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ANALYSIS

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A spatial overview of the global importance of Indigenous lands for conservation

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Understanding the scale, location and nature conservation values of the lands over which Indigenous Peoples exercise traditional rights is central to implementation of several global conservation and climate agreements. However, spatial information on Indigenous lands has never been aggregated globally. Here, using publicly available geospatial resources, we show that Indigenous Peoples manage or have tenure rights over at least ~38 million km² in 87 countries or politically distinct areas on all inhabited continents. This represents over a quarter of the world's land surface, and intersects about 40% of all terrestrial protected areas and ecologically intact landscapes (for example, boreal and tropical primary forests, savannas and marshes). Our results add to growing evidence that recognizing Indigenous Peoples' rights to land, benefit sharing and institutions is essential to meeting local and global conservation goals. The geospatial analysis presented here indicates that collaborative partnerships involving conservation practitioners, Indigenous Peoples and governments would yield significant benefits for conservation of ecologically valuable landscapes, ecosystems and genes for future generations.

There are at least 370 million people who define themselves as Indigenous[1], are descended from populations who inhabited a country before the time of conquest or colonization and who retain at least some of their own social, economic, cultural and political institutions[2]. Irrespective of their global diversity, Indigenous Peoples (Supplementary Information section 1) often express deep spiritual and cultural ties to their land and contend that local ecosystems reflect millennia of their stewardship, with Indigenous Peoples' lands representing one of the oldest forms of conservation units[3,4]. Moreover, they assert that Indigenous rights do not require state-sanctioned approval to exist[5]. While Indigenous Peoples' land rights are acknowledged and implemented to varying degrees across time and geography, even when refused or ignored, Indigenous Peoples frequently retain de facto influence over their ancestral lands. This is often regardless of state-imposed tenure[6] and/or the pressures and conflicts that surround them. Important efforts exist nationally, regionally and globally to recognize and map Indigenous lands[7]. Yet, global maps of Indigenous Peoples' land occupation or management are often contentious because they tend to rely on state-sanctioned data that can be deployed to disenfranchise Indigenous Peoples[8]. The dearth of reliable data on Indigenous Peoples' lands in many parts of the world has implications not only for securing their rights but also for the conservation and management of a significant proportion of terrestrial global biodiversity[4,9,10].

Increasingly sophisticated spatial tools are being developed to determine national responsibilities towards global environmental targets[11]. Yet, there is currently no comprehensive global assessment of the extent to which Indigenous Peoples' stewardship and global conservation values intersect. Existing datasets such as LandMark suggest that overlap is substantial[12]. In this paper, we provide a first estimation of the overlap between Indigenous Peoples' terrestrial lands and protected areas[13], human anthropogenic biomes (anthromes)[14] and the degree that humans influence these lands (for which we use the updated global Human Footprint[15]). These analyses allow us to understand the extent to which Indigenous Peoples are involved in managing areas of high conservation value (see Methods). Our results will contribute to global policy recognition of the conservation attributes of Indigenous Peoples' lands, including the Strategic Plan for Biodiversity 2011–2020[16] and its successor, the UN Sustainable Development Goals[17,18] and to the fulfilment of the aspirations of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[19].

Extent and conservation importance of Indigenous lands

We first created a global map of terrestrial lands managed or owned by Indigenous Peoples throughout the world (Fig. 1). This dataset is based on information compiled in 127 data sources, including cadastral records for state-recognized Indigenous Peoples' lands, publicly accessible participatory mapping, models based on census

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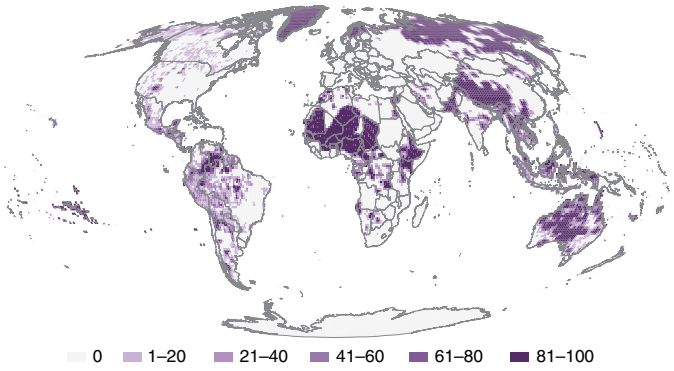

Fig. 1 | Global map of lands managed and/or controlled by Indigenous Peoples (percentage of each degree square mapped as Indigenous in at least one of 127 source documents; Supplementary Information section 2). Blank areas do not necessarily indicate an absence of Indigenous Peoples or their lands, but rather areas for which an Indigenous connection cannot be inferred based on publicly available geospatial data. Note that the equal area Mollweide projection adopted gives appropriate weight to tropical regions where most Indigenous Peoples have land but at the expense of accuracy in shape, which can make it difficult to determine Indigenous lands in some countries on the margins of the map, such as New Zealand (see Supplementary Information section 3).

data and maps derived from scholarly publications. We identified Indigenous Peoples' lands in 87 of 235 countries or administratively independent entities, excluding Antarctica and uninhabited islands in the Southern Ocean (Supplementary Information section 2). This encompassed areas where Indigenous Peoples' land tenure is officially recognized and where, according to our data sources, Indigenous Peoples retain a substantial de facto influence on land management. We define land management here as the process of determining the use, development and care of land resources in a manner that fulfils material and non-material cultural needs, including livelihood activities such as hunting, fishing, gathering, resource harvesting, pastoralism and small scale agriculture and horticulture.

Our results show that Indigenous Peoples have rights to and/or manage at least 37.9 million km^2 of land in nearly all mainland countries in the Americas, around the Arctic, throughout most of the forested lands of south and Southeast Asia, across Africa particularly in rangelands and deserts but also forests, and throughout countries in Oceania, including many small island nations (Fig. 1, Supplementary Information sections 3 and 4). The proportion of countries with Indigenous Peoples is highest in Africa and lowest in Europe-Central Asia (Supplementary Information sections 5 and 6). In total, Indigenous Peoples influence land management across at least 28.1% of the land area.

About 7.8 million km^2 (20.7%) of Indigenous Peoples' lands are within protected areas, encompassing at least 40% of the global protected area (Fig. 2, Supplementary Information section 5) with the proportion of Indigenous land in protected areas significantly higher than the proportion of other lands that are protected (Fig. 3, Supplementary Information section 6). The relationship between Indigenous Peoples and conserved areas varies in nature. While some protected areas (as defined by states and/or the International Union for Conservation of Nature (IUCN)) are under the governance of Indigenous Peoples themselves, others are governed by state authorities with varying degrees of respect for the presence of Indigenous Peoples. This respect ranges from collaborative governance where Indigenous Peoples are consulted on decisions, to de facto management and use of protected areas by Indigenous Peoples despite threats of eviction. Our data do not provide information on either the legal relationship or the nature of the use made of protected areas by Indigenous Peoples. It does indicate, however, that the scale of spatial overlap positions Indigenous Peoples as important global actors in protected area management. The contributions of some Indigenous Peoples to national protected area coverage have sometimes been provided with free, prior and informed consent, as is the case with Indigenous Protected Areas that make up 45% of the protected area network in Australia[20]. In many regions, however, protected areas have been imposed over Indigenous Peoples' lands without consent, sometimes leading to conflict, social disadvantage and displacement[21].

Around half of the global terrestrial environment can be classified as human-dominated[22]. Using this as a measure of human influence, we estimated that Indigenous Peoples' lands account for 37% of all remaining natural[23] lands across the Earth (Fig. 2, Supplementary Information section 3). A higher proportion (67%) of Indigenous Peoples' lands was classified as natural compared with 44% of other lands (Fig. 3, Supplementary Information sections 3 and 6). Even though no global data are available on other anthropogenic pressures such as grazing, burning, hunting or fishing, the drivers assessed by the Human Footprint (which range from roads, access, population density and different agricultural land use activity) are suitable surrogates[15]. Consistent with this, most parts of the planet managed and/or owned by Indigenous Peoples have low-intensity land uses: less than 3.8 million km^2 (10.2%) of the world's urban areas, villages and non-remote croplands are on Indigenous Peoples' lands, whereas, in contrast, they encompass 24.9 million km^2 (65.7%) of the remotest and least inhabited anthromes (Fig. 2, Fig. 4, Supplementary Information section 4). Many of these remote Indigenous areas are nevertheless under pressure from intensive development[24].

Indigenous impacts on land management

The striking feature of our analysis is that although Indigenous Peoples' represent <5% of the global population[1], they currently manage or have rights over many of the world's most sparsely populated, intact places. Countless Indigenous management institutions have already proven to be remarkably persistent and resilient, suggesting that such governance forms can shape sustainable human-landscape relationships in many places[25–27]. This means that, even for localities where Indigenous Peoples are still in the process of regaining land rights, the maintenance of the conservation values of a significant share of the planet depend on the institutions and actions of Indigenous Peoples[28]. This analysis similarly highlights the pressing need to understand the interactions between Indigenous and environmental considerations as an essential back drop when negotiating local or global conservation agreements on and off Indigenous lands[29,30]. Nonetheless, Indigenous–conservation alliances should not assume that all Indigenous Peoples have a strong desire or willingness to maintain the natural environment in its current state[31]. This is because Indigenous Peoples have a wide range of legitimate political, cultural and economic aspirations for their lands and, as a result, conservation priorities and regulations often differ or even clash with Indigenous management[32].

There is also the need to consider any implied expectation of asking Indigenous Peoples to take on the burden of our global conservation challenges without providing them with adequate resources and support. Conservation policies that aim to protect wilderness on Indigenous lands need to ensure that these policies not only deliver biodiversity returns but receive strong local support and align with Indigenous Peoples' motivations, governance and capacities. This reinforces the importance of 'bottom-up' approaches to conservation investment and policy design, particularly given the limited success of 'top-down' Indigenous–conservation agreements to date[3,33]. There is a wide array of innovative approaches and tools to facilitate discussion of collaboration,

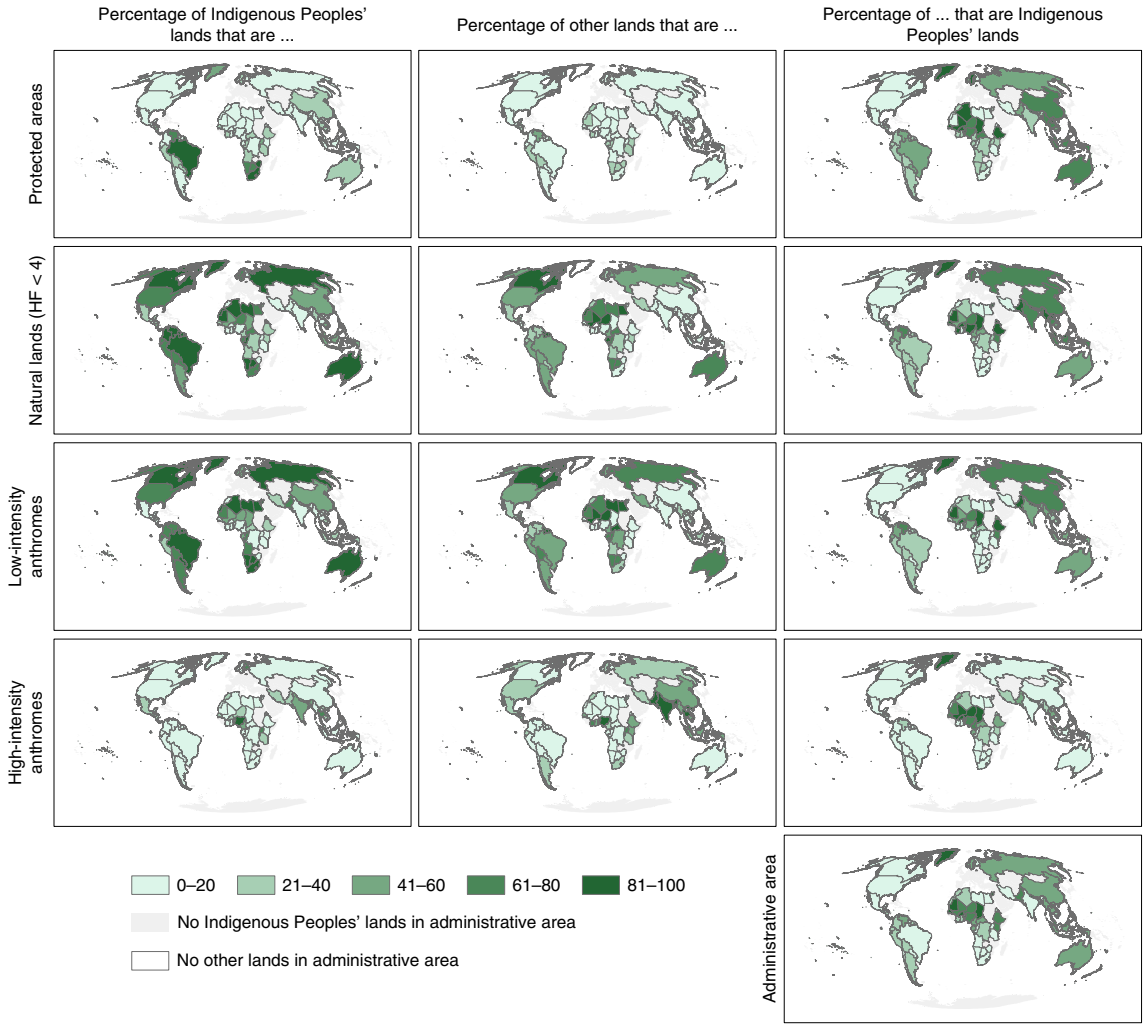

Fig. 2 | Spatial comparison of Indigenous Peoples' and other lands. National percentages of Indigenous Peoples' and other lands in protected areas[13], with a Human Footprint score < 4 (ref. [22]) and in low- and high-intensity anthromes[14], as well as the percentage of each land type that is mapped as either Indigenous Peoples' or other.

co-management and power-sharing around conservation initiatives, for reasons of social justice and more inclusive environmental governance. These include sets of Indigenous-led codes of ethical conduct in conservation (for example, Akwe: Kon Guidelines and The Tkarihwaié:ri Code of Ethical Conduct[34,35]) and tools for dialogue such as the Whakatane mechanism[36], providing a collaborative framework that can ensure the full and effective involvement of Indigenous Peoples in conservation, while respecting their rights and institutions. The use of these policy support tools is particularly relevant for defining and negotiating resource sharing rights in different conservation contexts.

More importantly, the emphasis should be to recognize and support the contributions that Indigenous Peoples and local communities make to the conservation of biodiversity in the most appropriate way, not necessarily through protected areas. Some may be by the designation of protected areas after due process (including free, prior and informed consent) but it may also be through the recognition of 'other effective area-based conservation measures' (OECMs) such as proposed under the Aichi Biodiversity Target 11 of the Convention on Biological Diversity (CBD)[37] or simply by working to support ongoing activities outside of any formal recognition or reporting requirements. Indigenous Peoples' lands are expected to constitute a substantial subset of the world's OECMs, in cases where conservation is not necessarily the primary objective but is nevertheless an outcome[38].

Indeed Indigenous Peoples often manage their lands in ways that are compatible with, and often actively support, biodiversity conservation[4]. They can co-produce, sustain and protect genetic, species and ecosystem diversity all over the world by 'accompanying' natural processes, for example creating cultural landscapes with high habitat heterogeneity[39] and developing and restoring ecosystems with novel species combinations of wild and domesticated species[40]. Furthermore, Indigenous-led approaches have highlighted innovative ways to design conservation reserves, environmental policy instruments, wildlife monitoring and management programmes[41–43]. Approaches that take into account Indigenous Peoples' unique ties with nature and their extensive Indigenous Knowledge are providing pathways that re-evaluate existing conservation frameworks[44]. As such, this will open up myriad opportunities for partnerships between conservation practitioners and Indigenous Peoples to create mutual benefits[37,45].

Need for Indigenous Peoples' voices in land use decisions

We acknowledge that any global assessment of Indigenous Peoples' lands is potentially contentious (see Supplementary Information section 7). Official definitions of Indigenous Peoples are often contested, as are legally sanctioned boundaries that delimit Indigenous Peoples' territories. Nonetheless, OECMs are likely to increase in extent as overlaps between conservation areas and Indigenous

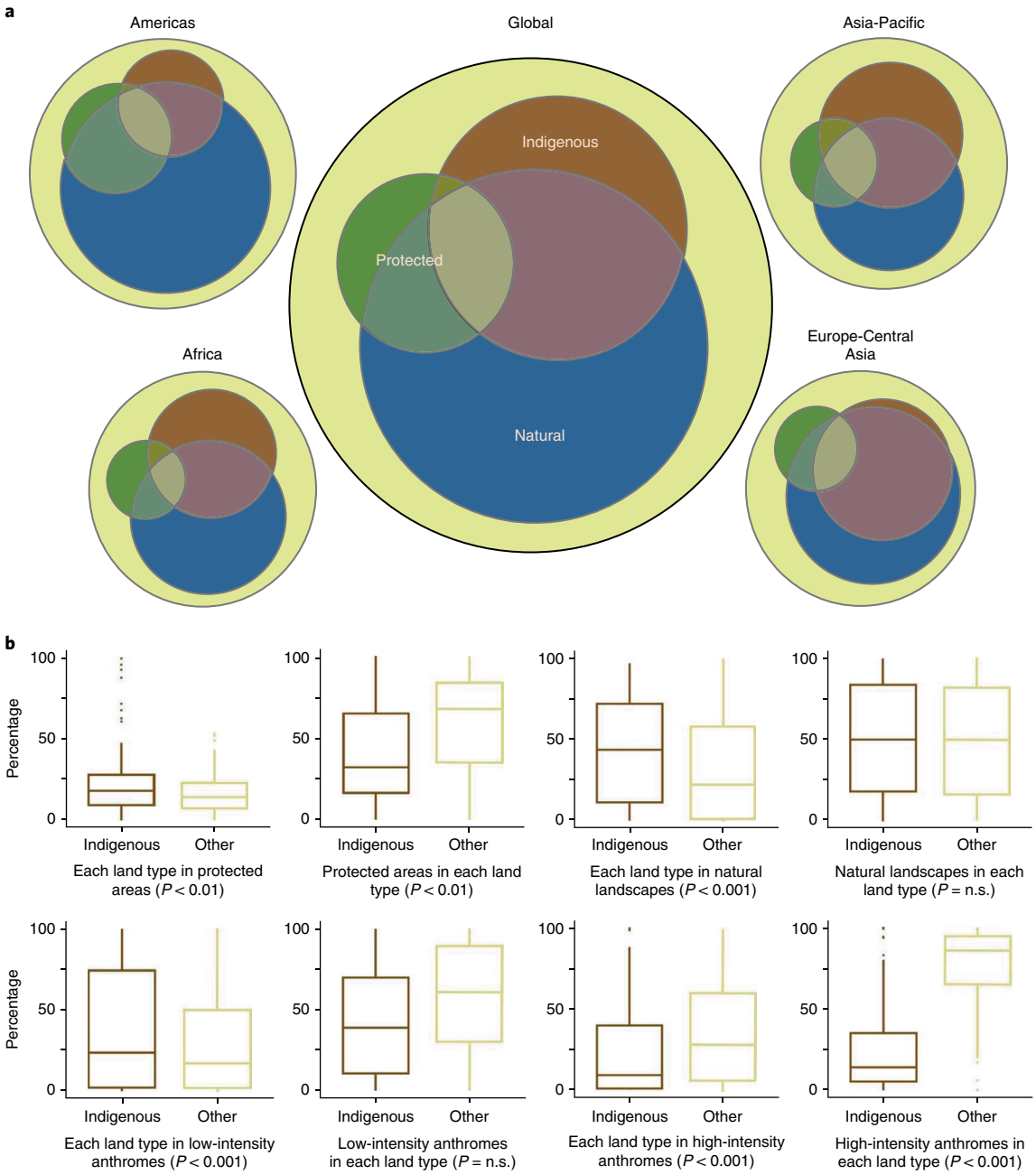

Fig. 3 | Regional variation in the conservation values of Indigenous Peoples' and other lands. a, Intersections among Indigenous lands, protected areas and natural landscapes globally and for each IPBES region. Circles and intersections are all proportional to area with the largest circle scaled to the land area of the Earth (135.2 million km^2 excluding Antarctica). **b,** Comparisons between Indigenous Peoples' lands and other lands for protected areas, natural areas (Human Footprint score < 4), low-intensity anthropogenic biomes (anthromes) and high-intensity anthromes. Significance assessed with Mann–Whitney Wilcoxon test for countries with land in both categories ($n = 84$); the box contains 50% records, the bar represents the median percentage. See Supplementary Information section 6.

Peoples' lands and interests are progressively identified. This will mean that we move further towards achieving some elements of the Aichi Biodiversity Target 11 than is currently being reported; yet, the contributions of Indigenous Peoples to the management and monitoring of protected areas are rarely recognized in official statistics[10].

We are also aware that self-identification as 'Indigenous' may not be plausible in some countries and that Indigenous Peoples' rights and land management practices vary greatly in extent, scope and influence[46]. Nonetheless, Indigenous Peoples increasingly choose to engage in global forums and debates about the state and future of the planet's environment, including through participation in global policy-related processes such as IPBES and the CBD. This has led to the participation of representatives of Indigenous Peoples in IPBES assessments, and will lead to the active engagement of representatives of Indigenous Peoples in development of the post-2020 global biodiversity framework that will replace the *Strategic Plan for Biodiversity 2011–2020* when it comes to an end. These efforts need to sit alongside local, context-specific and Indigenous-led agreements on how the conservation of our planet's ecosystems can safeguard Indigenous Peoples' rights and futures[28], and vice versa. There is already good evidence that recognition of the practices, institutions and rights of Indigenous Peoples in global environmental

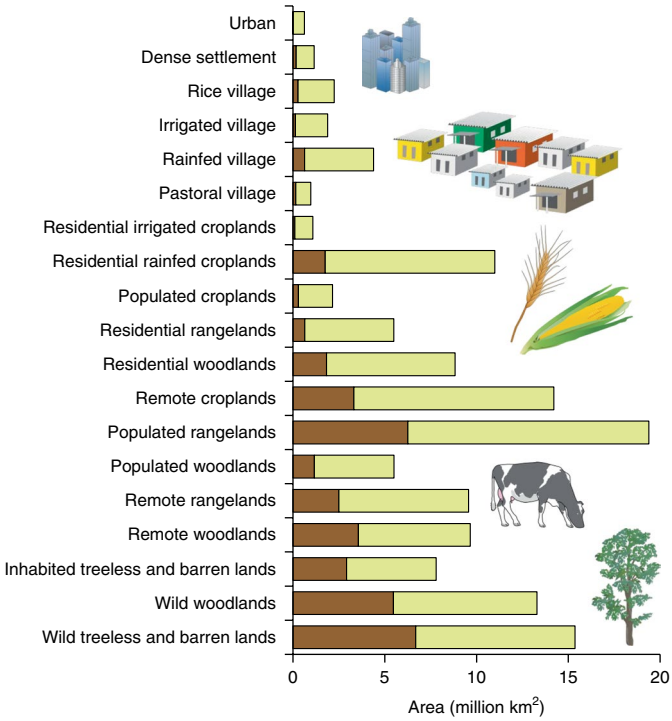

Fig. 4 | Area of each anthropogenic biome (anthrome[14]) on Indigenous Peoples' land (brown) compared with other lands (yellow). Intensity of land use on each anthrome declines from top to bottom. Credit: Images courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/).

governance is essential if we are to develop and achieve the next generation of global biodiversity targets[16,18,37,38].

Methods

Overview. To assess the role of Indigenous Peoples in the conservation of biodiversity across the world, we used five spatial datasets: (1) administrative areas; (2) geographical extent of Indigenous Peoples' lands; (3) protected areas; (4) the Human Footprint; and (5) anthromes. For each country or administratively independent entity, we intersected these datasets to calculate the area of Indigenous Peoples' lands, protected areas, natural lands, and low- and high-intensity anthromes. Geospatial analyses were conducted in the Mollweide projection using ArcGIS v10.4.1 and ArcGIS Pro v1.3.

Administrative areas. Geospatial data for the world's administrative areas were sourced from the Global Administrative Areas (GADM) spatial database[47]. Administration areas were dissolved according to ISO3 and Name_0 attributes for geoprocessing at a country or administratively independent entity level. For presentation purposes, administration areas were later grouped into four regions following the IPBES regionalization[48]. The following areas were consolidated in our analyses: Aland Islands and Finland; China, Macao and Hong Kong; Australia, Christmas, Norfolk and Cocos Keeling Islands; Cyprus, Akrotiri and Dhekelia; USA Minor Outlying Islands and, although a French Territory, Clipperton Island; United Kingdom, Guernsey, Jersey and Isle of Man.

Indigenous Peoples' lands. We used the International Labour Organization's definition of Indigenous Peoples[2] (Supplementary Information section 1). The geographical extent of Indigenous lands was sourced or delineated based on open-access published sources (Supplementary Information section 2). In selecting these information sources, priority was given to peer-reviewed literature, books by academic publishers and reputable data providers such as documented on the LandMark Global Platform of Indigenous and Community Lands[12].

Protected areas. We used the World Database on Protected Areas (WDPA)[13] to determine the extent of mostly state-managed protected areas, but also a fairly good sample of community managed reserves and some private reserves. Data were provided with the following filters applied: removal of protected areas with a designation of UNESCO MAB Biosphere Reserves because they may include large areas that do not meet the IUCN definition of protected areas; removal of areas with a status of 'not reported' or 'proposed'; creation of circular buffers around point data based on reported areas and removal of point data with no reported area. We further deleted areas designated as 100% marine protected areas (attribute MARINE = 2) because our study focused on terrestrial areas. Protected areas on Reunion, attributed to France, and American Samoa, attributed to the United States of America, were reclassified to the islands on which they occur.

The WDPA database contained overlapping protected areas with different IUCN management categories and different ISO3 codes. To account for this and to create a flat WDPA layer for each administrative area, all protected areas with a particular ISO3 code were selected and clipped to the extent of the relative GADM administration area. Where protected areas overlapped, a single IUCN management category was assigned according to the following hierarchy: Ia, Ib, II, III, IV, V, VI, Not Assigned, Not Reported, Not Applicable. Creating a flat layer using this method avoided inflated protected area coverage values and excluded protected areas from neighbouring countries that nominally extend beyond their jurisdiction.

Human Footprint. Human Footprint data are a standardized measure of cumulative human pressures on the environment that take into account the extent of built environments, crop land, pasture land, human population density, night-time lights, railways, roads and navigable waterways[15]. The Human Footprint ranges between values of 0 and 50, calculated at a 1 km^2 resolution across the Earth's terrestrial surface. Land can be considered human-dominated rather than 'natural' using a Human Footprint value threshold of 4 or greater[22]; a value of 0 is equivalent to no detectable human pressures of the type incorporated in the index. Human Footprint maps for 1993 and 2009 were downloaded from the Dryad Digital Repository[49]. It has been used to measure and classify habitat degradation[22], connectivity for species[50], global wilderness decline[23] and the extent of human influence on protected areas[51].

Anthromes. Anthropogenic biomes (anthromes) characterize the human-altered form and dynamics of terrestrial ecosystems[14]. They denote long-term patterns in human populations and their land use, taking into account population density, agricultural village development, percentage cover by crops, pasture and rice, irrigated land area and areas potentially covered by trees[52,53]. Anthromes version 2 data were calculated using a 100 km^2 equal area hexagonal discrete global grid format. For presentation, we grouped anthromes as either low intensity or high intensity to show differences in use between Indigenous Peoples' and other lands. Remote rangelands, remote woodlands, inhabited treeless and barren lands, wild woodlands and wild treeless and barren lands anthromes were classified as low intensity; urban, dense settlement, rice village, irrigated village, rainfed village, pastoral village, residential irrigated croplands, residential rainfed croplands and populated croplands were classified as high intensity.

Statistical analysis. Regional variation in the proportion of countries in each region with Indigenous Peoples was tested with chi-square with Fisher exact test to test pairs, with P values adjusted using the Bonferroni method. Comparisons of percentages of different land types under Indigenous Peoples' and other lands were undertaken using the Mann–Whitney Wilcoxon test for countries with both land types. For countries with Indigenous Peoples, percentages of each land type in each region were compared using the Kruskal–Wallace test.

Data availability. The data from administrative areas that support the findings of this study are available from Global Administrative Areas[47]. Data used for Indigenous Peoples' land mapping are provided in Supplementary Information section 2 and the derived maps are available from the author S.T.G. on reasonable request. The protected areas data that support the findings of this study are available from the UN Environment World Conservation Monitoring Centre[13], the Human Footprint data are available in the Dryad Digital Repository[49] and the anthromes version 2 data are available from the author E.E. on reasonable request.

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Author contributions

S.T.G. conceived the paper, drafted the initial text and analysed data. S.T.G., T.D., M.V.J., B.M., A.S. and I.L. located the maps and I.L. undertook the GIS analysis. J.E.F., K.K.Z., I.L. and H.G. analysed data. All 20 authors contributed ideas and finalized the text.

Competing interests

The authors declare no competing interests.

Additional information

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