

Loss of the world's smallest forests

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Abstract

A large number of small forests typically harbor higher biodiversity than a small number of large forests totaling the same area, suggesting that small patches are disproportionately valuable for biodiversity conservation. However, policies often favor protection of large forest patches. Here we demonstrate a global trend of higher deforestation in small than large forest patches: the likelihood that a randomly selected forest plot disappeared between 1992 and 2020 increased with decreasing size of the forest patch containing that plot. Our results imply a disproportionate impact of forest loss on biodiversity relative to the total forest area removed. Achieving recent commitments of the post-2020 Global Biodiversity Framework will require revision of current policies and increased societal awareness of the importance of small habitat patches for biodiversity protection.

KEYWORDS

biodiversity, conservation, deforestation, habitat loss, policy, post-2020 Global Biodiversity Framework

Habitat degradation is a primary driver of ongoing biodiversity loss (Brennan et al., 2022). In response to this trend, the Secretariat of the United Nations Convention on Biological Diversity has recently set the target of setting aside for nature at least 30% of the Earth's lands and seas by 2030 (Dinerstein et al., 2019). Achieving this goal will require almost doubling the area of terrestrial surface currently protected in <10 years (Dinerstein et al., 2019). Given the global biodiversity crisis, it is imperative that these unprecedented investments are guided by effective conservation principles (Dinerstein et al., 2019; Riva & Fahrig, 2022).

Traditional reserve design for biodiversity conservation follows the principle that large habitat patches should be preferred to small habitat patches (Fahrig et al., 2022). As a result, many international policies discount the conservation value of small patches (e.g., via minimum patch size thresholds) (Fahrig et al., 2022; Wintle et al., 2019). Yet, cumulatively, large numbers of small patches typically harbor more species than fewer large patches of the same total area (Fahrig et al., 2022; Riva & Fahrig, 2022; Wintle et al., 2019). Habitat within small patches also tends to be more accessible to human activity, because in anthropogenic landscapes most remaining habitat is typically in small patches (Taubert et al., 2018; Valdés et al., 2020). These three aspects—low protection, high cumulative

biodiversity, and high accessibility—suggest a conundrum: small habitat patches are often disproportionately important in biodiversity conservation, but are also more exposed to human activity (Riva & Fahrig, 2022). Whether higher exposure translates into a higher likelihood of habitat loss, however, remains unknown.

Forests are crucial habitats for nature and people. Forests cover ~30% of the planet's terrestrial surface and support ~80% of the Earth's flora and fauna. Human populations have shaped and stewarded forests for thousands of years, but deforestation peaked in the 20th century (Curtis et al., 2018; Ellis et al., 2021). Although slowing since the 1980s, deforestation is still one of the most widespread forms of anthropogenic disturbance of habitat worldwide (Curtis et al., 2018). The economic, social, and political drivers of deforestation have been studied extensively (Curtis et al., 2018; Ellis et al., 2021). However, it is unclear whether these drivers result in a higher deforestation rate in small than large forest patches.

We determined whether each of one million, randomly selected, 9 ha plots forested in 1992 remained forested in 2020, and how this related to the sizes of the forest patches containing each plot in 1992 (Figure 1). Overall, global forest cover decreased from 4432 million ha to 4384 million ha between 1992 and 2020, a net loss of ~48 million ha which is equal to ~1.1% of the global forest cover present

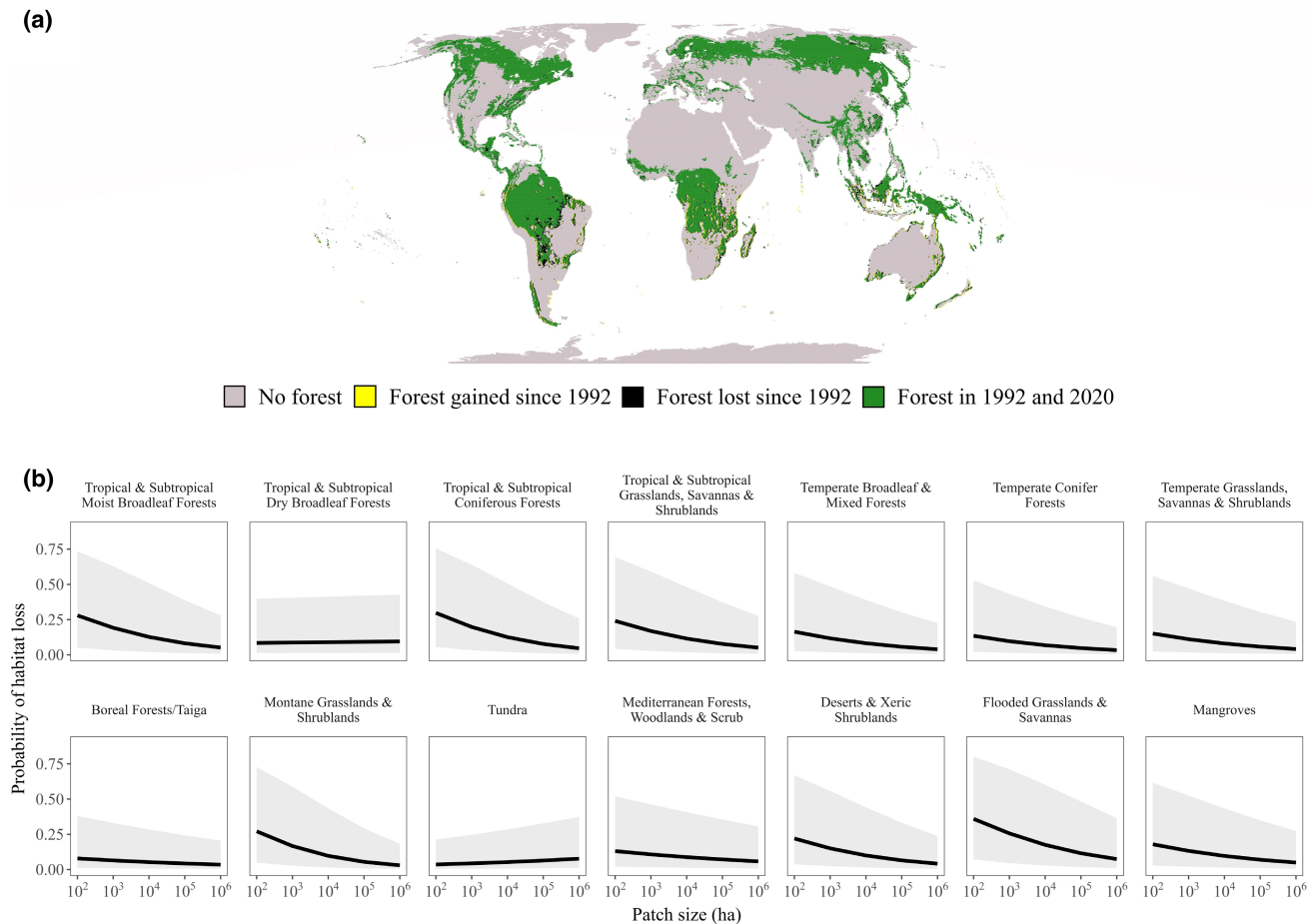


FIGURE 1 (a) Global change in forest cover between 1992 and 2020; (b) probability that a forest plot in 1992 was lost as a function of the area of the forest patch containing that plot, and of the ecoregion where the plot was located. Analyses were conducted at a resolution of 0.3 km, but (a) is shown at a resolution of 30km for visualization purposes. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/gcb.16449)]

in 1992 (Figure 1a; ~5.7% loss of forest cover, in black, and ~4.6% gain of forest cover, in gold), an area ~2 times that of the United Kingdom. We found a significant, negative relationship between the probability that a forest plot was lost and the area of the forest patch containing the plot (Figure 1b, Table S2). On average, 16.6% of sample plots that fell within 10^2 ha patches disappeared, 9.2% of plots that fell within 10^4 ha patches disappeared, and 4.9% of samples that fell within $\geq 10^6$ ha patches disappeared. This trend was consistent across the Earth's ecoregions, with two exceptions—Tundra and Tropical & Subtropical Dry Broadleaf Forests (Figure 1b, Table S4).

For Tundra, this makes sense because wildfires are the most common cause of forest loss there (Curtis et al., 2018), and large patches facilitate the spread of fire. The cause of the slightly higher forest loss in large patches of Tropical & Subtropical Dry Broadleaf Forest is less clear. The production of commodities including beef, soy, or palm oil is responsible for very large losses of forest in these areas (Curtis et al., 2018) (see, e.g., Paraguay, Bolivia, and Argentina in the Neotropical realm, and Malaysia and Indonesia in the Indomalayan realm; Figure 1A). Therefore, similar deforestation rates in small and large patches in the Tropical & Subtropical Dry Broadleaf Forest

could be the result of widespread, large-scale, commodity-driven ongoing deforestation events (Blum et al., 2022).

Our analysis has important implications for how the post-2020 Global Biodiversity Framework should be implemented. It suggests that priority should be placed on protecting small forest patches in human-dominated regions. A recent definition considered “small” protected areas as those under 3500ha (Brennan et al., 2022). Given that forests smaller than 3500ha currently account for at least 9.5% of the world's forests area overall—1.25 times the area of India—and at least 32.8% of forests in human-dominated landscapes (Supplementary Material), their conservation will be crucial for ensuring that the forest protected under the post-2020 Framework is actually effective in protecting global biodiversity. Note that forests much smaller than 3500ha can deliver disproportionately high ecosystem services (Valdés et al., 2020) and harbor disproportionately high biodiversity, including species of conservation concern and habitat specialist species (Riva & Fahrig, 2022). Our results are therefore very conservative, because the 0.3 km spatial resolution of our global forest cover dataset inherently overlooks millions of smaller forest patches (Taubert et al., 2018; Valdés et al., 2020),

while our analysis suggests that those patches are likely the most affected by deforestation (Figure 1B).

In practice, encouraging protection of small patches will require both new policies and legislation, and a fundamental shift in how people conceptualize and interact with small habitat patches. Policy shifts are important but will not be sufficient because much deforestation occurs despite legislation prohibiting it. For example, about 50% of deforestation in the tropics is illegal (Blum et al., 2022). Widespread societal acknowledgment of the value of small patches would encourage small-scale conservation actions and empower local organizations to protect habitat. The cumulative effect of thousands of such actions will go a long way toward stemming biodiversity declines.

CONFLICT OF INTEREST

Authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in "Loss of the world's smallest forests (Riva et al. 2022, Global Change Biology)" at <https://doi.org/10.5061/dryad.69p8cz956>. The R script used in analysis is also mirrored at https://github.com/FedericoRiva/Small_forests_loss.

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SUPPORTING INFORMATION

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