Conservation Biology

National contributions to global ecosystem values

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Abstract: Current conservation templates prioritize biogeographic regions with high intensity ecosystem values, such as exceptional species richness or threat. Intensity-based targets are an important consideration in global efforts, but they do not capture all available opportunities to conserve ecosystem values, including those that accrue in low intensity over large areas. We assess six globally-significant ecosystem values—intact wilderness, freshwater availability, productive marine environments, breeding habitat for migratory wildlife, soil carbon storage, and latitudinal potential for range shift in the face of climate change—to highlight opportunities for high-impact broadly-distributed contributions to global conservation. Nations can serve as a cohesive block of policy that can profoundly influence conservation outcomes. Contributions to global ecosystem values that exceed what is predicted by a nation's area alone, can give rise to countries with the capacity to act as 'conservation superpowers', such as Canada and Russia. For these conservation superpowers, a relatively small number of national policies can have environmental repercussions for the rest of the world.

Keywords: breeding habitat, freshwater, global resource supply, marine productivity, policy, range shift, soil carbon storage, wilderness

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Introduction

Conventional, global-scale conservation focuses almost exclusively on high-intensity ecosystem values, such as species richness, biomass concentration, or areas where threats to biodiversity are extreme (Brooks et al. 2006). *Ecosystem values* is a broad term that encompasses natural capital (Mace et al. 2015), ecosystem services (Diaz et al. 2015), and other aspects of nature's contributions to people (Diaz et al. 2018). Intensity-based measures of ecosystem values (e.g., species richness) are an important consideration in global conservation efforts, but they can miss opportunities to conserve diffuse ecosystem values (i.e., those that accrue at low intensity over large areas, for example, soil carbon) (Kareiva & Marvier 2003). Diffuse ecosystem values represent an oft overlooked complement to traditional conservation foci. Nations with large landmasses are at the nexus of diffuse ecosystem values and broad policy-relevant planning regions and, as such, have the potential to make key contributions to global conservation efforts through domestic action.

The combined land area of the world's 8 largest countries—Russia, Canada, United States, China, Brazil, Australia, India, and Argentina—account for 50% of Earth's land area yet represent 3% of the world's nations. Because decision-making power is concentrated in the hands of so few nations, these larger countries disproportionately influence the global supply of ecosystem values (assuming policies in large countries are more likely to impact large land areas and that the probability of policy change is not inversely correlated with country size) (Supporting Information). Consequently, a relatively small number of national policies can have environmental repercussions for the rest of the world. We assessed 6 globally significant ecosystem values—intact wilderness, freshwater availability, productive marine environments, breeding habitat for migratory wildlife, soil carbon storage, and latitudinal potential for range shift in the face of climate change—to highlight opportunities for high-impact broadly distributed contributions to global conservation (Supporting Information).

Global Nature Reserves

Loss of habitat is currently the single biggest threat to biodiversity (Maxwell et al. 2016) and is being driven by an ever-expanding human footprint (Venter et al. 2016). Wilderness, which we define as landscapes with a low industrial footprint (i.e., in the lowest quintile [Supporting Information]) that can include use and modification by indigenous people and traditional resource users, is critical to maintaining the world's biodiversity (Venter et al. 2016). Wilderness lands with a low level of human disturbance retain natural ecological processes and provide high-quality habitat for terrestrial wildlife and source populations for reintroductions (Watson et al. 2016).

Half the world's least human-disturbed lands occur in just 2 countries, Russia and Canada (Fig. 1). Based on their large areas alone, Russia and Canada could be expected to contain substantial swaths of wilderness but could also be heavily altered by development. Indeed, Russia has the second largest proportion of the world's least heavily human-disturbed areas (24%) but has the third highest proportion of the world's most heavily human-disturbed areas (7.5%) (Supporting Information). In contrast, Canada has the most wilderness of any nation in the world (26%) and is ranked relatively low, nineteenth, in its proportion of heavily human-disturbed land (1%). The national balance of least human-disturbed to most human-disturbed areas suggests Canada's land-protection policies are of particularly high global relevance (Lamb et al. 2018).

Global Cisterns

Water quality, distribution, and availability are major development challenges globally (Grey et al. 2013). Glaciers currently provide over 15% of the world's population with water and are increasingly important as climate-change accelerates (Barnett et al. 2005). More than half the world's total water (surface and glacier-stored freshwater) is found in only 3 nations (Fig. 1). The global supply of surface freshwater resides predominantly within Canada (26%), Russia (14%), and the United States (11%); glacier-stored water resides predominantly within China (35%), Canada (10%), and Kyrgyzstan (6%). For nations with considerable availability of both surface and glacier-stored water, water policies and management of water supply will have consequences for the global persistence of aquatic ecosystems and their interactions with adjacent terrestrial and marine ecosystems.

Oceans of Responsibility

Continental shelves are productive for both biodiversity and human uses (Martínez et al. 2007). Jurisdiction over most continental shelves usually resides within the adjacent nation. As such, domestic policies that influence ecological conditions on the continental shelf can exert tremendous impact on sustainability of marine resources, with trickle-down effects to nations with much smaller contributions to continental shelf area (Halpern et al. 2008). Transitory species, such as migratory fishes and marine mammals that move across national marine boundaries, can be especially susceptible to declines in

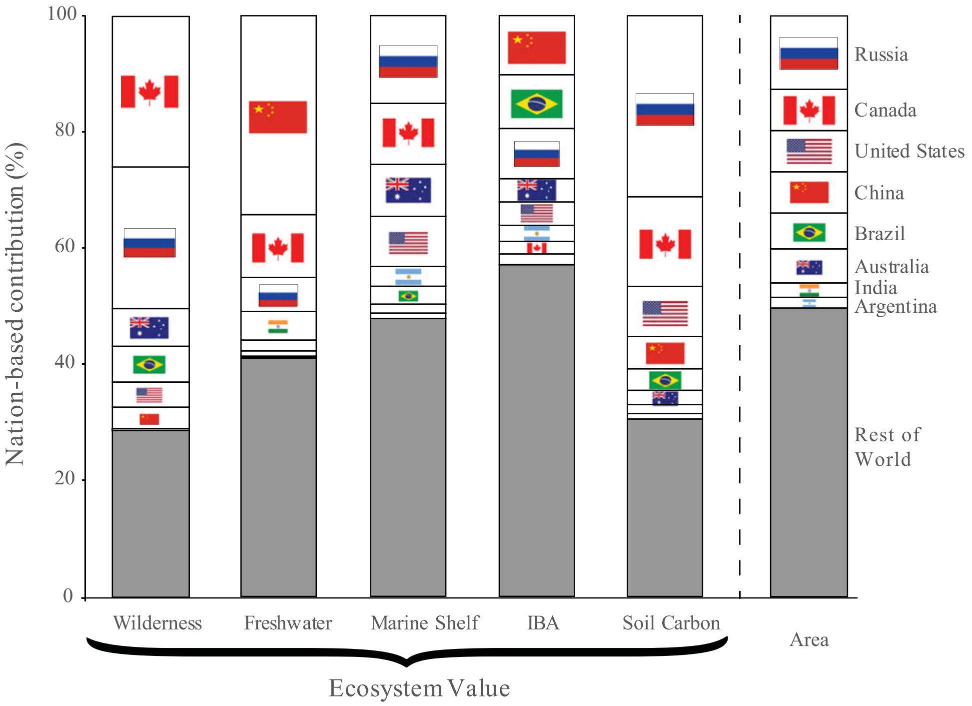

Figure 1. Contributions by country to global ecosystem values. The 8 largest countries (right-most bar), representing >50% of global land area, are ranked for their contribution to 5 ecosystem values. Flag size is proportional to contribution (largest flag, number 1; smallest flag, number 8). For each value (wilderness, freshwater, continental shelf, important bird area, soil carbon [Supporting Information]), a few countries hold considerable global responsibility.

ecological conditions (Pauly et al. 2002). Even within a nation fish stocks that are not at sustainable levels (Baum & Fuller 2016) represent lost potential food sources whose recovery is largely dependent on national management decisions. The top 3 ranked contributors to the global supply of continental shelf area are Russia (15%), Canada (11%), and the United States and Australia (9% each) (Fig. 1).

Global Nurseries

Important bird and biodiversity areas (IBAs) have been established to increase the protection of critical stopover and breeding areas for many species (Fishpool & Evans 2001). There are over 12,000 terrestrial and marine IBAs in the world (total 14,452,985 km^2). Of terrestrial IBAs (total ~10,043,263 km^2), 10 countries hold ~50% of total land area. China (10%), Brazil (9%), and Russia (8%) contribute most of the global supply of IBAs. The importance of IBAs for small and large nations is shaped by the migratory patterns of wildlife. Indeed, for bird communities, migrants may consume up to 78% of all energy in northern areas and drive many ecosystem process (Fristoe 2015). Protection targets for breeding grounds and migratory routes (Davy et al. 2017) link domestic policies to globally important ecosystem values associated with migratory species. The relative importance of breeding areas for other migratory, aerial species (e.g., bats and insects) are less well understood but likely follow similar patterns of accrual in nations with larger land area.

Global Carbon Storage

Loss of biosphere carbon stores (e.g., due to tropical deforestation, peat harvesting, wildfires) is a global concern (House et al. 2002). Storing carbon in soil reduces greenhouse gas emissions into the atmosphere, thereby decelerating global climate change (Alamgir et al. 2016). Boreal and tundra regions affect both productivity and CO_2 balance and retain large amounts of carbon-rich biomass and soils (Moen et al. 2014). Russia (31%), Canada (15%), and the United States (9%)—the 3 largest countries—rank respectively as the most significant contributors to global soil carbon stores (Fig. 1). Policies of larger nations that emphasize the conservation of soil carbon stores will bring benefits to a changing world.

A Global Climate Buffer

Climate change is expected to be a major driver of species loss over the next 50 years and could double the extinction risk species currently face due to habitat degradation and fragmentation (Urban 2015; Newbold 2018). The impacts of climate change on biodiversity are lessened when species can shift their ranges along climatic gradients (Pecl et al. 2017). Thus, the extent of latitude within a country provides a measure of the availability of climatic gradients with the potential to support biodiversity redistribution (Carroll et al. 2018). Six nations span more than 20° in latitude (Brazil 27.2°, Russia 25.5°, Chile 25.4°, China 23.3°, Argentina 21.4°, Canada 21.2°

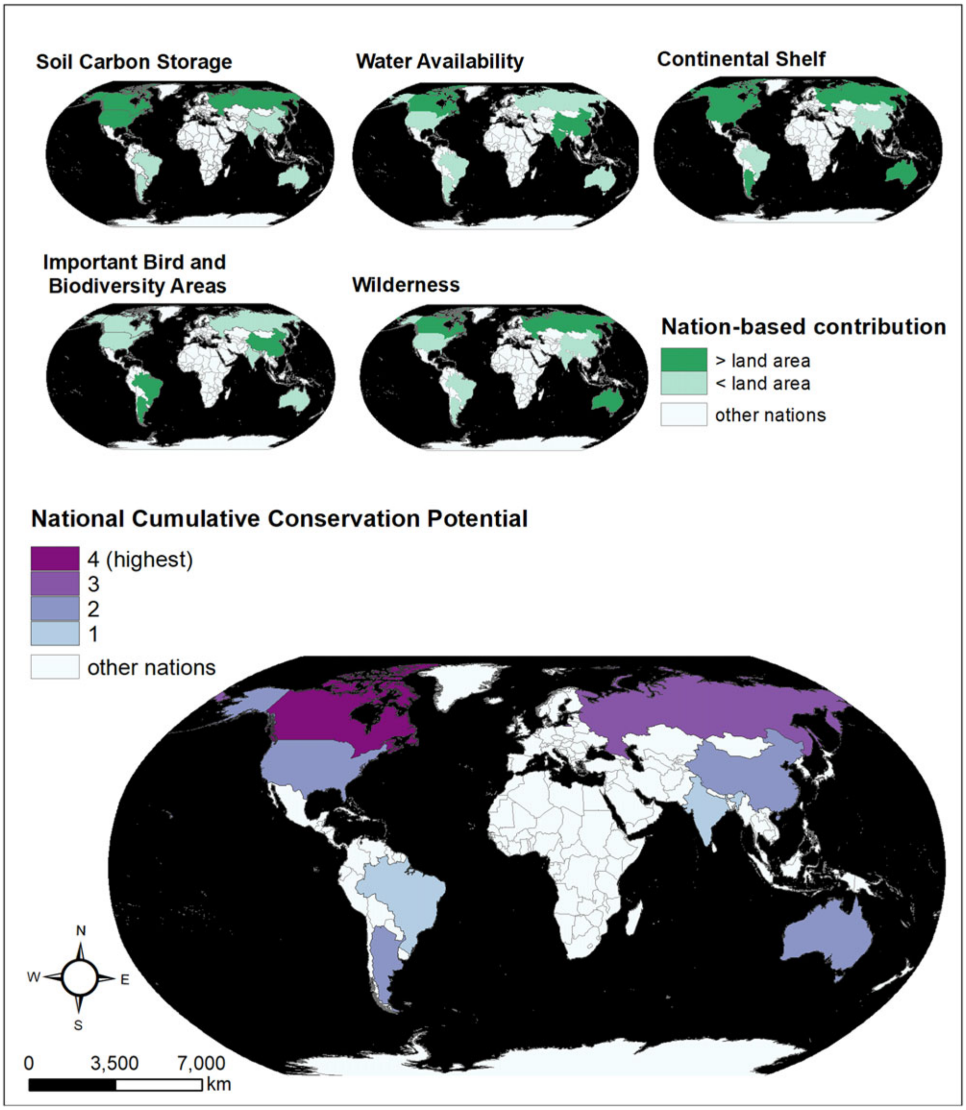

Figure 2. National potential for the 8 largest countries to contribute to global ecosystem values in excess of expectations based on national land area for (a) each of the ecosystem values that represent global proportions (wilderness, freshwater, continental shelf, important bird areas, soil carbon) and (b) total number of the assessed ecosystem values that exceed global proportions (1, nation exceeds expected contribution to an ecosystem value only once; 4, nation exceeds expected contribution to an ecosystem value for 4 unique ecosystem values).

[Supporting Information]) (these values do not represent a percentage out of a global total and so are not included in Figs. 1 and 2 or Supporting Information). Policies to promote connectivity within these nations are thus particularly able to facilitate range shifts in response to climate change.

Conclusions

Due to interactions of global patterns of biogeography and variation in the area of the world's nations, the domestic policies of a few nations exert disproportionate influence on global conservation outcomes (Fig. 1; Supporting Information). For this reason, it is worth considering how a country serves as a planning unit in the prioritization of global conservation resources (Beger et al. 2015), alongside other prioritization schemes (Brooks et al. 2006). A focus on national conservation contributions to global ecosystem values should be viewed as complementary to intensity-based prioritizations (Fig. 2).

Contributions to global ecosystem values that exceed what is predicted by area alone, can give rise to countries with the capacity to act as conservation superpowers (Fig. 2). Although this pattern is not exclusive to large countries, the overall global impact may be minimal for smaller nations. Of the 8 largest nations, Canada's contributions to each of the assessed ecosystem values most frequently exceeded global share of land (i.e., 7%) and was followed closely by Russia (Fig. 2). The 8 largest nations have the capacity to safeguard substantial amounts of remaining global ecosystem values. Through implementation of domestic policies, these same nations could contribute to the degradation of ecosystem values with sizeable net negative repercussions at a global scale. Nations that are among the top contributors to the global supply of ecosystem values carry both the opportunity and responsibility to become leaders in conservation actions and outcomes.

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Supporting Information

A description of data calculations (Appendix S1), accumulation curve for ecosystem values and data sources (Appendix S2), and a spreadsheet of national contributions to assessed global ecosystem values for all 243 countries (Appendix S3) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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