REVIEW

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The performance and potential of protected areas

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Originally conceived to conserve iconic landscapes and wildlife, protected areas are now expected to achieve an increasingly diverse set of conservation, social and economic objectives. The amount of land and sea designated as formally protected has markedly increased over the past century, but there is still a major shortfall in political commitments to enhance the coverage and effectiveness of protected areas. Financial support for protected areas is dwarfed by the benefits that they provide, but these returns depend on effective management. A step change involving increased recognition, funding, planning and enforcement is urgently needed if protected areas are going to fulfil their potential.

The past few decades have seen protected areas undergo a pronounced expansion, geographically and conceptually. The collective decisions of governments, publicly funded bodies and local communities have created the rapid growth of protected areas throughout the world[1]; land and sea management has seldom changed so quickly over such a large area (Fig. 1). At the same time, as many natural ecosystems fragment[2], the expectations placed on protected areas by a growing diversity of stakeholders have dramatically increased. Protected areas are now created not only to conserve iconic landscapes and seascapes and to provide habitat for endangered wildlife, but also to contribute to the livelihood of local communities, to bolster national economies through tourism revenues, to replenish fisheries and to play a key part in the mitigation of, and adaptation to, climate change, among many other functions[3]. Importantly, these new demands are in addition to, rather than as a replacement for, earlier motivations, necessitating trade-offs between competing objectives[4,5]. Although the expanded role of protected areas may have fuelled their establishment, their constantly changing focus makes them vulnerable to accusations of failure to achieve one or more of these objectives.

In this Review we explore the extent to which the potential of the global protected area estate is being met and outline the ways in which performance can be improved. We first discuss how broad objectives for protected areas have changed over the past century and how this has corresponded with substantial growth in the global protected area estate. We provide evidence that protected areas — when they are well managed and targeted at threats that they can abate — can deliver a wide range of benefits: protecting magnificent landscapes and seascapes, achieving biodiversity conservation and delivering essential ecosystem services. But we show that the current coverage of the global protected area estate is still well short of meeting core 2020 targets outlined in the Convention on Biological Diversity (CBD)[6]. We explore key issues that are affecting protected area effectiveness and provide recent examples of what seems to be a backslide in commitment by some nations through the defunding, downscaling and delisting of protected areas. Given the key role of protected areas in many social and environmental agendas, the current targets set for conservation and development, and the reduced political commitment in some countries, we conclude this Review with a call for a step change in support for the global protected area estate.

The protected area movement

Protected areas are not a modern concept. In different forms, they have been around for millennia, whether they are sacred sites guarded by indigenous communities, 'tapu' areas for communal resource use in the Pacific island region or hunting areas set aside to benefit the ruling classes[7]. Over the past century the modern concept of protected areas has been developed and refined, and the global protected area estate has grown extremely rapidly, from a handful of sites at the turn of the twentieth century to more than 162,000 legally designated (statutory) national protected areas, covering more than 28.4 million square kilometres (or 5.6% of Earth's surface)[1] (Fig. 1; see Supplementary Methods for details of protected area calculations). The amount of land now found in statutory protected areas comprises a total area greater than that of South and Central America, and the amount of sea comprises a total area greater than that of the Caribbean Sea, South China Sea, Mediterranean Sea and Bering Sea. These numbers are further augmented by many additional protected areas that are not included in the official tally — those established by local communities, indigenous peoples, private individuals, non-profit trusts, religious groups and even corporations[8] — some of which, such as indigenous territories in the Amazon basin, can themselves be extremely large[9].

The modern protected-area movement had its nineteenth-century origins in North America, Australia, Europe and South Africa, where protected areas were mainly set up to protect spectacular natural features and wildlife[10], principally in areas with little potential for economic use[11]. Although many were set up with the dual mandates of landscape and species protection and public use, it was not until around the middle of the twentieth century that tourism inside protected areas accelerated[12]. In some developing countries, the income associated with protected areas is of national significance[13]; in Rwanda, tourism revenue from visits to see mountain gorillas inside Volcanoes National Park is now the country's largest source of foreign exchange, raising US$200 million annually[14].

Emerging concern over environmental degradation in the last quarter of the twentieth century influenced motives for establishing protected areas[15]. Recognition of the importance of *in situ* conservation led to a marked expansion of the global terrestrial protected area estate in the 1970s as countries moved to establish protected area networks where species and ecosystems could be conserved from the rapid changes

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taking place elsewhere (Fig. 1). The decision to use protected areas as a core conservation strategy seems to be well justified: recent reviews have concluded that, most of the time, well-managed protected areas reduce rates of habitat loss (the chief threat to biodiversity[16]) in both terrestrial[17,18] and marine[19,20] environments. There is also strong evidence that protected areas maintain species population levels (including threatened species) better than other management approaches[17,21–25]. For example, well-managed marine protected areas (MPAs) have been found to contain more than 5 times the total large fish biomass and 14 times the shark biomass compared with fished areas[20], and a study of 60 terrestrial protected areas in the tropics found that when they are well managed, there is a positive outcome for biodiversity[26]. This protection also extends to species that have high financial value and are under intense pressure from well-organized criminal groups[27,28].

However, because of the rapid growth of protected areas in the latter half of the twentieth century, the contact that local communities had with them increased. At times this growth was in conflict with the needs of local communities and with efforts to address poverty and increase economic development[29,30]. This resulted in widespread criticism of management practices in some protected areas by those concerned with human rights. During this period, management priorities began to shift towards greater recognition of the rights of local communities regarding the governance of the areas in which they live; many protected areas now have management regimes that engage local communities and consciously seek to balance conservation with local livelihoods[31]. In addition, the part that protected areas play in poverty alleviation and fostering economic development in the surrounding communities gained increased attention, and there is now evidence of positive contributions in many regions[4,32,33].

During the past two decades we have witnessed a greater emphasis on the role that functioning ecosystems have in maintaining human societies[34]. Well-managed protected areas can provide crucial ecosystem services, including water, food security, protection of wild relatives of crops, maintenance of wild fish stocks and carbon storage[35–38]. As populations urbanize, the role that protected areas have in providing clean water for cities is increasing: a third of the world's 100 largest cities rely on protected areas as a significant source of drinking water[39]. Protected areas are also now seen as a crucial component of global climate change mitigation efforts[38], and are likely to play an increasingly important part in REDD+ (reducing emissions from deforestation and forest degradation, plus the conservation, sustainable management and enhancement of forest carbon stocks) schemes.

Although there is a strong global consensus within the conservation community that the principal role of protected areas is nature conservation[40], in practice they are expected to make much wider ecological, social and economic contributions to human society. It is not yet clear what the overall impact of these increasing demands on protected areas will be or whether additional demands will arise in the future[4].

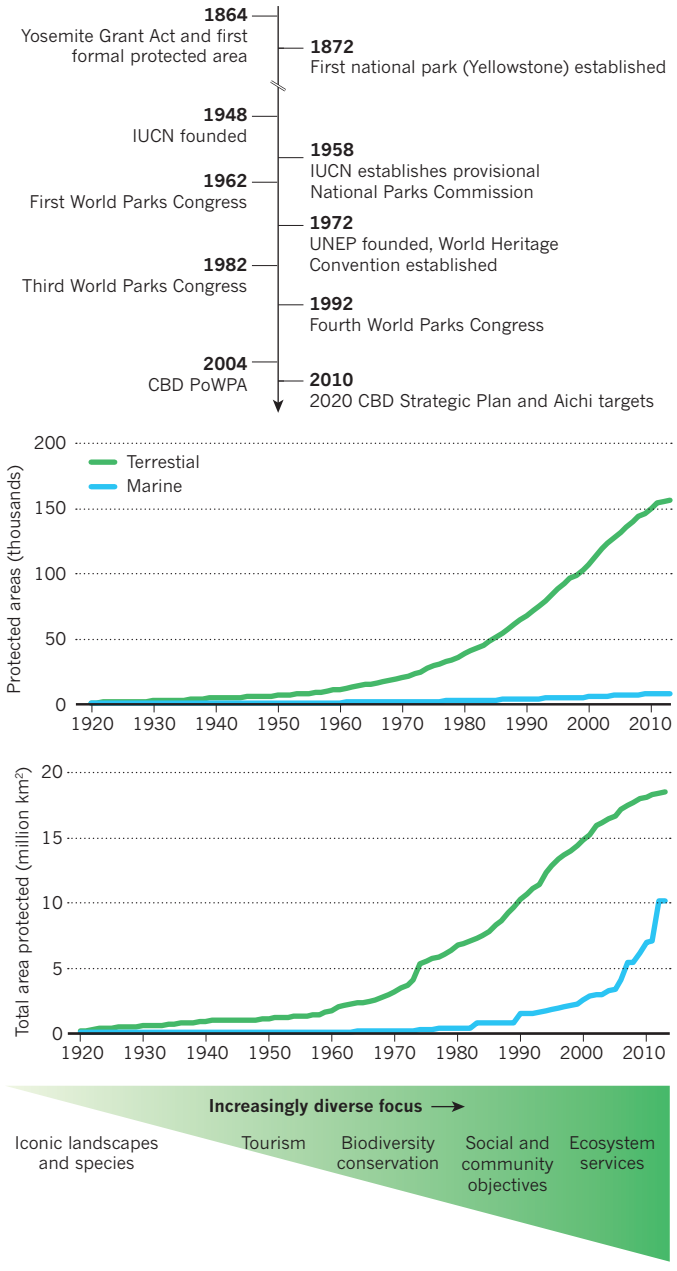

Figure 1 | Growth of the modern terrestrial and marine protected area estate. Growth in protected areas is aligned with a series of key events that have signalled an expansion of objectives over the past 150 years, starting with the establishment of the first formal protected area in 1864 (see Supplementary Table 1). New and increasingly diverse focal objectives have added to, rather than replaced, pre-existing objectives so that the requirements for management of protected areas have expanded over time. The growth was calculated using data obtained from the World Database on Protected Areas[1].

Coverage and targets for terrestrial protected areas

As of April 2014 (ref. 1), the official global portfolio of nationally designated terrestrial protected areas numbered 155,584 and covered 18.4 million km^2, or 12.5% of the terrestrial realm (Supplementary Methods). This is still well short of the current CBD target of 17%[6], a figure that has grown from 10% since the 2000–2010 strategic plan, but is still a political compromise that many conservation scientists believe is too low[41]. The shortfall is larger still when you consider CBD guidance that states protected areas should target places of "importance for biodiversity" that are "ecologically representative"[6]. At broad ecological scales, coverage markedly varies between major terrestrial biomes and ecoregions[42]. Using the latest available data[1], we found that only 300 terrestrial ecoregions (36%) have more than 17% coverage, with 237 regions (29%) having less than 5% coverage and 68 (8%) having less than 1% coverage (Fig. 2a). When finer-scale analyses are conducted to assess whether protected areas are being placed in areas important for conserving species, the same patterns of variability occur. Among key biodiversity areas (KBAs)[43], only 28% of Important Bird Areas (sites identified as crucial for bird biodiversity) and 22% of Alliance for Zero Extinction sites (sites that hold more than 95% of the global population of an endangered species[44]) are adequately covered by existing protected areas[16]. A recent global analysis of all threatened birds, amphibians and mammals (n = 4,118) found that 17% are not found in a single protected area and 85% do not have sufficiently large populations in protected areas to give them a reasonable chance of long-term survival[45]. In comparison, a decade ago 20% of globally threatened terrestrial birds, mammals and amphibians were not found in a single protected area and 89% were inadequately represented[46].

In the past, the patchy representation of species and ecosystems in

protected areas has often been attributed to weaknesses in planning methods[47]. But these new analyses show that significant additions to the terrestrial protected area estate over the past two decades (Fig. 1) have not significantly lessened biases towards higher elevations, steeper slopes, and lands of lower productivity, lower economic worth and low human density[48]. Progress in achieving ecological representation has almost come to a stop, and this is likely to have serious ramifications when it comes to threats such as climate change[49,50].

Coverage and targets for marine protected areas

Progress towards the CBD's target of 10% of coastal and marine areas being protected[6] has been much slower than progress towards their terrestrial equivalent (Fig. 1). The goal is also much less ambitious than the 15–20% target proposed by non-governmental organizations (NGOs) and other groups attending the 2010 CBD Conference of the Parties. The tradition of open access to marine systems is a possible reason why it has taken longer for MPAs to be embraced than terrestrial protected areas. However, growth rates have been increasing since the World Summit on Sustainable Development in 2002 (ref. 51), and it is estimated that the 7,318 MPAs cover about 10.1 million km^2 (or 3%) of the world's marine environments[1]. Most designated MPAs have been restricted to national waters, with MPAs now covering about 6.6% of delimited exclusive economic zones globally[52]. The recent trend towards establishing very large (greater than 100,000 km^2) MPAs is accelerating the expansion of global coverage: a recent analysis found that ten existing or under-creation MPAs account for more than 53% of the world's total MPA coverage[53]. Although large and remote MPAs may be important for maintaining functioning marine ecosystems, they will not avert imminent and direct anthropogenic threats in populated, coastal waters in which pressures on biodiversity often remain intense[53]. With these biases in mind, it is unsurprising that only 46 (20%) of the 232 marine ecoregions have more than 10% coverage and 107 ecoregions (46%) have less than 1% coverage (Fig. 2b). To our knowledge, there has been no fine-scale global analysis of MPA coverage of species or important marine biodiversity areas; this means there is a significant shortfall in our understanding of protected area gaps in the marine realm.

Protected area effectiveness

Beyond achieving a percentage protected area coverage in the marine and terrestrial realm, the latest CBD targets[6] also call for protected areas to be effectively managed. Although systematic research into protected area effectiveness is still in its infancy, there are global studies that point to a significant shortfall in effectiveness — only 20–50% of protected areas assessed were found to be effectively managed[26,54,55]. These global averages mask even more critical situations in some ecosystems, and there are now many examples of protected areas not achieving basic objectives. For example, a recent assessment of coral reefs within MPAs in the western Pacific Ocean's Coral Triangle found that only 1% were effectively managed[56], and research examining vegetation loss in protected areas in South Asia has shown that the trajectories of habitat conversion rates inside protected areas are sometimes indistinguishable from those of unprotected lands[57]. There is also evidence that threatened species populations inside some protected areas are declining[58], including charismatic fauna such as lions (*Panthera leo*)[59], Sumatran rhinoceros (*Dicerorhinus sumatrensis*)[60] and African elephants (*Loxodonta africana*)[61].

Even some globally renowned protected areas, formally designated as UNESCO (United Nations Educational, Scientific and Cultural Organization) World Heritage Sites, have been shown to have experienced serious ecological degradation, partly due to poor management effectiveness. Australia's Great Barrier Reef Marine Park, for example, has experienced significant degradation, with large declines in coral cover in less than 30 years, as well as substantial declines in species populations, and habitat condition and extent across large areas of the park[62,63]. Similarly, Ecuador's Galapagos National Park and Marine Reserve — one of the best-known protected areas in the world — has widespread

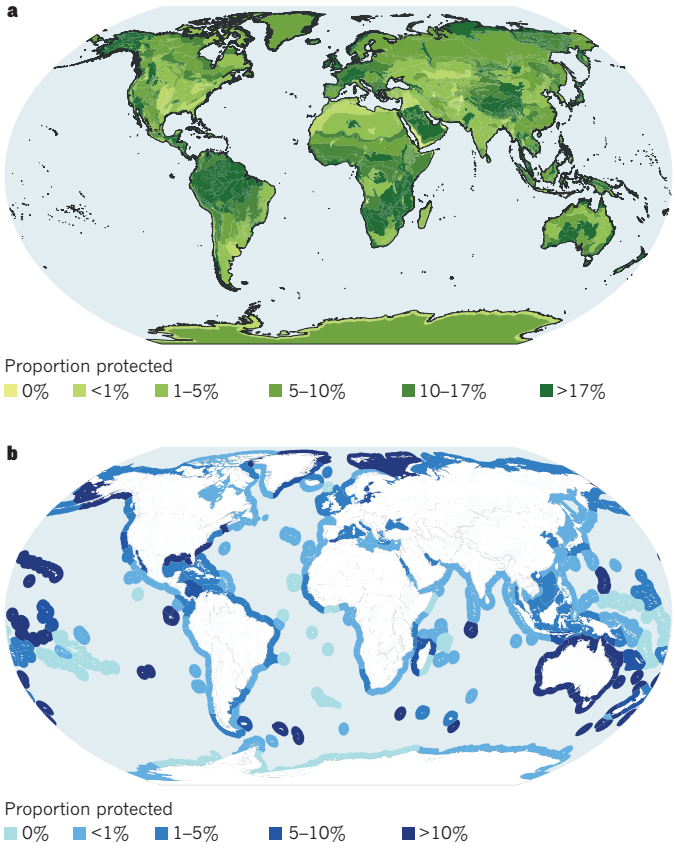

Figure 2 | Percentage of each terrestrial and marine ecoregion represented in the 2014 protected area estate. **a**, The shortfall in protected area coverage of terrestrial ecoregions ($n = 827$) relative to the Convention on Biological Diversity (CBD) target of 17%. As of 2014, only 300 ecoregions (36%) have more than 17% coverage, with 68 (8%) having less than 1% coverage and 237 (29%) of all ecoregions having less than 5% coverage. **b**, The shortfall in protected area coverage of marine ecoregions ($n = 232$) relative to the CBD target of 10%. As of 2014, only 46 (20%) of the marine ecoregions have more than 10% coverage with 107 (46%) having less than 1%. (See Supplementary Methods for details of protected area calculations.)

problems including alien species invasion, population collapse of exploited marine species[64] and declines in ecosystem condition[65].

Under-resourcing of protected area management is the primary reason for poor performance in protected area effectiveness, especially in the developing world[66]. Fewer than 6% of the countries reporting to the CBD in 2003 indicated that resources for management of protected areas were adequate, and it is unlikely this number has improved substantially[67]. A lack of resources affects boundary demarcation, effective law enforcement, natural and cultural resource management, and the provision of adequate park infrastructure, all of which affect protected area performance[54,66]. Effectiveness is further undermined by poor governance quality and bureaucratic inefficiency in many protected areas, alienating stakeholders and eroding support for management decisions[68]. Political corruption and armed conflict also undermines protected areas in many parts of the world, rendering protection efforts ineffective. Addressing these issues is likely to be a pre-condition for successfully instituting other reforms to improve management[69].

Resources currently available for management pale in comparison with the challenges a protected area faces. Underlying pressures such as demographic growth, climate change and human consumption of natural resources, are all increasing, contributing to direct drivers of damage from encroachment, agriculture, infrastructure projects and timber demand[70]. These pressures are on the increase around many protected areas, with important implications for the overall effectiveness of the protected area — there are generally strong, positive correlations

between threats outside and inside protected areas[71]. Mining is now a serious pressure, with a recent global analysis showing that mining activity inside protected areas collectively affects 6% of the terrestrial protected area estate, and mines within 10 km of parks influence 14% of the global estate[72]. In the face of mounting threats, protected-area managers are hampered by the linked problems of insufficient resources, lack of capacity and, in many cases, a poor understanding about how to address the suite of pressures.

Declining support for protected areas

Despite making global commitments towards increasing the size and effectiveness of the protected area estate within the CBD framework[6], there is now significant evidence that some governments are sliding back on their commitment to support protected areas through disproportionate funding cuts, reductions in professional staff and by ignoring their own policies (Fig. 3, Supplementary Table 2). If this is representative of a global trend, many protected areas will be left seriously exposed, especially in the context of pre-existing levels of underfunding and rising threats.

Although more common in developing countries[73], inadequate financing of protected areas is also becoming increasingly prevalent in some of the richest countries, such as Australia, the United States and Canada, where major reductions in staffing levels and funding have been recently observed (Supplementary Table 2). For example, between 2009 and 2013, the US National Parks Service's main operational budget for national parks fell by nearly 13% (excluding the supplemental funding provided in response to Hurricane Sandy)[74]. Chronic underfunding has led to a deferred maintenance backlog estimated at between $9.03 billion and $13.28 billion, which has continued to build over the past decade[74]. In Canada, budget cuts have severely affected the science capacity of Parks Canada; ecosystem-science positions were cut by up to 30%, even though an expert panel, which was set up to review the integrity of Canada's national parks, had identified the need for greater investment in this area to redress what they identified as significant impairments to the ecological condition of protected areas[75].

Arguably, a more intransigent form of protected-area failure is government changes, through policy, that open up sites to resource extraction, or partial or full 'degazettement'. This practice has been labelled protected area downgrading, downsizing and degazettement (PADDD)[76], where downgrading is the legal authorization of an increase in the number, magnitude or extent of human activities within a protected area; downsizing is the decrease in size of a protected area through a legal boundary change; and degazettement is the loss of legal protection for an entire protected area. A recent global analysis of 543 instances of PADDD indicated that all three forms are increasing[77].

Most instances of PADDD have occurred in developing countries, where demographic changes and demand for land have put pressure on ecosystems, and where governments seek revenue from natural resources to meet development needs. It is not uncommon for the ministries responsible for mining or logging to issue leases on land or water that are already designated as protected. For example, in Uganda, active oil exploration and development is occurring inside protected areas, including the western portion of Murchison Falls National Park and inside three wildlife reserves that contain threatened species such as lions and Rothschild's giraffe (*Giraffa camelopardalis rothschildi*)[78]. Examples of downsizing include the World Heritage Sites the Selous Game Reserve in Tanzania, which was reduced to allow for uranium mining, and the Virgin Komi Forests in Russia where significant boundary changes to reserves such as the Yugyd Va National Park were made to allow mining (Supplementary Table 2). These are not isolated cases; a review of oil and gas concessions and protected areas in sub-Saharan Africa found that concessions overlapped park boundaries in 17.3% of International Union for Conservation of Nature (IUCN) category I–II sites and in more than a quarter of world heritage sites[79].

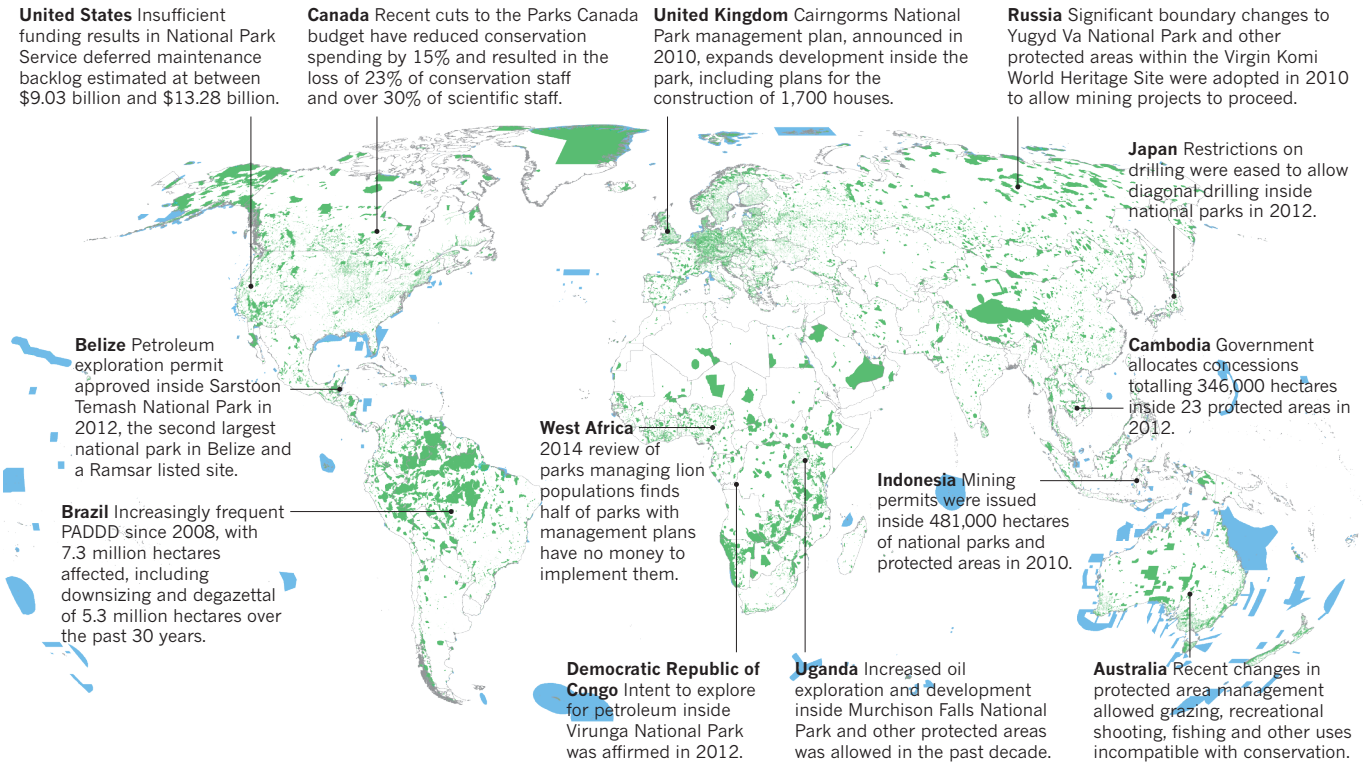

Figure 3 | A global portrait of different forms of decline in government support in terms of protected areas. Here we provide examples of recent (defined as the past 10 years) decisions made by governments that are leading to a decline in the effectiveness of protected area estates within countries. The blue and green areas show the spatial extent of the global protected area estate as of April 2014 (ref. 1). Examples are well-documented instances of this retreat; it should be noted that many more examples remain poorly documented. More information and additional examples are provided in Supplementary Table 2. PADDD, protected area downgrading, downsizing and degazettement.

Full degazettement is a more unusual form of PADDD, but is also on the increase (Fig. 3; Supplementary Table 2): the Arabian Oryx Sanctuary in Oman was removed from the World Heritage List after the government reduced the size of the reserve by 90% to allow for oil and gas extraction[80]. Developed countries are not immune to PADDD, as witnessed in Australia in recent years with the opening up of parks to allow industrial logging, livestock grazing, mining, recreational hunting and fishing[81]. In the United Kingdom, a proposed high-speed rail link will damage or destroy ten Sites of Special Scientific Interest, government-recognized protected areas and nine NGO-run Wildlife Trust reserves[82].

The case for a step change

The current biodiversity crisis would be much more severe had the establishment of protected areas in the last century not occurred. But a fundamental increase in support of the global protected area estate is now urgently needed if it is to fully deliver its potential. Countries are still well short of what they formally agreed to do in the 2020 CBD strategic plan[6], and the resources currently provided for protected-area management are, for the most part, insufficient. Many countries are even failing to take adequate steps to maintain what they have already designated for protection. The increasing number of governments overtly or covertly decreasing resources and allowing incompatible use of protected areas sounds a clear alarm bell for current and future performance.

This erosion of support for maintaining and growing the global protected area estate is occurring at a time when anthropogenic climate change, the sudden upsurge in poaching, 'land-grabbing' by powerful businesses and increased mining activity are all making conservation challenges more complex. As human populations grow and pressures on natural ecosystems increase, more species and ecosystems are becoming predominantly (and in some cases, completely) confined to protected areas. These include large, threatened mammals such as the Asian elephant (*Elephas maximus*)[83], the tiger (*Panthera tigris*)[27] and all rhinoceros species[84], but also numerous plants, reptiles and amphibians[44,85]. At the same time, large-scale anthropogenic modification of natural ecosystems means that protected areas are now crucial for sustaining a large proportion of the world's poorest people by providing them with life's most basic subsistence necessities — food, water, shelter and medicine[3].

A business-as-usual approach, by which most countries do not provide adequate resources to ensure effective management of protected areas and undervalue the need for continued expansion of the protected area estate, means that the broad goals of the estate will fail. A fundamental step change is needed to ensure both the current and future potential of the estate is met.

First, countries need to create management regimes for existing protected areas that ensure they are effective together with policies that support protected-area systems. Management outside protected areas can, and must, make crucial contributions to securing the future of biodiversity, but this is in no way a replacement for the clear benefits that protected areas provide, especially with respect to conserving KBAs[43]. Crucially, policies should be aligned within government so that the actions of ministries dealing with development, resource extraction and agriculture do not undermine those of ministries concerned with the environment and conservation. Much progress could be achieved simply by implementing approved policies on protected areas that have already been established through multilateral environmental agreements such as the CBD, the Ramsar Convention on Wetlands and the World Heritage Convention, as well as implementing the IUCN's guidance on the definition, management objectives and governance types within protected areas[40]. Adopting the legal principle of non-regression when it comes to environmental laws is also an important action that countries can take[86]. Another part of the step change is for countries to acknowledge that the widening expectations of protected area systems, along with growing pressures on protected areas, increase the burden for all those involved in management and requires improvements rather than declines in policy and resource support.

Second, countries need to invest adequately in protected areas to ensure that their objectives are achieved. Part of this is recognizing the return on investment that well-managed protected areas provide by conserving natural heritage and increasing the social and economic well-being of their citizens[4,87]. Countries need to start quantifying the services provided by protected areas and recognizing the costs of protected-area degradation — it should be noted that many of the benefits will not easily be measurable in monetary terms. In Australia, the 2012–13 budget for the Great Barrier Reef Marine Park Authority was approximately Aus$50 million, but tourism to the reef was worth more than Aus$5.2 billion annually to the Australian economy[62]; this income is seriously threatened by the current degradation of the reef. In 2009, the Canadian government spent Can$800 million, but the contribution to the economy was Can$4.6 billion and supported the employment of 64,000 people[75]. A better understanding of the returns on investment would help to persuade countries of the need to provide resources to protected areas that better match the benefits received. In the Eastern Arc Mountains in East Africa, one-third of protected areas do not receive the minimum funds necessary to be effective reserves, even though it would only require reinvestment of 13% of the revenue raised through protected area tourism in Tanzania to fully fund the protected area estate[88].

There is ample evidence to justify more state support of protected areas. But good arguments do not always translate into large amounts of financial resources, and conservation is often an early casualty of any government funding squeeze. As a consequence, the third component of the step change is to accept the fact that governments will often not supply sufficient financial resources for protected areas and that there is a need to identify innovative models for ensuring protected area success; in other words, to encourage the wider community to take collective responsibility for protected areas. Non-conventional funding sources (philanthropic contributions, and payments for ecosystem service mechanisms such as REDD+) have the potential to be crucially important future alternative funding sources, as do mechanisms such as offsets and 'debt-for-nature swaps' from the corporate sector[89]. All these options need careful appraisal and, where appropriate, more strategic application; we know that some of them can work in some places, but they are currently applied very sporadically[90,91]. In addition to broadening the funding base of protected areas, the next required change of approach is for a similar explosion in management collaborations. Building resilient social constituencies that advocate on behalf of protected areas and biodiversity conservation requires the formation of coalitions across local, national and international actors (government, NGO, business and community groups) across the political spectrum; yet too little attention has been paid to the requirements of building a political constituency that will underpin long-lasting commitments to conservation[92]. At the site scale, volunteers can provide a substantial resource for managers of protected areas, filling roles ranging from those involving site maintenance to anti-poacher patrols, and there is evidence to show that properly planned voluntary efforts can be harmonized with professional activities to produce the desired management outcomes[93]. For example, partnerships between protected area agencies and scientists can bridge research and monitoring gaps in a mutually beneficial way, and citizen science can not only provide information for managers but also build a supportive and hopeful constituency for conservation[94–96].

Finally, most countries still need to expand their protected area networks to meet CBD obligations and the pressing needs outlined in this Review. The challenges of achieving this on an increasingly crowded planet should not be underestimated. It will require countries to embrace transparent planning frameworks to identify the new areas needed to achieve the objectives outlined clearly by the CBD, rigorous stakeholder consultation, imaginative application of a range of management approaches and then acting on plans and monitoring results transparently. A key element is to expand reporting beyond simply the area of land and seas gazetted to include ecological connectivity, management

effectiveness, equity, social and economic benefits, and the contribution of the system to conserving areas that are important for biodiversity.

The package of responses needed for the step change is neither impossible nor unreasonable, although individual countries may struggle with some of the components. Fundamentally, it requires the recognition that protected areas are core to the future of life on our planet. Estimations of the annual cost of adequately managing an expanded network of marine and terrestrial protected areas range from $45 billion to $76 billion[97,98], the lower of which is just 2.5% of the global military expenditure[99]. But adequate protection of marine and terrestrial environments is also crucial to global security. It seems sensible to invest an amount equivalent to a tiny percentage of global military spending to help provide security for humans and all other living organisms on Earth through a system of marine and terrestrial protected areas that is operating at its full capacity. Although we need to understand and report on the performance of protected areas, we also need to focus on the promise and potential they provide for the well-being of the planet and its inhabitants. ■

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