Climate Change Responses


Photo of arctic fox by Eric Post

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COMMENTARY Open Access

# Anticipating novel conservation risks of increased human access to remote regions with warming

Eric Post[1*] and Jedediah Brodie[2]

**Abstract**

The consequences for wildlife conservation of climate change facilitation of human access to currently remote areas are poorly considered but potentially significant. Focusing on species of cultural and conservation concern in the Arctic and Tropics, we advocate a re-evaluation of the process of assigning protected area status to account for such risks. We identify areas currently lacking protected status in both regions that are prone to loss of wildlife habitat due to increased human access and direct climate change, and outline measures for updating their conservation status. Policy foresight along these lines will help buffer wildlife against previously unanticipated consequences of climate change.

**Keywords:** Arctic, Climate change, Deforestation, Harvest, IUCN, Sea ice, Tropics, Wildlife

## Background

Wildlife in two regions with high rates of endemism, the Arctic and the Tropics, may be uniquely vulnerable to extinction risk in a changing climate but not solely for previously anticipated reasons such as direct impacts of climate [1,2] or biotic attrition related to range-shift gaps [3]. Although there has been a wealth of recent research on the effects of climate change on wildlife populations in both regions [2-7], scant attention has been paid to a conservation crisis that may arise in the near future as a consequence of interactions between climate change and human access to wildlife and their habitat [8]. We propose that the nexus of rising temperatures and increased human access to remote areas poses a largely unanticipated threat to wildlife in general and to species endemic to the Arctic and the Tropics in particular.

Both of these regions are at particularly prominent risk of developing novel climates within the 21st century under a scenario in which unmitigated carbon emissions result in an atmospheric $CO_2$ concentration of 856 ppm by the year 2100 (emissions scenario A2; Figure 1A) [9]. This risk is abated somewhat if carbon emissions are held to a point at which atmospheric $CO_2$ reaches 549 ppm by 2100 (emissions scenario B1; Figure 1A), but the Tropics remain at greatest risk even under this optimistic scenario. Both the Arctic and Tropics are also at great risk of undergoing a loss of existing climates by 2100 under both scenarios (Figure 1C) [9]. The concepts of development of novel climates and loss of existing climates may seem identical, and indeed the geographic distributions of their risks under each climate change scenario overlap considerably (Figure 1). The novelty of future climatic conditions at a given locale is defined as the dissimilarity between projected climatic conditions at the end of the 21st century and conditions at that locale averaged over the 20th century, while the loss of existing climatic conditions is defined as the dissimilarity between realized 20th century conditions at a locale and its nearest 21st century climatic analog [9]. Hence, development of novel climates may include, for instance, increasing variability around unchanging mean conditions, while disappearance of existing climatic conditions would include a shift away from current mean conditions at any particular locale.

In each case, development of novel climates and eventual disappearance of existing climates, wildlife species may suffer habitat loss as well as increased human access to existing habitats either for direct exploitation of wildlife or for other reasons that pose more indirect threats. Crucially, the zone of highest probability of development of novel climates and disappearance of existing climates overlaps almost perfectly with the zone of

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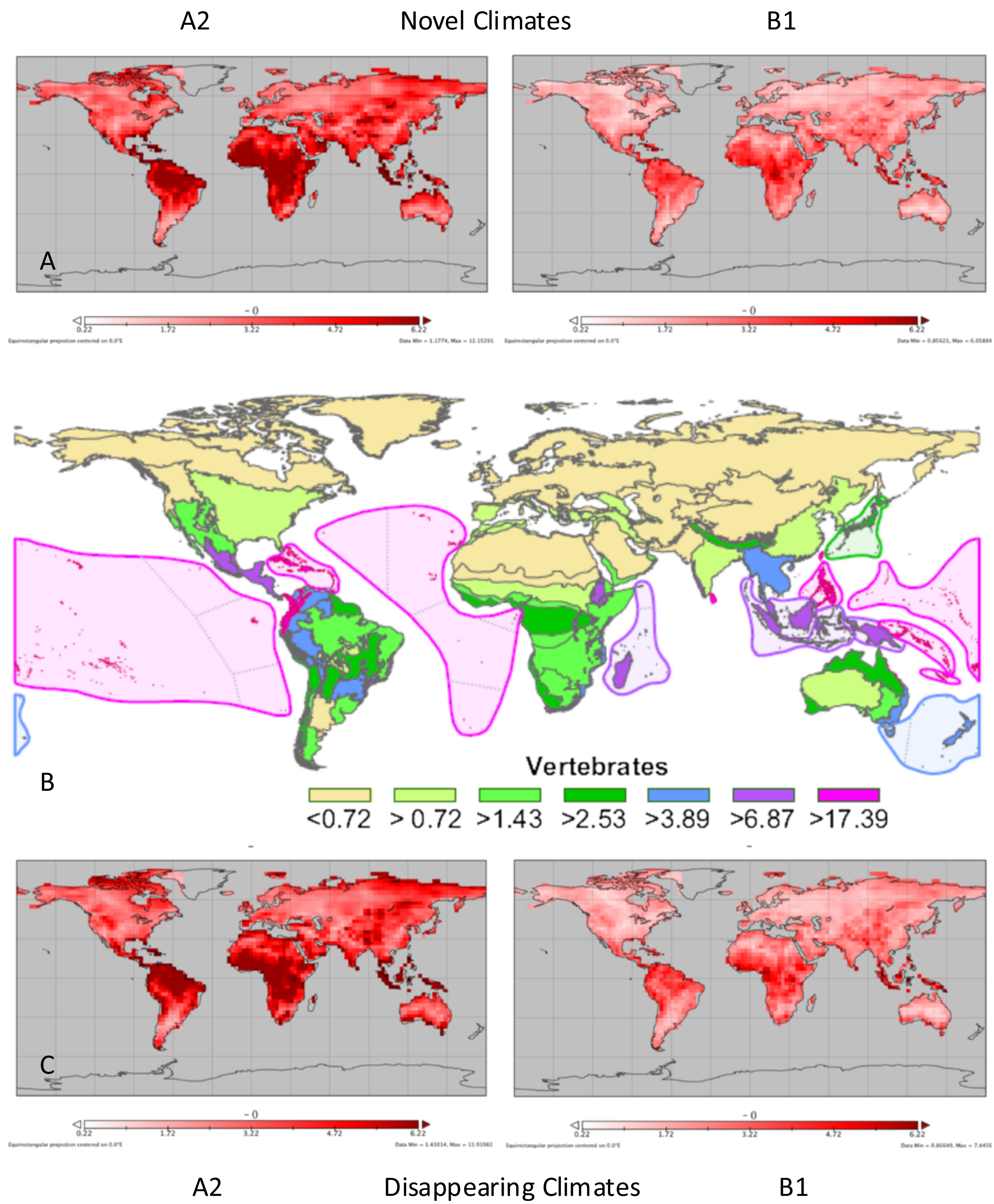


**Figure 1 Global probabilities of development of novel climatic conditions, global rates of endemism and species richness of vertebrates, and global probabilities of disappearance of existing climatic conditions.** Global probabilities of development of novel climatic conditions by 2100 **(A)**; darker shading indicates higher probability, under scenarios of development of high (A2) and mid-range (B1) atmospheric $CO_2$ concentrations (modified from ref. [9]). **(B)** Global rates of endemism and species richness of vertebrates; the spectrum from pale tan, through green and blue, to red indicates increasing endemism and richness (modified from ref. [10]). **(C)** As in **(A)**, but global probabilities of disappearance of existing climatic conditions by 2100 (modified from ref. [9]).

highest vertebrate species endemism and richness across the Tropics (Figure 1B) [10], threatening niche disappearance for these specialists [11].

The potential for synergisms arising from changes in human access and increased efficacy of wildlife harvest resulting from climate change, and climate change itself, in the dynamics of wildlife populations is currently underappreciated. In arctic Alaska, human exploitation of Pacific walrus is vulnerable to adverse climatic conditions [12], while stranding of walrus on shorelines after unexpectedly early and rapid sea ice retreat, reported twice in the past several years, may leave them more vulnerable to exploitation or harassment [13]. In northeast Greenland, recent increases in numbers of narwhal harvested annually do not apparently relate to increased effort but instead to increased ease of access by hunters to narwhals in Smith Sound, likely as a result of changing sea ice conditions [14]. As well, any climate-change induced enhancement in human access to remote regions of the Arctic for mineral and other natural resource exploration and extraction is likely to increase wildlife disturbance and avoidance, especially for culturally and economically important species such as caribou and their predators [13,15,16].

Across much of the Tropics, vertebrate hunting by humans is already unsustainable and, in many areas, is the single greatest threat to the persistence of large mammals and birds [17]. Indeed, abundant populations of large mammals in tropical forests are for the most part now confined to either the few well-protected national parks [18,19] or areas that are still sufficiently remote to have limited hunting pressure [20]. Yet an increase in the annual number of dry days expected to occur in tropical forests in the Brazilian Amazon, West Africa, and Southeast Asia [21] is likely to increase human access to currently remote areas [22]. Rates of deforestation in the Amazon, for instance, increase with dry season severity [23]. Relatedly, seasonal transportation disruptions [24], as documented in several tropical African countries as well as in India, will likely be reduced as rainy seasons become drier, potentially improving human access to remote forests or increasing the economic feasibility of logging. Resultant increases in human population pressure, or in hunting associated with logging [25], may exacerbate hunting impacts on tropical vertebrates. This threat may be particularly pronounced at the margins of protected areas, where human population growth rates and consequent pressure on wildlife are already much greater than in rural regions away from protected areas [26].

Improved hunting access to remote areas due to tropical drying will likely have pronounced and immediately negative consequences for large-bodied mammals that are a major focus of conservation. A recent individual-based model of red howler monkey population dynamics indicates that increased human access to unprotected areas resulted in disproportionately large increases in population losses per unit area, increases in male turnover in troops, and increases in infanticide, thereby increasing local extinction risk [27]. Although not directly related to climate change, this example illustrates the potential consequences for species of conservation concern of increasing human access to unprotected areas. Moreover, the population dynamics of several species of neotropical primates, including red howler monkeys, display negative co-variation with the El Niño Southern Oscillation [28]. This suggests that interactive effects of increased hunting access to such species coupled with direct effects of tropical warming will be devastating, potentially pushing them past thresholds beyond which they cannot recover.

We urge policy makers, wildlife managers, conservation organizations, and international development agencies to place priority on developing strategic plans that foresee increased human access to remote regions as a near-term consequence of climate change. We urge this because increased human access to remote regions potentially poses a threat to wildlife species of conservation concern that are already under pressure from climate change and exploitation in the Arctic and Tropics [7,28]. Establishing policy that limits human access to and development of currently remote regions as a means of buffering the effects of climate change on wildlife may, in turn, reduce the risk of exacerbating climate change through wildlife extinction [29]. We advocate a reevaluation of the process of assigning protected area status to account for such risks.

## Review

### Climate change, increasing human access, and conservation risk in the Arctic and Tropics

In the Arctic, warming is anticipated to increase accessibility of near-coastal and remote marine zones of all eight arctic nations, through loss and thinning of sea ice, by up to 28% by the middle of the 21st century, in addition to reducing traverse times of these zones over the same period [30]. The United States Navy estimates that a continued reduction of annual minimum sea ice extent will increase the navigability of arctic waters, resulting, over the next decade, in as many as 175 open-water days in the Bering Strait, and 45 open-water days in the Northern Sea Route and Transpolar Route [31]. By the middle of the 21st century, diminishing September sea ice extent is expected to increase substantially the frequency and feasibility of trans Arctic Ocean voyages for common open-water vessels [32]. Hence, shipping activity is expected to increase in offshore and remote marine zones across the Arctic, further increasing access to coastal regions and marine wildlife habitat. Simultaneously, expected temperature increases under

IPCC Scenario A2 have the potential to affect habitat of species of conservation concern, such as the ivory gull (*Pagophila eburnea*), polar bear (*Ursus maritimus*), walrus (*Odobenus rosmarus*), and narwhal (*Monodon monoceros*) in southeastern Greenland; and ivory gulls, polar bears, and narwhal in northeastern Canada, where category I or II International Union for the Conservation of Nature (IUCN) protected areas are currently lacking (Figure 2A).

Moreover, current climatic conditions are expected to disappear under IPCC Scenario A2 over broad regions of northeastern Russia and the Canadian Arctic Archipelago and to disappear in several locations currently inhabited by the ivory gull, including within the Canadian Arctic Archipelago, Novaya Zemlya, the Svalbard Archipelago, and off the eastern coast of Greenland (Figure 2). In the Canadian Arctic Archipelago, there currently exist no protected areas under IUCN categories I, II, V, or VI within the zones of disappearing climates, and neither Greenland nor the Canadian Arctic Archipelago currently contains IUCN category Ia sites (Figure 2). The ivory gull is listed on the

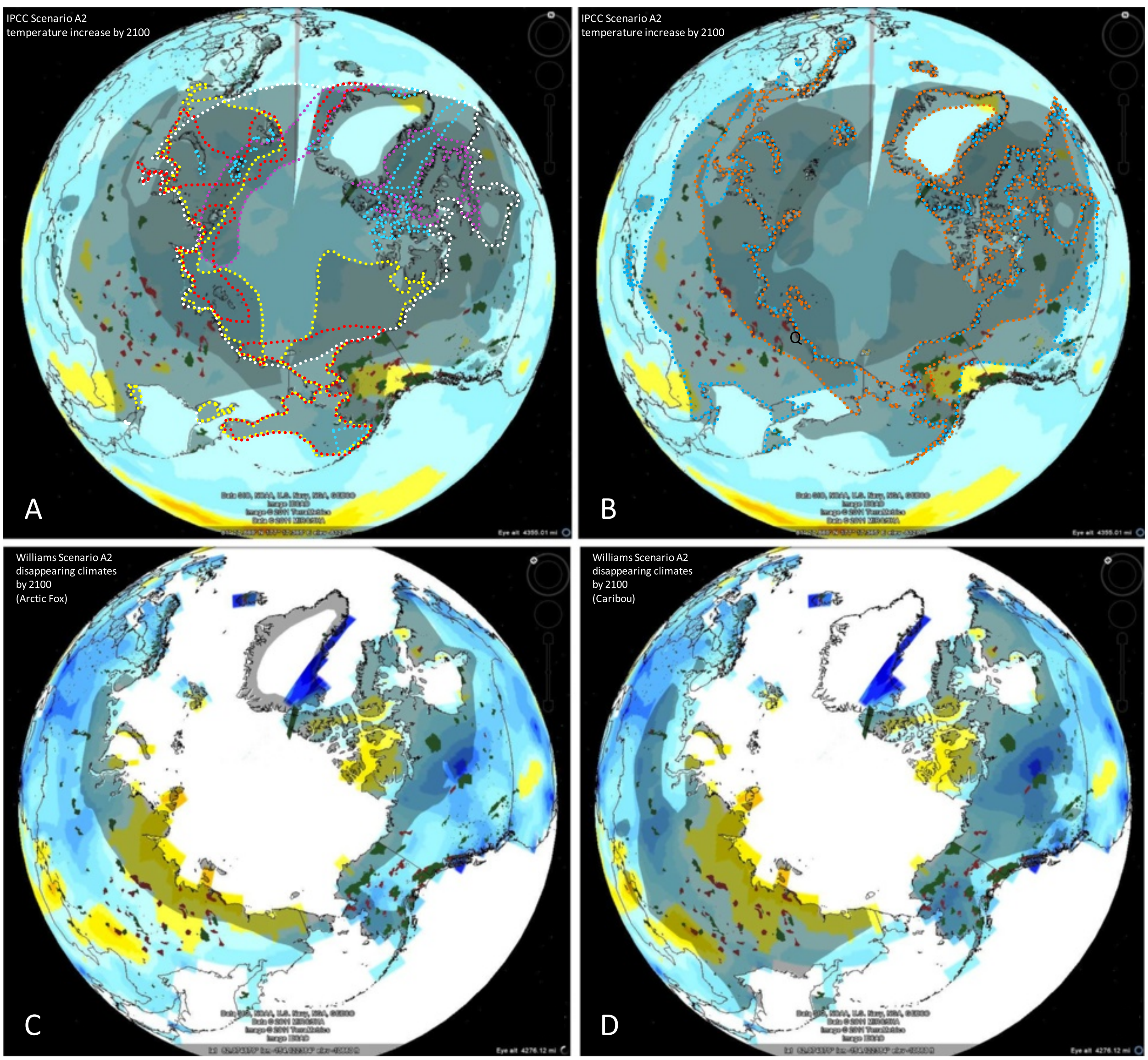


**Figure 2 Distributions of species of conservation concern in the Arctic, overlain by maps of projected local temperature change under IPCC Scenario A2 (A, B), and maps of probability of disappearance of existing local climatic conditions from ref. [9] under the same scenario (C, D), by the year 2100.** Marine and coastal species ranges indicated in panel **(A)** include the walrus (red), beluga whale (yellow), narwhal (purple), ivory gull (light blue), and polar bear (white). Distributions of two terrestrial species, arctic fox and caribou, are indicated by gray shading in panels **(C)** and **(D)**. Current IUCN protected areas in category I or II, and in category V or VI, are shaded green and red, respectively. Maps produced in part using Google Earth.

IUCN Red List as near-threatened and in severe decline [33]. The extremely limited distribution of this species, combined with the prospects for development of novel climatic conditions and disappearance of existing climatic conditions, together with the near absence of strictly protected areas throughout its distribution, signal the potential for elevated extinction risk to it. The inclusion of the beluga whale (*Delphinapterus leucas*) on the IUCN's list of climate change flagship species also indicates that improved protected status is needed for areas within its distribution at risk of undergoing loss of current climatic conditions, such as the Russian and Canadian arctic archipelagos (Figure 2). As well, the IUCN Red List notes that the Pacific walrus subspecies may be at pronounced risk because of sea ice loss along coastal margins and due to increased human access to haul-outs in coastal areas [33]. The lack of IUCN protected areas in categories I and II along Alaska's central arctic coast and along the entire arctic coast of Russia, where the probability of disappearance of current climatic conditions is highest, should be of particular concern with regard to this species, especially considering the potential for increased shipping activity as sea ice diminishes.

In the Tropics, climate change may exacerbate human pressure on remote forested regions already at risk of increased use for livestock farming and mineral extraction. Since the 1980s, forest buffers around 70% of 198 IUCN categories I and II areas, those with the highest conservation status, have declined due to deforestation, and 25% of IUCN categories I and II areas lost forest cover within their boundaries [34]. These losses were greatest in South America and Southeast Asia and occurred primarily in dry tropical forests [34], suggesting that drying due to warming in the Tropics may facilitate further deforestation. Road construction is also expected to be facilitated in the Tropics by warming and consequent drying and may, in turn, leave forest fragments additionally vulnerable to climate change [35]. Roads built for official infrastructure projects in the Tropics also catalyze the construction of unofficial roads, further exacerbating deforestation [35]. In Brazil, for instance, unofficial roads have expanded by a factor of four since 2001 and now account for more than 80% of the entire road network in the state of Pará [36]. In the southwestern Amazon alone, road building and associated land use is estimated to reduce forest cover and mammalian species diversity by 67% and 40%, respectively, by 2050 [35].

In the Southeast Asian tropics, regions of expected temperature increase over the next century under IPCC Scenario A2 display considerable overlap with the distribution of species such as the critically endangered Sumatran orangutan (*Pongo abelii*) and the endangered Malayan tapir (*Tapirus indicus*) on Sumatra (Figure 3A). The Sumatran orangutan, in particular, appears at great risk due to its extremely restricted distribution. Only three IUCN category Ia protected sites, with the highest level of biodiversity conservation, currently exist on Sumatra, with a single one of these within the distribution of the Sumatran orangutan. The Malayan tapir will likely also face increasing pressure because of the fragmented nature of its distribution combined with the lack of IUCN category I or II protected areas within its distribution on the Malay Peninsula, where temperature increases are also likely to be pronounced (Figure 3A). The scattered and fragmented distribution of tigers (*Panthera tigris*) in southeast Asia, together with a minimal distribution of protected areas, appears to be of greatest concern in Vietnam, Cambodia, and northeastern- and southwestern India, where temperature increases will be greatest (Figure 3A). Disappearance of current climatic conditions under IPCC Scenario A2 is most likely throughout Sumatra, the Malay Peninsula, and southern Vietnam and Cambodia, overlapping nearly completely the distributions of all three species in those regions (Figure 3B).

Among neotropical species, the greatest threats of expected temperature increases over the next century to species such as the endangered Baird's tapir (*Tapirus bairdii*), Colombian woolly monkey (*Lagothrix lugens*), and the jaguar (*Panthera onca*) are likely to arise in northwestern Colombia, where only one IUCN category Ia site is currently found (Figure 3C). Jaguars may also be at risk in eastern Ecuador and northwestern Peru, where very few protected areas fall within the region of greatest expected temperature increase, only one of which is of IUCN category Ia (Figure 3C). Even greater risk to all three species may stem from the high likelihood of disappearance of current climatic conditions throughout the distributions of these species (Figure 3D). The Colombian woolly monkey is unique among these three species in the extent of IUCN category I or II protected areas within its distribution, while Baird's tapir currently exists under the least protection throughout Central America (Figure 3C,D), where there are currently but five IUCN category Ia sites.

## The current process of protected area assignment

The International Union for the Conservation of Nature (IUCN) has outlined a process of assignment of protected area status under guidelines that operate downward through a hierarchy of objectives. These begin with identification of management objectives, assessment of the site's compatibility with the IUCN's protected area criteria, and documentation of the site's characteristics and justification for status as a protected area. Subsequently, a proposed management category is assigned for local governmental consideration [37]. The categories of IUCN protected areas range along a spectrum from strictest protection of biodiversity (category I) to sustainable management and human extraction permitted (category VI). Admittedly, the IUCN does foresee an increasing need to account for

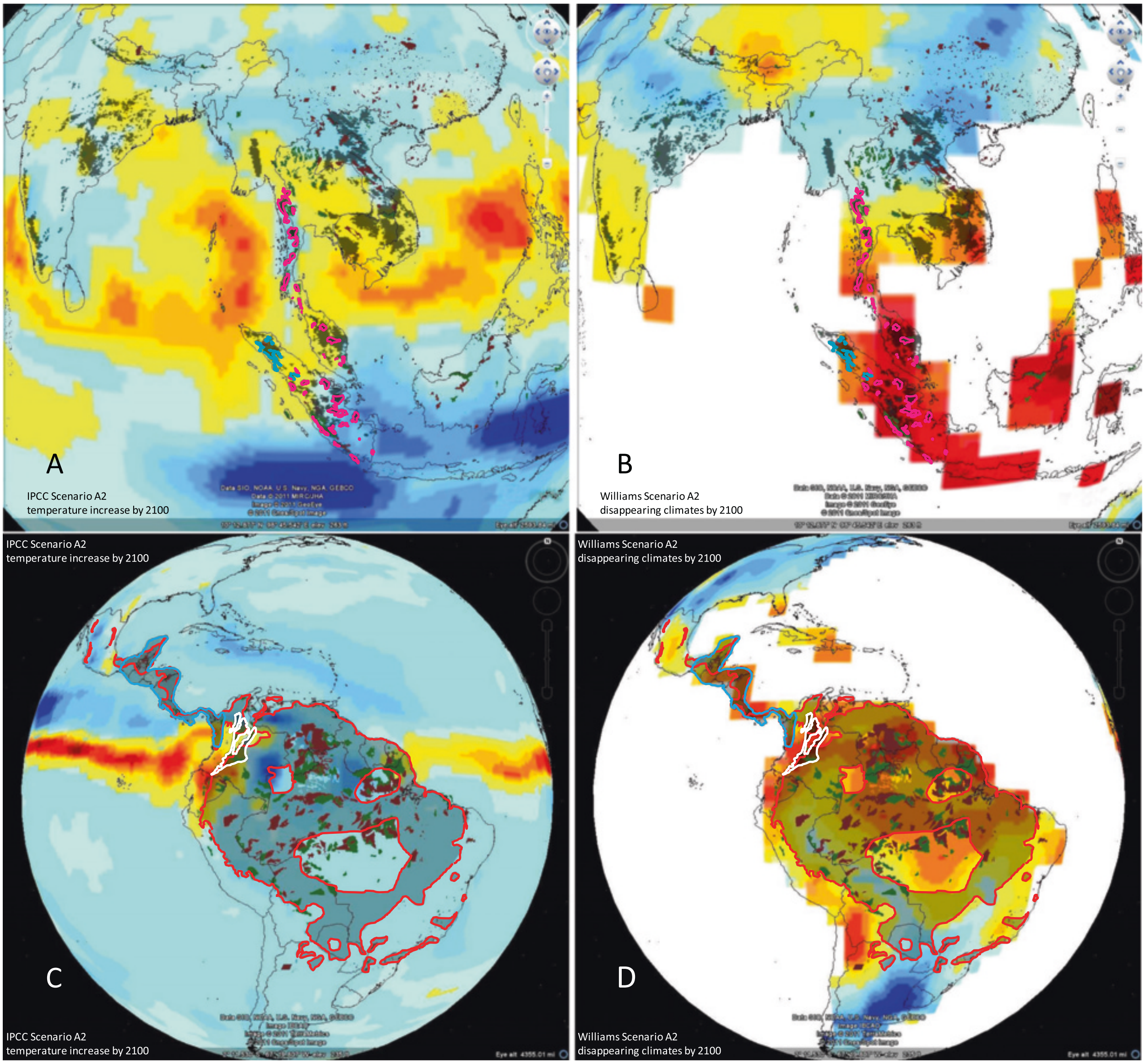


**Figure 3 Distributions of species of conservation concern in the Tropics, overlain by maps of projected local temperature change under IPCC Scenario A2 (A, C), and maps of probability of disappearance of existing local climatic conditions from ref. [9] under the same scenario (B, D), by the year 2100.** Species in the Asian tropics **(A, B)** include the Malayan tapir (pink), Sumatran orangutan (blue), and tiger (gray). Species in the Neotropics include Baird's tapir (blue), Colombian woolly monkey (white), and jaguar (red). IUCN protected areas in category I or II, and in category V or VI, are shaded green and red, respectively. Maps produced in part using Google Earth.

climate change impacts in this decision making process and the assignment of protected areas among these categories. However, this need is currently focused on such actions as species translocations, habitat management (which would necessitate increasing application of category IV assignments), and re-assignment of cultural landscapes currently under category V status to category I status as they become unsustainable for human use and are abandoned by humans in response to climate change [37]. Hence, the existing process of protected area assignment does not take into account the potential for habitat loss due to the interaction between climate change and *increasing* human land use, pressure, and wildlife exploitation.

We suggest that the IUCN's adaptive decision making process will be improved by explicitly accounting for the risks posed by increased human access to remote wildlife habitat in regions of high endemism resulting from climate change, rather than solely from expectations of reduced human use. As described above, the Arctic and Tropics appear poised to develop novel climates and to lose existing climates, within the 21st century, resulting in loss of wildlife habitat. The development of novel climates may also, however, promote the suitability of wildlife habitat in areas that are currently unsuitable for some species and which therefore currently lack protected status. We recommend that the IUCN and conservation ecologists engage more directly with geophysicists, geographers, and climate scientists to improve understanding of the complex interactions among disappearance or evolution of climates, resultant changes in human access to remote areas, and consequent erosion of existing—or development of new—wildlife habitat. Consultation with social scientists, with expertise on local cultural perspectives and how these may or may not shift in response to changing access to remote regions with climate change, is also highly recommended.

Implementing measures to elevate the status of existing protected areas, and to establish new ones, may prove to be an essential component of wildlife conservation in anticipation of climate change. In tropical West Africa, for instance, it is estimated that elevating the status of 12 of 16 existing key biodiversity areas to IUCN category I–IV sites would enhance the protection of 13 of 14 threatened species of large mammals endemic to that region [38]. We also focus here primarily on mammals of cultural and conservation interest in the Arctic and Tropics. Human access to remote areas in both regions is expected to be highly responsive to climate change, and mammals worldwide exhibit high rates of endemism [39]. Furthermore, large mammals are at greatest risk among the 20% of extant species considered vulnerable to extinction [40].

## Conclusion

Wilderness protection is essential to the conservation of biodiversity but must embody an adaptive process to be effective in the face of changing pressures [41]. Recent consideration in the United States Congress of House Resolution 1581, the Wilderness and Roadless Area Release Act of 2011, is a relevant example of legislation that has the potential to increase human access to remote regions of the U.S. Arctic. This resolution would have released "public lands administered by the Bureau of Land Management (BLM)…that have not been designated as wilderness and identified by BLM as not suitable for designation as wilderness from further study for wilderness designation". Such legislation should be informed by the risk to wildlife conservation posed by the nexus between increased access and climate change to the persistence of many species of conservation concern.

We recommend that policy makers, wildlife managers, conservation organizations, and international development agencies place priority on developing strategic plans that foresee increased human access to remote regions as a near-term consequence of climate change, and one that poses an immediate threat to wildlife species of conservation concern that are already under pressure from climate change and exploitation in the Arctic and Tropics [7,28]. In this context, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) may perform a valuable service as a catalyst and mediator in discussions between the IUCN, local stakeholders, and conservation and climate change scientists. Previously, the IPBES has been effective in engaging partners such as United Nations agencies, non-governmental organizations, and local governments in implementing and fronting scientific input into the process of drafting policy that relates to biodiversity conservation. For instance, a recent report sponsored by such multi-organizational networking highlighted the importance of tailoring the management and conservation of habitats and species, respectively, toward specialized intervention where necessary to reduce the risks of multiple stressors, in particular by eliminating human stressors on the most threatened species within protected areas [42]. This approach poses the benefit of suggesting that protected area status in, for example, IUCN categories V and VI, need not be interpreted rigidly when the conservation risks of climate change in human-access areas become imminent, leaving room for intervention aimed at protecting entire populations of species at risk without upgrading the status of the protected area of concern.

We also recommend revising the status of extant IUCN protected areas, including upgrading categories V and VI areas to categories I and II in areas at risk of developing novel or disappearing climates over the next century. This would increase restrictions on human access to and use of such sites where they overlap with distributions of species of conservation interest. Such species might include, for example, those with the most limited distributions and fewest protected areas within their current distributions where these overlap with disappearing current—and novel forthcoming—climatic conditions. Examples include establishment of new category I or II sites within the range of the ivory gull and Pacific walrus in the Arctic and establishment of additional category I sites within the ranges of the Sumatran orangutan, Malayan tapir, Baird's tapir, and Colombian woolly monkey in the Tropics where none currently exist. Although we are unaware of any studies demonstrating explicitly that category Ia sites maintain or promote biodiversity conservation more effectively than categories III, IV, or V sites that permit human use, we argue that the former should be more effective simply because inaccessibility to humans is one of the most effective means of preserving biodiversity in any natural area [22].

The biodiversity benefits of protected areas are highly dependent upon effective management, but ensuring that protected areas are appropriately classified will ensure that the necessary range of options is available to management personnel. Establishing new protected areas in regions of endemism of species at risk of experiencing loss of current climatic conditions may be preferable to upgrading the status of existing protected areas because obvious risks and obstacles to the strategy of upgrading the status of protected areas might undermine such efforts. These include establishing a precedent for altering protected area status that might result eventually in downgrading some existing categories I and II sites to categories permissive of human exploitation. Additionally, they include challenges inherent to local enforcement of changes in protected area status and lags in the implementation of such changes deriving from protracted policy discussions involving numerous stakeholders. In the shorter term, more comprehensive analyses of the intersection between novel and disappearing climates and lack of protected areas for other species will highlight additional priorities. Establishing and enforcing policy that limits human access to and development of currently remote regions as a means of buffering the effects of climate change on wildlife may, in turn, reduce the risk of exacerbating climate change through wildlife extinction [29] as well as buffer affected ecosystems from loss of diversity-related stability and resistance to disturbance [42,43].

### Abbreviations

BLM: Bureau of Land Management; IPBES: Intergovernmental Platform on Biodiversity and Ecosystem Services; IPCC: Intergovernmental Panel on Climate Change; IUCN: International Union for the Conservation of Nature; ppm: Parts per million.

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

Both authors contributed equally to the conceptual development of this review and its writing. Both authors read and approved the final version.


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