Target 11: Protected Areas

By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Preface

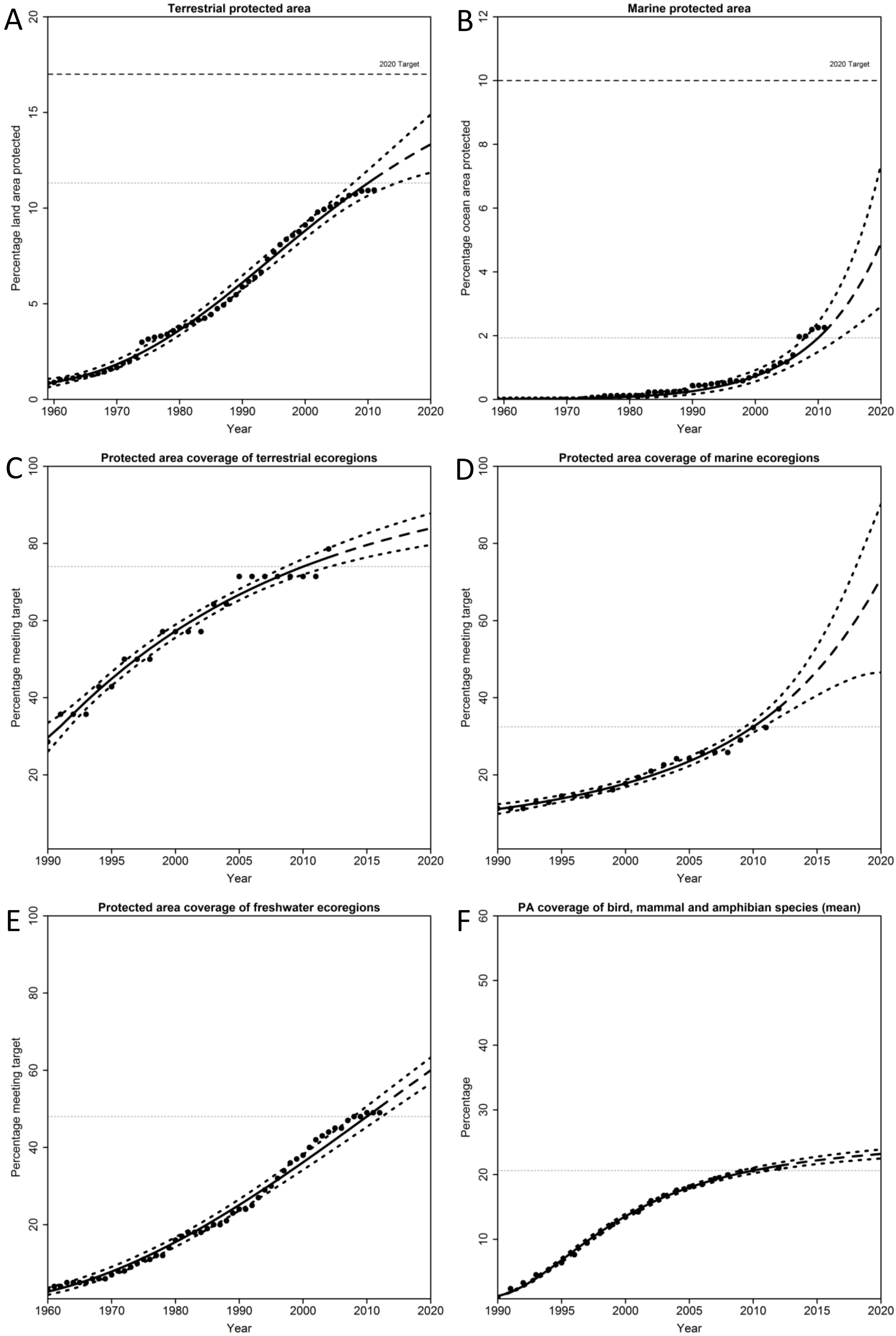
This analysis looks at protected area (PA) coverage, both geographically and in terms of ecological representation (using ecoregions). The use of ecoregions to assess ecological representativeness of protected areas ignores the considerable ecological variation within these regions, but addressing this shortcoming was beyond the scope of this work. It also explores protected area effectiveness, in terms of management inputs and biodiversity outcomes, taking into account climate change-induced changes in protected areas representativeness in longer term scenarios. Preliminary analyses are also presented on equitable management. Freshwater environments are accorded a relatively large degree of attention given their areal coverage. This is because freshwater environments are poorly represented in terms of data, assessments and protection, and because of the added complexities of these systems given their inherent connectedness.

1. Are we on track to achieve the 2020 target?

1.a. Status and trends

Protected area coverage has increased rapidly in recent years on land and in the sea (Fig 11.1 A, B). Protected areas coverage continues to grow, although rates have slowed somewhat in recent years (Fig 11.1 A, B).

In 2011, 10.9% of global land area was covered by protected areas. In January 2011, 49 of the parties to the CBD (23%) had exceeded the target of protecting 17% of terrestrial areas.


A
Terrestrial protected area
2020 Target
Percentage land area protected
Year
B
Marine protected area
2020 Target
Percentage ocean area protected
Year
C
Protected area coverage of terrestrial ecoregions
Percentage meeting target
Year
D
Protected area coverage of marine ecoregions
Percentage meeting target
Year
E
Protected area coverage of freshwater ecoregions
Percentage meeting target
Year
F
PA coverage of bird, mammal and amphibian species (mean)
Percentage
Year

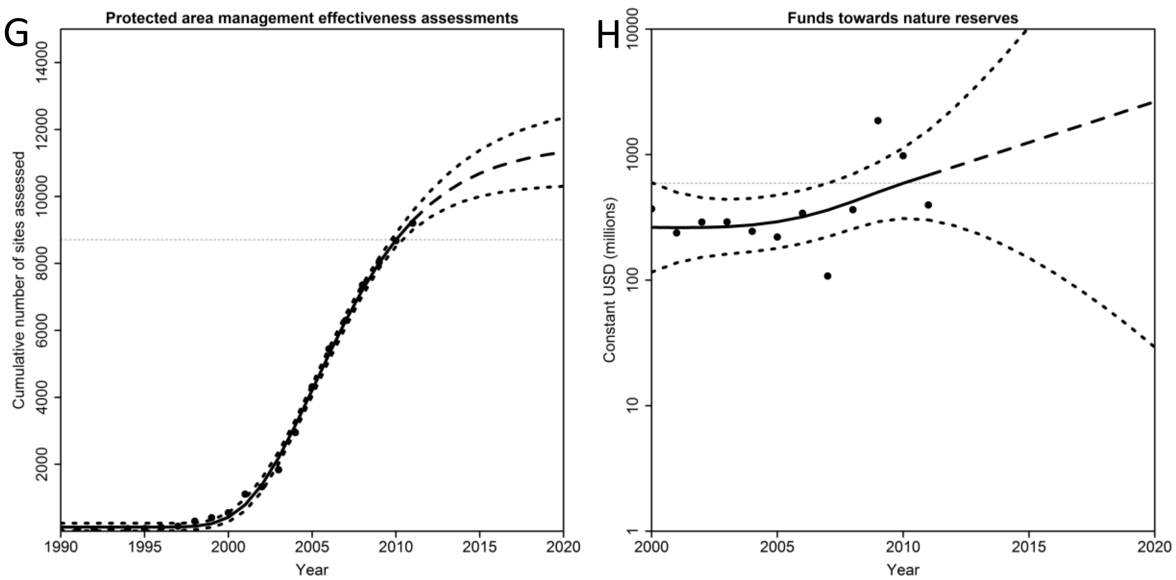


Figure 11.1. Recent trends and extrapolations to 2020 in the cumulative percentage of global terrestrial (A) or marine (B) area covered by terrestrial and marine protected areas; in the percentage of terrestrial (C), freshwater (D) and marine (E) ecoregions that meet a threshold level of protection (17% for terrestrial; 10% for marine and freshwater); in the coverage of the distributions of bird, mammal and amphibian species by protected areas (F); in the global cumulative number of protected area management effectiveness assessments (G); and in funding for protected areas (H). Data from recent trends are indicated by points, continuous lines indicate the fit to data, dashed lines are extrapolations to 2020 and dotted lines indicate the 95% confidence intervals. Data are from the World Database on Protected Areas (WDPA) (A-B); S. H. M. Butchart et al. (unpublished data) (C-F); J. Geldmann et al. (unpublished data) (G); and AidData (http://aiddata.org/) (H). Extrapolations are based on the assumption that underlying mechanisms continue to follow trends. Methods for model fitting are described in the introductory chapter.

In 2011, 2.3% of global marine surface area was represented by protected areas. Since 2010, the number of countries and territories which have 10% or more of their marine jurisdictional area incorporated into marine protected areas increased from 12 to 28 (Spalding et al. 2013). On the other hand, 111 out of 193 countries and territories worldwide (including landlocked countries) have less than 1% MPA coverage (Spalding et al. 2013). It should be noted that only a small number of MPAs are responsible for most of the existing global MPA coverage (DeVillers et al. 2014). Furthermore, conservation progress may not be as great as it appears because many MPAs are placed where they minimise conflict with stakeholders, rather than where biodiversity is most threatened (DeVillers et al. 2014). The majority of MPAs are situated within jurisdictional waters, and MPA coverage of high seas waters remains low (Spalding et al. 2013).

Establishment of high seas MPAs is limited because the international legal framework currently has inadequate enforcement mechanisms for ensuring compliance with conservation and management regulations in areas beyond national jurisdiction (Kimball 2005). Extensive protection of the high seas only began in 2010, with the declaration of the South Orkney Islands Southern Shelf MPA and six OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) MPAs in the North Atlantic (Spalding et al. 2013) The need for conservation of biodiversity in the high seas was recognised at the

2012 UN Conference on Sustainable Development, at which government leaders considered the possible development of a new legal instrument under the UN Convention on the Law of the Sea (Ban et al. 2013). While there is, as yet, no global agreement to establish MPAs in areas beyond national jurisdiction (Kimball 2005), the UNGA has called for the protection of vulnerable marine ecosystems in the high seas[1]. Importantly, some authors have noted the need for more ecologically representative systems of MPAs in areas beyond national jurisdiction (Ban et al. 2013; Freestone 2012). For instance, the Global Open Oceans and Deep Seabed Biogeographic Classification system classifies open oceans and deep sea habitats within and beyond the continental shelf (UNESCO 2009).

In 2010, 17% of the world's total river length was protected. The evaluation of protection afforded to inland waters is more complicated than simply summarizing the total area protected. Given the longitudinal nature of rivers and streams, and their interconnections, it is important to consider not only the total area or length of inland waters protected, but to also quantify the amount of river or stream protected upstream (Abell et al. 2007; Linke et al., 2007; Nel et al., 2007; Januchowski-Hartley et al. 2011). Reporting on the protection of inland waters has been hampered by this complexity, and to the best of our knowledge no comprehensive assessment of national level protection of inland waters exists. Globally, 69% of rivers have no protected areas in their upstream catchment, and only South and Central America have greater than 10% of total upstream catchment area protected (with 26% in South America and 12% in Central America; Lehner, B. et al., unpublished data). Regions with the lowest percentage of river length protected include Asia and North America (11 and 12% protected, respectively), while the poorest protection of upstream catchment area is in Europe and the Middle East, and North America (less than 7% protected; Lehner, B. et al., unpublished data).

Protected area coverage has also represented a growing number of the world's ecoregions: currently 55% of terrestrial ecoregions and 37% of marine ecoregions have at least 10% coverage (Figure 11.1 C, D) and 7% of terrestrial and 7% of marine ecoregions have at least 75% coverage (Butchart, S. H. M. et al. unpublished data). On the other hand, 7% of terrestrial and 28% of marine ecoregions have less than 1% coverage of protected areas (Butchart, S. H. M. et al. unpublished data); 49% of freshwater ecoregions have at least 10% coverage (Fig. 11.1 E), but 8% of freshwater ecoregions have less than 1% protected area coverage (Januchowski-Hartley unpublished data). Many of the poorly protected freshwater ecoregions occur in areas of North America, islands in the Pacific Ocean, and in xeric or endorheic basins where inland waters are often temporary. Protected area coverage varies widely across ecoregions (Fig. 11.2).

[1] Protection of VMEs was first called for in Res 59/25 and subsequently reaffirmed by additional resolutions, most notably Resolutions 61/105 and 64/72: UNGA Resolution 59/25 (paragraphs 66 – 69) http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N04/477/70/PDF/N0447770.pdf?OpenElement; UNGA Resolution 61/105 (paragraphs 10, 80-83, 88-90) http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N06/500/73/PDF/N0650073.pdf?OpenElement; UNGA Resolution 64/72 (para 77, 113-117, 119-123, 124, 126) http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N09/466/15/PDF/N0946615.pdf?OpenElement

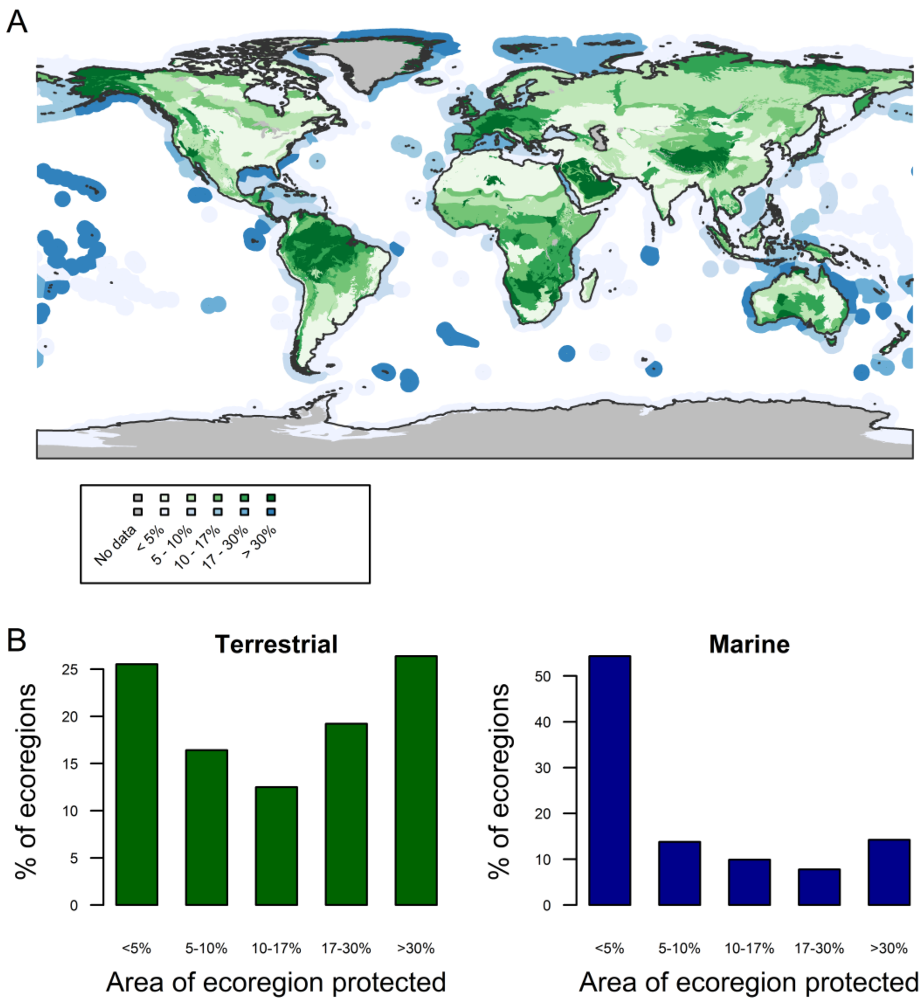


Figure 11.2. a) Percentage coverage by protected areas of marine and terrestrial ecoregions; b) percentage of ecoregions with different percentage coverage by protected areas. Coverage data were supplied by Stu Butchart, from Butchart, S. H. M. et al. (unpublished data). Ecoregions are from WWF.

Areas of particular importance for biodiversity have been increasingly well represented over the last 100 years. 23% of AZEs and 22% of IBAs fall entirely within protected areas (cross-reference to Target 12). Sites of importance for biodiversity are often ignored in national protected area expansion plans and have not always been targeted by recent protected area designations. However, as noted in section 1.c. there are many countries that have developed plans to address gaps in their protected area systems, including plans to improve coverage of areas of high importance for biodiversity. Approximately a quarter of all AZEs and IBAs currently fall entirely within protected areas (data from Stuart Butchart), but global rates of declaration of these areas are declining compared with non-priority areas (Butchart et al., 2012; Cantú-Salazar et al., 2013). The coverage of the distributions of bird, mammal and amphibian species by protected areas has increased rapidly over the last two decades and now stands at 37.5%, although the rate of increase has slowed (Figure 11.1 F). For freshwater environments, the Amazon River is one of the best protected in the world with greater than 25% of its total river length protected (Lehner, B. et al., unpublished data). The protection afforded in the Amazon Basin is important for the security of freshwater biodiversity as it supports the highest number of freshwater species (Collen et al. 2013).

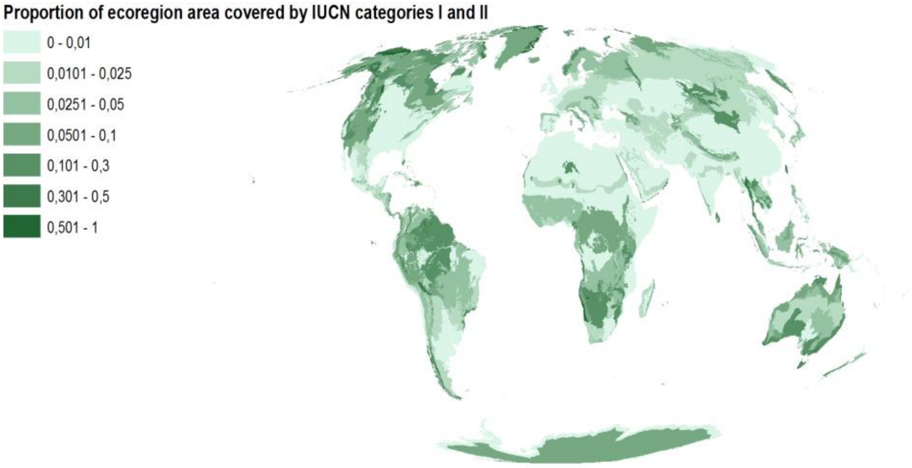
However, basins in the Southeast United States and Southeast Asia also support high levels of freshwater biodiversity (Collen et al. 2013), but have less than 10% of total river length protected, and in a number of cases (e.g. coastal basins along the Gulf of Mexico) have less than 5% of river length protected. In addition, many of these basins with high species richness and low protection are subject to high levels of human impact (e.g. Vorosmarty et al. 2010), suggesting the need for further protection and conservation actions to mitigate these stressors (see Chapters 5 and 8).

Begin Box 11.1 Global coverage of IUCN protected areas

Along the IUCN range of protected areas management regimes, categories I (Wilderness area and Strict nature reserve) and II (National Park) offer the strictest levels of protection, whereas the categories III to VI (Natural monument, Habitat management area, Protected landscape, Managed resource protected area) allow for higher levels of human intervention and even certain levels of resource use. As a result, the distribution of protection levels reveals different socioeconomic contexts, opportunity costs and historical perspectives across the world.

For instance, North America pioneering of national parks is still visible in the high coverage that protected areas of category I and II have, particularly in the Western part of the continent (Figure 11.3). Conversely, Europe has focused in the last decades on protected areas managed for specific species or habitats (European Council, 1979, 1992). Additionally, cultural aspects related to rural lifestyles are emphasized in the management plans of many European protected areas. Reflecting this context and associated policy options, ecoregions in Europe present a higher coverage of protected areas of categories III-VI than of categories I-II, and in several ecoregions the protection of wilderness is lower than 2.5% (Figure 11.3).

Some world ecoregions with high categories I and II coverage coincide with low human densities such as the most northern latitudes of North America and much of Australia. But in South America, Sub-Saharan Africa and Southeast Asia, where both conservation efforts and human population pressures are high (Brooks et al., 2006; McKee et al., 2004), we encounter relatively high area coverage for both the strictest IUCN protection categories (I - II) and the looser ones (III - VI) (Figure 11.3).



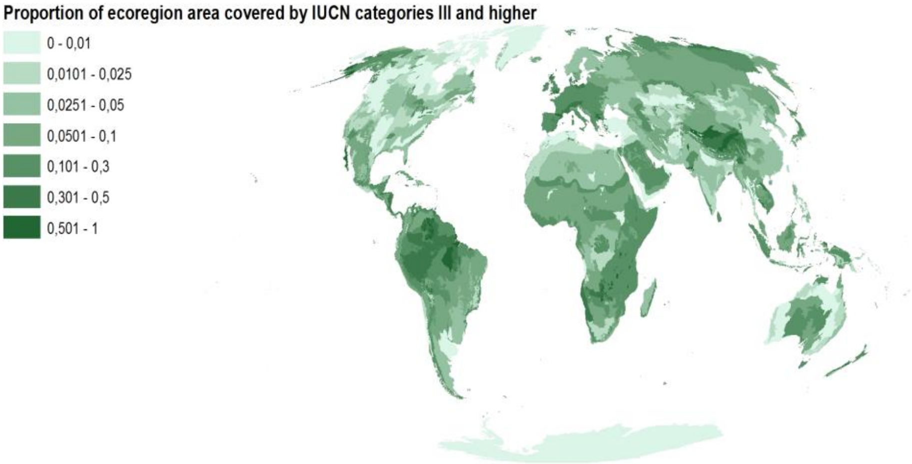


Figure 11.3. The distribution across world ecoregions of protected area coverage in IUCN categories I and II (A) and in IUCN categories III, IV, V, VI and unreported and not applicable (B). Colors represent the proportion of the ecoregion land surface covered by protected areas. Source: World Database of Protected Areas (UNEP/WCMC) and Terrestrial Ecoregions (WWF).

End Box 11.1

It is also important to know the coverage of areas of importance for ecosystem services by protected areas. However, insufficient information exists at present to assess this.

Available evidence suggests that community-based and co-managed (communities with some combination of national or subnational government and/or private company) approaches have increased dramatically in the past 20 years (although to some extent this might represent increased reporting), a trend that seems to be continuing (Blomley et al. 2008; Bowler et al. 2010; Bertzky et al. 2012; Weeks et al. 2010), although data on these Indigenous and Community Conserved Areas (ICCAs) is not comprehensive globally and often not reported by national protected area authorities (Stolton et al., 2014). On average, community managed forests have been shown to more effectively reduce rates of deforestation than the large protected areas officially recognized by IUCN (Porter-Bolland et al. 2012). In the marine realm, Locally Managed Marine Protected Areas (LMMAs) contributed much of the protection afforded to coral reefs, mangroves and sea grasses (Visconti et al., 2013. In Fiji, LMMAs protected 40% of fringing reefs, non-fringing reefs, mangroves, intertidal zones and other benthic substrata (Mills et al., 2011); they are also important in the Philippines, Japan (Makino et al., 2009) and elsewhere in Southeast Asia. Locally managed freshwater protected areas, common across areas of Southeast Asia and parts of South America, are highly underreported and therefore there are currently no reliable statistics to report. Similarly, private protected areas are also increasing around the world, but there are no reliable statistics on past trends with which to extrapolate into the future.

Assessments of management inputs and actions, as measured using various management effectiveness tools (Leverington et al. 2010), have increased dramatically over the past decade (Fig. 11.1 G), with over 8000 sites now assessed and hundreds being added each year, particularly in regions where the Global Environment Facility is actively supporting protected area projects. Results from different protected areas show a very wide range of scores, and a recent assessment of 4100 protected areas designated 13% as having 'clearly inadequate' management, 62% as having 'basic management' and 24% as having 'sound management' (Leverington et al. 2010). However, repeat assessments suggest that management effectiveness scores are generally increasing over time (Leverington et al. 2010). Effective management of protected areas relies, at least in part, on adequate funding. There has been no clear recent trend in funding allocated to protected areas (Figure 11.1 H). There is no global assessment of MPA effectiveness. Many MPAs are less effective than intended due to management problems or poor spatial selection or design (Spalding et al. 2013), and a recent assessment of 1147 coral reef MPAs worldwide found that almost half (47%) were ineffective, while only 15% were considered fully effective, and 38% were partially effective (Burke et al. 2011).

Protected areas will only continue to be effective if species are able to move among them, especially in the face of climate change. For mammals, the level of connectivity in networks of protected areas differs among species groups, because large species move across wide areas and reach protected areas that are far apart (Fig 11.3; Santini, L. et al. unpublished data). The higher level of connectivity in large mammals is not related to the level of threat, which is higher in large than in small mammals notwithstanding. Connectivity is also uneven across continents, with North and South America having the most connected networks. Europe's protected areas – although at a high density – are small on average and so overall connectivity is low. The protected area network in Asia is poorly connected for all mammals, including the highly threatened ungulates and primates. In recognition of this lack of connectivity, there are a large number of initiatives around the word that are aiming to develop corridors between protetced areas to allow movement of animals (and plants). For example, recent work in South Africa has identified that corridor networks that allow long-distance movement of large mammals are important for conserving plant species distributions and long-distance inter-population seed dispersal (Potts et al. 2013). Connectivity between reserves is of particular importance for protecting and maintaining populations of freshwater-dependent species (Pringle, 2001; Fausch et al., 2002; Fullerton et al., 2010; Hermoso et al. 2012; Simaika et al. 2013).

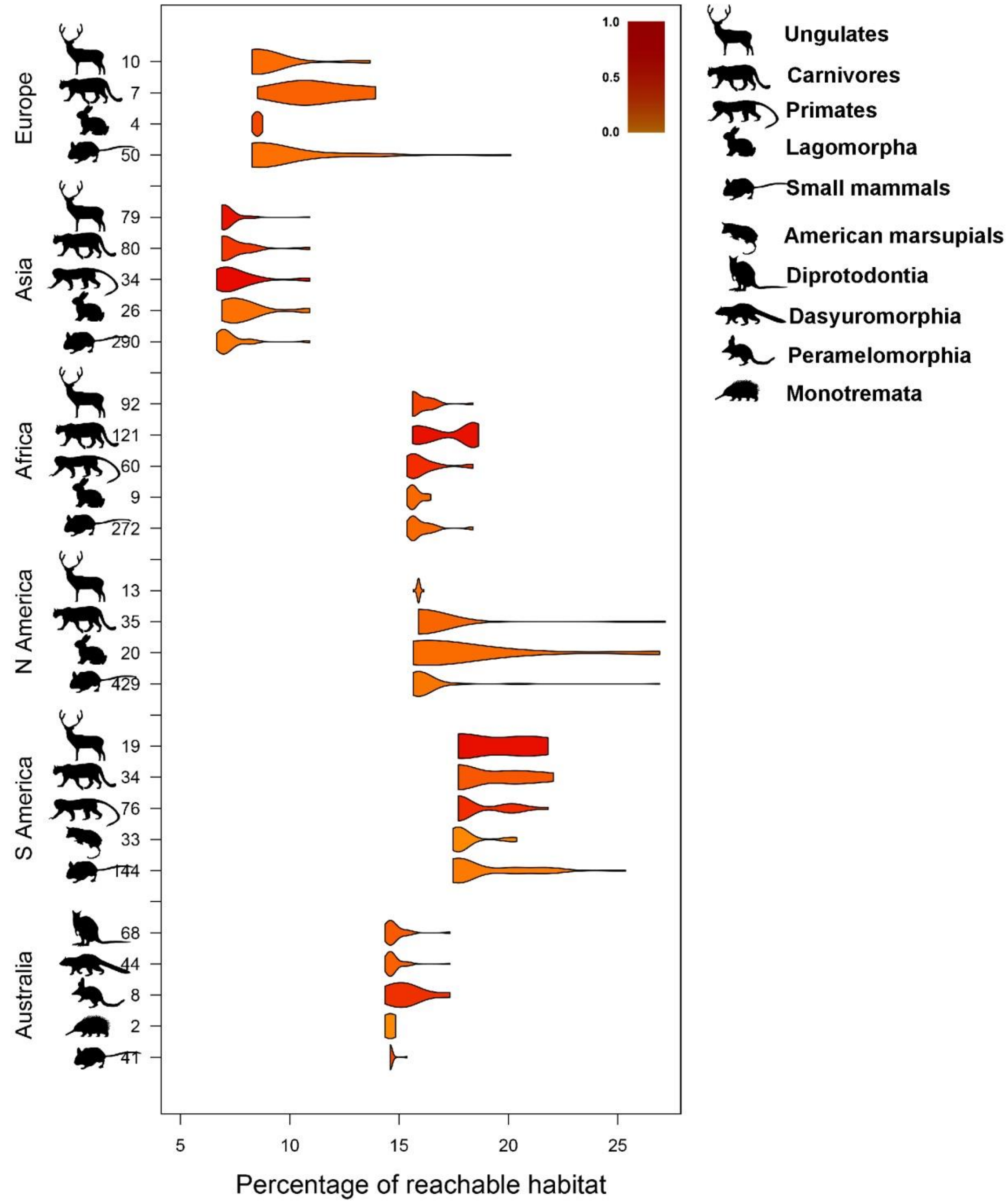


Figure 11.3. Connectivity of Protected Areas for different mammal groups in each continent, measured as percentage of suitable habitat that species can reach within and across protected areas (Santini et al., unpublished data). Numbers of species per continent are reported next to each animal picture; bar thickness represent the proportion of species. Colour shading represents the percentage of threatened species from 0 (yellow) to 100% (red) (see floating bar for colour reference).

1.b. Projecting forward to 2020

Extrapolations of the recent trends in protected areas establishment do not reach 17% of terrestrial areas and 10% of the total marine area protected by 2020 (Fig. 11.1 A, B). However, many countries already have or will by 2020 achieve the 17% Target for terrestrial areas, and if they meet their national targets (UNEP/CBD/WG-RI/4/INF/5), global coverage of protected areas will reach 17.5% by 2020. Similarly, it is unlikely that all ecoregions will meet the sub-target of 10% coverage by 2020 (Figure 11.1 C-E). The coverage of the distributions of bird, mammal and amphibian species by protected areas, and the number of assessments of management actions in protected areas, are not likely to increase substantially by 2020 (Figure 11.1 F, G). More than 80% of the AZE (459 sites) and 70% of the IBA (8106 sites) require additional protection if these critical areas for conservation are to be fully included in the protected area estate (Butchart et al. 2012; see also chapter 12). There is currently no complementary data for inland waters, which limits extrapolation of protection for these systems.

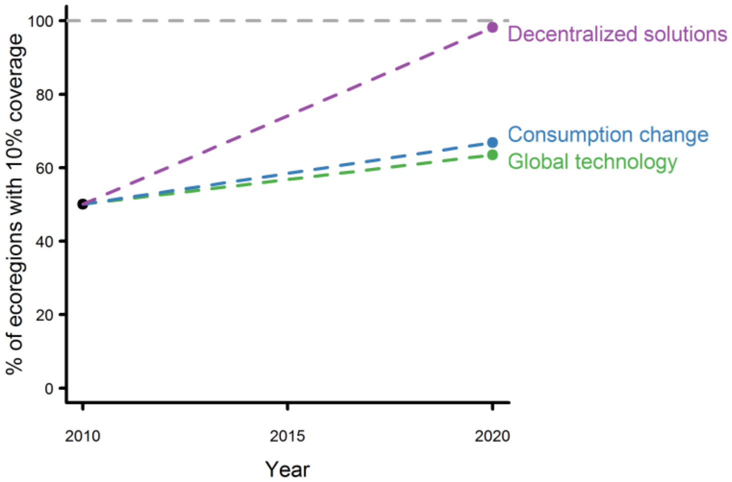


Figure 11.4. Predicted percentage of terrestrial ecoregions having more than 10% coverage by protected areas under the Rio+20 scenarios.

Several socio-economic scenarios have been developed that meet the 2020 target for the terrestrial realm (RIO+20, OECD 17%, Rethinking PA20% and 50%). In these scenarios, the coverage of protected areas is set to meet the target of at least 17% of land surface by 2020 within known socio-economic constraints, showing that achieving the target is realistic. For the Rio+20 scenarios, the best representation of ecoregions is achieved in the Rio+20 'Decentralized Solutions' scenario (Fig. 11.4), which is designed to protect all ecoregions. However, some of the ecoregions will not achieve 10% protection because conversion from agricultural areas to protected areas is assumed to be unrealistic and ecoregions in desert or ice biomes do not need explicit protection. A less geographically balanced effort to increase protected area coverage (Rio+20 'Global Technology' scenario, focusing on protecting 17% of biomes) results in percentages of ecoregions meeting the target that are essentially equal to the current status (Fig. 11.4). Note that these scenarios assume effective management of protected areas, and are based on a different baseline value for 2010 than the status and trends work.

It is far harder to project how management effectiveness will change between now and 2020 owing to a shortage of effectiveness assessments, and our limited understanding of what makes a protected area effective.

1.c. Country actions and commitments[2][3]

Almost all of the national biodiversity strategies and action plans (NBSAPS) examined contain targets, or similar elements, related to protected areas (high). These targets are largely in line with Aichi Biodiversity Target 11 (high). Generally the emphasis of the targets that have been set is on increasing the size of protected area systems (high). A few countries, for example Belgium, Japan and Finland have set targets which call for increases to the size of protected areas similar to what has been set out in Aichi Biodiversity Target 11. However, most countries have not specified a specific quantitative target related to protected area coverage (medium). Further, there appears to be a general focus on terrestrial environments (low). An example which is counter to this trend is Malta, whose protected area target focuses on maintaining its terrestrial protected area coverage and to improve its marine protected areas network. Similarly, England has established as a priority action to have 25% of its waters being covered by protected areas by 2016.

A number of countries, such as Myanmar and Suriname, have chosen to focus on improving the management or effectiveness of their existing protected areas estate (medium). However overall there appears to be relatively less attention to this issue in the targets that have been established (low). Similarly few targets explicitly address the connection or integration of protected areas into wider landscapes and seascapes (medium). However, Colombia is linking the further development and consolidation of its system of protected areas with wider land use planning in order to promote ecological connectivity. Australia has set a target of establishing four collaborative continental-scale linkages to improve ecological connectivity by 2015.

Few targets explicitly address issues related to ecological representativeness (high). Similarly relatively few targets explicitly refer to protecting areas which are particularly important for biodiversity. One example, which is counter to this general trend, is Brazil, which in its protected areas target has committed to protecting 30% of the Amazon among other things.

In addition to NBSAPs, many countries that have developed plans to address gaps in their protected area systems. In fact, 72 countries have identified 197 priority actions within Protected Area Action Plans formally submitted to the Secretariat relating to PoWPA goal 1.1: "To establish and strengthen national and regional systems of protected areas integrated into a global network as a contribution to globally agreed goals" [4]. Examples of

---

[2] This assessment is based on an examination of the national biodiversity strategies and action plans from the following countries: Australia, Belarus, Belgium, Colombia, Democratic People's Republic of Korea, Dominican Republic, El Salvador, England, The European Union, Finland, France, Ireland, Japan, Malta, Myanmar, Serbia, Spain, Suriname, Switzerland, Timor Leste, Tuvalu and Venezuela. In addition it considers the set of national targets developed by Brazil. This assessment will be further updated and refined to account for additional NBSAPS and as such these initial findings should be considered as preliminary and were relevant a level of confidence has been associated with the main statements. This assessment focuses on the national targets, objectives, priority actions and similar elements included in the NBSAPs in relation to the international commitments made through the Aichi Biodiversity Targets.

[3] Comments not addressed: 1) Should say explicitly how many NBSAPs were examined and how many of these contained targets; 2) it is not clear what 'high' refers to it (in brackets); 3) Say what proportion of countries 72 represents; 4) explain POWPA because this is introduced for the first time here; 5) Add Switzerland to the list after "Examples of countries with such plans include but are not limited to:..."

[4] PoWPA action plans can be accessed at http://www.cbd.int/protected/implementation/actionplans/

countries with such plans include but are not limited to: South Africa, Mexico, Peru, Colombia, Argentina, Costa Rica, Croatia, Yemen, Guatemala, Brazil, Cook Islands, Kiribati, India, Burundi, and Palau.

Overall these national targets or similar commitments will make a substantial contribution towards the attainment of Aichi Biodiversity Target 11 (medium). The diversity of the formulation of national targets is likely a reflection of different national circumstances and the different elements contained in the global target. In generally it appears that a greater attention to management effectiveness and ecological representativeness may be needed (low) if this target is to be met by 2020.

2. What needs to be done to reach the Aichi Target?

2.a. Actions

Well-governed and effectively managed protected areas are a proven method for safeguarding both habitats and populations of species and for delivering important ecosystem services. As such, progress towards this target will greatly facilitate the attainment of other Aichi Biodiversity Targets notably targets 5, 10, 12, 13 and 14. The GBO-4 assessed that, taking current commitments into account, the target of expanding protected areas to cover 17 per cent of terrestrial areas by 2020 is likely to be met globally, although protected area networks remain unrepresentative and many critical sites for biodiversity are poorly conserved. The target for coverage of the protection of coastal waters is also expected to be met, although the deep-sea and open-ocean areas, including the high seas, are much less well covered. Inadequate management of protected areas remains widespread. Against this background, possible key actions to accelerate progress towards all elements of this target include:

(a) Further developing protected area networks, giving priority to marine and coastal areas (including deep-sea and open-ocean habitats) inland waters (especially upstream areas) and under-represented ecoregions as well as areas of particular importance for biodiversity;

(b) Employing a landscape or seascape approach to optimize the contribution of protected areas to habitat connectivity, the provision of ecosystem services and efforts to achieve Target 5;

(c) Improving the management effectiveness of protected areas, undertaking regular assessments of management effectiveness; and

(d) Enhancing cooperation with indigenous and local communities in the design and management of protected areas (*Target* 18).

The main source of guidance for Target 11 is the programme of work on protected areas and decisions X/31 and XI/24, as well as the programme of work on marine and coastal biodiversity.

To achieve the target of protecting 17% of terrestrial areas will require coverage to be increased by 5.5 million km^2; to do so in an ecologically representative way, on the other hand, will require 10.8 million km^2 (Ervin & Gidda, 2012). To cover 10% of all marine areas will require 27.8 million km^2 of additional area, but only 2.9 million km^2 or 425000 km^2 to achieve the target in waters up to 200 and 12 nautical miles of shorelines, respectively (Teh, unpublished data). While there are limited data to identify what it would take to effectively achieve the 17% target for inland waters, the additional complexity of protecting upstream areas for inland waters suggests that it could require greater (or at least different areas) than are needed to meet this target for terrestrial environments (Abell et al. 2007; Lehner, B. et al., unpublished data).

Meeting target 11 also requires that the expansion of protected areas increases the ecological representation of the global network, in terms of ecoregions, sites of global importance for biodiversity, and the distributions of species. In particular, there needs to be increased representation of freshwater habitats, including up- and down-stream areas, and also of marine habitats.

It is also necessary that protected areas are effectively managed. In order to achieve this will require more effort to assess the effectiveness of protected areas and to ensure that appropriate management practices are put in place.

2.b. Costs and Cost-benefit analysis

The High Level Panel report (Ervin & Gidda, 2012) estimated that to achieve the target will cost by 2020 a total of between US$73.8 billion and US$679.9 billion (US$9.2 to US$85.0 billion annually), through: a) creating new protected areas (US$44.2 billion to US$278.6 billion); (b) establishing connectivity corridors (US$21.3 billion to US$344.8 billion); (c) effectively managing new and existing protected areas (US$7.7 billion to US$53.5 billion); (d) strengthening protected area enabling environments and sustainable finance (US$ 0.5 billion to US$2.9 billion); and (e) conducting key protected areas assessments (US$25 million to US$78 million). Balmford et al. (2002) suggest a lower figure of US$45 billion for an effective network of marine and terrestrial protected areas. On the other hand estimates assuming an ecologically representative network arrive at estimates toward the upper end of the estimates from the High Level Panel report: to represent and effectively manage areas of importance for biodiversity (specifically Key Biodiversity Areas) is estimated to cost $76.1 billion annually (McCarthy et al., 2012). Larger protected areas are likely to be more cost effective in terms of both establishment (McRae-Strub et al., 2011) and effective management (Ervin & Gidda, 2012).

There are several benefits of investment in protected areas apart from biodiversity conservation, including water security, food security, hazard mitigation, health and climate-change mitigation (Balmford et al., 2002; Scharlemann et al., 2010; Meyerhoff et al., 2012). The return on investment in terrestrial protected areas has been estimated at between 7:1 and 100:1 (Balmford et al., 2002; Ervin & Gidda, 2012; Meyerhoff et al., 2012; High Level

Panel, 2013). There has been no comprehensive cost-benefit analysis for marine protected areas owing to the difficulty of predicting and estimating the economic benefits of future marine protected areas. However, regional studies suggest that investments will yield positive economic outcomes, with estimates returns on investment between 1.8:1 and 41.5:1 (van Beukring & Ceasar, 2004; Pham et al., 2005; Pascal, 2011; High Level Panel, 2013). Furthermore, it has been shown that economic benefits from fisheries and tourism are greater after reserve establishment than before (Sala et al., 2012).

3. What are the implications for biodiversity in 2020?

The successful achievement of area-based targets for protected areas designation does not guarantee a desirable outcome in terms of biodiversity conservation. Recent estimates confirm that the current global network of terrestrial protected areas still falls short of adequately representing biodiversity (Butchart et al. 2012; Cantú-Salazar et al., 2013; Rodrigues et al., 2013). Overall, evidence suggests that existing protected areas tend to have a positive effect on natural land cover, although results vary widely across different reserves (Bruner et al., 2001; Joppa & Pfaff, 2011; Geldmann et al. 2013). In terms of conserving species diversity, results have been much more mixed, with the majority of protected areas seeing ongoing declines in plant and animal populations, although at lower rates than in surrounding areas (Craigie et al., 2010; Laurance et al., 2012; Geldmann et al. 2013). Other approaches have shown that extinction risk was lower and increased more slowly for species for which most or all important sites were protected compared to those for which fewer or no sites were protected (Butchart et al., 2012).

It is expected that the effective management of protected areas leads to improvements in the status of biodiversity within them. Although there is little reported evidence of the relationships between management interventions and conservation outcomes for terrestrial protected areas, one recent review of 35 studies did reveal that targeted interventions (anti-poaching etc.) had a positive effect in over 80% of cases (Geldmann et al. 2013).

In the marine realm, poor design and management of many MPAs means that they currently have a minimal effect on achieving marine biodiversity conservation (Carey et al. 2000). However, there is strong evidence that well-managed marine protected areas can have positive effects on biodiversity: recent studies show that several measures of biodiversity are substantially improved compared either with before the establishment of the reserve or with unprotected areas nearby (Lester et al., 2009; Babcock et al., 2010), and Locally Managed Marine Protected Areas have been shown to have effective outcomes for benthic habitats (Mills et al., 2011).

Inland waters are likely to be the least effectively managed environments because there are few targeted protected areas for inland waters, and in many cases where protection does exist (e.g. Ramsar sites) upstream areas are not protected or managed in a way that will effectively abate threats (Abell et al. 2007; Januchowski-Harley et al. 2011; Chessman 2013). Furthermore, the pervasiveness of in-stream barriers can prevent fish movement into and out of protected areas (Januchowski-Hartley et al. 2011; 2013). Regional-scale assessments of the coverage and effectiveness of protected areas have shown that freshwaters are not only under-protected, but that the placement of protected areas is ineffective for conserving freshwater habitats and species (Herbert et al. 2010; Januchowski-Hartley et al. 2011; Chessman, 2013).

Results of modelling analyses suggest that expansion of the world's protected areas network will have a positive effect on biodiversity (Fig. 11.5; see also Target 12). Expanding protected areas to 20% of land surface area could lead to a net reduction in biodiversity loss by 2030 compared to a baseline 'business-as-usual' scenario (Figure 5, bottom bar). This net effect is comprised of a positive effect owing to reduction of habitat modification inside protected areas compared to the baseline scenario (Fig. 11.5, top bar), and an indirect negative effects primarily related to the displacement of agricultural activity from newly protected areas (Fig. 11.5 middle bar).

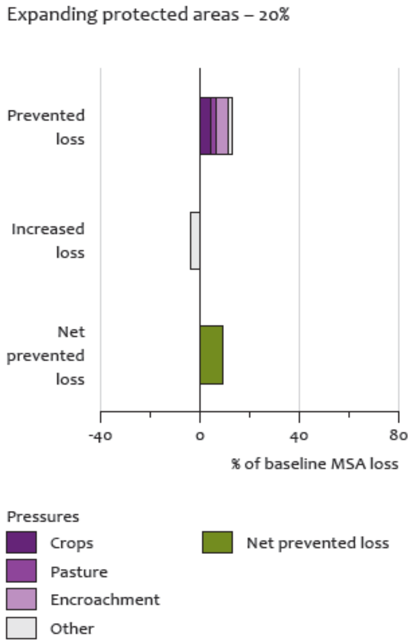


Figure 11.5. Consequences for projected biodiversity (measured as Mean Species Abundance; MSA) in 2030 of expanding the terrestrial protected area coverage to 20% of the terrestrial surface, compared to a baseline scenario where the existing network of protected areas is unchanged. Increased loss is caused by transfer of agricultural activity to non-protected areas. *Source: Netherlands Environmental Assessment Agency (2010).*

4. What do scenarios suggest for 2050 and what are the implications for biodiversity?

In all scenarios, habitat loss and fragmentation, pollution and existing roads are expected to continue to negatively affect biodiversity in terrestrial protected areas until 2050, but climate change will become an increasingly important threat.

Terrestrial scenarios that include reductions of these pressures in addition to increasing protected areas are much more efficient in reducing biodiversity loss than scenarios that focus on protected areas alone (see Target 12). Comparisons of several development options suggest that increasing the coverage of protected areas to 20% has modest but important effects on reducing biodiversity that are similar in magnitude to reducing deforestation to low levels or strongly limiting the use of biofuels, but are smaller than the effects of changing dietary consumption patterns or reducing agricultural waste (see chapter 21).

Towards the middle of the century, species are expected to respond to climate change through changes in their physiology, phenology and distribution (Bellard et al., 2012), leading to species range shifts, changes in community composition, vegetation structure and ecosystem function (e.g. Thuiller et al., 2005; Araujo et al., 2006; Araujo et al., 2011; Schloss et al., 2011; Hickler et al., 2012). There is now strong observational evidence that mobile species such as insects and birds have responded to climate warming over the last several decades by moving at rates that are the order of 17 km/decade towards the poles (Chen et al. 2011). Thus, "future conservation efforts should be fully aware that distribution of biodiversity, and species of concern, will be dramatically altered by climate change and that increased extinctions risks are one of the possible outcomes" (Araujo et al., 2011). Climatic and environmental changes that will influence future dynamics of species distributions are a challenge for conservation, which is currently focused on preserving the present and restoring the past (Strange et al., 2011). It is likely that many species will not be protected by existing conservation networks in the future (Hole et al., 2011). However, even if protected areas might in the future be less suited to support species they were originally designed for, they nevertheless play an important role as stepping stones and establishment centres for species spreading to new habitats (Hiley et al., 2013; Lawrence et al. 2011). In addition, considerable changes such as land use change and habitat transformation and fragmentation are to be expected in the landscape matrix surrounding protected areas, making dispersal across these landscapes problematic (Beaumont & Duursma, 2012; Hamilton et al. 2013).

The current network of protected areas will likely be insufficient to adequately protect biodiversity around the globe. By 2080, some models suggest that suitable climate will be lost for about 50% of species in protected areas in Europe, and for nearly two-thirds of species currently protected in Natura 2000 areas (Araujo et al., 2011). Considerable regional differences can be observed, with alpine and sub-arctic species particularly strongly affected. Similar losses of suitable climate can be observed in Important Bird Areas (IBAs) in Asia (Fig. 11.6), where it is predicted that ranges with suitable climate will decrease for nearly half of bird species of conservation concern by 2085 (Bagchi et al., 2013).

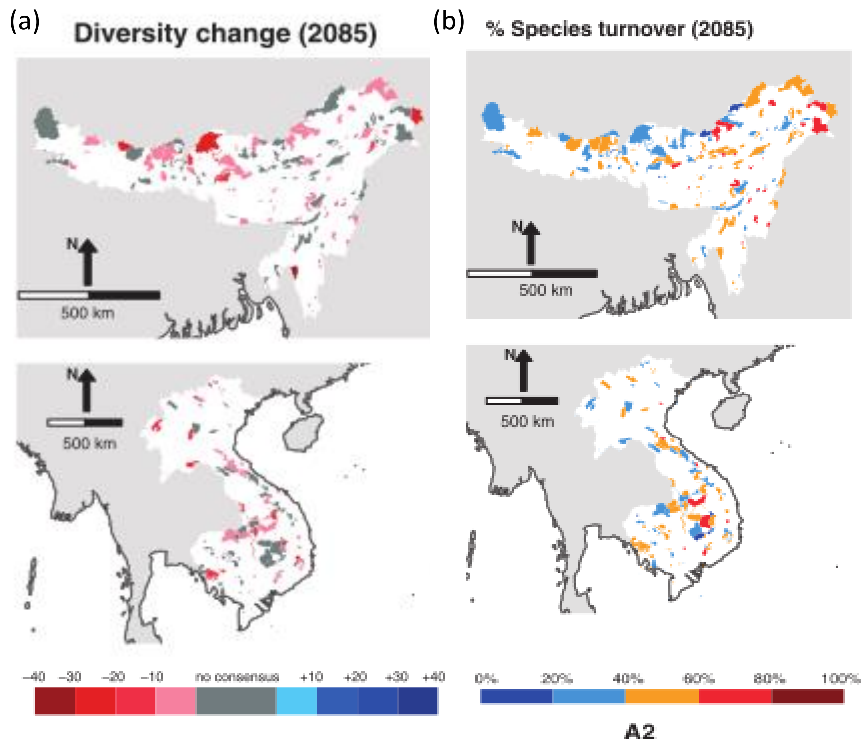


Figure 11.6. (a) Projected changes in number of species of conservation concern and (b) percentage species turnover by 2085 in Important Bird Areas of the Eastern Himalayas (top) and lower Mekong (bottom). Projections are based on a strong greenhouse gas emissions scenario (IPCC SRES A2). *Source: Bagchi et al, 2013, Global Change Biology*

In Sub-Saharan Africa, although suitable climate will persist for most species at IBAs, a considerable turnover of species (> 75%) is predicted for nearly half of the IBA's by 2085. Considerable regional differences in species turnover are shown, with priority species mainly affected in the wet savanna (Miombo) regions of East and Southern Africa (Hole et al., 2009). Overall, climate change is projected to reduce the overall effectiveness of IBAs in Southern Africa (Coetzee et al., 2009).

To minimize the impacts of climate change on the effectiveness of protected areas, a number of measures have been suggested (Hannah et al., 2007; Hannah, 2010; Araujo et al., 2011; Carvalho et al., 2011; Hole et al., 2011; Lemieux et al., 2011; Kingsford, 2011; Beaumont, 2012; Bagchi, 2013). These include:

- Designation of protected areas to include regions where species of special concern are projected to occur in future. This will require regional and continental scale cooperation.
- Maximising representation of environments in a given region, e.g., by including altitudinal or latitudinal gradients within protected areas or protected area networks.
- Implementation of mechanisms for integrated landscape management to facilitate movement of species between conservation areas.
- Climate adaptation strategies on conservation sites.
- Restoration of critical habitats.
- Reduction of non-climate pressures.

Gillson et al. (2013) suggest that conservation strategies should not only be based on climate-driven ranges shifts, and proposed a conservation and management prioritisation framework based on landscape conservation capacity attributes in addition to species vulnerability to climate change.

For inland waters, climate change could exacerbate the negative effects of drying conditions that are currently natural in many temporal river systems (Hermoso et al. 2012). Coupled with existing and growing threats from dams and water extraction, this could affect the distribution and movement of freshwater biodiversity (Bates et al., 2008; Morrongiello et al., 2011). Therefore, it will be essential to protect refugia to maintain individuals that can repopulate a wider range of habitats when more favourable conditions are restored after seasonal or prolonged droughts (Larned et al., 2010). Minimizing and managing upstream and downstream threats from changes in human land use, expansions of dams (e.g., Lehner et al. 2008; Vorosmarty et al. 2010) and water extraction will also be critical for protected areas to be effective for inland waters and the species that they support.

Climate change is projected to cause shifts in geographic ranges of marine organisms, affecting the distribution of marine biodiversity (Cheung *et al*. 2009). Projections using species distribution models suggest a generally poleward shift in exploited marine fishes and invertebrates, resulting in high rates of local extinction in the tropics and semi-enclosed seas, while rate of invasion is projected to be high in the Arctic. Trophic interactions in marine food webs are also projected to be affected (Ainsworth *et al*. 2011; Fulton 2011; Fernandes *et al*. 2013). These responses will add to and interact with the effects of other human stressors on marine biodiversity and fisheries productivity, such as overfishing, pollution and habitation degradation.

Marine protected area effectiveness is also likely to be influenced by climate change (Soto 2001; McLead *et al*. 2008). Possible impacts include: (1) changes in quality and distribution of critical habitats such as coral reefs; (2) changes in the distribution of marine biodiversity (but see Jones et al., 2013); (3) changes in protected area connectivity; (4) changes in ecosystem structure and productivity; and (5) changes in human activities, such as spatial fishing patterns.

5. Uncertainties

Target 11 can be split into a number of separate components: the total coverage of protected areas, the degree to which biodiversity is represented, management effectiveness and equitability, and connectivity in the wider landscape. While data exist for the assessment of the first two components, those for the third and fourth are less developed. This gap may be filled to some extent in the coming years by a framework for the assessment of management effectiveness of protected areas provisionally called the Green List of well-managed protected areas, to be presented at the IUCN World Parks Congress in November 2014.

In the terrestrial scenarios, a protected area is defined as an area free from agricultural land use, infrastructure development, hunting and gathering. The effect of protected areas on biodiversity is therefore also based on this definition. However in reality the protected areas might not be free from agricultural land use, infrastructure development, hunting and gathering, and therefore the effect of protected areas on biodiversity might be dampened. Key assumptions made by the socio-economic scenarios include: that bare areas cannot be turned into protected areas (so deserts are excluded); that grid cells close to agriculture areas are preferred for new protected areas; and that agricultural land cannot be transformed into natural habitat as this would be too expensive.

Future distributions of species depend on a range of drivers (including, but not restricted to, abiotic conditions, biotic interactions, human-induced environmental changes as well as species-specific dispersal, establishment and demographic processes), that are also likely to change over time (Anderson 2013). Most correlative models used to predict species distribution, however, base habitat suitability on current environmental data, and apply this to future climate (Anderson 2013, Dormann 2007), and neglect biotic interactions as well as ecological processes (Cheaib et al., 2012) that determine the final distribution of a species (Pagel & Schurr, 2012). Furthermore, only very few models take into consideration the potential of a species to adapt to new conditions, i.e. the phenotypic plasticity and local adaptation (Bocedi et al., 2013, Morin & Thuiller 2009). Furthermore, various models used to predict species distributions vary in the their sensitivity to climate change (such as changes in CO_2, temperature or precipitation), based on the different approaches how these factors are represented in the models (Cheaib et al., 2012). Uncertainties and errors in model prediction may also arise from the quality of initial data sets used to parametrise and validate the models (e.g. Lintz et al., 2013, Buisson et al., 2010), and mismatches between scales of data and modelling (Wiens et al, 2009).

6. Dashboard – Progress towards Target

	Target Elements	Status	Comment	Confidence
Target 11	At least 17 per cent of terrestrial and inland water areas are protected		Extrapolations show good progress and the target will be achieved if existing commitments on designating protected areas are implemented. Inland water protection has distinct issues.	High
	At least 10 per cent of coastal and marine areas are protected		Marine protected areas are accelerating but extrapolations suggest we are not on track to meet the target. With existing commitments, the target would be met for territorial waters but not for exclusive economic zones or high seas	High

	Target Elements	Status	Comment	Confidence
	Areas of particular importance for biodiversity and ecosystem services protected		Progress for protected Key Biodiversity Areas, but still important gaps. No separate measure for ecosystem services	High
	Protected areas are ecologically representative		Progress, and possible to meet this target for terrestrial ecosystems if additional protected areas are representatives. Progress with marine and freshwater areas, but much further to go	High for terrestrial and marine, low for inland waters.
	Protected areas are effectively and equitably managed		Reasonable evidence of improved effectiveness, but small sample size. Increasing trend towards community involvement in protection. Very dependent on region and location	Low
	Protected areas are well connected and integrated into the wider landscape and seascape		Initiatives towards corridors and transboundary parks, but still not sufficient connection. Freshwater protected areas remain very disconnected	Low or very low.

Compiled by Tim Newbold, Matt Walpole, Neil Burgess, Cornelia Krug, Carlo Rondinini, Steph Januchowski-Hartley, Louise Teh and Paul Leadley, with contributions from Jennifer van Kolck, Piero Visconti, Stuart Butchart, Michel Bakkenes, Henrique Pereira and Silvia Ceausu
Extrapolations: Derek Tittensor
NBSAPs and National Reports: Kieran Mooney / CBD secretariat
Dashboard: Tim Hirsch

6. References cited

Abell R, Allan JD, Lehner B (2007) Unlocking the potential of protected areas for freshwaters. Biological Conservation 134: 48–63.

Ainsworth, C.H., Samhouri, J.F., Busch, D.S. et al., 2011. Potential impacts of climate change on Northeast Pacific marine foodwebs and fisheries. ICES Journal of Marine Science 68, 1217-1229.

Anderson, R. P. (2013). A framework for using niche models to estimate impacts of climate change on species distributions, 1297, 8–28. doi:10.1111/nyas.12264

Araújo, M.B., Alagador, D., Cabeza, M., Nogués-Bravo, D., Thuiller, W., 2011. Climate change threatens European conservation areas. *Ecology Letters* 14, 484–92.

Araújo, M.B., Thuiller, W., Pearson, R.G., 2006. Climate warming and the decline of amphibians and reptiles in Europe. *Journal of Biogeography* 33, 1712–1728.

Babcock, R.C., Shears, N.T., Alcala, A.C., Barrett, N.S., Edgar, G.J., Lafferty, K.D., McClanahan T.R. & Russ, G.R. (2010) Decadal trends in marine reserves reveal differential rates of change in direct and indirect effects. PNAS, 107, 18256-18261.

Bagchi, R., Crosby, M., Huntley, B., Hole, D.G., Butchart, S.H.M., Collingham, Y., Kalra, M., Rajkumar, J., Rahmani, A., Pandey, M., Gurung, H., Trai, L.T., Van Quang, N., Willis, S.G., 2013. Evaluating the effectiveness of conservation site networks under climate change: accounting for uncertainty. *Global Change Biology* 19, 1236–48.

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K., Turner, R.K., 2002. Economic reasons for conserving wild nature. *Science* (New York, N.Y.) 297, 950–3.

Ban, N.C., Bax, N.J., Gjerde, K.M. et al. 2014. Systematic conservation planning: a better rcipe for managing the high seas for biodiversity conservatino and sustainable use. Conservation Letters 7:41-54.

Bates, B.C., Kundzewicz, Z.W., Wu, S. & Palutikof, J.P. (2008) Climate change and water. Technical paper of the Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva.

Beaumont, L.J. & Duursma, D. 2012. Global projections of 21st century land-use changes in regions adjacent to Protected Areas. *PloS One* 7, e43714.

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., Courchamp, F., 2012. Impacts of climate change on the future of biodiversity. *Ecology Letters* 365–377.

Bertzky, C., Corrigan, C., Kemsey, J., Kenney, S., Ravilious, C., Besançon, C., Burgess, N. (2012). Protected Planet Report 2012: Tracking Progress Towards Global Targets for Protected Areas. UNEP-WCMC, Cambridge.

Blomley, T., Pfliegner, K, Isango, J., Zahabu, E., Ahrends, A. and N.D. Burgess. (2008). Seeing the Wood for the Trees: Towards an objective assessment of the impact of Participatory Forest Management on forest condition in Tanzania. Oryx 42:380-392.

Bocedi, G., Atkins, K. E., Liao, J., Henry, R. C., Travis, J. M. J., & Hellmann, J. J. (2013). Effects of local adaptation and interspecific competition on species' responses to climate change. Annals of the New York Academy of Sciences, 83–97. doi:10.1111/nyas.12211

Bowler, D., Buyung-Ali, L., Healey, J.R., Jones, J.P.G, Knight, T. and Pullin, A.S. (2010) The evidence base of community forest management as a mechanism for supplying global environmental benefits and improving local welfare. Environmental Evidence:www.environmentalevidence.org/SR48

Brooks, T.M., Mittermeier, R.A., da Fonseca, G.A.., Gerlach, J., Hoffmann, M., Lamoreux, J.F., Mittermeier, C.G., Pilgrim, J.D., and Rodrigues, A.S.. (2006). Global biodiversity conservation priorities. Science 313, 58.

Bruner et al, 2001

Buisson, L., Thuiller, W., Casajus, N., Lek, S., & Grenouillet, G. (2010). Uncertainty in ensemble forecasting of species distribution. Global Change Biology, 16(4), 1145–1157. doi:10.1111/j.1365-2486.2009.02000.x

Burke, L., Reytar, K., Spalding, M. & Perry, A. 2011. *Reefs at Risk Revisited*. World Resources Institute, Washington, DC.

Butchart, S.H.M., Scharlemann, J.P.W., Evans, M.I., Quader, S., Aricò, S., Arinaitwe, J., Balman, M., Bennun, L. a, Bertzky, B., Besançon, C., Boucher, T.M., Brooks, T.M., Burfield, I.J., Burgess, N.D., Chan, S., Clay, R.P., Crosby, M.J., Davidson, N.C., De Silva, N., Devenish, C., Dutson, G.C.L., Fernández, D.F.D.Z., Fishpool, L.D.C., Fitzgerald, C., Foster, M., Heath, M.F., Hockings, M., Hoffmann, M., Knox, D., Larsen, F.W., Lamoreux, J.F., Loucks, C., May, I., Millett, J., Molloy, D., Morling, P., Parr, M., Ricketts, T.H., Seddon, N., Skolnik, B., Stuart, S.N., Upgren, A., Woodley, S., 2012. Protecting important sites for biodiversity contributes to meeting global conservation targets. *PloS One* 7, e32529.

Cantú-Salazar, L., Orme, C.D.L., Rasmussen, P.C., Blackburn, T.M., Gaston, K.J., 2013. The performance of the global protected area system in capturing vertebrate geographic ranges. *Biodiversity and Conservation* 22, 1033–1047.

Carey, C., Dudley, N. & Stolton, S. 2000. *The importance and vulnerability of the world's protected areas*. WWF International, Gland, Switzerland.

Carvalho, S.B., Brito, J.C., Crespo, E.G., Watts, M.E., Possingham, H.P., 2011. Conservation planning under climate change: Toward accounting for uncertainty in predicted species distributions to increase confidence in conservation investments in space and time. *Biological Conservation* 144, 2020–2030.

Cheaib, A., Badeau, V., Boe, J., Chuine, I., Delire, C., Dufrêne, E., … Leadley, P. (2012). Climate change impacts on tree ranges: model intercomparison facilitates understanding and quantification of uncertainty. Ecology letters, 15(6), 533–44. doi:10.1111/j.1461-0248.2012.01764.x

Chen, I.-C., Hill, J.K., Ohlemüller, R., Roy, D.B., Thomas, C.D., 2011. Rapid Range Shifts of Species Associated with High Levels of Climate Warming. *Science* 333, 1024–1026.

Chessman, 2013.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L. et al. 2009. Projecting global marine biodiversity impacts under climate change scenarios. Fish and Fisheries 10, 235-251.

Coad, L., Leverington, F., Burgess, N., Cuadros, I., Geldmann, J., Marthews, T.R., Mee, J., Nolte, C., Stoll-Kleemann, S., Vansteelant, N., Zamora, C., Zimsky, M. and Hockings, M., 2013. Progress towards the CBD Protected Area Management Effectiveness targets. *PARKS*, 19(1)

Coetzee, B.W.T., Robertson, M.P., Erasmus, B.F.N., Van Rensburg, B.J., Thuiller, W., 2009. Ensemble models predict Important Bird Areas in southern Africa will become less effective for conserving endemic birds under climate change. *Global Ecology and Biogeography* 18, 701–710.

Craigie, I.D., Baillie, J.E.M., Balmford, A., Carbone, C., Collen, B., Green, R.E., Hutton, J.M., 2010. Large mammal population declines in Africa's protected areas. *Biological Conservation* 143, 2221–2228.

Devillers, R., Pressey, R.L., Grech, A., Kittinger, J.N., Edgar, G.J., Ward, T., Watson, R. 2014. Reinventing residual reserves in the sea: are we favouring ease of establishment over need for protection? Aquatic Conservation: Marine and Freshwater Ecosystems. DOI: 10.1002/aqc.2445

Dormann, C. F. (2007). Promising the future? Global change projections of species distributions. Basic and Applied Ecology, 8(5), 387–397. doi:10.1016/j.baae.2006.11.001

Ervin, J., Gidda, S., 2012. *Resource requirements for Aichi Targets 11 – Protected Areas*. Convention on Biological Diversity, Montreal, Canada.

European Council (1979). Council Directive 79/409/EEC on the conservation of wild birds.

European Council (1992). EU Habitats Directive (92/43/EEC). Consol. Text Off. Off. Publ. Eur. Union CONSLEG 1992LOO43–0105–2004.

Fausch, K.D., Torgersen, C.E., Baxter, C.V. & Li, H.W. (2002) Landscapes to riverscapes: bridging the gap between research and conservation of stream fi bri. BioScience, 52, 483–498.

Fernandes J.A., Cheung W.W.L., Jennings S. et al., Modelling the effects of climate change on the distribution and production of marine fishes: accounting for trophic interactions in a dynamic bioclimate envelope model. Global Change Biology 19: 2596-2607.

Freestone, D. 2012. International governance, responsibility and management of areas beyond national jurisdiction. International Journal of Marine & Coastal Law 27:19-204.

Fullerton, A.H., Burnett, K.M., Steel, E.A., Flitcroft, R.L., Pess, G.R., Feist, B.E., Torgersen, C.E., Miller, D.J. & Sanderson, B.L. (2010) Hydrological connectivity for riverine fish: measurement challenges and research opportunities. Freshwater Biology, 55, 2215–2237.

Fulton, E. A. 2011. Interesting times: winners, losers, and system shifts under climate change around Australia. – ICES Journal of Marine Science, 68: 1329–1342.

Geldmann, J. , Barnes, M. , Coad, L. , Craigie, I., Hockings, M. & Burgess, N. 2013. Effectiveness of terrestrial protected areas in reducing biodiversity and habitat loss. CEE 10-007. *Collaboration for Environmental Evidence*: www.environmentalevidence.org/ SR10007.html.

Geldmann, J., Barnes, M., Coad, L., Craigie, I.D., Hockings, M. and Burgess, N.D. (2013) Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. *Biological Conservation*, 161: 230-238.

Gillson, L., Dawson, T.P., Jack, S., McGeoch, M. a, 2013. Accommodating climate change contingencies in conservation strategy. *Trends in Ecology & Evolution* 28, 135–42.

Hamilton CM, Martinuzzi S, Plantinga AJ, Radeloff VC, Lewis DJ, et al. (2013) Current and Future Land Use around a Nationwide Protected Area Network. PLoS ONE 8(1): e55737. doi:10.1371/journal.pone.0055737

Hannah, L., 2010. A global conservation system for climate-change adaptation. Conservation biology : the journal of the Society for Conservation Biology 24, 70–7.

Hannah, L., Midgley, G., Andelman, S., Araújo, M., Hughes, G., Martinez-Meyer, E., Pearson, R., Williams, P., 2007. Protected area needs in a changing climate. *Frontiers in Ecology and the Environment* 5, 131–138.

Herbert et al. 2010.

Hermoso, V., Kennard, M.J. & Linke, S. 2012. Integrating multidirectional connectivity requirements in systematic conservation planning for freshwater systems. Diversity and Distributions **18**: 448-458.

Hickler, T., Vohland, K., Feehan, J., Miller, P. a., Smith, B., Costa, L., Giesecke, T., Fronzek, S., Carter, T.R., Cramer, W., Kühn, I., Sykes, M.T., 2012. Projecting the future distribution of European potential natural vegetation zones with a generalized, tree species-based dynamic vegetation model. *Global Ecology and Biogeography* 21, 50–63.

Hiley, J.R., Bradbury, R.B., Holling, M., Thomas, C.D., 2013. Protected areas act as establishment centres for species colonizing the UK. *ransactions of the Royal Society B: Biological sciences* 280, 20122310.

Hole, D.G., Huntley, B., Arinaitwe, J., Butchart, S.H.M., Collingham, Y.C., Fishpool, L.D.C., Pain, D.J., Willis, S.G., 2011. Toward a management framework for networks of protected areas in the face of climate change. *Conservation Biology* 25, 305–15.

Hole, D.G., Willis, S.G., Pain, D.J., Fishpool, L.D., Butchart, S.H.M., Collingham, Y.C., Rahbek, C., Huntley, B., 2009. Projected impacts of climate change on a continent-wide protected area network. *Ecology Letters* 12, 420–31.

Januchowski-Hartley et al. 2013

Januchowski-Hartley SR, Pearson RG, Puschendorf R, Rayner T (2011) Fresh Waters and Fish Diversity: Distribution, Protection and Disturbance in Tropical Australia. PLoS ONE 6(10): e25846.

Jones, M., Dye, S.R., Fernandes, J.A. et al., 2013. Predicting the impact of climate change on threatened species in UK waters. PLoSONE DOI: 10.1371/journal.pone.0054216

Joppa, L.N., Pfaff, A., 2011. Global protected area impacts. *Transactions of the Royal Society B: Biological sciences* 278, 1633–8.

Kimball, Lee A. (2005). The International Legal Regime of the High Seas and the Seabed Beyond the Limits of National Jurisdiction and Options for Cooperation for the establishment of Marine Protected Areas (MPAs) in Marine Areas Beyond the Limits of National Jurisdiction. Secretariat of the Convention on Biological Diversity, Montreal,Technical Series no. 19, 64 pages.

Kingsford, R.T., 2011. Conservation management of rivers and wetlands under climate change - a synthesis. *Marine and Freshwater Research* 62, 217.

Larned, S.T., Datry, T., Arscott, D.B. & Tockner, K. (2010) Emerging concepts in temporary-river ecology. Freshwater Biology, 55, 717–738.

Laurance, W.F. et al. (2012) Averting biodiversity collapse in tropical forest protected areas. *Nature*, 489, 290-294.

Lawrence, D.J., Larson, E.R., Reidy Liermann, C.A., Mims, M.C., Pool, T.K. & Olden, J.D. 2011. National parks as protected areas for U.S. freshwater fish diversity. Conservation Letters **4**: 364-371.

Lemieux, C.J., Beechey, T.J., Gray, P. A., 2011. Prospects for Canada's protected areas in an era of rapid climate change. *Land Use Policy* 28, 928–941.

Lester, S.E., Halpern, B.S., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B.I., Gaines, S.D., Airame, S., Warner, R.R. 2009. Biological effects within no-take marine reserves: a global synthesis. Mar Ecol Prog Ser 384: 33-46.

Leverington, F., Costa, K.L., Pavese, H., Lisle, A., Hockings, M., 2010. A global analysis of protected area management effectiveness. *Environmental Management* 46, 685–98.

Linke S, Pressey RL, Bailey RC, Norris RH (2007) Management options for river conservation planning: condition and conservation re-visited. Freshwater Biology 52: 918–938.

Lintz, H. E., Gray, A. N., & McCune, B. (2013). Effect of inventory method on niche models: Random versus systematic error. Ecological Informatics, 18, 20–34. doi:10.1016/j.ecoinf.2013.05.001

Makino, M., Matsuda, H. & Sakurai, Y. (2009) Expanding fisheries co-management to ecosystem-based management: A case in the Shiretoko World Natural Heritage area, Japan. *Marine Policy*, 33, 207-214.

McCarthy, D.P., Donald, P.F., Scharlemann, J.P.W., Buchanan, G.M., Balmford, A., Green, J.M.H., Bennun, L.A., Burgess, N.D., Fishpool, L.D.C., Garnett, S.T., Leonard, D.L., Maloney, R.F., Morling, P., Schaefer, H.M., Symes, A., Wiedenfeld, D.A. & Butchart, S.H.M. (2012) Financial costs of meeting global biodiversity conservation targets: Current spending and unmet needs. Science 338: 946-949.

McKee, J.K., Sciulli, P.W., Fooce, C.D., and Waite, T.A. (2004). Forecasting global biodiversity threats associated with human population growth. Biol. Conserv. 115, 161–164.

McLead, E., Salm, R, Green, A., Almany, J. 2008. Designing marine protected area networks to address the impacts of climate change. Frontiers in Ecology and the Environment 7, doi:10.1890/070211.

MDG Annual Report

Meyerhoff et al. 2012

Mills, M., Jupiter, S.D., Pressey, R.L., Ban, N.C. & Comley, J. 2011. Incorporating effectiveness of community-based management in a national marine gap analysis for Fiji. Conservation Biology **25**: 1155-1164.

Morin, X., & Thuiller, W. (2009). Comparing niche- and process-based models to reduce prediction uncertainty in species range shifts under climate change. ECOLOGY, 90(5), 1301–1313. doi:10.1890/08-0134.1

Morrongiello, J.R., Beatty, S.J., Bennett, J.C., Crook, D.A., Ikedife, D.N.E., Kennard, M.J., Kerezsy, A., Lintermans, M., McNeil, D.G., Pusey, B.J. & Rayner, T. (2011) Climate change and its implications for Australia's freshwater fish. Marine and Freshwater Research, 62, 1082-1098.

Navarro, L., and Pereira, H. (2012). Rewilding Abandoned Landscapes in Europe. Ecosystems 15, 900–912.
Nel JL, Roux DJ, Maree G, Kleynhans CJ, Moolman J, et al. (2007) Rivers in peril inside and outside protected areas: a systematic approach to conservation assessment of river ecosystems. Diversity and Distributions 13: 341–352.
Nicholson, E., Collen, B., Barausse, A., Blanchard, J.L., Costelloe, B.T., Sullivan, K.M.E., Underwood, F.M., Burn, R.W., Fritz, S., Jones, J.P.G., McRae, L., Possingham, H.P., Milner-Gulland, E.J., 2012. Making robust policy decisions using global biodiversity indicators. *PloS One* 7, e41128.
OECD, 2012: *OECD Environmental Outloot to 2050*. OECD Publishing.
Pascal, N. 2011. Cost-benefit analysis of community based marine protected areas: 5 cases studies in Vanuatu, South Pacific. Research report, CRISP-CRIOBE (EPHE/CNRS), Moorea, French Polynesia, 107 pp.
Pham, K.N., Tran, V.H.S., Cesar, H. 2005. Economic valuation of the Hon Mun Marine Protected Area. PREM Working Paper 05/13. Institute for Environmental Studies, Uvije Universiteit Amsterdam. Available at www.prem-online.org Accessed 26 April 2014.
Porter-Bolland, L., E. A. Ellis, M. R. Guariguata, I. Ruiz-Mall´en, S. Negrete-Yankelevich, and V. Reyes-Garc´ıa. 2012. Community managed forests and forest protected areas: an assessment of their conservation effectiveness across the tropics. Forest Ecology and Management 268:6–17.
Potts, A.J., Hedderson, T.A. and Cowling, R. (2013) Testing large-scale conservation corridors designed for patterns and processes: comparative phylogeography of three tree species. Diversity and Distributions 19: 1418-1428.
Pringle, C.M. (2001) Hydrologic connectivity and the management of biological reserves: a global perspective. Ecological Applications, 11, 981–998.
Rodrigues et al. 2013
Sala, E., Costello, C., Dougherty, D., Heal, G., Kelleher, K., Murray, J.H., Rosenberg, A.A., Sumaila, R. 2013. A general business model for marine reserves. PLoS ONE 8(4): e58799. doi:10.1371/journal.pone.0058799.
Scharlemann, J.P.W., Kapos, V., Campbell, A., Lysenko, I., Burgess, N.D., Hansen, M.C., Gibbs, H.K., Dickson, B. and Miles, L (2010). Securing Tropical Forest Carbon: the Contribution of Protected Areas to REDD. Oryx 44: 352-357.
Schloss, C. A, Lawler, J.J., Larson, E.R., Papendick, H.L., Case, M.J., Evans, D.M., DeLap, J.H., Langdon, J.G.R., Hall, S. A., McRae, B.H., 2011. Systematic conservation planning in the face of climate change: bet-hedging on the Columbia Plateau. *PloS One* 6, e28788.
Simaika, J.P., Samways, M.J., Kipping, J., Suhling, F., Dijkstra, K.-D.B., Clausnitzer, V., Boudot, J.-P. & Domisch, S. 2013. Continental-scale conservation prioritization of African dragonflies. Biological Conservation **157**: 245-254.
Soto, C.G. 2001. The potential impacts of global climate change on marine protected areas. Reviews in Fish Biology and Fisehries 11, 181-195.
Spalding, M., Melanie, I., Milam, A., Fitzgerald, C. & Hale, L.Z. 2013. Protecting Marine Spaces: Global Targets and Changing Approaches. In Chircop, A., Coffen-Smout, S. & McConnell, M. (eds.). *Ocean Yearbook 27*. Martinus Nijhoff Publishers, Leiden, pp. 213-248.
Spalding, M., Wood, L., Fitzgerald, C., Gjerde, K., 2010. The 10% Target: Where Do We stand? In: Toropova, C., Meliane, I., Laffoley, D., Matthews, E., Spalding, M. (Eds.), *Global Ocean Protection: Present Status and Future Possibilities*. IUCN, The Nature Conservancy, UNEP-WCMC, UNEP, UNU-IAS, Agence des aires marines protégées, France, Gland, Switzerland, Arlington, USA, Cambridge, UK, Nairobi, Kenya, Tokyo, Japan, and Brest, France.
Stolton, S., Dudley, N. & Redford, K. H. (2014) *PPA Futures: Assessing and advancing the role of private protected areas: a project funded by the Linden Trust for Conservation*. IUCN, Gland, Switzerland.
Strange, N., Thorsen, B.J., Bladt, J., Wilson, K. a., Rahbek, C., 2011. Conservation policies and planning under climate change. *Biological Conservation* 144, 2968–2977.
Thuiller, W., Lavorel, S., Araújo, M.B., Sykes, M.T., Prentice, I.C., 2005. Climate change threats to plant diversity in Europe. *Proceedings of the National Academy of Sciences of the United States of America* 102, 8245–50.
UNESCO. 2009. *Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification*. Paris, UNESCO-IOC. (IOC Technical Series, 84)
van Beukering, P., Cesar, H. 2004. Economic analysis of marine managed areas in the main Hawaiian islands. Cesar Environmental Economics Consulting, Arnhem, Netherlands.

Visconti, P. et al. 2013. Effects of errors and gaps in spatial datasets on assessment of conservation progress. Conservation Biology **27**: 1000-1010.

Vörösmarty, C.J. et al. 2010. Global threats to human water security and river biodiversity. Nature **467**: 555-561.

Weeks, R., G. R. Russ, A. C. Alcala, and A. T. White. 2010. Effectiveness of marine protected areas in the Philippines for biodiversity conservation. Conservation Biology 24:531–540.

Wiens, J. a, Stralberg, D., Jongsomjit, D., Howell, C. a, & Snyder, M. a. (2009). Niches, models, and climate change: assessing the assumptions and uncertainties. Proceedings of the National Academy of Sciences of the United States of America, 106 Suppl , 19729–36. doi:10.1073/pnas.0901639106