Report

Current Biology

# Catastrophic Declines in Wilderness Areas Undermine Global Environment Targets

## Highlights

- Globally important wilderness areas are ignored in conservation policy
- We reveal that extensive losses of wilderness have occurred in the last two decades
- Efforts aimed at protecting wilderness areas are failing to keep pace with its loss
- International policy must recognize the actions needed to maintain wilderness areas

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## In Brief

Watson et al. discover that the Earth's wilderness areas are disappearing at a rate that has significantly outpaced their protection over the past two decades. Despite their ecological, climatological, and cultural importance, wilderness areas are ignored in multilateral environmental agreements, highlighting the need for urgent global policy attention.

Watson et al., 2016, Current Biology *26*, 2929–2934
November 7, 2016 
http://dx.doi.org/10.1016/j.cub.2016.08.049

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# Catastrophic Declines in Wilderness Areas Undermine Global Environment Targets

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http://dx.doi.org/10.1016/j.cub.2016.08.049

## SUMMARY

**Humans have altered terrestrial ecosystems for millennia [1], yet wilderness areas still remain as vital refugia where natural ecological and evolutionary processes operate with minimal human disturbance [2–4], underpinning key regional- and planetary-scale functions [5, 6]. Despite the myriad values of wilderness areas—as critical strongholds for endangered biodiversity [7], for carbon storage and sequestration [8], for buffering and regulating local climates [9], and for supporting many of the world's most politically and economically marginalized communities [10]—they are almost entirely ignored in multilateral environmental agreements. This is because they are assumed to be relatively free from threatening processes and therefore are not a priority for conservation efforts [11, 12]. Here we challenge this assertion using new comparable maps of global wilderness following methods established in the original "last of the wild" analysis [13] to examine the change in extent since the early 1990s. We demonstrate alarming losses comprising one-tenth (3.3 million km$^2$) of global wilderness areas over the last two decades, particularly in the Amazon (30%) and central Africa (14%). We assess increases in the protection of wilderness over the same time frame and show that these efforts are failing to keep pace with the rate of wilderness loss, which is nearly double the rate of protection. Our findings underscore an immediate need for international policies to recognize the vital values of wilderness and the unprecedented threats they face and to underscore urgent large-scale, multifaceted actions needed to maintain them.**

## RESULTS AND DISCUSSION

### Contemporary Wilderness Loss

We mapped decline of wilderness areas, defining "wilderness" as biologically and ecologically largely intact landscapes that are mostly free of human disturbance [2–4, 11]. These areas do not exclude people, as many are in fact critical to certain communities, including indigenous peoples [14, 15]. Rather, they have lower levels of impacts from the kinds of human uses that result in significant biophysical disturbance to natural habitats, such as large-scale land conversion, industrial activity, or infrastructure development. We measured temporal change in wilderness extent by producing a global map of wilderness and assessing it against a spatially comparable map for the early 1990s (Figures 1 and S1). Both maps were devised using the same methodological framework as the original "last of the wild" map published in 2002 [13], but taking advantage of recently available datasets of in situ anthropogenic pressures. Following established practice, we exclude Antarctic and other "rock and ice" and "lake" ecoregions [16, 17].

We discovered that a total of 30.1 million km$^2$ (or 23.2% of terrestrial areas) of the world's land area now remains as wilderness, with the majority located in North America, North Asia, North Africa, and the Australian continent (Figures 1 and S1). An estimated 3.3 million km$^2$ has been lost since the early 1990s (approximately a 9.6% loss in two decades; Figure 2), with the most loss occurring in South America (experiencing 29.6% loss) and Africa (experiencing 14% loss).

Encouragingly, the majority of wilderness (82.3%, or 25.2 million km$^2$) is still composed of large contiguous areas of at least 10,000 km$^2$. Although this is an arbitrary threshold, wilderness areas of this size are often considered as globally significant wilderness blocks [2, 11]. This is also the size threshold for identifying sites hosting intact ecological communities, adopted in the International Union for Conservation of Nature and Natural Resources (IUCN) standard for Key Biodiversity Areas [18]. Yet there was substantial erosion of these large wilderness areas over the past two decades, with losses amounting to 2.7 million km$^2$ (Figure 1). A total of 37 of the 350 wilderness blocks that

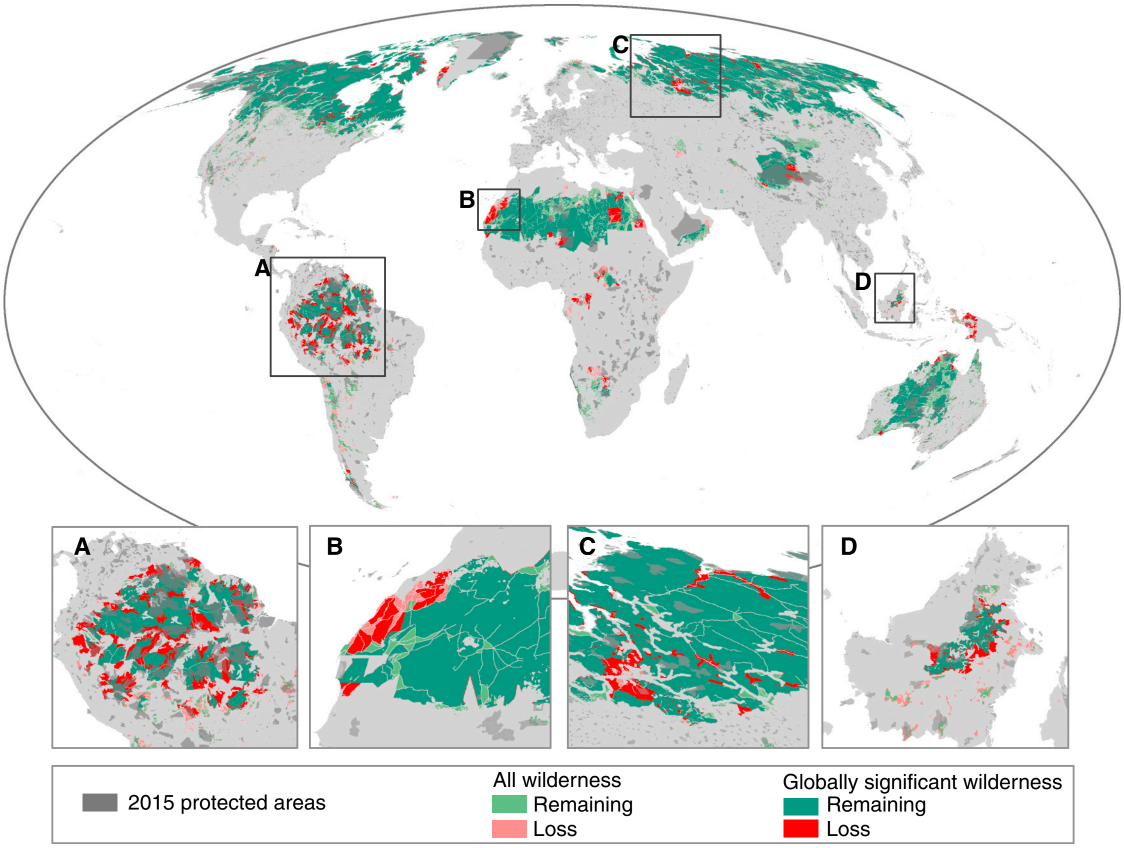


**Figure 1. Change in the Distribution of Wilderness and Globally Significant Wilderness Areas since the Early 1990s**
Globally significant wilderness areas are defined as wilderness areas >10,000 km$^2$. The insets are focused on the Amazon (A), the western Sahara (B), the West Siberian taiga (C), and Borneo (D). See also Figures S1 and S2.

were present in the early 1990s have fallen below the area threshold used here for categorization as globally significant, and 74% of all blocks experienced erosion in areal extent. A total of 27 ecoregions (environmentally and ecologically distinct geographic units at the global scale [19]) have lost all of their remaining globally significant wilderness areas since the early 1990s, including those areas in the Northwestern Congolian Lowland Forests and the Northern New Guinea Lowland Rain and Freshwater Swamp Forests ecoregions. South America suffered particularly high losses in the Amazon basin, with the largest wilderness block being reduced from 1.8 million km$^2$ to 1.3 million km$^2$ (a loss of over 30% in extent; Figures 1 and S1), and wilderness areas in the Ucayali Moist Forests and Iquitos Varzeá ecoregions dropping below the globally significant threshold. This trajectory of wilderness loss in the Amazon is particularly concerning, given that overall deforestation rates reportedly dropped significantly across the Amazon Basin between 2005–2013 [20].

These recent losses have contributed further to existing biases in the geographical distribution of globally significant wilderness. Of Earth's 14 terrestrial biomes, three located mostly in the tropics (Tropical and Subtropical Coniferous Forests, Mangroves, and Tropical and Subtropical Dry Broadleaf Forests) now have no globally significant wilderness area remaining, with the last areas disappearing from two of these biomes over the last two decades. A further five biomes now have less than 10% wilderness remaining (Figure 2).

## Disparity between Wilderness Protection and Loss

Protected areas spearhead global efforts to conserve nature, and when properly managed they are particularly effective for combating the effects of habitat loss and degradation [21]. Since its inception, and through work plans such as the Aichi Targets of The Strategic Plan for Biodiversity 2011–2020 [22], the Convention on Biological Diversity (CBD) has promoted protected areas as a vital conservation mechanism. Consequently, there has been a pronounced expansion of the global protected area estate over the past two decades, with its extent being an almost doubled since the Rio Earth Summit in 1992 [16]. However, despite this growth, the increase in protection of wilderness has lagged significantly behind losses over the past two decades: 2.5 million km$^2$ of wilderness areas (including 2.1 million km$^2$ considered globally significant) was newly protected, whereas 3.3 million km$^2$ (including 2.7 million km$^2$ considered globally significant) was lost. In some biomes, there has been a stark contrast between the area lost and the amount protected (Figure 2). For example, the Mediterranean Forests, Woodlands, and Scrub biome lost 37% of its globally significant wilderness extent since the early 1990s, yet there was no reciprocal protection of the remaining wilderness areas. Similarly, 23% of the

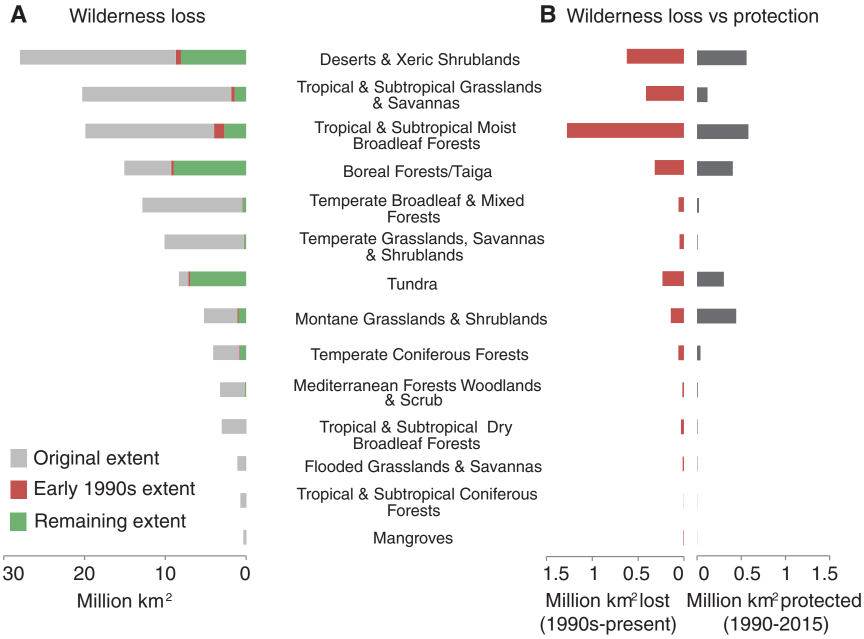


**Figure 2. Historic and Current Extent of All Wilderness Area and the Degree to which It Is Protected**

(A) Historic (gray) and current (green) extent of all wilderness area, as well as the area lost since the early 1990s (red) across the world's terrestrial biomes.

(B) The wilderness area lost (red) and protected (gray) during 1990–2015.

See also Figure S2.

globally significant wilderness was lost from the Tropical and Subtropical Grasslands, Savannas, and Shrublands, with only 8.5% protected in the last two decades.

## Consequences of Continued Wilderness Loss

The current levels of non-protection and consequent loss of wilderness areas across the planet have important ramifications for achieving global climate mitigation goals [8]. For example, the total stock of terrestrial ecosystem carbon (~1,950 petagrams of Carbon [Pg C]) is greater than that of oil (~173 Pg C), gas (~383 Pg C), coal (~446 Pg C), or the atmosphere (~598 Pg C) [23], and a significant proportion of this carbon is found in the globally significant wilderness areas of the tropics and boreal region [8, 24]. It is estimated that 32% of the total global stock of forest biomass carbon is stored in the boreal forest biome [24] and that the Amazon region stores nearly 38% (86.1 Pg C) of the carbon (228.7 Pg C) found above ground in the woody vegetation of tropical America, Africa, and Asia [25]. Thus, avoiding emissions by protecting the globally significant wilderness areas of the boreal and Amazon in particular will make a significant contribution to stabilizing atmospheric concentrations of $CO_2$. Protection of intact forest ecosystems from industrial land uses is particularly important, given that they store more carbon than degraded forests and are more resilient to external perturbations, including climate variability, fire, and illegal logging, poaching, and mining [8, 26].

Although both the boreal and Amazon have suffered significant forest loss and degradation, these landscapes still support globally significant wilderness areas and are increasingly threatened by industrial forestry, oil and gas exploration, anthropogenic fire, and rapid climate change. If allowed to continue unchecked, these impacts will result in depletion of ecosystem carbon stocks and significant $CO_2$ emissions, converting the biome into a large carbon source [27]. For example, on Borneo and Sumatra in 1997, human-induced fires burned into recently converted wilderness areas harboring large peat carbon stores, causing the release of over 1 Pg C [28], which is equivalent to about 10% of all annual anthropogenic $CO_2$ emissions [29].

In terms of biodiversity values, an analysis of the IUCN Red List for terrestrial mammals—one of the taxonomic groups that has been most completely assessed—shows that Earth's remaining wilderness areas also sustain the last strongholds of many imperiled species (see Table S1). The geographic ranges of one-third of all terrestrial mammal species overlap with globally significant wilderness areas, including extensive parts of the distribution of 12% (143) of all threatened mammal species. Thus, ongoing and rapid loss of wilderness increases the risk of extinction for species that are already highly threatened. It is also well established that wilderness areas are critical for wide-ranging and migratory species reliant on intact ecosystems (and their associated ecological processes) and represent residual habitats for disturbance-sensitive species and for those that have a conflictual coexistence with humans, such as many of the world's large carnivores [30].

Wilderness areas also provide benefits derived from their large-scale and self-organization [13], and in many instances they are likely to operate as entire systems, where losses in one area inevitably affect long-term environmental outcomes in another [31–33]. For example, in the Amazon, it is thought that at least 60% of the forest cover is required to maintain the hydrological cycle [34], and so conservation action at the scale of the whole ecosystem is required to ensure that this large wilderness area is maintained. In Australian rangeland and desert ecosystems, the ecological influence of large spatial-scale surface-groundwater hydrological dynamics is pervasive, and losses in one area can degrade habitat quality elsewhere, with significant, long-term implications for biodiversity [35, 36]. In the Anthropocene era, where the human footprint is now altering many of Earth systems processes [37], wilderness areas serve as natural observatories where we can study the ecological and evolutionary impacts of global change. They also serve as natural controls for comparison with areas where intensifying land use and land cover changes are occurring. As intact, large-scale ecosystems become rarer, their value is increasingly appreciated. For instance, we are already seeing growing efforts to "rewild" some human-dominated ecosystems in Europe and North America [38]; remaining

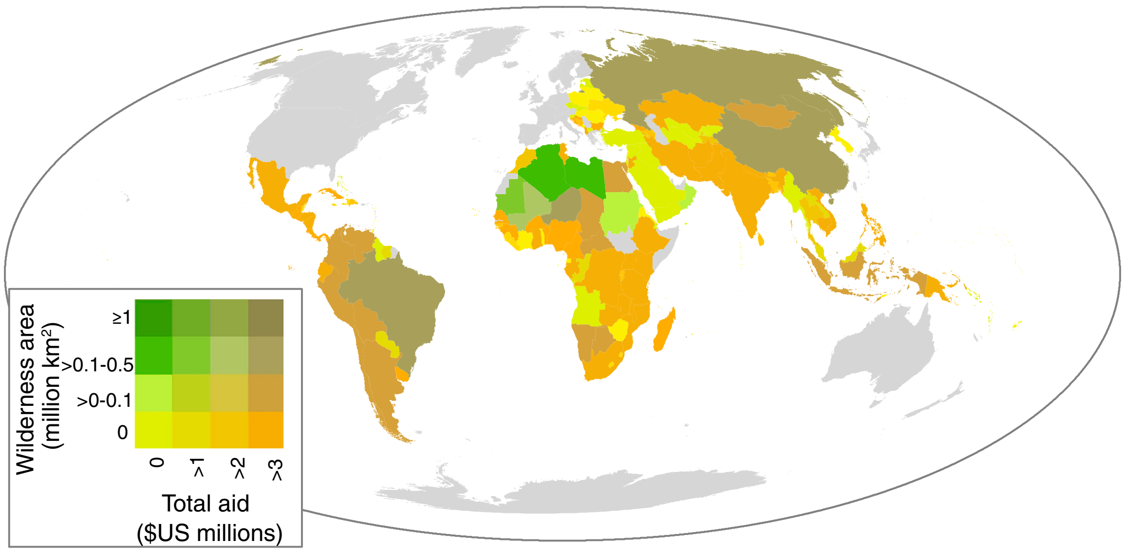


**Figure 3. Amount of Conservation Aid and Extent of Wilderness Now Remaining per Country**

Amount of conservation aid is shown in millions of US$, and extent of wilderness is shown in million km$^2$. Gray areas indicate countries that received no aid. See also Figure S3.

wilderness areas provide the reference points and biological feedstock for these initiatives. Without concerted preservation of existing wilderness areas, there will be a diminished capacity for large-scale ecological restoration.

## Implications for Multilateral Environmental Agreements

The recent severe loss of wilderness is impacting options for achieving strategic goals outlined in key multilateral environmental agreements, including the CBD's 2020 Aichi Targets and the United Nations Framework on Climate Change (UNFCCC) Paris Agreement [22, 39]. There are a number of reasons why globally significant wilderness areas are ignored in policy deliberations. International definitions of forests have not differentiated between types of forests and in some cases actually treat primary forests, degraded forests, and plantations as equivalent [40]. International polices do not acknowledge the special qualities and benefits that flow from ecosystem processes operating at large scales. For example, there is no formal text within the UNFCCC, United Nations World Heritage Convention (WHC), or CBD that prioritizes or even recognizes the benefits derived from large intact landscapes for nature and people. An emphasis on degraded, fragmented, and altered ecosystems has ramifications for national environmental strategies. The tendency is to focus national biodiversity conservation plans on remnant habitats and endangered populations [3, 41], with few nations clearly articulating conservation goals for wilderness area.

The lack of recognition of wilderness in global accords and national policy also has implications for international funding programs such as the Global Environment Facility, Green Climate Fund, and Critical Ecosystems Partnership Fund, which are distributing billions of dollars in support for programs to help achieve the goals of multilateral environmental agreements. Within the CBD funding mechanisms, for example, 80% of funds have been allocated to nations with <20% of all wilderness area (Figures 3 and S2). The neglect of wilderness is arguably even more acute in funding under the UNFCCC and Paris Agreement finance discussions. Although there is strong financing for forest conservation under the UNFCCC REDD+ mechanism to reduce emissions from deforestation and degradation, the rules stipulate that this financing must target areas with high baseline levels of deforestation [42]. Such efforts, though valuable for other purposes, serve to direct funds away from forested wilderness areas that are presumed safe from deforestation and degradation. As our results demonstrate, however, wilderness is under immense land use pressures, and there is an urgent need for greater conservation effort in these areas to help maintain their ecological intactness and integrity of function.

What would it take to halt the rapid loss of wilderness and of globally significant areas in particular? Achieving meaningful changes in policy at the global level is more likely if there is first a critical mass of support at the national level. Ideally, this should be evidenced through national strategies and plans that recognize the values of wilderness areas and specify policies for their protection. In any case, by creating clear text within operational guidelines, work plans, and ongoing negotiations of key multilateral environmental agreements, international conservation investments can then be mobilized and focused in a manner that can fund activities to help protect wilderness areas. These activities will vary based on the specific context of different nations and regions, but there is a clear need to focus on halting current threatening activities that have been leading to the recent erosion of wilderness areas, including limiting road expansion [43]; preventing industrial mining, forestry, and other large-scale agricultural operations [43]; and enforcing existing legal frameworks considering that half of all tropical forest clearing between 2000 and 2012 was illegal [44–46]. A key goal could be to proactively fund conservation interventions in wilderness areas where degrading activities are currently absent but are projected to occur in the near future.

Conservation actions should include (1) creating large and, where necessary, multi-jurisdictional protected areas; (2) establishing mega-conservation corridors between protected areas; and (3) enabling indigenous communities to establish community conservation reserves [15]. Funding could also be used to establish payments for ecosystem service programs that recognize the direct and indirect economic benefits that wilderness areas provide, such as being a secure source of fresh water, reducing disaster risks, and storing large carbon stocks [9]. There are some encouraging examples where these types of activities are being undertaken. For example, in Brazil, the Amazon Region Protected Areas (ARPA) program supports the creation and management of protected areas and sustainable natural resource management reserves [47]. The overarching aim of these protected areas and reserves is to maintain forest carbon stocks, protect large-scale ecological processes, and establish sustainable use by local peoples. This program is now extending beyond Brazil to Peru and Colombia. The Canadian Boreal Forest Conservation Framework is a similar example, with an overall aim of conserving the long-term integrity of the boreal forest biome by protecting at least 50% of the Boreal in a network of large interconnected protected areas and supporting sustainable communities via ecosystem-based resource management and stewardship practices across the remaining landscape [48].

These positive examples are too few, and we argue that immediate action to protect the world's remaining wilderness areas on a large scale is now necessary, including in global policy platforms. All wilderness areas, regardless of their size threshold, warrant immediate scrutiny for conservation action, especially in regions with low levels of remaining wilderness areas. The continued loss of wilderness areas is a globally significant problem with largely irreversible outcomes for both humans and nature: if these trends continue, there could be no globally significant wilderness areas left in less than a century. Proactively protecting the world's last wilderness areas is a cost-effective conservation investment and our best prospect for ensuring that intact ecosystems and large-scale ecological and evolutionary processes persist for the benefit of future generations.

## SUPPLEMENTAL INFORMATION

Supplemental Information includes Supplemental Experimental Procedures, three figures, and one table and can be found with this article online at http://dx.doi.org/10.1016/j.cub.2016.08.049.

## AUTHOR CONTRIBUTIONS

Conceptualization and Methodology Development, J.E.M.W., D.F.S., M.D.M., J.A., W.F.L., E.S., B.M., and O.V.; Formal Analysis, J.E.M.W., D.F.S., M.D.M., J.A., and O.V.; Writing – Original Draft, J.E.M.W., D.F.S., M.D.M., J.A., O.V., and B.M.; Writing – Review & Editing, J.E.M.W., D.F.S., M.D.M., J.A., W.F.L., E.S., B.M., and O.V.

## ACKNOWLEDGMENTS

We especially thank Doug Shiel, Erik Meijaard, Clive MacAlpine, Joe Walston, John Robinson, Tom Evans, Marc Hockings, Tom Brooks, and Nigel Dudley among the vast array of conservation professionals who have helped us with this idea over the past 2 years. We thank four anonymous reviewers for their helpful feedback on an earlier version of this manuscript.

Received: April 27, 2016
Revised: July 11, 2016
Accepted: August 19, 2016
Published: September 8, 2016

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