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Review

# Whose perspective counts? A critical look at definitions of terms used for natural and near-natural forests

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## SUMMARY

The way forests are defined, using terms such as ancient, old-growth, primary, sacred, or intact forest landscapes, has far-reaching impacts on how, why, and where forests are conserved and managed. Definitions of terms such as "old-growth forests" have been discussed individually but not collectively assessed. Here, we review the definitions and uses of terms associated with natural and near-natural forests using systematic mapping methods and critical analysis. Our findings reveal a variety of definitions for different terms, although a few frequently cited ones prevail. Our results also highlight the dominance of Western institutions and scientific knowledge in shaping global discourses on forest conservation, often at the expense of Indigenous and local perspectives. Despite the increasing recognition of the value-based benefits that forests provide, definitions that explicitly incorporate values are scarce. This omission of the voices of forest-proximate communities and a lack of consideration for their local values and needs result in recognition, contextual, and procedural inequities when employing mainstream terms to define natural and near-natural forests.

## INTRODUCTION

Forests are at the forefront of efforts to conserve and restore biodiversity and address climate change, as reiterated for instance under the Glasgow Leaders' Declaration at COP 2021.[1] Worldwide they harbor a majority of the world's terrestrial species, most of them in the tropics,[2,3] and hence are important to combat species' global population declines and extinctions.[4–7] The role of forests for climate and water regulation and for the sustainable provision of bioenergy, other wood-based materials, and non-timber products is crucial in the context of climate change.[8–10] Beyond their vital roles for biodiversity conservation and climate-change mitigation and adaptation, forests face various demands and needs that extend to supporting livelihoods, serving as a source of safety nets, and contributing to poverty reduction and overall well-being.[11,12] These demands are particularly pronounced for the 1.2 billion individuals who rely on forests in the tropics.[13] Moreover, a significant global population of 1.4 billion resides in areas identified as priorities for forest and ecosystem restoration.[14] Additionally, the larger global population of 1.6 billion people who live in proximity to forests also benefit from the resources and services they provide.[15]

Despite such importance, forests worldwide continue to face climate and land-use changes, leading to ongoing loss and degradation.[16,17] Forests encounter multi-faceted challenges arising not only from the rapid transformations in forest cover but also from the inherent instability and sometimes narrowness and inadequacy of approaches to perceiving forests.[18] As such, current challenges confronting forests provide an opportunity for learning, especially by delving into the interplay among discursive terminologies used to describe and/or define forests, values held or ascribed to forests, and boundaries, and reflecting on their implications for practice to achieve sustainable solutions.

Forests are observed and valued through diverse perspectives and interests. Chazdon et al.[19] identified eight perspectives on forests depending on the management objectives, including forests as a home, landscape component, or provider of ecosystem services. Those perspectives matter when talking about forests and what they mean for us, and ultimately influence our definitions of forests and associated terminologies. However, how forests are defined plays a pivotal role in shaping policy and

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decision-making processes, providing the "conceptual, institutional, legal, and operational basis for the policies and monitoring systems that drive or enable deforestation, forest degradation, reforestation, and forest restoration"[20] (as cited in Chazdon et al.[19]). Additionally, the individuals or entities responsible for defining forests are of great significance, as they bring forth their values that influence the shaping of these definitions.

Defining forests is a highly intricate task due to numerous factors. First, the term "forest" is not universally present in all languages. Instead, it may be expressed through more abstract concepts, such as the "outside realm," or through specific terms denoting different forest types.[21] Furthermore, even within languages where the term "forest" exists, its meaning can vary depending on the user. For instance, in England the term "forest" specifically refers to conifer plantations, while the term "woods" is used to describe native broadleaved forests. However, individuals unfamiliar with this practice may use the English word "forest" to refer to both types of forests indiscriminately. Second, the process of defining forests is multi-faceted and has undergone significant changes. A key development has been the increased utilization of satellite-based assessments of land cover, which use quantifiable characteristics and measures for defining forests, such as tree cover, tree height, and minimum area covered. While these attributes and indicators are often perceived as objective and measurable, classifying land-cover features from satellite imagery is not free from underlying assumptions and social constructions.[22] Moreover, different organizations apply varying classifications based on similar characteristics, resulting in discrepancies. For instance, the minimum threshold of tree cover required for an area to be classified as a forest can vary widely, from 10% to 60%, leading to substantial implications for the estimation of global forest extent.[23] Third, the inclusion or exclusion of certain land uses within the classification of forest cover is another complexity in forest definitions. Some estimates of forest cover may encompass oil palm plantations and similar land uses, while others may exclude them, leading to divergent results.[18] Also, any restrictions in attempts to define forests have implications on the socio-cultural relationships that are recognized, allowed, and fostered (or not).[24]

These variations and inconsistencies highlight the significant problems in defining forests and subsequently labeling them with mainstreamed terminologies. Further, it is not only the quantity of forest cover that matters; the quality of the forests is also of paramount importance. As such, varying contextual factors and differing perspectives do shape forest definitions. When considering aspects such as biodiversity, it becomes essential to examine the composition of the forest cover. In this regard, understanding the extent of forest types known to possess high biodiversity, such as primary or old-growth forests, at the landscape, country, or global level becomes crucial. Different terms are used to describe forests and forest areas that contain high biodiversity, and they are defined based on qualitative characteristics, including age and the presence or absence of disturbances. For example, the UN Food and Agriculture Organization (FAO)[25] defines primary forest as "naturally regenerated forest of native tree species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed."

Finally, perceptions of forests and their meaning can change over time.[26] For example, in the past pristine forests have been seen as wilderness, something to be tamed, whereas nowadays they are valued exactly because of their undisturbed nature.[27] Also, a given forest type or population of trees can be perceived differently under different knowledge systems or contexts, including being based on the relative associated socio-economic value during different time periods. Over time, perceptions of *Prunus serotina*, the black cherry, in Germany have transitioned from being valued as a timber tree to being seen as a versatile non-timber species, a forest pest, a controllable weed, and eventually a species that co-exists with us.[28]

While individual definitions have been considered, there has not been a comprehensive review of how all these definitions interact or relate to each other in the broader context of forest conservation and management. Scholars have been questioning the definitions and meanings assigned to forests, including the use of ideological, but restricting, labels and terminologies, and pointing to associated problematic implications.[18,24] Nonetheless, scant studies have investigated the evidence base of the terms used for such definitions and their proponents and actors. In this article, our focus is on examining the different terminologies used to describe natural or near-natural forests while exploring the commonalities and differences between these terms. Specifically, we aim to analyze how terms associated with these forest types, such as old-growth or sacred forests, are defined on the basis of their qualitative characteristics, and draw the implications of such discursive terms. In this article we use the term "definition" broadly to refer to "a description of the nature, scope, or meaning of something."[29]

Here we address the following key questions to bring clarity to the terminologies linked to natural and near-natural forests. How are terms related to natural and near-natural forests defined in the existing literature? What is the prevalence of different terms within the literature? Does the terminology vary among different actors who shape and use these terms, particularly those who define different forest types? And finally, do different actors employ distinctive terms and characteristics to describe these forest types?

We followed a predefined systematic map protocol[30] and adhered to the guidelines for systematic evidence syntheses by the Collaboration for Environmental Evidence.[31] We conducted a comprehensive search in English, Spanish, and French and screened articles based on predefined inclusion criteria. We extracted descriptions of the various terms of natural or near-natural forests and grouped the definitions into eight categories: structural aspects, time, origin, function/ecology, values, intactness, management, and threats (Table 1). The closing section of the article, experimental procedures, documents the complete methods outlining our synthesis process and explains deviations from the protocol.

Our findings reveal a wide range of definitions for various terms related to natural and near-natural forests, but they often lack meaningful inclusion of local and Indigenous viewpoints. These findings also illustrate the diverse ways different actors conceptualize and define these forest types, emphasizing concerns related to social equity and inclusion within the resulting discourse. This underscores the necessity of fostering a common understanding of these terms among conservation researchers and decision makers, encouraging reflection on the inclusiveness

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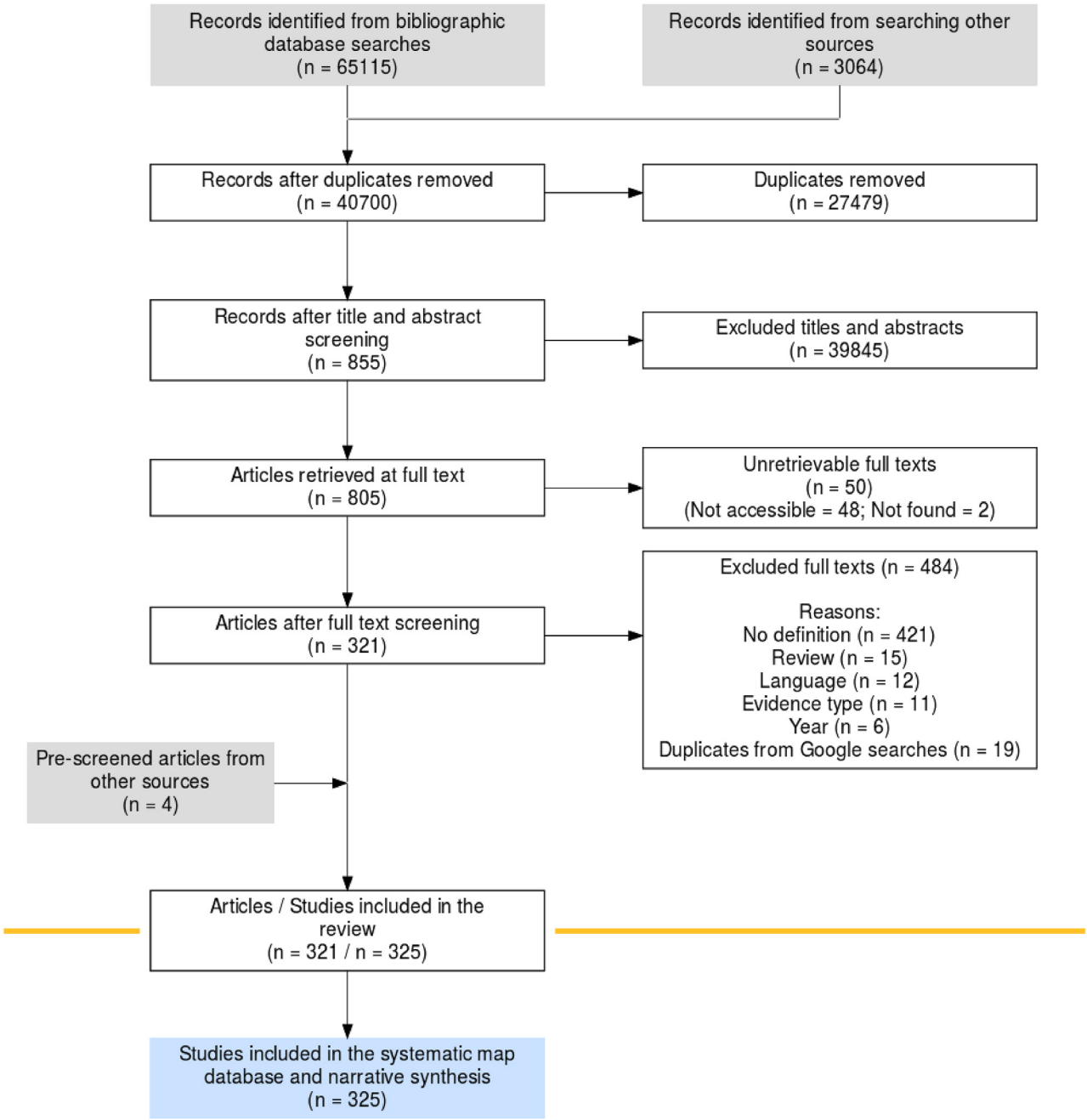


**Figure 1. Articles included/excluded at different stages of screening**
The figure was created using the ROSES Flow Chart ShinyApp.[120]

of perspectives underlying natural and near-natural forest terminology, which significantly impacts conservation practices.

## RESULTS

### The evidence base

Our searches resulted in 68,179 articles, which were further reduced to a pool of 40,700 references for screening after duplicate removal (Figure 1—for further details of the searches see Tables S1–S6). Following agreed-upon adjustments and modification of the inclusion criteria to contain one of the terms "consider," "define," "meaning," "delineate," "describe," "explain," "characterize," "conceptualize," "signify," and "refer to," we used the search function in the EPPI-Reviewer[32] to exclude 25,243 articles. The remaining 15,457 articles we screened manually, except 50 unretrievable articles. Further details of the searches can be found in Tables S1–S6. In the end, we screened 803 articles at full text and included 325 articles in the final synthesis (Table S7 and supplemental references). The most common reason for exclusion at the full-text stage was a lack of definition.

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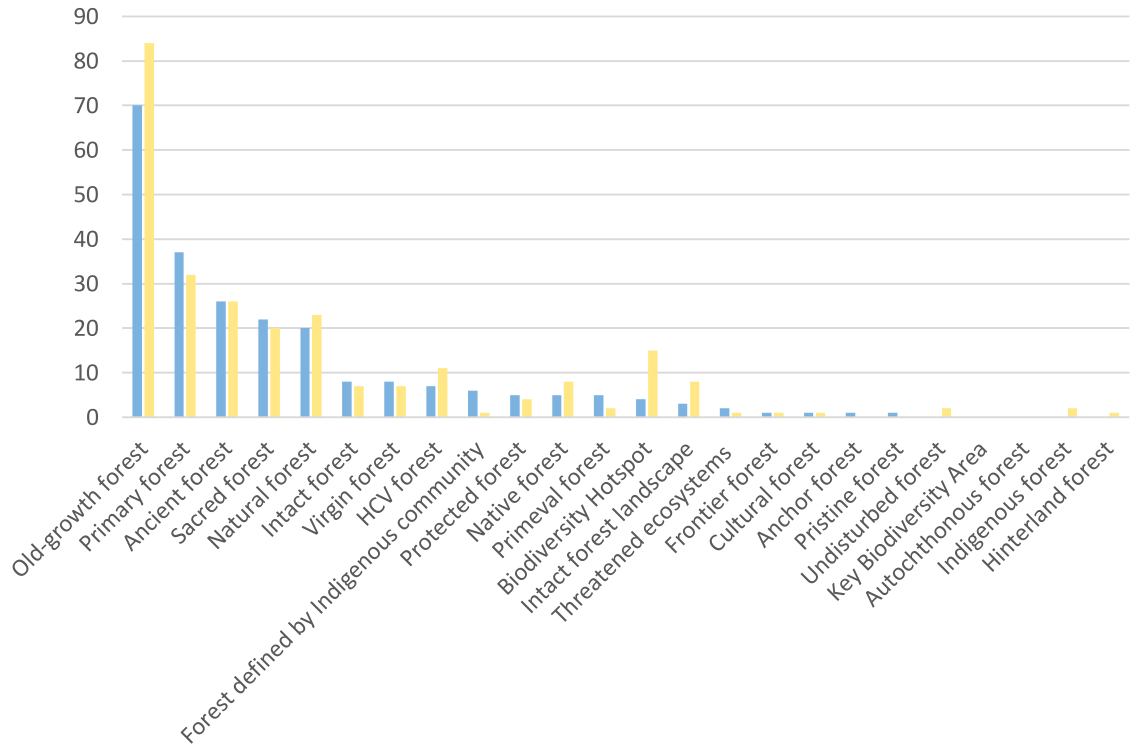


**Figure 2. The number of definitions per term used for natural and near-natural forest terms**

The blue bars represent the original definitions provided by the authors of the article, while the orange bars indicate definitions that were cited from another article. Note that one article could contain more than one definition.

A majority, 82.5%, of the included articles came from the three bibliographic databases. Google searches resulted in an additional 11.5% of included articles and organizational websites 6% of the articles. In addition, there were four definitions that came from the International Union for Forest Research Organizations (IUFRO) SilvaTerm Database.

## Definitions of different terms

We found altogether 488 definitions linked with the 22 different terms used for natural and near-natural forests (Figure 2). Old-growth forest was the most defined term, followed by primary forest, ancient forest, natural forest, and sacred forest. For most terms, there was nearly an even split between original definitions (i.e., defined by authors of the article) and cited definitions (i.e., definition cited from another source). Intact forest landscapes (IFLs), biodiversity hotspots (although the concept is broader, only articles on forests were included), and old-growth forests had more cited than original definitions, indicating that there are some established definitions for those terms. Some terms had only one type of definition, e.g., pristine forest or undisturbed forest. We found no definitions for autochthonous forest (synonymous to native forest) and key biodiversity areas in the pool of articles analyzed, indicating that these are less commonly used in the context of forests.

## Location of studies

Most studies that contained a definition of a term used for natural or near-natural forests came from the temperate regions, followed by the tropical and boreal regions (Figure 3). We found 32 studies that were global in nature, and most of those studies included definitions of IFLs, high conservation value (HCV) forest, or primary forest.

A more detailed examination of the location of studies that contained a definition for the five most defined terms indicates clear geographical patterns where different definitions are used (Figure 4). The term old-growth forest is used especially in North America, although we found related definitions in studies from Chile to Thailand. For example, "old-growth forests in the Pacific Northwest region of the United States are characterized by the presence of large trees, understory and midstory vegetation layers, high spatial heterogeneity, standing and downed dead wood, and diverse arrays of plant species with differing life forms and autecology."[33] Studies containing definitions for ancient forest were almost exclusively conducted in Europe, except for two studies in Canada and one in Chile. Within Europe the majority of studies came from the United Kingdom, where ancient forests are defined, for example, as "land that has been continuously wooded since A.D. 1600 in England and Wales and A.D. 1750 in Scotland."[34] On the contrary, natural and primary forest were terms that had definitions in studies all over the world. Finally, India was the dominant location for studies containing a definition for sacred forest, such as "sacred groves are tracts of richly diverse virgin forest (…) While these groves were defined in different ways by different writers, the natural or near-natural state of vegetation in the sacred groves and the protection of these groves by local communities through social taboos and prohibitions represented the spiritual and ecological ethos of those communities."[35]

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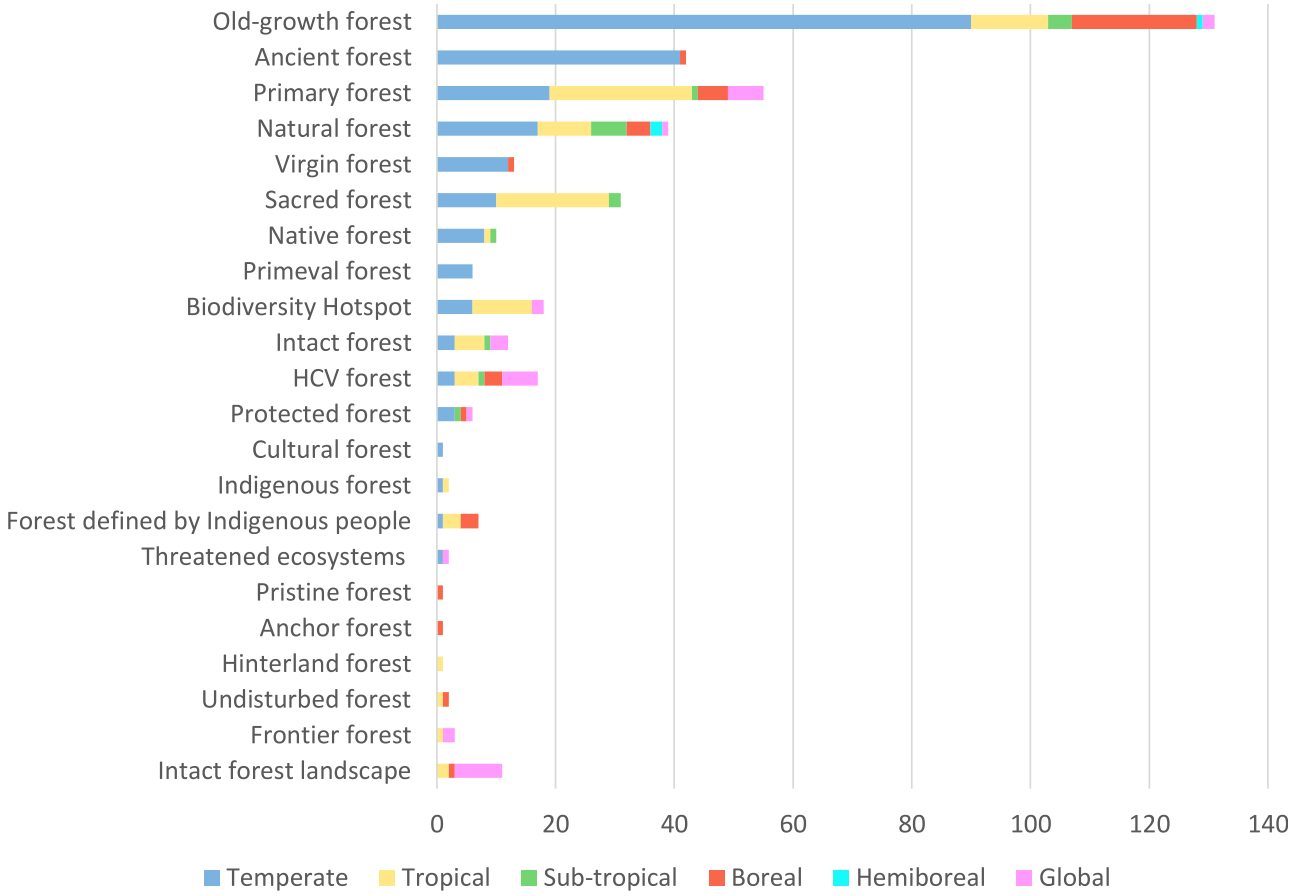


**Figure 3. Regional distribution of studies that provided definitions for natural and near-natural forest terms**

## Who defines forest types?

Most of the definitions for terms for natural and near-natural forests came from researchers—355 in total. Governmental agencies were involved in defining different terms in 150 cases and non-governmental organizations (NGOs) in 48 cases. Local and Indigenous communities were less frequently associated with the definition of terms for natural and near-natural forests, totaling 53 instances, including 22 involving Indigenous communities and 31 involving local communities. It is important to note that our categorization followed the lead author's identification, and we did not independently determine the designation of local or Indigenous communities.

We found variations on who is involved in defining different terms (Figures 5 and S1). Local and Indigenous communities were most often involved in defining the term sacred forest but largely less linked to the definitions of other terms. For example, Constant and Taylor[36] describe the meaning of sacred forests for the Vhavenda clan in South Africa: "Sacred natural sites commonly featured in rural narratives as sacred forests (Zwifho) that represent different meanings to different people. Sacred forests are protected by custodians from specific clans of the Vhavenda that represent the abodes of ancestral spirits, are places of rituals, harbor biodiversity and serve multiple ecosystem functions such as attracting rain to support nature and human populations." In contrast, researchers were involved in defining all terms except anchor forest, which is a term that the ITC, a nonprofit consortium made up of American Indian Tribes and Alaska Native corporations, uses "to refer to a large forested landscape managed through joint management commitments, across property boundaries by neighboring landowners, with the intent of maintaining working forestlands and forest products infrastructure."[37] Similarly, NGOs, multilateral global institutions, and government agencies were notably involved in defining almost all of the different terms. For instance, the definition of primary forest showed a notable influence from the UN FAO, illustrating discursive influence driven by international organizations. There were few cases in which a national park management entity or a company was involved or proposed a definition. For example, a paper and packaging company, Stora Enso,[38] defines old-growth forests in its environmental guidelines as "forest of exceptionally high conservation value due to its combination of very old trees, very large trees, ecologically valuable forest structure, large quantities of woody debris, and species composition representative of the specific ecosystem (ecosite and ecodistrict) in which it is found. Old growth is an ecosite-specific condition that must be identified using locally valid biological criteria."

## Characteristics of definitions

Definitions for different terms were often characterized by features from multiple categories, and hardly any of the terms

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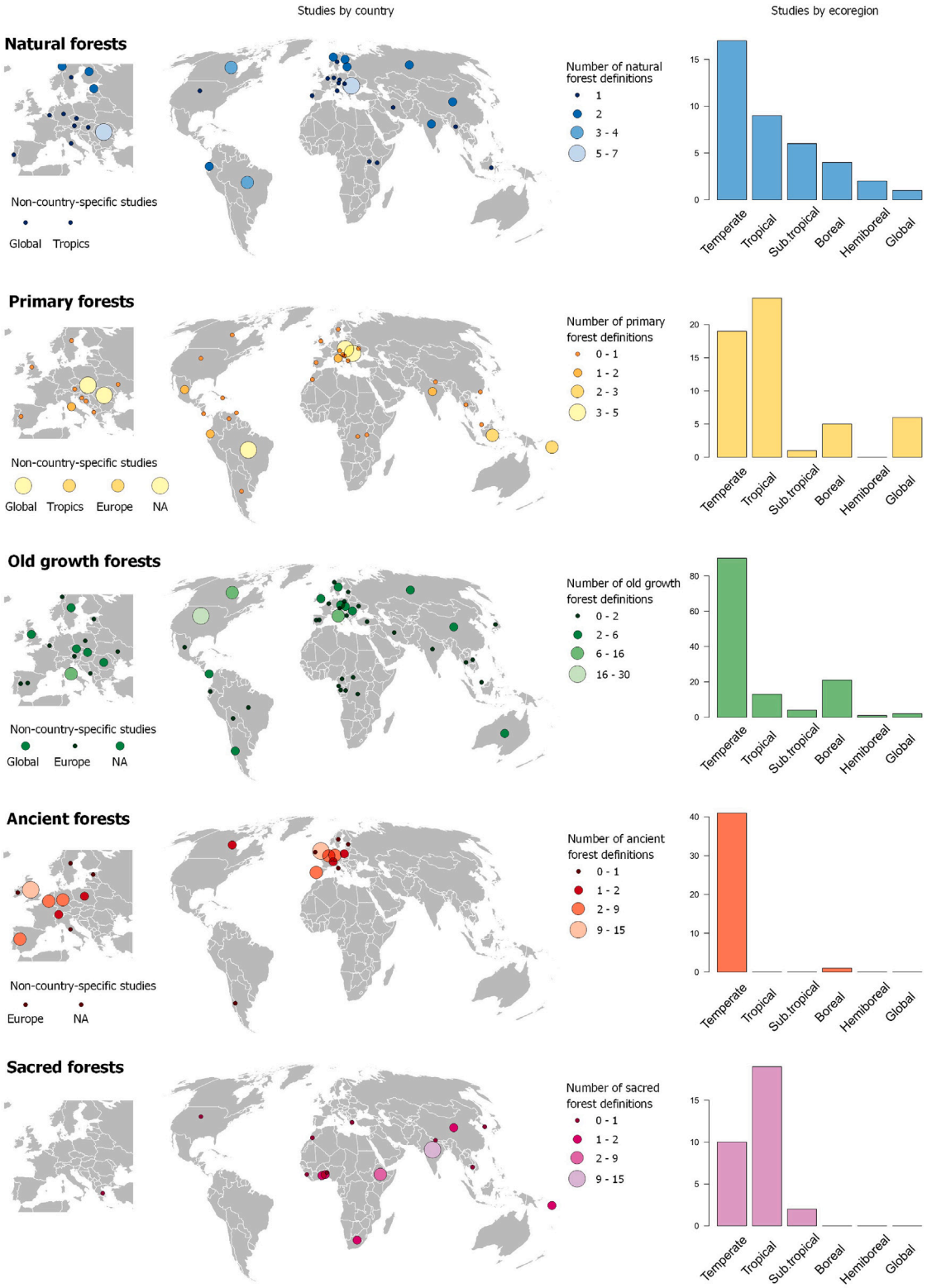


**Figure 4. Geographical distribution and ecoregional focus of studies on commonly defined terms associated with natural and near-natural forests**

The dots represent the number of studies conducted either by country or, if no specific country is mentioned, by region. Europe is shown in a separate panel for clarity. Bar plots on the right indicate numbers of studies by ecoregion for each forest type.

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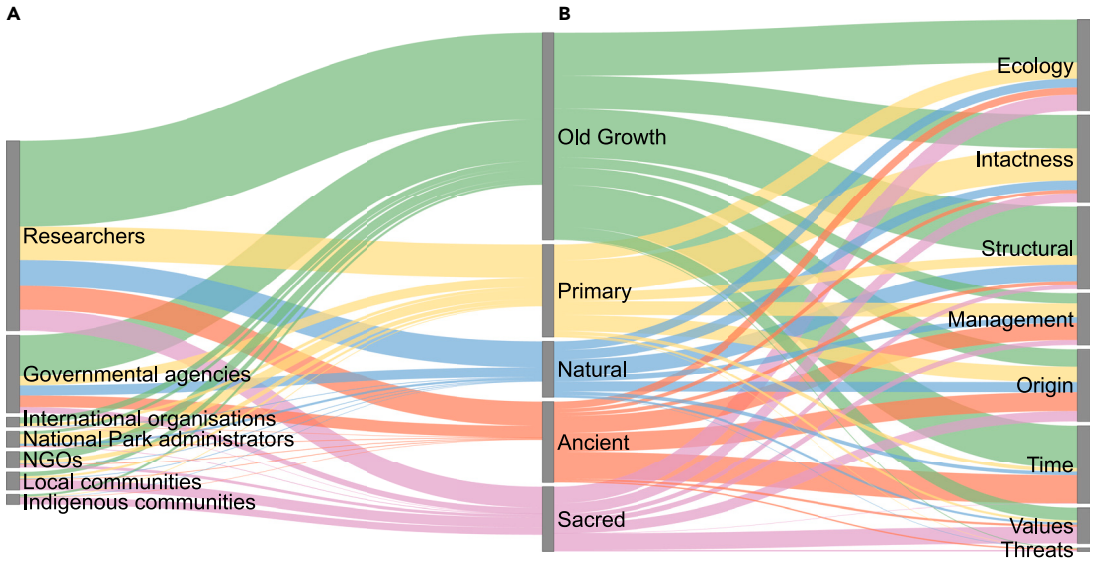


**Figure 5. Those involved in defining commonly defined natural and near-natural forest terms and characteristics of these terms**
(A) Different actors and (B) characteristics. The characteristics were defined as follows. Structural aspects: definition includes mention of structural characteristics, e.g., deadwood; origin: native species or Indigenous composition mentioned; time: length of time the forest has been in continuous existence; function/ecology: definition mentions ecosystem services or other ecological functions; values: forest is defined by its value, e.g., associated with high biodiversity or cultural value; intactness: forest is defined by the degree of the absence of human modification; management: forest management or anthropogenic use is mentioned in the definition; threats: threats are linked with the value of forest and its definition.

were defined purely by features from one category (Figures 5 and S2). Functional and structural aspects as well as intactness were the most often used features in the definitions overall, followed by time and origin. At the other end, threats were rarely mentioned apart from definitions linked with biodiversity hotspots. For example, South American temperate rainforests were defined as a biodiversity hotspot "because of their high percentage of endemic species, and the threats they face, including land conversion to pastures, agricultural fields and exotic tree plantations."[39]

Exploring the commonalities between the definitional terms reveals certain patterns. Natural and old-growth forests were most often characterized by structural aspects and ecological or functional aspects. For example: "Temperate old-growth forests are characterized by a high diversity of structures, and a high level of heterogeneity in the spatial arrangement of the individual structures. For example, old-growth forests typically incorporate a variety of sizes and conditions of live trees, snags, and logs on the forest floor, including some specimens that are old and/or large for the forest type and site under consideration."[40] Functional aspects and ecology were also prominent in definitions for biodiversity hotspots and when forests were defined by Indigenous people.

Intactness was a shared feature in definitions for several terms. It was the most occurring feature on definitions for primary, virgin, intact, primeval, undisturbed, and pristine forests as well as IFLs. For example, Borlea et al.[41] define virgin forest as "untouched forest; an area that has never been disturbed by human intervention, with natural structure and dynamics. The soil, climate, entire flora, fauna, and life process have not been disturbed or changed by logging, grazing and direct or indirect anthropogenic influences." Intactness also featured multiple times in definitions for natural, old-growth, and sacred forests.

Time, origin, and management were key features in definitions for ancient forests as illustrated by Davies et al.[42]: "The trees and shrubs in ancient woodlands may have been felled or cut for coppice at various times since 1600, but as long as the area has remained as woodland, i.e., the coppice stools have regrown or the stand has been replanted soon after felling, then it still counts as ancient woodland. Because it may have been cut over many times in the past, ancient woodland does not necessarily contain old trees." Time was also a key feature for old-growth forest definitions whereas origin and management (or lack thereof) were often mentioned in definitions for natural and primary forests.

Value-based definitions were rare apart from sacred and HCV forests as well as forests defined by Indigenous people. Willow[43] illustrates a common theme of how forest is an integral part of the Indigenous people's identity rather than something external to be defined by its attributes: "First Nations people see the forest as a source of subsistence from which their cultural identities and intergenerational histories cannot be disentangled." However, different values of forest were mentioned also when meaning of old-growth forests and some other forest types, including ancient, natural, and primary forest, was described. For example, McMullin and Wiersma[44] write "in the UK, there are forests designated as "ancient woodlands" that are valued as important ecological and cultural components of the landscape (Spencer and Kirby 1992). These forests are not characterized by the presence of large, stately, old trees per se but rather by the length of time that they have existed as woodlands (Spencer and Kirby 1992)."

The dominance of researchers and government agencies in the data and small number of definitions by other actors makes it difficult to compare definitions for different terms across different actors. However, we can emphasize some striking

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observations. Value and function-based definitions were more commonly used by Indigenous and local communities. For example, forest was defined based on the ecosystem services it provides: "Messages conveyed on an ongoing basis shape the knowledge of the people, who view that the forest is the source of life, if the forest is not properly maintained, then water will not be available. Such knowledge is established because the community strongly believes the messages conveyed by their ancestors from the ancient times who have always preserved their forests."[44] However, value-based definitions were not necessarily linked to conservation as noted by Booth and Skelton:[45] "Tl'azt'en First Nation people now view the forest as a financial resource that they can use, or that they can look at to provide for their family. So, it has changed some values, family values, or traditional values [Tl'azt'en community member]."

In contrast, researchers and government agencies preferred definitions based on attributes that can be measured either through remote sensing or in the field or where the threshold date is known, e.g., ancient forest. The same was true for international organizations. Definitions associated with a national park management entity were mainly about ecology and human influence, but two of them also included management aspects. NGOs were involved in definitions that had aspects from ecology to human influence and values as exemplified by HCV forest and IFL definitions. For example, as defined by WWF International,[46] "HCVFs are forests of outstanding and critical importance due to their high environmental, socio-economic, biodiversity or landscape values. HCVFs could therefore include, for example, slope forests in the European Alps protecting human settlements, the sacred burial grounds of a North American First Nation people, habitats of threatened orangutans in Southeast Asia, or large landscape forests in Siberia."

## Commonly cited definitions

When considering the definitions of the five most common terms (old-growth, primary, natural, ancient, and sacred forests) and those with a significant number of cited sources (HCV, biodiversity hotspots, and IFLs), there were certain prominent sources. Wirth was the most prominent author for defining old-growth forest with three different articles (book chapters) from the same book,[47–49] which had been cited 11 times (8.6%). Interestingly, one of the cited book chapters is an introduction to the book and another one is a review article, which does not provide a definition but rather discusses definitions found in the literature and gives an overview of common criteria found in publications for defining old-growth forests. Wirth et al.[48] explicitly state that their goal was not to provide yet another definition of old-growth forest. In addition, Franklin, Spies, and Lindenmayer were prominent names among authors defining old-growth forests appearing either in collaboration with each other or as authors for separate articles. These authors had 16 different articles cited between them in the pool of included articles. The UN FAO and the US Department of Agriculture were both cited four times as sources for definitions of old-growth forests.

While we found several different sources for definitions of primary forest, the only stand-out source was the UN FAO definition (13 citations). A primary forest is a "naturally regenerated forest of native tree species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed" (e.g., FAO[50]). Similarly, UN FAO was the only source cited more than once (four citations in total) for definitions of natural forest, although different authors cited different UN FAO publications. The definitions of natural forest attributed to the UN FAO stemmed from its primary forest definition.

Most of the cited definitions of ancient forest referred to Peterken's work (21 citations). Peterken has made the term "ancient woodland" (British term for ancient forest) widely known since the 1970s when he prepared the first list of ancient forest indicator species for identification of the most precious woodland areas in Britain. Peterken defined ancient woodlands as "all primary woodland, the lineal descendants of Britain's primeval woodland, whose wildlife communities, soils and sometimes structure have been least modified by human activities."[51] He proposed a threshold date to distinguish between primary and secondary woodlands: "The threshold itself can for convenience be placed about 1600, before which time secondary woods were rarely created by planting."[52]

Almost all of the definitions of IFLs found in the articles could be traced back to work by Potapov and colleagues, who define IFLs as "a seamless mosaic of forests and associated natural treeless ecosystems that exhibit no remotely detected signs of human activity or habitat fragmentation and are large enough to maintain all native biological diversity, including viable populations of wide-ranging species."[53] Similarly, Myers was a prominent source for biodiversity hotspots (7 citations out of 19 definitions) with his two key publications; the earlier conceptualized biodiversity hotspots as "areas rich in biodiversity, with a large number of endemic species and which have a high degree of environmental degradation,"[54] and the latter expanded the criteria to require that a "hotspot contains endemic plant species comprising at least 0.5% of all plant species world-wide."[55] Other prominent authors who defined biodiversity hotspots were Mittermeier et al. (four citations) and Brooks (three citations). Finally, definitions of HCV forests are mostly linked to the Forest Stewardship Council (FSC). This is not surprising, as the concept was adopted by FSC in 1998 and has since become a key part of its forest management certification standards. In contrast to the other common defining terms for natural and near-natural forests, sacred forests did not have prominent cited sources. Rather, several different sources were cited.

When we further analyzed the connectedness of the included articles through citation network and co-authorship, we found similar results. The citation network shows cross-citation and cross-referencing among the included articles but also many unconnected articles (Figures S3 and S4). Analysis of the co-authorship showed that 86 of the included articles share a co-author (Figures S5 and S6). Articles on IFLs by Potapov et al.[53,56] and Watson et al.[57] were at the core of both sets, with an article by Sabatini et al.[58] on primary forests forming the connection to the larger set of the citation network.

Finally, we looked at the geographical areas from which the definitions for the terms of natural and near-natural forests originated, based on the first author's institution. We focused on old-growth, primary, and natural forests (i.e., citations linked with UN FAO Forest Resources Assessment publications), IFLs, biodiversity hotspots, and ancient forests, as these terms had prominent sources that were cited often. We found that all the sources of

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definitions come from institutions based in the United States, United Kingdom, Germany, and Italy.

## DISCUSSION

We analyzed how different terms for natural and near-natural forests are defined in the literature, and if and how terminologies vary among different actors who use and shape them. In this section we elaborate on our findings, emphasizing the importance of expanding the scope of definitions to include the diverse perspectives held by various stakeholders. Efforts to expand the definition framework of forests can allow for a broader and comprehensive understanding of their socio-ecological importance for various global to local users, incorporating the multiple values and perspectives associated with them.

### Multitude of definitions requires shared understanding

Our results highlight the wide range of definitions and terminologies used to describe various natural and near-natural forests within the literature. We see that there are terms that are commonly used, such as old-growth and primary forests, whereas others, such as hinterland forest, are more marginal and have not become mainstream terms in scientific research.

Even where common definitions for terms exist, these are not necessarily universally applied. In some cases, this stems from place specificity where researchers want to capture the characteristics of a specific forest type in the definition. This is typical, for example, for old-growth forests where different types of old-growth forests, especially in North America, have their own definition linked with specific characteristics of the old-growth forest type in question.[48,59,60] This is because "old-growth conditions vary in detail among essentially all forest types in terms of their exact attributes, which is why type-specific definitions are necessary. However, old-growth conditions differ profoundly between moist westside forests, which are characterized by highly infrequent, stand replacement events, and dry eastside forests, which were characterized by frequent low-severity fire events."[59]

Similarly, in the case of sacred forests, researchers capture the place-specific cultural values in defining sacred forests. For the Abbo Wonsho community of Sidama in Ethiopia "sacred forests are likened to ancestors, embodying and enlivening the local custodian community's sense of identity and concretizing their spatial-temporal existence,"[61] whereas the Bunong, a focal group of Indigenous people who practice subsistence farming in Mondulkiri province of Cambodia, "truly believe that the forest belongs to the spirits, and that everyone should have access to it (…) Access to the resource—the forest—is obtained through sacrifices to the spirits."[62] Although applying the same definitions would be helpful when synthesizing research on those forest types, capturing the varying nature of forests defined under one term ensures that variability across or between forest types can be considered.

In addition to having multiple definitions for different terms of natural and near-natural forests, the terms are often used interchangeably. This is especially common for the forest terms "natural," primary," old-growth," and "virgin," which can create confusion if not clarified. Hence, more important than the number of definitions and meanings a term may have is the establishment of a shared understanding among individuals. For example, Jeanloz et al.[63] concluded after conducting research that "natural forests was understood by some as primary or original forests, whereas we meant forests with original tree species." Similarly, sacred forests are often seen as one of the oldest forms of conservation protecting remnant native forest patches (e.g., Allendorf et al.[64] and Prashanth Ballullaya et al.[65]). This is not always the case, as Zeng[66] notes: "With all the emphasis in conservation on preserving forest, what was remarkable in this case was that after a forest was destroyed, it could be resurrected and re-sacralized through community engagement." These examples show that making assumptions of others' understanding or basing one's own understanding on general assumptions can lead to misconceptions, which can bias research results and have implications on practical management and conservation decisions. Therefore, it is crucial to allocate time and resources toward establishing a shared understanding of the definitions and the on-ground realities when conducting research, and even more importantly when making decisions regarding management and conservation.

### Lack of Indigenous and local communities' voices

When we look at the overall picture, often-used definitions came solely from institutions based in Western high-income countries. Certain definitions exhibit patterns that align with the origin and applicability of the respective terms. For instance, the concept of an ancient forest is predominantly Eurocentric, as evidenced by the fact that the majority of studies utilizing this term were conducted in Europe. Its applicability is dependent on the availability of historical information, mainly in the form of land-use maps, as ancient forests are defined as "forests that have continuously existed for at least two centuries as forests, according to historical maps, historical site descriptions or other indications,"[67] with the date being as early as AD 1600 in some definitions. However, other terms are globally applicable even though they originated in Western countries. Intact forest landscapes and biodiversity hotspots are examples of such terms.

In our review, very few definitions for terms for different natural and near-natural forests came from studies where Indigenous and local communities were involved as actors defining a forest type. This can partly stem from the fact that we looked at terms of specific forest types, such as primary or natural forest, rather than definitions of forest in general; for example, some of the definitions, such as those for old-growth forest, have been developed specifically to identify forest types based on structural aspects. Yet far too often Western scientific knowledge is seen as objective and superior, leading it to be prioritized in decision and policy making. It also reflects historical perspectives in forest conservation and management, where local and Indigenous communities have been either ignored or seen as adversaries to the goal of conservation.[68,69] In her seminal paper "Whose conservation," Georgina Mace[69] identified four different framings of conservation starting from the 1960s: nature for itself, nature despite people, nature for people, and nature and people. In these framings we see conservation moving from complete exclusion of people toward a shared understanding and co-existence with nature. Despite a shift toward community-based approaches in the early 1990s, preservationist approaches for conservation (i.e., nature for itself, nature despite people) have

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continued to be upheld[69,70] and are enforced in terms such as virgin or pristine forest or wilderness.[71]

## Understanding intrinsic qualities and values of forests

Almost all terms for natural and near-natural forest types had varied definitions that captured multiple aspects. In contrast, there was a scarcity of descriptions classifying forest types based on the benefits they provide, such as the associated held and assigned values, in comparison to those focusing on measurable attributes. This is not surprising when considering the context, i.e., scientific knowledge being thought as objective and purely descriptive in nature. Hence, historically, definitions have been more technical in nature rather than capturing what a forest means intrinsically or for people living in or nearby it.[72–74] Introduction of the concept "ecosystem services" shifted the discourse toward recognition of the benefits forests and other ecosystems provide and the different values they have,[75,76] but a narrow set of values, mainly economic and utilitarian, continues to dominate policy-making approaches.[77,78] Although personal values of decision makers center on intrinsic values of nature, collectively there is a shift toward utilitarian valuation reflecting current practices in environmental and nature valuation approaches.[79] The rise of discourse on forests as carbon sinks is an example of the utilitarian valuation of forests at the expense of more intrinsic biodiversity values or values that a forest has for local and Indigenous communities.

Increased focus on values and value-driven approaches can lead to a further shift whereby socio-cultural, local, and Indigenous values beyond just utilitarian and economic are equally recognized both conceptually and in practice. This may have implications on how we define natural and near-natural forest types as illustrated by Yazzie[79]: "Indian forests are closely linked to the well-being of Indian communities,[80] and forest management must recognize the needs of the community along with other social and economic programs (…) However, given the distinctive differences in Indian tribes, and unique differences in forest management, tribal membership concerns, etc., old-growth characteristics are undefined, and should remain so in Indian country." Recognition of different values may also lead to reduced conflicts[81] and better outcomes for people and nature (e.g., Pereira et al.[82]), as exemplified by Peterken almost 40 years ago "Where traditional management continues or can be revived, ancient woods provide a living demonstration of conservation in the broader sense of a stable enduring relationship between people and nature."[51]

Even technical definitions based on measurable characteristics, such as intactness, can have a large element of subjective judgment. For example, what is considered significant degradation may vary from the perspective of the beholder, management objectives, and even timescales considered. This subjectivity leaves a definition such as "a forest that is free of significant anthropogenic degradation (which we term 'intact forest')"[57] open for interpretation, even though the authors give examples of human actions such as forest fragmentation, logging, and over-harvesting. As Davies et al.[83] illustrate, however, it is not just current but also historical socio-politico-physical disturbance that can have an impact. The authors contended that "anthropogenic disturbance is a ubiquitous feature of the forests of the Solomon Islands (Bayliss-Smith et al. 2003), as such no forest in this region can be considered "primary" in its truest sense. We therefore use intact forest to refer to the lowland, evergreen tropical rainforest (0–500 m a.s.l.) with—historical, but presently—limited human disturbance." Hence, intactness is not necessarily synonymous with naturalness even if some definitions give that impression. Even where a characteristic is defined in numerical terms, its meaning can vary between different definitions as exemplified by Bhagwat et al.[84]: "Our intact forest definition is stricter than FAO's closed forest, with a threshold of 80% compared to the FRA threshold of 40% canopy cover."

## Increasing the range of perspectives

Implementing a global concept locally without considering local and/or Indigenous culture and values is problematic. For example, Madagascar is considered a biodiversity hotspot because it has high biological diversity and endemism that is threatened by human activity. Following the launch of the biodiversity hotspots concept,[85] funding and interest from Western institutions in Madagascar increased.[86,87] When implementing conservation measures, there was a tendency to overlook the insights from knowledge which is deeply rooted in the close interdependence with nature. Instead, there was a prevailing inclination to impose a Western value system, often based on oversimplified assumptions.[88,89] It is not surprising that conservation efforts have faced challenges in Madagascar. While there has been some progress, the integration of cultural values, referring to ideas, customs, and social behavior within a society, into conservation design and practice remains incomplete.[87,90]

Considering that Indigenous people manage or have tenure for approximately a quarter of the world's land surface (~38 million $km^2$)[91] and protect 80% of global biodiversity, including 40% of the ecologically intact landscapes, inclusiveness of their views and values is overdue to be integrated when terms for different natural and near-natural forest types are defined. A recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services report on conceptualization of multiple values of nature and its benefits stated that "using a typology of the values of nature can provide guidance to decision makers on understanding and engaging with the diverse ways in which people relate to and value nature."[77] The same is true for definitions because they form the basis for forest policy, management, and conservation.[20] Inclusion of views and values of local and Indigenous communities in defining terms for different forest types acknowledges the role Indigenous and local knowledge plays in safeguarding biological and cultural diversity in many places[92] as well as the impact people have had on terrestrial ecosystems throughout history.[93,94]

The principle of equal respect for different knowledge systems, values, and rights extends beyond local and Indigenous communities, serving as a foundation for designing policies and projects that have equity at their heart. Recognitional equity emphasizes the importance of acknowledging and respecting diverse values, identities, and associated rights—here in relation to forests.[95,96] To ensure the inclusion of marginalized individuals in decision-making processes, especially in defining various forest types, it is also necessary to address both procedural and contextual aspects of equity.[97] Procedural equity entails equitable involvement of all stakeholders in the decision-making

process, ensuring their voices are heard and valued. Contextual equity considers the historical and present socio-economic and cultural constraints that may affect participation and influence decisions.

Designing and implementing effective dialogs between stakeholders is key for achieving equity in conservation and broadly in environmental management,[98] but too often current stakeholder engagement processes have not been inclusive and equitable or have failed to resolve conflicts around management and conservation.[99–101] New approaches to stakeholder engagements that are inclusive by design, which allow participants to experience perspectives of others and reveal inherent power structures and imbalances, have been proposed as a way forward to more equitable and effective environmental decision making.[102] Addressing these three dimensions of equity creates an opportunity to address the fourth dimension of equity at a later stage: distribution of benefits, costs, and responsibilities. The equity implications of policy and decision making about conservation and restoration, including those driven by large-scale priority mapping exercises, can be substantial,[103] and input from those most affected is sorely needed from the earliest stages of policy making to effective implementation to ensure successful outcomes.[104]

### Limitations of the study

Because we required certain terms to be found in abstracts, it is certain that we have missed some articles that contain definitions, but considering the time it takes to retrieve and read roughly 40,000 articles at full text, reading all articles was not an option given time and money constraints. However, we believe that the number of retained articles was large enough for our results to accurately reflect general trends for definitions of different terms for natural and near-natural forest types.

In our study, we searched information in English, French, and Spanish, categorizing terms related to natural and near-natural forests mainly into predefined categories. While our approach allowed us to create new categories such as "anchor forests" when necessary, it is important to acknowledge that this method excluded the vast majority of the world's languages. This limitation implies that we might have missed definitions and perspectives that do not align with our predefined categories. Languages are not merely tools of communication; they also encapsulate unique knowledge systems, world views, and cultural perspectives, significantly shaping values attached to local environments.[105] Our dataset primarily represents Western knowledge systems due to the dominance of English, French, and Spanish in academic literature. We recognize the missed opportunity to capture the richness of diverse knowledge systems, especially those held by Indigenous communities and speakers of non-dominant languages.[106] While our study aimed for inclusivity, it is essential to acknowledge that our approach remains somewhat normative by defining categories and mapping terms onto them. We recognize the boundaries of such approaches and the importance of including a broader range of languages to capture a more comprehensive and diverse set of perspectives.

## FUTURE DIRECTIONS

In this article, we have provided insights into the definitions and usage of terminology associated with natural and near-natural forests. These terms are used in research and practice to signal the importance of these forest types for biodiversity conservation and thereby to show where to prioritize conservation from global to local level and conjure images of what is lost if action is not taken. Sacred forests are an exception, as the term is used to describe forest areas that have been maintained over time through cultural practices. However, discursive uses of such terms to signal conservation importance are useful, although this comes with limitations. As the terms are mostly based on qualitative biophysical characteristics rather than ecological and societal values, they capture an abstract meaning of the forest rather than what and why the forest is valued for, especially by local and Indigenous communities. This, as we argued, does not foster social equity and inclusion.

To improve their practices and maximize positive outcomes for biodiversity and affected groups, researchers should consider three key fundamental aspects: sensitivity to context, representation of diverse voices, and the management of power dynamics.[107] First, fostering sensitivity to context is crucial. This involves recognizing the unique socio-cultural, economic, and ecological circumstances in which research takes place. It requires researchers to understand and respect local and Indigenous knowledge systems, community values, and the specific needs and aspirations of the affected groups. Furthermore, conservation scientists from Western countries should strive for true collaboration and community-engaged processes when working in landscapes dominated by specific various local and Indigenous socio-cultural realities that need nuanced approaches and attentions, as opposed to projecting their perspective onto these landscapes and contexts, often through the limited and detached approach often referred to as "helicopter research."[108,109]

Second, representation of diverse voices is essential for inclusive research practices. Researchers must strive to involve and empower individuals from marginalized communities, ensuring their perspectives and knowledge are incorporated in decision-making processes. This approach recognizes the relationship between cultural heritage and custodial communities, emphasizing the need to respect and uphold their rights.[110] Embracing social learning and knowledge co-creation is vital. Instead of a one-way street of knowledge dissemination, researchers should engage in multi-way knowledge exchange, where diverse stakeholders actively contribute and co-construct knowledge.[111,112]

Lastly, researchers should recognize the power they have in shaping discourses around conservation science and practice.[113] They need to be mindful of the implications that arise when using definitions solely based on environmental characteristics, especially when these have implications on the rights of local and Indigenous communities.[14,104] Biodiversity hotspots identification processes exemplify how research can drive subsequent action but also the pitfalls of one-sided thinking. There is a growing recognition of the need to shift the focus in conservation and ecology from global priority maps that are devoid of local considerations. By centering knowledge co-construction processes and amplifying local and Indigenous voices while engaging with unavoidable power challenges,[114,115] researchers can increase understanding and considerations of specific socio-political contexts, challenges, and opportunities in conservation prioritization decisions.[116] Such an approach holds

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promise to promote inclusiveness and ensures that research findings are more relevant and applicable to real-world conservation efforts.

Overall, researchers should strive for clarity in the definitions of the terms they employ to shape forest conservation and ensure shared understanding of these definitions among all relevant stakeholders. It is advisable to utilize existing definitions of terms when appropriate while remaining cognizant of the limitations associated with them. We recommend adopting inter-disciplinary approaches for future research, recognizing that incorporating social science perspectives and embracing value-based definitions would facilitate more robust research outcomes and inform evidence-based practices that align with the needs and aspirations of all stakeholders involved.

Finally, the challenge with forests lies in striking a just balance between biodiversity conservation, climate change, and livelihood preservation. This calls for concerted efforts to address the inherent complexities. By adopting a broader range of terminologies that are widely shared and better suited to promote social equity and inclusion, policy makers can more effectively address the complexity and interdependence of ecological, social, and cultural values associated with forests. Doing so can enable the diverse array of voices to shape the future of forest management and conservation in a more sustainable way.

## EXPERIMENTAL PROCEDURES

### Resource availability

#### *Lead contact*

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#### *Materials availability*

No new materials were generated by this study.

#### *Data and code availability*

All data have been deposited at the Open Science Framework under doi.org/10.17605/OSF.IO/YRJKF and are publicly available as of the date of publication.

### Deviations from the protocol

We made the following deviations from our published protocol.[30] When we conducted the search in the Scopus database we divided the search string into two segments for years 2017–2021. Each year had more than 2,000 articles and as there was a limit on how many articles could be exported at once, the division was a necessity. We used the following search strings.

(1) "TITLE-ABS-KEY (( forest* OR woodland*) AND ("High Conservation Value" OR "Biodiversity hotspot*" OR "Threatened Ecosystem*" OR "Key Biodiversity Area*" OR "Critical habitat*" OR ( ( indigenous OR native OR "first nation" OR aboriginal OR autochthonous) AND (tribe OR tribal OR community OR communal OR communities OR people) )) ) AND PUBYEAR = XXX"

AND

(2) "TITLE-ABS-KEY (( ( "Stable forest" OR "Stable woodland" OR "Primary Forest*" OR "Primary Woodland*" OR "Ancient Forest*" OR "Ancient Woodland*" OR "Intact Forest Landscape*" OR "Old-Growth Forest*" OR "Old-growth Woodland*" OR "Endangered Forest*" OR "Endangered Woodland*" OR "hinterland forest*" OR "hinterland woodland*" OR "intact forest*" OR "intact woodland*" OR "pristine forest*" OR "pristine woodland*" OR "natural forest*" OR "natural woodland*" OR "undisturbed forest*" OR "undisturbed woodland*" OR "native forest*" OR "native woodland*" OR "sacred forest*" OR "sacred woodland*") )) AND PUBYEAR = XXX"

Another deviation from the protocol occurred in the abstract screening stage. We achieved a 95% screener agreement after two rounds of screening 100 articles independently and comparing the results between the screeners. However, after screening several thousands of studies and discussing many cases where the screener was unsure, we concluded that there was still too much arbitrariness in the inclusion/exclusion decisions. Hence, the screening criteria were modified. The modified criteria are outlined in the "article screening and study eligibility criteria" section.

Final deviation of the protocol is that contrary to what we outlined in the protocol, we did not trace articles that were cited as sources of definitions. Instead, we marked definitions based on cited articles as cited definitions and included them in the systematic map if they fulfilled the criteria for a definition. In these cases, articles published before 2005 were accepted as sources of definition.

### Search for articles

#### *Bibliographic searches*

The searches were conducted in English, Spanish, and French. We conducted searches in Web of Science Core Collection (WoS), Scopus, and CABI Forest Science Database (July 30 to September 2, 2021). WoS was searched using the institutional subscription of the University of Helsinki. Scopus was searched using the institutional subscription of the ETH Zürich. CABI Forest Science Database was searched using a University of Helsinki's guest access given to the first author of this paper. We used the same search string for the CABI Forest Science Database as for the WoS (Table S2). The search was limited to the "management" section of the database to increase relevance of the search results. We set search alerts for both WoS and Scopus, and new articles from the searches were included for screening until December 31, 2021 when the search alerts were discontinued.

#### *Other searches*

We conducted internet searches in English between December 17, 2021 and January 28, 2022 and in French and in Spanish between July 21, 2022 and August 10, 2022 using Google search engine. We used "private" mode to conduct the Google searches to prevent the influence of previous browsing history and location on search results. We conducted the search with no limitations other than excluding citations and patents. We searched organizational websites between May 24 and 25, 2022. When searching articles in the organizational websites, we used the publication section of the website if the organization had one. If it did not, we used the "search" function of the front page. We modified the search strings based on the capability of the search interface provided on the website. We looked through the publication section if the website did not have a search interface.

We searched the SilvaTerm Database for definitions of the terms included in the systematic mapping. The SilvaTerm Database is a terminological database for forestry built by SilvaVoc, a project on forest terminology by the IUFRO. We also examined how Russia, Canada, Gabon, the Democratic Republic of Congo, and Brazil define natural and near-natural forests in their legislation. We focus on these countries because of their substantial forest areas, especially their intact forest landscapes. (Intact forest landscapes are "a seamless mosaic of forests and associated natural treeless ecosystems that exhibit no remotely detected signs of human activity or habitat fragmentation and are large enough to maintain all native biological diversity, including viable populations of wide-ranging species."[53]). We provide full details of the searches in the supplemental information.

#### *Duplicate removal*

All references from the academic databases were imported into the EPPI-Reviewer, and duplicates were removed. After initial verification, duplicates were automatically marked and removed. The threshold for similarity was set at 0.85, i.e., 85% similarity between the items. After the first round of automatic duplicate removal, 20 groups of the remaining suggested duplicates were checked. Based on the check, the threshold for automatic duplicate removal was further increased to 90% of similarity for the remaining groups. The groups that remained after the 90% similarity threshold were manually checked to avoid false positives.

### Article screening and study eligibility criteria

We screened articles in two stages: first title and abstract and then full text. Before screening started, authors involved in screening screened 100 articles independently. Once done, we compared the results and discussed discrepancies we had in our screening decisions. During our discussions, our perceptions and implementation of the screening criteria became clearer. As the 5% threshold for acceptable discrepancies was not met after the first 100 articles, a second set was independently screened. The process was repeated once more before the threshold was met. After the third set, we had less than 5% divergence in our inclusion/exclusion decisions and felt that we could confidently proceed with the screening. To be included into the full-text stage, an article needed to fulfill the following criteria.

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**Table 1. Variables recorded during data extraction and different categories used to characterize definitions**

| Variables recorded during data extraction | Categories used to characterize the definitions |
|---|---|
| Forest type defined | Structural aspects: definition includes mention of structural characteristics, e.g., deadwood |
| Study biome (boreal, hemiboreal, temperate, subtropical, tropical, global; not available was recorded for studies that did not take place in a specified geographical location) | Origin: native species or Indigenous composition mentioned |
| Study country | Time: length of time the forest has been in continuous existence |
| Stakeholders involved in the study | Function/ecology: definition mentions ecosystem services or other ecological functions |
| Year of the definition | Values: forest is defined by its value, e.g., associated with high biodiversity or cultural value |
| Source of the definition (i.e., author[s] of the article) | Intactness: forest is defined by the degree of the absence of human modification |
| Type of definition (original or cited; cited used for definitions that cite another article) | Management: forest management or anthropogenic use is mentioned in the definition |
| By whom the definition is (academia, international organization, government department, non-governmental organization, Indigenous people, local people, and company) | Threats: threats are linked with the value of forest and its definition |
| Definition (any text that formed intentional definition) | |

- Article is within the realms of forest policy, management, and conservation
- It has policy or management implications
- It is published in or after the year 2005

We excluded articles that were:

- Not on forests
- Exclusively on secondary forests or plantations
- Review articles without novel contributions (e.g., a review that would propose a new definition based on literature would be included)

After screening several thousand articles, the screening team concluded that the inclusion criteria were too ambiguous. Hence, they amended the inclusion criteria so that an article needed to have one of the following words in the title or abstract to proceed to the full-text screening stage: "consider," "define," "meaning," "delineate," "describe," "explain," "characterize," "conceptualize," "signify," and "refer to." After operating such an adjustment, screener alignment was ensured by screening 50 articles jointly. In addition, the first author checked screening decisions of other screeners for a further 50 articles. There was 100% screener agreement on the double-screened 50 articles and, hence, the team was confident to proceed with the screening. During the screening process, any articles that did not contain the designated words but potentially contained a definition were marked. A subset of 100 articles from this group was later checked to triangulate potential bias of excluding useful articles.

At the full-text screening stage, we included articles if they contained an intentional definition of a term for natural or near-natural forest. Following Cook,[117] intentional definition is a definition which specifies the necessary and sufficient conditions for something (which for us means segments describing forests) to be a member of a set (in our case a forest definition). Our necessary conditions were descriptors of forests. Hence, articles were included if they had:

- Definitions built on typical characteristics and functions
- Definitions based on age (e.g., ancient forests)
- Explicit forest values (e.g., definitions based on values held by Indigenous people)
- Further classifications (e.g., into different subtypes of primary forest)

The following criteria were used for excluding articles.

- Definition is built on a comparison between two specific forests and not generalizable for all forests within a category, e.g., "primary forest in the area contains taller trees than secondary forest in the area"
- Specifics of the definition focus on a specific forest attribute that can vary between different forests within a category (e.g., "XX $m^3$ deadwood")
- Unclear forest type
- Changes in extent (e.g., area loss of certain forest types)

We discussed all uncertain cases and made a joint decision on inclusion/exclusion after the discussion. One screened article was written by one of the co-authors of this paper; therefore, the inclusion of that article was decided by other authors in accordance with the criteria.

### Study validity assessment

We did not assess study validity of the included studies, as the purpose of this study is to give an overview of the existing definitions.

### Data coding and extraction strategy

We conducted data coding and extraction in the EPPI-Reviewer. In addition to metadata (author, year, title, journal) that is automatically extracted in the EPPI-Reviewer, we recorded different variables to answer the research questions (Table 1).

Two of the co-authors (N.L. and S.S.) conducted data coding and extraction. To ensure a shared understanding of what is meant by an intentional definition in this study, they extracted data together from ten studies. Furthermore, the pair had multiple discussions on the course of data extraction to clarify cases where they felt unsure in deciding whether something is a definition or not. Once all the definitions were extracted, they were exported into an Excel file for further processing and analysis.

### Data analysis and synthesis

We produced a narrative synthesis of data from all the included studies and describe the evidence base in figures. We used the ROSES Flow Chart ShinyApp[32] to create Figure 1 to report article inclusion/exclusion at the different stages of the systematic mapping process. To study how common various definitions are, we counted the incidence rate for different articles and authors for the most common forest types (old-growth, primary, ancient, sacred, and natural forests) and those with a significant number of cited sources (HCV, biodiversity hotspots, and IFLs). We also used citationchaser[118] and VosViewer[119] to conduct network analysis of the included articles. We used citationchaser to visualize the whole network based on the included articles, their references, and articles that have cited them. VosViewer was used to visualize connections between the included articles based on co-authorship. We used QGIS to create maps highlighting the number of studies by country in which a study that contained a definition of the most common forest types had taken place.

To look at how terms linked with natural or near-natural forests are described in the literature, we characterized them based on eight different categories (Table 1). We presented the preliminary results of this work at the European Conference of Tropical Ecology in Montpellier in June 2022. Feedback received included a suggestion to add a further category "threats" into the

classification of the definitions. We integrated the suggestion into the synthesis. A definition could have characteristics from more than one category.

## SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.oneear.2023.10.003.

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## AUTHOR CONTRIBUTIONS

Conceptualization, C.A.G., P.O.W., S.S., and N.L.; methodology, S.S. and N.L.; article screening, N.L., O.H., A.I., S.S., F.K., I.N.S.D., P.O.W., and N.B.-L.; data coding and extraction, N.L. and S.S.; formal analysis, S.S. and N.L.; writing – original draft, S.S. and N.L.; writing – review & editing, F.K., I.N.S.D., P.O.W., N.B.-L., O.H., A.I., and C.A.G.; visualization, F.K., S.S., and N.B.-L.; supervision, S.S.; project administration, P.O.W., C.A.G., and S.S.; funding acquisition, C.A.G. and P.O.W. All authors have read and agreed to the published version of the manuscript.

## DECLARATION OF INTERESTS

The authors declare no competing interests.

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