Water Treatment Managers in the Llobregat River, Spain. *Ecol. Econ.* **2013**, *90*, 196–205. [CrossRef]
97. Guo, Z.W.; Xiao, X.M.; Li, D.M. An Assessment of Ecosystem Services: Water Flow Regulation and Hydroelectric Power Production. *Ecol. Appl.* **2000**, *10*, 925–936. [CrossRef]
98. Nguyen, T.T.; van Dien, P.; Tenhunen, J. Linking Regional Land use and Payments for Forest Hydrological Services: A Case Study of Hoa Binh Reservoir in Vietnam. *Land Use Policy* **2013**, *33*, 130–140. [CrossRef]

99. Nunez, D.; Nahuelhual, L.; Oyarzun, C. Forests and Water: The Value of Native Temperate Forests in Supplying Water for Human Consumption. *Ecol. Econ.* **2006**, *58*, 606–616. [CrossRef]
100. Mattos, J.B.; Santos, D.A.; Teixeira Falcao Filho, C.A.; Santos, T.J.; dos Santos, M.G.; Fernandes de Paula, F.C. Water Production in a Brazilian Montane Rainforest: Implications for Water Resources Management. *Environ. Sci. Policy* **2018**, *84*, 52–59. [CrossRef]
101. Yaron, G. Forest, Plantation Crops Or Small-Scale Agriculture? an Economic Analysis of Alternative Land use Options in the Mount Cameroon Area. *J. Environ. Plan. Manag.* **2001**, *44*, 85–108. [CrossRef]
102. Barth, N.C.; Döll, P. Assessing the Ecosystem Service Flood Protection of a Riparian Forest by Applying a Cascade Approach. *Ecosyst. Serv.* **2016**, *21*, 39–52. [CrossRef]
103. Brookhuis, B.J.; Hein, L.G. The Value of the Flood Control Service of Tropical Forests: A Case Study for Trinidad. *For. Policy Econ.* **2016**, *62*, 118–124. [CrossRef]
104. Aguilar, F.X.; Obeng, E.A.; Cai, Z. Water Quality Improvements Elicit Consistent Willingness-to-Pay for the Enhancement of Forested Watershed Ecosystem Services. *Ecosyst. Serv.* **2018**, *30*, 158–171. [CrossRef]
105. Teich, M.; Bebi, P. Evaluating the Benefit of Avalanche Protection Forest with GIS-Based Risk Analyses-A Case Study in Switzerland. *For. Ecol. Manag.* **2009**, *257*, 1910–1919. [CrossRef]
106. Grilli, G.; Nikodinoska, N.; Paletto, A.; De Meo, I. Stakeholders' Preferences and Economic Value of Forest Ecosystem Services: An Example in the Italian Alps. *Balt. For.* **2015**, *21*, 298–307.
107. Olschewski, R.; Bebi, P.; Teich, M.; Wissen Hayek, U.; Grêt-Regamey, A. Avalanche Protection by Forests—A Choice Experiment in the Swiss Alps. *For. Policy Econ.* **2012**, *17*, 19–24. [CrossRef]