

THE ECONOMIC VALUE OF THE PLANET'S FOREST ECOSYSTEMS

A meta-analysis

Griffith Climate Action Beacon Science
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1 FOREST ECOSYSTEM SERVICES

Our planet's forests provide many benefits that are essential to society's continued well-being. Yet forests are subjected to ongoing loss and degradation from extractive activities, such as logging and clearing for mining and agriculture. Whilst these activities provide financial benefit to those who carry them out, unless we understand the value of what is lost when the forests are cleared and degraded, we will not be able to make informed decisions about their use and management. These benefits derive from what are called 'ecosystem services', which include three broad categories: provisioning services – such as wood, food, and fibre; regulating services – such as carbon storage, water filtration, and coastal protection; and cultural services – such as recreation, aesthetics, and spiritual wellbeing.

How much society values those forest ecosystem services that are bought and sold through markets, such as wood, can be readily assessed economically. However, it is not so straightforward for many other ecosystem services that are not or cannot be exchanged on a market. Rather, they are provided by nature for 'free' as what are known as common pool resources or public goods. As such, their true value to society is often opaque, which means we tend to over-use or spoil them. From an economic perspective, this is due to 'market failure' – as most of the forest ecosystem services do not have their true scarcity value reflected in market prices nor the full cost of their use. In most instances, these are the forests' regulating ecosystem services. Lack of such comprehensive economic valuation is a major barrier to well-informed policy and forest management for wider society's benefit.

In cases where there is conflict between marketed and non-marketed demands on forest goods and services, it tends to be the marketed uses that take priority as their benefits are captured privately and often more immediately. In many instances, such as timber and biomass energy extraction, marketed uses are often damaging to regulating and cultural forest ecosystem services. For other uses such as eco-tourism and other cultural services, the impacts can be more benign.

Economic valuation of ecosystem services is a way of demonstrating their importance to society and decision making, which can help improve forest policy, planning and management. We can deduce both marketed and non-marketed ecosystem service values using different valuation techniques. The consideration of both helps us to make more informed decisions

about forests and related environmental issues, such as climate mitigation and biodiversity conservation. This information can also help to promote or design financial incentives, such as payments for ecosystem services (PES) schemes that aim to support the conservation of forests and preserve the otherwise non-marketed ecosystem services they provide.

2 SYSTEMATIC LITERATURE REVIEW AND ANALYSIS

We reviewed historic economic valuation studies to ascertain how and where different forest ecosystem services have been valued and to identify the drivers of value estimates and knowledge gaps. We did this through a systematic review and meta-analysis – a rigorous process whereby major databases of published literature are searched using pre-defined key terms and publications that fit the criteria to have consistent data points recorded, synthesised, and collated for statistical analysis. This statistical analysis enables us to understand variations in economic values from the range of studies and to disentangle the contributions of different ecosystem service values to a forest's estimated aggregated value.

Following the eligibility criteria and value standardization processes, we retained 261 studies for the statistical analysis. Our data analysis revealed limitations in the existing literature including:

- 1. Important forest regions and ecological zones are under-studied**
There is an absence of studies from important forest regions, such as the tropical rainforests in Central Africa and the boreal and temperate forests of North America and Russia.
- 2. Bias towards market pricing valuation techniques**
Economic valuation studies are dominated with market pricing approaches, which emphasise forest management that maximizes industrial production instead of long-term social benefits, such as carbon storage and water quality improvements.
- 3. Failure to evaluate trade-offs between values**
There is a disregard for the range of other values— i.e., underestimated, or lost values (the 'opportunity costs') when extractive uses, such as logging and clearing for mining and agriculture take precedence.

As discussed further below, these limitations have important implications for forest conservation.

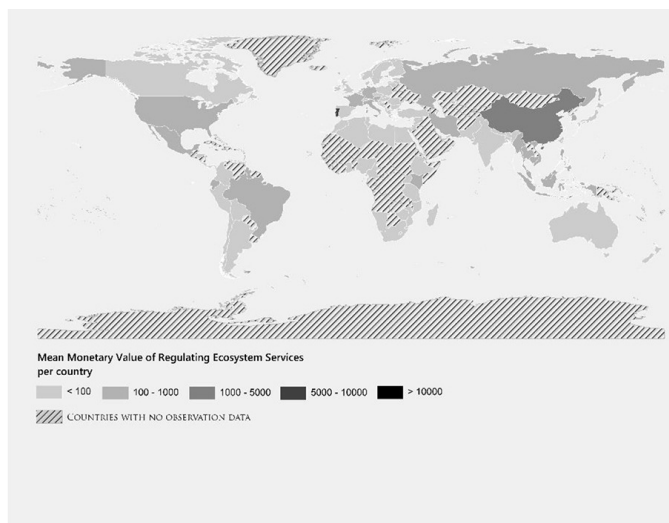
2.1 IMPORTANT FOREST REGIONS OR ECOLOGICAL ZONES ARE UNDER STUDIED

Our review found most (41%) studies have been conducted in Asian countries. Studies from Europe, Africa, and North America accounted for 21%, 15%, and 11% of the total number of studies respectively. China, India, USA, Brazil, and Indonesia were the five most represented countries, each with more than ten studies.

This finding reveals that some globally important forests, including the tropical rainforest in the Democratic Republic of Congo (the second largest rainforest, after the Brazilian Amazon), the boreal and temperate forests in Russia and Canada are not well represented in the literature. In addition, we found quite divergent estimated values for ecosystem services across countries.



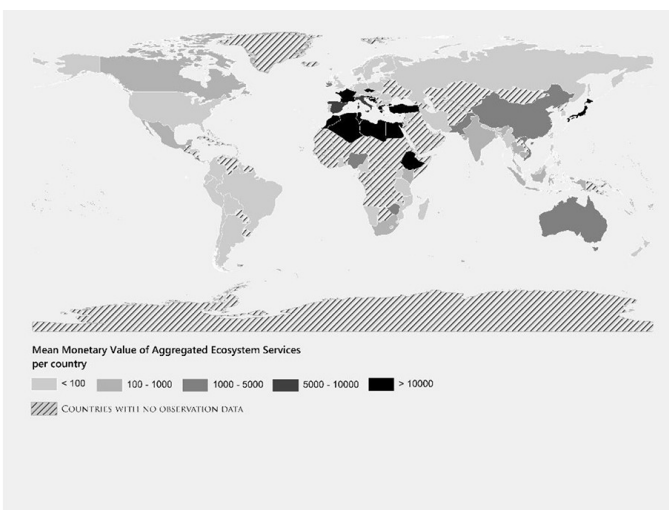
Panel A Value estimates for provisioning services



Panel B Value estimates for regulating services



Panel C Value estimates for cultural service



Panel D Value estimates for aggregated ecosystem services

Figure 1 Distribution of average value estimates for the three broad categories of ecosystem services (Panels A-C) and their aggregate value (Panel D).

2.2 BIAS TOWARDS MARKET PRICING VALUATION TECHNIQUES

The economic values of forest ecosystem services can be estimated using a wide range of different techniques, including:

- market pricing (e.g., the contribution of ecosystems to the value of timber sales);
- cost-based approaches (e.g., replacement costs, avoided damage costs);
- revealed preferences —i.e., values based on related markets (e.g., travel costs, hedonic prices);
- stated preferences or survey-based approaches (e.g., contingent valuation); and
- benefit transfer (taking the estimates from one site and applying them to another).

These techniques lend themselves to estimating different types of forest values. For example, market pricing techniques are used to estimate the value of direct use provisioning services, such as timber and fibre products. Conversely, stated preferences techniques are the only methods that can be used to estimate both use and non-use values from public goods and provide aggregated ecosystem services values.

In our systematic review, market pricing methods accounted for 57% of all value estimates. In contrast, few primary studies applied revealed preference and cost-based methods. This dominance of market pricing can result in decision making being biased towards market-oriented forest management. In addition, the application of cost-based methods, such as the avoided cost or replacement cost, which are commonly used for estimating the value of regulating ecosystem services, was also quite limited. These gaps limit our understanding of the value of ecosystem services like coastal flood protection services of mangroves or the damage from wildfire.

2.3 FAILURE TO EVALUATE TRADE-OFFS BETWEEN VALUES

Our review also showed that most forest economic valuation studies have focused on estimating the value of a single ecosystem service provided by a forest, rather than estimating an aggregate value of all benefits. Often this is a result of the forest being the subject of study to ensure it is managed in a certain way to maximise the benefit from a specific ecosystem service. For instance, a natural forest managed for industrial production of timber can generate a high value for that ecosystem service which is frequently captured by private interests. However, this singular value needs to be considered in the context of the costs of the 'environmental externalities' (that is, negative impacts) that result from the extractive uses, which are carried by everyone else in society. This dominance of market pricing can result in decision making being biased towards market-oriented forest managements.

Failure to evaluate the trade-offs involved in different forest uses and management can result in economic information that can, for example, seemingly support the conversion of primary forests to forests used for logging. Therefore, a proper understanding of the trade-offs can only be done when extractive values are contrasted with valuation of aggregated non-extractive ecosystem service benefits. Our study and meta-analysis revealed the values for multiples of ecosystem services, when estimated together, are much higher than the value of singular extractive uses (see Table 1).

This is an important illustration of the trade-offs between industrial and conservation forest management and in how, when, and who captures the monetary and non-monetary values of forests. Conservation efforts and alternative land use planning decisions require consideration of the public goods value of ecosystem services and the trade-offs between these services and those captured privately.



Source Lingchor from Unsplash

Ecosystem services	Median value estimates (USD/ha/year)	Observations
Provisioning services		
Water supply	171	16
Food-terrestrial plants & animals	31	57
Food-freshwater plants & animals	580	17
Food-marine plants, algae & animals	229	21
Nutrients and natural feed	52	10
Timber and fibre products	146	103
Chemicals from plants & animals	73	15
Genetic materials	167	1
Biomass based energy	52	33
Other provisioning	13	1
Regulating services		
Bioremediation	83	9
Dilution, filtration, and sequestration	78	12
Air flow regulation	847	11
Water flow regulation	160	32
Mass flow regulation	430	29
Atmospheric regulation	75	107
Water cycle regulation	527	15
Pedogenesis & soil cycle regulation	149	15
Life cycle maintenance	411	18
Pest and disease control	46	5
Cultural services		
Non-extractive recreation	156	50
Information and knowledge	528	2
Spiritual and symbolic	28	7
Non-use values	114	46
Aggregated ecosystem services	1,837	126

Table 1 Summary statistics on the values of forest ecosystem services. The median values are estimated using observations for each type of ecosystem services. The value estimates are obtained from the 261 eligible studies with a total of 758 observations. Note that multiple observations could be taken from a single study.

3 CONCLUSION

Our systematic review and meta-analysis findings demonstrate the relevance of economic valuation of ecosystem services for socially optimal policy making. We found that the literature on economic valuation of forest ecosystem services has been limited in terms of its coverage of some of the world's most important forest regions and ecological zones. Our study also revealed a preponderance in the literature for market-pricing techniques over non-market techniques, reflecting the historically greater focus on estimating a narrow set of extractive uses, particularly managed forestry for timber. This has left important weaknesses in our understanding of bundles (or aggregations) of ecosystem services provided by the world's forests, where in many instances the extractive uses involved trading-off the benefits from other provisioning, regulatory, and cultural ecosystem services. Information of the value of all forest ecosystem services is needed when assessing the costs and benefits of a proposed change in forest use. Our meta-analysis underlines the importance of considering the economic value of multiples of ecosystem services when formulating public policy that supports forest conservation over the management of forest for single-use, extractive industrial production, or clearing for mineral extraction and agriculture. Understanding the drivers of the value estimates of forest ecosystem services helps identify better policy interventions for global forest conservation efforts.

In this regard, our findings support local, regional, and global efforts to address the problem of deforestation and degradation in ways that support Indigenous access and use rights of forests, reduce biodiversity loss, and minimize atmospheric greenhouse gas concentrations. Inclusive conservation management of forests informed by valuation of the benefits from all their ecosystem services is vital to the achievement of the development targets in the United Nations Sustainable Development Goals, meeting the emissions reduction challenges set out in the Paris Agreement on climate change, advancing the conservation objectives of the Convention on Biological Diversity, and supporting the survival, dignity and well-being of the world's Indigenous Peoples, as articulated in the UN Declaration on the Rights of Indigenous Peoples.

SOURCE REFERENCE

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