

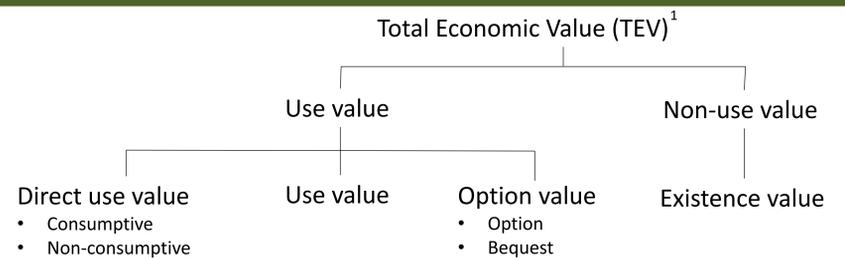
# Identifying Trends in Forested Watershed Ecosystem Services Valuation: A Global Meta-Analysis

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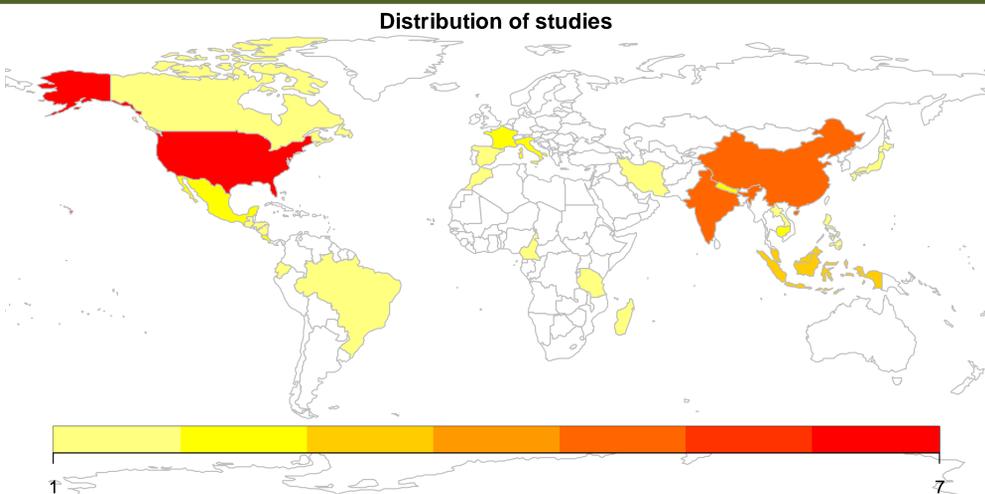
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## Background and Objectives

The ecosystem services (ES) approach is a conceptual framework for recognizing the role ecosystems play in human welfare. While the framework has been implemented by economists and policymakers to justify conservation, there remain many methodological issues. By identifying conceptual strengths and limitations in the literature, we can aid the wider adoption of ES as a conservation tool.



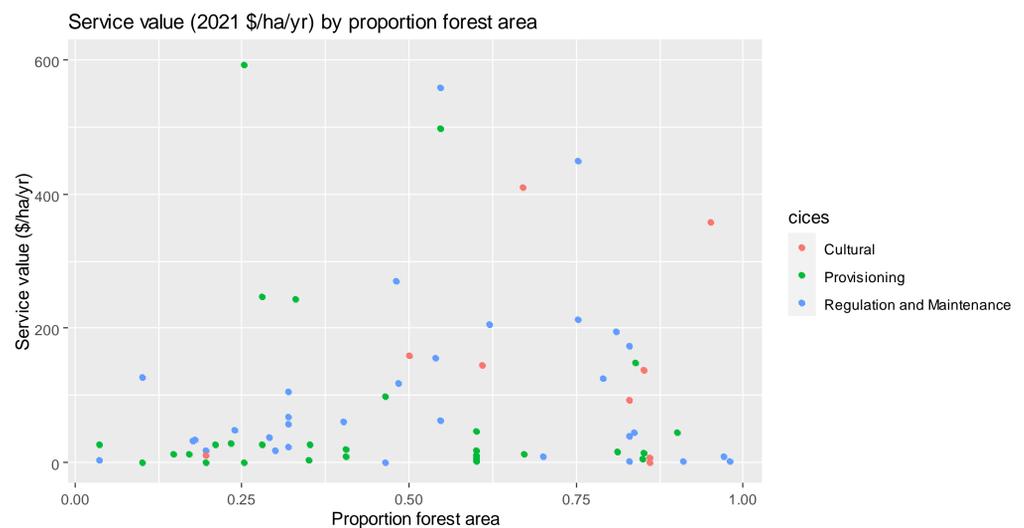
## Data Collection



- Systematic literature search using Google Scholar, SCOPUS, Econlit.
- Regional biases: countries, continents, biomes overrepresented/understudied in dataset.
- Obstacles:
  - Double-counting: distinction between intermediate or final ES
  - Overlapping: ES part of multiple ES categories
- Introduction of a new ES categorization to address these obstacles in application.
- Identification of 53 valuation studies generating 108 unique ES values.

## Heterogenous data, problematic trends

- Cook's distance measures suggest presence of high level of outliers.
- Breusch-Pagan (BP) test shows clear heteroscedasticity problem.
- Log transformation dependent variable somewhat mitigates heteroscedasticity.
- Use of heteroscedasticity-constant robust standard errors and Generalised Least Squares (GLS).
- Recommended that GLS be used for n=100 when the ratio of the largest to smallest variance is greater than 1.22.



## Heterogenous data, problematic trends

$$\ln y_i = \alpha + X_{sti}\beta_{st} + X_{sii}\beta_{si} + X_{esi}\beta_{es} + \epsilon_i$$

- Market, PES valuation methods obtain higher estimates.
- Service values from tropical forests are lower than other biomes.
- No difference between final and intermediary services. Economists do not model these distinctly.
  - Non-market studies often do not specify to respondents the nature of a service valued.
  - Market studies often use cost proxies but again often do not distinguish.
- Leave-One-Out-Cross-Validation (LOOCV) is used for model validation, OLS/GLS perform better than Random Effects (improved prediction performance).

Table 1: Regression models

Variable	OLS	p-value (robust)	GLS	p-value	Random effects	p-value
Constant	2.07	0.236	2.07	0.161	0.96	0.613
Land-use change	0.59	0.468	0.59	0.399	0.61	0.462
Time	-0.03	0.497	-0.03	0.404	-0.02	0.551
Market	2.51***	0.01	2.51***	0.003	2.84	0.007
Mean	0.31	0.783	0.31	0.723	0.58	0.603
Degradation	-1.15**	0.071	-1.15**	0.071	-1.21	0.111
PES	1.89**	0.044	1.89**	0.042	2.18*	0.073
Site area	-7.33e-09*	0.095	-7.33e-09	0.210	-6.64e-09	0.510
Population density	3.06e-03	0.212	3.06e-03	0.124	3.97e-03	0.125
GDP per capita	-8.12e-06	0.691	-8.12e-06	0.649	2.32e-06	0.920
Riparian	-0.44	0.653	-0.44	0.594	-0.18	0.852
Tropical	-0.93**	0.046	-0.93*	0.060	-0.61	0.346
Provisioning	-0.44	0.446	-0.44	0.355	-0.26	0.615
Cultural	1.00	0.252	1.00	0.232	1.23	0.187
Industrial	0.35	0.570	0.35	0.539	0.21	0.735

## Conclusions

- Systematic literature review of watershed ES valuation shows biases: tropical forests, forests in East Asia, the United States overrepresented.
- Market valuation studies There are identifiable trends in watershed valuation literature, however the meta-regression specification shows there remain problems in the conceptual understanding of ecosystem services.
- Significant data limitations, harmonizing data difficult as ES are difficult to standardize across methodological approaches and types of services.

<sup>1</sup>Pagiola, Stefano, Konrad Von Ritter, and Joshua Bishop. "Assessing the economic value of ecosystem conservation." (2004).